Pariksha Saathi — Teaching and Pedagogy (CTET) Notes

9 topics • 83 lessons • updated 28 October 2026

These notes are written by an AI assistant - they are the same lessons the Pariksha Saathi app shows. They have not been reviewed by a subject-matter expert. Check facts that matter against an official source or a standard textbook, and tell us about any error: parikshasaathi.com/contact/

The Teaching and Pedagogy (CTET) topics in the syllabus of: CTET. Each topic ends with a link to its free practice questions; full mock tests are free in the Pariksha Saathi app and on the website.

Contents

Child Development and Pedagogy
Environmental Studies Pedagogy (Paper I)
Inclusive Education and Children with Special Needs
Language Pedagogy (Language I and II)
Mathematics Pedagogy
Mathematics, Classes I-V (Paper I)
Mathematics, Classes VI-VIII (Paper II)
Science and its Pedagogy (Paper II)
Social Studies and its Pedagogy (Paper II)
Revision sheet

Child Development and Pedagogy

Child Development and Pedagogy

What the exam asks: Child Development and Pedagogy (CDP) is a compulsory 30-question section in both CTET Paper I and Paper II, and every state TET follows the same pattern. Roughly half the questions are theory recall (Piaget, Kohlberg, Vygotsky, intelligence theories, learning theories, thinkers and their key terms) and the rest are classroom scenarios ("A teacher notices that..."). In scenario questions the correct option is always the child-centred, inclusive, constructivist choice endorsed by NCF 2005 and RTE 2009; options that reward rote learning, labelling, punishment, competition or exclusion are distractors.

Development and its principles: Growth is quantitative (height, weight) and stops; development is qualitative, lifelong and includes growth. Development follows fixed directions - cephalocaudal (head to toe) and proximodistal (centre of the body outwards) - and proceeds from general to specific. It is continuous, cumulative, predictable in sequence but variable in rate, and all domains (physical, cognitive, social, emotional, language) are interrelated. Heredity sets the potential, environment shapes how far it is realised; the accepted view is the interaction of both, not one alone. Socialisation begins with the family (the primary agent), then school, peers and media (secondary agents).

Piaget and Vygotsky: Piaget's cognitive constructivism has four stages - sensorimotor (0-2 years, object permanence), pre-operational (2-7, symbolic play, egocentrism, animism, centration, irreversibility), concrete operational (7-11, conservation, reversibility, seriation, classification) and formal operational (11 and above, abstract and hypothetico-deductive reasoning). Key processes are schema, assimilation (fitting new information into an existing schema), accommodation (changing the schema) and equilibration. Vygotsky's social constructivism stresses culture and language: the Zone of Proximal Development is the gap between what a child can do alone and with help; scaffolding is the temporary support given by a More Knowledgeable Other; private speech guides thinking and later becomes inner speech. Piaget said development precedes learning; Vygotsky said learning leads development.

Moral, psychosocial and other stage theories: Kohlberg's three levels, each with two stages - pre-conventional (punishment avoidance; self-interest exchange), conventional (good boy/nice girl approval; law and order) and post-conventional (social contract; universal ethical principles) - were derived from responses to the Heinz dilemma.

Erikson's psychosocial crises for school ages are initiative vs guilt (3-6), industry vs inferiority (6-12) and identity vs role confusion (adolescence). Bruner gave the enactive, iconic and symbolic modes of representation, discovery learning and the spiral curriculum. Freud divided personality into id (pleasure principle), ego (reality principle) and superego (morality) and described defence mechanisms such as rationalisation, projection and sublimation.

Intelligence and individual differences: Spearman's two-factor theory (g and s), Thurstone's seven primary mental abilities, Guilford's structure of intellect (operations, contents, products), Cattell's fluid and crystallised intelligence, Sternberg's triarchic theory (analytical, creative, practical) and Gardner's multiple intelligences (eight: linguistic, logical-mathematical, spatial, musical, bodily-kinaesthetic, interpersonal, intrapersonal, naturalistic) are standard theories of intelligence. Binet gave the concept of mental age; Stern's ratio IQ = (mental age / chronological age) x 100 was popularised by Terman in the Stanford-Binet scale. Goleman popularised emotional intelligence. Gender is a social construct distinct from biological sex; teachers must avoid gender stereotypes in tasks, examples and expectations. Differences of language, caste, religion and community are resources for an inclusive classroom, not deficits. Learning disabilities to know: dyslexia (reading), dysgraphia (writing), dyscalculia (arithmetic) and dyspraxia (motor coordination); ADHD is a separate attention condition, not a learning disability.

Learning theories: Pavlov's classical conditioning (dog, bell, salivation) pairs a neutral stimulus with an unconditioned stimulus. Thorndike's trial-and-error learning gave the laws of readiness, exercise and effect. Skinner's operant conditioning uses reinforcement (positive adds a reward, negative removes an aversive stimulus - both increase behaviour) and punishment (decreases behaviour); the variable-ratio schedule is most resistant to extinction. Kohler's chimpanzee Sultan showed insight learning (Gestalt); Tolman's rats showed latent learning and cognitive maps; Bandura's Bobo doll experiment established observational learning (attention, retention, reproduction, motivation). Memory questions cover Ebbinghaus's forgetting curve, chunking (Miller's 7 plus or minus 2) and proactive versus retroactive interference. Transfer of learning can be positive, negative or zero.

Motivation, assessment and pedagogy: Maslow's hierarchy runs from physiological needs through safety, belonging and esteem to self-actualisation. Intrinsic motivation (interest, curiosity) is preferred over extrinsic rewards; Weiner's attribution theory says children who attribute failure to lack of effort (internal, controllable) persist more than those who blame ability. Assessment for learning is formative and diagnostic, assessment of learning is summative; CCE covers scholastic and co-scholastic areas continuously; portfolios, rubrics, anecdotal records and self-assessment are the preferred tools. Criterion-referenced tests compare a child to a standard, norm-referenced tests compare children to each other. Open-ended "why" and "what if" questions assess readiness and promote critical thinking. Children fail mainly because teaching ignores their prior ideas (alternative conceptions) and context; errors are windows into a child's thinking, not faults to punish.

Progressive thinkers and policy: Dewey (learning by doing, school as a miniature society), Montessori (prepared environment, sensory didactic apparatus, auto-education), Froebel (kindergarten, gifts and occupations, play), Rousseau (Emile, naturalism), Pestalozzi (head, heart and hand), Kilpatrick (project method), Tagore (Shantiniketan, learning in nature), Gandhi (Nai Talim or Basic Education, craft-centred, mother tongue, Wardha 1937) and Gijubhai Badheka (Divaswapna). NCF 2005 (chaired by Yash Pal) has five guiding principles: connecting knowledge to life outside school, moving away from rote methods, enriching curriculum beyond textbooks, making examinations flexible and integrated with classroom life, and nurturing an identity informed by democratic values. RTE 2009 gives every child of 6 to 14 years free and compulsory elementary education (Article 21A, 86th Amendment 2002), reserves 25 per cent of entry-class seats in private unaided schools for disadvantaged groups and weaker sections, bans screening, capitation fees, physical punishment and mental harassment, and sets teacher norms in its Schedule (classes I-V: two teachers for up to 60 children, three for 61-90 and four for 91-120, i.e. about 30:1, with a pupil-teacher ratio not exceeding 40:1 above 200 children; classes VI-VIII: at least one teacher for every 35 children).

Traps: Do not confuse negative reinforcement with punishment; assimilation with accommodation; proactive with retroactive interference; growth with development; sex with gender; formative with summative; interpersonal with intrapersonal intelligence; Piaget's and Vygotsky's views on private speech. In scenario questions, reject any option that labels, segregates, compares children publicly, uses rewards as the main driver, or asks for more drill.

Examples

- Growth is quantitative and stops at maturity; development is qualitative, continuous and lifelong - growth is part of development, not the other way round.
- Cephalocaudal = head to toe (a baby controls its head before its legs); proximodistal = centre outwards (shoulder control before finger control).
- Piaget's stages in order: Sensorimotor (0-2, object permanence), Pre-operational (2-7, egocentrism, animism), Concrete operational (7-11, conservation, reversibility), Formal operational (11+, abstract reasoning).
- Assimilation = fitting new information into an existing schema (calling a zebra a 'horse'); accommodation = changing the schema (learning that stripes make it a zebra).
- Vygotsky's ZPD is the distance between what a child can do alone and with help; the help itself is scaffolding, given by the More Knowledgeable Other and withdrawn gradually.
- Kohlberg: Pre-conventional (punishment, self-interest) - Conventional (approval, law and order) - Post-conventional (social contract, universal principles). Six stages, three levels, two each.
- IQ = (Mental Age / Chronological Age) x 100. A 10-year-old with a mental age of 12 has IQ 120; Binet gave mental age, Stern the formula, Terman the Stanford-Binet.
- Negative reinforcement INCREASES behaviour by removing something unpleasant (cancelling homework for good behaviour); punishment DECREASES behaviour. Both are Skinner's operant terms.
- Learning disabilities: dyslexia - reading; dysgraphia - writing; dyscalculia - arithmetic; dyspraxia - motor coordination. ADHD is attention and impulsivity, not a learning disability by definition.
- Assessment FOR learning = formative, continuous, diagnostic, used to improve teaching; assessment OF learning = summative, at the end, used for grading and certification.
- Thinkers and key terms: Dewey - learning by doing; Montessori - prepared environment; Froebel - kindergarten; Bruner - spiral curriculum; Kilpatrick - project method; Gandhi - Nai Talim; Badheka - Divaswapna.
- RTE 2009 numbers: age 6 to 14, Article 21A, 25 per cent seats for weaker sections in private unaided schools, teacher norms: classes I-V two teachers for up to 60 children (30:1) and PTR not above 40:1 once enrolment exceeds 200; classes VI-VIII at least one teacher for every 35 children.

> **Quick revision:** Growth quantitative, development qualitative and lifelong; cephalocaudal head-to-toe, proximodistal centre-outwards; Piaget: sensorimotor, pre-operational, concrete, formal; assimilation vs accommodation; Vygotsky ZPD, scaffolding, MKO; Kohlberg 3 levels 6 stages; Erikson 6-12 industry vs inferiority; IQ = MA/CA x 100; Gardner 8 intelligences; Skinner negative reinforcement increases behaviour; Bandura Bobo doll; Maslow self-actualisation at top; formative = assessment for learning; NCF 2005 (Yash Pal) 5 principles; RTE 2009: 6-14 years, Art 21A, 25% EWS, PTR 30:1.

Growth and Development: Concept, Principles and Stages of Childhood

Growth, development and maturation: Growth means quantitative change in the body - increase in height, weight and the size of organs - which can be measured and which slows down and stops once physical maturity is reached. Development is wider: it is the orderly, progressive series of qualitative and quantitative changes in body, mind, language, emotions and social behaviour that continues throughout life, from conception to old age. Growth is therefore one part of development; a child can grow taller without becoming more mature in her thinking. Maturation is the unfolding of changes programmed by heredity, such as sitting, walking or the onset of puberty, which happen without special training, while learning is change produced by experience and practice. Development is the joint result of maturation and learning. Its domains - physical, motor, cognitive, language, emotional, social and moral - are interrelated: a child with an untreated hearing loss may fall behind in speech, reading and friendships.

Continuity, sequence and direction: Development is continuous: it goes on gradually from conception, and each new ability builds on what came before rather than appearing from nowhere. It follows a definite and predictable sequence: a baby coos, then babbles, then speaks single words and then sentences; she sits before she stands and stands before she walks. It proceeds from general to specific: an infant first reaches out with the whole arm and body, and only later picks up a grain with thumb and forefinger. It is cumulative and integrated, as small skills

combine into larger ones, such as separate letter shapes combining into fluent handwriting. Early experiences have a lasting effect, so the first years of life deserve special care.

Cephalocaudal, proximodistal and individual differences: Two directional principles are tested every year. The cephalocaudal principle says that development proceeds from head to toe: an infant controls the head and neck before the trunk, and the trunk before the legs. The proximodistal principle says that it proceeds from the centre of the body outwards: control of the shoulders and arms comes before control of the wrists and fingers. This is why a young child first grips a thick crayon with the whole fist, and why fine pencil work should not be forced too early. The principle of individual differences says that although all children pass through the same sequence, they do so at different rates, so two seven-year-olds in the same class may be far apart in reading. Finally, development is the product of the interaction of heredity and environment: heredity sets the range of possibilities, and environment decides how much of that range is realised.

Stages of childhood: Books divide childhood into broad stages whose ages are approximate and vary slightly between authors. The prenatal stage runs from conception to birth and is the period of the fastest growth. Infancy runs from birth to about 2 years: reflexes give way to voluntary movement, attachment to caregivers forms and the first words appear. Early childhood, about 2 to 6 years, is the preschool period of rapid language growth, pretend play and endless questions; Elizabeth Hurlock called it the pre-gang age, the toy age and the questioning age. Later childhood, about 6 to 12 years, covers the primary school years: logical thinking about concrete things develops and belonging to a group of same-age friends becomes very important, which is why Hurlock called it the gang age. Adolescence, roughly 12 to 18 years, begins with puberty and brings rapid physical change, abstract thinking and the search for identity; G. Stanley Hall described it as a period of storm and stress. CTET Paper I deals with children of 6 to 11 years (Classes I to V) and Paper II with the 11 to 14 age group (Classes VI to VIII).

Development and learning: How development and learning are related is a favourite CTET theme. Piaget held that development precedes learning: a child can learn a concept only when the necessary mental structures have formed, so teaching must wait for readiness. Vygotsky held the opposite, that good learning runs ahead of development and pulls it forward, which is why teaching should aim at the zone of proximal development. Arnold Gesell's co-twin studies showed the role of maturation: a twin who was given stair-climbing training later, when more mature, quickly caught up with the twin who had been trained earlier. The balanced view for a teacher is that maturation sets readiness, while rich experiences, language and interaction carry development forward, so learning and development support each other.

In the classroom: A teacher who knows these principles gives Class I children clay, beads, paper tearing and colouring before fine pencil work, does not compare a slow reader with the fastest one, offers several routes to the same goal and attends to the whole child - health, feelings and friendships as well as marks. In a typical CTET question, a teacher who notices that a child lags behind in one area should observe her closely and support her at her own pace, not label her or hold her back, since development is continuous, individual and shaped by the environment.

Examples

- Growth is quantitative (height, weight), measurable and stops at maturity; development is qualitative as well as quantitative, lifelong, and includes growth.
- Maturation = changes that unfold from heredity without training (sitting, walking, puberty); learning = change from experience and practice; development needs both.
- Cephalocaudal = head to toe: a baby holds up its head before it can sit or stand. Proximodistal = centre outwards: arm control comes before finger control.
- General to specific: a baby first reaches with the whole arm and body, and later picks up a small object with thumb and forefinger.
- Same sequence, different rates: every child babbles before speaking and stands before walking, but at a different age - the principle of individual differences.
- Stages (approximate): prenatal (fastest growth), infancy 0-2 years, early childhood 2-6, later childhood 6-12, adolescence about 12-18.

- Hurlock: early childhood = pre-gang age, toy age, questioning age; later childhood = gang age. G. Stanley Hall: adolescence = a period of storm and stress.
- Piaget: development precedes learning (wait for readiness). Vygotsky: learning leads development (teach in the zone of proximal development).
- Gesell's co-twin study: the twin trained later in stair-climbing caught up quickly with the twin trained earlier - evidence for maturation.
- CTET Paper I CDP is about children of 6-11 years (Classes I-V); Paper II about children of 11-14 years (Classes VI-VIII).

> **Quick revision:** Growth quantitative and stops, development qualitative and lifelong; development = maturation + learning; continuous, sequential, general to specific, cumulative; cephalocaudal head to toe, proximodistal centre outwards; same sequence, different rates; heredity x environment; infancy 0-2, early childhood 2-6, later childhood 6-12 (gang age), adolescence 12-18 (storm and stress, Stanley Hall); Piaget: development precedes learning; Vygotsky: learning leads development.

Heredity, Environment and Socialisation: Nature, Nurture and the Teacher's Role

Heredity: Heredity is the passing of characteristics from parents to children through genes, which are carried on chromosomes in the nucleus of the body's cells. A human cell normally has 46 chromosomes in 23 pairs, one member of each pair coming from the mother and one from the father, and a child's genetic make-up is fixed at conception. Heredity influences eye and skin colour, blood group, body build, the range of possible height, the rate of maturation and, to some extent, temperament and general mental ability. Gregor Mendel's experiments on pea plants in the nineteenth century laid down the basic laws of inheritance. Heredity does not decide everything, however: it sets a range, a potential, within which the environment works.

Environment: Environment means all the external influences that act on a person from conception onwards. The prenatal environment includes the mother's nutrition, health and exposure to drugs, alcohol or infections. After birth come the physical environment (food, climate, housing, sanitation), the social environment (family, neighbourhood, school, peers, community) and the cultural environment (language, customs, values and beliefs). Poverty, malnutrition and lack of stimulation can keep a child from reaching her potential, while books, conversation, play and caring adults help her achieve it.

The nature-nurture debate: Francis Galton, who wrote Hereditary Genius (1869) and popularised the phrase nature and nurture, argued that ability is mainly inherited. Long before him John Locke had described the newborn mind as a tabula rasa, a blank slate written on by experience, and the behaviourist John B. Watson boasted that, given a dozen healthy infants, he could train any one of them to become any kind of specialist. Twin studies help separate the two influences: identical (monozygotic) twins share all their genes, so differences between identical twins reared apart point to the environment, while their similarities point to heredity. The accepted view today is interactionist: development is the product, not the sum, of heredity and environment, and neither works alone. A child born with musical potential will not become a musician without exposure to music, and no amount of coaching can create a potential that is absent. For a teacher the practical lesson is that ability is not fixed at birth, so no child should be written off.

Socialisation and its agents: Socialisation is the lifelong process through which a child learns the language, norms, values, roles and behaviour of her society and becomes a functioning member of it. Primary socialisation takes place in the family in the early years: there the child learns her mother tongue, forms attachments and absorbs her first ideas of right and wrong, of gender roles and of who 'we' are, which is why the family is called the child's first school. Secondary socialisation follows through the school, peer groups, neighbourhood, religious and community bodies and the mass media. The school brings formal rules, less personal relationships, children from other backgrounds and a planned curriculum, along with a hidden curriculum - unstated lessons about obedience, competition or equality taught through routines. Peers offer relationships among equals in which children learn cooperation, sharing, settling quarrels and conformity; in adolescence peer influence often rivals that of parents. Television and the internet supply models and information but also stereotypes about gender, appearance and consumption.

Bronfenbrenner and parenting styles: Urie Bronfenbrenner's ecological systems theory places the child at the centre of nested systems: the microsystem (family, classroom, friends) with which she interacts directly; the mesosystem, the links between microsystems, such as contact between parents and teachers; the exosystem, settings that affect her indirectly, such as a parent's workplace; the macrosystem of culture, values and laws; and the chronosystem, change over time. Diana Baumrind described the authoritative parenting style (warm but firm, with reasons explained), the authoritarian style (strict, demanding obedience, with little warmth) and the permissive style (warm but with few limits); a fourth, uninvolved or neglectful style was added later by Eleanor Maccoby and John Martin. Authoritative parenting is generally linked with the best outcomes, and the same balance of warmth and clear expectations makes a good classroom.

Culture, learning and the teacher: Children come to school with knowledge built in their homes and communities - counting with money, plants and animals they know, songs, stories and often two or three languages. NCF 2005 asks teachers to connect knowledge to life outside school and to treat this home knowledge and multilingualism as resources, not deficits. A teacher is herself an agent of socialisation and a role model, and children copy her fairness, language and attitudes. When a child from a tribal community uses words from her home language, or the child of a farming family knows a great deal about crops, the teacher should bring that knowledge into the lesson. She should avoid stereotyping any caste, religion, region, class or gender, build a classroom where every child belongs, and keep in touch with parents so that home and school work together. In a CTET item, the right answer usually treats the child's background as a strength and the school as a place that respects diversity.

Examples

- Heredity: passing of traits through genes on chromosomes; a human cell has 46 chromosomes in 23 pairs; genetic make-up is fixed at conception and sets the potential.
- Environment: every external influence from conception onwards - prenatal (mother's health and nutrition), physical, social and cultural; it decides how far potential is realised.
- Galton (Hereditary Genius, 1869) stressed heredity; Locke's tabula rasa and Watson's 'dozen healthy infants' boast stressed environment; today's view is interaction.
- Identical (monozygotic) twins reared apart are studied to separate heredity from environment: differences between them point to the environment.
- Primary agent of socialisation: the family (the child's first school). Secondary agents: school, peer group, community, religious bodies and mass media.
- Hidden curriculum: the unstated lessons a school teaches through its routines and relationships - about obedience, competition, gender roles or equality.
- Bronfenbrenner: microsystem (family, school), mesosystem (links between them), exosystem (parent's workplace), macrosystem (culture), chronosystem (time).
- Baumrind: authoritative (warm and firm - best outcomes), authoritarian (strict, little warmth), permissive (warm, few limits); uninvolved style added by Maccoby and Martin.
- NCF 2005: connect knowledge to life outside school; a child's home language and community knowledge are resources, not deficits.

> **Quick revision:** Heredity = genes on 46 chromosomes (23 pairs), fixed at conception, sets potential; environment = prenatal, physical, social, cultural; Galton (1869) heredity, Locke tabula rasa and Watson environment; development = heredity x environment; family primary agent, school, peers, media secondary; hidden curriculum; Bronfenbrenner micro, meso, exo, macro, chrono; Baumrind: authoritative best; home knowledge and languages are resources (NCF 2005).

Piaget's Theory of Cognitive Development: Schema, Four Stages and Classroom Use

Who Piaget was: Jean Piaget (1896-1980) was a Swiss psychologist who called his field genetic epistemology, the study of how knowledge develops. While helping to standardise intelligence tests in Paris, he noticed that children of the same age gave the same kinds of wrong answers, and concluded that children do not simply know less than adults but think in a qualitatively different way. Using the clinical method - flexible interviews and close observation -

he built the theory now called cognitive constructivism: the child is an active 'little scientist' who constructs knowledge by acting on the world, not a passive receiver of information.

Schema, adaptation and equilibration: A schema is an organised pattern of action or thought that a child uses to make sense of experience, such as a baby's sucking schema or a toddler's schema for 'dog'. Adaptation, the process of adjusting to the environment, has two sides. Assimilation is fitting a new experience into an existing schema: a child who knows dogs calls a cow a 'big dog'. Accommodation is changing an existing schema, or creating a new one, when the experience does not fit: she learns that a cow is a different animal. Organisation is the tendency to combine schemas into larger, more coherent systems. When new information conflicts with existing ideas, the child experiences disequilibrium or cognitive conflict, and equilibration is the self-regulating drive to restore balance through assimilation and accommodation; it is the engine of cognitive growth. Piaget named four factors in development: maturation, experience with the physical world, social transmission and equilibration.

Sensorimotor and pre-operational stages: The stages come in a fixed order, though their ages are only approximate. In the sensorimotor stage (birth to about 2 years) the infant knows the world through her senses and movements; reflexes grow into deliberate, goal-directed actions, and object permanence - knowing that an object still exists when it is out of sight - develops in the second half of the first year and is secure by about 2 years, when deferred imitation and the first symbolic thought appear. In the pre-operational stage (about 2 to 7 years), often divided into a preconceptual phase (2-4) and an intuitive phase (4-7), children use symbols, language and pretend play (a stick becomes a horse), but their thinking is not yet logical. They show egocentrism, the inability to see from another's point of view, which Piaget demonstrated with the three mountains task; animism, believing that lifeless things are alive ('the moon is following me'); artificialism, believing that natural things were made by people; centration, attending to only one feature of a situation; and irreversibility, being unable to undo an action mentally. So they fail conservation tasks: when equal amounts of water are poured into a tall thin glass and a short wide one, they say the tall glass has more.

Concrete and formal operational stages: In the concrete operational stage (about 7 to 11 years) children reason logically about real, concrete objects and events. They achieve conservation - understanding that quantity does not change when only shape or arrangement changes - usually first for number, then for mass, and later for weight and volume, an unevenness Piaget called horizontal decalage. They show reversibility (mentally pouring the water back), decentration (attending to height and width together), seriation (arranging sticks by length), classification including class inclusion, and transitivity (if A is taller than B and B is taller than C, then A is taller than C), but they still struggle with purely hypothetical problems. In the formal operational stage (about 11 years onwards) adolescents think abstractly, reason about possibilities and propositions, and use hypothetico-deductive reasoning: they form hypotheses and test them systematically, changing one variable at a time, as in Piaget's pendulum problem. David Elkind later described adolescent egocentrism, with its imaginary audience and personal fable.

Using Piaget in class: In primary classes, teach through concrete materials and activity - bundles of sticks for place value, real coins for money, measuring actual objects - before moving to symbols. Create cognitive conflict deliberately: ask children to predict whether a ball of clay weighs the same after it is rolled into a long snake, then let them check. Treat errors as windows into the child's thinking; the child who says the tall glass holds more is reasoning by centration, not being careless. Respect readiness: abstract rules forced on concrete thinkers become rote learning. Encourage peer discussion, because hearing other points of view helps children move beyond egocentrism.

Critiques: Later research showed that Piaget underestimated young children: Martin Hughes's 'policeman doll' task, set in a situation that made sense to children, found that many preschoolers could take another's point of view, and Renée Baillargeon's experiments suggested that infants grasp object permanence earlier than he thought. Critics also argue that the stages are less sharp and more uneven than he proposed, and that he gave too little weight to culture, language and adults - the gap that Vygotsky fills. His central insights remain at the heart of CTET: children actively construct knowledge, think differently from adults and learn best through activity, exploration and discussion.

Examples

- Schema = organised pattern of thought or action; adaptation = assimilation + accommodation; equilibration = the drive to resolve cognitive conflict (disequilibrium).
- Assimilation: a toddler calls a cow a 'big dog' (fits the old schema). Accommodation: she learns that it is a cow (changes the schema).
- Sensorimotor (0-2): learning through senses and actions, goal-directed behaviour, object permanence, deferred imitation.
- Pre-operational (2-7): symbolic and pretend play, egocentrism (three mountains task), animism, artificialism, centration, irreversibility, no conservation.
- Concrete operational (7-11): conservation, reversibility, decentration, seriation, classification, transitivity - logic about concrete things only.
- Formal operational (11+): abstract, propositional and hypothetico-deductive reasoning; testing one variable at a time (pendulum problem).
- Conservation comes first for number, then mass, later weight and volume; such unevenness within a stage is horizontal decalage.
- Piaget's four factors of development: maturation, physical experience, social transmission and equilibration.
- Piaget in class: concrete materials before symbols, deliberate cognitive conflict, errors as windows into thinking, readiness, peer discussion.
- Critiques: underestimated young children (Hughes's policeman doll task, Baillargeon on object permanence), stages less fixed, culture and language neglected.

> **Quick revision:** Piaget (Swiss, 1896-1980), genetic epistemology, clinical method, child as little scientist; schema, assimilation, accommodation, equilibration; sensorimotor 0-2 object permanence; pre-operational 2-7 egocentrism, animism, centration, irreversibility; concrete operational 7-11 conservation, reversibility, seriation, classification; formal operational 11+ hypothetico-deductive; horizontal decalage; concrete materials and cognitive conflict; critique: underestimated children, neglected culture.

Vygotsky and Bruner: ZPD, Scaffolding, Modes of Representation and Discovery Learning

Vygotsky's sociocultural theory: Lev Vygotsky (1896-1934) was a Soviet psychologist whose ideas reached the wider world mainly through translations of Thought and Language and the collection Mind in Society. His theory is called social constructivism or sociocultural theory: children construct knowledge, but they do so through interaction with other people and with the tools of their culture, above all language. In his general law of cultural development, every higher mental function appears twice - first between people, on the social plane, and then inside the child, on the individual plane. A child first counts with her mother, pointing at objects together, and later counts alone in her head. Thinking is thus mediated by cultural tools such as words, numbers, maps and writing, which differ from one culture to another.

Zone of proximal development: Vygotsky defined the ZPD as the distance between the actual developmental level, shown by what a child can do independently, and the level of potential development, shown by what she can do under adult guidance or in collaboration with more capable peers. Tasks below the zone are already mastered and teach little; tasks beyond it are too hard even with help; real learning happens inside it. Two children with the same score when working alone may have very different zones, so Vygotsky argued that assessment should look at what a child can do with help, not only at what she does alone - the idea behind dynamic assessment. Because learning in the zone pulls development forward, he held that the only good learning is that which is in advance of development.

Scaffolding and the more knowledgeable other: The support given within the ZPD is called scaffolding. The term was introduced by David Wood, Jerome Bruner and Gail Ross in 1976, building on Vygotsky's ideas, and CTET treats it as part of his framework. Scaffolding is temporary and adjustable - hints, prompts, leading questions, modelling a step, breaking a task into parts, a worked example, a picture or a chart - and it is gradually withdrawn (faded) as the child gains competence, just as a builder's scaffolding is removed once the wall can stand. The person who gives it is the more knowledgeable other (MKO): a teacher, parent, older sibling, classmate or even a computer program - anyone who understands that particular task better. In class this means peer tutoring,

cooperative work in mixed-ability groups, reciprocal teaching in which pupils take turns leading a discussion, and a teacher who thinks aloud while solving a problem.

Private speech: Young children often talk aloud to themselves while working ('this piece goes here... no, there'). Vygotsky called this private speech and saw it as a tool of self-regulation: the child uses speech, first learned from others, to plan and guide her own actions. It increases when tasks become difficult, and with age it turns into silent inner speech, which is verbal thought. Piaget had called the same talk egocentric speech, a sign of immature thinking that fades as the child becomes social. Hence a typical CTET answer: a teacher should not stop a child who talks to herself while solving a puzzle, because the talk is helping her think.

Bruner's modes of representation: Jerome Bruner (1915-2016), an American psychologist, was a leader of the cognitive movement in education. He described three modes in which knowledge is represented. In the enactive mode, dominant in infancy, knowledge is stored as actions - a child knows a bicycle by riding it. In the iconic mode, developing in early childhood, it is stored as images and pictures. In the symbolic mode, from about 7 years, it is stored in words, numbers and other symbols. Unlike Piaget's stages these modes are not left behind; adults still use all three. The concrete-pictorial-abstract sequence used in teaching mathematics follows directly: count real objects, then pictures, then numerals.

Discovery learning and the spiral curriculum: In The Process of Education (1960) Bruner argued that the foundations of any subject can be taught to any child at any stage of development in some intellectually honest form. Two ideas follow. Discovery learning asks children to find principles and relationships for themselves by exploring examples - for instance, measuring many circular objects to discover that the distance around is always a little more than three times the distance across - with the teacher guiding the inquiry, which makes knowledge more lasting and transferable. The spiral curriculum returns to the same big ideas again and again across the classes, each time at a higher level of complexity: fractions are first met as sharing a roti equally, later as points on a number line and later still as rational numbers.

Comparing the thinkers: Piaget sees the child as a lone scientist, with development leading learning; Vygotsky sees an apprentice who learns through social interaction, with learning leading development; Bruner stresses that good instruction and guided discovery speed growth. In CTET questions, Vygotsky points to group work, peer tutoring, scaffolding and dialogue in the child's own language, and Bruner to hands-on discovery, the spiral curriculum and the move from concrete to pictorial to symbolic.

Examples

- ZPD = the gap between what a child can do alone (actual developmental level) and with guidance or more capable peers (potential developmental level).
- Scaffolding: temporary, adjustable support (hints, prompts, modelling, breaking a task into steps) that is gradually withdrawn; term coined by Wood, Bruner and Ross (1976).
- More knowledgeable other (MKO): anyone who understands the task better - teacher, parent, older child, classmate, even a computer program.
- Vygotsky: every higher mental function appears twice - first between people (social plane), then within the child (individual plane).
- Private speech: Vygotsky - self-guiding speech that becomes inner speech; Piaget - egocentric speech, a sign of immaturity. Do not stop a child who talks to herself while working.
- Bruner's modes: enactive (actions), iconic (images), symbolic (words and numbers) - the basis of the concrete-pictorial-abstract approach.
- Bruner, The Process of Education (1960): any subject can be taught in an honest form at any stage; discovery learning; spiral curriculum.
- Spiral curriculum: the same big ideas are revisited in later classes at increasing depth and complexity.
- Vygotsky in class: mixed-ability groups, peer tutoring, reciprocal teaching, dialogue, a teacher who thinks aloud, and dynamic assessment.

Quick revision: Vygotsky (1896-1934): social constructivism, culture and language as tools, social plane then individual plane; ZPD = actual vs potential level; scaffolding temporary and faded (Wood, Bruner, Ross 1976); MKO; private speech becomes inner speech; learning leads development; Bruner (1915-2016): enactive, iconic, symbolic modes; discovery learning; spiral curriculum; The Process of Education 1960.

Moral and Personality Development: Kohlberg, Gilligan and Erikson

Piaget's start on moral development: Moral development is the growth of a child's understanding of right and wrong and of her ability to act on it. Piaget, in The Moral Judgment of the Child (1932), watched children playing marbles and asked them about short stories. Younger children, in the stage of heteronomous morality or moral realism (roughly 5 to 10 years), treat rules as fixed and made by authorities, and judge an act by its consequences: a child who broke fifteen cups by accident seems naughtier than one who broke a single cup while sneaking jam. Older children, in autonomous morality (from about 10 years), see rules as agreements that can be changed and judge acts by intentions. Lawrence Kohlberg (1927-1987), an American psychologist, extended this work into a fuller stage theory.

Kohlberg's method and the Heinz dilemma: Kohlberg presented boys aged 10 to 16 with moral dilemmas. In the best known, Heinz's wife is dying of a special kind of cancer; a druggist in the town has discovered a drug that might save her but charges ten times what it cost him to make; Heinz can raise only about half the price, the druggist refuses to sell it cheaper or let him pay later, and Heinz breaks into the shop and steals the drug. Should he have done it, and why? Kohlberg was interested not in whether the answer was yes or no but in the reasoning behind it, since the same 'yes' can come from fear of blame or from a belief in the value of human life. From such reasoning he described three levels, each with two stages.

The three levels and six stages: At the pre-conventional level, typical of most children under about 9, morality is external. Stage 1, obedience and punishment orientation: an act is wrong if it is punished. Stage 2, individualism and exchange: right is what serves one's own interest, and fairness is a deal - 'you help me, I help you'. At the conventional level, typical of older children, adolescents and most adults, the person conforms to the expectations of others and of society. Stage 3, good interpersonal relationships, the 'good boy - nice girl' orientation: be good to win approval. Stage 4, maintaining the social order, the law-and-order orientation: obey laws and do one's duty because society needs order. At the post-conventional level, reached by only a minority of adults, morality rests on self-chosen principles. Stage 5, social contract and individual rights: laws are agreements for the common good and can be changed democratically. Stage 6, universal ethical principles: act on principles such as justice, equality and human dignity, even against the law. The stages occur in an invariant order, none is skipped, and moral reasoning depends on cognitive development, though reasoning does not always predict action.

Gilligan's critique and the classroom: Carol Gilligan, a colleague of Kohlberg, argued in In a Different Voice (1982) that his theory was biased because it was built on an all-male sample and treated an ethic of justice and rights as the highest morality. Women, she said, more often reason from an ethic of care - responsibility, relationships and avoiding harm - and were therefore wrongly scored lower, often at Stage 3. In class, morality cannot simply be lectured into children. Teachers can discuss real dilemmas from stories and school life, ask 'why' instead of accepting a ready answer, let children frame classroom rules together and model fairness themselves; Kohlberg set up 'just community' schools run by democratic discussion.

Erikson's psychosocial theory: Erik Erikson (1902-1994), a German-born American psychoanalyst, reworked Freud's psychosexual stages into a lifespan theory of eight psychosocial stages, set out in Childhood and Society (1950). At each stage a person faces a crisis, a turning point between two outcomes, and a positive resolution gives a basic strength or virtue. The stages are trust vs mistrust (infancy, hope), autonomy vs shame and doubt (about 1 to 3 years, will), initiative vs guilt (about 3 to 6, purpose), industry vs inferiority (about 6 to 12, competence), identity vs role confusion (adolescence, fidelity), intimacy vs isolation (young adulthood, love), generativity vs stagnation (middle adulthood, care) and integrity vs despair (old age, wisdom). Unlike Freud, Erikson stressed social relationships and culture rather than sexual drives, and saw development continuing throughout life.

Erikson in the school years: Three stages matter most for teachers. In initiative vs guilt, preschool children want to plan, make and try things; adults who welcome questions and play build purpose, while constant scolding makes children feel guilty for trying. Industry vs inferiority covers the primary years, when children want to be competent and productive and to be recognised for finished work. A teacher who sets achievable tasks, praises effort and progress and avoids public comparison builds industry, whereas repeated failure and ridicule produce a sense of inferiority. Identity vs role confusion belongs to adolescence: students of Classes VI to VIII begin to ask 'who am I?' and try out roles, friendships and values, so they need clubs, responsibilities, career awareness and respectful guidance rather than labels. Erikson coined the term identity crisis.

Examples

- Piaget's moral stages: heteronomous (moral realism - rules fixed, judge by consequences) then autonomous (rules changeable by agreement, judge by intentions).
- Heinz dilemma: Heinz steals an overpriced drug to save his dying wife; Kohlberg scored the reasoning given, not the yes-or-no answer.
- Pre-conventional level: Stage 1 obedience and punishment; Stage 2 individualism and exchange ('you help me, I help you').
- Conventional level: Stage 3 good boy - nice girl (approval); Stage 4 law and order (duty, social order). Most adolescents and adults reason here.
- Post-conventional level: Stage 5 social contract and individual rights; Stage 6 universal ethical principles. Reached by only a minority of adults.
- Gilligan, In a Different Voice (1982): Kohlberg's all-male sample and focus on justice ignored the ethic of care.
- Erikson's eight stages (Childhood and Society, 1950): trust, autonomy, initiative, industry, identity, intimacy, generativity, integrity - each against its opposite.
- Primary school years (about 6-12): industry vs inferiority - set achievable tasks, praise effort, avoid public comparison.
- Adolescence: identity vs role confusion (Erikson coined 'identity crisis'); Marcia's statuses: diffusion, foreclosure, moratorium, achievement.

> **Quick revision:** Piaget: heteronomous (consequences) to autonomous (intentions); Kohlberg (Heinz dilemma, reasoning not answer): pre-conventional (1 punishment, 2 exchange), conventional (3 good boy-nice girl, 4 law and order), post-conventional (5 social contract, 6 universal principles); invariant order; Gilligan 1982 ethic of care; Erikson 8 psychosocial stages: initiative vs guilt 3-6, industry vs inferiority 6-12, identity vs role confusion in adolescence.

Theories of Learning: Pavlov, Thorndike, Skinner, Kohler's Insight and Constructivism

What learning is: Learning is a relatively permanent change in behaviour or understanding that results from experience or practice, as opposed to changes caused by maturation, fatigue, illness or drugs. Theories differ on what changes and how. Behaviourists study observable behaviour and explain learning as connections between stimuli and responses shaped by the environment, with the learner largely passive. Gestalt and cognitive psychologists study perception and thinking and explain learning as the reorganisation of understanding. Constructivists see the learner as actively building knowledge.

Pavlov's classical conditioning: Ivan Pavlov (1849-1936), a Russian physiologist who received the Nobel Prize in 1904 for his work on digestion, noticed that dogs began to salivate before the food arrived. Food is an unconditioned stimulus (UCS) that naturally produces salivation, the unconditioned response (UCR). When a neutral stimulus such as a bell is repeatedly presented just before food, it becomes a conditioned stimulus (CS) that alone produces salivation, now a conditioned response (CR). If the bell is then sounded again and again without food, the response fades (extinction), but it may return after a rest (spontaneous recovery). Similar stimuli also produce the response (generalisation), while responding only to the specific stimulus is discrimination. John B. Watson, the founder of behaviourism, showed with 'Little Albert' (1920) that fear can be conditioned in the same way. A child punished or humiliated during mathematics may come to fear the subject itself, so the classroom must feel safe.

Thorndike's connectionism: Edward Thorndike (1874-1949), an American psychologist, placed hungry cats in puzzle boxes with food outside. By trial and error a cat eventually worked the latch and escaped, and over repeated trials

the time taken fell gradually, which he explained as the strengthening of a stimulus-response bond. His theory, called connectionism or trial-and-error learning, gave three primary laws. Law of readiness: when a person is ready to act, acting is satisfying and being prevented is annoying, so learning should begin when the child is prepared. Law of exercise: bonds strengthen with use and weaken with disuse, so practice should be regular and meaningful. Law of effect: responses followed by satisfying results are strengthened and those followed by annoying results are weakened; Thorndike later found that reward works far better than punishment. He also gave subsidiary laws such as multiple response, attitude (set), partial activity, analogy and associative shifting.

Skinner's operant conditioning: B. F. Skinner (1904-1990) studied rats and pigeons in an operant chamber, the Skinner box, where pressing a lever or pecking a key produced food. In operant conditioning, behaviour is shaped by its consequences. Reinforcement increases a behaviour: positive reinforcement adds something pleasant (praise, a star), and negative reinforcement removes something unpleasant (a child who completes her work is excused from extra homework). Punishment decreases a behaviour: positive punishment adds something unpleasant, and negative punishment takes away something pleasant, such as play time. Continuous reinforcement gives the quickest learning, but intermittent schedules - fixed ratio, variable ratio, fixed interval and variable interval - make behaviour last longer, with variable ratio the most resistant to extinction. Complex behaviour is built by shaping, the reinforcement of successive approximations, which also underlies Skinner's programmed instruction and teaching machines: small steps, active response, immediate feedback and self-pacing.

Gestalt and insight learning: Gestalt psychology, founded in Germany by Max Wertheimer with Wolfgang Kohler and Kurt Koffka, held that the whole is more than the sum of its parts and that we perceive organised patterns (laws of proximity, similarity, closure and figure-ground). Kohler, working with chimpanzees on Tenerife in the Canary Islands, placed bananas out of reach. After failed attempts and a pause, the chimpanzee Sultan suddenly joined two sticks to rake in the fruit; others stacked boxes to climb up. Kohler called this insight: a sudden restructuring of the perceptual field in which the relations between parts are grasped, the 'aha' experience. Insight learning is sudden rather than gradual, depends on seeing the whole situation, is retained well and transfers to new problems. In class, present problems as wholes, allow time to think and help pupils see relationships instead of memorising steps.

Constructivism: Constructivism holds that learners build their own knowledge by connecting new experiences to what they already know. Cognitive constructivism (Piaget) stresses the individual's mental activity; social constructivism (Vygotsky) stresses dialogue and culture. Knowledge is not transmitted ready-made, prior ideas - including misconceptions - shape what is learned, and learning is active, contextual and social. NCF 2005 adopts this view and asks teachers to move away from rote methods. A constructivist lesson begins with a question or an experience, lets children explore, predict and discuss, and only then builds the formal concept, as in the 5E cycle of engage, explore, explain, elaborate and evaluate.

Choosing among theories: Behaviourist techniques suit habits, practice of basic facts and routines; Gestalt ideas suit problem-solving; constructivist methods suit building concepts. Albert Bandura's social learning theory adds that children learn by observing models, through attention, retention, reproduction and motivation, so the teacher's own conduct also teaches. In CTET scenarios the best answer avoids punishment, uses reinforcement wisely and leads children to discover and explain ideas themselves.

Examples

- Learning = a relatively permanent change in behaviour from experience or practice (not from maturation, fatigue, illness or drugs).
- Pavlov (classical conditioning): food (UCS) gives salivation (UCR); a bell paired with food becomes a CS that gives salivation (CR); extinction, spontaneous recovery, generalisation, discrimination.
- Watson's Little Albert (1920): fear of a white rat was conditioned in an infant - a reminder that punishment can make children fear a subject.
- Thorndike (hungry cat in a puzzle box): trial and error, connectionism; laws of readiness, exercise (use and disuse) and effect.
- Skinner: positive reinforcement adds something pleasant, negative reinforcement removes something unpleasant - both increase behaviour; punishment decreases it.

- Variable-ratio reinforcement is the most resistant to extinction; shaping = reinforcing successive approximations; programmed instruction = small steps with immediate feedback.
- Kohler (chimpanzee Sultan, sticks and boxes, Tenerife): insight learning - sudden understanding of the whole situation, well retained and transferable.
- Gestalt psychology: the whole is more than the sum of its parts; founded by Wertheimer, with Kohler and Koffka.
- Constructivism: learners actively build knowledge on prior ideas; NCF 2005 favours it; 5E cycle: engage, explore, explain, elaborate, evaluate.

> **Quick revision:** Learning = relatively permanent change from experience; Pavlov classical conditioning (UCS, UCR, CS, CR, extinction, spontaneous recovery, generalisation); Watson Little Albert 1920; Thorndike trial and error, laws of readiness, exercise, effect; Skinner operant: positive and negative reinforcement increase, punishment decreases, variable ratio most lasting, shaping, programmed instruction; Kohler insight (Sultan); Gestalt whole more than parts; constructivism (NCF 2005).

Intelligence, Creativity and Individual Differences: IQ, Gardner, Sternberg and Diversity

Individual differences: No two children are alike. They differ in physical traits, intelligence, aptitude, creativity, interests, attitudes, personality, learning style, pace of learning, language, socio-economic and cultural background, and in abilities and disabilities. These differences arise from the interaction of heredity and environment. The CTET syllabus asks teachers to understand individual differences among learners, including diversity of language, caste, gender, community and religion, and to treat that diversity as a resource. A single lecture pitched at an imaginary 'average' child fails many real children, so the teacher must plan for variety.

Measuring intelligence and IQ: Alfred Binet, with Theodore Simon, produced the first practical intelligence test in France in 1905 to identify children who needed special help in school, and introduced the idea of mental age - the level of performance typical of a given age. William Stern (1912) proposed the intelligence quotient as mental age divided by chronological age, and Lewis Terman of Stanford University, in the Stanford-Binet scale (1916), multiplied it by 100: IQ = (MA / CA) x 100. A child of 10 with a mental age of 10 has an IQ of 100; with a mental age of 8 her IQ is 80; with a mental age of 12 it is 120. Because mental age stops rising in adulthood, David Wechsler introduced the deviation IQ, which compares a person with others of the same age on a scale with a mean of 100 and a standard deviation of 15. On Wechsler's classification, 90-109 is average and 130 or above very superior, while a score below 70 together with difficulty in everyday adaptive skills indicates intellectual disability. IQ tests are culturally loaded and measure only part of ability, so they must never be used to label a child.

Gardner's multiple intelligences: Howard Gardner of Harvard, in Frames of Mind (1983), rejected a single general intelligence and proposed several relatively independent intelligences: linguistic, logical-mathematical, spatial, musical, bodily-kinaesthetic, interpersonal (understanding others) and intrapersonal (understanding oneself). He added the naturalist intelligence in the 1990s, making eight, and has discussed existential intelligence as a possible ninth. Each child has a unique profile of strengths. A teacher can open the same topic through several doors - a story, a number pattern, a map or diagram, a song, a role play, a group task, a reflective journal or a nature walk - and let children show their learning in different ways.

Other theories of intelligence: Robert Sternberg's triarchic theory (1985) has three parts: analytical or componential intelligence, used in academic problem-solving; creative or experiential intelligence, used in dealing with new situations; and practical or contextual intelligence, the 'street smartness' used in adapting to everyday life. Charles Spearman's two-factor theory (g and s), Louis Thurstone's primary mental abilities, J. P. Guilford's structure of intellect and Raymond Cattell's fluid and crystallised intelligence are also asked. Emotional intelligence, the ability to perceive, understand and manage one's own and others' emotions, was proposed by Peter Salovey and John Mayer (1990) and popularised by Daniel Goleman's 1995 book, which named five components: self-awareness, self-regulation, motivation, empathy and social skills.

Creativity and divergent thinking: Guilford distinguished convergent thinking, which narrows down to the one correct answer, from divergent thinking, which produces many varied answers to an open problem. Creativity tests such as those of E. Paul Torrance score divergent thinking on fluency (the number of ideas), flexibility (the variety of

categories), originality (unusual ideas) and elaboration (detail). A creative child may not have the highest IQ, and a child with a high IQ may not be creative. Teachers nurture creativity with open-ended questions ('How many uses can you think of for an old tyre?'), by accepting unusual answers, tolerating ambiguity and mistakes, giving time and freedom, and dropping the idea that every question has only one right answer.

Learning styles and catering to diversity: Children also differ in how they prefer to take in information. The visual, auditory and kinaesthetic (VAK) model, extended as VARK with reading and writing, is widely taught, although research does not show that matching teaching to a single preferred style improves learning; the practical lesson is to present ideas in many modes. Differentiated instruction varies content, process and product according to each child's readiness, interests and learning profile, using flexible grouping, peer tutoring, tiered tasks and a choice of ways to show learning. Gifted children need enrichment (deeper and broader work) and sometimes acceleration; children who learn slowly need more time, concrete aids and remedial support rather than labels. Inclusive education, backed by the RTE Act 2009 and the Rights of Persons with Disabilities Act 2016, which lists 21 specified disabilities, means teaching all children together in the regular classroom with the support each one needs.

Examples

- Binet and Simon (1905): first practical intelligence test and the idea of mental age; Stern (1912): IQ = MA/CA; Terman (Stanford-Binet, 1916): multiplied by 100.
- IQ = (MA / CA) x 100: CA 10, MA 8 gives IQ 80; CA 10, MA 12 gives IQ 120. Wechsler's deviation IQ has a mean of 100 and a standard deviation of 15.
- Gardner (Frames of Mind, 1983): linguistic, logical-mathematical, spatial, musical, bodily-kinaesthetic, interpersonal, intrapersonal, plus naturalist = eight.
- Interpersonal intelligence = understanding others (leaders, counsellors); intrapersonal intelligence = understanding oneself (self-aware, reflective).
- Sternberg's triarchic theory: analytical (componential), creative (experiential) and practical (contextual, 'street smart') intelligence.
- Emotional intelligence: Salovey and Mayer (1990); Goleman (1995) - self-awareness, self-regulation, motivation, empathy, social skills.
- Divergent thinking = many possible answers (creativity); convergent thinking = one correct answer. Creativity is scored on fluency, flexibility, originality, elaboration.
- Differentiated instruction varies content, process and product; gifted children need enrichment, slow learners need time and remedial support, not labels.
- Rights of Persons with Disabilities Act 2016 lists 21 specified disabilities; inclusion means teaching all children together with the support they need.

> **Quick revision:** Individual differences from heredity x environment, diversity a resource; Binet-Simon 1905 mental age; Stern 1912 IQ = MA/CA, Terman Stanford-Binet 1916 x 100; Wechsler deviation IQ mean 100, SD 15; Gardner 1983 eight intelligences (naturalist added later); Sternberg analytical, creative, practical; EI Salovey-Mayer 1990, Goleman 1995; Guilford divergent thinking: fluency, flexibility, originality, elaboration; differentiated instruction; RPwD Act 2016, 21 disabilities.

Language and Thought, and Gender as a Social Construct in the Classroom

Piaget on language and thought: For Piaget, thought comes first and language reflects it. Children form concepts through action, and words are attached to concepts they already have; language by itself does not create logical thinking. Much of the talk of pre-operational children is egocentric speech - speaking without adjusting to the listener, or talking to oneself - which mirrors their egocentric thinking and declines by about 7 years as they learn to take other perspectives. On this view, a teacher should provide experiences first and the vocabulary for them afterwards.

Vygotsky on language and thought: Vygotsky held that thought and speech have different roots and develop separately at first - pre-linguistic thought in the infant and pre-intellectual speech such as crying and babbling - until around 2 years, when they meet: thought becomes verbal and speech becomes rational. Language, first used

socially to communicate, is turned inward as private speech and then inner speech, and becomes the main tool of thinking. Language therefore shapes thought, and social interaction drives cognitive growth, so classroom talk, discussion and explaining one's reasoning are the very means by which children learn to think. Edward Sapir and Benjamin Lee Whorf went further with the hypothesis of linguistic relativity: the language we speak influences how we perceive and think about the world.

How children acquire language: Behaviourists, led by Skinner in Verbal Behavior (1957), explained language learning through imitation and reinforcement. Noam Chomsky criticised this view and argued that children are born with a language acquisition device (LAD), an innate capacity tuned to a universal grammar common to all languages. The evidence includes the speed of learning, the fact that children produce sentences they have never heard, and overgeneralisation errors such as 'goed' or 'mouses', which show rules being applied rather than words being copied. Bruner added that the LAD needs a language acquisition support system (LASS) of adults who talk with the child. The usual sequence - cooing, babbling (around 6 months), the one-word stage (around the first birthday) and the two-word or telegraphic stage - is similar across languages, and Eric Lenneberg proposed a critical period for language that ends around puberty.

Language in the classroom: NCF 2005 treats multilingualism as a resource, asks schools to use the child's home language as a bridge, and wants language taught across the curriculum, because every subject is learned through language. The RTE Act 2009 (Section 29) says the medium of instruction shall, as far as practicable, be the child's mother tongue, and NEP 2020 says that wherever possible it should be the home language, mother tongue or local language at least until Grade 5, and preferably until Grade 8 and beyond. A child who mixes languages or makes errors is learning, not failing; the teacher should model correct use and encourage talk rather than correct every slip or punish the use of the home language.

Gender as a social construct: Sex refers to the biological differences between male and female bodies; gender refers to the roles, behaviour, attributes and expectations that a society considers appropriate for men and women. Gender is socially constructed: it is learned through socialisation - the toys children are given, the chores they are assigned, the language adults use ('boys don't cry'), the media, textbooks and school routines - and it varies across cultures and over time. Gender roles are the tasks and behaviour expected of each gender, such as the idea that cooking is women's work. Gender stereotypes are fixed, oversimplified generalisations, such as 'boys are better at mathematics' or 'girls are weak and emotional', and they limit both girls and boys. Children develop a sense of gender identity by about 2 to 3 years, and, in Kohlberg's account, gender constancy - the understanding that one's gender does not change with clothes or activities - by about 5 to 7 years.

The teacher's response to gender: Gender bias in schools is often unintended: asking boys to carry benches and girls to sweep or decorate, calling on boys more often for mathematics and science, praising girls for neatness and boys for ideas, or using books in which women appear only at home. A gender-sensitive teacher rotates duties among all children, forms mixed groups, uses gender-neutral language, gives equal attention and opportunity in sports, science and leadership, uses counter-stereotypical examples such as women scientists, pilots and athletes and men who cook and care for children, and discusses stereotypes openly when children voice them. NCF 2005 treats gender as a concern that cuts across the whole curriculum, and NEP 2020 counts girls and transgender students among the socio-economically disadvantaged groups and proposes a Gender-Inclusion Fund. In a CTET question, the right answer challenges the stereotype through discussion and equal opportunity without ridiculing the child who voiced it.

Examples

- Piaget: thought comes first and language reflects it; the egocentric speech of pre-operational children declines by about 7 years.
- Vygotsky: thought and speech have separate roots and merge around 2 years; speech becomes private speech and then inner speech - language shapes thought.
- Chomsky: language acquisition device (LAD) and universal grammar; errors like 'goed' and 'mouses' show rule learning, not imitation.

- Skinner, Verbal Behavior (1957): language learned by imitation and reinforcement. Bruner: LASS - the support of adults who talk with the child.
- Sapir-Whorf hypothesis (linguistic relativity): the language one speaks influences how one thinks and perceives.
- Medium of instruction: RTE Act 2009 - the mother tongue as far as practicable; NEP 2020 - home language at least till Grade 5, preferably till Grade 8 and beyond.
- Sex is biological; gender is socially constructed, learned through socialisation, and varies across cultures and over time.
- Gender stereotypes such as 'boys are better at maths' or 'girls should do the decoration' are countered with rotated duties, mixed groups and counter-examples.
- NEP 2020 counts girls and transgender students among socio-economically disadvantaged groups and proposes a Gender-Inclusion Fund.

> **Quick revision:** Piaget: thought precedes language, egocentric speech; Vygotsky: thought and speech merge around 2 years, private then inner speech, language shapes thought; Chomsky LAD, universal grammar, overgeneralisation; Skinner Verbal Behavior 1957; Bruner LASS; Sapir-Whorf; RTE: mother tongue as far as practicable; NEP 2020: home language till Grade 5; sex biological, gender social construct; stereotypes and roles; rotate duties, mixed groups, counter-examples.

Assessment for Learning: Formative Assessment, CCE, Rubrics and Bloom's Taxonomy

Assessment of, for and as learning: Assessment is the process of gathering evidence of what children know and can do and using it to make decisions. Assessment of learning is summative: it comes at the end of a unit, term or year and is used to grade, certify, promote or report. Assessment for learning is formative: it goes on during teaching, gives feedback to both teacher and child, and is used to adjust teaching and plan next steps. Assessment as learning puts the child in charge: through self-assessment, peer assessment and reflection she monitors her own learning and develops metacognition, an awareness of how she thinks and learns. NCF 2005 and NEP 2020 both want the balance shifted from assessment of learning towards assessment for and as learning.

Formative, summative and diagnostic: The terms formative and summative were introduced by Michael Scriven in 1967 for evaluating programmes and were applied to student learning by Benjamin Bloom and his colleagues. Formative assessment uses observation, questioning, discussion, quizzes, homework and projects; its purpose is improvement, so it should not be marked harshly. Summative assessment uses unit tests and term-end and board examinations. Diagnostic assessment digs into the specific cause of a learning difficulty - for example, finding that a child's subtraction errors come from always taking the smaller digit from the larger - and is followed by remedial teaching. Norm-referenced tests compare a child with other children; criterion-referenced tests compare her with fixed learning outcomes.

Continuous and Comprehensive Evaluation: CCE, already recommended by the National Policy on Education 1986, was strongly backed by NCF 2005, whose position paper on examination reforms criticised the stress and rote learning caused by one-time examinations, and the RTE Act 2009 made it law for elementary classes: Section 29 asks for comprehensive and continuous evaluation of the child's understanding of knowledge and ability to apply it, and Section 30 says no child shall be required to pass any board examination until elementary education is completed. 'Continuous' means that assessment is part of everyday teaching, spread across the year. 'Comprehensive' means that it covers scholastic areas (subjects) and co-scholastic areas (life skills, attitudes, values, health, arts and sports), using many tools: observation, anecdotal records, checklists, rating scales, portfolios, projects, oral work, and self and peer assessment. Results are reported through grades and descriptive feedback rather than raw marks. The no-detention rule of Section 16 was modified by the RTE (Amendment) Act 2019, which provides for regular examinations in Classes 5 and 8 and, after a re-examination, lets the appropriate government (Centre or state) decide whether a child may be held back. In December 2024 the Centre amended the RTE rules so that, in its own schools such as Kendriya and Navodaya Vidyalayas, a child who fails the Class 5 or 8 re-examination is held back, though not expelled.

Portfolios and rubrics: A portfolio is a purposeful collection of a child's work over time - drafts and final pieces, drawings, project reports, worksheets and her own reflections - that shows growth and effort, not just a final score. A

rubric is a scoring guide that lists the criteria for a task and describes what performance looks like at each level, for example beginning, developing, proficient and exemplary for the content, organisation and presentation of a project. Rubrics make assessment transparent and consistent, and when shared before the task they show children what good work looks like. Analytic rubrics score each criterion separately; holistic rubrics give one overall judgement.

Questioning and Bloom's taxonomy: Benjamin Bloom and his colleagues published the Taxonomy of Educational Objectives in 1956, classifying objectives into cognitive, affective and psychomotor domains. The original cognitive levels were knowledge, comprehension, application, analysis, synthesis and evaluation. In 2001 Lorin Anderson and David Krathwohl revised it, using verbs and placing create at the top: remember, understand, apply, analyse, evaluate and create; they also added a knowledge dimension of factual, conceptual, procedural and metacognitive knowledge. Questions can be pitched at each level: 'Name the parts of a plant' (remember), 'Why do plants kept indoors bend towards the window?' (understand), 'Where would you keep a potted plant, and why?' (apply), 'Compare desert plants with water plants' (analyse), 'Should this old tree be cut for a road? Why?' (evaluate) and 'Design an experiment to test whether plants need light' (create). The affective domain, set out by Krathwohl, Bloom and Masia in 1964, runs from receiving and responding to valuing, organisation and characterisation. Good questioning mixes open and closed questions, allows wait time and invites children's own questions.

NEP 2020 and competency-based assessment: NEP 2020 calls for a shift from summative, rote-memory testing to regular, formative, competency-based assessment that tests higher-order skills such as analysis, critical thinking and conceptual clarity. It proposes a 360-degree, multidimensional holistic progress card that includes self-assessment, peer assessment and teacher assessment; school examinations in Grades 3, 5 and 8, conducted by the appropriate authority; board examinations redesigned to test core capacities rather than months of coaching; and PARAKH (Performance Assessment, Review, and Analysis of Knowledge for Holistic Development) as a national assessment centre that sets norms. In CTET terms, good assessment is ongoing, uses varied tools, gives specific feedback rather than only marks, covers all aspects of development, involves the child in judging her own work, and improves teaching rather than labelling or ranking children.

Examples

- Assessment of learning = summative (at the end, for grading); for learning = formative (during teaching, feedback to improve); as learning = self and peer assessment, metacognition.
- Formative and summative were coined by Michael Scriven (1967); diagnostic assessment finds the cause of a difficulty and is followed by remedial teaching.
- CCE: 'continuous' = throughout the year as part of teaching; 'comprehensive' = scholastic and co-scholastic areas (life skills, attitudes, values, health, arts, sports).
- RTE Act 2009: Section 29 - comprehensive and continuous evaluation; Section 30 - no board examination until elementary education is completed.
- RTE (Amendment) Act 2019: regular examinations in Classes 5 and 8, a re-examination for those who fail, and the government may decide whether to hold children back.
- Portfolio = purposeful collection of a child's work over time showing growth; rubric = criteria with described performance levels, shared in advance.
- Bloom (1956): knowledge, comprehension, application, analysis, synthesis, evaluation. Anderson and Krathwohl (2001): remember, understand, apply, analyse, evaluate, create.
- Affective domain (Krathwohl, Bloom and Masia, 1964): receiving, responding, valuing, organisation, characterisation.
- NEP 2020: competency-based, formative assessment; 360-degree holistic progress card; school examinations in Grades 3, 5 and 8; PARAKH as national assessment centre.
- Norm-referenced tests compare children with one another; criterion-referenced tests compare each child with set learning outcomes.

Quick revision: Assessment of (summative), for (formative), as (self and peer, metacognition) learning; Scriven 1967; diagnostic then remedial; CCE = continuous + comprehensive (scholastic, co-scholastic), NPE 1986, NCF 2005, RTE Sections 29 and 30; 2019 amendment: exams in Classes 5 and 8; portfolio, rubric, anecdotal record; Bloom 1956, revised 2001: remember, understand, apply, analyse, evaluate, create; NEP 2020: competency-based, holistic progress card, PARAKH.

How Children Learn and Why They Fail: Motivation, Emotion and Child-Centred Education

Motivation: Motivation is the inner state that arouses, directs and sustains behaviour towards a goal. Intrinsic motivation comes from the activity itself - curiosity, interest, the pleasure of mastering something - while extrinsic motivation comes from outside rewards and pressures such as marks, prizes, praise or fear of punishment. Intrinsic motivation produces deeper and longer-lasting learning; studies of the overjustification effect found that rewarding children for an activity they already enjoyed reduced their later interest in it. Edward Deci and Richard Ryan's self-determination theory says intrinsic motivation grows when three needs are met: autonomy (some choice), competence (tasks that can be mastered) and relatedness (belonging). Carol Dweck's work on mindsets shows that children who believe ability grows with effort keep trying after failure, so teachers should praise effort, strategy and progress rather than calling children clever.

Maslow's hierarchy of needs: Abraham Maslow (1943) arranged human needs in a hierarchy: physiological needs (food, water, sleep), safety needs (security, freedom from fear), love and belongingness, esteem (respect, recognition, self-respect) and, at the top, self-actualisation, the fulfilment of one's potential. The lower four are deficiency needs and self-actualisation is a growth need; lower needs must be reasonably met before higher ones can motivate. A hungry child, a child afraid of being beaten or a child who feels she does not belong cannot concentrate on fractions. That is why the mid-day meal, a safe and fear-free classroom and a teacher who makes every child feel accepted are preconditions for learning, not extras.

Cognition, emotion and attention: Interest, joy and curiosity open the mind, while fear, anxiety and humiliation narrow attention and block memory. The Yerkes-Dodson law states that performance improves with arousal only up to an optimum, beyond which it declines, so moderate challenge helps but heavy pressure harms. The Yash Pal Committee report Learning Without Burden (1993) and NCF 2005 both warn against the joyless burden of rote learning, and the RTE Act 2009 bans physical punishment and mental harassment (Section 17) and asks that the child be made free of fear, trauma and anxiety (Section 29). Attention is the focusing of consciousness on a stimulus; it is selective, and its span is short in young children. Novelty, movement, interest and personal relevance hold it, so teachers vary activities and link lessons to children's lives.

Why children 'fail': The CTET syllabus puts 'fail' in quotation marks for a reason: much failure belongs to the system rather than the child. Causes include teaching that ignores what children already know and their alternative conceptions; a medium of instruction the child does not understand; a curriculum and examples cut off from her life; rote learning and fear of punishment; poverty, hunger, illness and child labour; being a first-generation learner with no help at home; undiagnosed vision, hearing or learning difficulties; and low teacher expectations, since children tend to live up or down to what is expected of them - the Pygmalion effect studied by Robert Rosenthal and Lenore Jacobson (1968). Labelling a child as weak or holding her back usually deepens the problem. The teacher's job is to find the cause and change the teaching.

Learning difficulties: A child with a specific learning disability has average or above-average intelligence but a persistent difficulty in one area: dyslexia in reading and spelling (confusing letters such as b and d, slow decoding), dysgraphia in handwriting and written expression, dyscalculia in number sense and arithmetic, and dyspraxia in motor coordination. Specific learning disabilities are among the 21 disabilities listed in the Rights of Persons with Disabilities Act 2016. A slow learner, by contrast, learns all subjects more slowly because of below-average general ability and needs more time and repetition. Both need early identification, multisensory teaching, extra time, a supportive class and, where available, help from special educators - never ridicule.

Child-centred and progressive education: Child-centred education puts the child's needs, interests, experiences and pace at the centre of the curriculum. Jean-Jacques Rousseau, in Emile (1762), argued for a natural education

that follows the child's development. Johann Pestalozzi stressed the harmonious development of head, heart and hand and learning from real objects. Friedrich Froebel, a German educator, founded the kindergarten, a 'garden of children' in which children grow like plants through play, songs and his 'gifts' and 'occupations', with the teacher as a gardener. Maria Montessori, an Italian physician, opened the first Casa dei Bambini (Children's House) in Rome in 1907; her method uses a prepared environment, self-correcting didactic apparatus, sensory training and freedom within limits, so that children teach themselves (auto-education) while the teacher observes and guides. John Dewey, the American pragmatist and author of Democracy and Education (1916), taught that education is a process of living rather than mere preparation for later life, that children learn by doing and solving real problems, and that the school should be a miniature democratic community; his student William Kilpatrick developed the project method. In such classrooms the teacher is a facilitator, not the only source of knowledge: she plans experiences, asks open questions, builds on children's ideas and language, and keeps fear out of the classroom.

Examples

- Intrinsic motivation (curiosity, interest, mastery) gives deeper learning than extrinsic rewards; rewarding an activity children already enjoy can reduce their interest (overjustification).
- Self-determination theory (Deci and Ryan): autonomy, competence and relatedness nourish intrinsic motivation.
- Maslow (1943): physiological, safety, love and belonging, esteem, self-actualisation; a hungry or frightened child cannot learn - hence mid-day meals and fear-free classrooms.
- Yerkes-Dodson law: performance rises with arousal up to an optimum and then falls - moderate challenge helps, heavy pressure harms.
- RTE Act 2009: Section 17 bans physical punishment and mental harassment; Section 29 asks that the child be free of fear, trauma and anxiety.
- Pygmalion effect (Rosenthal and Jacobson, 1968): teachers' expectations shape children's performance.
- Specific learning disability: average or higher intelligence but difficulty in one area (dyslexia, dysgraphia, dyscalculia, dyspraxia); a slow learner is slower in all areas.
- Froebel - kindergarten, play, gifts; Montessori - Casa dei Bambini (Rome, 1907), prepared environment, auto-education; Dewey - learning by doing, Democracy and Education (1916).
- Rousseau - Emile (1762), natural education; Pestalozzi - head, heart and hand; Kilpatrick - project method.
- Teacher as facilitator: plans experiences, asks open questions, builds on children's ideas and language, and keeps fear out of the classroom.

> **Quick revision:** Intrinsic over extrinsic motivation; overjustification; Deci-Ryan autonomy, competence, relatedness; Maslow 1943 physiological, safety, belonging, esteem, self-actualisation; Yerkes-Dodson optimum arousal; Learning Without Burden 1993; RTE Section 17 no physical punishment; much 'failure' is the system's; Pygmalion effect 1968; SLDs in RPwD Act 2016; Rousseau Emile 1762, Pestalozzi, Froebel kindergarten, Montessori 1907, Dewey 1916, Kilpatrick project method; teacher as facilitator.

Free practice questions: parikshasaathi.com/q/child-development-pedagogy/

Environmental Studies Pedagogy (Paper I)

Environmental Studies (EVS) and its Pedagogy (Paper I)

What the exam asks: CTET Paper I has 30 questions on Environmental Studies. About half test content at the level of the NCERT class III to V textbooks (titled Looking Around, Aas-Paas in Hindi) and about half test pedagogy: the nature and scope of EVS, the vision of NCF 2005, approaches to teaching, assessment under CCE, and classroom scenarios. Pedagogy questions rarely ask for definitions. They give a situation and expect you to pick the option that reflects a child-centred, experiential, locally rooted, integrated view of EVS. Options that say lecture, dictate, copy from the textbook or hold a written test are almost always wrong.

Nature and scope of EVS: At the primary stage EVS is an integrated area of study that draws on science, social science and environmental education. It is not taught as separate science and social studies because a young child perceives the surroundings as a whole, not in disciplinary compartments. In classes I and II, EVS themes are

transacted through language and mathematics; from class III to V it is a separate subject. Its scope covers the natural, social and cultural environment of the child, and its aims include awareness, skills of observation and inquiry, and values such as care for the environment and respect for diversity. Environmental education is narrower: it aims mainly at awareness, attitudes and action for protecting the environment, whereas EVS is a full curricular area in which environmental concerns are woven in.

NCF 2005 themes: The EVS syllabus is organised around six themes rather than topics or chapters: Family and Friends, Food, Shelter, Water, Travel, and Things We Make and Do. Family and Friends has four sub-themes: Relationships, Work and Play, Animals and Plants. Each theme is revisited in classes III, IV and V with increasing depth, which is called a spiral approach. Mapping and directions appear under Shelter ('Mapping my neighbourhood', Class III) and mapping and aerial views under Travel in Class V; occupations, pottery, weaving and tools come under Things We Make and Do.

Learning principles: EVS lessons begin with the child's own experience because learning is meaningful only when new ideas connect with what the child already knows (the constructivist view of the learner as an active constructor of knowledge). Related principles are learning from the immediate environment, from known to unknown, from concrete to abstract, from local to global, from simple to complex and learning by doing. The textbook is one resource among many, not the only source. The questions in Looking Around are meant to make children observe, think, discuss and ask, not to be answered by copying from the chapter. The community, parents, local artisans, the village pond and the market are all resources for EVS.

Approaches and methods: Thematic presentation, inquiry and activity based learning, projects, field visits, surveys, story-telling, discussion, demonstration, experimentation, observation, concept mapping and role play are all recommended. Match the approach to the situation: a survey when children collect information from many homes, a project when a group investigates a question over several days, role play when the goal is empathy or seeing another person's perspective, experimentation when children test an idea themselves, and demonstration when the teacher shows a process that is unsafe or needs scarce material. Open-ended questions (what would happen if...) and probing questions (why do you think so?) are preferred over yes/no recall questions. Misconceptions are handled by letting children test their belief through an activity and discussion, not by simply announcing the correct fact.

Assessment in EVS: Continuous and comprehensive evaluation uses observation of children, oral questions, drawings, portfolios (a collection of a child's work over time), anecdotal records (short notes of a significant incident), checklists, rubrics (criteria with levels of performance), group work assessment and self and peer assessment. NCERT lists indicators of learning: observation and reporting, discussion, expression, explanation, classification, questioning, analysis, experimentation, concern for justice and equality, and cooperation. Questions can describe a child's behaviour and ask which indicator it reflects.

Values and sensitivity: Looking Around deliberately shows fathers cooking, girls playing kabaddi, a naval officer named Wahida, a girl in a wheelchair (Chuskit), families of different kinds and children from tribal, rural and urban homes. The purpose is to challenge stereotypes of gender, disability, caste and region, and to build respect for diversity and concern for justice.

Content hotspots: Ants follow a smell trail; animals with ears visible outside and hair on the body give birth to young ones; the koel lays its eggs in a crow's nest; the tailor bird stitches leaves; clove is a flower bud, cinnamon is bark, turmeric and ginger are underground stems; coconut is dispersed by water; seeds need water, air and warmth to germinate, and most do not need light (a few species do); Assam has stilt houses, Manali wooden sloping roofs, Rajasthan thick mud walls, Srinagar houseboats, the Arctic igloos; Jaisalmer harvested rain in lakes like Ghadsisar; the Konkan Railway runs from Roha to Thokur; Gaurav Jani stayed with the Changpa of Ladakh in rebo tents; Amrita Devi Bishnoi died saving khejri trees in 1730; Chipko began in Uttarakhand in 1973.

Traps: Do not confuse EVS (a curricular area) with environmental education (awareness and action). Energy, Air and Health are not among the six NCF themes. Potato is a stem, not a root. Malaria is mosquito-borne, not water-borne. In CCE questions, the option about a single written test is unlikely to be the answer. In scenario questions, prefer the option where children act, observe, discuss or investigate rather than the one where the teacher explains.

Examples

- Six NCF 2005 EVS themes: Family and Friends, Food, Shelter, Water, Travel, Things We Make and Do. Mnemonic: Family Feeds Shelter, Water Travels, Things Work.
- Family and Friends has four sub-themes: Relationships, Work and Play, Animals, Plants.
- Classes I-II: EVS through language and maths; classes III-V: EVS as a separate integrated subject; classes VI onwards: separate science and social science.
- A survey collects information from many people (sources of water at home); a project investigates one question over days and ends in a product or report.
- Portfolio = collection of a child's work over time; anecdotal record = brief note of one significant incident; rubric = criteria with levels of performance.
- Indicators of learning in EVS include observation and reporting, classification, questioning, experimentation, concern for justice and equality, and cooperation.
- Spices: clove is a dried flower bud, cinnamon is bark, turmeric and ginger are underground stems, black pepper is a fruit, saffron is the stigma of a flower.
- Houses: Assam stilt houses on bamboo, Manali wooden houses with sloping roofs, Rajasthan thick mud walls and flat roofs, Srinagar houseboats, Arctic igloos of snow.
- Water-borne: cholera, typhoid, diarrhoea, jaundice. Mosquito-borne: malaria, dengue. Anopheles carries malaria (Ronald Ross).
- Konkan Railway: Roha (Maharashtra) to Thokur (Karnataka) through Goa, about 740 km, opened 1998; in class IV, Omana's train journey from Ahmedabad to Kottayam, via Goa, runs over this route (the textbook does not name the Konkan Railway).
- Amrita Devi Bishnoi, Khejarli (Jodhpur) 1730, khejri trees; Chipko, Uttarakhand 1973, villagers hugged trees; Gaura Devi led Reni women in 1974.
- Seed dispersal: wind (madar/aak, dandelion with hair), water (coconut), animals (burrs that stick to fur), bursting pods (soyabean, pea).

> **Quick revision:** EVS = integrated science + social science + environmental education, separate subject from class III; NCF 2005 six themes: Family and Friends, Food, Shelter, Water, Travel, Things We Make and Do; sub-themes of Family and Friends: Relationships, Work and Play, Animals, Plants; NCERT textbook: Looking Around; principles: known to unknown, concrete to abstract, local to global, learning by doing; CCE tools: portfolio, anecdotal record, checklist, rubric; ants follow smell; clove = flower bud; coconut dispersed by water; Konkan Railway Roha-Thokur; Chipko 1973 Uttarakhand.

Family and Friends in NCERT EVS: Relationships, Work and Play, Animals and Plants

Why this theme comes first: Family and Friends is the first of the six EVS themes and the only one divided into sub-themes: Relationships, Work and Play, Animals, and Plants. It starts where the child already is, with the people at home and friends nearby, and widens to the community and the living world. In Looking Around (Aas-Paas), the NCERT books for classes III to V, the theme runs through stories, poems and activities in all three books and returns each year with more depth.

Relationships: The books show families as they really are, not one ideal type. Families can be Different (class III) shows families of many sizes and kinds and asks who lives in each child's home. Changing Families (class IV) shows how a family changes when a baby is born (Nimmi), when a parent is transferred to another city (Tsering) and when someone in the family marries (Nazli). Like Father, Like Daughter (class V) asks which features, such as curly hair, eye colour or dimples, children share with their relatives, tells of Gregor Mendel's experiments with pea plants, and separates such inherited traits from what we learn from our surroundings, such as language or music (polio, it notes, is not inherited). A teacher should never assume that every child lives with a mother and a father; a family-tree activity must leave room for every kind of family.

Work and Play: Work We Do and Games We Play (class III) ask who does which work at home and which games are played indoors and outdoors. Hu Tu Tu, Hu Tu Tu (class IV) is built around kabaddi (hu-tu-tu is one of its regional names), shows a team of girls playing it, and tells of the sisters Jwala, Leela and Heera of Mumbai, who played it

when girls were not allowed to. Who will do this Work? (class V) raises the question of dignity of labour: why cleaning toilets and drains is looked down upon, and how in Gandhiji's Sabarmati Ashram everyone, guests included, had to empty the toilet baskets, while Gandhiji himself later cleaned village toilets near Wardha. Children learn that all work is useful and that housework is not only women's work.

Animals: In class III, Poonam's Day Out asks children to group the animals they see by how they move, and Flying High looks at birds, their feathers and the shapes of their beaks. In class IV, Ear to Ear shows that animals with ears seen outside the body, such as the cat, cow and elephant, have hair and give birth to young ones, while birds have only ear holes and lay eggs; A Day with Nandu describes an elephant herd of females and young ones, led by the oldest female, which young males leave at about 14 to 15 years; and Anita and the Honeybees tells of Anita Kushwaha of Bochaha village in Muzaffarpur district, Bihar, who took up beekeeping, and explains that only the queen bee lays eggs while worker bees collect nectar. In class V, A Snake Charmer's Story, about the Kalbeliya community, asks whether a snake hears the been or follows its movement (snakes have no outer ears), names four poisonous snakes, the cobra, common krait, Russell's viper and saw-scaled viper (the 'big four' behind most snakebites in India), and notes that the law now forbids catching and keeping snakes (the Wildlife (Protection) Act, 1972).

Plants: The Plant Fairy (class III) asks children to observe the plants near them, compare leaf shapes and take bark and leaf rubbings. In class IV, The Valley of Flowers begins in the valley in Uttarakhand where flowers bloom for only a few weeks a year and moves on to Madhubani floral designs, flowers eaten as vegetables and itr from Kannauj; and Abdul in the Garden is about roots, which hold a plant firmly in the ground and take in water, and roots we eat such as radish. Seeds and Seeds (class V) deals with sprouting and with how seeds travel: on the wind, stuck to animals' fur, and thrown out by bursting pods such as soyabean. The Story of Amrita (class IV) tells how, almost three hundred years ago, Amrita, her daughters and many villagers of Khejadli near Jodhpur gave their lives hugging the khejadi trees to save them from the king's men (history records 363 Bishnois killed in 1730); the Government of India's Amrita Devi Bishnoi award honours those who protect wildlife.

Living things in our lives: The books keep returning to how people depend on living things for food, wool and silk, medicine, fuel and work (bullocks, camels, yaks), and Web of Life (class III) shows how trees, soil, water, animals and people are linked in one web on which our lives depend. Children are asked to care: not to tease animals, to keep water for birds in summer, and to respect the knowledge of forest dwellers, beekeepers and snake charmers. Chuskit Goes to School (class IV), in which Abdul, the other children and the teachers level the road and bridge the river so that Chuskit, a girl in a wheelchair in Ladakh, can reach school, carries the message of inclusion.

In the classroom: In a typical CTET situation, a teacher asks children to bring photographs of their father and mother, and one child lives with an aunt. The better plan frames such activities around 'the people I live with'. Good practice also includes watching an ant trail form around a few grains of sugar, observing a nest without touching it, interviewing grandparents about the games they played, and letting children group animals by their own criteria before introducing the textbook's groups.

Examples

- Family and Friends is the only EVS theme with sub-themes: Relationships, Work and Play, Animals, Plants.
- Class IV Ear to Ear: animals with ears seen outside the body (cat, cow, elephant) have hair and give birth to young ones; birds have ear holes and lay eggs.
- Class IV A Day with Nandu: an elephant herd has females and young ones, is led by the oldest female, and young males leave at about 14-15 years.
- Class IV Anita and the Honeybees: Anita Kushwaha of Bochaha, Muzaffarpur (Bihar) took up beekeeping; only the queen bee lays eggs, worker bees collect nectar.
- Class V A Snake Charmer's Story: Kalbeliya community; snakes have no outer ears, so the been's movement matters, not its sound; the four poisonous snakes named are the cobra, common krait, Russell's viper and saw-scaled viper; catching snakes is banned (Wildlife (Protection) Act 1972).
- Class IV The Story of Amrita: Amrita and the villagers of Khejadli, near Jodhpur, died to save khejadi trees (363 Bishnois, 1730); the Amrita Devi Bishnoi award honours wildlife protection.

- Class IV The Valley of Flowers: the valley in Uttarakhand blooms for a few weeks a year; Madhubani floral art (Bihar), flowers eaten as vegetables, itr from Kannauj (UP); collect only fallen flowers.
- Class V Who will do this Work?: dignity of labour; in Gandhiji's Sabarmati Ashram everyone, guests included, emptied the toilet baskets, and Gandhiji himself cleaned village toilets near Wardha.
- Class IV Chuskit Goes to School: Chuskit, a girl in a wheelchair in Ladakh, reaches school with her friends' help; a lesson in inclusion.
- Classroom rule: frame family activities as 'the people I live with' so that no child's family is treated as odd.

> **Quick revision:** Family and Friends: only theme with sub-themes (Relationships, Work and Play, Animals, Plants); families differ and change (birth, marriage, moving for work); inherited vs learnt features; ears seen outside = hair + young ones; elephant herd led by oldest female; Anita Kushwaha, Bihar, honeybees; Kalbeliya, four poisonous snakes, Wildlife Act 1972; Amrita and the Bishnois of Khejadli (363, 1730); Valley of Flowers (Uttarakhand), itr of Kannauj; girls' kabaddi; dignity of labour; inclusive family activities.

Food, Water and Shelter in EVS: Food Habits, Water Sources and Conservation, Houses in Different Regions

Food and why food habits differ: In EVS, food is studied as part of daily life and culture, not as a list of nutrients. All food comes from plants or animals; people in different regions eat differently because of what grows there, the climate and custom; and needs change with age, from a baby's milk to soft food for an old person with few teeth. In class IV, Basva's Farm follows an onion crop in a Karnataka village from sowing to harvest, and From Market to Home follows Vaishali's family of vegetable sellers and asks which vegetables spoil quickly and which keep for some days. A Seed tells a Farmer's Story (class V) compares older farming, with home-saved seeds and manure, with newer farming that uses bought seeds, chemical fertilisers, pesticides and much more water.

Cooking, tasting and keeping food: What is Cooking (class III) covers foods eaten raw and cooked, ways of cooking such as boiling, frying, roasting and steaming, utensils of iron, brass, aluminium, steel and clay, and what gives the heat for cooking; The Story of Food asks who cooks and who serves in the family. From Tasting to Digesting (class V) teaches the tastes the tongue senses (sweet, salty, sour and bitter), that digestion begins in the mouth with saliva, and the story of Alexis St. Martin, left with a hole in his stomach by a gunshot in 1822, through which Dr William Beaumont studied how the stomach digests food; it also asks why many children go hungry. Mangoes Round the Year covers food spoiling, the fungus on stale bread, and keeping food by sun-drying (aam papad) and with salt, sugar or oil, as in pickles.

Water, its sources and its problems: Rain is the main source of fresh water; it fills rivers, lakes and ponds and seeps underground, from where wells, hand pumps and tube wells draw it. Water O' Water! and Drop by Drop (class III) look at the uses of water, who fetches it, and how it is stored and saved. A River's Tale (class IV) follows a river from the hills to the plains and shows how waste and factories make it dirty; Too Much Water, Too Little Water deals with unsafe drinking water, a water park beside villagers who have no water, and the children's panchayat Bhima Sangh in Karnataka, which revived an old tank. Experiments with Water (class V) lets children find out what floats, sinks or dissolves, and mentions the Dead Sea, so salty that people float in it. A Treat for Mosquitoes links stagnant water with disease: malaria spreads through the bite of the female Anopheles mosquito (Ronald Ross showed its role at Secunderabad in 1897 and received the Nobel Prize in 1902), while dengue is spread by the Aedes mosquito, which breeds in clean water collected in coolers, tyres and pots.

Saving water, old and new: Every Drop Counts (class V) shows that people in India have long collected rainwater: stepwells (baolis), tanks and lakes such as Ghadsisar in Jaisalmer, made by King Ghadsi about 650 years ago, and covered underground tanks (kund or tanka) in the Rajasthan desert that store rain running off a clean, sloping catchment or a roof. A good lesson starts from the children's own homes: where our water comes from, who brings it and from how far, how it is stored, and how it is kept clean by covering, filtering or boiling.

Shelter and why houses differ: Houses differ with climate, the materials found nearby, the work people do, the dangers of a place and what families can afford. Chhotu's House and A House Like This (class III) introduce many kinds of homes. In class IV, Changing Times is told by Chetandas, whose family came from Dera Gazikhan (now in

Pakistan) at Partition and built a mud house in Haryana; over sixty years it changed to unbaked bricks and an iron-and-cement roof, then baked bricks, marble chips and tiles. Nandita in Mumbai compares a one-room home among huts, where water is filled at a public tap at 4 a.m., with flats in high-rise buildings. In class V, A Shelter so High! describes Tashi's stone house in Ladakh, with thick mud-and-lime walls and a flat roof, and the Changpa of Changthang, who move with their yaks and pashmina goats and live in rebo tents of yak hair, and When the Earth Shook! recalls the Gujarat earthquake of 26 January 2001 and what to do when one strikes.

Houses across regions: Common examples in EVS books and CTET questions are stilt houses of bamboo in Assam and other flood-prone areas, raised above water and away from animals; thick mud walls, small windows and flat roofs in Rajasthan to keep out the heat; sloping roofs of wood or slate in snowy hill areas such as Himachal Pradesh, so that snow and rain slide off; steep sloping roofs in rainy Kerala; houseboats on the Dal Lake in Srinagar; and igloos of snow blocks in the Arctic.

In the classroom: Food and homes touch a child's identity, so a teacher must never rank them: vegetarian and non-vegetarian food, eating with hands or spoons, and kutcha or pucca houses are different, not better or worse. Useful activities are a week's food diary, a survey of cooking fuels used at home, a chart of water sources in the neighbourhood, comparing water from a tap, a pond and a hand pump by look and smell (never taste), and making model houses from local materials while asking why houses in the children's own area are built as they are.

Examples

- Class III What is Cooking: foods eaten raw and cooked; boiling, frying, roasting and steaming; utensils of iron, brass, aluminium, steel and clay.
- Class V From Tasting to Digesting: tastes are sweet, salty, sour and bitter; digestion begins in the mouth with saliva; Dr William Beaumont studied digestion through the stomach wound of Alexis St. Martin (shot in 1822).
- Class V Mangoes Round the Year: food spoils through fungus and germs; it is kept by sun-drying (mamidi tandra or aam papad) and with salt, sugar or oil (pickles).
- Rain is the main source of fresh water; groundwater is drawn through wells, hand pumps and tube wells.
- Class V Every Drop Counts: traditional rainwater harvesting - stepwells (baolis), Ghadsisar lake in Jaisalmer (made by King Ghadsi about 650 years ago), kund or tanka in Rajasthan.
- Malaria: female Anopheles, stagnant water; Ronald Ross, Secunderabad 1897, Nobel Prize 1902. Dengue: Aedes mosquito, clean stored water in coolers and tyres.
- Class V Experiments with Water: floating, sinking and dissolving; the Dead Sea is so salty that people float in it.
- Class V A Shelter so High!: the Changpa of Changthang, Ladakh, herd yaks and pashmina goats and live in rebo tents of yak hair.
- Houses and climate: stilt houses in Assam (floods), thick mud walls and flat roofs in Rajasthan (heat), sloping roofs in Himachal (snow) and Kerala (heavy rain), houseboats in Srinagar, igloos in the Arctic.
- Classroom rule: food habits and houses are different, never better or worse; begin from where the children's own food and water come from.

> **Quick revision:** Food comes from plants and animals, habits differ by region, climate, age and custom; cooking: boiling, frying, roasting, steaming; tastes and saliva; Beaumont and Alexis St. Martin (1822); keeping food by drying, salt, sugar, oil; rain is the main source of fresh water; stepwells, Ghadsisar, kund or tanka; Anopheles malaria, Ross 1897 and 1902; Aedes dengue; Dead Sea; houses differ by climate and materials: stilt (Assam), mud walls (Rajasthan), sloping roofs (Himachal, Kerala), rebo (Changpa).

Travel, and Things We Make and Do: Transport, Communication, Maps, Crafts and Work

The two themes: Travel is about how people, goods and messages move from place to place, and it also carries maps, directions and the experience of new places. Things We Make and Do covers the crafts, buildings, tools and occupations through which people meet their needs. Both join science (fuels, materials) with social science (history, geography, livelihoods), as the integrated EVS syllabus intends.

Modes of transport: The class III chapter From Here to There looks at the vehicles children have travelled in, how their elders travelled earlier, and transport that needs fuel compared with transport moved by animals or people,

such as the bullock cart, rickshaw, boat and bicycle. The class IV chapter Going to School shows how children in different parts of India reach school: across a bamboo bridge in Assam, on a trolley pulled over a river along a rope in Ladakh, in a vallam (a small wooden boat) in Kerala, by camel cart in Rajasthan or by bullock cart, on foot through forests, over snow and along rocky mountain paths, and on bicycles. Omana's Journey and From the Window follow a girl's train journey from Ahmedabad to Kerala, with the stations, tunnels, bridges and changing landscape on the way. In class V, What if it Finishes...? explains that petrol, diesel and kerosene come from deep under the ground and will one day run out, so they must be used with care, and Sunita in Space is about the astronaut Sunita Williams and how the Earth looks from space.

Communication: Messages also travel. The class III chapter Here comes a Letter follows the journey of a letter through the post and shows the postcard and the envelope; the 6-digit PIN code (Postal Index Number), introduced in 1972, helps in sorting mail. The class III chapter Saying without Speaking is about communicating without words, through gestures, facial expressions, the mudras of dance and sign language. Over time news has travelled through messengers, drum beats, pigeons, letters, the telegram, the telephone, mobile phones and the internet.

Maps and directions: Mapping skills grow step by step. The syllabus begins mapping in class III with a simple two-dimensional drawing of the classroom and the neighbourhood (Mapping my neighbourhood, under Shelter), and the class III chapter Left-Right practises left and right, traces Ruchira's route from home to school and introduces a map in which symbols stand for places. In class IV the syllabus adds directions with respect to a landmark, more symbols and a first idea of scale. By class V children read and draw simple top (bird's-eye or aerial) views; Walls Tell Stories gives a map of Golconda fort with the four directions and a scale of 1 cm to 110 metres. The teaching order is from the child's own space to the distant one: first the classroom, then the school and the route home, and only later the state and the country. Since a map is a drawing seen from above, children can begin by drawing the top view of a glass, a book or their desk.

Things We Make and Do: This theme looks at what people make with their hands and the knowledge behind it. The class III chapter Making Pots shows how pots are shaped from clay and baked in a kiln to make them strong; a clay pot (matka) keeps water cool because water seeping through its tiny pores evaporates. A Beautiful Cloth (class III) looks at the saree and the dupatta, the many ways they are worn, and how cloth is woven and decorated. The class IV chapter Pochampalli is about Vani and Prasad of Mukhtapur village in the Pochampalli mandal of Telangana, whose weaver family dyes the thread before weaving but is paid too little for its sarees; Pochampalli is famous for ikat, in which the threads are tied and dyed in a pattern before they are woven. The class V chapter Walls Tell Stories uses the Golconda fort in Hyderabad, a mud fort around 1200 that the Qutb Shahi Sultans ruled from 1518 to 1687, to show how buildings tell us about the past: thick walls, bastions and huge gates for defence, clay pipes that carried water, and a design in which words spoken at the Fateh Darwaza (the main gate) can be heard at the king's palace.

Work and workers: Work is part of the theme too. The class IV chapter Defence Officer: Wahida presents Lieutenant Commander Wahida Prism, a doctor in the Indian Navy from Rajouri district, Jammu and Kashmir. The stories of farmers, beekeepers, snake charmers, weavers, potters and migrant workers show that every occupation has its own skills and knowledge. Class V chapters such as No Place for Us? and On the Move Again show Jatrya's family, whose village Khedi is drowned by a dam, and Dhanu's family, who leave their village every year to cut sugarcane, and how this affects children's schooling, which links Travel with justice and equality.

In the classroom: Bring the work into the classroom and take the class to the work: invite a potter, weaver, postman or bus conductor, visit a post office or railway station, let children try a simple craft, survey how classmates come to school and map the route. CTET options that suggest reading out the chapter, copying a list of vehicles or memorising the parts of a post office are wrong. Stereotypes about work (only men drive, only women cook, cleaning is a lowly job) should be questioned through discussion.

Examples

- Class IV Going to School: bamboo bridge (Assam), trolley over a river (Ladakh), vallam (small boat) in Kerala, camel cart (Rajasthan) and bullock cart, walking through forests and snow, bicycles.

- Class IV Omana's Journey and From the Window: a girl's train journey from Ahmedabad to Kerala, with tunnels, bridges and changing landscape.
- Class V What if it Finishes...?: petrol, diesel and kerosene come from under the ground, are limited and must be used with care.
- Class III Here comes a Letter: the journey of a letter through the post, postcard and envelope; the PIN code has 6 digits and was introduced in 1972.
- Class III Saying without Speaking: gestures, facial expressions, dance mudras and sign language.
- Mapping order: own classroom, school and route home first, then district, state and country; a map is a top (aerial) view drawn with symbols and a key.
- Class IV Pochampalli (Telangana): Vani and Prasad's weaver family dyes thread before weaving; Pochampalli ikat - threads are tied and dyed in a pattern before weaving.
- Class V Walls Tell Stories: Golconda fort, Hyderabad, Qutb Shahi Sultans (1518-1687); words spoken at the Fateh Darwaza are heard at the king's palace; a map with directions and scale.
- Class III Making Pots and A Beautiful Cloth: clay pots baked in a kiln; the saree and dupatta and the ways they are worn; a matka cools water by evaporation.
- Class IV Defence Officer: Wahida - Lieutenant Commander Wahida Prism, a doctor in the Indian Navy, breaking the stereotype that defence jobs are for men.

> **Quick revision:** Travel: land, water, air; fuel vs animal or human power; Going to School (bamboo bridge, trolley, vallam in Kerala); Omana's train journey Ahmedabad to Kerala; petrol and diesel are limited; communication: letter, postcard, 6-digit PIN (1972), gestures and sign language; maps: own space first, top view, symbols, key; Things We Make and Do: pottery, weaving, ikat of Pochampalli, Golconda fort; Wahida; migration and displacement; dignity of every occupation.

Concept and Scope of EVS: Integrated EVS, NCF 2005 and the Six Themes

What EVS is: Environmental Studies is the curricular area through which a child of the primary classes studies her surroundings: the natural environment (plants, animals, water, air, soil, weather), the social environment (family, neighbours, community, work, institutions such as the post office and the market) and the cultural environment (food, clothes, festivals, crafts, languages). Environment here means everything around the child, not only nature and pollution. EVS is not a simplified mix of science and social studies; it helps young children make sense of the world as they experience it, by observing, asking, doing and talking.

Why it is integrated: A child of 6 to 10 years does not see the world in separate subjects. Looking at a pond, she sees water, fish, buffaloes, people washing clothes, a festival on its bank and the smell of waste all together. NCF 2005 therefore treats EVS at the primary stage as one integrated area drawing on science, social science and environmental education; this is the integrated (also called thematic or interdisciplinary) approach. In classes I and II there is no separate EVS textbook: EVS concerns are woven into the language and mathematics books, which use the child's home, school and surroundings as their context. From class III to V, EVS is a separate subject; NCERT's textbooks for it written after NCF 2005 are Looking Around (Aas-Paas). From class VI it divides into science and social science. NEP 2020 places classes III to V in the preparatory stage of its 5+3+3+4 design, and NCF-SE 2023 names this curricular area The World Around Us.

Environmental education within EVS: Environmental education aims at awareness, knowledge, attitudes, skills and participation for protecting the environment, the five objectives set out in the Tbilisi Declaration of 1977. NCF 2005, drawing on its focus group on Habitat and Learning, recommends that environmental education be infused into all subjects through projects and activities rather than taught as one more subject; at the primary stage it is infused into EVS. EVS is therefore the larger curricular area and environmental education one of its strands, a distinction CTET questions draw on.

Objectives of EVS teaching: The NCERT syllabus for the elementary stage lists the objectives of EVS: to help children relate the natural, social and cultural environment to one another; to build understanding from observation and lived experience rather than abstractions; to make children curious about social phenomena, starting with the

family and moving to wider spaces; to nurture curiosity and creativity, especially about the natural environment; to develop awareness of environmental issues; to engage children in exploratory, hands-on activities that build skills such as observation, classification and inference; to emphasise design and fabrication, estimation and measurement as a prelude to technological and quantitative skills; and to help children address gender concerns and issues of marginalisation and oppression with values of equality, justice and respect for human dignity and rights.

The six themes and the spiral: The syllabus is organised around six themes: Family and Friends (with the sub-themes Relationships, Work and Play, Animals and Plants), Food, Shelter, Water, Travel, and Things We Make and Do. Themes were chosen instead of separate topics because a theme lets the child see connections: water links rain, rivers, drinking, health, festivals and who fetches it at home. The same themes recur in classes III, IV and V with more depth and a widening circle, from the self and family to the neighbourhood, the country and the world, in line with Jerome Bruner's idea of a spiral curriculum. The syllabus is laid out in four columns, Questions, Key Concepts/Issues, Suggested Resources and Suggested Activities, and it deliberately begins with key questions rather than key concepts, signalling that EVS learning begins from children's curiosity, not from definitions.

Scope beyond facts: EVS also develops process skills (observing, recording, classifying, comparing, predicting, measuring, estimating, mapping, drawing and communicating), concern for health, hygiene and safety (including what to do in a disaster), and values: sensitivity to gender, caste, disability and poverty, respect for every kind of work, and care for living things. Equity is built into the content itself, through stories of girls who play kabaddi, a girl who uses a wheelchair, families displaced by a dam and children who migrate with their parents for work.

Policy anchors: NCF 2005's guiding principles fit EVS closely: connecting knowledge to life outside the school, moving away from rote learning, enriching the curriculum so that it goes beyond textbooks, making examinations more flexible and part of classroom life, and nurturing a caring identity within a democratic polity. The RTE Act 2009 (Section 29) asks for learning through activities, discovery and exploration in a child-friendly and child-centred manner, freedom from fear, trauma and anxiety, and continuous and comprehensive evaluation. NEP 2020 makes experiential learning, including hands-on, arts-integrated and sports-integrated learning and storytelling-based pedagogy, the standard approach in every subject.

Examples

- EVS studies the child's natural, social and cultural environment as one whole; it is not a diluted mix of science and social studies.
- Classes I-II: EVS woven into language and maths books; classes III-V: separate subject (Looking Around / Aas-Paas); class VI onwards: science and social science.
- Integrated EVS = science + social science + environmental education, presented through themes (thematic or interdisciplinary approach).
- Environmental education is a strand within EVS; NCF 2005 recommends infusing it across subjects through projects (focus group on Habitat and Learning).
- Tbilisi Declaration 1977: five objectives of environmental education - awareness, knowledge, attitudes, skills, participation.
- Six themes: Family and Friends, Food, Shelter, Water, Travel, Things We Make and Do; they recur in a spiral (Bruner) from class III to V.
- The NCERT EVS syllabus has four columns - Questions, Key Concepts/Issues, Suggested Resources, Suggested Activities - and begins with key questions rather than key concepts.
- RTE Act 2009, Section 29: learning through activities, discovery and exploration in a child-centred manner; freedom from fear, trauma and anxiety; continuous and comprehensive evaluation.
- NEP 2020: 5+3+3+4 design, classes III-V form the preparatory stage; NCF-SE 2023 names the area The World Around Us.

> **Quick revision:** EVS = natural, social and cultural environment as one whole; integrated (science + social science + environmental education); classes I-II through language and maths, III-V separate (Looking Around), VI onwards split; EE infused (NCF 2005, Habitat and Learning); Tbilisi 1977 five objectives; six themes in a spiral; syllabus columns: Questions, Key Concepts, Resources, Activities; RTE Section 29; NEP 2020 preparatory stage; NCF-SE 2023 The World Around Us.

Learning Principles in EVS: Prior Knowledge, Learning from Surroundings, Questioning and Children's Ideas

Children come with ideas: No child enters an EVS class empty. A child from a farming family knows when wheat is sown, a fisher's child knows which fish come in which season, and a child who fetches water knows how far the hand pump is. NCF 2005 asks teachers to treat this experience as the starting point of learning. This is the constructivist view: the learner builds knowledge by connecting new experience with what she already knows. In Piaget's terms, a new experience is either fitted into an existing schema (assimilation) or the schema itself is changed (accommodation) to restore balance (equilibration). For Vygotsky, this building happens through talk and interaction with peers, parents and teachers, and the support given within the zone of proximal development (scaffolding) is withdrawn as the child becomes able. David Ausubel held that what the learner already knows is the most important single factor in learning.

Maxims of teaching that follow: EVS teaching moves from known to unknown, from concrete to abstract, from simple to complex, from near to far (local to global) and from particular to general. A lesson on water begins with the water at the child's home, not with the water cycle; a lesson on maps begins with the classroom, not with the map of India. Learning by doing (John Dewey) and learning through play are central, because most children of classes III to V are in Piaget's concrete operational stage (about 7 to 11 years): they reason well about real objects and events, but not yet about abstract ideas.

Learning from the surroundings: The school campus, a tree, a pond, the market, the post office, the bus stand, a farm and a potter's workshop are all EVS classrooms. Family members, the shopkeeper, the health worker, the postman and the farmer hold knowledge that no textbook carries. Learning from the surroundings makes ideas real, lets every child contribute from her own life, and puts into practice NCF 2005's first guiding principle, connecting knowledge to life outside the school. It also respects local knowledge: the names of plants in the child's language, local ways of storing grain and water, and traditional crafts.

Questioning: In EVS a child's question is valued as much as an answer. Children's 'why' and 'how' questions show what they are thinking and are the best entry points for inquiry; when a teacher does not know an answer, 'let us find out together' is better than silencing the child. The teacher's own questions should be mostly open-ended (What would happen if the pond dried up?), divergent (In how many ways do we use water at home?) and probing (Why do you think so?), rather than closed questions with one-word recall answers. A few seconds of wait time after a question lets more children think and respond. The questions in Looking Around, with prompts such as Tell, Discuss, Find out, Write and Draw, often have no single right answer: the textbook expects children's own observations and opinions.

Children's ideas and misconceptions: Children build their own explanations from everyday experience, and many differ from scientific ideas; these are called misconceptions, alternative conceptions or children's ideas. Common ones at the primary stage are: heavy things sink and light things float; plants take their food from the soil; plants are not living because they do not move about; a bat is a bird, a whale is a fish and a spider is an insect; the moon makes its own light; seeds need sunlight to germinate. Such ideas are logical from the child's point of view and do not disappear when the right answer is announced. The teacher first draws them out through questions, drawings or predictions, then gives an experience that conflicts with them, such as a big wooden log that floats and a small iron nail that sinks, and lets children discuss and revise their ideas. This is cognitive conflict leading to accommodation. Ridiculing a wrong idea only teaches children to stop sharing their thinking.

Every child is different: Children learn at different paces and in different ways; Howard Gardner's idea of multiple intelligences reminds teachers that some children show understanding better through drawing, movement, music or

talk than through writing. Many children speak a home language different from the school language; NCF 2005 and the RTE Act 2009 favour the mother tongue as far as practicable, so children should be allowed to explain in their own words and language. Children with disabilities, first-generation learners and children from marginalised groups should find their own lives represented in the class.

A CTET situation: During a lesson on birds, a child says a hen is not a bird because it hardly flies. The teacher should not simply say 'wrong'. She can ask the class what all birds have in common, let them look at feathers, beaks and eggs, and help them see that animals are grouped by shared features, not by a single ability such as flying.

Examples

- Constructivism: the learner builds knowledge by linking new experience with prior knowledge; Piaget - assimilation, accommodation, equilibration; Vygotsky - social interaction, ZPD, scaffolding.
- Ausubel: what the learner already knows is the most important single factor in learning.
- Maxims: known to unknown, concrete to abstract, simple to complex, near to far (local to global), particular to general.
- Most children of classes III-V are in Piaget's concrete operational stage (about 7-11 years) and learn best from real objects and events.
- NCF 2005's first guiding principle - connect knowledge to life outside the school - is the basis of learning from the surroundings.
- Good questions: open-ended (what would happen if...), divergent (in how many ways...), probing (why do you think so?); allow wait time.
- Common misconceptions: heavy things sink; plants get their food from the soil; plants are not living; a bat is a bird; a whale is a fish; a spider is an insect; the moon makes its own light.
- Handling misconceptions: draw out the idea, give a conflicting experience (a log floats, a nail sinks), discuss, let children revise - never ridicule.
- Home language and local plant names are resources: let children explain in their own words; local knowledge counts as knowledge.

> **Quick revision:** Children bring prior knowledge; constructivism (Piaget: assimilation, accommodation, equilibration; Vygotsky: ZPD, scaffolding; Ausubel: prior knowledge matters most); maxims known to unknown, concrete to abstract, local to global; concrete operational stage 7-11; learning from surroundings and community; value children's questions; open, divergent and probing questions with wait time; misconceptions: elicit, create cognitive conflict, test, discuss; respect home language and diversity.

Approaches and Activities in EVS: Activity, Inquiry, Field Trips, Surveys, Experiments, Stories and Drama

Activity-based and experiential learning: In activity-based learning children learn by doing things themselves (observing, collecting, sorting, measuring, making, drawing) rather than by listening. An activity helps only when it has a learning purpose and is followed by discussion; a craft done to fill time is not activity-based learning. Experiential learning adds reflection on the experience. David Kolb described it as a cycle of concrete experience, reflective observation, abstract conceptualisation and active experimentation. For example, children sow moong seeds on wet and dry cotton (experience), note which ones sprout (observation), conclude that seeds need water to germinate (concept), and then test whether they also need light by keeping one wet set in a dark box (experimentation).

Inquiry and discovery: In inquiry-based learning children start from a question, plan how to find the answer, collect evidence, draw conclusions and share them; the teacher guides but does not give the answer first. Inquiry can be guided (the teacher gives the question and materials) or open (children choose the question). Jerome Bruner's discovery learning is close to this: children find relationships for themselves and remember them better. The 5E model (Engage, Explore, Explain, Elaborate, Evaluate) is one way to plan an inquiry lesson, and predict-observe-explain is a short routine: children predict (Will this float?), observe, and then explain any gap between what they expected and what happened.

Field trips, surveys and projects: A field trip takes the class to where learning lives: a pond, a farm, a post office, a bank, a railway station, a potter's workshop or a historical building. It works only when planned in three stages: before the trip (purpose, questions to ask, permission, safety, worksheets), during it (observing, interviewing, noting and sketching, collecting fallen leaves rather than plucking them) and after it (discussion, a report, a chart or a display). A survey collects the same information from many people or places, for example the sources of drinking water in children's homes, the fuels used for cooking or how classmates come to school; children record it with tally marks and show it in tables, pictographs or bar graphs, which links EVS with mathematics. A project is longer: a group investigates one question over days or weeks, such as where the school's waste goes. W.H. Kilpatrick, who developed the project method from Dewey's ideas, described its steps as purposing, planning, executing and judging.

Experiments and practical work: Simple experiments let children test ideas instead of accepting them: which things float or sink, which dissolve in water, what happens to a plant kept in the dark, whether a wet cloth dries faster in the sun or the shade. Children should handle the materials themselves in small groups, predict before doing, record honestly what they see, and repeat when results differ. A teacher demonstration is the right choice only when an activity is unsafe (fire, sharp tools) or the material is scarce. An unexpected result is a chance to discuss what went differently, not a failure.

Discussion: Talk in pairs, small groups and the whole class lets children put their ideas into words, hear other views and revise their own. Looking Around asks children to discuss again and again, often on questions with more than one answer, such as who should do the housework or why some people are forced to leave their homes. The teacher keeps the talk respectful, draws in quiet children and accepts every reasoned view; think-pair-share is one simple structure for it.

Stories, drama and the arts: The NCERT EVS books teach through stories, poems, letters, diary entries, interviews, comic strips and pictures because a narrative carries facts and feelings together: Amrita Devi's sacrifice, Anita's honeybees and Chuskit's journey to school stay in memory far longer than a list of facts. Role play and drama help children stand in another person's place, for example a family whose village is drowned by a dam, a snake charmer who has lost his work or a migrant child who misses school, which builds empathy and concern for justice. Puppets, songs, art, model-making and games suit young learners as well, and NEP 2020 names arts-integrated, sports-integrated and storytelling-based pedagogy.

Choosing the approach: Match the method to the goal. To gather information from many homes, use a survey; for an investigation lasting days, a project; for empathy, role play; for testing an idea, an experiment done by the children; for an unsafe process, a demonstration; for first-hand experience of a place, a field trip. For example, if a teacher wants children to understand the water problems of their locality, a survey of water sources and the time spent fetching water, followed by discussion, is better than a lecture on water scarcity. The option in which children observe, do, ask, discuss or find out is almost always better than one in which the teacher lectures, dictates notes or reads out the chapter.

Examples

- Kolb's experiential learning cycle: concrete experience, reflective observation, abstract conceptualisation, active experimentation.
- Inquiry: question, plan, collect evidence, conclude, communicate; guided inquiry gives the question, open inquiry lets children choose it.
- 5E model: Engage, Explore, Explain, Elaborate, Evaluate; POE routine: predict, observe, explain.
- Field trip in three stages: before (purpose, questions, permission, safety), during (observe, interview, record), after (discuss, report, display).
- Survey: the same information from many sources (water sources at home, cooking fuels); record with tally marks, show as a pictograph or bar graph.
- Project method: W.H. Kilpatrick, from Dewey's ideas; steps are purposing, planning, executing and judging.
- Demonstration only when an activity is unsafe or material is scarce; otherwise children do the experiment in groups.
- Role play builds empathy: a family displaced by a dam, a snake charmer who has lost his work, a migrant child.

- Stories in Looking Around (Amrita Devi, Anita, Chuskit) carry facts together with feelings and values.
- NEP 2020: experiential learning through hands-on, arts-integrated, sports-integrated and storytelling-based pedagogy.

> **Quick revision:** Activity-based (learning by doing with a purpose); experiential (Kolb cycle); inquiry and Bruner's discovery; 5E and POE; field trip before, during, after; survey from many sources with tally and graphs; project (Kilpatrick: purposing, planning, executing, judging); experiments by children, demonstration only if unsafe; discussion, think-pair-share; stories, role play and drama for empathy; NEP 2020 experiential, arts- and sports-integrated, storytelling.

EVS Teaching Material and Aids: Local Environment, Textbooks, Worksheets and the Teacher as Facilitator

The local environment as the first resource: For EVS the best teaching aid is often outside the classroom: the trees and plants of the school campus, birds and insects, the sky and the weather, soil, a pond or tank, and the people and places of the neighbourhood. Real objects (realia) such as seeds, leaves, feathers, grains, clay, utensils and tools let children touch, smell, compare and sort. A nature corner or EVS corner where children bring and label what they find, a school garden, and a weather chart kept by the children through the year turn the surroundings into a continuing resource. Collecting must be responsible: fallen leaves and seeds, not plucked flowers or caught animals.

Other aids: Pictures, charts, photographs, models, maps and a globe, flash cards, puppets, audio and video recordings and ICT resources bring in what children cannot see directly, such as a desert, a snow-covered village or a houseboat. Low-cost and no-cost material made by the teacher and children from waste such as bottles, cartons, newspaper and bottle caps is encouraged: it is cheap and local, and it shows children that they too can make things. An aid must serve the learning goal and be handled by children, not just shown; a chart of the water cycle hung on the wall teaches far less than children making their own model of how rainwater collects.

Community resources: Parents and grandparents (on old games, food and ways of storing water), farmers, potters, weavers, carpenters, the postman, the health worker, the forest guard and the panchayat member can be invited to class or interviewed by children. Places such as the post office, bank, railway station, primary health centre, museum and a local monument make ideas concrete. Using these resources also tells children that knowledge lives in their community and that their families' work has value.

The textbook and its features: Looking Around has 24 chapters in class III, 27 in class IV and 22 in class V. It speaks directly to the child in a conversational style, uses true stories of people and places across India, poems, letters, diaries, interviews, cartoons and many pictures, and asks children to Tell, Discuss, Find out, Write, Draw and Do. Its questions are often open-ended and tied to the child's own life (What do you do at home to save water?), and each class V chapter ends with What we have learnt, questions that show how learning can be assessed and ask children to explain ideas in their own words. The books avoid definitions to be memorised and deliberately show diversity: girls playing kabaddi, a woman doctor in the Navy, children with disabilities, tribal, rural and urban lives, and families of many kinds. The textbook is a guide and one resource among many; the teacher may change examples to suit the local context, and it is not meant to be read aloud line by line or learnt by heart.

Worksheets: A worksheet is a structured sheet that guides a child's activity, observation or thinking: a table to record a survey, a picture to label, a grid for grouping animals, a space to draw what was seen on a field trip, or open questions after an experiment. Good EVS worksheets use pictures and simple language, ask children to observe, record, compare and explain rather than only fill blanks, leave room for different answers, and can be graded for children at different levels. They can be used before a lesson (to draw out prior ideas), during an activity, or after it for practice and assessment, and finished worksheets can go into the child's portfolio.

The teacher as facilitator: NCF 2005 sees the teacher not as the only source of knowledge but as a facilitator who creates situations in which children learn. In EVS this means planning activities around children's lives, asking good questions and listening to the answers, encouraging children to explore, discuss and work in groups, accepting more than one answer where the question allows, linking the classroom with the community, observing and recording each

child's progress, and being a co-learner who is willing to find out alongside the children. The teacher must also be sensitive: never shaming a child's home, food or language, and questioning stereotypes when they come up.

A CTET situation: A school has no laboratory and little money for teaching aids. The right response is not to skip activities or wait for a kit, but to use the school campus, local and waste material, and members of the community. Likewise, when the textbook shows a crop or a house that children have never seen, the teacher should begin from the crops and houses of their own area and then compare.

Examples

- The first resource for EVS is the local environment: the school campus, trees, a pond, the market and the people of the neighbourhood.
- Realia (real objects) such as seeds, leaves, feathers and tools let children touch, compare and sort; collect fallen leaves, not plucked flowers.
- Low-cost and no-cost aids are made from waste such as bottles, cartons and newspaper by teachers and children together.
- Community resources: parents, grandparents, farmers, artisans, the postman, the health worker; places such as the post office, bank, railway station and health centre.
- Looking Around: 24 chapters in class III, 27 in class IV, 22 in class V; prompts Tell, Discuss, Find out, Write, Draw; class V chapters end with What we have learnt.
- The EVS textbook shows diversity (girls playing kabaddi, a woman naval doctor, a girl in a wheelchair) and avoids definitions to be memorised.
- The textbook is one resource among many; the teacher may adapt its examples to the local context.
- A good worksheet: pictures, simple language, observe-record-compare-explain tasks, room for different answers, graded levels.
- Teacher as facilitator: plans experiences, asks and listens, encourages group work, accepts more than one answer, learns alongside children, records progress.

> **Quick revision:** Local environment is EVS's first resource; realia, nature corner, school garden, weather chart; charts, models, maps, globe, ICT; low-cost and no-cost aids from waste; community people and places; Looking Around has 24, 27 and 22 chapters, conversational, true stories, open questions, What we have learnt (class V), diversity, no rote definitions; worksheets for observing and recording, graded; teacher as facilitator and co-learner.

Assessment in EVS (CCE, Indicators, Portfolios) and Common Problems in Teaching EVS

CCE in EVS: The RTE Act 2009, Section 29(2)(h), requires comprehensive and continuous evaluation of the child's understanding of knowledge and her ability to apply it. Continuous means assessment is part of everyday teaching, not only at the end of a term; comprehensive means it covers all aspects of learning, including skills, attitudes and values, not only the recall of facts. Formative assessment (assessment for learning) takes place during teaching to find out how children are learning and to adjust the teaching; summative assessment (assessment of learning) sums up what has been learnt at the end of a unit or term; assessment as learning means children reflect on their own learning through self and peer assessment. In EVS the purpose of assessment is to improve learning, not to label, rank or fail children.

Indicators of learning in EVS: NCERT's Source Book on Assessment for Classes I-V in Environmental Studies (2008) lists indicators that teachers can watch for. Observation and reporting: noticing details, reading pictures, narrating and recording what was seen. Discussion: listening, talking, giving opinions and finding out from others. Expression: drawing, body movement, creative writing, modelling and other forms. Explanation: giving reasons and making logical connections. Classification: grouping, comparing and contrasting by features. Questioning: showing curiosity and framing questions. Analysis: predicting, guessing and inferring from evidence. Experimentation: trying things out, improvising and making things. Concern for justice and equality: sensitivity towards the disadvantaged and people with disabilities. Cooperation: sharing, taking responsibility and initiative, and working together. The note for teachers in the class V Looking Around lists the same ten indicators (its English edition calls the first Observation and Recording) and suggests observing 3 to 5 children every day and noting comments.

Reading an indicator question: A child who sorts leaves into smooth-edged and toothed ones is showing classification; one who asks why the pond dries up in summer, questioning; one who guesses that a seed kept without water will not sprout, analysis (prediction); one who draws and describes what she saw at the post office, observation and reporting or expression; one who builds a model of a stilt house from sticks, experimentation; one who says a classmate in a wheelchair should also be able to reach the playground, concern for justice and equality; and one who shares materials and divides work in a group, cooperation.

Tools of assessment: EVS uses observation of children at work, oral questions and conversation, drawings, worksheets, projects, survey and field-trip reports, models, role plays, checklists (yes or no for listed behaviours), rating scales (degrees such as always, sometimes, rarely), rubrics (criteria with a description of each level), anecdotal records (short dated notes on one significant incident) and portfolios. A written test is only one tool and, for young children, often the least informative. Questions should be open-ended and built on a situation or picture (Why are houses in Assam built on stilts?), not 'define' or 'name' questions. Progress is recorded as descriptive remarks that tell the child and the parents what she can do and what to work on next, with specific and encouraging feedback, and children are not compared with one another.

Portfolios: A portfolio is a purposeful collection of a child's work over time, such as drawings, worksheets, survey sheets, pressed leaves, field-trip notes and self-assessment sheets, chosen by the child with the teacher. Because each piece is dated, it shows growth rather than a single performance; it supports parent-teacher meetings and helps the child reflect on her own progress. It is a tool of continuous and formative assessment, not a file of only the neatest finished work.

Common problems in EVS teaching: Several problems recur, each with a remedy. EVS is often taught as facts to be memorised and tested; the remedy is activity, discussion and the assessment of skills. It is often split into separate science and social studies periods, which breaks the integrated approach; teaching through themes restores it. Teachers rely only on the textbook and read it aloud instead of using the surroundings. Large classes and a lack of material make activities seem impossible, but group work, peer learning and low-cost local material solve much of this. Pressure to finish the syllabus leaves no time for field trips, yet a short walk around the school or one theme-based project can replace many lectures. Children's home language may differ from the school language, so they should be allowed to speak in it and local names should be used. Some teachers avoid sensitive topics such as caste, gender, disability or poverty, or unknowingly reinforce stereotypes; EVS requires these to be discussed with care. Lack of training in the integrated approach is addressed through in-service training and teacher handbooks.

What the right option looks like: When a CTET option says the teacher should give a written test, award marks for neat copying, compare children or punish a wrong answer, it goes against CCE and against the RTE Act 2009, whose Section 17 forbids physical punishment and mental harassment. The better option assesses through observation during activities, accepts children's own words, records progress over time and uses the findings to change the teaching.

Examples

- RTE Act 2009, Section 29(2)(h): comprehensive and continuous evaluation of the child's understanding of knowledge and ability to apply it.
- Assessment for learning = formative; assessment of learning = summative; assessment as learning = self and peer reflection.
- NCERT Source Book on Assessment (Classes I-V, EVS, 2008) indicators: observation and reporting, discussion, expression, explanation, classification, questioning, analysis, experimentation, concern for justice and equality, cooperation.
- Sorting leaves by their edges = classification; guessing what will happen to a seed without water = analysis (prediction); asking why a pond dries up = questioning.
- Helping a classmate in a wheelchair reach the playground = concern for justice and equality; sharing work in a group = cooperation.
- Checklist = yes or no for listed behaviours; rating scale = degree; rubric = criteria with level descriptions; anecdotal record = dated note on one significant incident.

- Portfolio = dated collection of a child's work over time that shows progress, chosen with the child; used in parent-teacher meetings.
- Good EVS assessment items are open-ended and picture- or situation-based; progress is recorded as descriptive remarks, not only marks.
- Problems and remedies: rote facts - activities; split into science and social studies - themes; textbook only - surroundings; large classes - group work; no material - low-cost local aids; language gap - home language.
- RTE Act 2009, Section 17: no physical punishment or mental harassment of children.

> **Quick revision:** CCE (RTE Section 29(2)(h)): continuous during teaching, comprehensive across skills and values; formative = for learning, summative = of learning, self and peer = as learning; NCERT 2008 indicators: observation and reporting, discussion, expression, explanation, classification, questioning, analysis, experimentation, concern for justice and equality, cooperation; tools: observation, checklist, rating scale, rubric, anecdotal record, portfolio; descriptive feedback, no labelling; problems: rote, splitting, textbook only, large classes, language.

Free practice questions: parikshasaathi.com/q/evs-pedagogy/

Inclusive Education and Children with Special Needs

Inclusive Education and Children with Special Needs

What the exam asks: In CTET Paper I and Paper II (Child Development and Pedagogy, Part B: Concept of Inclusive Education and Understanding Children with Special Needs) about 5 to 6 questions come from this unit, and state TETs follow the same pattern. Questions are of two kinds: theory recall (definitions, Acts, years, names of aids) and classroom scenarios that begin with 'A child in your class...'. In the scenario type the correct answer is always the inclusive, child-centred, strengths-based option; any option that segregates, labels, punishes, lowers expectations or shifts the child out of the regular class is a distractor.

Segregation, integration, mainstreaming and inclusion: Segregation means educating children with disabilities separately in special schools. Integration (and the older American term mainstreaming) means placing the child in a regular school but expecting the child to adjust to an unchanged system; mainstreaming often meant part-time placement in the regular class. Inclusion reverses the direction: the school changes its curriculum, teaching, assessment and environment so that every child learns together. Inclusion rests on the social model of disability (barriers lie in society and the school, not in the child), unlike the medical model (deficit in the individual) and the charity model (pity). The principle of least restrictive environment says the child should be educated with peers as far as possible.

Diversity beyond disability: Inclusion also covers children from disadvantaged groups: SC, ST, other backward classes, girls, first-generation learners (first in the family to attend school), migrant children and linguistic minorities. The RTE Act 2009 defines a 'child belonging to disadvantaged group' as one disadvantaged by social, cultural, economic, geographical, linguistic, gender or such other factor; a 2012 amendment added children with disabilities. Article 350A asks every State to provide instruction in the mother tongue at the primary stage for linguistic minorities. The teacher's role is to treat home language and culture as resources, hold high expectations, and avoid stereotyping. Labelling leads to the self-fulfilling prophecy (Pygmalion effect, Rosenthal and Jacobson, 1968). Use person-first language: 'a child with visual impairment', not 'the blind boy'.

Learning difficulties and disabilities: Specific learning disability (SLD) under the RPwD Act 2016 covers dyslexia (reading: letter reversals such as b/d, slow laboured reading, poor spelling), dysgraphia (writing: illegible handwriting, trouble putting thoughts on paper), dyscalculia (number sense, symbols, number facts), dyspraxia (motor planning and coordination) and developmental aphasia. SLD is not caused by low intelligence or laziness. ADHD shows inattention, hyperactivity and impulsivity; seat the child near the teacher, give short tasks and movement breaks. Autism spectrum disorder involves difficulty in social communication, restricted and repetitive behaviour, insistence on sameness and sometimes echolalia; use visual schedules, predictable routines and concrete instructions. Intellectual disability means significant limitations in intellectual functioning and adaptive behaviour with onset in the developmental period; Down syndrome (trisomy 21) is a common cause; teach concretely, in small steps, with

repetition and praise. Hearing impairment signs: asking for repetition, turning one ear, loud speech, not responding from behind; the teacher faces the child, seats him in front and uses visual cues. Visual impairment signs: holding the book close, squinting, rubbing eyes, headaches. Cerebral palsy is a non-progressive disorder of movement and posture from damage to the developing brain, not a disease of the muscles and not infectious. Speech and language impairments include stammering (fluency), articulation disorders and aphasia; give time and do not finish the child's sentences. Emotional and behavioural disorders show as persistent aggression, defiance, withdrawal or anxiety and call for positive behaviour support: find the function of the behaviour, teach alternative skills, reinforce the desired behaviour.

Gifted, talented and creative learners: Gifted children show rapid learning, advanced vocabulary, curiosity, and the ability to see relationships; they can also be bored, disruptive or underachieving if unchallenged. Renzulli's three-ring conception: above-average ability, task commitment and creativity. Acceleration means moving faster (grade skipping, early admission); enrichment means going broader and deeper at the same level. Creativity is divergent thinking (Guilford) with fluency, flexibility, originality and elaboration (Torrance). A gifted child with a disability is 'twice-exceptional'.

Key tools of inclusion: The WHO (ICIDH 1980) distinguishes impairment (loss of structure or function), disability (activity limitation) and handicap (social disadvantage). Universal Design for Learning (CAST) has three principles: multiple means of representation, of action and expression, and of engagement. An Individualised Education Programme is a written plan of goals, services and accommodations made by a team of class teacher, special educator, parents and the child. Teaching strategies: remedial teaching after diagnostic assessment, multi-sensory (VAKT) methods such as Fernald and Orton-Gillingham, peer tutoring, cooperative learning in heterogeneous groups, buddy system, differentiated instruction (Tomlinson: content, process, product, environment), and multiple intelligences (Gardner) and learning styles for varying presentation. Accommodations (extra time, scribe, Braille or large print, oral testing) change how a child shows learning; modifications change what is taught. Assistive aids: Braille (six-dot cell, Louis Braille of France, 1824), Taylor frame and abacus for arithmetic, audio books and screen readers (JAWS, NVDA) for visual impairment; hearing aids, cochlear implants, FM systems and Indian Sign Language for hearing impairment; ramps, handrails, accessible toilets and tactile paths for a barrier-free campus. The resource teacher or special educator (registered with the Rehabilitation Council of India) supports the child and the class teacher in and alongside the regular classroom. The class teacher screens and refers; diagnosis is done by specialists. Involve parents: they give information, continuity at home and support for the IEP.

Legal and policy framework: Kothari Commission (1964-66) recommended the common school system. IEDC scheme 1974 (integrated education). NPE 1986 said children with mild and motor handicaps should study in common schools. Rehabilitation Council of India Act 1992. Salamanca Statement 1994 (UNESCO) called on schools to accommodate all children. PWD Act 1995 recognised 7 disabilities. National Trust Act 1999. Sarva Shiksha Abhiyan (2001) adopted zero rejection: no child with special needs is denied admission. NCF 2005 said inclusion must be implemented in all schools. UNCRPD adopted 2006, ratified by India 2007. RTE Act 2009: 25 percent seats in private unaided schools (Section 12(1)(c)). RPwD Act 2016: 21 disabilities, benchmark disability at 40 percent, Section 17 on inclusive education, free education for children with benchmark disabilities between 6 and 18 years (Section 31).

Traps: Integration is not inclusion; mainstreaming is a form of integration. Dyslexia is reading, dysgraphia writing, dyscalculia maths, dyspraxia motor. The PWD Act is 1995, the RPwD Act 2016 (21 categories, not 7). UNCRPD was adopted 2006 and ratified by India 2007. Salamanca was UNESCO, not WHO. Remedial teaching is not punishment and never replaces diagnosis. Accommodation is not lowering of standards.

Examples

- Direction test: in integration the child adjusts to the school; in inclusion the school adjusts to the child.
- Four Ds of SLD: Dyslexia = reading, Dysgraphia = writing, Dyscalculia = maths, Dyspraxia = motor coordination.
- Three-ring giftedness (Renzulli): Above-average ability + Task commitment + Creativity.
- Impairment is at the body level (loss of a limb), disability at the activity level (cannot walk), handicap at the social level (cannot get a job).

- UDL triangle (CAST): multiple means of Representation, Action and Expression, Engagement.
- Years to remember: IEDC 1974, NPE 1986, RCI 1992, Salamanca 1994, PWD Act 1995, SSA 2001, NCF 2005, UNCRPD 2006, RTE 2009, RPwD 2016.
- PWD Act 1995 listed 7 disabilities; RPwD Act 2016 lists 21; benchmark disability means 40 percent or more.
- Braille cell has 6 raised dots; Louis Braille was French; Taylor frame and abacus are for arithmetic of visually impaired learners.
- Accommodation changes HOW the child shows learning (scribe, extra time, Braille); modification changes WHAT is taught.
- Acceleration = faster (grade skipping); enrichment = broader and deeper at the same grade.
- Teacher's role in identification: observe, screen, support and refer; diagnosis and labelling are for specialists, never the class teacher.
- Zero rejection (SSA): no child with special needs is denied admission whatever the kind or degree of disability.

> **Quick revision:** Inclusion: school adapts to child; integration: child adapts to school; segregation: special schools. SLD = dyslexia (reading), dysgraphia (writing), dyscalculia (maths), dyspraxia (motor). Renzulli: ability, task commitment, creativity. UDL (CAST): representation, action/expression, engagement. Braille 6 dots, Louis Braille (France); Taylor frame for maths. Kothari 1964-66 common school; IEDC 1974; NPE 1986; Salamanca 1994 (UNESCO); PWD Act 1995 (7); SSA zero rejection; NCF 2005; UNCRPD 2006, India 2007; RTE 2009 25%; RPwD 2016: 21 categories, 40% benchmark, Sec 17.

Segregation, Integration and Inclusion: Models of Disability and the Salamanca Statement

Four ways a school can respond: An education system can respond to a child with a disability or any other difference in four ways. Exclusion keeps the child out of school altogether. Segregation educates the child in a separate setting, such as a special school for blind or deaf children. Integration places the child in a regular school but expects the child to fit in: the curriculum, timetable, teaching and examinations stay as they are, and the child is helped to cope, perhaps through a resource room or a visiting special teacher. Inclusion changes the school instead: the teacher plans lessons, materials, seating, group work and assessment from the start so that every child, with or without a disability, learns in the same class. In integration the child is placed in the system; in inclusion the system is redesigned for the child. Inclusion is a continuing process of removing barriers to every child's presence, participation and achievement.

How integration led to inclusion: The move away from segregation drew on the normalisation principle, which Bengt Nirje of Sweden described in 1969: people with disabilities should live patterns of everyday life as close as possible to those of others. In India the Integrated Education for Disabled Children (IEDC) scheme of 1974 followed this idea. It was progress, but many children ended up 'in the class but not of the class': present, yet not taking part, because teaching had not changed. Inclusion grew from this experience, and Indian policy moved from IEDC to the zero-rejection approach of Sarva Shiksha Abhiyan and then to the inclusive education duties of the RPwD Act 2016.

Models of disability: How a teacher thinks about disability decides what she does. The medical model treats disability as a defect within the individual, to be diagnosed and treated by professionals; in class it leads to a focus on what the child cannot do. The charity model sees persons with disabilities as objects of pity who need kindness rather than rights. The social model, developed by disabled people's organisations in Britain in the 1970s and named by the scholar Michael Oliver, separates impairment (a loss of body function, such as low vision) from disability (the exclusion that results when society puts up barriers, such as print-only textbooks or a classroom reached only by stairs); removing these attitudinal, physical, communication and institutional barriers is society's duty. The rights-based model, reflected in the UN Convention on the Rights of Persons with Disabilities (UNCRPD, 2006), treats persons with disabilities as holders of rights; its Article 24 requires an inclusive education system at all levels. The WHO's International Classification of Functioning, Disability and Health (ICF, 2001) combines the medical and social views in a biopsychosocial model: disability arises from the interaction between a health condition and the environment.

The Salamanca Statement: The World Conference on Special Needs Education: Access and Quality was held at Salamanca, Spain, from 7 to 10 June 1994, organised by Spain with UNESCO. Representatives of 92 governments and 25 international organisations adopted the Salamanca Statement and Framework for Action on Special Needs Education. It affirmed that every child has a fundamental right to education and unique learning needs, and that children with special educational needs must have access to regular schools, which should accommodate them within a child-centred pedagogy. Its best-known conclusion is that regular schools with an inclusive orientation are the most effective means of combating discriminatory attitudes, building an inclusive society and achieving education for all. Salamanca built on the World Conference on Education for All at Jomtien, Thailand (1990) and the UN Standard Rules on the Equalization of Opportunities for Persons with Disabilities (1993), and is widely cited as the starting point of the inclusive education movement.

Why inclusion matters in a classroom: Inclusion improves learning for everyone. Children with disabilities gain peer models for language and social behaviour, higher expectations and preparation for life in their own community. Classmates learn empathy, cooperation and respect for difference, and strategies used for one child, such as visual aids, clear instructions and group work, help every learner. Inclusion also follows from the Constitution: equality before law (Article 14), no discrimination on grounds of religion, race, caste, sex or place of birth (Article 15), the right to education for children aged 6 to 14 (Article 21A) and the directive to provide public assistance in cases of disablement (Article 41). NCF 2005 asks schools to treat diversity as a resource rather than a problem, and Sustainable Development Goal 4 (2015) commits countries to inclusive and equitable quality education for all.

How CTET tests this: Questions describe a situation and ask for the teacher's best response. If a child with low vision joins your class, inclusion means changing the seating, the print size and your use of the blackboard, not asking the parents to move the child to a special school. Options saying that the child should be taught separately, must adjust to the class or deserves pity, or that the disability is the child's own problem, reflect segregation, integration, the charity model or the medical model. Choose the option that removes a barrier, involves the child fully and keeps expectations high.

Examples

- Exclusion = no school; segregation = separate special school; integration = regular school, child adjusts; inclusion = regular class, school adapts to every child.
- 'In the class but not of the class' describes integration without real participation - the gap that inclusion set out to close.
- Medical model: disability is a defect in the person to be treated or cured; social model: disability is created by barriers in society and school.
- Charity model treats persons with disabilities as objects of pity; the rights-based model (UNCRPD 2006) treats them as holders of rights.
- Social model: impairment is a loss of body function (low vision); disability is the exclusion caused by barriers (print-only books, stairs).
- Salamanca Statement: World Conference on Special Needs Education, Salamanca, Spain, 7-10 June 1994; Spain with UNESCO; 92 governments and 25 international organisations.
- Salamanca: regular schools with an inclusive orientation are the most effective means of combating discriminatory attitudes.
- UNCRPD Article 24 deals with inclusive education; the WHO's ICF (2001) is the biopsychosocial model of disability.
- Normalisation principle: Bengt Nirje, Sweden, 1969 - the root of integration; IEDC (1974) was India's integration scheme.
- In a CTET scenario the right option removes a barrier and keeps the child in the regular class with high expectations.

> **Quick revision:** Exclusion; segregation = special school; integration = child adjusts to school; inclusion = school adapts to child; medical model = deficit in person; charity model = pity; social model = barriers in society (Michael Oliver); rights model = UNCRPD 2006, Art 24; ICF 2001 biopsychosocial; normalisation, Nirje 1969; IEDC 1974; Salamanca 7-10 June 1994, Spain + UNESCO, 92 governments; Jomtien 1990; Articles 14, 15, 21A, 41; NCF 2005: diversity is a resource.

Law and Policy for Inclusion: RPwD Act 2016, RTE Act 2009, Samagra Shiksha and NEP 2020

From the 1995 Act to the 2016 Act: India's first comprehensive disability law, the Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act, 1995, recognised 7 conditions: blindness, low vision, leprosy-cured, hearing impairment, locomotor disability, mental retardation and mental illness. It reserved 3 per cent of government posts and 3 per cent of seats in government and government-aided educational institutions. After India ratified the UNCRPD in 2007, it was replaced by the Rights of Persons with Disabilities (RPwD) Act, 2016, in force from 19 April 2017, which moves from welfare to rights; its Hindi name is the Divyangjan Adhikar Adhiniyam.

The 21 disabilities: The Schedule of the 2016 Act lists 21 specified disabilities: blindness, low vision, leprosy-cured persons, hearing impairment (deaf and hard of hearing), locomotor disability, dwarfism, intellectual disability, mental illness, autism spectrum disorder, cerebral palsy, muscular dystrophy, chronic neurological conditions, specific learning disabilities, multiple sclerosis, speech and language disability, thalassemia, haemophilia, sickle cell disease, multiple disabilities including deaf-blindness, acid attack victims and Parkinson's disease. A person with benchmark disability is one with not less than 40 per cent of a specified disability, as certified by a certifying authority.

What the Act says about schools: The Act defines inclusive education as a system in which students with and without disability learn together and teaching and learning are suitably adapted to the needs of different types of students with disabilities. Section 16 asks every institution funded or recognised by the government to admit children with disabilities without discrimination, make buildings accessible, provide reasonable accommodation and individualised support, educate blind, deaf and deaf-blind children in the most appropriate languages and modes of communication, detect specific learning disabilities early, and monitor each child's participation and progress. Section 17 asks governments to survey school-going children every five years to identify children with disabilities, train teachers in sign language and Braille, set up resource centres, give books and assistive devices free up to the age of 18, and modify examinations by allowing extra time, a scribe and exemption from second and third language courses. Section 31 gives every child with benchmark disability aged 6 to 18 the right to free education in a neighbourhood school or a special school of his or her choice.

Reservation numbers to remember: Under Section 32, government and government-aided institutions of higher education must reserve not less than 5 per cent of seats for persons with benchmark disabilities and allow 5 years' relaxation in the upper age limit for admission. Under Section 34, not less than 4 per cent of the vacancies in each group of posts in government establishments are reserved: 1 per cent each for blindness and low vision, for deaf and hard of hearing, and for locomotor disability (including cerebral palsy, leprosy-cured, dwarfism, acid attack victims and muscular dystrophy), and 1 per cent for autism, intellectual disability, specific learning disability, mental illness and multiple disabilities.

RTE Act 2009 and children with disabilities: The Right of Children to Free and Compulsory Education Act, 2009, in force from 1 April 2010, gives every child aged 6 to 14 the right to elementary education in a neighbourhood school. Its 2012 amendment placed children with disabilities explicitly within the definition of a child belonging to a disadvantaged group and let a child with multiple or severe disability opt for home-based education. Other safeguards: no screening procedure or capitation fee at admission (Section 13); 25 per cent of entry-level seats in private unaided schools for weaker sections and disadvantaged groups (Section 12(1)(c)); no physical punishment or mental harassment (Section 17); age-appropriate admission with special training for out-of-school children (Section 4); and a child-centred, activity-based curriculum, free from fear, trauma and anxiety, in the mother tongue as far as practicable, with comprehensive and continuous evaluation (Section 29).

Samagra Shiksha: Launched in 2018-19, Samagra Shiksha is an integrated scheme for school education from pre-school to Class 12, merging Sarva Shiksha Abhiyan (2001), Rashtriya Madhyamik Shiksha Abhiyan (2009) and Teacher Education. Its inclusive education component for children with special needs (CWSN) supports identification and assessment, aids and appliances, Braille and large-print books, special educators, therapy, transport and escort support, stipends for girls with disabilities, and home-based education for children with severe disabilities. It carries forward the older IEDC (1974) and IEDSS (2009-10, Classes 9 to 12) schemes.

NEP 2020 on equity and inclusion: Chapter 6 of NEP 2020, Equitable and Inclusive Education: Learning for All, names Socio-Economically Disadvantaged Groups (SEDGs) by gender identity (female and transgender), socio-

cultural identity (SC, ST, OBC and minorities), geography (villages, small towns, aspirational districts), disability including learning disability, and socio-economic condition (migrant communities, low-income households, orphans, children in vulnerable situations, the urban poor). It proposes a Gender-Inclusion Fund to build the country's capacity to give all girls and transgender students quality education, and Special Education Zones for regions with large SEDG populations. For children with disabilities it promises barrier-free access under the RPwD Act, special educators with cross-disability training, resource centres, a choice of regular or special school for children with benchmark disabilities, home-based education for those unable to attend school, and standardisation of Indian Sign Language across the country.

Examples

- PWD Act 1995: 7 disabilities, 3 per cent of posts and 3 per cent of seats; RPwD Act 2016: 21 disabilities, in force from 19 April 2017.
- Benchmark disability: not less than 40 per cent of a specified disability, certified by a certifying authority.
- RPwD Act Section 32: at least 5 per cent of seats in government and government-aided higher education institutions, plus 5 years' relaxation in upper age limit.
- RPwD Act Section 34: at least 4 per cent of government vacancies - 1 per cent each for visual, hearing and locomotor disabilities; 1 per cent for autism, intellectual disability, SLD, mental illness and multiple disabilities.
- RPwD Act Section 31: free education for children with benchmark disabilities aged 6 to 18; the RTE Act covers all children aged 6 to 14.
- RPwD Act Section 16: admit without discrimination, accessible buildings, reasonable accommodation, individualised support, early detection of specific learning disabilities.
- RPwD Act Section 17: survey every five years, teachers trained in sign language and Braille, free books and assistive devices up to 18, extra time, scribe and language exemption in examinations.
- RTE (Amendment) Act 2012: children with disabilities included in 'disadvantaged group'; home-based education option for children with multiple or severe disabilities.
- Samagra Shiksha (2018-19) merged SSA, RMSA and Teacher Education; covers pre-school to Class 12; has a CWSN inclusive education component.
- NEP 2020 Chapter 6: SEDGs, Gender-Inclusion Fund, Special Education Zones, choice of regular or special school, standardised Indian Sign Language.

> **Quick revision:** PWD Act 1995: 7 disabilities, 3% posts and seats; RPwD Act 2016 (in force 19 April 2017): 21 disabilities, benchmark 40%; Sec 16 duties of schools; Sec 17 survey every 5 years, free aids to 18, scribe, extra time; Sec 31 free education 6-18; Sec 32: 5% higher education seats, 5 years age relaxation; Sec 34: 4% posts; RTE 2009 (6-14), 2012 amendment: home-based education; Samagra Shiksha 2018-19 = SSA + RMSA + TE; NEP 2020 Ch 6: SEDGs, Gender-Inclusion Fund, SEZs, ISL.

Learning Disabilities, ADHD and Autism: Signs a Teacher Sees and Classroom Strategies

What a learning disability is: A specific learning disability (SLD) is a neurological difference in how the brain takes in, processes or expresses information. The RPwD Act 2016 describes it as a group of conditions with a deficit in processing spoken or written language, shown as difficulty in understanding, speaking, reading, writing, spelling or calculating, and it names perceptual disabilities, dyslexia, dysgraphia, dyscalculia, dyspraxia and developmental aphasia. For CTET, three features matter: the child has average or above-average intelligence; the difficulty is specific (a child may explain a science experiment yet be unable to read the worksheet); and it is not caused by poor teaching, low effort, poverty or a problem of sight or hearing, though these must be ruled out. It is lifelong, but with the right strategies the child can succeed.

Dyslexia and dysgraphia: Dyslexia is a difficulty with reading that arises mainly from weak phonological processing, the linking of sounds to letters. A teacher sees slow, effortful reading, guessing a word from its first letter, confusion of b and d, p and q, or was and saw, losing the place or skipping lines, poor spelling, and good understanding when the same text is read aloud to the child. Strategies: multisensory phonics in which the child sees a letter, says its sound and traces it in sand (the visual-auditory-kinaesthetic-tactile or VAKT approach of the Fernald and Orton-Gillingham methods), reading aloud to the child, audio books, large print, extra time and oral tests. Dysgraphia is a

difficulty with writing: an awkward grip, illegible letters of mixed size and spacing, very slow copying from the board, and a wide gap between what the child can say and write. Strategies: pencil grips, lined or squared paper, printed notes instead of copying, shorter written tasks, and oral, typed or drawn answers.

Dyscalculia and dyspraxia: Dyscalculia is a difficulty with number sense and arithmetic. The child may count on fingers long after classmates stop, confuse signs such as + and x, reverse digits (writing 21 for 12), misalign columns in addition, struggle with place value, and find telling time and handling money hard. Strategies: concrete materials such as beads, bundles of sticks and the abacus before symbols, the number line, squared paper to keep digits in columns, and short daily practice. Dyspraxia, also called developmental coordination disorder, affects the planning of movement: the child seems clumsy, bumps into things, finds buttons, shoelaces, scissors and ball games hard, and often writes untidily. Strategies: break movements into steps, allow extra time, give pencil grips and wide-ruled paper, and suggest an occupational therapist through the school.

ADHD: Attention deficit hyperactivity disorder shows as inattention (careless mistakes, unfinished tasks, losing things, distractibility), hyperactivity (fidgeting, leaving the seat, talking excessively) and impulsivity (blurting out answers, not waiting for a turn). It is not itself a specific learning disability, but the two often occur together. Strategies: seat the child near the teacher and away from doors and windows, give one instruction at a time and check understanding, break work into short parts with a checklist, allow movement breaks or classroom jobs such as handing out books, praise good behaviour immediately and specifically, and keep routines predictable. Punishment and public scolding make the problem worse.

Autism spectrum disorder: Autism, first described by Leo Kanner in 1943, involves persistent difficulty in social communication and interaction together with restricted, repetitive behaviour and interests. A teacher may notice little eye contact, a preference for playing alone, difficulty with jokes and idioms (taking 'it is raining cats and dogs' literally), echolalia (repeating words just heard), distress at sudden changes, repetitive movements such as hand-flapping, strong reactions to noise, light or touch, and deep interest in one topic. Being a spectrum, it varies widely: some children do not speak, others are exceptionally able in particular areas. Strategies: a visual timetable, advance warning of any change, short and literal instructions, social stories that explain situations step by step, a quiet corner, using the child's special interest to motivate, and helping classmates include the child.

Learning disability, slow learning and learning difficulty: A slow learner learns every subject more slowly than classmates because general ability is below average, though not in the range of intellectual disability; the child needs more time, repetition, concrete examples and remedial teaching, and slow learning is not a category under the RPwD Act. A child with a learning disability has average or higher intelligence and an unexpected gap in one area. A learning difficulty is a broader, often temporary problem caused by outside factors such as long absence, an unfamiliar language of teaching or stress at home, and it eases when the cause is removed. Intellectual disability is different again: significant limits in both reasoning and adaptive behaviour beginning in childhood, conventionally with an IQ below about 70.

The teacher's role: The class teacher observes the child, keeps anecdotal records and work samples, uses diagnostic tests to find the pattern of errors, adapts her teaching, and refers the child for specialist assessment through the school and parents. She does not diagnose or label the child, and never calls him lazy, careless or dull.

Examples

- Dyslexia = reading (b/d and was/saw confusions, slow reading, poor spelling); dysgraphia = writing; dyscalculia = number and arithmetic; dyspraxia = planning of movement.
- A child with a specific learning disability has average or above-average intelligence; the difficulty is in one area, not general.
- VAKT (visual, auditory, kinaesthetic, tactile) multisensory teaching underlies the Fernald and Orton-Gillingham methods for dyslexia.
- Dyscalculia support: concrete materials (beads, bundles of sticks, abacus), the number line, squared paper to keep digits in columns.
- Dyspraxia is also called developmental coordination disorder; the child seems clumsy and may need an occupational therapist.

- ADHD = inattention + hyperactivity + impulsivity; seat near the teacher, one instruction at a time, short tasks, movement breaks, immediate praise.
- ADHD is not itself a specific learning disability, but the two often occur together.
- Autism (described by Leo Kanner, 1943): difficulty in social communication + restricted, repetitive behaviour; use a visual timetable, warn before changes, give literal instructions.
- Echolalia (repeating words just heard) and distress at changes in routine are signs often seen in autism.
- Slow learner: slow in all subjects, below-average general ability; learning disability: normal intelligence, difficulty in one area; learning difficulty: often temporary, caused by outside factors.

> **Quick revision:** SLD: neurological, average or higher intelligence, difficulty in one area; dyslexia = reading (b/d), dysgraphia = writing, dyscalculia = maths, dyspraxia = movement (DCD); VAKT, Fernald, Orton-Gillingham; ADHD: inattention, hyperactivity, impulsivity, not an SLD but often co-occurs; autism (Kanner 1943): social communication + repetitive behaviour, visual timetable, echolalia; slow learner: slow in all subjects, not an RPwD category; learning difficulty often temporary; teacher observes and refers, never labels.

Visual, Hearing and Locomotor Disabilities: Braille, Indian Sign Language and Classroom Changes

Visual impairment and its signs: The RPwD Act 2016 lists blindness and low vision as separate disabilities. A child with low vision has some useful sight and can often read large print with aids; a blind child depends on touch and hearing. A teacher should suspect a problem when a child holds the book very close or very far, squints, tilts the head, rubs the eyes or complains of headaches, copies wrongly from the blackboard, skips lines while reading, or bumps into furniture. Such a child should be referred for an eye examination, since many need only spectacles.

Teaching children with visual impairment: Seat the child in front, near the board, with good light and no glare. Say aloud everything you write or point to ('the triangle on the left has a right angle'), address the child by name, and keep the classroom layout and the child's belongings in fixed places. Provide large-print, high-contrast material, magnifiers, tactile maps and diagrams with raised lines, real objects to handle, and audio books. Screen readers such as JAWS and NVDA read a computer screen aloud. For arithmetic, blind learners use the Taylor frame and the Cranmer abacus, and talking calculators help too. A white cane and orientation and mobility training let the child move about the school independently. In examinations the child may use a scribe, a Braille paper or extra time.

Braille: Braille is a system of raised dots read by touch. Louis Braille of France, who lost his sight as a small child, developed it in 1824, at the age of 15, while a student at the Royal Institute for Blind Youth in Paris, by adapting the night writing code of Charles Barbier. Each Braille cell has 6 dots in two columns of three, giving 63 possible patterns. It is written with a slate and stylus (punched from right to left on the reverse side, so that the raised dots read from left to right) or with a Braille writing machine such as the Perkins Brailler. Bharati Braille adapts the cells to Indian scripts. World Braille Day, 4 January, marks Louis Braille's birthday in 1809. Braille is a code for writing a language, not a language in itself.

Hearing impairment: The RPwD Act 2016 divides hearing impairment into deaf (a hearing loss of 70 decibels in the speech frequencies in both ears) and hard of hearing (a loss of 60 to 70 decibels in both ears). Signs include asking for repetition, watching the speaker's face closely, turning one ear towards the sound, not responding when called from behind, very loud or unclear speech, delayed language, and ear discharge or earache. Classroom changes: seat the child in front and slightly to one side, ideally in a semicircle or U-shaped arrangement so that the child can see the faces of the teacher and classmates; face the class when speaking and never talk while writing on the board; speak clearly at a normal pace without shouting or exaggerated lip movements; keep the light on your face rather than behind you; reduce background noise; write key words and homework on the board; use pictures, gestures and captioned videos; give the child a buddy to share notes; and check understanding by asking the child to explain, not by asking 'Did you understand?'.

Sign language and communication: Indian Sign Language (ISL) is a complete visual language with its own grammar; it is not Hindi or English spelled out in signs. The Indian Sign Language Research and Training Centre was set up in New Delhi in 2015, and NEP 2020 calls for ISL to be standardised across the country. Approaches to teaching deaf children include the oral approach (speech and lip-reading), the manual approach (sign language) and

total communication, which combines speech, signs, finger-spelling, gestures, lip-reading and writing. Assistive devices include hearing aids, which amplify sound; cochlear implants, which stimulate the hearing nerve directly; and FM systems, in which the teacher wears a microphone that sends her voice straight to the child's hearing aid. A teacher who learns a few ISL signs sends the child a strong message of acceptance.

Locomotor disability: The Act defines locomotor disability as an inability to carry out activities associated with the movement of oneself and of objects, arising from a problem of the musculoskeletal or nervous system or both, and it includes cerebral palsy, leprosy-cured persons, dwarfism, muscular dystrophy and acid attack victims. Causes include polio, amputation, spinal injury and cerebral palsy. Many of these children have no difficulty in learning; what often limits them is the building. A barrier-free school has ramps with handrails, wide doors, accessible toilets, a ground-floor classroom, clear aisles wide enough for a wheelchair and desks of suitable height. Aids include wheelchairs, crutches, callipers, artificial limbs, tricycles, pencil grips, page-turners and adapted keyboards. Adapt physical education so that the child takes part, give extra time to move between rooms and to write, and use peer helpers without letting others do everything for the child.

Examples

- Signs of a vision problem: holding the book too close, squinting, rubbing the eyes, headaches, copying wrongly from the board - refer the child for an eye test.
- Child with visual impairment: front seat, good light, say aloud what you write, keep the classroom layout fixed, give large-print and tactile material.
- Braille: Louis Braille (France, born 4 January 1809) developed it in 1824 at the age of 15; 6-dot cell, 63 patterns; adapted from Charles Barbier's night writing.
- A slate and stylus writes Braille from right to left on the reverse; the Perkins Brailler is a Braille writing machine; Bharati Braille is for Indian scripts.
- Taylor frame and Cranmer abacus are arithmetic aids for blind learners; JAWS and NVDA are screen readers.
- RPwD Act 2016: deaf = 70 decibel hearing loss in both ears; hard of hearing = 60 to 70 decibel loss in both ears.
- Child with hearing impairment: front seat to one side, U-shaped seating, face the class, never talk while writing on the board, use visuals and captions.
- Total communication combines speech, signs, finger-spelling, gestures, lip-reading and writing; ISL has its own grammar; the ISL Research and Training Centre was set up in New Delhi in 2015.
- A hearing aid amplifies sound; a cochlear implant stimulates the hearing nerve; an FM system carries the teacher's voice straight to the child.
- Locomotor disability includes cerebral palsy, leprosy-cured, dwarfism, muscular dystrophy and acid attack victims; ramps, handrails, wide doors and accessible toilets make a school barrier-free.

> **Quick revision:** Visual: blindness and low vision; signs: squinting, holding the book close; front seat, say aloud what you write, large print, tactile maps, JAWS/NVDA, Taylor frame, Cranmer abacus; Braille: Louis Braille, 1824, 6 dots, 63 patterns, slate and stylus, World Braille Day 4 January; deaf 70 dB, hard of hearing 60-70 dB; face the class, U-shaped seating; ISL has own grammar, ISLRTC 2015; total communication; hearing aid, cochlear implant, FM system; locomotor: ramps, wide doors, wheelchairs, callipers.

Gifted, Creative and Disadvantaged Learners: Identifying and Supporting Them Without Labels

Who is gifted: A gifted child shows ability well above that of age-mates in one or more areas. Older definitions relied on IQ alone, as in Lewis Terman's long-term studies of high-IQ children begun in the 1920s. Modern views are broader. Renzulli's three-ring model sees giftedness where above-average ability, task commitment and creativity overlap, and Gardner's theory of multiple intelligences means a child may be gifted in music, movement, understanding people or the natural world, not only in language and logic. Signs a teacher notices include learning quickly with little repetition, a large vocabulary, unusual questions, deep interest in one topic, long concentration on chosen tasks, quick grasp of relationships and a mature sense of humour. The word talented is often used for high ability in a particular field such as music, sport or art.

Identifying them: No single test is enough. Teachers use several sources together: observation in class and in activities, achievement and aptitude tests, creativity tests such as the Torrance Tests of Creative Thinking, portfolios of work, and nominations by parents, peers and the child. Gifted children are easily missed when they are bored and disruptive, when they hide their ability to fit in, when they study in a language that is not their own, or when they also have a disability (twice-exceptional children). Girls and children from poor families are often overlooked because adults expect less of them.

Enrichment and acceleration: Enrichment broadens and deepens learning at the same grade through open-ended projects, independent research, questions at the analyse, evaluate and create levels of Bloom's revised taxonomy, clubs, olympiads, mentors and learning corners. Renzulli's Enrichment Triad describes three types: general exploratory activities, group training in thinking and research skills, and individual or small-group investigation of real problems. Acceleration moves the child faster: early admission, grade skipping, subject acceleration (for example, doing higher-class mathematics only) and curriculum compacting, in which material already mastered is skipped. Jawahar Navodaya Vidyalayas, set up under the National Policy on Education 1986 mainly for talented rural children, are another provision. NEP 2020 asks teachers to recognise and nurture such talent through enrichment material, topic-centred clubs and olympiads. Giving a gifted child more of the same work as a reward for finishing early is a common mistake.

Creative children: Creativity is the ability to produce ideas that are both new and useful. Guilford distinguished convergent thinking (finding the one correct answer) from divergent thinking (producing many possible answers), and Torrance measured divergent thinking by fluency (number of ideas), flexibility (variety of kinds of ideas), originality (unusual ideas) and elaboration (detail). Graham Wallas (1926) described four stages of the creative process: preparation, incubation, illumination and verification. A creative child may ask odd questions, give unexpected answers, dislike rote work and seem non-conforming. Intelligence and creativity are related but not the same: a child with a high IQ need not be creative. The teacher fosters creativity by asking open-ended questions ('In how many ways can we use a brick?'), brainstorming without judging, accepting unusual answers, allowing time and play, and never ridiculing an idea.

Disadvantaged and marginalised learners: Many children face barriers that have nothing to do with ability: poverty and hunger, child labour, seasonal migration, caste and gender discrimination, life in remote areas, or a home language different from the school's. First-generation learners are the first in their families to go to school; their parents may not be able to help with homework or read school notices. Children of linguistic minorities and tribal children often meet a textbook language they do not speak, so they may seem slow when they are only unfamiliar with the language. Article 350A asks every state to provide facilities for instruction in the mother tongue at the primary stage to children of linguistic minority groups, NCF 2005 treats multilingualism as a resource, and NEP 2020 says that wherever possible the home language should be the medium of instruction until at least Grade 5, preferably till Grade 8 and beyond. Schemes such as the Mid-Day Meal (1995) and the Kasturba Gandhi Balika Vidyalayas (2004) for girls from disadvantaged groups address some of these barriers.

What the teacher does, without labelling: Connect lessons to the child's own life, work and local knowledge (a child who sells vegetables already does a great deal of mental arithmetic); allow the home language in class and build bridges to the school language; set homework that does not need parents' help or bought materials; give extra support quietly within school; and hold high expectations of every child. Avoid labels such as backward, weak or poor, seating by caste, class or ability, and remarks based on stereotypes, because a label lowers the teacher's expectations and the child's self-belief and can become a self-fulfilling prophecy. The guiding idea is difference, not deficit: the child's background is a resource to build on, not a lack to be fixed. Under Section 4 of the RTE Act, an out-of-school child is admitted to an age-appropriate class and given special training to catch up.

Examples

- Renzulli's three rings: above-average ability + task commitment + creativity; Gardner: a child may be gifted in any of the multiple intelligences.
- Identify gifted children from several sources: observation, achievement tests, creativity tests, portfolios, and parent, peer and self nomination.

- Twice-exceptional: gifted and also having a disability; such children are often missed.
- Enrichment = broader and deeper at the same grade (projects, clubs, olympiads); acceleration = faster (early admission, grade skipping, subject acceleration, curriculum compacting).
- Renzulli's Enrichment Triad: Type I general exploratory activities, Type II group training activities, Type III investigation of real problems.
- Guilford: convergent thinking (one answer) vs divergent thinking (many answers); Torrance: fluency, flexibility, originality, elaboration.
- Wallas (1926), stages of the creative process: preparation, incubation, illumination, verification.
- First-generation learners are the first in their family to attend school; set homework that does not depend on parents' help.
- Article 350A: mother-tongue instruction at the primary stage for linguistic minorities; NCF 2005: multilingualism is a resource.
- Difference, not deficit: a disadvantaged child's background is a resource; labels lower expectations and can become self-fulfilling prophecies.

> **Quick revision:** Gifted: Renzulli three rings (ability, task commitment, creativity), Gardner MI, Terman IQ studies; identify from several sources; twice-exceptional; enrichment = broader/deeper, acceleration = faster, curriculum compacting; Enrichment Triad; JNV under NPE 1986; creativity: Guilford divergent thinking; Torrance fluency, flexibility, originality, elaboration; Wallas 1926 four stages; disadvantaged: first-generation, migrant, linguistic minorities; Art 350A; NCF 2005 multilingualism; KGBV 2004; difference not deficit; no labels.

Inclusive Classroom Practice: UDL, Differentiated Instruction, Peer Learning, IEPs and Assessment

Universal Design for Learning: Universal design began in architecture, where the American architect Ronald Mace argued that buildings should be usable by everyone from the start; a kerb cut made for wheelchairs also helps people with prams and suitcases. Universal Design for Learning (UDL), developed by CAST (the Center for Applied Special Technology, USA) under David Rose and Anne Meyer, applies this to teaching: instead of planning for an average child and later adjusting for the rest, the teacher builds flexibility into every lesson. UDL has three principles: multiple means of engagement (the why of learning: choice, relevance, collaboration), multiple means of representation (the what: text, pictures, audio, models, demonstration) and multiple means of action and expression (the how: writing, speaking, drawing, building, acting). A lesson on the water cycle that uses a diagram, a demonstration with a boiling kettle, a song and a choice of ways to show learning is a UDL lesson.

Differentiated instruction: Carol Ann Tomlinson describes differentiation as the teacher's response to the learner's needs. The teacher varies content (what is learnt), process (how it is learnt), product (how learning is shown) and the learning environment, according to each child's readiness, interests and learning profile. Practical tools include tiered tasks on the same concept at three levels of challenge, learning stations, choice boards, flexible groups that change with the task, and graded worksheets. Differentiation does not mean a separate lesson for every child or lower goals for some; all children work towards the same core understanding by different routes. It fits Vygotsky's zone of proximal development: each child gets work just beyond what he can do alone, with scaffolding that is withdrawn as competence grows.

Cooperative and peer learning: In cooperative learning, small mixed-ability groups work towards a shared goal. David and Roger Johnson named five elements: positive interdependence, individual accountability, face-to-face promotive interaction, social skills and group processing. In the jigsaw technique (Elliot Aronson, 1971) each member learns one part of a topic and teaches it to the group, so every child, including a child with a disability, holds a piece the others need. Think-pair-share gives shy children time to think before speaking. Peer tutoring pairs a more able classmate with a learner who needs help; in Vygotsky's terms the tutor is a more knowledgeable other, and both children gain. A buddy system helps a child with a visual or physical disability move about and share notes. Group work fails when one child does everything, so the teacher assigns roles and checks each child's contribution.

Individualised Education Plan: An Individualised Education Plan or Programme (IEP), first required in the USA by the Education for All Handicapped Children Act of 1975, is a written plan for one child with special needs. It records

the child's present level of performance, strengths and needs; annual goals broken into short-term, measurable objectives; the teaching methods, materials and assistive devices to be used; accommodations in class and in examinations; who will do what (class teacher, special educator, therapist, parents); and how and when progress will be reviewed. It is made by a team that includes the parents and, where possible, the child, and it is revised regularly. The RPwD Act 2016 asks schools to give children with disabilities individualised support, and in Indian schools the IEP is usually drawn up by the special educator or resource teacher together with the class teacher and parents.

The teacher's attitude: Policy documents repeatedly name attitudes as one of the biggest barriers to inclusion. An inclusive teacher believes every child can learn, sees disability as one part of a child and not the whole, uses person-first language ('a child with autism'), shows empathy rather than pity, and keeps expectations high but realistic. She prepares classmates by talking openly about differences, models respectful behaviour, avoids comparisons and does not over-protect. She works with the special educator, parents and community, seeks training when needed, and reflects on what worked. In a CTET question, the correct option almost always shows the teacher adapting her own practice instead of blaming the child, the parents or the child's background.

Adapting assessment: Assessment should let each child show what he has learnt without being blocked by the disability. Accommodations change how the child is assessed while keeping the standard the same: extra time, a scribe or reader, Braille or large-print papers, oral answers, a separate quiet room, rest breaks, and simpler wording that does not change the concept being tested. The RPwD Act 2016 specifically mentions extra time, a scribe or amanuensis, and exemption from second and third language courses. Modifications, which change what is assessed, are used only when the IEP calls for them. Inclusive classrooms favour continuous and comprehensive evaluation (RTE Act, Section 29), formative assessment, portfolios, observation, projects and self- and peer-assessment, and they compare a child's progress with his own earlier performance rather than only with classmates. NEP 2020 recommends a holistic, 360-degree progress card that reports the child's growth in all domains.

Examples

- UDL (CAST; David Rose and Anne Meyer): engagement = the why, representation = the what, action and expression = the how of learning.
- Universal design began in architecture (Ronald Mace): a kerb cut made for wheelchairs helps everyone else as well.
- Tomlinson's differentiation: vary content, process, product and learning environment by readiness, interest and learning profile.
- Differentiation means different routes to the same core goal - not lower goals and not a separate lesson for each child.
- Johnson and Johnson's five elements of cooperative learning: positive interdependence, individual accountability, face-to-face interaction, social skills, group processing.
- Jigsaw (Elliot Aronson, 1971): each child learns one part of the topic and teaches it to the group.
- Peer tutoring uses a more knowledgeable other (Vygotsky) and benefits both the tutor and the learner.
- IEP: present level, measurable goals, methods and aids, accommodations, responsibilities and review - made with the parents; first required in the USA in 1975.
- Accommodation = change in how a child is assessed (extra time, scribe, Braille); modification = change in what is assessed.
- Inclusive assessment: CCE, portfolios, observation, self-assessment, comparison with the child's own earlier work; NEP 2020: 360-degree progress card.

> **Quick revision:** UDL (CAST, Rose and Meyer): engagement, representation, action and expression; universal design from architecture (Ronald Mace); differentiation (Tomlinson): content, process, product, environment by readiness, interest, profile; ZPD and scaffolding; cooperative learning (Johnson and Johnson, 5 elements); jigsaw (Aronson 1971); peer tutoring, think-pair-share, buddy system; IEP (USA 1975), team-made, measurable goals; person-first language, high expectations; accommodation vs modification; CCE, portfolios; NEP 2020 360-degree progress card.

Free practice questions: parikshasaathi.com/q/inclusive-education/

Language Pedagogy (Language I and II)

Language Pedagogy (Language I and Language II)

What the exam asks: In CTET Paper I and Paper II, both Language I and Language II carry 30 questions each, of which 15 are on the pedagogy of language development. State TETs follow the same pattern. The questions are of two kinds: direct recall of theories, methods and terms, and classroom scenarios where you must pick the best teacher response. The scoring rule of thumb is simple. The correct option is almost always the one that is communicative and meaning-focused, learner-centred rather than teacher-centred, treats the child's home language and errors as resources, and integrates skills instead of drilling them in isolation.

Theories of language acquisition: Krashen distinguishes acquisition (subconscious, natural, through meaningful exposure) from learning (conscious study of rules). His five hypotheses are acquisition-learning, monitor (learned rules only edit output), natural order (structures are acquired in a predictable sequence), input (comprehensible input at i+1, one step above the current level) and affective filter (anxiety, low motivation and low self-esteem block input). Chomsky proposed an innate Language Acquisition Device and universal grammar; children produce sentences they have never heard, which behaviourism cannot explain. Skinner's behaviourist view says language is verbal behaviour learnt through imitation, practice and reinforcement. Vygotsky stresses social interaction and the zone of proximal development (scaffolding, a term introduced later by Wood, Bruner and Ross, is the teaching support built on that idea); speech first serves communication and is then internalised as inner speech for thinking. Piaget called the child's self-directed talk egocentric speech and saw language as dependent on cognitive development.

Stages of language development: cooing (around 2 months), babbling (around 6 months, repeated syllables like ba-ba), holophrastic or one-word stage (around 12 months, one word carries a whole sentence), telegraphic or two-word stage (around 18 to 24 months, content words only, like daddy go), then multi-word speech. Listening and speaking develop before reading and writing, and oral language is the base on which literacy is built.

Multilingualism and the home language: NCF 2005 treats multilingualism as a resource and a classroom strategy, not a problem. The mother tongue or home language should be the medium at the primary stage, and other languages should be built on it. The three-language formula evolved as a consensus at the 1961 meeting of the Chief Ministers, was modified by the Kothari Commission (1964 to 66) and adopted in the National Policy on Education 1968. No dialect or variety is inferior; a child who speaks a regional variety should not be corrected with ridicule. The gap between home language and school language is a major reason for early reading failure, and the best teacher response is to use the home language as a bridge. Cummins distinguishes BICS (basic interpersonal communication skills, conversational fluency acquired in one to two years) from CALP (cognitive academic language proficiency, which takes five to seven years). Code-switching is the natural alternation between languages and should be accepted; register is the variety of language suited to a situation.

Methods and approaches: Grammar-translation teaches rules deductively and translates sentences; it neglects speaking. The direct method bans the mother tongue and teaches orally with inductive grammar. The audio-lingual method uses pattern drills and habit formation, rooted in behaviourism and structural linguistics. The structural-situational approach grades structures and presents them in situations. Communicative language teaching (CLT) aims at communicative competence through authentic materials, pair and group work, information gap and role play, with fluency valued over accuracy. Task-based learning organises lessons around meaningful tasks with a non-linguistic outcome. The bilingual method of C.J. Dodson uses the mother tongue only for meaning. Total physical response (James Asher) links commands to actions. The natural approach (Krashen and Terrell) delays speech and gives comprehensible input. Whole language puts meaning first; phonics teaches sound-letter correspondence. The constructivist approach lets learners build meaning from experience.

The four skills: LSRW. Listening and reading are receptive; speaking and writing are productive. Skimming gets the gist; scanning locates a specific detail. Intensive reading studies a short text closely; extensive reading is wide reading for pleasure. Silent reading is for comprehension and speed; reading aloud is for pronunciation and expression. Bottom-up processing decodes letters to words; top-down processing uses prior knowledge to predict meaning. Emergent literacy means children know a great deal about print before formal reading, so classrooms

should be print-rich, with big books and shared reading. Decoding (sounding out) and comprehension (making meaning) are different; a child who reads fluently but cannot answer questions needs comprehension work. Dyslexia is a specific reading difficulty, not low intelligence. Writing is taught through the process approach (pre-writing, drafting, revising, editing, publishing) rather than product alone, moving from controlled through guided to free writing. Invented spelling is a normal developmental stage and should not be penalised in early grades.

Grammar, vocabulary and literature: Grammar is best taught inductively and in context, through functional use rather than isolated rules. Vocabulary is learnt in context and through use, not from word lists. Poetry is taught for enjoyment, rhythm and imagery, not for paraphrase or moral extraction; prose is used for intensive reading and comprehension. The textbook is one resource, not the only one; supplementary readers, realia, flash cards, charts and multimedia enrich learning.

Errors and assessment: Errors are systematic and reflect the learner's current rule system (competence); mistakes and slips are performance lapses the learner can self-correct. Over-generalisation (goed, foots) shows active rule learning. Selinker's interlanguage is the learner's evolving system; fossilisation is when errors become permanent. Corder argued that errors are evidence of learning and should be analysed, not punished. Remedial teaching follows diagnostic testing. Assessment should be continuous and comprehensive, with portfolios, oral tests, cloze tests, dictation and rubrics. Formative assessment improves learning during the course; summative assessment judges achievement at the end. Comprehension questions are literal (stated in the text), inferential (read between the lines) and evaluative (judge or react).

Traps: Do not pick options that say the teacher should punish errors, forbid the mother tongue, make children memorise rules first, or teach the four skills in isolation. Do not confuse acquisition with learning, errors with mistakes, skimming with scanning, or BICS with CALP. Remember that the teacher is a facilitator who provides opportunities, not a lecturer who transmits rules.

Examples

- Krashen's five hypotheses in one line: Acquire naturally, Monitor edits, Natural order, Input i+1, Affective filter low. Mnemonic: A-M-N-I-A.
- Error versus mistake: an error is systematic and the learner cannot self-correct (competence); a mistake or slip is a one-off performance lapse the learner can fix when pointed out.
- Stage order: cooing (2 months), babbling (6 months), holophrastic one-word (12 months), telegraphic two-word (18 to 24 months). Remember C-B-H-T.
- Skimming is reading a newspaper headline page for the gist; scanning is looking for your train number in a timetable.
- BICS is playground language acquired in 1 to 2 years; CALP is classroom academic language that takes 5 to 7 years (Cummins).
- Method and name pairs: TPR - James Asher; Natural Approach - Krashen and Terrell; Bilingual Method - C.J. Dodson; Interlanguage - Selinker; Error Analysis - Corder; LAD - Chomsky.
- A child who says 'goed' or 'foots' is over-generalising a rule, which is evidence of active learning, not of carelessness.
- Three-language formula: evolved at the 1961 Chief Ministers' meeting, modified by the Kothari Commission (1964 to 66), adopted in the National Policy on Education 1968.
- Receptive skills are listening and reading; productive skills are speaking and writing. Oral skills come before written skills.
- Bottom-up reading goes from letters to sounds to words to meaning; top-down reading starts from prior knowledge and predictions.
- Process writing stages: pre-writing, drafting, revising, editing, publishing. The product is judged only at the end.
- Grammar-translation is deductive and mother-tongue based; direct method is inductive and bans the mother tongue; audio-lingual drills habits; CLT values fluency and meaning.

> **Quick revision:** Krashen: acquisition (subconscious) vs learning; monitor; natural order; input i+1; affective filter; Chomsky: LAD and universal grammar; Skinner: imitation and reinforcement; Vygotsky: social interaction, ZPD; Piaget: egocentric speech; stages: cooing, babbling, holophrastic, telegraphic; NCF 2005: multilingualism is a resource, home language as medium; three-language formula: Kothari Commission, NPE 1968; CLT: communicative competence, fluency over accuracy; error (systematic) vs mistake (slip); interlanguage (Selinker), fossilisation; BICS vs CALP (Cummins); skimming = gist, scanning = detail; process writing; inductive grammar in context.

Language Acquisition and Learning: Krashen, Chomsky, Skinner, Vygotsky and Piaget

Acquisition versus learning: Stephen Krashen separated two ways of developing a language. Acquisition is subconscious: the child picks up the language while using it for real purposes, as every child picks up the home language without lessons. Learning is conscious: knowing the rules and being able to state them, the way students study grammar for an examination. Krashen held that only acquired knowledge drives fluent speech and that learning does not turn into acquisition. A teacher who only explains rules produces children who can define a noun but cannot speak, while a classroom rich in stories, talk and meaningful reading lets the language be acquired.

The monitor, input and affective filter: In the monitor hypothesis, learned rules act only as an editor that checks output, and the monitor works only when the speaker has time, is focused on correctness and knows the rule; that is why a child may get a written grammar exercise right yet make the same error in free speech. Krashen called learners who check everything over-users, those who rely only on feel under-users, and those who balance the two optimal users. The input hypothesis says we acquire by understanding messages slightly beyond our current level, i+1, with the help of context, pictures and gestures; speaking emerges on its own once enough comprehensible input has built up, so a silent period in a new learner is normal. The affective filter hypothesis says anxiety, low motivation and low self-confidence raise a mental block that stops input from being acquired, so a child who is laughed at for a wrong word learns less even from good input. The natural order hypothesis adds that structures are acquired in a predictable order that teaching cannot rearrange.

Behaviourist and nativist views: B.F. Skinner, in Verbal Behavior (1957), treated language as behaviour shaped by operant conditioning: the child imitates, adults reinforce correct forms, and repeated responses become habits. This explains why children pick up the words and accent of their surroundings, and it lies behind drill methods. Noam Chomsky's review of the book in 1959 argued that it cannot explain why children produce sentences they have never heard, make errors such as goed and mouses that no adult models, and master a complex grammar from limited and imperfect speech, the poverty of the stimulus argument. Chomsky proposed an innate Language Acquisition Device (LAD) and a universal grammar, principles common to all human languages, so that exposure only sets the details of a particular language. He also separated competence, the speaker's internal knowledge of the language, from performance, its actual use.

Vygotsky and Piaget on language and thought: For Lev Vygotsky language is social in origin and the most important cultural tool for thinking. In Thought and Language (Russian original 1934), thought and speech grow from separate roots and meet at about the age of 2; speech then moves from social speech, used to communicate, to private speech, the audible self-talk with which children of about 3 to 7 years guide themselves through a task, and finally to silent inner speech that directs thinking. Jean Piaget, in The Language and Thought of the Child (1923), called the same self-talk egocentric speech, a sign that the young child cannot yet take another person's point of view, which fades as the child becomes social; he also described the collective monologue, in which children in a group each talk aloud without really responding to one another. For Piaget language reflects thought, so concepts must develop before words for them become meaningful. Vygotsky's view supports talk, group work and scaffolding; Piaget's supports concrete experience before vocabulary.

Interaction and the critical period: Interactionists combine the two sides. Jerome Bruner accepted an inborn readiness but argued that adults provide a Language Acquisition Support System (LASS): routines like naming pictures in a book, in which the adult does most of the work at first and hands over more as the child grows. The critical period hypothesis, put forward by Eric Lenneberg in 1967, holds that language is acquired most easily from early childhood until about puberty, as the brain matures. The case of Genie, found in 1970 at the age of 13 after years of isolation, who learnt many words but never mastered grammar, is often cited. Many researchers now prefer

the term sensitive period: older learners can learn languages well, but a native-like accent is far more likely when exposure begins early. NEP 2020 notes that children learn languages most quickly between 2 and 8 years of age.

What CTET asks: Acquisition is helped by exposure to meaningful language, a fear-free atmosphere and chances to use language, not by memorising rules. A child who says I goed home has worked out a rule for herself, which supports the nativist and cognitive views, and the teacher should model the correct form rather than punish. Know the pairs: LAD and universal grammar with Chomsky, operant conditioning with Skinner, private speech with Vygotsky, egocentric speech with Piaget, LASS with Bruner, i+1 and the affective filter with Krashen, and the critical period with Lenneberg.

Examples

- Krashen: acquisition is subconscious (how every child picks up the home language); learning is conscious knowledge of rules; learned rules only act as a monitor that edits output.
- Input hypothesis: comprehensible input at i+1, one step above the learner's level; speaking emerges after enough input, so a silent period in a new learner is normal.
- Affective filter: anxiety, low motivation and low self-confidence block input; a teacher lowers it with a fear-free class, praise for attempts and no ridicule of errors.
- Skinner, Verbal Behavior (1957): language is verbal behaviour learnt through imitation, reinforcement and habit formation; the basis of drill methods.
- Chomsky (review of Skinner, 1959): innate LAD, universal grammar, poverty of the stimulus; competence (knowledge of language) vs performance (actual use).
- Vygotsky: social speech, then private speech (about 3 to 7 years), then inner speech; language is a cultural tool of thought. Piaget: egocentric speech and collective monologue; thought comes before language.
- Bruner: LASS (Language Acquisition Support System), the adult routines that support the child's inborn readiness for language.
- Critical period: Eric Lenneberg (1967), from early childhood to puberty; Genie (found 1970, aged 13) is the classic case; NEP 2020: children learn languages fastest between 2 and 8.
- A child who says goed or foots is over-generalising a rule she worked out herself, evidence that language is not learnt by imitation alone.

> **Quick revision:** Krashen: acquisition (subconscious) vs learning (conscious); monitor edits output; over-, under- and optimal users; input i+1; silent period; affective filter; Skinner, Verbal Behavior 1957: imitation, reinforcement; Chomsky 1959 review: LAD, universal grammar, poverty of stimulus, competence vs performance; Vygotsky: social, private (3-7), inner speech; Piaget: egocentric speech, collective monologue; Bruner: LASS; Lenneberg 1967: critical period; Genie.

Principles of Language Teaching, Multilingualism and the Role of the Home Language

Principles that guide a language class: A language is acquired by using it for real purposes, so teaching moves from the known to the unknown, from oral to written, from concrete to abstract and from meaning to form, starting from the child's own experience and language. The four skills are taught together, because in life we listen, speak, read and write in combination. Children need plenty of exposure to rich, meaningful language, chances to talk, read and write about things that interest them, and an atmosphere in which errors are accepted as part of learning. Language is also identity: belittling a child's speech belittles the child and her family.

NCF 2005 on language: The National Curriculum Framework 2005 says language is not learnt only in the language period: every subject is learnt through language, which is the idea of language across the curriculum, often summed up as every teacher is a language teacher. It says that multilingualism, which is part of every Indian child's identity, must be used as a resource, a classroom strategy and a goal; its focus group on the teaching of Indian languages was chaired by Rama Kant Agnihotri. NCF 2005 asks that the home language be the medium of learning in the early years, supports the three-language formula as a route to multilingualism, and wants English to be learnt alongside the child's languages, not in place of them. It recognises that every language and dialect is rule-governed; no variety is primitive or inferior.

Multilingualism as a resource: NCF 2005 cites research linking bilingual proficiency with cognitive growth, divergent thinking, social tolerance and scholastic achievement. A multilingual class can compare how one idea is said in Hindi, Bhojpuri, Urdu and English, collect the words for one object in all the children's languages, translate short texts, or let a child explain a concept to a friend in their shared language. The teacher's task is not to suppress other languages but to build bridges from them to the school language. Jim Cummins's interdependence idea supports this: abilities such as reading for meaning, once developed in one language, transfer to another, so time spent in the mother tongue is not time lost for the second language.

The three-language formula: The formula grew out of a consensus at the conference of Chief Ministers in 1961, was examined and modified by the Kothari Commission (1964 to 66) and was adopted in the National Policy on Education 1968. In Hindi-speaking states it means Hindi, English and a modern Indian language, preferably a southern language; in non-Hindi-speaking states it means the regional language, Hindi and English. The National Policy on Education 1986 reaffirmed it. NEP 2020 keeps the formula with greater flexibility: no language is imposed on any state, the three languages are chosen by states, regions and students, and at least two of the three must be native to India. NCF-SE 2023 names the three languages R1, R2 and R3.

Mother tongue as the medium: A child taught in an unfamiliar language spends her energy on decoding the language instead of understanding the content, a major cause of early school failure. Article 350A of the Constitution asks every state to provide facilities for instruction in the mother tongue at the primary stage to children of linguistic minority groups, and Section 29(2)(f) of the RTE Act 2009 says the medium of instruction shall, as far as practicable, be the child's mother tongue. NEP 2020 says that wherever possible the medium of instruction until at least Grade 5, but preferably till Grade 8 and beyond, will be the home language, mother tongue, local language or regional language, and asks for bilingual teaching-learning materials. NCF-FS 2022 settled that in the foundational stage (ages 3 to 8) the main medium is the child's home language or most familiar language.

Translanguaging in practice: Translanguaging means letting learners use their whole language repertoire for learning instead of keeping languages in separate boxes. The term comes from Welsh bilingual classrooms, where Cen Williams used it, and was developed by Ofelia García. A class may read a story in Hindi, discuss it in the children's home languages and then write a summary in Hindi; a child may answer an oral question in her mother tongue while the teacher restates it in the school language; bilingual word walls and picture dictionaries made by the children help. Code-switching is the natural alternation between languages within a conversation, while translanguaging, as used in the classroom, is a deliberate teaching strategy; neither should be punished.

What CTET asks: The right option accepts and uses the child's home language, treats multilingualism as an asset, builds the second language on the first, and never punishes a child for speaking her own language. A Class 1 teacher whose pupils speak a tribal language at home should begin with that language through stories, songs and bilingual material and build Hindi or English on it. Options saying that the school language must be enforced from the first day, or that dialects are corrupt forms of the standard language, are wrong.

Examples

- Language across the curriculum (NCF 2005): every subject is learnt through language, so language education is not confined to the language class; the idea is often summed up as every teacher is a language teacher.
- NCF 2005: multilingualism must be used as a resource, a classroom strategy and a goal; its focus group on Indian languages was chaired by Rama Kant Agnihotri.
- Three-language formula: Chief Ministers' conference 1961; Kothari Commission 1964 to 66; NPE 1968; reaffirmed in NPE 1986; NEP 2020: flexible, no imposition, at least two of the three languages native to India.
- Article 350A: facilities for instruction in the mother tongue at the primary stage for children of linguistic minority groups.
- RTE Act 2009, Section 29(2)(f): the medium of instruction shall, as far as practicable, be the child's mother tongue.
- NEP 2020: home language or mother tongue as the medium until at least Grade 5, preferably till Grade 8 and beyond; bilingual teaching-learning materials.
- Cummins's interdependence: reading and thinking skills built in the first language transfer to the second, so time in the mother tongue is not wasted.

- Translanguaging (Cen Williams, Welsh bilingual classrooms; developed by Ofelia García), as a classroom approach, is a planned use of the learner's full language repertoire; code-switching is natural alternation in conversation.
- Principles: known to unknown, oral before written, meaning before form, skills integrated, errors accepted, every dialect respected.

> **Quick revision:** Known to unknown, oral before written, meaning before form, integrated skills; NCF 2005: language across the curriculum, multilingualism a resource, strategy and goal (Agnihotri focus group); Cummins: interdependence; three-language formula: 1961, Kothari 1964-66, NPE 1968, NPE 1986, NEP 2020 (two of three native); Article 350A; RTE Section 29(2)(f); NEP 2020: mother tongue till Grade 5, preferably 8; NCF-FS 2022; translanguaging (Cen Williams, García).

Listening and Speaking: Developing Oral Language in the Classroom

Why oral language comes first: Children listen long before they speak, and speak long before they read and write; by the time they enter school they already use their home language with considerable skill. Listening and speaking are the foundation of literacy: a child who has heard many stories and talked about them has the vocabulary, sentence patterns and sense of how stories go that reading depends on. Listening is a receptive skill and speaking a productive one, but both are active. Hearing is the physical reception of sound; listening means attending to it, interpreting it and responding. A silent class is not necessarily a learning class, because children learn language by using it.

Sub-skills and stages of listening: Good listening involves telling similar sounds apart (ship and sheep, or kal and kaal in Hindi), recognising stress and intonation, getting the gist, picking out details, predicting, inferring a speaker's feelings and following instructions. Listening lessons work best in three stages. Before listening the teacher sets a purpose and builds interest (look at this picture: what might the story be about?); while listening the children do a task, such as ticking pictures, filling a chart or following directions; after listening they discuss, retell, act out or write. Useful activities include read-aloud stories, rhymes and songs, listen and draw, listen and do (Total Physical Response), Chinese whispers, dictation and recorded announcements.

Building speaking: Speaking develops when children have something to say and someone to say it to. Activities include show-and-tell, picture talk, telling about one's own experiences, storytelling and retelling, role play and dramatisation, puppet shows, interviews, discussions and debates, and information-gap tasks in which each partner has information the other needs. Reciting poems and rhymes builds rhythm and confidence. Pair work and small groups give every child more talking time than whole-class question and answer, in which a few children speak. Shy children speak more readily in pairs first, when given wait time after a question, and when the topic is close to their lives. Fluency, smooth and easy speech, and accuracy, correctness of form, both matter, but in the early stages fluency and confidence come first.

Storytelling, role play and discussion: Storytelling is the richest oral activity in the primary class. A story told with expression, gestures, repetition and pauses for children to predict gives comprehensible input, new words in context and a model of narrative; children can then retell it, change the ending, act it out or tell their own. Role play asks children to speak as someone else in a situation, such as a shopkeeper and a customer, which practises the language of daily life and lowers anxiety because the child speaks as a character. Discussions on topics from children's lives build the ability to give reasons, agree and disagree politely, and listen to others.

Language as a tool: Children use language to do things, not only to name them. Michael Halliday described seven functions of language in young children: instrumental (getting what one wants: I want water), regulatory (controlling others: do this), interactional (getting along with others), personal (expressing feelings and identity), heuristic (finding out: why is the sky blue?), imaginative (creating make-believe) and representational or informative (giving information). Vygotsky adds that language is a tool for thinking, and NCF 2005 wants children to use language to question, reason and express themselves. A good class gives children reasons to ask, explain, persuade, imagine and report.

Responding to errors in speech: When a child says I goed to the market, or in Hindi maine khana khai instead of maine khana khaya, the error is part of learning. Correcting every slip interrupts the child's thought and raises the

affective filter, and children who are corrected harshly stop speaking. The teacher should respond first to what the child means and model the correct form naturally, a technique called recasting: Oh, you went to the market? What did you buy? Other gentle techniques are asking for clarification, pausing so the child can correct herself, and noting common errors for a short focused activity later. During fluency activities the teacher does not interrupt. A child's dialect or accent is not an error to be corrected through ridicule.

What CTET asks: The best response to a spoken error is to accept the attempt and model the correct form, not to stop the child and correct her publicly. Speaking develops through chances to talk in meaningful situations, not through memorising and reciting answers. Listening is an active skill that needs a purpose and a task, and storytelling, role play and discussion are the standard answers for building oral skills in the primary classes.

Examples

- Hearing is the physical reception of sound; listening is attending, interpreting and responding. Listening and reading are receptive skills; speaking and writing are productive.
- Natural order of development: listening, speaking, reading, writing (LSRW); oral language is the base on which literacy is built.
- Listening lesson stages: pre-listening (purpose, prediction), while-listening (a task such as ticking pictures), post-listening (discussion, retelling, writing).
- Speaking activities: show-and-tell, picture talk, storytelling, role play, puppet shows, interviews, debates and information-gap pair work.
- Pair and group work give every child more speaking time; shy children speak first in pairs and need wait time after a question.
- Halliday's seven functions: instrumental, regulatory, interactional, personal, heuristic, imaginative, representational (informative).
- Recast: the teacher repeats the child's idea in the correct form without saying it was wrong (Child: I goed there. Teacher: You went there? What did you see?).
- Fluency (smooth, easy speech) comes before accuracy (correct form) in the early stages; do not interrupt fluency activities to correct.
- Minimal pairs train sound discrimination: ship and sheep in English, kal and kaal in Hindi.

> **Quick revision:** Oral language before literacy; listening (receptive) and speaking (productive) are both active; hearing is not listening; pre-, while- and post-listening; TPR, read-aloud, listen and draw, dictation; show-and-tell, storytelling, role play, debates, information gap; pair work, wait time; fluency before accuracy; Halliday's seven functions; recast, clarification, self-correction; accept dialect, no ridicule.

Reading: Readiness, Phonics and Whole Language, Types of Reading and Comprehension

Reading is making meaning: Reading is not merely turning letters into sounds; it is constructing meaning from print using what the reader already knows. NCF 2005 asks that children read for meaning from the very beginning rather than spend years on letters and words without sense. Bottom-up processing decodes letters into sounds and words; top-down processing uses prior knowledge, context and prediction; skilled readers combine the two, which is called the interactive model. Schema theory explains why a child who has never seen a train struggles with a story set at a railway station: comprehension depends on background knowledge, so the teacher builds it before reading.

Reading readiness and emergent literacy: Before formal reading, children need oral language, interest in books, the ability to tell shapes and sounds apart, and phonological awareness, the ability to hear rhymes, syllables and individual sounds in words. They also need concepts about print: that print carries meaning, how a book is held, that Hindi and English are read from left to right and top to bottom, and that spaces separate words. Marie Clay used the term emergent literacy for this early knowledge, which children build long before formal teaching from signboards, packets and storybooks. Readiness is therefore developed, not simply awaited, through rhymes, sound games, picture reading, story sessions and scribbling.

Phonics, whole language and the Hindi methods: Phonics teaches the relation between letters and sounds and how to blend sounds into words (k-a-m-a-l, kamal); it is a bottom-up approach that gives children a key to unfamiliar

words. The look-and-say approach teaches whole words by sight. The whole-language approach, associated with Kenneth Goodman, who called reading a psycholinguistic guessing game (1967), starts from meaningful texts and children's own language and holds that decoding skills grow inside meaningful reading. A balanced approach, now widely recommended, joins systematic phonics with meaningful reading. Hindi teaching books divide methods into synthetic ones, from part to whole (the alphabet method, the phonic method, the syllable method), and analytic ones, from whole to part (the word, sentence and story methods). Because Devanagari is largely phonetic, sound-based methods work well, but they must lead quickly to meaningful words and sentences.

Types of reading: Reading aloud helps beginners with pronunciation, fluency and expression and lets the teacher hear difficulties; the teacher's own model reading is valuable at every stage. Silent reading is faster, keeps attention on meaning and is how adults read, so children move towards it as they grow. Intensive reading is the close study of a short text, such as a textbook lesson, for detailed understanding and language features; extensive reading is reading many longer texts for pleasure and general understanding, such as library books, and builds fluency, vocabulary and the reading habit. Skimming is reading quickly for the gist, as when glancing over a news report; scanning is searching for one piece of information, as when finding a name in a list or a train in a timetable.

Building comprehension: Comprehension is built before, during and after reading. Before reading, the teacher activates prior knowledge, introduces a few key words and asks children to predict from the title and pictures. During reading, children check predictions, ask questions, visualise and connect the text with their lives, and the teacher may think aloud to show how a good reader handles a difficult sentence. After reading, children retell, summarise, discuss, dramatise or write a response. Questions should go beyond the literal (answer stated in the text) to the inferential (reading between the lines) and the evaluative (judging and responding), and some should be open-ended. A child who reads fluently but cannot answer questions has a comprehension problem, not a decoding problem.

The print-rich classroom: A print-rich environment surrounds children with meaningful print they can use: labels on objects such as the door and the blackboard, name cards, a calendar and a weather chart, word walls, charts of rhymes, children's own writing and drawings with captions, newspapers, and a reading corner with picture books and big books. Labels in the children's home languages alongside the school language help multilingual learners. Print should be at children's eye level, changed often, and actually used: the teacher points to it and invites children to read it. Shared reading with a big book, in which the teacher reads and points while children join in, shows the direction of print and links speech to print.

What CTET asks: The purpose of reading is comprehension; a print-rich environment promotes emergent literacy; skimming is for the gist and scanning for specific details; extensive reading is for pleasure and builds the reading habit; and good questions make children think instead of copying lines from the text.

Examples

- Bottom-up reading: letters to sounds to words to meaning; top-down reading: prior knowledge and prediction; skilled readers use both (interactive model).
- Reading readiness: oral language, phonological awareness (rhymes, syllables, sounds), concepts about print, visual discrimination and interest in books.
- Emergent literacy (Marie Clay): children know a great deal about print before formal teaching; a print-rich environment supports it.
- Phonics teaches letter-sound relations and blending; whole language (Kenneth Goodman: reading as a psycholinguistic guessing game, 1967) starts from meaningful texts; balanced literacy joins the two.
- Hindi reading methods: synthetic, part to whole (alphabet, phonic, syllable); analytic, whole to part (word, sentence, story).
- Reading aloud: pronunciation and expression in early grades; silent reading: speed and comprehension; intensive: close study of a short text; extensive: wide reading for pleasure.
- Skimming: reading a news report quickly for its main idea; scanning: looking for your roll number in a result list.
- Comprehension levels: literal (stated), inferential (implied), evaluative (judged); include open-ended questions.
- Print-rich classroom: labels, name cards, word walls, charts, children's own writing, a reading corner and big books, at eye level and in use.

Quick revision: Reading is meaning-making (NCF 2005); bottom-up, top-down, interactive; schema theory; readiness: oral language, phonological awareness, concepts about print; emergent literacy (Marie Clay); phonics vs whole language (Goodman 1967), balanced literacy; Hindi: synthetic vs analytic methods; loud, silent, intensive, extensive; skimming = gist, scanning = detail; pre-, during, post-reading; literal, inferential, evaluative; print-rich classroom, big books.

Writing: Stages of Development, Process Writing and Feedback That Helps

Writing as communication: Writing is a productive skill and the most demanding of the four, because the writer must organise thoughts, choose words, follow the conventions of spelling and punctuation, and keep a reader in mind without the help of tone and gesture. It comes last in the natural order but is closely tied to reading: children who read widely write better. NCF 2005 criticises making children copy from the board or reproduce memorised answers; writing should be meaningful self-expression from the start, for a real purpose and a real reader. Handwriting and neatness matter, but they are not the same as the ability to write.

Stages of writing development: Young children pass through recognisable stages. They begin with scribbling, first random and then controlled, and use drawing as a form of writing. Next come letter-like shapes and mock letters, then strings of real letters unrelated to sounds. Then they begin to match letters to sounds. J. Richard Gentry (1982) described five stages of spelling: precommunicative (random letters with no link to sounds), semiphonetic (a few letters stand for the main sounds of a word), phonetic (every sound heard is written), transitional (standard spelling patterns begin to appear) and correct or conventional. As an illustration (these are sample spellings, not Gentry's own), a child might write monster as MSR, then MONSTR, then MONSTUR, before MONSTER. Each stage shows growing understanding and should be valued, not dismissed as untidy work.

Invented spelling: When a child writes I lik my dg, or in Hindi writes a short i for a long i (as in पानि for पानी), she is using invented or temporary spelling, writing words as she hears them. This shows that she understands that letters stand for sounds and is applying that knowledge, and it lets her write the many words she knows orally instead of the few she can spell. In the early grades the teacher accepts invented spelling, responds to the message, and moves children towards conventional spelling through reading, word walls, personal word books and short focused lessons. Insisting on perfect spelling from the start makes children write only safe, short sentences.

Process writing: The product approach judges only the finished piece. The process approach, developed in the 1970s and 1980s by researchers such as Donald Graves, treats writing as a series of stages: pre-writing (brainstorming, discussion, mind maps, listing ideas), drafting (getting ideas down without worrying about correctness), revising (improving content and organisation, often after peer or teacher feedback), editing (correcting spelling, grammar and punctuation) and publishing or sharing (display, reading aloud, a class magazine). The stages are recursive: a writer may return to brainstorming while revising. A short teacher-child writing conference about a draft is the heart of the method. Writing also moves from controlled (copying, filling blanks) through guided (writing with a frame or model) to free writing.

Creative and functional writing: Creative writing expresses imagination and feeling: stories, poems, diary entries, describing a picture, continuing a story, or writing from the point of view of a character or an object (if I were a tree). Functional writing serves practical needs: messages, notices, letters and applications, invitations, lists, posters, reports and forms. Both are needed. Good tasks give a purpose and an audience (write to the principal asking for a library period) rather than a bare topic (write an essay on the cow). Children may also draft in their home languages when that helps them express their ideas.

Feedback that helps: Feedback works best when it is specific, timely and focused. Comments on content and ideas come first (your description of the fair is vivid; tell me more about what you saw), and mechanics come later, at the editing stage. Covering a page in red ink discourages children and teaches little; it is better to focus on one or two patterns at a time, such as full stops or a particular matra. Written comments and conversation help more than a bare mark. Children can use simple checklists or rubrics for self-assessment and peer feedback, keep portfolios that show progress over time, and revise after feedback. In a dialogue journal the teacher replies to what the child has written as a reader, not as a corrector, which builds motivation.

What CTET asks: Brainstorming is the first stage of process writing; invented spelling is a normal developmental stage; writing should have a purpose and an audience; feedback should address ideas before mechanics; copying from the board and memorised essays do not develop writing; and the best writing tasks are open-ended and connected to children's lives.

Examples

- Writing is the most demanding productive skill; it develops last in the natural order but grows with wide reading.
- Development: scribbling (random, then controlled), drawing, mock letters, letter strings, invented spelling, transitional spelling, conventional spelling.
- Gentry (1982) stages of spelling: precommunicative, semiphonetic, phonetic, transitional, correct.
- Invented spelling (I lik my dg; पानि for पानी) shows letter-sound knowledge; accept it in early grades and move gradually to conventional spelling.
- Process writing: pre-writing (brainstorming), drafting, revising (content), editing (mechanics), publishing; the stages are recursive.
- Controlled writing (copying, filling blanks), guided writing (with a frame or model), free writing (own ideas).
- Creative writing: stories, poems, diary entries; functional writing: letters, notices, messages, invitations, applications, reports.
- Good feedback: specific, timely, ideas before mechanics, one or two error patterns at a time, comments rather than a bare mark.
- Writing conference: a short teacher-child talk about a draft; dialogue journal: the teacher replies to content as a reader, not a corrector.

> **Quick revision:** Writing: most demanding productive skill; NCF 2005 against copying and memorised answers; stages: scribbling, drawing, mock letters, letter strings, invented spelling, conventional; Gentry 1982: precommunicative, semiphonetic, phonetic, transitional, correct; process writing (Graves): pre-writing, drafting, revising, editing, publishing; controlled, guided, free; creative vs functional; feedback: ideas first, specific, portfolios, dialogue journals.

Teaching Grammar and Vocabulary: Inductive and Deductive Methods, Grammar in Context

What grammar is for: Every child who speaks a language already knows its grammar implicitly: a five-year-old Hindi-speaking girl says मैं जाती हूँ and never मैं जाती हैं, though she cannot state the rule. School grammar makes this knowledge explicit and refines it, especially for the written and formal language. Prescriptive grammar lays down rules of correct use; descriptive grammar describes how people actually use the language. NCF 2005 warns against teaching grammar in the early years as definitions and rules to be memorised; grammar should help children understand and use language better, and it is learnt best when it arises from meaningful texts and use.

Deductive teaching: In the deductive method the teacher states the rule first, gives examples, and then the learners practise, moving from rule to example. It is quick and systematic, suits older learners who can handle abstract rules, and is the way of the grammar-translation method. But it is teacher-centred, keeps learners passive, and the rule is often forgotten because it was never discovered. Example: the teacher writes that a noun is the name of a person, place or thing, gives five examples, and asks children to underline nouns in sentences.

Inductive teaching: In the inductive method learners first meet many examples in context, notice the pattern, form the rule themselves with the teacher's guidance, and then apply it, moving from example to rule. It is learner-centred, gives deeper understanding and longer retention, and suits children, though it takes more time. Example: children read a short story in the past tense, list what the characters did, notice that most verbs take -ed while some change form (went, saw), and frame the rule; in Hindi they collect sentences such as लड़का खेलता है and लड़की खेलती है and discover how the verb changes with gender. The direct method and the communicative approach use induction, and CTET treats the inductive, contextual approach as the better one for school learners.

Grammar in context and the communicative approach: Grammar in context means teaching a structure through a text or situation in which it is naturally used: the simple present through a description of a daily routine, comparatives through comparing two animals, the imperative through a recipe. Dell Hymes argued that knowing a language means knowing not only its grammar but how to use it appropriately in social situations, which he called communicative

competence. Michael Canale and Merrill Swain (1980) divided it into grammatical, sociolinguistic and strategic competence, and Canale (1983) added discourse competence. In the communicative approach grammar serves meaning: learners use language for real tasks, and the teacher draws attention to a form briefly when the need arises, rather than teaching isolated rules in advance.

What knowing a word means: Knowing a word means knowing its sound and spelling, its meanings, how it fits into sentences, the words it goes with (collocations, such as heavy rain and not strong rain), its word family, and when it is appropriate to use. Receptive vocabulary, the words understood in listening and reading, is always larger than productive vocabulary, the words used in speaking and writing. Words are learnt gradually through many meetings in different contexts, which is why wide reading is the biggest source of new vocabulary. Lists of words and meanings to be memorised give little usable knowledge.

Building vocabulary: Young children learn new words through real objects (realia), pictures, actions, mime and Total Physical Response. Children should be encouraged to guess meaning from context before turning to a dictionary. Useful activities include word webs or semantic maps (all the words connected with rain), word walls, personal word books, word families and word building with prefixes and suffixes (happy, unhappy, happiness; सफल, असफल, सफलता), synonyms and antonyms met in context, matching and sorting games, crosswords, and language games such as antakshari. New words should be used again in speaking and writing so that they become productive.

What CTET asks: The inductive method moves from examples to rule and is preferred for children; grammar should be taught in context and through use; communicative competence is Hymes's term; vocabulary grows through reading, context and repeated use, not memorised lists; and guessing meaning from context comes before the dictionary.

Examples

- Deductive method: rule, then examples, then practice; teacher-centred and quick; used in grammar-translation.
- Inductive method: examples in context, learners discover the rule, then practise; learner-centred, deeper retention; preferred for children.
- Prescriptive grammar says how one should speak or write; descriptive grammar describes how people actually use the language.
- Grammar in context: simple present through a daily routine, comparatives through comparing animals, imperatives through a recipe.
- Communicative competence: Dell Hymes; components (Canale and Swain, 1980): grammatical, sociolinguistic, strategic; discourse competence added by Canale (1983).
- Receptive vocabulary (understood) is larger than productive vocabulary (used); a word needs many meetings in varied contexts.
- Vocabulary activities: realia, pictures, mime, TPR, word webs, word walls, word families, prefixes and suffixes, guessing from context, word games.
- Word building: happy, unhappy, happiness; in Hindi सफल, असफल, सफलता (prefix अ-, suffix -ता).
- Children already know their home language's grammar implicitly; school grammar makes it explicit rather than teaching it from nothing.

> **Quick revision:** Implicit grammar known before school; prescriptive vs descriptive grammar; deductive: rule to example, teacher-centred, grammar-translation; inductive: example to rule, learner-centred, preferred; grammar in context; Hymes: communicative competence; Canale and Swain 1980: grammatical, sociolinguistic, strategic; Canale 1983: discourse; receptive vs productive vocabulary; collocations; realia, word webs, word walls, prefixes and suffixes, guessing from context.

Methods and Materials: Grammar-Translation to Task-Based Teaching, Textbooks and Language Games

Approach, method and technique: Edward Anthony (1963) separated three levels. An approach is a set of beliefs about the nature of language and how it is learnt; a method is an overall plan for presenting language, based on an approach; a technique is a particular classroom activity, such as a drill or a role play. Methods have changed as

views of language and learning changed: from language as rules to be learnt, to habits to be formed, to communication to be practised.

Grammar-translation and direct methods: The grammar-translation method, also called the classical method because it was used to teach Latin and Greek, teaches grammar rules deductively, uses bilingual word lists, and has learners translate sentences and passages between the mother tongue and the target language. The mother tongue is the medium, reading and writing are the focus and accuracy matters most. It is easy to use in large classes, but learners rarely learn to speak. The direct method arose in the late 19th century as a reaction; Maximilian Berlitz opened his first school in 1878. It uses only the target language, conveys meaning through objects, pictures and demonstration, teaches grammar inductively, and puts speaking and everyday vocabulary first. It needs fluent teachers and struggles with abstract words.

Audio-lingual and structural methods: The audio-lingual method grew out of the US Army's language programme of the Second World War and drew on structural linguistics and Skinner's behaviourism. It treats language as habit: learners memorise dialogues and practise pattern drills (repetition, substitution, transformation, chain drills), minimal pairs train pronunciation, and errors are prevented because they are thought to form bad habits. The structural approach, long used for English in Indian schools, selects and grades sentence structures and vocabulary and presents them in situations. These methods build accuracy and pronunciation but tend to produce mechanical learners who cannot use language creatively.

Communicative and task-based teaching: Communicative Language Teaching (CLT), which grew in Britain and Europe in the 1970s, aims at communicative competence. D.A. Wilkins's Notional Syllabuses (1976) organised teaching around notions such as time and quantity and functions such as requesting, apologising and inviting, rather than structures. CLT uses authentic materials, pair and group work, information gaps, role plays and problem solving; the teacher is a facilitator, fluency is valued alongside accuracy, and errors are tolerated as part of learning. Task-Based Language Teaching (TBLT) organises lessons around tasks with a clear outcome, such as planning a class trip or finding the differences between two pictures, in which meaning is primary. In India, N.S. Prabhu's Bangalore Project (1979 to 84) taught English through problem-solving tasks without a grammar syllabus. Jane Willis (1996) set out the task cycle: pre-task, task, planning, report, then a language focus.

Other methods in brief: Total Physical Response (James Asher) links commands to actions and suits young beginners; the Silent Way (Caleb Gattegno) keeps the teacher largely silent and uses coloured rods; Suggestopedia (Georgi Lozanov) uses relaxation and music to lower anxiety; Community Language Learning (Charles Curran) treats the teacher as a counsellor; the natural approach (Krashen and Terrell) stresses comprehensible input; and the bilingual method (C.J. Dodson) uses the mother tongue to convey meaning. No single method suits every class; teachers combine methods, and the constructivist view of NCF 2005 favours learner-centred, meaning-focused practice that uses children's languages.

Textbooks and multimedia: The textbook is a useful resource but not the whole curriculum; NCF 2005 asks teachers to go beyond it, link lessons to children's lives and use other materials. Supplementary readers, newspapers, magazines, posters, advertisements, menus and timetables bring authentic language into the room. Realia, flash cards, picture cards, charts and puppets support young learners. Audio and video recordings, radio, films and digital resources give exposure to varied voices and accents, and recording children's own speech lets them listen to themselves. Materials should suit learners' age, interests, language background and culture, and should be inclusive in how they show gender, region and disability.

Children's literature and language games: Stories, poems, folk tales, picture books and big books give rich language in memorable contexts, build imagination and empathy, and are the basis of extensive reading; a class library is one of the best investments a school can make. Poems are taught for enjoyment, rhythm and imagery. Language games such as word chains, antakshari, bingo, Simon says, dumb charades, twenty questions, crosswords and Chinese whispers give meaningful practice in a relaxed setting, which lowers the affective filter. A game should have a clear language purpose and involve every child, not only the quickest.

Examples

- Edward Anthony (1963): approach (beliefs about language and learning), method (overall plan), technique (classroom activity).
- Grammar-translation (classical method): deductive rules, translation, bilingual word lists, reading and writing, accuracy; neglects speaking.
- Direct method: target language only, meaning through objects and pictures, inductive grammar, speaking first; Berlitz's first school opened in 1878.
- Audio-lingual method: grew from the US Army programme of the Second World War; structural linguistics plus behaviourism; dialogues, pattern drills, habit formation, errors prevented.
- CLT: communicative competence; notions and functions (Wilkins, Notional Syllabuses, 1976); authentic materials, information gap, role play; the teacher as facilitator.
- Task-based teaching: meaning-focused tasks with an outcome; N.S. Prabhu's Bangalore Project (1979 to 84); Jane Willis's task cycle (1996).
- Method and name pairs: Silent Way - Caleb Gattegno; Suggestopedia - Georgi Lozanov; Community Language Learning - Charles Curran; TPR - James Asher; Bilingual method - C.J. Dodson.
- The textbook is one resource, not the curriculum: add authentic materials, realia, flash cards, audio and video, and children's literature.
- Language games give purposeful practice in a low-anxiety setting and should involve every child.

> **Quick revision:** Anthony 1963: approach, method, technique; grammar-translation: classical, deductive, translation, speaking neglected; direct method: target language only, inductive, Berlitz 1878; audio-lingual: Army method, behaviourism, pattern drills; structural approach; CLT: 1970s, Wilkins 1976, information gap, facilitator; TBLT: Prabhu's Bangalore Project 1979-84, Willis 1996; Silent Way (Gattegno), Suggestopedia (Lozanov), CLL (Curran); textbook one resource; children's literature; language games.

Assessment in Language, Reading and Writing Difficulties and Remedial Teaching

Assessing language as ability: Language assessment should check what children can do with language, not how much they have memorised. Questions on a lesson already taught often test memory; unseen passages, open-ended questions, and tasks such as writing a message or describing a picture test real ability. Assessment should cover all four skills and be continuous, because a single written examination cannot show listening and speaking. It should improve learning: assessment for learning (formative), assessment as learning (self-assessment and reflection) and assessment of learning (summative).

Assessing the four skills: Listening is assessed through following instructions, answering questions on a story read aloud, listen-and-draw tasks and dictation. Speaking is assessed by observing children during show-and-tell, role play, discussion and storytelling, with checklists or rubrics for fluency, pronunciation, vocabulary, content and confidence. Reading is assessed through reading aloud for fluency, running records (Marie Clay) of the errors a child makes while reading, retelling, comprehension questions at the literal, inferential and evaluative levels, and cloze tests, in which words are deleted from a passage at regular intervals (Wilson Taylor, 1953). Writing is assessed through portfolios of drafts and finished pieces, using rubrics for content, organisation, vocabulary and mechanics. Other tools are anecdotal records, rating scales, self-assessment and peer assessment.

CCE in language: Section 29(2)(h) of the RTE Act 2009 requires comprehensive and continuous evaluation (CCE) of the child's understanding of knowledge and ability to apply it. Continuous means assessment is part of everyday teaching, not only at the end of a term; comprehensive means it covers all aspects of learning, including oral skills, reading habits and attitudes, not only written answers. Formative assessment during learning gives feedback to improve it; summative assessment judges achievement at the end. NEP 2020 calls for a shift from rote-based summative testing to regular, formative, competency-based assessment and a holistic, 360-degree progress card that includes self-assessment and peer assessment.

Errors and mistakes: S. Pit Corder (1967) argued that learners' errors are significant because they reveal the system the learner is building. An error comes from a gap in knowledge and is systematic: the learner repeats it and cannot

correct it even when it is pointed out. A mistake is a slip in performance, from tiredness or haste, which the learner can correct herself. Errors are interlingual when they come from the mother tongue, such as a Bengali speaker saying मेरा किताब for मेरी किताब because Bengali has no grammatical gender, and intralingual when they come from the new language itself, such as over-generalised forms like goed and childs. Error analysis tells the teacher what to teach next.

Diagnosing reading and writing difficulties: Diagnostic assessment looks for the specific cause of a difficulty. Signs of reading difficulty include slow, word-by-word reading, guessing words from the first letter, confusing similar letters such as b and d or घ and ध, losing the place, and poor recall of what was read. Miscue analysis, developed by Kenneth Goodman, studies the kinds of departures from the text a reader makes. Signs of writing difficulty include illegible handwriting, uneven spacing and size, frequent reversals and spelling far below the child's reading level. Dyslexia (difficulty in reading), dysgraphia (in writing) and developmental aphasia (in language) are among the specific learning disabilities listed in the Rights of Persons with Disabilities Act 2016; they are not signs of low intelligence and need early identification and specialist support.

Remedial teaching: Remedial teaching follows diagnosis and targets the specific difficulty, usually in small groups or one to one; it is not repeating the same lesson louder and slower. It may include phonological awareness and phonics practice, multisensory techniques such as tracing letters in sand while saying the sound (the VAKT approach of visual, auditory, kinaesthetic and tactile learning, associated with Grace Fernald), graded readers, paired reading with a classmate, extra time and plenty of encouragement. The cycle is identify, diagnose, plan, teach and reassess. Children who have already mastered a skill get enrichment activities.

The language of a diverse classroom: Indian classrooms include children with different home languages and dialects, first-generation learners, migrant children and children with disabilities. William Labov showed that non-standard dialects are as logical and rule-governed as the standard one, so a child's speech is a difference, not a deficit. The teacher welcomes home languages, accepts answers in the home language in the early grades while building the school language, uses bilingual materials, forms mixed groups so that children help one another, and avoids labelling or comparing children. In CTET terms, the best response to a child who struggles is to find out why and adapt the teaching, not to blame the child or the family.

Examples

- Assess language as ability: unseen passages, open-ended questions and real tasks, not recall of a lesson already taught.
- Listening: following instructions, questions on a story, dictation; speaking: observation with checklists and rubrics during role play and discussion.
- Reading assessment: running records (Marie Clay), miscue analysis (Kenneth Goodman), cloze tests (Wilson Taylor, 1953), comprehension at three levels.
- RTE Act 2009, Section 29(2)(h): comprehensive and continuous evaluation (CCE); NEP 2020: formative, competency-based assessment and a 360-degree progress card.
- Error (Corder, 1967): systematic, from a gap in knowledge, not self-corrected; mistake: a performance slip the learner can correct herself.
- Interlingual error: from the mother tongue (मेरा किताब from a Bengali speaker); intralingual error: from the new language (goed, childs).
- Specific learning disabilities in the RPwD Act 2016 include dyslexia, dysgraphia, dyscalculia, dyspraxia and developmental aphasia.
- Remedial cycle: identify, diagnose, plan, teach, reassess; small groups, multisensory VAKT (Grace Fernald), graded readers, peer support.
- Labov: non-standard dialects are logical and rule-governed; a dialect is a difference, not a deficit; build the school language on the home language.

Quick revision: Assess ability not memory: unseen passages, open tasks; all four skills; for, as and of learning; running records (Clay), miscue analysis (Goodman), cloze (Taylor 1953), rubrics, portfolios; RTE Section 29(2)(h): CCE; NEP 2020: 360-degree progress card; Corder 1967: error (systematic) vs mistake (slip); interlingual vs intralingual; dyslexia, dysgraphia (RPwD Act 2016); remedial: diagnose first, multisensory VAKT (Fernald); Labov: difference not deficit.

Free practice questions: parikshasaathi.com/q/language-pedagogy/

Mathematics Pedagogy

Mathematics Pedagogy

What the exam asks: In CTET Paper I and Paper II, the Mathematics section has 30 questions, of which about 15 are on pedagogical issues. These are mostly classroom scenarios (a child makes an error, a teacher chooses a method or a TLM), interpretation of children's thinking, and recall of theories (Piaget, Bruner, Van Hiele, Dienes, Vygotsky, Polya) and of NCF 2005. The correct option almost always reflects the constructivist, child-centred vision: build on what the child already knows, treat errors as information, use concrete materials before symbols, and avoid rote drill.

Nature of mathematics and NCF 2005: Mathematics is abstract, logical, precise, symbolic, hierarchical (each concept rests on earlier ones) and deductive (results are proved from axioms, not verified by experiment). It is also a language with its own symbols and grammar, and this is why word problems are hard for children: the difficulty is usually linguistic, not computational. NCF 2005 says the main goal of mathematics education is the mathematisation of the child's thought processes. It distinguishes the narrow aim (useful capabilities, especially numeracy) from the higher aim (developing the child's inner resources to think and reason mathematically, pursue assumptions to their logical conclusion and handle abstraction). The NCERT Position Paper on Teaching of Mathematics lists the core problems as fear and failure, a disappointing curriculum, crude assessment and inadequate teacher preparation, and says children should learn to enjoy mathematics and see it as something to talk about and communicate. Processes named in NCF are problem solving, use of heuristics, estimation and approximation, optimisation, use of patterns, visualisation, representation, reasoning and proof, making connections and mathematical communication. The textbook is a tool, not the curriculum.

Children's thinking and informal mathematics: Children arrive with intuitive mathematics from home and the community (counting on fingers, the change a vendor's child computes without pen and paper, measurement with hand spans). This street or folk mathematics is a resource to build on, not an obstacle. Gelman and Gallistel's counting principles are one-to-one correspondence, stable order, cardinality (the last number named tells how many), abstraction and order irrelevance. Pre-number concepts are classification, seriation, one-to-one matching and comparison. Piaget placed primary children in the concrete operational stage (about 7 to 11 years); a child who thinks a spread-out row of five buttons has more than a tightly packed row has not yet conserved number. Bruner's three modes of representation are enactive (doing), iconic (pictures) and symbolic (numerals and signs), which is the basis of the concrete-pictorial-abstract sequence. Van Hiele's levels of geometric thinking run from visualisation (a square is a square because it looks like one) through analysis (listing properties) and informal deduction (a square is a rectangle because it has all the properties of one) to deduction and rigour; the levels are sequential and depend on instruction, not age. Dienes' principles include perceptual variability (show one concept through many materials) and mathematical variability (vary the irrelevant features so the essential one stands out). Vygotsky's zone of proximal development justifies scaffolding and peer work.

Misconceptions and what errors reveal: Errors are systematic and are windows into thinking, so the first response is diagnosis, not more practice. Writing three hundred five as 3005 shows weak place-value understanding. In 52 minus 27 = 35 the child subtracts the smaller digit from the larger in each column, so regrouping is not understood. Five times zero equals five shows zero is treated as having no effect. Believing one-fifth is bigger than one-third because five is bigger than three, or 0.25 is bigger than 0.7 because 25 is bigger than 7, shows whole-number reasoning carried into fractions and decimals. Multiplication always makes bigger and division always makes smaller break down with numbers less than one. Writing 12 in 8 + 4 = __ + 5 shows the equals sign is read as the answer

comes next rather than as a balance. Reading 3a as three apples is the letter-as-object misconception. Thinking shapes with equal perimeter must have equal area confuses the two attributes.

Methods and problem solving: Inductive goes from examples to a rule; deductive from the rule to examples. Analytic starts from what is to be found and works back to what is known; synthetic goes from the known to the unknown. The heuristic method (Armstrong) makes the child a discoverer; the laboratory method uses hands-on activity; the project method (Kilpatrick) uses purposeful real-life tasks; play-way suits early classes. Polya's four steps are understand the problem, devise a plan, carry out the plan and look back. Open-ended problems have many correct answers or routes; problem posing (asking children to make a problem) is a creative, higher-order task. Mental mathematics, estimation and meaningful practice are valued; algorithms should follow understanding, not replace it.

Teaching-learning materials: Dienes blocks and the abacus for place value; number line for integers and operations; geoboard and dot paper for shapes, area and perimeter; tangram for spatial sense; Cuisenaire rods for number relationships; fraction strips and paper folding for fractions; unit cubes for volume; a pan balance for the meaning of equality. Measurement should move from direct comparison to non-standard units to standard units, and 3D solids should be explored before 2D figures because children handle objects first. Data handling at primary level begins with pictographs and tally marks.

Assessment and planning: Formative assessment is continuous and used to improve learning; summative is at the end. Diagnostic tests locate the exact difficulty, and remedial teaching follows them. CCE, rubrics, portfolios, oral assessment and open-book tests let the teacher assess processes and reasoning, not just final answers. Bloom's revised taxonomy (remember, understand, apply, analyse, evaluate, create) helps design questions; asking a child to write a word problem for 24 divided by 6 is a create-level task. Herbartian steps are preparation, presentation, association, generalisation and application; the constructivist 5E model is engage, explore, explain, elaborate, evaluate.

Traps: Maths anxiety comes from fear of failure, timed tests, public shaming and emphasis on speed and one right method, not from the subject itself. Gender stereotypes (boys are better at maths) are learnt, and teachers must counter them. Indian contributions, such as Brahmagupta's rules for zero and the decimal place-value system, can be used for motivation. In the exam, options that recommend more drill, memorising rules, or labelling the child are usually inconsistent with NCF 2005.

Examples

- NCF 2005 in one line: the main goal of mathematics education is the mathematisation of the child's thought processes; narrow aim = numeracy, higher aim = thinking mathematically.
- Bruner's EIS: Enactive (do it with objects), Iconic (draw it), Symbolic (write 3 x 4 = 12). Same as concrete-pictorial-abstract.
- Van Hiele ladder: Visualisation, Analysis, Informal deduction, Deduction, Rigour. A child who says a square is a rectangle because it has all its properties is at informal deduction.
- Gelman and Gallistel counting principles: one-to-one, stable order, cardinality, abstraction, order irrelevance. Counting 1, 2, 3, 5, 6 breaks stable order.
- 52 - 27 = 35 is not carelessness: the child subtracts the smaller digit from the larger in each column and has not understood regrouping.
- Whole-number reasoning in fractions: a child says 1/5 > 1/3 because 5 > 3, and 0.25 > 0.7 because 25 > 7. Fix with fraction strips and a number line, not a rule.
- 8 + 4 = __ + 5 answered as 12 shows the equals sign is read as 'answer comes next'; a pan balance shows it means 'is the same as'.
- Polya's four steps: Understand, Plan, Carry out, Look back. Looking back means checking and reflecting on the solution.
- Inductive = examples to rule; Deductive = rule to examples. Analytic = unknown to known (why?); Synthetic = known to unknown (how?).

- TLM match: Dienes blocks and abacus for place value, geoboard for area and perimeter, tangram for spatial sense, Cuisenaire rods for number relationships, pan balance for equality.
- Herbart: Preparation, Presentation, Association, Generalisation, Application. 5E: Engage, Explore, Explain, Elaborate, Evaluate.
- Bloom revised: Remember, Understand, Apply, Analyse, Evaluate, Create. Asking a child to make a word problem for 24 / 6 is a create-level task.

> **Quick revision:** NCF 2005: mathematisation of thought; narrow aim numeracy, higher aim mathematical thinking; Position Paper problems: fear and failure, curriculum, assessment, teacher preparation; Piaget concrete operational 7-11, conservation of number; Bruner enactive-iconic-symbolic; Van Hiele visualisation, analysis, informal deduction, deduction, rigour; Dienes perceptual and mathematical variability; Polya understand, plan, carry out, look back; errors are systematic windows into thinking, diagnose first; 1/5 > 1/3 and 0.25 > 0.7 are whole-number reasoning; equals sign is a balance; Herbart 5 steps, 5E model.

Nature of Mathematics: Logic, Patterns, Inductive and Deductive Reasoning

What kind of subject mathematics is: Mathematics deals with ideas, not with objects. The number 3 is not three mangoes or three pencils; it is what every collection of three has in common, so even the simplest numeral is an abstraction. Mathematics is logical (each step follows from the earlier ones), precise (a square has four equal sides and four right angles, not just a box shape), symbolic (an idea is compressed into signs such as $3 + 4 = 7$ or $a \times b = b \times a$) and hierarchical or sequential (place value rests on grouping, multiplication on addition). It is also cumulative: a result Euclid proved around 300 BCE is still true, because mathematical truth is settled by proof, not by experiment, majority opinion or the teacher's authority. Because mathematics is hierarchical, a gap in an early concept shows up years later.

Mathematics as the study of patterns: Mathematics is often described as the science of patterns: patterns in numbers (2, 4, 6, 8 or 1, 4, 9, 16), in shapes (tiles, borders, rangoli), in operations (adding 9 is adding 10 and taking away 1) and in data. Recognising, extending, describing and creating patterns is where algebraic thinking begins. A child who says that each new square in a row of matchstick squares needs 3 more matchsticks is already generalising, long before letters are used. The teacher asks children to state the rule in their own words and predict a later term.

Inductive reasoning: Induction moves from particular cases to a general rule. Children add 1, $1 + 3$, $1 + 3 + 5$ and $1 + 3 + 5 + 7$, get 1, 4, 9 and 16, and notice that the sum of the first few odd numbers is always a square number; or they measure the angles of several triangles they have drawn and find each total close to 180°. Induction is natural for children, suits the primary classes and is how conjectures are formed, but it does not prove anything. The expression $n^2 + n + 41$ gives a prime number for every n from 0 to 39, yet at $n = 40$ it gives 1681, which is 41×41. A pattern seen in many cases can still fail, so an inductive conclusion is a strong guess that needs checking.

Deductive reasoning and proof: Deduction moves from a general statement already accepted to a particular conclusion that must be true. If the angles of every triangle add up to 180° and two angles are 60° and 70°, the third must be 50°. Formal mathematics is deductive: it starts from undefined terms (point, line, plane), definitions, and axioms or postulates assumed to be true, and proves theorems from them; Euclid's Elements, built on definitions, postulates and axioms, is the classic model. Deduction gives certainty but is abstract, so it suits older learners in Piaget's formal operational stage (from about 11 years). A single counterexample disproves a general claim: 'all prime numbers are odd' fails because of 2. The principle of mathematical induction, despite its name, is a method of deductive proof. The inductive-deductive method uses induction to discover a rule and deduction to justify it.

How children think mathematically: Children are not empty vessels; they build their own strategies. A child who works out $9 + 6$ as $10 + 5$, or $49 + 49$ as $50 + 50$ minus 2, is reasoning about the structure of numbers and should be asked to explain it. In Piaget's concrete operational stage (about 7 to 11 years) children reason logically about objects they can see and handle and understand reversibility (if $3 + 5 = 8$, then $8 - 5 = 3$), but purely verbal or hypothetical reasoning is hard for them. Reasoning at the primary level means justifying, so the most useful

questions are 'How do you know?' and 'Will this always work?'. Logical thinking grows through sorting, comparing, ordering, finding the odd one out and making if-then statements.

NCF 2005 and mathematisation: NCF 2005 makes the mathematisation of the child's thought processes the main goal of school mathematics: the ability to look at a situation mathematically, pick out its quantities and relations, represent them with numbers, diagrams, tables or symbols, work on that representation and interpret the result in the situation. Its Position Paper on Teaching of Mathematics bases its vision on twin premises: all students can learn mathematics, and all students need to learn mathematics. It wants children to enjoy mathematics rather than fear it, to see it as more than formulas and mechanical procedures, to talk about it and work on it together, to pose and solve meaningful problems, and to use abstraction to see relationships and structures and to argue the truth or falsity of statements. As the paper puts it, quoting David Wheeler, it is more useful to know how to mathematise than to know a lot of mathematics.

Exam angle: In CTET, 'mathematics is mainly fast calculation or memorising formulas' is the wrong option. Finding a rule from examples is inductive; applying a known rule or proving a result is deductive. When a child uses an unusual strategy, ask her to explain it, because the reasoning matters more than the answer.

Examples

- Nature of mathematics: abstract, logical, precise, symbolic, hierarchical (sequential) and cumulative; its truths are established by proof, not by experiment or authority.
- Mathematics is called the science of patterns; extending and describing patterns (each new matchstick square needs 3 more sticks) is the start of algebraic thinking.
- Inductive reasoning: particular to general (examples to rule); natural for children and good for discovery, but it gives a conjecture, not a proof.
- Deductive reasoning: general to particular (rule to example); gives certainty; suits older learners; formal geometry proves theorems from axioms and postulates.
- Children adding 1, 1 + 3, 1 + 3 + 5 and getting square numbers each time are using induction; using the angle sum of 180° to find a missing angle is deduction.
- $n^2 + n + 41$ is prime for every n from 0 to 39, but at n = 40 it gives 1681 = 41 × 41: a pattern seen many times is still not a proof.
- One counterexample disproves a general claim: 2 is an even prime, so 'all primes are odd' is false.
- Euclid's Elements (about 300 BCE): definitions, postulates and axioms lead to theorems by proof, the model of deductive mathematics; Euclid tried to define point and line, which modern geometry takes as undefined terms.
- Piaget: concrete operational (about 7 to 11 years) reasons with real objects and understands reversibility (3 + 5 = 8, so 8 − 5 = 3); formal operational (from about 11) reasons hypothetically and deductively.
- NCF 2005: the main goal is mathematisation of the child's thought processes; its Position Paper on Teaching of Mathematics rests on twin premises (all students can learn mathematics and all need to learn it) and quotes David Wheeler: it is more useful to know how to mathematise than to know a lot of mathematics.

> **Quick revision:** Mathematics is abstract, logical, precise, symbolic, hierarchical and cumulative, the science of patterns; truth by proof; induction: examples to rule, gives a conjecture; deduction: rule to example, gives certainty; one counterexample disproves; Euclid: axioms to theorems; Piaget concrete operational 7-11, formal from 11; NCF 2005 goal: mathematisation of the child's thought; Position Paper: all can and all need to learn mathematics; Wheeler: knowing how to mathematise matters more than knowing a lot of mathematics.

Place of Mathematics in the Curriculum: Aims, NCF 2005 Position Paper and NEP 2020

Why every child studies mathematics: Mathematics is a core subject of school education because it serves several purposes at once. Its utilitarian value lies in daily life: buying and selling, reading time and calendars, measuring cloth or land, and budgeting. Its disciplinary value lies in training the mind to reason, to be precise and to follow an argument. Its cultural value comes from its place in human heritage, including India's gifts of zero and the decimal place-value system. Its aesthetic value appears in symmetry, tiling, rangoli and the beauty of patterns, and its social value in the fair sharing, data and planning that every community needs.

Narrow and higher aims: NCF 2005 separates two aims. The narrow aim is to develop useful capabilities, particularly numeracy: numbers, number operations, measurement, decimals and percentages. The higher aim is to develop the child's inner resources to think and reason mathematically, to pursue assumptions to their logical conclusion and to handle abstraction, including the ability and attitude to formulate and solve problems. The narrow aim is necessary but not enough: a child taught only to compute can add a bill but may not be able to decide whether 'buy 2, get 1 free' is a better deal than a 30 percent discount. NCF 2005 also asks for a curriculum that is ambitious (it aims at the higher aim), coherent (arithmetic, algebra and geometry connect into one ability to solve problems) and important (it deals with problems worth solving).

The Position Paper on Teaching of Mathematics: Prepared by one of the 21 National Focus Groups set up for NCF 2005, the paper names four core problems: a sense of fear and failure among most children; a curriculum that disappoints both a talented minority and the non-participating majority; crude methods of assessment that encourage the perception of mathematics as mechanical computation; and a lack of teacher preparation and support. Its recommendations answer them one by one: shift the focus from the narrow aims to the higher aims; engage every student with a sense of success while offering conceptual challenges to the emerging mathematician; change assessment so that it examines students' mathematisation abilities rather than procedural knowledge; and enrich teachers with a variety of mathematical resources.

What each stage should emphasise: The Position Paper gives stage-wise priorities. At the pre-primary stage all learning occurs through play rather than didactic teaching: instead of reciting the number sequence by rote, children link counting with quantity in small sets and make simple comparisons and classifications, one dimension at a time. At the primary stage a positive attitude towards and a liking for mathematics matter as much as the skills learnt; number and operations are built from concrete experience along with spatial understanding, measurement and data handling, and games, puzzles and stories connect mathematics with everyday thinking. At the upper primary stage children get their first taste of the power of mathematics through abstract ideas, such as algebraic notation, that compress earlier learning. At the secondary stage they begin to see the structure of mathematics as a discipline, with proof, modelling and data analysis.

Linking with life and other subjects: The first guiding principle of NCF 2005 is connecting knowledge to life outside the school, and mathematics links naturally with other subjects. In EVS children read maps and record the weather in tables; in language they meet number rhymes and stories; in science they measure and draw graphs; in social science they use scale and directions; in art they make symmetric designs; in physical education they record scores and times. Integration does not mean losing the mathematics in a theme: the teacher plans the mathematical idea first and then picks a real context that needs it, such as planning the cost of a class picnic or surveying how children come to school and drawing a pictograph.

NEP 2020 and foundational numeracy: NEP 2020 calls foundational literacy and numeracy (FLN) an urgent national mission and the highest priority of the school system, because the ability to read, write and perform basic operations with numbers is an indispensable prerequisite for all later learning. It aimed at universal FLN in primary school by 2025 and proposed a 3-month play-based school preparation module for Grade 1. Its 5+3+3+4 structure begins with a Foundational stage of 5 years (3 years of pre-school or Anganwadi plus Grades 1 and 2, ages 3 to 8), followed by the Preparatory (Grades 3 to 5), Middle (Grades 6 to 8) and Secondary (Grades 9 to 12) stages. It stresses mathematical and computational thinking from the foundational stage through puzzles and games.

NIPUN Bharat in brief: To carry out the FLN mission, the Ministry of Education launched NIPUN Bharat (National Initiative for Proficiency in Reading with Understanding and Numeracy) in 2021, with the goal that every child achieves foundational literacy and numeracy by the end of Grade 3, by 2026-27. The NCF for the Foundational Stage (2022) then set out the curriculum for ages 3 to 8, built on play, activity and conversation. In CTET, options saying that mathematics is mainly for the bright few, or mainly a preparation for competitive exams, contradict the premise that all children can learn it.

Examples

- Values of teaching mathematics: utilitarian (daily life), disciplinary (trains reasoning), cultural (heritage such as zero and place value), aesthetic (symmetry, patterns) and social.

- NCF 2005 narrow aim: useful capabilities, especially numeracy. Higher aim: think and reason mathematically, pursue assumptions to their logical conclusion, handle abstraction, formulate and solve problems.
- A good mathematics curriculum (NCF 2005) is ambitious (higher aim), coherent (arithmetic, algebra and geometry connected) and important (problems worth solving).
- Position Paper core problems: fear and failure; a curriculum that disappoints the talented minority and the non-participating majority; crude assessment; poor teacher preparation and support.
- Position Paper recommendations: shift to higher aims; success for every student with challenge for the emerging mathematician; assess mathematisation, not procedure; enrich teachers' resources.
- Stage-wise: pre-primary through play; primary, a positive attitude and liking for mathematics; upper primary, first taste of the power of abstraction (algebra); secondary, structure of mathematics, proof and modelling.
- NEP 2020: FLN is an urgent national mission; universal FLN in primary school by 2025; 5+3+3+4 structure with a Foundational stage of ages 3 to 8 (pre-school plus Grades 1 and 2).
- NIPUN Bharat (2021, Ministry of Education): every child to achieve foundational literacy and numeracy by the end of Grade 3, by 2026-27.
- Integration in practice: a pictograph of how children come to school (EVS), symmetric rangoli (art), a class picnic budget (daily life).

> **Quick revision:** Values: utilitarian, disciplinary, cultural, aesthetic, social; NCF 2005 narrow aim numeracy, higher aim mathematical thinking; curriculum ambitious, coherent, important; Position Paper problems: fear and failure, curriculum, crude assessment, teacher support; recommendations: higher aims, success for all, assess mathematisation, teacher resources; NEP 2020 FLN mission, 5+3+3+4; NIPUN Bharat 2021: FLN by end of Grade 3 by 2026-27.

Language of Mathematics, Word Problems and Community Mathematics

Mathematics as a language: Mathematics has its own symbols (+, −, ×, ÷, =, <, >, %), its own vocabulary (numerator, perimeter, quotient, parallel) and its own grammar, in which order and position carry meaning: 52 is not 25, 8 − 5 is not 5 − 8, and 3a means 3 × a. A symbol compresses an idea, so a child who reads symbols without the idea behind them is reading a language she does not understand. Symbols should therefore come after experience and talk, not before: first the action (putting 3 marbles and 4 marbles together), then everyday words ('3 and 4 more make 7'), then mathematical words ('the sum'), and only then 3 + 4 = 7.

Words that mean something else: Many mathematical words are ordinary words with a special meaning, such as table, product, difference, volume, odd, mean, face, degree, power and right (as in right angle). Some phrases reverse the order in which the symbols are written: '5 less than 8' is 8 − 5, and 'subtract 3 from 10' is 10 − 3. Children who have learnt key-word tricks ('more means add, left means subtract') go wrong when the words are not a reliable guide: 'Ravi has 12 marbles. He has 5 more than Sita. How many does Sita have?' contains 'more', yet the answer is 12 − 5 = 7. The remedy is to make sense of the situation, by acting it out or drawing it, rather than hunting for key words.

Why word problems are hard: In word problems the difficulty is often in reading and understanding rather than in calculating. Newman's error analysis (Anne Newman, 1977) follows the stages a child must pass through: reading the problem, comprehending it, transforming it into a mathematical form, using process skills to compute, and encoding the answer back in the terms of the problem. Many errors happen before any arithmetic is done. The teacher helps by reading the problem aloud, asking children to retell it in their own words, drawing or acting it out, using familiar names and contexts, and asking children to make up a story for a number sentence such as 20 ÷ 4, which shows whether they understand the operation.

Home language and school mathematics: Children come to school with a home language that may differ from the language of the textbook, and their number words may follow different patterns. Most Hindi number names from 11 to 99 say the ones before the tens: सत्तावन (57) is literally seven and fifty, while the numeral is written tens first, which can lead to reversals such as writing 75. A name such as उनतीस (29) means one less than thirty, and the English names for 13 to 19 also say the ones first. A child who handles quantities well in her mother tongue may look weak

only because the school words are new. NCF 2005 treats multilingualism as a resource: let children reason and explain in the language they know, accept their informal words, and then bridge to the standard terms.

Ethnomathematics: Children also bring mathematics from home and community. The Brazilian mathematician Ubiratan D'Ambrosio gave the name ethnomathematics to the mathematics practised by cultural groups: weavers counting threads for a border pattern, masons and carpenters measuring and setting right angles, farmers estimating land and harvest, women drawing symmetric kolam and rangoli on a grid of dots, potters and tailors working with shapes and sizes, and traditional units such as the hand span (बालिश्त), the cubit (हाथ) and the bigha. A well-known study of child street vendors in Brazil by Carraher, Carraher and Schliemann (1985) found that children who calculated correctly while selling often failed the same sums when they were written in school form: the knowledge was real, but school had not connected with it.

Using community mathematics in class: The teacher treats this knowledge as a starting point, not as wrong or unscientific. She can set up a classroom shop with real price lists, ask children how their families measure land, grain or cloth, invite a mason or tailor to show their methods, compare a local unit with a standard unit, and accept children's own mental methods before teaching the standard written algorithm. India's heritage helps too: the Lilavati of Bhaskaracharya (12th century) taught arithmetic through verse problems about everyday situations. When school mathematics respects the mathematics of the home and the market, children see that they are already mathematical thinkers.

Exam angle: When a child solves sums orally in the market but fails in written form, the right step is to build on the informal method and connect it to written symbols. When a child struggles with word problems, the right step is to work on language and comprehension (retelling, drawing, acting out), not to give more computation practice. Rejecting a child's home language, local units or own method is always the wrong option.

Examples

- Order carries meaning in mathematical language: 52 is not 25, 8 – 5 is not 5 – 8, and '5 less than 8' is written 8 – 5.
- Ordinary words with special meanings in mathematics: table, product, difference, volume, odd, mean, face, degree, power, right.
- Key-word trap: 'Ravi has 12 marbles, 5 more than Sita. How many has Sita?' says 'more' but needs 12 – 5 = 7. Teach children to understand the situation, not to hunt for key words.
- Sequence for symbols: action with objects, then everyday words, then mathematical words, then symbols (3 + 4 = 7).
- Newman's error analysis (1977): reading, comprehension, transformation, process skills, encoding; many word-problem errors happen before any calculation.
- Problem posing: asking children to write a story for 20 ÷ 4 checks whether they understand division as equal sharing or grouping.
- Hindi number names say the ones first: सत्तावन (57) is seven and fifty, which can cause reversals like 75; उनतीस (29) means one less than thirty.
- Ethnomathematics: name given by the Brazilian mathematician Ubiratan D'Ambrosio to the mathematics of cultural groups such as weavers, masons, farmers and kolam or rangoli makers.
- Carraher, Carraher and Schliemann (1985): Brazilian child vendors computed correctly in the market but often failed the same sums in written school form.
- Bhaskaracharya's Lilavati (12th century) taught arithmetic through verse problems on everyday situations.

> **Quick revision:** Mathematics has symbols, vocabulary and grammar; order matters (8 – 5 is '5 less than 8'); symbols after action and talk; key-word tricks fail; Newman: reading, comprehension, transformation, process skills, encoding; problem posing; Hindi names say ones first (सत्तावन 57); multilingualism is a resource; ethnomathematics (D'Ambrosio); Brazilian street vendors study 1985; build on home and market mathematics.

How Children Learn Number, Place Value and Geometry

Pre-number concepts: Before numbers make sense, a child needs some logical abilities that Piaget studied. Classification is sorting objects by a common property such as colour, shape or size, first by one attribute and later by two at once; it underlies the idea of a set. Class inclusion is understanding that a subclass is part of a larger class:

shown 7 roses and 3 lilies and asked 'Are there more roses or more flowers?', a pre-operational child says more roses. Seriation is arranging objects in order of size or length, which underlies the ordinal idea of number (first, second, third) and transitivity (if A is longer than B and B is longer than C, then A is longer than C). One-to-one correspondence, such as matching each cup with one saucer, lets a child compare two sets without counting.

Conservation and counting: Conservation is understanding that a quantity stays the same when only its appearance changes. A child who thinks a spread-out row of 5 buttons has more than a packed row is centring on one dimension, the length of the row, and lacks reversibility, the ability to move the buttons back in her mind. Conservation of number usually appears at about 6 to 7 years, well before conservation of weight and volume; Piaget called this uneven, domain-by-domain development horizontal décalage. Counting grows from rote counting (reciting number names) to rational counting (one number name for each object, with the last name telling how many). Subitising, seeing small quantities up to about 4 at a glance without counting, is built with dot cards, dice and finger patterns, and part-whole thinking (7 is 5 and 2, or 4 and 3) prepares the ground for addition and subtraction.

Place value: Place value is the idea that the value of a digit depends on its position: in 352 the face value of 5 is 5, but its place value is 50. It rests on grouping by tens and on zero as a placeholder, and weak place value is a major source of arithmetic errors in the primary classes. Children should first group real objects, bundling 10 sticks into a bundle and 10 bundles into a big bundle. Proportional models such as bundled sticks and Dienes blocks (unit, long, flat and cube for 1, 10, 100 and 1000), in which a ten really is ten times bigger, should come before non-proportional models such as the abacus, money or a place-value chart, where one bead or one ₹10 note stands for ten only by agreement. Exchange games (trade 10 units for 1 long) and expanded form (352 = 300 + 50 + 2) link the material to the written numeral. The Indian system groups digits as thousands, lakhs and crores (1,00,000); the international system as thousands and millions (100,000).

Van Hiele levels in depth: Pierre van Hiele and Dina van Hiele-Geldof, Dutch teachers, described five levels of geometric thinking, numbered 0 to 4 in some books and 1 to 5 in others: visualisation, analysis, informal deduction, deduction and rigour. Three features matter for teachers. The levels are sequential, so none can be skipped; progress depends on instruction and experience, not on age; and each level has its own language, so a teacher speaking at the deductive level to a child at the visual level is not understood, and the child may memorise without meaning. Most primary children are at the first two levels, recognising shapes first by appearance and then by their properties. The van Hieles also described five phases of learning that move a child up a level: information (inquiry), guided orientation, explicitation (putting it into words), free orientation and integration.

Spatial understanding: Piaget and Inhelder found that children's ideas of space develop from topological ideas (inside and outside, near and far, open and closed, order) through projective ideas (how an object looks from different viewpoints) to Euclidean ideas (length, angle, parallel lines, measurement). This is why primary geometry begins with the words of position (above, below, left, right, in front of, behind), with real 3D objects such as balls, boxes and cans before 2D shapes, and with tracing the faces of a box to find squares and rectangles. Spatial sense grows through drawing the top view and side view of objects, making and folding nets of a cube, finding lines of symmetry with mirrors and paper folding, reading simple maps of the classroom or the way to school, and making shapes with tangram pieces.

Classroom implications: Each idea needs experience before words and words before symbols. A teacher whose Class 1 child says the longer row has more buttons does not simply tell her the right answer; she lets the child match the buttons one-to-one and count both rows. A Class 3 child who writes four hundred six as 4006 needs bundles and Dienes blocks, not more dictation. A child who says a tilted square is not a square needs to see and handle squares of many sizes in many positions. In each case the teacher works on the concept that the error reveals.

Examples

- Class inclusion test: shown 7 roses and 3 lilies and asked 'more roses or more flowers?', a pre-operational child says more roses.
- Seriation: ordering by size or length; it underlies ordinal number (first, second, third) and transitivity (A > B and B > C, so A > C).

- Conservation: a quantity stays the same when its arrangement changes; it needs reversibility and decentring; number is conserved at about 6 to 7 years, volume much later; the uneven order is horizontal décalage.
- Rote counting is reciting number names; rational counting is one name per object, with the last name telling how many.
- Subitising: knowing small quantities (up to about 4) at a glance without counting; built with dot cards, dice and finger patterns.
- Place value: in 352 the face value of 5 is 5 and its place value is 50; expanded form 352 = 300 + 50 + 2; zero is a placeholder.
- Proportional models (bundled sticks; Dienes blocks: unit, long, flat, cube = 1, 10, 100, 1000) come before non-proportional ones (abacus, money, place-value chart).
- Van Hiele levels are sequential, cannot be skipped, depend on instruction not age, and each has its own language; learning phases: information, guided orientation, explicitation, free orientation, integration.
- Piaget and Inhelder: ideas of space go from topological (inside, near, open-closed) to projective (viewpoints) to Euclidean (length, angle, measurement); so 3D objects come before 2D shapes.

> **Quick revision:** Pre-number: classification, class inclusion, seriation, one-to-one correspondence, conservation (number at about 6-7, horizontal décalage); rote vs rational counting; subitising; place value: face value vs place value, grouping in tens, zero as placeholder; proportional models (bundles, Dienes) before abacus and money; Van Hiele 5 levels, sequential, instruction-dependent, 5 phases; space: topological, projective, Euclidean; 3D before 2D.

Teaching Approaches and Materials: CPA, Play-Way, Manipulatives and Problem Solving

Concrete-pictorial-abstract: The CPA sequence rests on Bruner's three modes of representation, enactive, iconic and symbolic. At the concrete stage children handle objects: they make 3 groups of 4 bottle caps. At the pictorial stage they draw or see the same thing: 3 rows of 4 dots, a bar model or equal jumps on a number line. At the abstract stage they write 3 × 4 = 12. The stages are linked, not just passed through: the teacher keeps asking children to connect the symbol with the picture and the object ('Show me where the 3 is in your drawing'), and a child who is stuck at the symbolic level is taken back to pictures or objects, not given more symbols.

Play-way and activity-based learning: Play is a young child's natural way of learning, and the Position Paper says all learning at the pre-primary stage occurs through play. Froebel's kindergarten used gifts (balls, blocks and shapes), Montessori designed self-correcting materials such as number rods and the spindle box, and Henry Caldwell Cook's book The Play Way (1917) gave the method its name. In mathematics, play means games with a purpose: snakes and ladders for counting on, dice and card games for number facts, a classroom shop for money, hopscotch for number order, and puzzles that need reasoning. Activity-based learning, following John Dewey's idea of learning by doing, has children measure the classroom, sort leaves, survey their friends or fold paper to find fractions, and then talk about what they found.

Manipulatives and what each teaches: Dienes blocks (multibase blocks, developed by Zoltan Dienes) model place value and regrouping; Dienes also designed attribute blocks for classification and logic. The abacus shows place value with beads on rods. Cuisenaire rods, 10 coloured rods of lengths 1 to 10 cm devised by the Belgian teacher Georges Cuisenaire and spread by Caleb Gattegno, show number relations such as 3 + 7 = 10, and also fractions. The geoboard, a board with a grid of pegs on which rubber bands make shapes, was also popularised by Gattegno and serves for shapes, area and perimeter. The tangram is a Chinese puzzle of 7 pieces (5 triangles, 1 square and 1 parallelogram) for spatial sense and composing shapes. Other useful materials are the number line, fraction strips, place-value cards, a pan balance, a clock, a measuring tape, mirrors for symmetry and no-cost items such as seeds, matchsticks, bangles and bottle caps. Materials do not teach by themselves: understanding comes from acting on them and reflecting, and the teacher must deliberately link each action to the written symbol.

Problem solving with Polya: George Polya's How to Solve It (1945) describes four steps. Understand the problem: what is known, what is asked, can you say it in your own words? Devise a plan: choose a strategy (heuristic) such as drawing a picture, making a table, looking for a pattern, guess and check, working backwards or solving a simpler problem. Carry out the plan, checking each step. Look back: check the answer against the question, try another method and ask whether the method works for other problems. A real problem is one where the way to the answer is

not known in advance; an exercise only practises a known procedure. Children need both, and problem posing, making up their own problems, goes a step further.

Projects and other methods: The project method of William Heard Kilpatrick (1918), based on Dewey's ideas, is a purposeful activity carried out in a social setting. Its steps are usually given as providing a situation, choosing (purposing), planning, executing, evaluating (judging) and recording. Mathematics projects include surveying the class's favourite fruits and drawing a bar graph, planning a class picnic within a budget, measuring the school ground, or keeping a family expenditure record for a month. The laboratory method uses hands-on investigations in a mathematics lab or corner; the heuristic or discovery method (Armstrong; Bruner's discovery learning) makes the child a finder; and cooperative group work lets children compare strategies. Lecture and demonstration have a place, but should not be the main method.

Choosing a method: The best method depends on the concept and the children. Concrete materials and play suit young children and new concepts; pictorial models bridge to symbols; problem solving and projects develop the higher aims; and practice is still needed, but after understanding and in meaningful forms such as games. In CTET, an option that starts with objects or a real situation and moves to symbols, or that lets children discover a rule, is usually preferred over one that begins by stating the rule or formula.

Examples

- CPA: concrete (3 groups of 4 caps), pictorial (3 rows of 4 dots or a bar model), abstract (3 × 4 = 12); based on Bruner's enactive, iconic and symbolic modes.
- Play-way: Froebel's gifts, Montessori's number rods and spindle box, Caldwell Cook's The Play Way (1917); snakes and ladders teaches counting on.
- Dienes blocks (unit, long, flat, cube) model place value and regrouping; Zoltan Dienes also made attribute blocks for classification.
- Cuisenaire rods: 10 coloured rods of 1 to 10 cm by Georges Cuisenaire, spread by Caleb Gattegno; used for number relations and fractions.
- Geoboard: pegs and rubber bands for shapes, area and perimeter. Tangram: 7 pieces (5 triangles, 1 square, 1 parallelogram) for spatial sense.
- Polya, How to Solve It (1945): understand, devise a plan, carry out the plan, look back; strategies include drawing, a table, a pattern, guess and check, working backwards and a simpler problem.
- A problem has no known path to the answer; an exercise practises a known procedure. Problem posing is making up one's own problems.
- Kilpatrick's project method (1918): situation, purposing, planning, executing, evaluating, recording; for example a class fruit survey shown as a bar graph.
- Materials do not teach by themselves: the teacher links each action on the material to the written symbol.

> **Quick revision:** CPA from Bruner: objects, pictures, symbols, linked both ways; play-way: Froebel gifts, Montessori materials, Caldwell Cook 1917; activity-based learning by doing (Dewey); Dienes blocks for place value, abacus, Cuisenaire rods (Gattegno), geoboard, tangram 7 pieces; Polya 1945: understand, plan, carry out, look back; problem vs exercise; Kilpatrick project method 1918; discover the rule before stating it.

Errors and Misconceptions in Arithmetic, Fractions, Decimals and Geometry

Slips, errors and misconceptions: Not every wrong answer is of the same kind. A slip is a careless, random mistake, such as copying a digit wrongly, which the child corrects at once when asked to check. A systematic error recurs in the same way across many items because the child is following a consistent but faulty rule; Brown and Burton (1978) called such rules buggy algorithms. A misconception is the underlying belief that produces systematic errors, often a rule that worked for whole numbers stretched too far. Slips need checking habits; systematic errors and misconceptions need teaching aimed at the concept.

Errors in whole-number arithmetic: In addition, 47 + 38 = 715 shows the child writing each column's total in full instead of regrouping 15 as 1 ten and 5 ones, and 47 + 38 = 75 shows the carried ten forgotten (the answer is 85). In subtraction, besides taking the smaller digit from the larger in each column, children go wrong when borrowing

across zero: 503 − 168 = 435 (the answer is 335) shows that the 0 in the tens place became 9 but the 5 hundreds were not reduced to 4. In multiplication, 23 × 14 = 115 shows the second partial product (23 × 10 = 230) written as 23 without its place value; the answer is 322. In division, 618 ÷ 6 = 13 (the answer is 103) shows a 0 in the quotient dropped because 6 does not go into 1. Each of these points to weak place value, not to weak tables.

Errors with fractions: Many fraction errors come from treating the numerator and the denominator as two separate whole numbers. 1/2 + 1/3 = 2/5 adds tops and bottoms; a quick check shows it cannot be right, since 2/5 is less than 1/2, one of the numbers being added. Saying 1/5 > 1/3 because 5 > 3 ignores that more equal parts means smaller parts. Calling any one of 4 unequal pieces one-fourth shows that the need for equal parts is not understood. Not seeing that 2/4 and 1/2 name the same amount shows that fractions are not yet seen as numbers with a place on the number line. Fraction strips, paper folding, sharing rotis equally and marking fractions on a number line help.

Errors with decimals and measurement: The longer-is-larger misconception (0.25 > 0.7, 0.125 > 0.5) carries whole-number thinking into decimals; the opposite shorter-is-larger misconception (0.3 > 0.35, because tenths are bigger than hundredths) also occurs. 0.3 × 0.2 = 0.6 (the answer is 0.06) shows that decimal places are not understood, and lining up the last digits instead of the decimal points when adding shows the point is treated as a separator rather than as a marker of place value. In measurement, children often start from 1 instead of 0 on the ruler or count the marks instead of the spaces between them, and many believe that two figures with the same perimeter must have the same area.

Errors in geometry and algebra: Children at the visual van Hiele level think that a square turned on its corner is a diamond and not a square, that a triangle must stand on a horizontal base, and that a square cannot be a rectangle. Many think an angle is bigger when its arms are drawn longer, because they look at length rather than the amount of turn. In early algebra, besides reading 3a as three apples, children write 2a + 3b = 5ab, think a letter must stand for one particular number, or assume that different letters cannot have the same value.

Error analysis: Error analysis is the teacher's systematic study of a child's mistakes to find the rule behind them. She collects several pieces of the child's work, looks for a pattern across items, forms a hypothesis ('he does not regroup'), tests it with a few designed items, and confirms it by asking the child to think aloud ('Tell me how you did this'), the clinical interview method Piaget used. Teaching then targets the misconception, often through cognitive conflict: the child meets a result that contradicts his rule, such as seeing that 2/5 is less than 1/2, and reorganises his idea (Piaget's disequilibrium and accommodation). Simply marking the answer wrong, re-teaching in the same way or setting more drill of the same type does not change the underlying idea.

What errors reveal: Errors show that children are actively making sense and applying rules they have constructed, often by overgeneralising from whole numbers. They are therefore information and a normal part of learning, not a sign of laziness to be punished. In CTET, an option saying that the error shows what the child has not yet understood, or that the teacher should find out how the child is thinking, is usually correct; an option saying the child is careless or needs more practice of the same kind usually is not.

Examples

- Slip: careless, random, corrected on checking. Systematic error: a consistent faulty rule (a buggy algorithm, Brown and Burton 1978). Misconception: the belief behind it.
- 47 + 38 = 715: column totals written in full, no regrouping. 47 + 38 = 75: carried ten forgotten. The answer is 85.
- 503 − 168 = 435: borrowing across zero, the tens became 9 but the hundreds were not reduced; the answer is 335.
- 23 × 14 = 115: second partial product written as 23 instead of 230 (answer 322). 618 ÷ 6 = 13: zero in the quotient dropped (answer 103).
- 1/2 + 1/3 = 2/5 adds tops and bottoms; check: 2/5 is less than 1/2, so it cannot be the sum.
- A fraction needs equal parts: calling one of 4 unequal pieces one-fourth is a misconception.
- Decimals: longer is larger (0.25 > 0.7), shorter is larger (0.3 > 0.35), and 0.3 × 0.2 = 0.6 instead of 0.06.
- Measurement errors: starting from 1 instead of 0 on a ruler, counting marks instead of spaces, thinking equal perimeter means equal area.
- Geometry errors: a tilted square called a diamond, a square not accepted as a rectangle, longer arms thought to make a bigger angle. Algebra: 2a + 3b = 5ab.

- Error analysis: collect work, find the pattern, form a hypothesis, test with designed items, interview the child, then teach through cognitive conflict.

> **Quick revision:** Slip vs systematic error vs misconception; buggy algorithms (Brown and Burton 1978); 47 + 38 = 715 and 503 − 168 = 435 show weak place value; 618 ÷ 6 = 13 drops a zero; 1/2 + 1/3 = 2/5; fractions need equal parts; longer-is-larger and shorter-is-larger decimals; ruler read from 1; tilted square; longer arms; 2a + 3b = 5ab; error analysis: pattern, hypothesis, test, interview, cognitive conflict; errors are information.

Diagnostic and Remedial Teaching in Mathematics: Slow and Gifted Learners

Why diagnosis comes first: When a child keeps getting one type of sum wrong, teaching the same lesson again, more loudly, rarely helps. Diagnosis means finding exactly what the child cannot do and why, as a doctor finds the cause before prescribing a medicine. Because mathematics is hierarchical, the cause is often an earlier gap: a child failing at subtraction with regrouping may not understand place value, and a child failing at fractions may not understand equal sharing. Diagnosis is the bridge between assessment and teaching.

Tools of diagnosis: The teacher observes children at work, analyses the errors in written work, asks children to explain their steps aloud, talks with them one to one, and uses diagnostic tests. A diagnostic test differs from an achievement test. An achievement test measures how much a child has learnt, gives a score and may rank children; a diagnostic test finds where and why a child is weak. It therefore covers a small unit broken into sub-skills, has several items for each sub-skill arranged from easy to difficult, is usually untimed, and is not used for grading or ranking. For two-digit subtraction, for example, separate items test subtraction without regrouping, with regrouping, with a zero in the minuend and in word problems, so the pattern of wrong items shows the exact step that fails.

The remedial cycle: Remedial teaching is planned instruction to remove the difficulty that diagnosis has found. The cycle runs: identify the children who are struggling, often through formative assessment; diagnose the specific difficulty and its cause; plan the remedial work; teach it; re-assess to check whether the difficulty has gone; and give feedback, diagnosing again if it has not. Good remedial teaching uses a different approach from the one that failed, usually going back to concrete materials and pictures; it works in small steps, starts from what the child can already do, gives immediate feedback and frequent success, and is done individually or in small groups. It must never label children as weak or keep them permanently apart from the class. Section 4 of the RTE Act 2009 likewise gives an out-of-school child admitted to an age-appropriate class the right to special training so that she can catch up.

Causes beyond the concept: Difficulty may also come from language (the child cannot read the word problem), from mathematics anxiety, from long absence, from teaching that gave rules without meaning, or from a specific learning disability. Dyscalculia is a specific learning disability in understanding numbers: despite normal intelligence and teaching, the child may have weak number sense and find it hard to count backwards, remember number facts, read a clock or tell which of two numbers is bigger. The Rights of Persons with Disabilities Act 2016 includes dyscalculia among specific learning disabilities, along with dyslexia, dysgraphia, dyspraxia and developmental aphasia. Such children need multisensory materials, extra time, number lines and other aids, and patience, not punishment.

Peer tutoring and group work: In peer tutoring a child who has understood a concept helps a classmate who has not. It works because a peer explains in familiar language, the learner asks questions freely, and the tutor deepens her own understanding by explaining, which is learning by teaching. It draws on Vygotsky's idea that learning in the zone of proximal development happens with help from a more knowledgeable other, who may well be a classmate. NEP 2020 also suggests peer tutoring as a voluntary and joyful activity under the supervision of trained teachers. Mixed-ability groups, pair work and cooperative games spread the same benefit across the class.

Slow learners: Slow learners can learn the same mathematics but need more time, more concrete experience and more practice. The teacher breaks a concept into small steps, keeps concrete and pictorial supports for longer, links tasks to the child's life, gives shorter assignments with frequent feedback, praises effort and progress, and avoids comparison with faster children. Expectations stay high; only the path and the pace change.

Gifted learners: Mathematically gifted children grasp ideas quickly, spot patterns, prefer reasoning to routine and may get bored by repetitive sums, so giving them more of the same sums is a mistake. Enrichment (horizontal) gives

deeper and broader work at the same level: puzzles, open-ended problems, investigations, problems with many solutions, problem posing and projects. Acceleration (vertical) lets them move faster through the curriculum. Both slow and gifted learners are best served in an inclusive classroom through differentiated tasks, in the spirit of the Position Paper's call to engage every student with a sense of success while offering conceptual challenges to the emerging mathematician.

Examples

- Diagnosis finds what and why; because mathematics is hierarchical, the cause is often an earlier gap, such as place value behind regrouping errors.
- Achievement test: how much is learnt, scored and ranked. Diagnostic test: where and why, small unit, items by sub-skill from easy to hard, usually untimed, not for grading.
- Remedial cycle: identify, diagnose, plan, teach, re-assess, give feedback; diagnose again if the difficulty remains.
- Remedial teaching uses a different approach (often back to concrete materials), small steps, immediate feedback and small groups, and never labels the child.
- RTE Act 2009, Section 4: special training for an out-of-school child admitted to an age-appropriate class.
- Dyscalculia: a specific learning disability with numbers; the RPwD Act 2016 lists it with dyslexia, dysgraphia, dyspraxia and developmental aphasia.
- Peer tutoring: the tutor learns by teaching and the learner gets help in familiar language; based on Vygotsky's ZPD and the more knowledgeable other; suggested in NEP 2020.
- Slow learners: the same goals with more time, smaller steps, longer use of concrete aids, frequent success and no comparison.
- Gifted learners: enrichment (horizontal: puzzles, open-ended problems, projects) or acceleration (vertical: faster pace), not more of the same sums.

> **Quick revision:** Diagnosis: what and why, often an earlier gap; tools: observation, error analysis, interview, diagnostic test (sub-skills, untimed, no ranking) vs achievement test; remedial cycle: identify, diagnose, plan, teach, re-assess; a different method in small steps; RTE Act Section 4 special training; dyscalculia in RPwD Act 2016; peer tutoring (Vygotsky, NEP 2020); slow learners: more time; gifted: enrichment and acceleration.

Evaluation in Mathematics: CCE, Open-Ended Questions, Rubrics and Maths Anxiety

Formative and summative: Michael Scriven introduced the terms formative and summative evaluation in 1967. Formative assessment, or assessment for learning, happens during teaching through questions, observation, class work, quizzes and conversation; its purpose is to improve learning by giving feedback to both child and teacher. Summative assessment, or assessment of learning, comes at the end of a unit or term and judges how much has been achieved. Assessment as learning means children assessing their own and their peers' work, which builds reflection. Good feedback in mathematics is descriptive ('your tens are lined up correctly; check the ones column again') rather than only a mark or a tick.

Continuous and comprehensive evaluation: Section 29(2)(h) of the RTE Act 2009 requires comprehensive and continuous evaluation of the child's understanding of knowledge and ability to apply it. Continuous means assessment is spread through the teaching-learning process rather than left to the end; comprehensive means it covers both scholastic areas and co-scholastic ones such as attitudes, interests and working with others. In mathematics, CCE uses many tools: oral questions, observation of children using materials, worksheets, projects, maths journals in which children write how they solved a problem, checklists, anecdotal records, portfolios, and self and peer assessment. NEP 2020 continues this shift from rote-based tests to regular, formative and competency-based assessment, proposes a 360-degree holistic progress card, and proposes a national assessment centre, PARAKH.

Understanding versus procedure: Richard Skemp (1976) distinguished instrumental understanding, knowing a rule and how to use it (rules without reasons), from relational understanding, knowing both what to do and why. Procedural knowledge is the ability to carry out algorithms; conceptual knowledge is knowing the relationships behind them. A test that only asks 'Add 3/4 + 1/8' checks procedure, while 'Which is bigger, 3/4 or 4/5? Show it with

a drawing', 'Explain why 0.5 and 1/2 are equal' or 'Write a story for 12 ÷ 3' checks understanding. The Position Paper criticises assessment that rewards only mechanical computation and recommends assessing mathematisation: whether children can formulate a problem, choose a method, reason and explain.

Open-ended questions: A closed question has one correct answer, such as 6 × 4 = ?. An open-ended question has many correct answers or many routes: 'The answer is 24. What could the question be?', 'Find two numbers whose sum is 50 and whose difference is less than 10', or 'Make three different shapes of area 6 square units on a geoboard'. Such questions have a low floor and a high ceiling, so every child can begin and able children can go further; they reveal how children think, encourage several strategies and reduce the fear of the single right answer. They are best scored with a rubric rather than simply marked right or wrong.

Portfolios and rubrics: A portfolio is a purposeful collection of a child's work over time: worksheets, drawings, project reports, problems solved in different ways and the child's own reflections. It shows growth rather than a single performance, and when children choose the pieces and say why, it also builds self-assessment. A rubric is a scoring guide that lists criteria and describes levels of performance for each. For a word problem the criteria might be understanding the problem, choice of strategy, accuracy of calculation and explanation, each described at 4 levels from beginning to excellent. An analytic rubric scores each criterion separately; a holistic rubric gives one overall judgement. Rubrics make marking fair and transparent, and when shared in advance they show children what good work looks like.

Mathematics anxiety: Mathematics anxiety is a feeling of tension and fear that interferes with handling numbers and solving problems; Richardson and Suinn developed the Mathematics Anxiety Rating Scale (MARS) in 1972. It is not built into the subject; it grows largely out of experiences: timed tests and speed drills, public correction and punishment, insistence on one right method, rote learning without understanding, comparison with other children, and adults who say mathematics is not for everyone or that girls are weaker at it. Anxiety uses up working memory, so an anxious child performs below her ability, avoids mathematics and falls further behind.

Reducing anxiety through assessment: The teacher reduces anxiety by using frequent low-stakes formative assessment instead of a few high-stakes tests, valuing the process and different methods, allowing time and oral explanation, treating mistakes as part of learning, using games, group work and real contexts, giving descriptive feedback, praising effort and strategies rather than speed, and avoiding labels and comparison. In CTET, the correct option is usually the one that assesses reasoning through varied tools and makes mathematics less threatening; options that rely only on timed paper-pencil tests of speed and memory are usually wrong.

Examples

- Formative and summative evaluation: terms introduced by Michael Scriven (1967); formative is assessment for learning during teaching, summative is assessment of learning at the end.
- RTE Act 2009, Section 29(2)(h): comprehensive and continuous evaluation of the child's understanding of knowledge and ability to apply it.
- CCE tools in mathematics: oral questions, observation, worksheets, projects, maths journals, checklists, anecdotal records, portfolios, self and peer assessment.
- Skemp (1976): instrumental understanding is rules without reasons; relational understanding is knowing what to do and why.
- Procedure item: 'Add 3/4 + 1/8'. Understanding items: 'Which is bigger, 3/4 or 4/5? Show it with a drawing' or 'Write a story for 12 ÷ 3'.
- Open-ended question: 'The answer is 24. What could the question be?'; many answers, low floor and high ceiling, best scored with a rubric.
- Portfolio: a purposeful collection of work over time that shows growth. Rubric: criteria with described levels; analytic scores each criterion, holistic gives one overall judgement.
- Maths anxiety: Richardson and Suinn's MARS (1972); caused by timed tests, public correction, one right method, comparison and stereotypes; it uses up working memory.
- Reducing anxiety: low-stakes formative assessment, valuing process and many methods, mistakes as learning, games and group work, descriptive feedback, praise for effort.

- NEP 2020: regular, formative, competency-based assessment; a 360-degree holistic progress card; a national assessment centre, PARAKH.

> **Quick revision:** Scriven 1967: formative (for learning) vs summative (of learning); assessment as learning; RTE Act Section 29(2)(h) CCE; CCE tools; Skemp 1976 instrumental vs relational understanding; assess understanding, not only procedure; Position Paper: assess mathematisation; open-ended questions, low floor and high ceiling; portfolios show growth; rubrics analytic and holistic; maths anxiety, MARS 1972, causes and remedies; NEP 2020 360-degree progress card, PARAKH.

Free practice questions: parikshasaathi.com/q/mathematics-pedagogy/

Mathematics, Classes I-V (Paper I)

Mathematics, Classes I-V (Paper I)

What the exam asks: In CTET Paper I the Mathematics section has 30 questions: 15 on content and 15 on pedagogical issues. Content questions are pitched at classes I to V (NCERT Math-Magic) but test the teacher's own command. The official content list is Geometry, Shapes and Spatial Understanding, Solids around Us, Numbers, Addition and Subtraction, Multiplication, Division, Measurement, Weight, Time, Volume, Data Handling, Patterns and Money. Expect direct sums, everyday word problems and short reasoning items.

Numbers: Place value is the value a digit gets from its position; face value is the digit itself. In 4,73,256 the 7 has place value 70,000 and face value 7. In the Indian system the first comma comes after the hundreds and then after every two digits: 1 lakh = 1,00,000 = 100 thousands. Zeros hold empty places, so four lakh five thousand thirty is 4,05,030. To round to the nearest hundred, look at the tens digit: 6,449 becomes 6,400 but 6,451 becomes 6,500. Even numbers end in 0, 2, 4, 6 or 8; odd + odd and even + even are even, while odd + even is odd. Ordinals: a child 14th from the front and 9th from the back stands in a queue of 14 + 9 - 1 = 22.

Addition and Subtraction: Write place under place and regroup: ten ones make one ten. 7,003 - 2,486 needs regrouping across zeros and gives 4,517; check: 2,486 + 4,517 = 7,003. Addition and subtraction undo each other, which is how missing numbers are found.

Multiplication and Division: Multiplication is repeated addition, or an array of rows and columns. Order does not change the product, and a number can be split: 23 × 15 = 23 × 10 + 23 × 5 = 345. In 47 × 36 the second partial product is 47 × 30 = 1,410, not 141. Division is equal sharing or repeated subtraction. Dividend = divisor × quotient + remainder, and the remainder is always less than the divisor: 1,000 ÷ 7 gives quotient 142 and remainder 6. In word problems decide what the remainder means: 460 children in buses of 45 need 11 buses, not 10. Factors divide a number exactly (36 has 9), multiples never end, and common multiples tell when two bells next ring together.

Fractions and decimals: A fraction names equal parts of a whole or of a collection: 3/4 of 56 mangoes is 42. Multiplying or dividing numerator and denominator by the same number gives equivalent fractions: 2/8 = 1/4. Among like fractions, the one with the larger numerator is larger. Tenths and hundredths extend place value to the right: 0.37 is 3 tenths and 7 hundredths, ₹ 25 and 5 paise is ₹ 25.05, and 6.08 m is 6 m 8 cm.

Geometry, shapes and solids: Children meet solids (cube, cuboid, cylinder, cone, sphere) before flat shapes. A cube has 6 faces, 12 edges and 8 vertices; a cuboid has the same numbers but rectangular faces; a cylinder has 2 flat circular faces and 1 curved surface; a cone has 1 flat face and 1 vertex; a sphere has only a curved surface. A square has 4 lines of symmetry, a non-square rectangle 2 and an equilateral triangle 3. Nets, tangrams, angles (right, acute, obtuse), simple maps and top views build spatial understanding.

Measurement, weight, time and volume: 1 m = 100 cm, 1 km = 1,000 m and 1 cm = 10 mm; 1 kg = 1,000 g; 1 litre = 1,000 mL. 1 hour = 60 minutes and 1 day = 24 hours; 4:30 p.m. is 16:30 on the 24-hour clock. Perimeter is the distance around a shape, 2 × (length + breadth) for a rectangle; area is the number of unit squares that cover it, length × breadth. A 5 cm by 3 cm rectangle has perimeter 16 cm and area 15 square cm. At this level volume is found by counting unit cubes.

Data handling, patterns and money: Tally marks record data; pictographs and bar graphs show it. Read the key: if one symbol stands for 5 children, 4 symbols mean 20. Patterns include repeating patterns, growing number patterns (2, 5, 10, 17, 26 has differences 3, 5, 7, 9), sums of odd numbers (the first n odd numbers add up to n × n) and magic squares: with 1 to 9, every line adds up to 15 and 5 sits in the centre. Money: ₹ 1 = 100 paise; add and subtract amounts by lining up the decimal points, and make simple bills as rate × quantity.

Common errors: dropping a zero in the quotient, subtracting the smaller digit from the larger in every column, adding numerators and denominators (1/2 + 1/4 is 3/4, not 2/6), thinking 0.65 is greater than 0.7, leaving a remainder that is not less than the divisor, and mixing up area and perimeter. Check every answer a second way: estimate, use the inverse operation or substitute back.

Examples

- Place value: in 4,73,256 the 7 is worth 70,000, while its face value is 7.
- Indian system: 1 lakh = 1,00,000 = 100 thousands, so four lakh five thousand thirty = 4,05,030.
- Rounding: 4,67,549 to the nearest thousand is 4,68,000, because 549 is at least 500.
- Subtraction across zeros: 7,003 - 2,486 = 4,517; check with 2,486 + 4,517 = 7,003.
- Division check: 1,000 = 7 × 142 + 6, so 1,000 ÷ 7 gives quotient 142 and remainder 6 (6 < 7).
- Zero in the quotient: 8,424 ÷ 8 = 1,053, not 153, because 4 hundreds ÷ 8 gives 0 whole hundreds, so the quotient has 0 in its hundreds place.
- Equivalent fractions: 3/5 = 21/35 (multiply both by 7) and 2/8 = 1/4 (divide both by 2).
- Decimals: ₹ 25 and 5 paise = ₹ 25.05, 6.08 m = 6 m 8 cm, and 0.7 = 0.70 is greater than 0.65.
- Solids: a cube has 6 faces, 12 edges and 8 vertices; a cone has 1 flat face, 1 curved surface and 1 vertex.
- Area and perimeter: a 5 cm by 3 cm rectangle has area 15 square cm and perimeter 16 cm.
- Magic square 1 to 9: rows 4, 9, 2 / 3, 5, 7 / 8, 1, 6; every row, column and diagonal adds up to 15.

> **Quick revision:** Paper I maths: 15 content + 15 pedagogy at class I-V level. Place value vs face value; Indian commas, 1 lakh = 1,00,000; round using the next digit. Regroup in + and -, check by the inverse. 23 × 15 = 230 + 115. Dividend = divisor × quotient + remainder, remainder < divisor; keep quotient zeros. Factors are limited, multiples endless. Equivalent fractions: same multiplier top and bottom; like fractions compare by numerator. ₹ 25.05 = ₹ 25 and 5 paise. Cube: 6 faces, 12 edges, 8 vertices. 1 m = 100 cm, 1 kg = 1,000 g, 1 L = 1,000 mL, 1 h = 60 min. Area is not perimeter. Read the pictograph key; magic square sum 15.

Numbers and Place Value: Lakhs, Expanded Form, Indian and International Systems, Roman Numerals

From counting to numbers: Before a child can use numbers she needs pre-number ideas: matching one object with one object (one-to-one correspondence), sorting and classifying by a property, and arranging things in order of size (seriation). Counting rests on five principles described by Gelman and Gallistel: one number name for each object (one-one), names always in the same order (stable order), the last name tells how many (cardinality), anything can be counted (abstraction), and the order of counting does not change the total (order irrelevance). A child who counts 7 beads correctly but, asked how many, starts again from 1 has not yet grasped cardinality. Math-Magic builds numbers in stages in Class 1 (1 to 9, 10 to 20, 21 to 50 and beyond), and in Class 2 children bundle sticks into tens, the bridge to place value.

Place value, face value and expanded form: Our numerals form a base-ten place-value system with ten digits, 0 to 9, in which each place is worth 10 times the place to its right: 10 ones make 1 ten, 10 tens make 1 hundred and 10 ten thousands make 1 lakh. The face value of a digit is the digit itself; its place value is the digit multiplied by the value of its place. In 5,08,374 the 8 has face value 8 and place value 8,000, a difference of 7,992. The place value of 0 is always 0. When a digit repeats, each copy has its own place value: in 63,536 the two 3s are worth 3,000 and 30, with sum 3,030 and difference 2,970. The expanded form writes a number as the sum of its place values: 5,08,374 = 5,00,000 + 8,000 + 300 + 70 + 4. Zeros drop out of the expanded form, and putting them back is where children slip: 4,00,000 + 6,000 + 9 = 4,06,009.

Forming and naming numbers: The greatest 5-digit number is 99,999; adding 1 gives 1,00,000, the smallest 6-digit number. There are 900 three-digit numbers (100 to 999). For the greatest number from given digits, write them in descending order; for the smallest, in ascending order, but never begin with 0. With 0, 3, 5 and 7 used once each, the greatest 4-digit number is 7,530 and the smallest 3,057, a difference of 4,473. The predecessor of 1,00,000 is 99,999. Number names follow the periods: 3,40,040 is three lakh forty thousand forty. A child who writes two thousand three as 20003 is writing the number as it sounds; place-value cards laid over each other (2000, then 3 on top) show why it is 2,003.

Indian and international systems: The Indian system has the ones period (ones, tens, hundreds) and then periods of two places each: thousands (thousands, ten thousands), lakhs (lakhs, ten lakhs) and crores (crores, ten crores). The international system uses periods of three places: ones, thousands, millions and billions. So after the first three digits from the right, Indian commas come after every two digits and international commas after every three. 10 lakh = 1 million, 1 crore = 10 million and 100 crore = 1 billion. 7,25,40,816 is read seven crore twenty-five lakh forty thousand eight hundred sixteen; in the international system it is written 72,540,816 and read seventy-two million five hundred forty thousand eight hundred sixteen. A crore has 7 zeros.

Comparing and ordering: The number with more digits is greater (10,000 > 9,999). With the same number of digits, compare from the leftmost place and stop at the first place where they differ: 4,05,999 < 4,50,000 because in the ten-thousands place 0 is less than 5. Ascending order runs from the smallest to the greatest, descending the other way, and on a number line every number is greater than those to its left. The symbols > and < open towards the greater number; children who mix them up can say the sentence aloud (45 is greater than 38) before writing it.

Roman numerals: The Roman system has seven symbols, I = 1, V = 5, X = 10, L = 50, C = 100, D = 500 and M = 1,000, and no zero. A symbol after a greater or equal one is added (VI = 6, LX = 60); a smaller symbol before a greater one is subtracted (IV = 4, XC = 90). Only I, X and C are subtracted, each only from the next two greater symbols: I from V and X, X from L and C, C from D and M. I, X, C and M may be repeated up to three times; V, L and D are never repeated or subtracted. So 99 is XCIX, not IC; 49 is XLIX, not IL; 444 is CDXLIV; and 1947 is MCMXLVII.

In the classroom: Place value is understood, not memorised, when children bundle sticks, exchange ten 1-rupee coins for a 10-rupee note, use an abacus or base-ten blocks and read numbers from a place-value chart. Common errors are skipping zeros when reading (4,05,030 is four lakh five thousand thirty) and confusing place value with face value. Asking children to show 146 in two ways, as 1 hundred 4 tens 6 ones and as 14 tens 6 ones, builds the flexible regrouping that addition and subtraction need.

Examples

- Face value and place value: in 5,08,374 the 8 has face value 8 and place value 8,000; the difference is 7,992.
- Repeated digit: in 63,536 the two 3s have place values 3,000 and 30; their sum is 3,030 and difference 2,970.
- Expanded form: 4,00,000 + 6,000 + 9 = 4,06,009; the empty places are held by zeros.
- Greatest and smallest 4-digit numbers from 0, 3, 5, 7 (each once): 7,530 and 3,057; difference 4,473.
- 99,999 + 1 = 1,00,000, the smallest 6-digit number; there are 900 three-digit numbers and 9,000 four-digit numbers.
- Systems: 10 lakh = 1 million, 1 crore = 10 million, 100 crore = 1 billion; 7,25,40,816 (Indian) = 72,540,816 (international).
- Comparing: more digits means greater; with equal digits compare from the left, so 4,05,999 < 4,50,000.
- Roman symbols: I 1, V 5, X 10, L 50, C 100, D 500, M 1,000; no zero; V, L and D are never repeated or subtracted.
- Roman numbers: 49 = XLIX, 99 = XCIX (not IC), 444 = CDXLIV, 1947 = MCMXLVII.
- Counting principles (Gelman and Gallistel): one-one, stable order, cardinality, abstraction and order irrelevance.

> **Quick revision:** Pre-number ideas: matching, sorting, seriation; the last number said gives how many (cardinality); place value = digit × value of its place, face value = the digit, place value of 0 is 0; 99,999 + 1 = 1,00,000; Indian periods of 3, 2, 2 digits, international 3, 3, 3; 10 lakh = 1 million, 1 crore = 10 million; compare from the left; Roman I, V, X, L, C, D, M, only I, X, C subtract, 99 = XCIX.

Addition and Subtraction: Regrouping, Properties, Estimation and Word Problems

What the operations mean: Children meet addition first as putting together (3 red and 4 blue balloons) and as adding on (5 birds, then 2 more arrive). Subtraction appears in three different situations: taking away (8 sweets, 5 eaten), comparing (Rani has 8 and Sonu has 5; how many more does Rani have?) and finding a missing part (I have 5; how many more to make 8?). All three are 8 - 5 = 3, but comparing and missing-part problems are harder because nothing is visibly removed. Math-Magic starts with objects, pictures and stories, uses the number line for jumps forward and back, and builds number facts such as all the ways to make 10 (1 + 9, 2 + 8 and so on) before any written method.

Carrying in addition: Write ones under ones and tens under tens, and add from the right. When a column adds up to 10 or more, ten of that place are exchanged for 1 of the next place: this is the carry (हासिल in Hindi-medium books). In 368 + 475, the ones give 8 + 5 = 13, so write 3 and carry 1 ten; the tens give 6 + 7 + 1 = 14, so write 4 and carry 1 hundred; the hundreds give 3 + 4 + 1 = 8, and the sum is 843. When several numbers are added the carry can be more than 1: in 79 + 86 + 98 the ones add up to 23, so 2 tens are carried and the sum is 263. A child who writes 13 under the ones, or forgets the carry, has learnt the steps without the idea of exchange.

Borrowing in subtraction: When the top digit is smaller, take 1 from the next place and exchange it for 10 of this place. In 802 - 357 the ones cannot do 2 - 7 and the tens place is empty, so 8 hundreds become 7 hundreds and 10 tens, and then 10 tens become 9 tens and 10 ones: 12 - 7 = 5, 9 - 5 = 4 and 7 - 3 = 4, giving 445. The best-known error is subtracting the smaller digit from the larger in every column, which turns 802 - 357 into 555. The child is following a rule, not guessing, so the teacher asks her to check by adding (357 + 555 is 912, not 802) and rebuilds the exchange with base-ten blocks or money. Subtracting from 1,000 has a shortcut children can discover: take each digit from 9 and the last one from 10, so 1,000 - 643 = 357.

Properties and the inverse link: Addition is commutative (36 + 47 = 47 + 36) and associative ((18 + 25) + 75 = 18 + (25 + 75) = 118), and adding 0 leaves a number unchanged, so 0 is the additive identity. Subtraction has none of these properties: 9 - 4 is not 4 - 9, and (10 - 4) - 3 = 3 while 10 - (4 - 3) = 9. Because subtraction undoes addition, one fact gives three more: if 845 + 238 = 1,083, then 238 + 845 = 1,083, 1,083 - 238 = 845 and 1,083 - 845 = 238. The same link solves missing numbers and missing digits. In 3?7 + 25? = 623, the ones need 7 + 6 = 13, and the tens then need 6 + 5 + 1 = 12, so both missing digits are 6 (367 + 256 = 623).

Mental methods and estimation: Children who understand place value invent their own methods: 498 + 267 is 500 + 267 - 2 = 765 (compensation), and 1,000 - 643 can be found by counting up: 643 to 650 is 7, to 700 is 50 more and to 1,000 is 300 more, 357 in all. Estimation rounds the numbers before calculating, to judge whether an answer is reasonable: 487 + 312 is about 500 + 300 = 800 (exactly 799), and 6,812 - 2,195 is about 6,800 - 2,200 = 4,600 to the nearest hundred (exactly 4,617). Rounding to the nearest thousand (7,000 - 2,000 = 5,000) is quicker but rougher, so the situation decides how close an estimate must be.

Word problems: Key words mislead. In 'Rani has 45 marbles, which is 18 more than Sonu has; how many does Sonu have?' the word more hides a subtraction: 45 - 18 = 27. Children should picture the situation with a drawing or a bar model and ask what is known and what is missing, instead of hunting for clue words. Two-step problems join the operations: a library has 1,245 books, buys 368 and gives away 179, so it now has 1,245 + 368 - 179 = 1,434. A train with 1,250 seats carrying 987 passengers has 263 empty seats. Asking children to make up their own story for a sum such as 50 - 18 shows whether they understand what subtraction means.

Examples

- Three meanings of subtraction: take away (8 sweets, 5 eaten), compare (8 and 5, how many more?) and missing part (5, how many more to make 8?); all give 3.
- Carrying: 368 + 475 = 843 (8 + 5 = 13, carry 1; 6 + 7 + 1 = 14, carry 1; 3 + 4 + 1 = 8).
- A carry can be more than 1: 79 + 86 + 98 = 263, because the ones add up to 23.
- Borrowing across a zero: 802 - 357 = 445; the error 'smaller digit from larger in every column' gives 555.
- Subtracting from 1,000: take each digit from 9 and the last from 10, so 1,000 - 643 = 357.
- Addition is commutative and associative with identity 0; subtraction is neither: (10 - 4) - 3 = 3 but 10 - (4 - 3) = 9.

- One fact gives three: 845 + 238 = 1,083, so 1,083 - 238 = 845 and 1,083 - 845 = 238.
- Missing digits: 3?7 + 25? = 623 is 367 + 256 = 623, so both missing digits are 6.
- Compensation: 498 + 267 = 500 + 267 - 2 = 765; estimation: 6,812 - 2,195 is about 6,800 - 2,200 = 4,600 (exactly 4,617).
- 'Rani's 45 marbles are 18 more than Sonu's' means Sonu has 45 - 18 = 27: the word more does not always mean add.

> **Quick revision:** Addition: putting together or adding on; subtraction: take away, compare or missing part; carry when a column reaches 10 (368 + 475 = 843); borrow across zeros (802 - 357 = 445, not 555); addition is commutative and associative with identity 0, subtraction is not; 845 + 238 = 1,083 gives 1,083 - 238 = 845; estimate by rounding (6,800 - 2,200 = 4,600); picture the problem, do not trust key words.

Multiplication and Division: Tables, Long Methods, Remainders, Factors, HCF and LCM

What multiplication and division mean: Multiplication begins as counting equal groups (the Class 2 chapter Counting in Groups) and as repeated addition: 4 + 4 + 4 = 3 × 4 = 12. An array of 3 rows of 4 chairs, turned sideways, shows 4 × 3, which is why the order does not change the product. Division has two meanings: equal sharing (12 laddoos among 3 children, how many each?) and equal grouping (12 laddoos, 3 to a box, how many boxes?); both give 4. Grouping is repeated subtraction: 12 - 3 - 3 - 3 - 3 reaches 0 in 4 steps. Division is the inverse of multiplication: 3 × 4 = 12 gives 12 ÷ 3 = 4 and 12 ÷ 4 = 3.

Tables and their patterns: Tables are best built, not only recited. Products in the table of 5 end in 5 or 0, and the table of 4 doubles the table of 2. In the table of 9 the tens digit rises by 1 as the ones digit falls by 1, and the digits of 18, 27, 36 up to 90 add up to 9. A forgotten fact can be rebuilt: 6 × 7 = 5 × 7 + 7 = 42 and 9 × 8 = 10 × 8 - 8 = 72. Multiplying by 100 moves each digit two places left (47 × 100 = 4,700). To multiply a 2-digit number by 11, write the sum of its digits between them: 11 × 23 = 253, and carry when the sum is more than 9, as in 11 × 57 = 627.

Long multiplication: The written method rests on place value and the distributive property. For 236 × 47, multiply by 7 to get 1,652, then by 4 tens to get 9,440 (the zero shows that it is 40, not 4), and add: 11,092. The grid method splits both numbers by place value: (200 + 30 + 6) × (40 + 7) gives 8,000 + 1,400 + 1,200 + 210 + 240 + 42 = 11,092; the Class 5 chapter Ways to Multiply and Divide likewise shows children more than one way to multiply and to divide. Multiplication is commutative, associative (2 × 5 × 37 = 10 × 37 = 370) and distributive: 7 × 105 = 700 + 35 = 735 and 8 × 99 = 800 - 8 = 792. Doubling one number and halving the other keeps the product: 25 × 36 = 50 × 18 = 900.

Long division and remainders: Divide from the greatest place. In 5,346 ÷ 6, 5 thousands cannot be shared among 6, so 53 hundreds give 8 with 5 hundreds left, 54 tens give 9 and 6 ones give 1: the quotient is 891, and 891 × 6 = 5,346. In 2,437 ÷ 12, 24 hundreds give 2, 3 tens give 0 tens (a zero that must be written) and 37 ones give 3 with 1 left: quotient 203, remainder 1, since 12 × 203 + 1 = 2,437. The remainder is always less than the divisor, and in word problems its meaning decides the answer: 100 eggs packed 12 to a tray fill 8 trays with 4 left over, but 100 children need 9 vans of 12 seats. 0 divided by any non-zero number is 0, division by 0 has no meaning, and 12 ÷ 4 is not 4 ÷ 12.

Factors, multiples and primes: A factor divides a number exactly; a multiple is the number times 1, 2, 3 and so on. The Class 5 chapter Be My Multiple, I'll be Your Factor introduces both ideas through games, and factors can be found by making rectangles: 24 counters form 1 × 24, 2 × 12, 3 × 8 and 4 × 6 arrays, so 24 has 8 factors. Factors are limited, multiples never end, and every number is a factor and a multiple of itself. A prime has exactly 2 factors (2, 3, 5, 7, 11 ...), a composite number more than 2, and 1 is neither; 2 is the only even prime, and there are 25 primes below 100. Divisibility tests save long division: by 2 if the last digit is even, by 3 or 9 if the digit sum is divisible by 3 or 9, by 4 if the last two digits form a multiple of 4, by 5 if the number ends in 0 or 5. 7,236 (digit sum 18, ending in 36) is divisible by 2, 3, 4, 6 and 9 but not by 5.

HCF and LCM at primary level: The highest common factor (HCF) is the greatest number that divides both numbers; the lowest common multiple (LCM) is the smallest number that both divide. Listing is enough here: the factors of 12 are 1, 2, 3, 4, 6, 12 and of 18 are 1, 2, 3, 6, 9, 18, so the HCF is 6; the multiples of 12 are 12, 24, 36 ... and of 18 are 18, 36 ..., so the LCM is 36. For two numbers, HCF × LCM = their product: 6 × 36 = 216 = 12 × 18.

Cutting into the largest equal pieces needs the HCF: ribbons of 24 cm and 36 cm give pieces of 12 cm. Happening together again needs the LCM: bells ringing every 4 and every 6 minutes ring together every 12 minutes, so after 9:00 a.m. they next ring together at 9:12 a.m.

Examples

- Division has two meanings: sharing (12 among 3, how many each?) and grouping (12 in 3s, how many groups?); both give 4.
- Table of 9: the tens digit rises as the ones digit falls, and the digits of every product from 18 to 90 add up to 9.
- 236 × 47 = 1,652 + 9,440 = 11,092; the second line is 236 × 40, so it needs the zero.
- Distributive shortcuts: 7 × 105 = 700 + 35 = 735; 8 × 99 = 800 - 8 = 792; 11 × 57 = 627.
- 2,437 ÷ 12 = 203 remainder 1; check 12 × 203 + 1 = 2,437; the zero in 203 must not be dropped.
- Meaning of the remainder: 100 eggs, 12 to a tray, fill 8 trays with 4 left over; 100 children, 12 to a van, need 9 vans.
- 24 has 8 factors (1, 2, 3, 4, 6, 8, 12, 24); 1 is neither prime nor composite; 2 is the only even prime; there are 25 primes below 100.
- 7,236: digit sum 18 and last two digits 36, so it is divisible by 2, 3, 4, 6 and 9, but not by 5 or 10.
- HCF of 12 and 18 = 6, LCM = 36, and 6 × 36 = 216 = 12 × 18.
- Largest equal pieces means HCF (24 cm and 36 cm give 12 cm pieces); together again means LCM (every 4 and 6 minutes gives every 12 minutes).

> **Quick revision:** Multiplication: equal groups, repeated addition, arrays; division: sharing or grouping, the inverse of multiplication; 236 × 47 = 11,092; 2,437 ÷ 12 = 203 remainder 1; remainder < divisor, round up or down as the situation needs; × is commutative, associative, distributive; ÷ 0 has no meaning; prime has exactly 2 factors, 1 is neither, 2 the only even prime; HCF for largest equal parts, LCM for together again; HCF × LCM = product.

Fractions and Decimals at Primary Level: Equivalent Fractions, Comparing, Adding and Money

Where fractions begin: Children use fraction words long before symbols: half a roti, a quarter of an hour, three-quarters of a glass. NCERT builds on this in Class 4 (Halves and Quarters) and Class 5 (Parts and Wholes) by folding paper, cutting shapes and sharing objects. The key idea is equal parts: a circle cut into 4 unequal pieces does not show quarters. In 3/4 the denominator 4 says how many equal parts the whole is divided into and the numerator 3 says how many of them are taken. A fraction can be part of a whole (a region), part of a collection (3/4 of 20 children), a point on the number line, a measure (1/2 m) or the result of a division: 3 rotis shared equally among 4 children give each child 3/4 of a roti.

Unit fractions and fractions of a collection: A unit fraction has numerator 1. The more parts a whole is cut into, the smaller each part, so 1/8 is smaller than 1/5; this surprises children who know that 8 is bigger than 5, and a sharing story (one cake among 8 friends or among 5) settles it. To find a fraction of a collection, divide by the denominator and multiply by the numerator: 2/5 of 30 = 30 ÷ 5 × 2 = 12. Fractions appear in measurement too: 3/4 of an hour is 45 minutes, 1/4 kg is 250 g and 3/4 m is 75 cm. Fractions less than 1 are proper; those equal to or greater than 1 are improper and can be written as mixed numbers: 7/4 = 1 3/4, because 7 quarters make one whole and 3 quarters more.

Equivalent fractions: Folding a paper strip in half, then in half again and again shows that 1/2 = 2/4 = 4/8: the parts get smaller, but more of them are taken. Multiplying or dividing the numerator and the denominator by the same non-zero number gives an equivalent fraction, and dividing both by their HCF gives the simplest (lowest) form: 18/24 = 3/4 (both divided by 6). Two fractions are equivalent when their cross products are equal: 2/3 and 10/15 are equivalent because 2 × 15 = 3 × 10 = 30. Adding the same number to the numerator and the denominator does not give an equivalent fraction: adding 1 to both terms of 1/2 gives 2/3, which is not equal to 1/2.

Comparing and ordering fractions: With the same denominator (like fractions) the greater numerator gives the greater fraction: 5/9 > 4/9. With the same numerator, the smaller denominator gives the greater fraction: 3/5 > 3/7, because fifths are bigger pieces than sevenths. Otherwise make the denominators equal: 2/3 = 8/12 and 3/4 = 9/12, so 3/4 is greater. Half is a handy benchmark: 3/8 is less than 1/2 (which is 4/8), while 4/7 is more than 1/2 because 4 is more than half of 7. Unit fractions grow as their denominators shrink, so in ascending order they run 1/6, 1/3, 1/2.

Adding and subtracting like fractions: When the pieces are the same size, simply count them: 2/7 + 3/7 = 5/7 and 5/8 - 3/8 = 2/8 = 1/4. The denominator names the size of the piece and does not change, so 2/7 + 3/7 = 5/14 is wrong; a fraction strip shows that 5 sevenths are still sevenths. Taking a part from a whole means writing 1 with the same denominator: if Ravi eats 3/8 of a cake and Sita eats 2/8, together they eat 5/8 and 1 - 5/8 = 3/8 is left. With halves, quarters, thirds and sixths, children can turn one fraction into the other by folding: 1/3 + 1/6 = 2/6 + 1/6 = 3/6 = 1/2.

Decimals from measures and money: The Class 5 chapter Tenths and Hundredths starts from measures children already know. 1 cm = 10 mm, so 1 mm = 1/10 cm = 0.1 cm and 4 cm 7 mm = 4.7 cm; 1 paisa is 1/100 of a rupee, so ₹ 7.75 is 7 rupees 75 paise. The decimal point separates the whole number from the parts, and the places to its right are tenths, hundredths and so on: in 46.27 the 2 is worth 2 tenths (0.2) and the 7 is worth 7 hundredths (0.07). Common fractions convert directly: 1/2 = 0.5, 1/4 = 0.25, 3/4 = 0.75 and 1/10 = 0.1. To compare decimals, give them the same number of places: 0.5 = 0.50, which is greater than 0.45 although 0.45 has more digits, and 2.3 = 2.30.

Money calculations: Rupees and paise are added and subtracted by lining up the decimal points: ₹ 45.50 + ₹ 28.75 = ₹ 74.25, and the change from ₹ 100 is ₹ 25.75. A bill multiplies the rate by the quantity: 3 kg of rice at ₹ 42.50 per kg costs ₹ 127.50. Shop games, price lists and bills give children a reason to handle decimals before they meet the word.

Examples

- Parts must be equal: a shape cut into 4 unequal pieces does not show quarters; in 3/4, 4 is the denominator (equal parts) and 3 the numerator (parts taken).
- Unit fractions: 1/8 < 1/5, because sharing among more people gives smaller shares.
- Fraction of a collection: 2/5 of 30 = 30 ÷ 5 × 2 = 12; 3/4 of an hour = 45 minutes; 1/4 kg = 250 g.
- Simplest form: 18/24 = 3/4 (divide both terms by their HCF 6); 2/3 = 10/15 because 2 × 15 = 3 × 10.
- Comparing: 5/9 > 4/9 (same denominator), 3/5 > 3/7 (same numerator), and 3/4 > 2/3 because 9/12 > 8/12.
- Like fractions: 2/7 + 3/7 = 5/7, not 5/14; 5/8 - 3/8 = 2/8 = 1/4.
- Fraction as division: 3 rotis shared among 4 children give each 3/4 of a roti; 7/4 = 1 3/4.
- Decimals: 4 cm 7 mm = 4.7 cm; in 46.27 the 7 is 7 hundredths; 0.5 > 0.45 because 0.50 > 0.45.
- Money: ₹ 45.50 + ₹ 28.75 = ₹ 74.25; change from ₹ 100 = ₹ 25.75; 3 kg at ₹ 42.50 per kg = ₹ 127.50.

> **Quick revision:** Fraction = equal parts; denominator = equal parts in the whole, numerator = parts taken; 1/8 < 1/5; 2/5 of 30 = 12; equivalent fractions: multiply or divide both terms by the same non-zero number, 18/24 = 3/4; like fractions: compare and add the numerators only (2/7 + 3/7 = 5/7); 1 mm = 0.1 cm, 1 paisa = ₹ 0.01; 0.5 > 0.45; ₹ 45.50 + ₹ 28.75 = ₹ 74.25.

Measurement: Length, Weight, Capacity, Time and Money in Standard and Non-standard Units

From comparing to standard units: Measurement develops in stages. Children first compare directly (which pencil is longer, which bag is heavier), then measure with non-standard units such as hand spans, cubits, foot lengths, steps, pencils or glasses, then see the need for a standard unit and finally convert between units. Math-Magic deliberately lets children get different answers with their own spans and steps (the Class 2 chapter The Longest Step), because the disagreement shows why a shop or a tailor needs the metre. On a ruler, measure from 0 or subtract the starting mark: a pencil lying from the 2 cm mark to the 9.5 cm mark is 7.5 cm long. Piaget found that young children do not yet conserve length or quantity: they may think a stick pushed forward has become longer, or that water poured into a taller, thinner glass has increased.

Length: 10 mm = 1 cm, 100 cm = 1 m and 1,000 m = 1 km. To change a larger unit into a smaller one, multiply; to change a smaller unit into a larger one, divide. So 3 km 45 m = 3,045 m, 2 m 5 cm = 205 cm and 4,250 m = 4 km 250 m. The unit should suit the object: millimetres for the thickness of a coin, centimetres for a pencil, metres for a room and kilometres for the distance between towns. A typical problem: from a 10 m rope, 3 pieces of 2 m 75 cm each are cut; together they measure 825 cm, so 175 cm, that is 1 m 75 cm, is left.

Weight (mass): A simple balance comes first: the heavier side goes down, and bigger is not always heavier (a pillow and a stone), as the Class 3 chapter Who is Heavier? and the Class 4 chapter How Heavy? How Light? show. 1 kg = 1,000 g, 1 g = 1,000 mg, 1 quintal = 100 kg and 1 tonne = 1,000 kg. Shop weights are usually 50 g, 100 g, 200 g, 500 g, 1 kg, 2 kg and 5 kg, so 700 g can be weighed with 500 g and 200 g, and 850 g with 500 g, 200 g, 100 g and 50 g. Adding with grams: 2 kg 350 g + 1 kg 875 g = 4 kg 225 g, since 350 g + 875 g = 1,225 g = 1 kg 225 g.

Capacity: Capacity is how much a container can hold. Children pour water, sand or rice from one container into another and count how many glasses fill a bottle or a bucket (the Jugs and Mugs chapters of Math-Magic), and then use the litre: 1 L = 1,000 mL, half a litre is 500 mL and a quarter litre 250 mL. A 2 L bottle fills 8 glasses of 250 mL. 3 L 400 mL - 1 L 750 mL = 1 L 650 mL, since 3,400 mL - 1,750 mL = 1,650 mL. A tall, thin bottle may hold less than a short, wide one, which children should check by pouring.

Time: Time is learnt first through daily routines and then through the clock and the calendar. The minute hand takes 1 minute for each small division and 5 minutes from one number to the next; the hour hand moves from one number to the next in 1 hour. 60 seconds = 1 minute, 60 minutes = 1 hour, 24 hours = 1 day, 7 days = 1 week and 12 months = 1 year of 365 days, or 366 days in a leap year, when February has 29 days. A year divisible by 4 is a leap year, but a century year is one only if it is divisible by 400 (2000 was, 1900 was not). January, March, May, July, August, October and December have 31 days; April, June, September and November have 30. 7:45 p.m. is 19:45 on the 24-hour clock. Intervals are found by counting on: a train leaving at 10:40 a.m. and arriving at 2:15 p.m. takes 20 minutes to reach 11:00 and 3 hours 15 minutes more, 3 hours 35 minutes in all. On a calendar, dates 7 apart fall on the same day: if 5 March is a Monday, so are 12, 19 and 26 March, and 1 April is a Sunday.

Money as a measure: Money measures value, and rupees and paise work like any other pair of units: ₹ 1 = 100 paise, so ₹ 12.50 = 1,250 paise. Children make the same amount in different ways (₹ 50 as two ₹ 20 notes and a ₹ 10 note, or five ₹ 10 notes) and give change by counting up from the price. Shopping problems use rate × quantity and the unitary method: if 12 pencils cost ₹ 60, 1 pencil costs ₹ 5 and 7 pencils cost ₹ 35. A bill for 2 kg of sugar at ₹ 46 per kg and 3 packets of biscuits at ₹ 15 each comes to ₹ 92 + ₹ 45 = ₹ 137, leaving ₹ 63 change from ₹ 200.

Examples

- Stages of measuring: direct comparison, non-standard units (span, cubit, step), standard units, then conversion; different spans give different answers, which is why a standard unit is needed.
- Ruler: an object from the 2 cm mark to the 9.5 cm mark is 7.5 cm long; measure from 0 or subtract the starting mark.
- Length: 3 km 45 m = 3,045 m; 2 m 5 cm = 205 cm; 4,250 m = 4 km 250 m; larger to smaller unit multiply, smaller to larger divide.
- Weight: 1 kg = 1,000 g, 1 quintal = 100 kg, 1 tonne = 1,000 kg; 2 kg 350 g + 1 kg 875 g = 4 kg 225 g.
- Capacity: 1 L = 1,000 mL; a 2 L bottle fills 8 glasses of 250 mL; 3 L 400 mL - 1 L 750 mL = 1 L 650 mL.
- Leap year: divisible by 4, but a century year only if divisible by 400 (2000 yes, 1900 no); February then has 29 days.
- Time interval: 10:40 a.m. to 2:15 p.m. is 3 hours 35 minutes; 7:45 p.m. is 19:45 on the 24-hour clock.
- Calendar: dates 7 apart fall on the same weekday; if 5 March is a Monday, 26 March is a Monday and 1 April a Sunday.
- Unitary method: 12 pencils for ₹ 60 means 1 pencil for ₹ 5, so 7 pencils cost ₹ 35.
- Piaget: young children do not yet conserve length or liquid quantity; pouring and re-measuring builds the idea.

> **Quick revision:** Compare, then non-standard units, then standard units, then convert; 10 mm = 1 cm, 100 cm = 1 m, 1,000 m = 1 km; 1 kg = 1,000 g, 1 quintal = 100 kg; 1 L = 1,000 mL; larger to smaller unit multiply, smaller to larger divide; 60 s = 1 min, 60 min = 1 h, 24 h = 1 day; leap year 366 days, century years only if divisible by 400; 10:40 a.m. to 2:15 p.m. = 3 h 35 min; ₹ 1 = 100 paise; bill = rate × quantity.

Geometry and Shapes: Solids, Plane Figures, Symmetry, Tangrams, Perimeter, Area and Nets

How children come to know shapes: Children handle solids long before they name flat shapes, so NCERT begins with things that roll, slide or stack: balls, boxes, cans and dice (Class 1 Shapes and Space, Class 2 What is Long, What is Round?). Pierre and Dina van Hiele described levels of geometric thinking. At the first level (visualisation) a child recognises a shape by its overall look, so a square tilted onto its corner may be called a diamond; at the next

level (analysis) she describes shapes by their properties, such as 4 equal sides and 4 right angles. Sorting, building and drawing move children from the first level to the second.

Solids, faces, edges and vertices: A face is a flat surface, an edge is where two faces meet and a vertex (corner) is where edges meet. A cube and a cuboid each have 6 faces, 12 edges and 8 vertices; a triangular prism has 5 faces, 9 edges and 6 vertices; a square pyramid has 5 faces, 8 edges and 5 vertices. For these flat-faced solids faces + vertices - edges = 2 (Euler's formula), a quick check: 6 + 8 - 12 = 2. A cylinder has 2 flat circular faces, 1 curved surface, 2 curved edges and no vertex; a cone has 1 flat face, 1 curved surface, 1 curved edge and 1 vertex; a sphere has only a curved surface.

Plane shapes and angles: A closed figure made of straight sides is a polygon: a triangle has 3 sides, a quadrilateral 4, a pentagon 5, a hexagon 6 and an octagon 8. A circle has a centre; the radius joins the centre to the circle, and the diameter, which passes through the centre, is twice the radius. Angles are compared with a right angle, the corner of a page (90 degrees): a smaller angle is acute and a larger one, still less than a straight line, is obtuse. A square and a rectangle both have 4 right angles; the square also has 4 equal sides, so every square is a rectangle but not every rectangle is a square.

Symmetry: A figure has line symmetry if it can be folded along a line so that the two halves match exactly; children test it by folding paper and with mirrors. A square has 4 lines of symmetry, a rectangle that is not a square 2, an equilateral triangle 3, an isosceles triangle 1, a scalene triangle none, a regular hexagon 6 and a circle infinitely many. In plain capital letters, A, M, T, U, V, W and Y have a vertical line of symmetry, B, C, D, E and K a horizontal one, and H, I, O and X both. The Class 5 chapter Does it Look the Same? adds turn (rotational) symmetry, in which a shape looks the same after part of a full turn: a square looks the same after every 1/4 turn, a rectangle after a 1/2 turn, and the letters H, N, S, X and Z after a 1/2 turn.

Tangrams and tiling: A tangram is a square cut into 7 pieces (tans): 2 large triangles, 1 medium triangle, 2 small triangles, 1 square and 1 parallelogram. Two small triangles can make the square, the medium triangle or the parallelogram, so these 3 pieces have equal areas, and every picture made from all 7 pieces has the area of the original square: the shape changes, the area does not. Tiling (tessellation) covers a surface without gaps or overlaps; squares, equilateral triangles and regular hexagons tile on their own, regular pentagons and circles do not.

Perimeter and area by counting: Perimeter is the length of the boundary, as of a fence round a field (the Class 4 chapter Fields and Fences); area is the amount of surface, counted in unit squares (the Class 5 chapter Area and its Boundary). On squared paper, count each full square as 1, a part more than half a square as 1 and exactly half a square as 1/2, and ignore parts less than half. The two ideas are independent: 12 unit squares arranged as 1 by 12, 2 by 6 or 3 by 4 always have area 12 but perimeters 26, 16 and 14 units, and rectangles of perimeter 20 cm (1 by 9, 4 by 6, 5 by 5) have areas 9, 24 and 25 square cm, the square enclosing the most. 1 square metre is 100 cm × 100 cm = 10,000 square cm.

Nets, views and maps: A net is a flat pattern that folds into a solid. A cube has 11 different nets, but a straight row of 6 squares or a block of 2 by 3 squares cannot fold into a cube (the Class 5 chapter Boxes and Sketches). On a standard dice the opposite faces add up to 7 (1 and 6, 2 and 5, 3 and 4). Spatial understanding also means seeing an object from the top, front and side (the Class 3 chapter Where to Look From) and reading maps with a scale: if 1 cm stands for 100 m, then 4.5 cm on the map is 450 m on the ground.

Examples

- Cube and cuboid: 6 faces, 12 edges, 8 vertices; triangular prism 5, 9, 6; square pyramid 5, 8, 5; faces + vertices - edges = 2.
- Cylinder: 2 flat faces, 1 curved surface, 2 curved edges, no vertex; cone: 1 flat face, 1 curved surface, 1 vertex; sphere: only a curved surface.
- van Hiele: at the visual level a tilted square is called a diamond; at the analysis level shapes are described by their properties.
- Lines of symmetry: square 4, non-square rectangle 2, equilateral triangle 3, isosceles 1, scalene 0, regular hexagon 6, circle infinitely many.

- Turn symmetry: a square looks the same after each 1/4 turn, a rectangle after a 1/2 turn; H, N, S, X and Z after a 1/2 turn.
- Tangram: 7 pieces (5 triangles, 1 square, 1 parallelogram); two small triangles equal the square, the medium triangle or the parallelogram in area.
- Same area, different perimeter: 12 unit squares as 1 by 12, 2 by 6 or 3 by 4 give perimeters 26, 16 and 14.
- Same perimeter 20 cm: rectangles 1 by 9, 4 by 6 and 5 by 5 have areas 9, 24 and 25 square cm; the square encloses the most.
- A cube has 11 nets; opposite faces of a dice add up to 7; on a map where 1 cm = 100 m, 4.5 cm = 450 m.

> **Quick revision:** Solids before plane shapes; face, edge, vertex; cube 6 faces, 12 edges, 8 vertices; triangular prism 5, 9, 6; square pyramid 5, 8, 5; F + V - E = 2; diameter = 2 × radius; right angle 90 degrees, acute less than 90, obtuse between 90 and 180; symmetry lines: square 4, non-square rectangle 2, equilateral triangle 3, circle infinite; tangram 7 pieces; perimeter = boundary, area = unit squares, they vary independently; a cube has 11 nets.

Patterns and Data Handling: Number and Shape Patterns, Tally Marks, Pictographs and Bar Graphs

Why patterns matter: Seeing, extending and describing patterns is the beginning of algebraic thinking, and Math-Magic returns to it in every class, for example in Play with Patterns in Classes 3 and 4 and Can You See the Pattern? in Class 5. Children first copy a pattern, then extend it, then make their own and finally put its rule into words. In a repeating pattern the smallest part that repeats is the core: red, blue, blue, red, blue, blue has the core red, blue, blue of length 3, so the 20th bead is found from 20 = 3 × 6 + 2; it is the 2nd item of the core, blue. Shape patterns include borders, rangoli, block prints, tilings and shapes that turn by a fixed amount at each step, such as an arrow turning a quarter turn clockwise each time, which points the same way again at every 4th step.

Growing number patterns: In 3, 7, 11, 15 ... the rule is add 4, so the next term is 19 and the 10th term is 3 + 9 × 4 = 39. When the differences change, look at the differences themselves: 2, 6, 12, 20, 30 has differences 4, 6, 8, 10, so the next term is 42 (the terms are 1 × 2, 2 × 3, 3 × 4 and so on). Square numbers 1, 4, 9, 16, 25 are dots arranged in squares; triangular numbers 1, 3, 6, 10, 15 are dots in triangles, and two consecutive triangular numbers make a square number (6 + 10 = 16). Doubling gives 1, 2, 4, 8, 16, 32. Patterns in calculation invite children to predict before calculating: 37 × 3 = 111, 37 × 6 = 222 and 37 × 9 = 333, and 11 × 11 = 121 while 111 × 111 = 12,321.

Patterns on grids and calendars: On a 1 to 100 number grid, a step to the right adds 1, a step down adds 10 and a step diagonally down to the right adds 11. On a calendar page a step down adds 7, so in any 2 by 2 block of dates the two diagonals have equal sums, and in any 3 by 3 block the 9 dates add up to 9 times the middle date (with 15 in the middle the block adds up to 135). Questions of this kind test whether the teacher can see why a pattern works, not only that it works.

Collecting and organising data: Data handling follows a cycle: ask a question that matters to the children (How do we come to school? In which month are our birthdays?), collect the data by counting, a survey or observation, organise it in a list or table, show it as a picture or graph, and then discuss what it tells. The Smart Charts chapters of Classes 3, 4 and 5 work in this way. Tally marks make counting easier: each item gets one stroke and every fifth stroke is drawn across the four before it, so the strokes form bundles of 5 that can be counted 5, 10, 15; a count of 23 shows 4 bundles and 3 single strokes.

Pictographs: A pictograph uses a picture or symbol for each item or group of items, and its key (scale) says what one symbol stands for. If one book symbol stands for 10 books borrowed, 3 symbols on Monday mean 30 books, 5 and a half symbols on Tuesday mean 55 and 2 symbols on Wednesday mean 20; the total is 105, and Tuesday exceeds Wednesday by 35. The key should suit the numbers: values of 40, 25 and 35 can be drawn with 1 symbol for 5, giving 8, 5 and 7 symbols. Counting the symbols without reading the key is the commonest wrong answer.

Bar graphs: A bar graph shows each category as a bar of equal width with equal gaps between bars; the length of a bar shows the value against a scale on the axis, and the axes, the scale and the title must be labelled. The favourite fruits of a class (mango 18, banana 12, apple 9, guava 6) drawn with 1 cm for 3 children give bars of 6, 4, 3 and 2 cm. From the graph children can read that 45 children were asked, that mango is the most popular, that twice as many chose mango as apple and that 2/5 of the class chose mango. Good questions move from reading one value

to comparing (how many more?), combining (how many in all?) and deciding (which fruit should the school buy most of?).

Examples

- Repeating pattern red, blue, blue: the core has length 3, and the 20th bead is blue because 20 = 3 × 6 + 2.
- 3, 7, 11, 15 ... adds 4 each time: the next term is 19 and the 10th term is 3 + 9 × 4 = 39.
- 2, 6, 12, 20, 30, 42: differences 4, 6, 8, 10, 12; the terms are 1 × 2, 2 × 3, 3 × 4 and so on.
- Square numbers 1, 4, 9, 16, 25; triangular numbers 1, 3, 6, 10, 15; two consecutive triangular numbers make a square: 6 + 10 = 16.
- Calculation patterns: 37 × 3 = 111, 37 × 6 = 222, 37 × 9 = 333; 111 × 111 = 12,321.
- Calendar: in a 3 by 3 block of dates the sum is 9 times the middle date (middle 15 gives 135).
- Tally marks come in bundles of 5 (four strokes and a fifth across them); 23 is 4 bundles and 3 strokes.
- Pictograph with key 1 symbol = 10 books: 5 and a half symbols mean 55 books; always read the key first.
- Bar graph of mango 18, banana 12, apple 9, guava 6 at 1 cm = 3 children: bars of 6, 4, 3 and 2 cm; 45 children in all.
- Data cycle: ask a question, collect, organise (tally, table), represent (pictograph, bar graph) and interpret.

> **Quick revision:** Patterns: copy, extend, create, describe the rule; a repeating pattern has a core; 3, 7, 11 ... has 10th term 39; squares 1, 4, 9, 16; triangular numbers 1, 3, 6, 10; number grid: right +1, down +10; calendar: down +7, a 3 by 3 block = 9 × middle date; data: question, collect, tally in 5s, pictograph with a key, bar graph with equal widths and a scale; read, compare, total, decide.

Volume, Capacity and Everyday Mathematics: Counting Cubes and Learning from Real Life

Volume and capacity: Volume is the amount of space an object takes up; capacity is how much a hollow container can hold. A brick has volume, while a bottle has both a volume and a capacity. Capacity is measured in litres and millilitres, volume in cubic units, and the two meet in one fact: a 1 cubic centimetre space holds 1 mL, so 1,000 cubic centimetres hold 1 L. At primary level volume is not found by a formula but by counting how many unit cubes, marbles or beads make or fill a shape, and by watching water rise.

Counting cubes: Children first build with cubes and count them one by one, then layer by layer. A cuboid 4 cubes long, 3 cubes wide and 2 cubes high has 4 × 3 = 12 cubes in each layer and 2 layers, 24 cubes in all, which is where length × breadth × height comes from in later classes. In a drawing of a stack, children often count only the cubes they can see, so building the stack first matters. The same 24 cubes can be rebuilt as 6 by 2 by 2 or 8 by 3 by 1: the shape changes but the volume does not, an idea of conservation that Piaget found children reach later than conservation of number. A cube 3 cubes on each side needs 27 unit cubes, so 19 more cubes turn a 2 by 2 by 2 cube (8 cubes) into it. If this 27-cube block is painted on the outside, the 8 corner cubes have 3 painted faces, the 12 edge cubes have 2, the 6 cubes at the centres of the faces have 1 and the 1 cube in the middle has none.

Volume by displacement: A stone dropped into a measuring jug pushes the water up by its own volume: if the level rises from 400 mL to 550 mL, the stone's volume is 150 cubic centimetres. The Class 5 chapter How Big? How Heavy? uses this idea: children mark a glass of water in marbles, compare objects by how much they raise the water level and find volumes in mL, then measure volume in centimetre cubes with matchboxes and paper cubes, and the chapter then turns to weight. Size and weight are different measures: a bigger object is not always heavier, and two objects of the same volume can weigh very differently.

Capacity problems: Capacity problems join measurement with the four operations. A 5 L can fills 20 bottles of 250 mL. A 1,200 L tank filled by a pipe at 40 L a minute is full in 30 minutes. If each member of a family of 5 uses 135 L of water a day, the family uses 675 L a day. Children should estimate first (a bucket holds roughly 10 to 15 L, a glass roughly 200 mL) and choose the right unit before calculating, and should check by pouring and measuring when the answer seems strange.

Everyday mathematics: CTET word problems come from ordinary life: shopping and bills, recipes, timetables, fares, calendars and saving. A recipe that needs 300 g of flour for 4 people needs 450 g for 6, since each person's share is 75 g. Saving ₹ 15 a week for 12 weeks gives ₹ 180. A bus that leaves at 7:30 a.m. on a journey of 4 hours 45 minutes

arrives at 12:15 p.m. Each problem asks children to read the situation, choose the operation, keep the units consistent and judge whether the answer makes sense, for example that a remainder of children means one more bus, not part of a bus.

How NCERT builds each idea: Math-Magic was written after NCF 2005, which states that the main goal of school mathematics is the mathematisation of the child's thinking. The books begin from the children's own world (a junk seller, a trip to Bhopal, a fish tale, jugs and mugs), use play, puzzles, stories and real objects, and ask children to estimate, explain and find more than one way. Ideas return in a spiral, each time deeper: measurement in every class, Smart Charts in Classes 3, 4 and 5, and length from steps to millimetres. The order is concrete, then pictorial, then abstract: cubes and water before pictures of stacks, and pictures before numbers and formulas. The newer NCERT book Joyful Mathematics for Classes 1 and 2 follows NCF-FS 2022, which settled that children in the Foundational Stage (ages 3 to 8, up to Class 2) learn through play, toys, games, rhymes and stories. NEP 2020 calls foundational literacy and numeracy for every child by Grade 3 an urgent national mission.

Examples

- Volume is the space an object takes up; capacity is what a container holds; 1 cubic cm holds 1 mL, and 1,000 cubic cm hold 1 L.
- Cuboid of 4 by 3 by 2 cubes: 12 cubes in each layer, 2 layers, 24 cubes; rebuilt as 6 by 2 by 2 it still has 24.
- To grow a 2 by 2 by 2 cube (8 cubes) into a 3 by 3 by 3 cube (27 cubes), add 19 cubes.
- Painted 3 by 3 by 3 cube: 8 small cubes with 3 painted faces, 12 with 2, 6 with 1 and 1 with none.
- Displacement: water rising from 400 mL to 550 mL shows that the stone's volume is 150 cubic cm.
- Capacity: a 5 L can fills 20 bottles of 250 mL; a 1,200 L tank filled at 40 L a minute is full in 30 minutes.
- Recipe scaling: 300 g of flour for 4 people is 75 g each, so 6 people need 450 g.
- A bus leaving at 7:30 a.m. on a 4 hours 45 minutes journey arrives at 12:15 p.m.
- NCF 2005: the main goal of school mathematics is mathematising the child's thinking; Math-Magic starts from the children's world and spirals.
- Joyful Mathematics (Classes 1 and 2) follows NCF-FS 2022: learning through play in the Foundational Stage (ages 3 to 8).

> **Quick revision:** Volume: space taken up, counted in unit cubes; capacity: what a container holds, in L and mL; 1 cubic cm = 1 mL; 4 × 3 × 2 = 24 cubes; 3 × 3 × 3 = 27; painted cube 8, 12, 6, 1; displacement 400 to 550 mL = 150 cubic cm; everyday problems: read, choose the operation, keep units, check sense; Math-Magic (NCF 2005): play, real contexts, spiral; Joyful Mathematics (NCF-FS 2022): play in the Foundational Stage.

Free practice questions: parikshasaathi.com/q/mathematics-content-p1/

Mathematics, Classes VI-VIII (Paper II)

Mathematics, Classes VI-VIII (Paper II)

What the exam asks: In CTET Paper II, Mathematics has 30 questions: 20 on content and 10 on pedagogical issues. Content questions are at NCERT class VI-VIII level but test the teacher's own command. The official content list is Number System (knowing our numbers, playing with numbers, whole numbers, negative numbers and integers, fractions), Algebra (introduction to algebra, ratio and proportion), Geometry (basic geometrical ideas in 2-D, understanding elementary shapes in 2-D and 3-D, symmetry and reflection, construction with straight edge, protractor and compasses), Mensuration and Data handling.

Knowing our numbers: Indian periods are ones, thousands, lakhs and crores, so 2,08,40,015 is two crore eight lakh forty thousand fifteen; international periods are ones, thousands and millions, so 1 million = 10 lakh. Place value is the digit times the value of its place (in 3,62,18,405 the 6 is worth 60,00,000). To estimate, round to the greatest place: 689 × 312 is about 700 × 300 = 2,10,000. In Roman numerals no symbol repeats more than three times, V, L and D never repeat, and only I, X and C are written before a larger symbol to subtract: 1984 = MCMLXXXIV.

Playing with numbers: A prime has exactly two factors; 1 is neither prime nor composite, and 2 is the only even prime. Divisibility: for 3 or 9, check the digit sum; for 4, the last two digits; for 8, the last three; for 11, the difference of the sums of alternate digits must be 0 or a multiple of 11. A number divisible by two co-prime numbers is divisible by their product, but one divisible by 4 and 6 need not be divisible by 24. HCF takes the common primes at their lowest powers, LCM all primes at their highest, and for two numbers HCF × LCM = their product. 'Greatest container' signals HCF; 'ring together again' signals LCM.

Whole numbers and integers: Whole numbers are closed under addition and multiplication, not under subtraction or division; 0 is the additive identity, 1 the multiplicative identity, and division by 0 is not defined. Integers model temperatures below zero, depths and losses. Subtracting an integer means adding its additive inverse: $-12 - (-20) = 8$. A product of non-zero integers is negative when the number of negative factors is odd.

Fractions, decimals and rational numbers: Make the denominators equal before adding or subtracting; to divide, multiply by the reciprocal: $4\ 1/2 \div 3/4 = 6$. A product of decimals has as many decimal places as all the factors together: $0.3 \times 0.02 = 0.006$. A rational number is p/q (p, q integers, $q \neq 0$), and between any two there are infinitely many: 9/24, 10/24 and 11/24 lie between 1/3 and 1/2. Exponents ($a \neq 0$): $a^m \times a^n = a^{m+n}$, $a^0 = 1$, $a^{-m} = 1/a^m$; standard form is $k \times 10^n$ with $1 \leq k < 10$. A perfect square never ends in 2, 3, 7 or 8; square and cube roots come from pairing or tripling prime factors: $\sqrt{1,764} = 42$.

Algebra: A variable stands for any number, as in the rule $3n + 1$ for the matchsticks in a row of n squares. An equation is solved by doing the same operation on both sides. A ratio compares quantities of the same kind in the same unit (50 cm : 2 m = 1 : 4); a : b = c : d is a proportion when $a \times d = b \times c$, and the unitary method first finds the value of one unit. Profit and loss per cent are calculated on the cost price.

Geometry: Angles on a straight line add up to 180° and those around a point to 360°; the angles of a triangle add up to 180° and those of a quadrilateral to 360°. Every square is a rectangle and a rhombus, but not the other way round. Convex polyhedra satisfy $F + V - E = 2$; a cube has 6 faces, 12 edges and 8 vertices. A square has 4 lines of symmetry, a non-square rectangle 2 and an equilateral triangle 3. Ruler and compasses alone give perpendicular bisectors, angle bisectors and angles of 60°, 30°, 90° and 120°.

Mensuration and data handling: A rectangle has perimeter $2(l + b)$ and area $l \times b$, a triangle has area $1/2 \times \text{base} \times \text{height}$, and a circle has circumference $2\pi r$ and area πr^2. The volume of a cuboid is $l \times b \times h$, and 1 litre = 1,000 cm^3. The mean is the sum divided by the number of values, the median the middle value in order (or the mean of the middle two), and the mode the most frequent value; a pie-chart sector is the same fraction of 360° as the item is of the total.

Common errors: adding numerators and denominators (1/2 + 1/3 is 5/6, not 2/5), treating $-(-a)$ as $-a$, swapping HCF and LCM, counting the whole numbers between 20 and 50 as 30 instead of 29, writing $2^3 = 6$, and confusing area with perimeter. Check each answer by substitution, estimation or the inverse operation.

Examples

- Indian and international systems: 4,07,30,500 = 40,730,500, read as four crore seven lakh thirty thousand five hundred, or forty million seven hundred thirty thousand five hundred.
- Divisibility: 4,15,512 is divisible by 8 because $512 = 8 \times 64$, and by 9 because its digit sum $4 + 1 + 5 + 5 + 1 + 2 = 18$ is a multiple of 9.
- HCF and LCM: $36 = 2^2 \times 3^2$ and $48 = 2^4 \times 3$, so HCF $= 2^2 \times 3 = 12$ and LCM $= 2^4 \times 3^2 = 144$; check $12 \times 144 = 36 \times 48 = 1,728$.
- Integers: $(-8) - (-13) + (-6) = -8 + 13 - 6 = -1$, and $(-3) \times (-4) \times (-5) = -60$ because there are three negative factors.
- Fractions and decimals: $2\ 1/2 \div 5/6 = 5/2 \times 6/5 = 3$, and $0.25 \times 0.4 = 0.100 = 0.1$.
- Exponents: $3^4 \times 3^{-2} = 3^2 = 9$, $(5/2)^{-2} = 4/25$, and 4,50,00,000 $= 4.5 \times 10^7$ in standard form.
- Squares and cubes: $1,764 = 2^2 \times 3^2 \times 7^2$, so $\sqrt{1,764} = 42$; $2,744 = 2^3 \times 7^3$, so $\sqrt[3]{2,744} = 14$.
- Algebra: if $3x + 7 = 25$, then $3x = 18$ and $x = 6$; check: $3 \times 6 + 7 = 25$.
- Ratio and percentage: ₹1,200 shared in the ratio 3 : 5 gives ₹450 and ₹750; an article bought for ₹800 and sold for ₹920 gives a profit of $120/800 \times 100 = 15\%$.

- Geometry and mensuration: a triangle with angles 47° and 68° has third angle 180° − 115° = 65°; a rectangle 12 m by 5 m has perimeter 34 m and area 60 m².
- Data handling: for 4, 7, 7, 9 and 13 the mean is 40 ÷ 5 = 8, the median is 7 and the mode is 7.

> **Quick revision:** Paper II maths: 20 content + 10 pedagogy at class VI-VIII level. Indian periods: lakh, crore; 1 million = 10 lakh. Place value = digit × value of its place. Roman: repeat at most 3 times; only I, X, C subtract. Divisibility: 3 and 9 by digit sum, 4 by last two digits, 8 by last three, 11 by alternate sums. HCF lowest powers, LCM highest; HCF × LCM = product. Whole numbers not closed under subtraction; −(−a) = +a. Divide fractions by the reciprocal. $a^m \times a^n = a^{m+n}$, $a^{-m} = 1/a^m$. Proportion a : b = c : d when ad = bc. Triangle 180°, quadrilateral 360°. Rectangle: area lb, perimeter 2(l + b). Mean, median, mode.

Number System: Integers, Rational Numbers, Divisibility, HCF and LCM

Whole numbers and integers: The natural numbers 1, 2, 3, ... become the whole numbers when 0 is added, and the integers when −1, −2, −3, ... are added too. Whole numbers are closed under addition and multiplication but not under subtraction (3 − 5) or division (5 ÷ 2); integers are closed under subtraction as well, but not under division, since (−9) ÷ 2 is not an integer. Multiplication distributes over addition, a × (b + c) = a × b + a × c, which gives quick products: 854 × 102 = 85,400 + 1,708 = 87,108. For any integer a, a ÷ (−1) = −a, 0 ÷ a = 0 when a ≠ 0, and a ÷ 0 is not defined.

Rational numbers: A rational number can be written as p/q, where p and q are integers and q ≠ 0, so every integer (−5 = −5/1) and every terminating decimal (0.75 = 3/4) is rational. In standard form the denominator is positive and the numerator and denominator have no common factor except 1: −45/30 and 36/−24 both become −3/2. To compare, use a common positive denominator: −3/4 = −9/12 and −5/6 = −10/12, so −3/4 > −5/6. Rational numbers are closed under addition, subtraction and multiplication, but not under division, as division by 0 is not defined. The additive inverse of a/b is −a/b and its reciprocal is b/a, so the reciprocal of −7/9 is −9/7, not 9/7, and 0 has no reciprocal.

Factors, multiples and primes: A prime has exactly two factors, a composite more than two, and 1 is neither. There are 25 primes up to 100, which the Sieve of Eratosthenes finds by striking out the multiples of 2, 3, 5 and 7 on a 100-chart; 2 is the only even prime, 4 the smallest composite and 9 the smallest odd composite. Twin primes differ by 2 (11 and 13); co-prime numbers have no common factor except 1 but need not be prime (8 and 15). A perfect number equals the sum of its other factors: 6 = 1 + 2 + 3 and 28 = 1 + 2 + 4 + 7 + 14.

Divisibility rules: Test 3 and 9 by the digit sum, 4 by the last two digits, 8 by the last three, 6 by both 2 and 3, and 11 by the difference between the sums of the digits in odd and even places, which must be 0 or a multiple of 11. For 61,809 the odd places give 9 + 8 + 6 = 23 and the even places 0 + 1 = 1; the difference 22 is a multiple of 11, and 61,809 = 11 × 5,619. If 21y5 is a multiple of 9, 8 + y must be 9 or 18, so the digit y is 1; if 31z5 is a multiple of 3, z is 0, 3, 6 or 9. General form explains the tricks: the two-digit number ab is 10a + b, so ab + ba = 11(a + b) and ab − ba = 9(a − b), and for three digits abc − cba = 99(a − c).

Prime factorisation, HCF and LCM: Every composite number is a product of primes in exactly one way apart from order, found by a factor tree or by repeated division. The HCF takes the common primes at their lowest powers and the LCM every prime at its highest. For $72 = 2^3 \times 3^2$, $108 = 2^2 \times 3^3$ and $180 = 2^2 \times 3^2 \times 5$, the HCF is $2^2 \times 3^2 = 36$ and the LCM is $2^3 \times 3^3 \times 5 = 1{,}080$. HCF × LCM = product holds for two numbers only: 36 × 216 = 7,776 = 72 × 108, but 36 × 1,080 is not 72 × 108 × 180.

Word problems: 'Greatest' or 'longest that measures exactly' points to the HCF, 'least' or 'together again' to the LCM; a remainder is first subtracted from the numbers for the HCF but added to the LCM at the end. The greatest number dividing 245 and 1,029 with remainder 5 is the HCF of 240 and 1,024, that is 16. The least number leaving remainder 5 when divided by 6, 15 and 18 is their LCM plus 5: 90 + 5 = 95. The smallest three-digit number divisible by 6, 8 and 12 is the first three-digit multiple of their LCM 24, that is 120, and the greatest is 24 × 41 = 984.

In the classroom: Typical errors are calling 1 a prime, thinking co-prime numbers must be prime, taking the LCM to be the product (the LCM of 6 and 8 is 24, not 48), and assuming that a number divisible by 4 and 6 is divisible by 24 (12 is not; the rule needs co-prime divisors, as 2 and 9 for 18). The teacher lets pupils arrange 12 counters into every

possible rectangle (1 × 12, 2 × 6, 3 × 4) to see factors in pairs, and marks multiples on a number line so that the first common mark shows the LCM.

Examples

- Closure: whole numbers are not closed under subtraction (3 − 5 = −2), integers are not closed under division ((−9) ÷ 2 = −4.5), and rational numbers are closed under addition, subtraction and multiplication.
- Distributive law for quick multiplication: 854 × 102 = 854 × 100 + 854 × 2 = 85,400 + 1,708 = 87,108.
- Standard form of a rational number: −45/30 = −3/2; comparing, −3/4 = −9/12 is greater than −5/6 = −10/12.
- The reciprocal of −7/9 is −9/7 and its additive inverse is 7/9; 0 has no reciprocal.
- Divisibility by 11: for 61,809, (9 + 8 + 6) − (0 + 1) = 22, a multiple of 11, and 61,809 = 11 × 5,619.
- Primes: there are 25 primes up to 100; 2 is the only even prime; 1 is neither prime nor composite; 6 and 28 are perfect numbers.
- $72 = 2^3 \times 3^2$, $108 = 2^2 \times 3^3$ and $180 = 2^2 \times 3^2 \times 5$, so their HCF is 36 and their LCM is 1,080.
- Remainders: the greatest number dividing 245 and 1,029 with remainder 5 is HCF(240, 1,024) = 16; the least number leaving remainder 5 on division by 6, 15 and 18 is 90 + 5 = 95.
- General form: ab + ba = 11(a + b), so 47 + 74 = 121 = 11 × 11; ab − ba = 9(a − b), so 74 − 47 = 27 = 9 × 3.

> **Quick revision:** Natural numbers are whole numbers, whole numbers are integers, integers are rational; whole numbers not closed under subtraction, integers not under division; rational p/q with q ≠ 0, standard form has a positive denominator and no common factor; reciprocal of −7/9 is −9/7; 25 primes up to 100, 1 neither prime nor composite; rule for 11: alternate digit sums differ by 0 or a multiple of 11; HCF lowest powers, LCM highest; HCF × LCM = product for two numbers only; with remainder r use HCF of (numbers − r) or LCM + r.

Fractions, Decimals, Exponents and Powers, Squares and Cubes

Fractions: An improper fraction can be written as a mixed fraction (17/5 = 3 2/5), and a fraction is in simplest form when the HCF of its numerator and denominator is 1 (36/48 = 3/4). Unlike fractions are compared through a common denominator or by cross-multiplying: 5/8 < 7/11 because 5 × 11 = 55 is less than 8 × 7 = 56. They are added through the LCM of the denominators: 2 3/5 + 1 3/4 = 52/20 + 35/20 = 87/20 = 4 7/20. 'Of' means multiply, so 3/4 of 16 = 12. Division is multiplication by the reciprocal: 3 1/3 ÷ 2/9 = 10/3 × 9/2 = 15, and a 6 m ribbon gives 6 ÷ 3/4 = 8 pieces of 3/4 m. Dividing by a proper fraction gives a larger answer, which surprises pupils who believe division always makes smaller.

Decimals: Each place to the right of the decimal point is one-tenth of the place before it. Fractions convert through an equivalent fraction with denominator 10, 100 or 1,000, or by division: 7/25 = 28/100 = 0.28 and 3/8 = 0.375. Decimals are compared place by place from the left, so 0.5 > 0.45 although 0.45 has more digits. A product has as many decimal places as its factors together (1.2 × 0.15 = 0.180 = 0.18), and division is easiest once the divisor is a whole number: 2.56 ÷ 0.16 = 256 ÷ 16 = 16.

Laws of exponents: For non-zero a and b and integers m and n: $a^m \times a^n = a^{m+n}$, $a^m \div a^n = a^{m-n}$, $(a^m)^n = a^{mn}$, $a^m \times b^m = (ab)^m$, $a^m \div b^m = (a/b)^m$ and $a^0 = 1$. Class VIII adds negative exponents, $a^{-m} = 1/a^m$, so $10^{-3} = 1/1{,}000$ and $(-2)^{-3} = -1/8$. A negative base gives a positive power for an even exponent and a negative one for an odd exponent: $(-1)^{101} = -1$. Worked forms: $(2^5 \times 2^3) \div 2^4 = 2^4 = 16$; $(3^{-1} + 4^{-1})^{-1} = (7/12)^{-1} = 12/7$; and if $5^m \div 5^{-3} = 5^5$, then m + 3 = 5 and m = 2. Note that $(2^3)^2 = 2^6 = 64$, while 2 raised to 3^2 is $2^9 = 512$.

Standard form: A number is in standard form when written as $k \times 10^n$ with $1 \le k < 10$ and n an integer. Large numbers have a positive n: the speed of light, about 300,000,000 m/s, is 3×10^8 m/s. Small numbers have a negative n: 0.000035 = 3.5×10^{-5}. In standard form the exponent decides first, so 3×10^{-5} is smaller than 2×10^{-4}. Expanded form with powers of 10 shows place value: $47{,}561 = 4 \times 10^4 + 7 \times 10^3 + 5 \times 10^2 + 6 \times 10^1 + 1 \times 10^0$.

Squares and square roots: A perfect square ends in 0, 1, 4, 5, 6 or 9 and in an even number of zeros, so 2,057 and 1,000 are not squares. The sum of the first n odd numbers is n^2 (1 + 3 + 5 + 7 + 9 = 25); there are 2n non-square numbers between n^2 and $(n + 1)^2$, so 18 between 81 and 100; and for m > 1, 2m, $m^2 - 1$ and $m^2 + 1$ form a Pythagorean triplet (m = 4 gives 8, 15, 17). Square roots come from pairing prime factors: $2{,}352 = 2^4 \times 3 \times 7^2$ is not a

square because 3 is unpaired, and multiplying by 3 gives 7,056 = 84^2 while dividing by 3 gives 784 = 28^2. For decimals, $\sqrt{12.25} = 3.5$ and $\sqrt{0.0081} = 0.09$.

Cubes and cube roots: The cubes of 1 to 10 are 1, 8, 27, 64, 125, 216, 343, 512, 729 and 1,000. The cube of a negative number is negative, so the cube root of −1,331 is −11. Cube roots come from grouping prime factors in threes: $10{,}648 = 2^3 \times 11^3$, so its cube root is 22, while $675 = 3^3 \times 5^2$ must be multiplied by 5 to give the cube $3{,}375 = 15^3$. In a perfect cube the last digit fixes the root's last digit (a cube ending in 8 has a root ending in 2, 7 gives 3, 3 gives 7, 2 gives 8), and the part left after striking off the last three digits fixes the rest: for 17,576 the root ends in 6 and 17 lies between $2^3 = 8$ and $3^3 = 27$, so the root is 26. $1{,}729 = 1^3 + 12^3 = 9^3 + 10^3$, the Hardy-Ramanujan number, is the smallest number that is a sum of two positive cubes in two different ways.

In the classroom: Pupils who say 0.45 > 0.5, 1/3 + 1/4 = 2/7 or $2^3 = 6$ have learnt rules without meaning. Fraction strips and number lines, place-value charts for decimals, squares drawn on grid paper for n^2 and unit cubes stacked into bigger cubes for n^3 tie each symbol to a picture before the shortcut is taught.

Examples

- Cross-multiplication: 5/8 < 7/11 because 5 × 11 = 55 is less than 8 × 7 = 56.
- Mixed fractions: 2 3/5 + 1 3/4 = 87/20 = 4 7/20, and 3 1/3 ÷ 2/9 = 10/3 × 9/2 = 15.
- Decimals: 3/8 = 0.375; 1.2 × 0.15 = 0.18; 2.56 ÷ 0.16 = 16; 0.5 is greater than 0.45.
- Exponents: $(2^5 \times 2^3) \div 2^4 = 16$; $(-2)^{-3} = -1/8$; $(3^{-1} + 4^{-1})^{-1} = 12/7$; $(-1)^{101} = -1$.
- $(2^3)^2 = 2^6 = 64$, but 2 raised to 3^2 is $2^9 = 512$; $a^0 = 1$ for every non-zero a.
- Standard form: $300{,}000{,}000 = 3 \times 10^8$ and $0.000035 = 3.5 \times 10^{-5}$; in $k \times 10^n$, $1 \le k < 10$.
- $2{,}352 = 2^4 \times 3 \times 7^2$: multiplying by 3 gives $7{,}056 = 84^2$, and dividing by 3 gives $784 = 28^2$.
- Squares: between $9^2 = 81$ and $10^2 = 100$ lie 2 × 9 = 18 non-square numbers; m = 4 in 2m, $m^2 - 1$, $m^2 + 1$ gives the triplet 8, 15, 17.
- Cube roots: $\sqrt[3]{10{,}648} = 22$; $\sqrt[3]{17{,}576} = 26$; $675 \times 5 = 3{,}375 = 15^3$; $1{,}729 = 1^3 + 12^3 = 9^3 + 10^3$.

Quick revision: To divide by a fraction multiply by its reciprocal; compare unlike fractions by cross-multiplying; decimal places in a product add up; $a^m \times a^n = a^{m+n}$, $(a^m)^n = a^{mn}$, $a^0 = 1$, $a^{-m} = 1/a^m$; standard form $k \times 10^n$ with $1 \le k < 10$; squares end in 0, 1, 4, 5, 6 or 9; sum of first n odd numbers = n^2; 2m, $m^2 - 1$, $m^2 + 1$ is a triplet; square roots by pairing prime factors and cube roots by grouping them in threes; $1{,}729 = 1^3 + 12^3 = 9^3 + 10^3$.

Algebra: Expressions, Linear Equations, Identities and Factorisation

Variables and expressions: A variable is a letter that can take different values, while a constant has a fixed value. Class VI algebra starts from patterns: n letters L made of matchsticks need 2n sticks and n letters C need 3n. In the expression $5xy^2 - 3x^2y + 7$ the terms are $5xy^2$, $-3x^2y$ and 7, the numerical coefficient of xy^2 is 5 and 7 is the constant term; expressions of one, two and three terms are monomials, binomials and trinomials. Like terms have the same variables raised to the same powers (7ab and −2ba are like; $3x^2y$ and $3xy^2$ are not), and only like terms can be added. Translating words needs care: '5 less than twice a number' is 2x − 5, not 5 − 2x.

Working with expressions: Subtracting an expression changes the sign of each of its terms: $(7x^2 - 4x + 2) - (3x^2 + x - 6) = 4x^2 - 5x + 8$. In multiplication the coefficients multiply and powers of the same variable add: $(-3x^2y) \times (4xy^3) = -12x^3y^4$. Each term of one bracket multiplies each term of the other: $(2x + 3)(x - 5) = 2x^2 - 10x + 3x - 15 = 2x^2 - 7x - 15$, which can be checked by putting x = 1 (5 × (−4) = −20 and 2 − 7 − 15 = −20).

Linear equations in one variable: A linear equation has its variable only to the power 1, and its solution is the value that makes both sides equal. Whatever is done to one side is done to the other; transposing a term with its sign changed is a short form of this. With the variable on both sides, collect it on one side: 5x − 3 = 3x + 7 gives 2x = 10 and x = 5. With fractions, multiply through by the LCM of the denominators: x/2 − 1/5 = x/3 + 1/4 times 60 becomes 30x − 12 = 20x + 15, so 10x = 27 and x = 27/10, when both sides equal 23/20. Likewise (6x + 1)/3 + 1 = (x − 3)/6 times 6 gives 12x + 2 + 6 = x − 3, so 11x = −11 and x = −1.

Word problems: Name the unknown, write the equation the words describe, solve it and check the answer against the story. The sum of three consecutive multiples of 8 is 888: with 8x, 8(x + 1) and 8(x + 2), 24x + 24 = 888, so x = 36

and the numbers are 288, 296 and 304. A two-digit number has digits adding up to 9 and grows by 27 when its digits are interchanged; with units digit b it is 10(9 − b) + b, the condition gives 18b − 81 = 27, so b = 6 and the number is 36.

Algebraic identities: An identity is true for every value of its variables, an equation only for particular values. The class VIII identities are $(a + b)^2 = a^2 + 2ab + b^2$, $(a - b)^2 = a^2 - 2ab + b^2$, $(a + b)(a - b) = a^2 - b^2$ and $(x + a)(x + b) = x^2 + (a + b)x + ab$. They make hard arithmetic easy: $103^2 = 10{,}000 + 600 + 9 = 10{,}609$; $99^2 = 10{,}000 - 200 + 1 = 9{,}801$; $197 \times 203 = 200^2 - 3^2 = 39{,}991$; and $51^2 - 49^2 = 100 \times 2 = 200$. The commonest error, $(a + b)^2 = a^2 + b^2$, fails for a = 1 and b = 2 (9 against 5); a square of side a + b shows the two missing rectangles of area ab.

Factorisation: Factorising writes an expression as a product, the reverse of expanding. Take out the common factor: $12a^2b + 15ab^2 = 3ab(4a + 5b)$. Regroup when no factor is common to all terms: $2xy + 2y + 3x + 3 = 2y(x + 1) + 3(x + 1) = (x + 1)(2y + 3)$. Recognise identities: $x^2 + 8x + 16 = (x + 4)^2$, $4y^2 - 12y + 9 = (2y - 3)^2$ and $49p^2 - 36 = (7p - 6)(7p + 6)$. For $x^2 + px + q$, find two numbers with product q and sum p: $x^2 + 5x + 6 = (x + 2)(x + 3)$, $y^2 - 7y + 12 = (y - 3)(y - 4)$ and $z^2 - 4z - 12 = (z - 6)(z + 2)$.

In the classroom: Pupils who read 3a as 'three apples' treat the letter as an object rather than a number, and then write $3x + 5x = 8x^2$, $3 + 2x = 5x$ or $(2a)^2 = 2a^2$. The teacher asks them to find and correct such errors (x + 2x + 3x is 6x, not 5x), to test any rule by substituting a number, and uses algebra tiles or area diagrams for products and identities.

Examples

- Like terms: 7ab and −2ba are like terms; $3x^2y$ and $3xy^2$ are unlike, so $3x^2y + 3xy^2$ cannot be simplified.
- '5 less than twice a number' is 2x − 5; 'a number decreased by 5 and then doubled' is 2(x − 5).
- $(7x^2 - 4x + 2) - (3x^2 + x - 6) = 4x^2 - 5x + 8$, and $(-3x^2y) \times (4xy^3) = -12x^3y^4$.
- 5x − 3 = 3x + 7 gives x = 5; x/2 − 1/5 = x/3 + 1/4 gives x = 27/10 after multiplying both sides by 60.
- Three consecutive multiples of 8 that add up to 888 are 288, 296 and 304.
- Identities: $(a + b)^2 = a^2 + 2ab + b^2$; $(a - b)^2 = a^2 - 2ab + b^2$; $(a + b)(a - b) = a^2 - b^2$; $(x + a)(x + b) = x^2 + (a + b)x + ab$.
- Mental arithmetic with identities: $103^2 = 10{,}609$; $99^2 = 9{,}801$; $197 \times 203 = 39{,}991$; $51^2 - 49^2 = 200$.
- Factorisation: $2xy + 2y + 3x + 3 = (x + 1)(2y + 3)$; $49p^2 - 36 = (7p - 6)(7p + 6)$; $z^2 - 4z - 12 = (z - 6)(z + 2)$.
- Check by substitution: for a = 1 and b = 2, $(a + b)^2 = 9$ but $a^2 + b^2 = 5$, so $(a + b)^2$ is not $a^2 + b^2$.

> **Quick revision:** Variable takes different values; terms, coefficients, like terms; only like terms add; subtracting an expression changes every sign; linear equation: same operation on both sides, clear fractions with the LCM, check by substitution; identity true for all values; $(a \pm b)^2 = a^2 \pm 2ab + b^2$, $(a + b)(a - b) = a^2 - b^2$, $(x + a)(x + b) = x^2 + (a + b)x + ab$; factorise by common factor, regrouping, identities or two numbers with product q and sum p.

Ratio, Proportion, Percentage, Profit and Loss, Simple and Compound Interest

Ratio and proportion: A ratio compares two quantities of the same kind in the same unit by division and has no unit itself; it is written in simplest form, so 40 minutes : 2 hours = 40 : 120 = 1 : 3. Two ratios are compared as fractions with a common denominator: 3 : 4 = 21/28 and 5 : 7 = 20/28, so 3 : 4 is greater. Four numbers are in proportion, a : b :: c : d, when the product of the extremes equals the product of the means (a × d = b × c): 15 : 45 :: 40 : 120 because 15 × 120 = 45 × 40 = 1,800. If 4, 6, 10 and x are in proportion, 4x = 60 and x = 15. To share in a ratio, add the parts: 36 pupils with boys and girls in the ratio 4 : 5 make 9 parts of 4 pupils each, so 16 boys and 20 girls.

Unitary method: Find the value of one unit first, then of the number required. If 6 pens cost ₹90, one costs ₹15 and 10 cost ₹150; if a car runs 150 km on 12 litres of petrol, it runs 12.5 km on one litre and 250 km on 20 litres. The same reasoning underlies percentages, profit and loss, and interest.

Percentage: Per cent means per hundred, so a fraction or decimal is converted by multiplying by 100: 3/8 = 37.5% and 0.045 = 4.5%. The whole is found from a part by dividing: if 25% of a number is 30, the number is 30 × 100/25 = 120. Increase or decrease per cent is always worked on the original value: a price rising from ₹40 to ₹50 rises by 10/40 × 100 = 25%, but falling from ₹50 to ₹40 falls by 10/50 × 100 = 20%.

Profit, loss and discount: Profit = selling price (SP) − cost price (CP), loss = CP − SP, and both per cents are calculated on the CP. Overhead expenses such as repairs or transport after buying are added to the CP: a scooter bought for ₹12,000, repaired for ₹3,000 and sold for ₹13,500 gives a loss of ₹1,500 on ₹15,000, which is 10%. With CP and gain per cent known, SP = CP × (100 + gain%)/100, so ₹600 at a 15% gain sells for ₹690; with SP and loss per cent known, CP = SP × 100/(100 − loss%), so an article sold for ₹1,140 at a 5% loss cost ₹1,200. Discount is a reduction on the marked price (MP) and its per cent is calculated on the MP: an MP of ₹2,000 with a 12% discount gives an SP of ₹1,760.

Simple and compound interest: Simple interest is charged on the principal alone, SI = P × R × T/100: ₹5,000 at 8% per annum for 3 years earns ₹1,200, so the amount is ₹6,200. Compound interest adds each period's interest to the principal, so the amount is $A = P(1 + R/100)^n$ and CI = A − P. ₹10,000 at 10% per annum compounded annually for 2 years amounts to 10,000 × 1.1 × 1.1 = ₹12,100, giving CI ₹2,100 against SI ₹2,000; the extra ₹100 is the interest on the first year's interest, and for 2 years CI − SI = $P(R/100)^2$. Compounded half-yearly, the rate is halved and the number of periods doubled: ₹8,000 at 10% per annum for 1 year becomes 8,000 × 1.05^2 = ₹8,820, a CI of ₹820. The same formula gives growth and depreciation: a population of 20,000 growing at 5% a year reaches 22,050 in 2 years, and a machine worth ₹50,000 losing 10% a year is worth 50,000 × 0.9^2 = ₹40,500 after 2 years.

Direct and inverse proportion: Two quantities are in direct proportion when they increase or decrease together in the same ratio, so x/y stays constant: if 6 m of cloth costs ₹210, 10 m costs ₹350. They are in inverse proportion when one increases as the other decreases in the same ratio, so x × y stays constant: if 15 workers build a wall in 48 hours, 30 workers take 24 hours, and a school day of 8 periods of 45 minutes split into 9 periods gives periods of 40 minutes, since 8 × 45 = 9 × 40 = 360. For a fixed distance, speed and time are inversely proportional (60 km/h for 2 hours or 80 km/h for 1.5 hours). Not every pair that grows together is proportional: a child's height increases with age, but not in a fixed ratio.

In the classroom: Pupils often add the same number to both terms of a ratio instead of multiplying, work a percentage change on the new value, or calculate profit per cent on the SP. Ratio tables, double number lines and shop role plays with price tags and bills make the multiplicative idea visible, and estimating first (25% off ₹798 is about ₹200 off) helps pupils judge whether an answer is sensible.

Examples

- A ratio needs the same unit: 40 minutes : 2 hours = 40 : 120 = 1 : 3.
- Proportion test: 15 : 45 :: 40 : 120 because 15 × 120 = 45 × 40 = 1,800; the fourth proportional to 4, 6 and 10 is 15.
- Percentage change is on the original value: ₹40 to ₹50 is a 25% rise, but ₹50 to ₹40 is a 20% fall.
- SP = CP × (100 + gain%)/100, so CP ₹600 at a 15% gain gives SP ₹690; CP = SP × 100/(100 − loss%), so SP ₹1,140 at a 5% loss gives CP ₹1,200.
- Overheads join the cost price: ₹12,000 + ₹3,000 repairs = ₹15,000; sold for ₹13,500, the loss is ₹1,500, or 10%.
- Discount is on the marked price: MP ₹2,000 with a 12% discount gives SP ₹1,760.
- SI = PRT/100: ₹5,000 at 8% per annum for 3 years gives SI ₹1,200 and amount ₹6,200.
- CI: ₹10,000 at 10% per annum for 2 years gives A = ₹12,100 and CI = ₹2,100; for 2 years CI − SI = $P(R/100)^2$ = ₹100.
- Half-yearly compounding: ₹8,000 at 10% per annum for 1 year is 5% for 2 half-years, giving ₹8,820.
- Inverse proportion: if 15 workers take 48 hours, 30 workers take 24 hours; 8 periods of 45 minutes equal 9 periods of 40 minutes.

> **Quick revision:** Ratio: same kind, same unit, no unit of its own; a : b :: c : d when ad = bc; unitary method finds one unit first; percentage change on the original value; profit and loss per cent on CP, discount per cent on MP, overheads added to CP; SI = PRT/100; $A = P(1 + R/100)^n$, CI = A − P; half-yearly: rate halved, periods doubled; 2-year CI − SI = $P(R/100)^2$; direct proportion: x/y constant; inverse: xy constant.

Geometry: Lines, Angles, Parallel Lines, Triangles and Congruence

Basic geometrical ideas: A line segment has two end points and a fixed length, a ray has one end point, and a line extends endlessly both ways; exactly one line passes through two given points. Angles are acute (less than 90°),

right (90°), obtuse (between 90° and 180°), straight (180°), reflex (between 180° and 360°) or complete (360°). The hour hand turns 30° an hour, so the hands make 60° at 2 o'clock and 120° at 4 o'clock.

Pairs of angles: Two angles are complementary if they add up to 90° and supplementary if they add up to 180°: the complement of 63° is 27° and its supplement 117°. Adjacent angles share a vertex and an arm without overlapping; a linear pair is a pair of adjacent angles whose other arms form a straight line, so it adds up to 180°. When two lines cross, the vertically opposite angles are equal. Two acute angles cannot be supplementary, and the angle equal to its complement is 45°. Supplementary angles in the ratio 4 : 5 are 80° and 100°, and an angle 30° more than its complement satisfies $x = (90° - x) + 30°$, so $x = 60°$.

Parallel lines and a transversal: A transversal cuts two or more lines at distinct points, and with two lines it makes eight angles. When the lines are parallel, corresponding angles are equal, alternate interior angles are equal, alternate exterior angles are equal, and interior angles on the same side of the transversal add up to 180°. The converses test for parallel lines: if a pair of corresponding or alternate angles is equal, or a pair of interior angles on the same side is supplementary, the lines are parallel. So if one of the eight angles is 70°, four are 70° and four are 110°; and if the interior angles on one side are 3x and 2x, then $5x = 180°$, $x = 36°$, and the angles are 108° and 72°.

Triangles: By sides a triangle is scalene, isosceles or equilateral; by angles, acute, right or obtuse. A median joins a vertex to the mid-point of the opposite side and always lies inside; an altitude is the perpendicular from a vertex to the opposite side (or its extension) and can fall outside an obtuse triangle; every triangle has 3 of each. The angles add up to 180°, and an exterior angle equals the sum of the two interior opposite angles, so an exterior angle of 115° with one interior opposite angle of 50° leaves 65° for the other. The base angles of an isosceles triangle are equal, so a vertex angle of 40° leaves 70° for each. Any two sides together are longer than the third, so 2 cm, 3 cm and 6 cm cannot form a triangle, and with sides of 12 cm and 8 cm the third lies between 4 cm and 20 cm. The largest angle is opposite the longest side.

Pythagoras property: In a right-angled triangle the square on the hypotenuse equals the sum of the squares on the other two sides, $h^2 = a^2 + b^2$; the Baudhayana Sulba Sutra states the same result for the diagonal of a rectangle. The converse decides whether a triangle is right-angled: 6, 8 and 10 satisfy $36 + 64 = 100$, but 6, 8 and 11 do not. Common triplets are 3, 4, 5; 5, 12, 13; 8, 15, 17 and 7, 24, 25. A 15 m ladder reaching a window 12 m high stands 9 m from the wall, since $15^2 - 12^2 = 81$; and a rhombus with diagonals of 16 cm and 30 cm, which bisect each other at right angles, has side $\sqrt{(8^2 + 15^2)} = 17$ cm and perimeter 68 cm.

Congruence: Congruent figures have the same shape and size. Writing $\Delta ABC \cong \Delta PQR$ also fixes the correspondence A ↔ P, B ↔ Q, C ↔ R, from which AB = PQ, $\angle B = \angle Q$ and so on. The class VII criteria are SSS (three sides), SAS (two sides and the included angle), ASA (two angles and the included side) and RHS (right angle, hypotenuse and one side); since the third angle follows from the other two, two angles and any corresponding side also suffice. AAA is not a criterion, because triangles with equal angles can differ in size, and two sides with an angle that is not between them do not in general fix a triangle. If AB = DE = 5 cm, $\angle B = \angle E = 60°$ and BC = EF = 7 cm, then $\Delta ABC \cong \Delta DEF$ by SAS.

In the classroom: Pupils who read the wrong scale of a protractor report 140° for a 40° angle, believe an altitude must lie inside the triangle, or mix up complementary and supplementary. Estimating before measuring (is it more or less than a right angle?), folding paper to make a perpendicular bisector, and tearing off the three corners of a paper triangle to place them together on a straight line let pupils discover each property before it is stated.

Examples

- The complement of 63° is 27° and its supplement 117°; supplementary angles in the ratio 4 : 5 are 80° and 100°.
- Clock: the hour hand moves 30° an hour, so the hands make 60° at 2 o'clock and 90° at 3 o'clock.
- Parallel lines cut by a transversal: corresponding, alternate interior and alternate exterior angles are equal; interior angles on the same side add up to 180° ($3x + 2x = 180°$ gives 108° and 72°).
- Exterior angle property: an exterior angle of 115° with one interior opposite angle of 50° gives the other interior opposite angle as 65°.
- Triangle inequality: 2 cm, 3 cm and 6 cm cannot make a triangle ($2 + 3 < 6$); with sides 12 cm and 8 cm the third side is more than 4 cm and less than 20 cm.

- Pythagorean triplets: 3, 4, 5; 5, 12, 13; 8, 15, 17; 7, 24, 25 (and multiples such as 6, 8, 10).
- Ladder: a 15 m ladder reaching a window 12 m high has its foot $\sqrt{(225 - 144)} = \sqrt{81} = 9$ m from the wall.
- Rhombus with diagonals 16 cm and 30 cm: side $= \sqrt{(64 + 225)} = \sqrt{289} = 17$ cm, perimeter 68 cm.
- Congruence criteria: SSS, SAS, ASA and RHS; AAA, and two sides with a non-included angle, are not criteria.
- Every triangle has 3 medians and 3 altitudes; the medians lie inside, but two altitudes of an obtuse triangle fall outside it.

> **Quick revision:** Complementary 90°, supplementary 180°; linear pair 180°; vertically opposite angles equal; with parallel lines, corresponding and alternate angles equal, same-side interior angles add to 180°; triangle angle sum 180°; exterior angle = sum of interior opposite angles; any two sides > third; $h^2 = a^2 + b^2$; triplets 3-4-5, 5-12-13, 8-15-17, 7-24-25; congruence by SSS, SAS, ASA, RHS, never AAA.

Geometry: Quadrilaterals, Circles, Symmetry, Constructions and Solid Shapes

Polygons: A polygon is a simple closed curve made only of line segments; it is regular when all its sides and all its angles are equal. The angle sum of a polygon of n sides is $(n - 2) \times 180°$, because the diagonals from one vertex cut it into $n - 2$ triangles: 360° for a quadrilateral, 540° for a pentagon, 720° for a hexagon. The exterior angles of a convex polygon, one at each vertex, add up to 360°, so each exterior angle of a regular polygon of n sides is $360°/n$. A regular polygon with exterior angle 45° has $360 \div 45 = 8$ sides, and one with interior angle 108° has exterior angle 72° and so 5 sides.

Quadrilaterals: A trapezium has a pair of parallel sides; a kite has two pairs of equal adjacent sides and perpendicular diagonals; a parallelogram has both pairs of opposite sides parallel. In a parallelogram opposite sides are equal, opposite angles are equal, adjacent angles are supplementary and the diagonals bisect each other, so one angle of 70° gives angles of 70°, 110°, 70° and 110°, and adjacent angles in the ratio 3 : 2 are 108° and 72°. A rhombus is a parallelogram with all sides equal, and its diagonals are perpendicular bisectors of each other; a rectangle is a parallelogram with every angle 90° and equal diagonals; a square is both. Every square is a rectangle and a rhombus, and every rectangle and rhombus is a parallelogram, but a rhombus whose angles are not 90° is not a rectangle.

Circles: A circle is the set of points at a fixed distance, the radius, from a fixed point, the centre. A chord joins two points of the circle; the diameter is a chord through the centre, the longest chord, equal to $2 \times$ radius, and it divides the circle into two semicircles. An arc is a part of the circle, a sector is the region between an arc and two radii, and a segment is the region between an arc and a chord. The ratio of circumference to diameter is the same for every circle and is called π, approximately 22/7 or 3.14.

Symmetry: A figure has line symmetry if a fold along a line, the mirror line, makes its two halves coincide. An isosceles triangle has 1 line of symmetry, an equilateral triangle 3, a rectangle 2, a rhombus 2, a square 4, a regular polygon of n sides n, a scalene triangle none and a circle infinitely many. A figure has rotational symmetry if it looks exactly the same more than once in a full turn; the number of times is the order, and 360° divided by the order is the angle of rotation. A square has order 4 (90°), an equilateral triangle 3 (120°), a rectangle 2 (180°) and a regular hexagon 6 (60°). Some figures have both kinds (a square, the letter H), some only line symmetry (the letter A) and some only rotational symmetry (the letters S, N and Z, or a parallelogram that is neither a rectangle nor a rhombus).

Constructions: With a ruler and compasses one can copy a line segment, draw the perpendicular bisector of a segment, draw a perpendicular to a line from a point, bisect an angle, and make angles of 60° (from an equilateral triangle), 120° (two 60° steps), 90°, 30° (half of 60°), 45° (half of 90°), 15° and 75°. A triangle can be constructed from SSS, SAS, ASA or RHS data, the same as the congruence criteria, because each set fixes exactly one triangle; it cannot be constructed when the sides break the triangle inequality or two given angles add up to 180° or more.

Visualising solid shapes: A polyhedron is a solid with flat polygonal faces, straight edges and vertices; cylinders, cones and spheres have curved surfaces and are not polyhedra. Every convex polyhedron obeys Euler's formula $F + V - E = 2$: a cube or cuboid has 6 faces, 8 vertices and 12 edges; a triangular prism 5, 6 and 9; a square pyramid 5, 5 and 8; a tetrahedron 4, 4 and 6; a pentagonal prism 7, 10 and 15. So a polyhedron with 12 vertices and 30 edges

has 20 faces, and none can have 10 faces, 20 edges and 15 vertices, since 10 + 15 – 20 = 5. A net is a flat shape that folds into a solid (a cube has 11 different nets), and opposite faces of a die add up to 7.

In the classroom: Pupils who know a square only in its usual position may deny that a tilted square is a square, or think a rhombus can never be a square. Showing shapes in many orientations, sorting quadrilaterals by their properties, folding cut-outs to find lines of symmetry, and building solids from straws and clay to count F, V and E move pupils from the van Hiele visualisation level, where shapes are known by their look, to the analysis level, where they are known by their properties.

Examples

- Angle sum of a polygon of n sides = (n – 2) × 180°: pentagon 540°, hexagon 720°; the exterior angles of a convex polygon add up to 360°.
- Regular polygons: exterior angle 45° means 8 sides; interior angle 108° means exterior angle 72° and 5 sides; a regular hexagon has interior angles of 120°.
- Parallelogram: one angle of 70° gives 70°, 110°, 70°, 110°; adjacent angles in the ratio 3 : 2 are 108° and 72°.
- Diagonals bisect each other in every parallelogram, are equal in a rectangle, perpendicular in a rhombus and a kite, and equal and perpendicular in a square.
- Circle: diameter = 2 × radius and is the longest chord; a sector is bounded by two radii and an arc, a segment by a chord and an arc.
- Lines of symmetry: isosceles triangle 1, equilateral triangle 3, rectangle 2, square 4, regular hexagon 6, circle infinitely many.
- Rotational symmetry: square order 4 (90°), equilateral triangle order 3 (120°), regular hexagon order 6 (60°); S and Z have order 2 but no line of symmetry.
- Ruler-and-compasses angles: 60°, 120°, 90°, 30°, 45°, 15°, 75°; triangles are constructed from SSS, SAS, ASA or RHS data.
- Euler's formula F + V – E = 2: cube 6 + 8 – 12 = 2; triangular prism 5 + 6 – 9 = 2; square pyramid 5 + 5 – 8 = 2.
- A cube has 11 different nets, and the opposite faces of a die add up to 7.

> **Quick revision:** Polygon angle sum (n – 2) × 180°, exterior angles 360°, regular polygon exterior angle 360°/n; parallelogram: opposite sides and angles equal, adjacent angles add up to 180°, diagonals bisect; rhombus diagonals perpendicular, rectangle diagonals equal, square both; diameter = 2r, longest chord; lines of symmetry: square 4, equilateral triangle 3, rectangle 2, circle infinite; rotation angle = 360°/order; ruler-compass angles 60°, 120°, 90°, 30°, 45°; Euler F + V – E = 2.

Mensuration: Perimeter, Area, Surface Area and Volume (Cube, Cuboid, Cylinder)

Perimeter: The perimeter is the length of the boundary of a closed figure: 2(l + b) for a rectangle, 4a for a square, the sum of the sides for a triangle and n × side for a regular polygon of n sides. Fencing a field 120 m by 80 m needs 2(120 + 80) = 400 m of wire, which at ₹15 a metre costs ₹6,000. The perimeter of a circle, its circumference, is 2πr or πd, with π taken as 22/7 or 3.14. A wheel of radius 35 cm covers 2 × 22/7 × 35 = 220 cm in one turn, so it makes 1,10,000 ÷ 220 = 500 turns in 1.1 km. A semicircle of radius 7 cm has perimeter πr + 2r = 22 + 14 = 36 cm; leaving out the diameter is a common error.

Area of plane figures: Area is the surface enclosed by a figure, measured in square units: 1 m² = 10,000 cm² and 1 hectare = 10,000 m². A rectangle has area l × b and a square a²; a parallelogram base × height, since cutting a triangle from one end and fixing it at the other makes a rectangle; a triangle 1/2 × base × height, half the parallelogram on the same base and height; a rhombus 1/2 × product of the diagonals; a trapezium 1/2 × sum of the parallel sides × distance between them; and a circle πr². So a parallelogram of base 12 cm and height 7.5 cm has area 90 cm²; a trapezium with parallel sides of 10 m and 16 m that are 8 m apart has 104 m²; a rhombus with diagonals of 12 cm and 18 cm has 108 cm²; and a circle of radius 14 cm has 22/7 × 196 = 616 cm².

Paths, rings and scaling: The area of a path or border is the outer area minus the inner area. A path 2.5 m wide round the outside of a garden 40 m by 30 m makes an outer rectangle 45 m by 35 m, so the path covers 1,575 – 1,200 = 375 m². A ring between circles of radius 14 cm and 7 cm has area 22/7 × (196 – 49) = 462 cm². Area

changes with the square of the scale: doubling the side of a square multiplies its area by 4, and tripling the radius of a circle multiplies its area by 9. Area and perimeter are not tied together: a 6 cm by 4 cm rectangle and a 5 cm square both have perimeter 20 cm but areas of 24 cm^2 and 25 cm^2.

Surface area: The surface area of a solid is the total area of its faces. A cuboid has total surface area $2(lb + bh + hl)$ and lateral surface area, the four walls, $2h(l + b)$; a cube has $6a^2$ and $4a^2$; a cylinder has curved surface area $2\pi rh$ and total surface area $2\pi r(r + h)$. A cuboid 10 cm × 8 cm × 5 cm has surface area $2(80 + 40 + 50) = 340$ cm^2. The four walls of a room 6 m long, 5 m wide and 4 m high have area $2 \times 4 \times (6 + 5) = 88$ m^2, so painting the walls and ceiling covers $88 + 30 = 118$ m^2. A closed cylinder of radius 7 cm and height 10 cm has curved surface area $2 \times 22/7 \times 7 \times 10 = 440$ cm^2 and total surface area $2 \times 22/7 \times 7 \times 17 = 748$ cm^2.

Volume and capacity: Volume is the space a solid occupies, in cubic units: $l \times b \times h$ for a cuboid, a^3 for a cube and πr^2h for a cylinder. Capacity is measured in litres: 1 cm^3 = 1 mL, 1,000 cm^3 = 1 L and 1 m^3 = 1,000 L. A tank 2 m × 1.5 m × 1 m holds 3 m^3, or 3,000 L; a cylinder of radius 7 cm and height 10 cm holds $22/7 \times 49 \times 10 = 1{,}540$ cm^3, or 1.54 L. A cuboid 8 cm × 6 cm × 4 cm holds $4 \times 3 \times 2 = 24$ cubes of side 2 cm, and a cuboid of volume 440 cm^3 on a base of 88 cm^2 is 5 cm high. Doubling every edge of a cube multiplies its surface area by 4 and its volume by 8.

In the classroom: The usual errors are mixing up area and perimeter, combining unlike units (cm with m, or cm with cm^2), forgetting to square the radius, and confusing surface area with volume. Before the formulas, pupils count unit squares on grid paper and build cuboids from unit cubes; they cut a circle into many equal sectors and rearrange them into a near-parallelogram of length πr and height r to see why its area is πr^2; and they unroll the label of a can to see that the curved surface of a cylinder is a rectangle of length $2\pi r$ and height h.

Examples

- Fencing: a field 120 m × 80 m has perimeter 400 m; at ₹15 a metre the wire costs ₹6,000.
- Wheel of radius 35 cm: circumference 220 cm, so it turns $1{,}10{,}000 \div 220 = 500$ times in 1.1 km.
- Semicircle of radius 7 cm: perimeter $22 + 14 = 36$ cm and area $1/2 \times 22/7 \times 49 = 77$ cm^2.
- Areas: parallelogram $b \times h$; triangle $1/2 \times b \times h$; rhombus $1/2 \times d_1 \times d_2$; trapezium $1/2 \times (a + b) \times h$; circle πr^2, so r = 14 cm gives 616 cm^2.
- A path 2.5 m wide outside a garden 40 m × 30 m has area $45 \times 35 - 40 \times 30 = 1{,}575 - 1{,}200 = 375$ m^2.
- Ring between radii 14 cm and 7 cm: $22/7 \times (196 - 49) = 22/7 \times 147 = 462$ cm^2.
- Room 6 m × 5 m × 4 m: the four walls are $2 \times 4 \times 11 = 88$ m^2, walls and ceiling together 118 m^2.
- Cylinder of radius 7 cm and height 10 cm: curved surface 440 cm^2, total surface 748 cm^2, volume 1,540 cm^3 = 1.54 L.
- Units: 1 m^2 = 10,000 cm^2; 1 hectare = 10,000 m^2; 1 L = 1,000 cm^3; 1 m^3 = 1,000 L.
- Same perimeter, different area: a 6 cm × 4 cm rectangle and a 5 cm square both have perimeter 20 cm, but areas 24 cm^2 and 25 cm^2.

> **Quick revision:** Rectangle $P = 2(l + b)$, $A = lb$; circle $C = 2\pi r$, $A = \pi r^2$; parallelogram bh; triangle $1/2\ bh$; rhombus $1/2\ d_1d_2$; trapezium $1/2\ (a + b)h$; path = outer − inner area; cuboid TSA $2(lb + bh + hl)$, walls $2h(l + b)$; cube $6a^2$; cylinder CSA $2\pi rh$, TSA $2\pi r(r + h)$; volumes lbh, a^3, πr^2h; 1 L = 1,000 cm^3, 1 m^3 = 1,000 L; doubling the edge of a cube: area ×4, volume ×8.

Data Handling: Mean, Median, Mode, Graphs and Probability

Collecting and organising data: Data recorded as it comes is raw data; a frequency table with tally marks (the fifth mark crossing the other four) shows how often each value occurs, and the range is the highest value minus the lowest. Large data are grouped into class intervals of equal width, such as 10-20, 20-30 and 30-40, where 10 is the lower limit, 20 the upper limit and 10 the class size; by convention a value equal to an upper limit, such as 20, is counted in the next interval, 20-30. A pictograph shows data with symbols and a key, so if one symbol stands for 10 cars, half a symbol stands for 5.

Mean, median and mode: These representative values describe a whole data set by one number. The arithmetic mean is the sum of the observations divided by their number; the median is the middle value once the data are arranged in order, and for an even number of values the mean of the middle two; the mode is the value that occurs

most often. For the marks 42, 37, 50, 45, 37, 48 and 56 the sum is 315, so the mean is 315 ÷ 7 = 45; in order they read 37, 37, 42, 45, 48, 50, 56, so the median is 45; the mode is 37; and the range is 56 − 37 = 19. For 10, 14, 18, 20, 25 and 31 the median is (18 + 20) ÷ 2 = 19. A data set can have more than one mode, or none if no value repeats.

Using the measures: The mean always lies between the smallest and largest values. Adding 5 to every value raises the mean, median and mode by 5, and doubling every value doubles them. A missing value comes from the total: if the mean of five numbers is 18 and four of them are 15, 20, 12 and 25, the fifth is 90 − 72 = 18; if the mean of six numbers is 20 and falls to 18 when one is removed, the removed number is 120 − 90 = 30. Extreme values pull the mean, so the median better represents the incomes of a village with one very rich family, while the mode answers which size or colour is most common, as a shopkeeper ordering shoes needs to know.

Bar graphs and histograms: A bar graph uses bars of equal width with equal gaps between them, their heights showing values on a stated scale (1 unit = 10 pupils); a double bar graph places two bars side by side to compare two sets, such as a class's marks in two terms. A histogram shows grouped data: the class intervals lie along the horizontal axis, the bars touch with no gaps, each bar's width is the class size and its height the frequency. When the first interval does not start at 0, a zigzag (kink) on the horizontal axis shows the break in the scale.

Pie charts: A pie chart, or circle graph, shows how a whole is divided into parts; each sector's central angle is the same fraction of 360° as the part is of the whole, so central angle = (value ÷ total) × 360°, and a percentage becomes degrees when multiplied by 3.6. If 36 pupils choose cricket (15), football (9), hockey (6) and kabaddi (6), the angles are 150°, 90°, 60° and 60°, adding up to 360°. Read backwards, a sector of 72° in a monthly expenditure of ₹50,000 is 72/360 = 1/5 of it, that is ₹10,000, and a 25% share is a 90° sector.

Chance and probability: An experiment such as tossing a coin or throwing a die has outcomes, and when they are equally likely the probability of an event is the number of outcomes favourable to it divided by the total number of outcomes. A die has 6 outcomes, so P(even number) = 3/6 = 1/2, P(number greater than 4) = 2/6 = 1/3 and P(prime) = 3/6 = 1/2, the primes being 2, 3 and 5. A bag of 3 red, 5 blue and 2 green balls gives P(blue) = 5/10 = 1/2 and P(not red) = 7/10. A probability lies between 0 for an impossible event and 1 for a sure event, and P(not E) = 1 − P(E). Tossing two coins gives the four outcomes HH, HT, TH and TT, so P(exactly one head) = 2/4 = 1/2.

In the classroom: Pupils find the median without first arranging the data, give the highest frequency as the mode instead of the value that has it, leave gaps between histogram bars, and use percentages directly as degrees in a pie chart. Collecting the class's own data (heights, birthdays, ways of coming to school), drawing graphs from it and asking what each graph does and does not show builds the habit of interpreting data, not only computing with it; tossing a coin 50 times shows that the proportion of heads comes close to 1/2 but need not equal it.

Examples

- Marks 42, 37, 50, 45, 37, 48, 56: mean 315 ÷ 7 = 45, median 45, mode 37, range 19.
- Even number of values: the median of 10, 14, 18, 20, 25, 31 is (18 + 20) ÷ 2 = 19.
- Missing value: the mean of 6 numbers is 20 and of the remaining 5 is 18, so the removed number is 120 − 90 = 30.
- Adding a constant to every value adds it to the mean, median and mode; multiplying every value by a number multiplies them by it.
- Class intervals 10-20, 20-30: the value 20 is counted in 20-30; the class size is 10.
- A histogram's bars touch and show grouped data; a bar graph has equal gaps between bars.
- Pie chart: central angle = (value ÷ total) × 360°, so 15 of 36 pupils is 150°, and 25% is 90°.
- Die: P(even) = 1/2, P(greater than 4) = 1/3, P(prime) = 1/2; for any event P(not E) = 1 − P(E).
- A bag of 3 red, 5 blue and 2 green balls: P(blue) = 5/10 = 1/2 and P(not red) = 7/10.
- Choose the median when there are extreme values, the mode for the most common size or choice, and the mean for an overall average.

Quick revision: Range = highest − lowest; value on an upper class limit goes to the next interval; mean = sum ÷ number; median = middle value after ordering (mean of middle two if even); mode = most frequent value; adding k to every value adds k to the mean, median and mode; bar graph has gaps, histogram none; pie-chart angle = value ÷ total × 360°, 1% = 3.6°; probability = favourable ÷ total equally likely outcomes, from 0 to 1; P(not E) = 1 − P(E).

Free practice questions: parikshasaathi.com/q/mathematics-content-p2/

Science and its Pedagogy (Paper II)

Science and its Pedagogy (Paper II)

What the exam asks: In CTET Paper II, candidates who choose the Mathematics and Science option answer 30 Science questions, set on the content of upper-primary science (Classes VI to VIII) and on how to teach it. This topic carries both kinds of question. Pedagogy items are mostly classroom scenarios: a child says something, a teacher must choose a method, or an assessment item must be classified. The correct answer almost always reflects the NCF 2005 vision, which is constructivist, inquiry-based and child-centred, treats the textbook as one resource among many, and values critical thinking over memorisation. Options that praise lecturing, dictation, rote learning, punishment or a single correct viewpoint are nearly always wrong. For the content questions, revise the NCERT science textbooks for Classes VI to VIII: food and nutrition, materials, the living world, motion and force, electricity and magnetism, light, heat, natural phenomena and natural resources.

Nature and aims of science: Science is both a product (facts, concepts, laws, theories) and a process (observing, measuring, hypothesising, experimenting, inferring, communicating). Scientific knowledge is empirical, objective, cumulative and tentative, meaning open to revision when new evidence appears. The NCF 2005 Position Paper on Teaching of Science lists six validity criteria for a good science curriculum: cognitive (age-appropriate), content (significant and correct), process (engaging with methods of science), historical (placing ideas in their developmental context), environmental (linked to the local and global environment) and ethical (honesty, objectivity, cooperation, freedom from fear and prejudice). Developing scientific temper is a Fundamental Duty under Article 51A(h). Scientific attitude includes curiosity, open-mindedness, objectivity, suspended judgement and respect for evidence, never acceptance of authority without evidence. Scientific literacy means using scientific understanding to take informed decisions in everyday life.

Process skills and the observation-inference trap: Observation uses the senses (the flame went out, the water level rose). Inference is an explanation drawn from observations (the flame went out because oxygen was used up). Prediction is a forecast made before an event based on past experience; a hypothesis is a testable tentative statement that links variables. In a fair test the variable deliberately changed is the independent variable, the one measured is the dependent variable, and everything else is controlled. A sentence from a scenario may need to be labelled as observation, inference, prediction or hypothesis.

Methods and approaches in science: The 5E model runs Engage, Explore, Explain, Elaborate, Evaluate; formal vocabulary is introduced only at the Explain stage, after hands-on exploration. The heuristic method (H.E. Armstrong) places the child as discoverer; the project method (W.H. Kilpatrick) and problem-solving method (John Dewey) begin with a real problem felt by learners. Lecture-cum-demonstration is economical but leaves students as passive observers. Inquiry teaching is recognised by questions such as 'What do you think will happen if... How can we find out?'. Concept maps (Joseph Novak) show concepts in boxes joined by labelled linking words. Cooperative techniques such as Jigsaw make each group member an expert on one part. Science exhibitions, science clubs and the National Children's Science Congress (children aged 10 to 17 doing projects on a focal theme) nurture creativity and innovation. Low-cost and no-cost improvised apparatus makes science concrete and accessible; ICT simulations are valuable where real experiments are unsafe or impossible.

Evaluation in science: Assessment should cover the cognitive, psychomotor (handling apparatus, practical work) and affective (attitudes, values, assessed through observation schedules and rating scales) domains. Bloom's revised taxonomy rises from Remember, Understand, Apply, Analyse, Evaluate to Create; 'explain why' is Understand, 'design an experiment' is Create. Formative assessment is assessment for learning during instruction;

summative is at the end. A diagnostic test identifies specific difficulties and is followed by remedial teaching. Open-ended questions, rubrics, portfolios and CCE assess process skills and growth, not just recall.

Misconceptions and problems in teaching science: Common misconceptions are that heavier objects fall faster, that seasons are caused by the Earth's distance from the Sun (actually the axial tilt), that plants take food from the soil (they make it by photosynthesis), that a bucket and a cup of water at the same temperature contain the same heat, and that current is used up by a bulb. The correct teacher response is to create cognitive conflict through an activity and discussion, not to simply assert the right answer. Other problems: rote learning, lack of laboratories, difficult technical vocabulary in an unfamiliar language (answer: build on the home language and everyday words), and gender stereotypes (answer: rotate roles so all children handle apparatus). Laboratory safety: add acid slowly to water, never water to acid.

Examples

- Observation versus inference: 'The water level rose in the jar' is an observation; 'because oxygen was used up' is an inference.
- 5E order mnemonic: Engage, Explore, Explain, Elaborate, Evaluate. New vocabulary appears only at Explain, after Explore.
- NCF 2005 validity criteria for science: Cognitive, Content, Process, Historical, Environmental, Ethical (remember 'C-C-P-H-E-E').
- Method founders: Heuristic = H.E. Armstrong; Project = W.H. Kilpatrick; Problem-solving and reflective thinking = John Dewey; Concept map = Joseph Novak.
- Bloom's revised taxonomy ladder: Remember, Understand, Apply, Analyse, Evaluate, Create. 'Design' or 'devise' signals Create; 'explain why' signals Understand.
- Fair test: the variable you change is independent, the one you measure is dependent, the rest are controlled.
- Misconception fixes: seasons come from axial tilt, not distance; plants make food by photosynthesis, soil only supplies water and minerals; current is the same throughout a series circuit.
- Lab safety rule: add acid to water, slowly, with stirring; never water to acid. Scientific temper is Fundamental Duty 51A(h).
- In pedagogy scenario questions, the answer that keeps the child active, builds on prior knowledge, offers multiple perspectives and treats the textbook as one resource is usually the one consistent with NCF 2005.

> **Quick revision:** Science is product + process; knowledge is tentative and empirical; NCF 2005 validity: cognitive, content, process, historical, environmental, ethical; scientific temper = Art 51A(h); observation uses senses, inference explains; 5E = Engage, Explore, Explain, Elaborate, Evaluate; heuristic = Armstrong, project = Kilpatrick, concept map = Novak; Bloom revised top = Create; diagnostic test precedes remedial teaching; add acid to water.

Food and the World of the Living: Nutrition, Cells, Microorganisms, Reproduction and Adolescence

Components of food: Food comes from plants and animals; animals are herbivores, carnivores or omnivores. Carbohydrates and fats give energy (fats give much more than the same amount of carbohydrates), proteins build the body, vitamins and minerals protect it against disease, dietary fibres (roughage) help throw out undigested food, and water helps absorb nutrients and remove wastes. Simple tests show nutrients: dilute iodine solution turns starch blue-black, copper sulphate with caustic soda solution turns protein violet, and fat leaves an oily patch on paper.

Deficiency diseases: A diet lacking a nutrient for a long time causes a deficiency disease. Lack of vitamin A causes loss of vision (night blindness), of vitamin B1 beriberi, of vitamin C scurvy with bleeding gums, and of vitamin D rickets with soft, bent bones; shortage of calcium weakens bones and teeth, of iodine causes goitre (a swollen thyroid gland in the neck) and of iron causes anaemia. Too little protein causes kwashiorkor, and too little protein and energy food together causes marasmus.

Nutrition in plants: Green plants are autotrophs: they make food by photosynthesis in their leaves, the plant's food factories. Chlorophyll traps sunlight, carbon dioxide enters through tiny pores called stomata, and water and minerals rise from the roots; carbohydrates, stored as starch, and oxygen are formed. Some plants take food from others: Cuscuta (amarbel) is a parasite on its host plant, and insectivorous plants such as the pitcher plant digest

trapped insects. Fungi such as mushrooms are saprotrophs living on dead, decaying matter, lichens are a partnership (symbiosis) of an alga and a fungus, and Rhizobium bacteria in the root nodules of legumes such as gram fix atmospheric nitrogen.

Nutrition in animals: Animal nutrition has five steps: ingestion, digestion, absorption, assimilation and egestion. In humans, incisors cut, canines tear, and premolars and molars grind the food. Saliva turns starch into sugar; hydrochloric acid in the stomach kills bacteria while its digestive juices break down proteins; and bile from the liver, stored in the gall bladder, acts on fats. The small intestine, about 7.5 m long, completes digestion, and its finger-like villi absorb digested food; the large intestine, about 1.5 m long, absorbs water and some salts. Cows and buffaloes are ruminants: grass stored in the rumen is partly digested into cud and chewed again.

The cell: The cell is the basic structural and functional unit of life; Robert Hooke first saw cells in a thin slice of cork in 1665. Organisms may be unicellular (Amoeba, bacteria) or multicellular, and the long, branched nerve cell shows how shape suits function. A typical cell has a cell membrane, cytoplasm and a nucleus whose chromosomes carry genes. Plant cells also have a cell wall, chloroplasts and usually a large vacuole. Bacteria are prokaryotes, without a nuclear membrane; cells with a well-organised nucleus are eukaryotes. The egg of the ostrich is the largest single cell.

Microorganisms, friend and foe: Most microorganisms can be seen only through a microscope; the main groups are bacteria, fungi, protozoa and some algae, while viruses multiply only inside a host cell. As friends, Lactobacillus sets milk into curd, yeast makes dough rise and turns sugar into alcohol (fermentation), Alexander Fleming found the antibiotic penicillin in a mould, and Edward Jenner's smallpox vaccine began vaccination. As foes, bacteria cause tuberculosis, typhoid, cholera, anthrax and citrus canker, viruses cause measles, chickenpox, polio and foot-and-mouth disease, a fungus causes rust of wheat, and a protozoan causes malaria, spread by the female Anopheles mosquito. Milk is pasteurised by heating it to about 70 °C for 15 to 30 seconds and then chilling it suddenly.

Reproduction: Plants reproduce asexually by vegetative propagation (potato eyes, ginger, Bryophyllum leaf buds, rose cuttings), budding (yeast), fragmentation (Spirogyra) and spores (fungi, moss, ferns). In sexual reproduction the stamen is the male part and the pistil, with stigma, style and ovary, the female part; pollination carries pollen to the stigma by wind, water or insects, fertilisation forms a zygote, the ovary becomes the fruit and the ovule the seed. In animals, fertilisation is internal in humans, cows and hens and external in frogs and fish; viviparous animals give birth to young ones, oviparous animals lay eggs. A tadpole becomes a frog by metamorphosis, and Dolly the sheep (1996) was the first mammal cloned from an adult cell.

Adolescence: Adolescence, from about 11 to 19 years of age, is the period in which the body moves towards reproductive maturity. Height increases suddenly, boys' shoulders broaden and their voice deepens as the larynx (Adam's apple) grows, sweat and oil glands become active and cause acne, and the sex organs mature. Testosterone from the testes and oestrogen from the ovaries drive these changes under the control of the pituitary gland. Menstruation begins at about 10 to 12 years, the cycle lasts about 28 to 30 days, and it stops at about 45 to 50 years. Humans have 23 pairs of chromosomes; a female is XX and a male XY, so the chromosome from the father decides the sex of the child. Teachers give correct information, dispel myths and stress nutrition and hygiene.

Examples

- Food tests: dilute iodine turns starch blue-black; copper sulphate with caustic soda turns protein violet; fat leaves an oily patch on paper.
- Deficiency pairs: vitamin A - night blindness; B1 - beriberi; C - scurvy (bleeding gums); D - rickets; iodine - goitre; iron - anaemia; protein - kwashiorkor; protein and energy - marasmus.
- Photosynthesis: carbon dioxide + water, with sunlight and chlorophyll, gives carbohydrate + oxygen; carbon dioxide enters through stomata; leaves are the food factories of the plant.
- Plant nutrition modes: Cuscuta (amarbel) - parasite; pitcher plant - insectivorous; mushroom and bread mould - saprotroph; lichen - alga and fungus in symbiosis; Rhizobium - fixes nitrogen in legume root nodules.
- Digestion: saliva acts on starch; stomach acid kills bacteria; bile from the liver (stored in the gall bladder) acts on fats; small intestine about 7.5 m, villi absorb food; large intestine about 1.5 m, absorbs water.

- Cell facts: Robert Hooke saw cells in cork in 1665; plant cells have a cell wall, chloroplasts and a large vacuole; bacteria are prokaryotes (no nuclear membrane); the ostrich egg is the largest single cell.
- Microbes: Lactobacillus - curd; yeast - bread and alcohol; Fleming - penicillin; Jenner - smallpox vaccine; malaria - a protozoan spread by the female Anopheles mosquito; pasteurisation - about 70 °C for 15-30 seconds, then sudden chilling.
- Flower: stamen (anther and filament) is male, pistil (stigma, style, ovary) is female; after fertilisation the ovary becomes the fruit and the ovule the seed.
- Adolescence about 11-19 years; testosterone (testes), oestrogen (ovaries), both under the pituitary; menstrual cycle about 28-30 days; female XX, male XY; the father's chromosome decides the child's sex.

> **Quick revision:** Carbohydrates and fats give energy, proteins build the body, vitamins and minerals protect; A night blindness, B1 beriberi, C scurvy, D rickets, iodine goitre, iron anaemia; photosynthesis in leaves through stomata and chlorophyll; Cuscuta parasite, pitcher plant insectivorous; small intestine about 7.5 m with villi; Hooke saw cells in 1665; Lactobacillus curd, Fleming penicillin, Jenner vaccine; ovary becomes fruit; adolescence 11-19 years; XY male.

Materials: Separation, Physical and Chemical Changes, Acids and Bases, Fibres, Metals, Fuels and Combustion

Sorting and separating: Materials are grouped by properties such as lustre, hardness, solubility, floating or sinking, and transparency (glass is transparent, oiled paper translucent, wood opaque). Mixtures are separated by hand-picking, threshing, winnowing (wind carries away the lighter husk), sieving, sedimentation and decantation, filtration, evaporation and churning. Salt mixed with sand is dissolved in water, filtered and the filtrate evaporated.

Physical and chemical changes: A physical change alters shape, size, colour or state without forming a new substance and is often reversible (melting wax, dissolving sugar, crystallisation). A chemical change forms a new substance, often with heat, light, sound, a change of colour, a smell or a gas. Magnesium ribbon burns with a brilliant white light to form magnesium oxide, whose solution is basic; vinegar with baking soda gives carbon dioxide, which turns lime water milky; and an iron nail in blue copper sulphate solution gets a brown coat of copper as the solution turns green (iron sulphate). Rusting needs both oxygen and water and is prevented by paint, grease or galvanisation, a coating of zinc.

Acids, bases and salts: Acids taste sour and turn blue litmus red; bases taste bitter, feel soapy and turn red litmus blue. Litmus comes from lichens, turmeric turns red with bases, and china rose (gudhal) indicator turns acids dark pink and bases green. NCERT pairs: vinegar has acetic acid, an ant's sting formic acid, citrus fruits citric acid, curd lactic acid, spinach oxalic acid, amla ascorbic acid (vitamin C) and tamarind tartaric acid; lime water is calcium hydroxide and milk of magnesia magnesium hydroxide. An acid and a base neutralise each other to give a salt and water, with heat. So an ant bite is treated with baking soda or calamine (zinc carbonate), acidic soil gets quicklime or slaked lime, and basic soil gets organic matter.

Fibre to fabric: Cotton grows in black soil and a warm climate, and ginning separates the seeds from the picked bolls; jute fibre is taken from the stem of the jute plant by retting. Fibres are spun into yarn on a takli or charkha and woven or knitted into fabric. Wool comes from sheep, yak, Angora and Kashmiri goats and camel; it is sheared, scoured, sorted, dyed and rolled into yarn, and sorters risk anthrax, called sorter's disease. Silk comes from the cocoon of the silkworm, whose life cycle runs egg, larva (caterpillar), pupa and moth; rearing silkworms is sericulture, the mulberry silkworm feeds on mulberry leaves, and tussar, mooga and kosa are other Indian silks.

Synthetic fibres and plastics: Rayon, called artificial silk, is made by chemically treating wood pulp; nylon, the first fully synthetic fibre, polyester, and acrylic, which looks like wool, are made from petrochemicals. Thermoplastics such as polythene and PVC soften on heating; thermosetting plastics such as bakelite (switches, handles of utensils) and melamine (kitchenware) do not soften once moulded. Plastics are non-biodegradable and burning them releases poisonous fumes, hence the 4R principle: Reduce, Reuse, Recycle, Recover.

Metals and non-metals: Metals are lustrous, malleable, ductile, sonorous and good conductors of heat and electricity; non-metals are generally dull, brittle and poor conductors, graphite being a conducting exception. Mercury is a liquid metal and bromine a liquid non-metal; sodium, soft enough to cut with a knife, is stored in

kerosene, and phosphorus is stored in water. Metal oxides are basic and non-metal oxides acidic. Many metals react with dilute acids to give hydrogen, which burns with a pop sound. A more reactive metal displaces a less reactive one from its salt solution: zinc displaces copper from copper sulphate, but copper cannot displace zinc.

Coal and petroleum: Coal, petroleum and natural gas are exhaustible fossil fuels formed from dead organisms over millions of years, while sunlight, air and wind are inexhaustible. Coal formed from forests buried about 300 million years ago, by carbonisation, and its processing gives coke (almost pure carbon, used to make steel), coal tar (for dyes, drugs, explosives, paints and naphthalene balls) and coal gas. Petroleum formed from organisms in the sea; refining separates LPG, petrol, kerosene, diesel, lubricating oil, paraffin wax and bitumen. NCERT records that the world's first oil well was drilled in Pennsylvania, USA, in 1859. The PCRA advises driving at a steady moderate speed and switching off the engine at traffic lights.

Combustion and flame: Combustion is a chemical process in which a substance reacts with oxygen to give off heat. It needs a fuel, air and heat up to the ignition temperature, the lowest temperature at which a substance catches fire; petrol, LPG and alcohol are inflammable, with very low ignition temperatures. Water can be boiled in a paper cup because it absorbs the heat and keeps the paper below its ignition temperature. Combustion can be rapid (gas stove), spontaneous (phosphorus at room temperature) or an explosion (crackers). A candle flame has a dark inner zone of unburnt wax vapour, a luminous middle zone of partial combustion and a non-luminous outer zone of complete combustion, the hottest, which goldsmiths use. Water is not used on oil or electrical fires; carbon dioxide is best there.

Examples

- Separation: winnowing - wind removes the lighter husk; sedimentation then decantation - pour off the clear water; filtration - insoluble solid from a liquid; salt from sand - dissolve, filter, evaporate.
- Physical change: no new substance, often reversible (melting, dissolving, crystallisation). Chemical change: a new substance, with heat, light, gas, colour change or smell (burning, rusting).
- Iron nail in copper sulphate solution: brown copper deposits and the blue solution turns green (iron sulphate) - a chemical change by displacement.
- Rusting needs both oxygen and water; galvanisation coats iron with zinc; a blacksmith heats an iron rim before fitting it because metals expand on heating.
- Natural acids: vinegar - acetic; ant sting - formic; citrus fruits - citric; curd - lactic; spinach - oxalic; amla - ascorbic (vitamin C); tamarind - tartaric.
- Indicators: litmus (from lichens) - blue turns red in acid; turmeric turns red in a base; china rose - dark pink in acid, green in base.
- Silkworm life cycle: egg, larva (caterpillar), pupa (cocoon), moth; sericulture = rearing silkworms; wool sorters may catch anthrax (sorter's disease).
- Thermoplastics (polythene, PVC) soften on heating; thermosetting plastics (bakelite, melamine) do not; 4R principle: Reduce, Reuse, Recycle, Recover.
- Coal products: coke (steel), coal tar (dyes, drugs, explosives, naphthalene balls), coal gas; the world's first oil well, as NCERT gives it: Pennsylvania, USA, 1859.
- Candle flame: inner zone dark (unburnt wax vapour), middle zone luminous (partial combustion), outer zone non-luminous and hottest (complete combustion).

> **Quick revision:** Winnowing, sedimentation, decantation, filtration, evaporation; physical change forms no new substance, chemical change does; rusting needs oxygen and water, galvanisation is a zinc coat; blue litmus turns red in acid, turmeric red in base; ant sting has formic acid; acid + base gives salt + water; silkworm egg-larva-pupa-moth; thermoplastic vs thermosetting; metals malleable and ductile; coke, coal tar, coal gas; ignition temperature; outer flame zone hottest.

Moving Things, People and Ideas: Measurement, Motion, Force, Pressure and Friction

Measuring distance: Measurement compares an unknown quantity with a known fixed quantity called a unit. The handspan, cubit, footstep and fathom differ from person to person, so standard units are needed; the International

System of Units (SI), adopted in 1960, uses the metre for length, with 1 m = 100 cm, 1 cm = 10 mm and 1 km = 1000 m. To measure correctly, place the scale along the length, keep the eye exactly above the point being read, and if the zero mark is broken start from a full mark such as 1 cm and subtract it at the end.

Types of motion: An object is in motion when its position changes with time. Motion along a straight line, as of a marching soldier or a falling stone, is rectilinear; motion along a circle, as of a point on a fan blade or a stone whirled on a thread, is circular; motion that repeats after a fixed interval, as of a pendulum, a swing or a sewing machine needle, is periodic. A body can show more than one kind at once: a bicycle wheel spins on its axle while moving forward.

Speed and time: Speed is the distance covered in unit time, speed = distance / time, measured in m/s or km/h; a bus covering 120 km in 2 hours has an average speed of 60 km/h. Motion along a straight line at constant speed is uniform; with changing speed it is non-uniform. A simple pendulum, a metal bob hung by a thread, has a time period (the time for one oscillation) that stays the same for a given length at a place, which is why pendulums were used in clocks; Galileo noticed this from a swinging lamp in a church. The second is the basic unit of time. A speedometer shows speed, an odometer records distance, and the distance-time graph of uniform motion is a straight line.

Force as a push or pull: A force is a push or a pull that arises from the interaction of at least two objects. It has magnitude and direction: forces in the same direction add up, opposite forces subtract, and balanced forces give a net force of zero. An unbalanced force changes an object's speed or its direction of motion, and a force can also change its shape. Contact forces need touch, such as muscular force and friction; non-contact forces act from a distance, such as magnetic force, electrostatic force (a comb run through dry hair attracts bits of paper) and gravitational force, by which the Earth pulls everything towards it. The SI unit of force is the newton.

Pressure: Pressure is the force acting on unit area, pressure = force / area, so the same force exerts more pressure on a smaller area: knives are sharpened and nails pointed, while porters place a round cloth on their heads and school bags have broad straps to spread the load. Liquids exert pressure on the bottom and walls of their container, and the pressure increases with depth, so water comes out with more force from the lowest hole of a bottle and dams are built wider at the base. The air exerts atmospheric pressure; a rubber sucker sticks to a smooth wall because the air presses it there, and our bodies are not crushed because the pressure inside them balances the air outside. The SI unit of pressure is the pascal (1 Pa = 1 N/m^2).

Friction: Friction opposes relative motion between two surfaces in contact. It arises from the interlocking of tiny irregularities, so it depends on the nature of the surfaces and on how hard they are pressed together. Static friction is greater than sliding friction, and rolling friction is the smallest, which is why wheels and ball bearings make moving loads easier. Friction is a necessary evil: without it we could not walk, write, light a matchstick or stop a vehicle, yet it wears out shoe soles, tyres and machine parts and wastes energy as heat. It is increased by treads on tyres, spikes on athletes' shoes and the coarse powder gymnasts rub on their hands, and reduced by lubricants (oil, grease, graphite), ball bearings, polishing and air cushions. Air and water exert fluid friction, or drag, so birds, fish, boats and aircraft have streamlined shapes.

Common confusions and classroom ideas: Many children believe that a moving object needs a continuous push to keep moving, or that a heavier object falls faster; both ideas go back to Aristotle and were challenged by Galileo. Rolling the same ball over a carpet, a cloth and a smooth floor, and seeing it travel farthest on the smoothest surface, shows that friction, not the absence of a push, stops it. Another is thinking that a book lying on a table has no force acting on it, when balanced forces act on it. Making a pendulum from a stone and a thread to measure its time period for different lengths, and plotting a distance-time graph for a toy car, turn this unit into hands-on inquiry.

Examples

- 1 m = 100 cm; 1 cm = 10 mm; 1 km = 1000 m; the SI unit of length is the metre; body measures such as the handspan, cubit and footstep are not standard.
- Rectilinear: marching soldier, falling stone; circular: a point on a fan blade; periodic: pendulum, swing, sewing machine needle; a bicycle wheel shows rotation and rectilinear motion together.
- Speed = distance / time; 120 km in 2 hours = 60 km/h; uniform motion gives a straight-line distance-time graph; the second is the basic unit of time.

- Time period of a simple pendulum = time for one oscillation; it is constant for a given length at a place; Galileo noticed it from a swinging lamp in a church.
- Force is a push or pull arising from the interaction of two objects; it can change speed, direction of motion or shape; SI unit newton.
- Contact forces: muscular force, friction. Non-contact forces: magnetic, electrostatic, gravitational.
- Pressure = force / area; sharp knife and pointed nail (small area, more pressure); broad bag straps and a porter's cloth roll (large area, less pressure); SI unit pascal.
- Liquid pressure increases with depth, so dams are wider at the base; atmospheric pressure holds a rubber sucker to a wall.
- Friction: static > sliding > rolling; increased by tyre treads and shoe spikes; reduced by lubricants, ball bearings and polishing; streamlined shapes reduce drag.

> **Quick revision:** 1 m = 100 cm, 1 km = 1000 m; rectilinear, circular and periodic motion; speed = distance / time in m/s or km/h; pendulum time period constant for a given length; force is a push or pull that can change speed, direction or shape; contact (muscular, friction) and non-contact (magnetic, electrostatic, gravitational) forces; pressure = force / area; liquid pressure rises with depth; static > sliding > rolling friction; lubricants and ball bearings reduce friction.

How Things Work: Electric Current and Its Effects, Magnets, Light and Sound

Cells and circuits: An electric cell has a positive terminal (the metal cap) and a negative terminal (the metal disc), and the chemicals inside it produce electricity until they are used up. A bulb has a thin filament joined to two terminals; it glows only in a closed circuit, in which current flows from the positive terminal through the bulb to the negative terminal, and a fused bulb has a broken filament. A switch opens or closes the circuit. Conductors such as metals, graphite and the human body let current pass; insulators such as rubber, plastic, wood and glass do not. Two or more cells joined positive to negative make a battery. Children experiment only with cells, never with the mains supply.

Heating and magnetic effects: A wire carrying current gets hot, an effect used in room heaters, electric irons, immersion heaters and geysers. The filament of an incandescent bulb glows but wastes much energy as heat, so CFLs and LEDs save electricity. An electric fuse is a wire of special material that melts and breaks the circuit when too much current flows because of a short circuit or overloading; MCBs switch off on their own. In 1820 Hans Christian Oersted found that a wire carrying current deflects a compass needle, showing that current has a magnetic effect. A coil of insulated wire around an iron piece becomes an electromagnet only while current flows; electromagnets lift scrap iron in cranes and work the electric bell.

Magnets: Magnetite is a natural magnet; artificial magnets are made as bars, horseshoes, cylinders and rings. Iron, nickel and cobalt are magnetic materials; wood, plastic, rubber, glass, copper and aluminium are not. Attraction is strongest at the poles, and a freely suspended bar magnet comes to rest in the north-south direction, the principle of the compass. Like poles repel and unlike poles attract; repulsion is the sure test of a magnet, since an unmagnetised iron bar is also attracted. Magnets lose their magnetism when heated, hammered or dropped, so they are stored in pairs with unlike poles on the same side, a piece of wood between them and soft iron keepers across the ends.

Light: Light travels in straight lines, which explains shadows and the inverted image in a pinhole camera; a shadow needs a source of light, an opaque object and a screen. By the laws of reflection the angle of incidence equals the angle of reflection, and the incident ray, the normal and the reflected ray lie in one plane. A plane mirror gives a virtual, erect image of the same size, as far behind the mirror as the object is in front, and laterally inverted, which is why AMBULANCE is written in reverse. A concave mirror gives a real, inverted image of distant objects and an enlarged, erect image of a very near one, so dentists, torches and headlights use it; a convex mirror always gives an erect, diminished image of a wide area, so vehicles use it as a rear-view mirror. A convex lens converges light and magnifies; a concave lens diverges it. A prism splits white light into seven colours, as raindrops do in a rainbow.

Seeing: We see an object when light from it enters our eyes. The iris controls the size of the pupil, and the lens focuses light on the retina, whose rods respond to dim light and cones to bright light and colour; the blind spot has

no light-sensitive cells. An image persists on the retina for about 1/16 of a second, which makes motion pictures possible. Louis Braille's raised-dot system lets visually challenged people read by touch.

Sound: Sound is produced by vibrating objects; our voice comes from the vocal cords in the larynx, which are about 20 mm long in men and about 5 mm shorter in women. Sound needs a medium and travels through solids, liquids and gases but not through a vacuum. The number of vibrations per second, the frequency in hertz (Hz), decides the pitch, and the amplitude decides the loudness, measured in decibels (dB). Humans hear sounds of about 20 Hz to 20,000 Hz, and dogs can hear higher frequencies. Sound above 80 dB becomes physically painful, and noise pollution can cause sleeplessness, hypertension and hearing loss.

Chemical effects of current: Tap water, salt solution and lemon juice conduct electricity, while distilled water is a poor conductor until salt is added; most conducting liquids are solutions of acids, bases and salts. A tester with an LED, which glows even with a weak current, shows conduction. Current through a solution can produce gas bubbles at the electrodes, deposit metal or change colour; in 1800 William Nicholson showed that current through water gives oxygen bubbles at the electrode joined to the positive terminal and hydrogen at the other. In electroplating with copper sulphate solution, copper from the plate joined to the positive terminal is deposited on the object joined to the negative terminal. Chromium plating gives taps, car parts and cycle handlebars a shiny, scratch-resistant surface, and tin-plated iron is used for food cans because tin is less reactive than iron.

Examples

- Closed circuit - the bulb glows; open circuit or fused (broken) filament - no current; conductors: metals, graphite, human body; insulators: rubber, plastic, wood, glass.
- Heating effect: heater, iron, geyser, fuse; an MCB switches off by itself on a short circuit or overload; CFLs and LEDs waste less energy as heat than incandescent bulbs.
- Oersted (1820): a wire carrying current deflects a compass needle; an electromagnet is a magnet only while current flows; used in cranes and electric bells.
- Magnetic materials: iron, nickel, cobalt; like poles repel; repulsion is the sure test of a magnet; store magnets in pairs with keepers.
- Plane mirror image: virtual, erect, same size, laterally inverted, as far behind the mirror as the object is in front.
- Concave mirror: dentists, torches, headlights; convex mirror: rear-view mirror (erect, diminished, wide view); convex lens: magnifying glass.
- Persistence of vision: about 1/16 of a second; rods - dim light, cones - colour; the blind spot has no light-sensitive cells.
- Sound needs a medium and cannot travel through a vacuum; pitch depends on frequency (Hz), loudness on amplitude (dB); human hearing about 20 Hz to 20,000 Hz; above 80 dB is painful.
- Electroplating: object at the negative terminal, plating metal at the positive; chromium on taps and handlebars; tin on iron for food cans; William Nicholson (1800) split water with current.

> **Quick revision:** Cell: positive metal cap, negative metal disc; a closed circuit lights the bulb; conductors vs insulators; heating effect in heater and fuse, MCB; Oersted 1820, magnetic effect; electromagnet in crane and bell; iron, nickel, cobalt magnetic; repulsion is the sure test; angle of incidence = angle of reflection; plane mirror image virtual, erect, laterally inverted; concave for dentists, convex for rear view; persistence 1/16 s; pitch-frequency, loudness-amplitude; electroplate the object at the negative terminal.

Natural Phenomena and Natural Resources: Winds, Lightning, Earthquakes, the Solar System, Water, Forests and Pollution

Rain, wind and cyclones: In the water cycle, water evaporates from seas, lakes and plants, condenses into clouds and returns as rain, hail or snow. Warm air expands and rises; wind blows from high pressure to low pressure, and high-speed wind is accompanied by reduced air pressure. Uneven heating of the equator and the poles, and of land and sea, drives winds such as the monsoon. A cyclone has a calm, very low-pressure centre called the eye; it is called a hurricane in the American continent and a typhoon in the Philippines and Japan, while a tornado is a dark, funnel-shaped cloud.

Thunder and lightning: Rubbing charges objects such as a plastic refill rubbed with polythene; like charges repel, unlike charges attract, and an electroscope detects charge. In a thunderstorm, air currents move upward and water droplets downward, separating charges: positive charges collect near the upper edges of the clouds and negative charges near the lower edges. When the charges grow very large, the air can no longer resist their flow, and lightning results; Benjamin Franklin showed lightning to be an electric spark. A lightning conductor carries the charge safely into the ground. No open place is safe: houses and closed cars or buses are, and outdoors one squats low with head between the hands, never lying flat, away from tall trees and running water.

Earthquakes: An earthquake is a sudden, brief shaking of the Earth caused by movement of the plates of its outer layer; plate boundaries are weak zones. In India, Kashmir, the Himalayas, the North-East, the Rann of Kutch, Rajasthan and the Indo-Gangetic plain are most prone. Strength is given on the Richter scale from seismograph records; destructive quakes exceed 7, and a quake of magnitude 6 has about 1000 times more destructive energy than one of magnitude 4. Bhuj in Gujarat was hit on 26 January 2001, and the quake of 8 October 2005, centred across the Line of Control, badly hit Uri and Tangdhar in north Kashmir. Quakes cannot be predicted, so buildings must be quake-safe, and during a quake one shelters under a sturdy table.

The Moon, stars and constellations: The Moon has no light of its own and reflects sunlight; its phases run from new moon to full moon in about 15 days, and we always see the same side. Star distances are given in light years, the distance light covers in one year; after the Sun the nearest stars are those of the Alpha Centauri system, about 4.3 light years away, of which Proxima Centauri is the closest. Stars appear to move from east to west because the Earth rotates from west to east, but the Pole Star seems fixed because it lies almost along the Earth's axis. Ursa Major (Saptarishi or the Big Dipper), Orion and Cassiopeia (a distorted W or M) are well-known constellations.

The solar system: The Sun and the bodies revolving around it, including eight planets, form the solar system; Pluto was reclassified as a dwarf planet in 2006. Mercury is nearest the Sun; Venus, the brightest planet, is called the morning or evening star though it is not a star, and rotates from east to west, as Uranus does; Mars is the red planet; Jupiter is the largest; Saturn has beautiful rings and is less dense than water. Asteroids orbit between Mars and Jupiter, Halley's comet returns about every 76 years, and meteors are shooting stars. Aryabhata, launched in 1975, was India's first artificial satellite.

Water and forests: About 71% of the Earth's surface is water, mostly salty; World Water Day falls on 22 March. Rain water seeping into the ground (infiltration) recharges groundwater, whose upper level is the water table. Overuse and deforestation lower the water table, so rainwater harvesting, traditional bawris and drip irrigation are needed. In a forest, decomposers turn dead matter into humus, so nothing is wasted. Forests release oxygen, absorb carbon dioxide, hold soil, soak up rain water and support food chains such as grass, deer, lion; deforestation brings soil erosion, floods, droughts and desertification.

Pollution: Air pollutants include carbon monoxide from incomplete burning, sulphur dioxide and nitrogen dioxide from burning fuels, and CFCs from refrigerators and aerosol sprays, which damage the ozone layer. Sulphur dioxide and nitrogen dioxide dissolve in rain to form acid rain, which corrodes the marble of the Taj Mahal (marble cancer), and carbon dioxide traps heat (the greenhouse effect), causing global warming. Water is polluted by sewage, industrial waste and farm chemicals; excess fertiliser makes algae grow, and their decay after death uses up the oxygen fish need. The Ganga Action Plan was launched in 1985. Boiling, filtration and chlorination make water safe; contaminated water spreads cholera, typhoid and jaundice.

Conservation: Wildlife sanctuaries, national parks and biosphere reserves protect biodiversity; the Pachmarhi Biosphere Reserve in Madhya Pradesh contains the Satpura National Park and the Bori and Pachmarhi wildlife sanctuaries. Endemic species live only in one area; NCERT names the sal, wild mango, bison and Indian giant squirrel as endemic there. The Red Data Book records endangered species. Project Tiger was launched in 1973, the Chipko movement began the same year, and recycling paper saves trees, since about 17 full-grown trees are cut to make one tonne of paper.

Examples

- Wind blows from high to low pressure; high-speed wind means lower air pressure; the eye of a cyclone is calm; hurricane (American continent), typhoon (Philippines, Japan).

- Lightning: positive charges near the upper edges of clouds, negative near the lower edges; a lightning conductor carries charge safely into the ground; Benjamin Franklin linked lightning with electric sparks.
- Lightning safety: squat low with the head between the hands, never lie flat; avoid tall trees, open fields and running water; closed cars and buildings are safe.
- Earthquakes: Richter scale, seismograph; magnitude 6 has about 1000 times the destructive energy of magnitude 4; Bhuj 26 January 2001; the 8 October 2005 quake, centred across the Line of Control, badly hit Uri and Tangdhar in north Kashmir.
- A light year is a distance, not a time; the Pole Star seems fixed because it lies almost along the Earth's axis; Ursa Major = Saptarishi; Cassiopeia looks like a distorted W or M.
- Planets: Mercury nearest the Sun; Venus brightest and rotates east to west; Mars red; Jupiter largest; Saturn less dense than water; Pluto a dwarf planet since 2006; Aryabhata (1975) was India's first satellite.
- Water: about 71% of the Earth's surface; World Water Day 22 March; water table, aquifers, infiltration; rainwater harvesting and drip irrigation save water.
- Acid rain from sulphur dioxide and nitrogen dioxide causes marble cancer of the Taj Mahal; CFCs damage the ozone layer; carbon dioxide causes the greenhouse effect; Ganga Action Plan 1985.
- Pachmarhi Biosphere Reserve (Madhya Pradesh): Satpura National Park and the Bori and Pachmarhi sanctuaries; endemic as NCERT lists them: sal, wild mango, bison, Indian giant squirrel; Project Tiger 1973; Red Data Book lists endangered species.

> **Quick revision:** Wind blows from high to low pressure; cyclone eye is calm; lightning from charge separation in clouds, conductor protects, squat but never lie flat; earthquakes from plate movement, Richter scale, Bhuj 2001; light year is a distance; Pole Star seems fixed; eight planets, Venus brightest, Jupiter largest; Aryabhata 1975; 71% of the surface is water, World Water Day 22 March; acid rain causes marble cancer; Ganga Action Plan 1985; Project Tiger 1973; Pachmarhi Biosphere Reserve.

Nature and Structure of Science: Process, Body of Knowledge, Aims and Scientific Attitude

Science as a body of knowledge: Science is organised knowledge about the natural world built on evidence, and it has a structure. Facts are observable, verifiable statements (pure water boils at 100 °C at sea level). Concepts are general ideas that group many facts (force, cell, solution). Principles and laws state relationships that hold under stated conditions (the laws of reflection, Newton's laws of motion). Theories are broad, well-tested explanations of many observations (the cell theory, the kinetic theory of matter). A hypothesis is a tentative, testable explanation not yet verified.

Science as a process: Science is also a way of finding out. The process involves observing, asking questions, forming hypotheses, designing fair tests, collecting and interpreting data, drawing conclusions and communicating them for others to check. Scientific knowledge is therefore empirical (based on evidence), tentative (open to revision with new evidence: the Sun-centred model of Copernicus replaced the Earth-centred one, and Pluto was reclassified as a dwarf planet in 2006), objective and verifiable (others can repeat the test), self-correcting and cumulative. There is no single fixed scientific method; imagination and creativity matter, and science is a social enterprise in which scientists share, criticise and build on one another's work. Process skills are commonly grouped as basic (observing, classifying, measuring, communicating, inferring, predicting) and integrated (controlling variables, formulating hypotheses, interpreting data, defining operationally, experimenting).

Aims at the upper primary stage: NCF 2005 holds that good science education is true to the child, true to life and true to science. At the upper primary stage (Classes VI to VIII) children should learn the principles of science through familiar experiences, work with their hands to design simple technological units and modules (for example, a working model of a windmill to lift weights), and continue learning about the environment and health, including reproductive and sexual health, through activities and surveys. Concepts are to be arrived at mainly through activities and experiments, with group work, discussion with peers and teachers, surveys, organisation of data and display through exhibitions in school and the neighbourhood. Science here must not be a diluted version of secondary school science. The progression runs from EVS at the primary stage to science at upper primary, science as a composite discipline at the secondary stage, and separate disciplines at the higher secondary stage.

The six validity criteria: The NCF 2005 Position Paper on Teaching of Science judges a curriculum by six validities. Cognitive validity: content, process, language and pedagogy suit the child's age and cognitive reach, so atomic structure in Class VI would violate it. Content validity: the information is significant and scientifically correct, and simplification must not trivialise or distort it. Process validity: the learner engages with the methods that generate and validate scientific knowledge, which nurtures curiosity and creativity, as when children design their own test of which soil holds most water. Historical validity: learners see how scientific ideas evolved and how social factors shaped science as a social enterprise. Environmental validity: science is set in the learner's local and global environment, with issues at the interface of science, technology and society, and prepares the learner for the world of work, as in a survey of the village pond. Ethical validity: the curriculum promotes honesty, objectivity, cooperation, freedom from fear and prejudice, and concern for life and the environment, as when a child reports actual readings that differ from the expected answer.

Scientific attitude: Scientific attitude is the habit of mind a science classroom builds: curiosity, open-mindedness, objectivity, honesty in recording observations, critical thinking, suspended judgement (not concluding before there is enough evidence), belief in cause and effect, rejection of superstition, perseverance, humility and readiness to change one's view when evidence demands. Jawaharlal Nehru popularised the phrase scientific temper in The Discovery of India (1946), and the 42nd Amendment of 1976 made developing the scientific temper, humanism and the spirit of inquiry and reform a Fundamental Duty under Article 51A(h). A teacher builds it by asking 'How do you know?', letting children test claims such as a cawing crow bringing guests, welcoming questions, saying 'I do not know, let us find out', and valuing an honestly reported experiment that did not work. Attitudes belong to the affective domain and are assessed through observation, anecdotal records, checklists and rating scales rather than written tests.

Science, technology, society and history: Science seeks to understand nature, while technology applies knowledge to solve practical problems; each feeds the other, and the science-technology-society (STS) view links classroom topics to energy, health and pollution. The history of science shows it as a human, cross-cultural enterprise: C.V. Raman's discovery of the Raman effect on 28 February 1928 is marked as National Science Day, and he won the Nobel Prize in Physics in 1930; J.C. Bose showed that plants respond to stimuli and built the crescograph; Salim Ali is called the Birdman of India; E.K. Janaki Ammal was a pioneering botanist who worked on sugarcane; and the texts of Charaka and Sushruta record ancient medicine and surgery. Such stories, including those of women scientists, counter the idea that science is only for a few.

Examples

- Fact: pure water boils at 100 °C at sea level; concept: force; law: the laws of reflection; theory: the cell theory; hypothesis: a tentative, testable explanation.
- Scientific knowledge is empirical, tentative, objective, verifiable, self-correcting and cumulative; Pluto's reclassification in 2006 shows that it is tentative.
- Basic process skills: observing, classifying, measuring, communicating, inferring, predicting. Integrated skills: controlling variables, formulating hypotheses, interpreting data, defining operationally, experimenting.
- NCF 2005: good science education is true to the child, true to life and true to science; upper primary science must not be a diluted version of secondary science.
- Six validities: cognitive (age-appropriate), content (correct and significant), process (methods of science), historical (how ideas evolved), environmental (local and global context, STS), ethical (honesty, objectivity, cooperation, freedom from fear and prejudice).
- A child honestly reports readings that differ from the textbook answer: this reflects ethical validity and the scientific attitude of honesty.
- Scientific temper: Article 51A(h), added by the 42nd Amendment (1976); the phrase was popularised by Nehru in The Discovery of India (1946).
- Suspended judgement means not drawing a conclusion until enough evidence has been collected.
- National Science Day, 28 February, marks C.V. Raman's discovery of the Raman effect (1928); Nobel Prize in Physics 1930; J.C. Bose built the crescograph.

Quick revision: Science = body of knowledge + process; fact, concept, law, theory, hypothesis; knowledge empirical, tentative, verifiable; basic and integrated process skills; NCF 2005: true to the child, to life and to science; upper primary learns through familiar experience, hands-on design and activities, not diluted secondary science; six validities: cognitive, content, process, historical, environmental, ethical; scientific temper Art 51A(h), 42nd Amendment 1976; National Science Day 28 February.

Approaches to Teaching Science: Inquiry, Discovery, Experiment, 5E Model, Projects and Concept Maps

Inquiry and discovery: In inquiry-based teaching, children ask a question, plan how to find out, collect evidence, explain it and share their findings, while the teacher acts as a facilitator who asks 'What do you think will happen if...?' and 'How can we find out?'. Inquiry ranges from structured (the teacher gives both the question and the procedure) through guided (the teacher gives only the question) to open (children frame their own question). Discovery learning, associated with Jerome Bruner, lets learners find a principle themselves through active exploration, usually with guidance. The heuristic method of H.E. Armstrong, from a Greek word meaning 'I find', puts the child in the position of a discoverer; it builds independence but is slow and needs skilled teachers. Instead of telling Class VI that some substances dissolve, the teacher gives salt, sugar, sand and chalk and lets groups find out which dissolve in water.

Observation and experiment: Careful, recorded observation is the starting point: a moon diary kept for a month, a nature walk or a herbarium of local leaves. An experiment tests an idea under controlled conditions, changing one variable, keeping the others constant and comparing with a control. To show that sunlight is needed for photosynthesis, a potted plant is kept in the dark for about 72 hours to remove its starch, part of a leaf is covered with black paper, and after some hours in sunlight only the uncovered part turns blue-black with iodine. The laboratory method develops psychomotor skills and honest recording; activities come before definitions, and children record what they actually see.

The 5E model: The 5E instructional model, developed by the Biological Sciences Curriculum Study (BSCS) in the late 1980s, applies constructivism. Engage: capture interest and bring out prior ideas, for example by asking why a torch does not light. Explore: groups handle a cell, a bulb and wires and try to make the bulb glow while the teacher listens and asks probing questions. Explain: children share what worked, and only now does the teacher introduce terms such as closed circuit, conductor and insulator. Elaborate: children apply the idea to a new situation, testing which classroom objects let current pass. Evaluate: children draw circuits and predict which bulbs will glow, while the teacher assesses throughout and children reflect on their learning.

Projects and problem solving: The project method of William Heard Kilpatrick (1918), a student of John Dewey, organises learning as a wholehearted, purposeful activity carried out in a social setting. Its steps are providing a situation, choosing and purposing, planning, executing, evaluating and recording. A Class VII project might survey how water is used and wasted in the neighbourhood, or grow a school kitchen garden. The problem-solving method rests on Dewey's reflective thinking: feeling a problem, defining it, collecting information, forming hypotheses, testing them and drawing conclusions. Both link science to real life and build cooperation, but need time, planning and resources.

Demonstration: A demonstration suits apparatus that is costly, scarce or dangerous, or a skill children must first see. A good demonstration is rehearsed beforehand, visible to every child, uses simple apparatus and safe practice, and involves the class. The Predict-Observe-Explain (POE) strategy of Richard White and Richard Gunstone asks children to predict the result, observe it and then explain any difference, which turns a demonstration into inquiry. In the lecture-cum-demonstration method the teacher explains while showing, which saves time and material, but children stay largely passive and gain no hands-on skill, so it should not replace their own activity.

Concept maps and organisers: A concept map, devised by Joseph Novak at Cornell University in the 1970s on the basis of David Ausubel's theory of meaningful learning, shows concepts in boxes joined by labelled links that form propositions, such as plants make food by photosynthesis. Maps run from general to specific, and cross-links show deep understanding; they are used to plan, revise, assess understanding and reveal misconceptions. Ausubel's

advance organiser gives a general framework before the details. A KWL chart (what I Know, Want to know, Learned) tracks progress, and analogies such as water flow for electric current help when their limits are discussed.

Integrated approach: NCF 2005 recommends EVS at the primary stage, integrating science and social science, and science at the upper primary stage linked with daily life, health, the environment and other subjects. Thematic teaching follows one theme, such as water, through its properties, the water cycle, pollution, conservation, traditional stepwells and the mathematics of measuring rainfall. NEP 2020 asks for experiential learning, arts-integrated and sports-integrated education, and no hard separation between curricular and extra-curricular activities or between the sciences and the arts.

Innovation in teaching: Improvised low-cost and no-cost apparatus, such as Arvind Gupta's toys from trash made with straws, matchboxes and rubber tubes, makes science concrete where laboratories are scarce. Science clubs, fairs and exhibitions, field trips, role play (children acting as planets), cooperative learning such as the jigsaw technique, peer tutoring, ICT simulations and virtual labs all encourage creativity. For children with special needs, tactile models, Braille labels, audio description and work in pairs make science inclusive.

Examples

- Inquiry levels: structured (teacher gives the question and procedure), guided (teacher gives only the question), open (children frame the question).
- Heuristic method = H.E. Armstrong ('I find'); discovery learning = Jerome Bruner; project method = W.H. Kilpatrick (1918); problem solving and reflective thinking = John Dewey.
- 5E: Engage, Explore, Explain, Elaborate, Evaluate; developed by BSCS; technical terms come only at Explain, after hands-on exploration.
- Fair test: change one variable, keep the others constant, compare with a control; e.g. a destarched plant, a half-covered leaf and the iodine test.
- Project method steps: providing a situation, choosing, planning, executing, evaluating, recording.
- POE (Predict-Observe-Explain) of White and Gunstone turns a demonstration into inquiry.
- Demonstration suits costly, scarce or dangerous apparatus; its weakness: children stay passive and gain no hands-on skill.
- Concept map = Joseph Novak, based on Ausubel's meaningful learning; concepts in boxes, linking words form propositions; it also reveals misconceptions.
- Integrated approach: EVS at the primary stage; NEP 2020 - experiential, arts- and sports-integrated learning, no hard separation between sciences and arts.
- Innovation: toys from trash (Arvind Gupta), science clubs and fairs, jigsaw, ICT simulations, tactile models for children with visual impairment.

> **Quick revision:** Inquiry: question, plan, evidence, explain, share; structured, guided, open; discovery = Bruner, heuristic = Armstrong; experiment changes one variable against a control; 5E (BSCS): Engage, Explore, Explain, Elaborate, Evaluate; project method = Kilpatrick 1918; problem solving = Dewey; POE turns demonstration into inquiry; concept map = Novak, based on Ausubel; integrated and thematic teaching; low-cost improvised apparatus.

Evaluation, Text Materials and Remedial Teaching in Science

CCE in science: The RTE Act 2009, in Section 29(2)(h), requires comprehensive and continuous evaluation of a child's understanding of knowledge and ability to apply it. Continuous means assessment runs through the year as part of teaching: formative assessment is assessment for learning, giving feedback while learning goes on, and summative assessment is assessment of learning at the end of a term; assessment as learning means children monitor their own learning through self- and peer-assessment. Comprehensive means it covers scholastic and co-scholastic areas: knowledge, process skills, attitudes, values and practical work. NEP 2020 asks for regular, formative, competency-based assessment that tests higher-order skills rather than rote memory.

Tools of assessment: Paper-pencil tests capture only part of science learning. Teachers also use oral questioning, observation during activities, anecdotal records (brief notes on significant incidents), checklists (yes or no for listed behaviours), rating scales (the degree of a quality), rubrics (criteria with performance levels, shared in advance),

portfolios (collected work showing growth over time), concept maps and open-ended questions with more than one acceptable answer. Feedback should be descriptive, telling the child what was done well and how to improve, rather than only a mark.

Assessing the three domains: Bloom's taxonomy of the cognitive domain (1956) was revised in 2001 by Anderson and Krathwohl as Remember, Understand, Apply, Analyse, Evaluate, Create. Krathwohl's affective domain runs from receiving and responding to valuing, organisation and characterisation, and R.H. Dave's psychomotor levels are imitation, manipulation, precision, articulation and naturalisation. Process skills are assessed through performance: to test controlling variables, show a set-up and ask which factor must be kept the same; to test recording, ask children to enter readings in a table. A task such as 'Design a way to find whether a ball bounces higher on a hard or a soft floor' assesses planning an investigation, a Create-level skill.

Practical work: Practical work is assessed for planning, handling apparatus correctly and safely, observing and recording honestly, interpreting results and communicating them, through observation of performance, laboratory records and short oral questions. Safety is part of it: never taste chemicals, waft vapours towards the nose instead of smelling directly, point a heated test tube away from people and add acid to water slowly. Where laboratories are lacking, kits and improvised apparatus let every child handle materials, and rotating roles in a group stops a few children, often boys, from doing the experiment while the rest watch.

Text materials and aids: NCF 2005 treats the textbook as one resource among many, not the whole curriculum; the teacher also uses the local environment, the community and children's own experience. NCERT's upper primary science books based on NCF 2005 are built around activities, with the characters Paheli and Boojho voicing children's questions; a good science textbook is accurate, age-appropriate, activity-based, gender-fair, linked to the environment and written in simple language. Edgar Dale's Cone of Experience (1946) places direct, purposeful experience at the base and verbal symbols at the top: the more concrete the experience, the more lasting the learning.

Misconceptions: Children bring their own ideas, called alternative conceptions or misconceptions, formed from daily experience and language: plants get their food from the soil, heavier objects fall faster, the Moon makes its own light, the phases of the Moon are caused by the Earth's shadow (that is an eclipse), seasons depend on distance from the Sun, a bat is a bird, a spider is an insect, a mushroom is a plant, and heat and temperature are the same. Such ideas persist and are not removed by simply telling. The constructivist sequence is to elicit the idea through a diagnostic question or concept cartoon, create cognitive conflict with an activity whose result contradicts it, help children restructure it through discussion, and apply it to new cases. Posner and colleagues (1982) said conceptual change needs dissatisfaction with the old idea and a new one that is intelligible, plausible and fruitful.

Diagnosis and remedial teaching: A diagnostic test locates the specific difficulty behind errors, for example whether a child who fails circuit questions does not know that a circuit must be closed or confuses conductors with insulators; it is not meant for grading. Remedial teaching follows, with a method different from the first one: concrete materials, small groups, peer tutoring, more examples and individual attention, then a re-test. Errors are windows into children's thinking, not occasions for punishment. Quick learners need enrichment, such as projects and challenging problems, rather than more of the same exercises.

Problems of teaching science: Common problems are rote learning driven by examinations, a lack of laboratories and equipment, large classes, an overloaded syllabus, science taught in a language the child does not speak at home, teachers untrained in activity-based methods, gender stereotypes about who can do science, and science cut off from daily life. Remedies follow NCF 2005 and NEP 2020: use the home language alongside the textbook language (NEP 2020 wants the home language, mother tongue or local language as the medium of instruction wherever possible until at least Grade 5, preferably till Grade 8 and beyond), improvise apparatus, use the community and the environment as resources, plan group work, and assess understanding rather than recall.

Examples

- RTE Act 2009, Section 29(2)(h): comprehensive and continuous evaluation of the child's understanding of knowledge and ability to apply it.

- Formative = assessment for learning (during teaching); summative = assessment of learning (end of term); assessment as learning = self- and peer-monitoring.
- Tools: anecdotal record (significant incidents), checklist (yes or no), rating scale (degree of a quality), rubric (criteria and levels), portfolio (growth over time).
- Revised Bloom (2001, Anderson and Krathwohl): Remember, Understand, Apply, Analyse, Evaluate, Create; affective domain: receiving to characterisation; psychomotor (Dave): imitation to naturalisation.
- Laboratory safety: never taste chemicals; waft vapours; point test tubes away from people; add acid to water, slowly; keep sand, water and first aid ready.
- Edgar Dale's Cone of Experience (1946): direct, purposeful experience at the base, verbal symbols at the top.
- NCF 2005: the textbook is one resource, not the only one; NCERT's science books based on NCF 2005 use Paheli and Boojho to voice children's questions.
- Misconception route: elicit, create cognitive conflict, restructure, apply; Posner and colleagues (1982): dissatisfaction, intelligible, plausible, fruitful.
- A diagnostic test finds the specific difficulty; remedial teaching re-teaches with a different method; quick learners get enrichment, not more of the same.
- NEP 2020: wherever possible, the home language, mother tongue or local language as the medium of instruction until at least Grade 5, preferably till Grade 8 and beyond.

> **Quick revision:** CCE = RTE Act 2009, Section 29(2)(h); formative is assessment for learning, summative of learning; anecdotal record, checklist, rating scale, rubric, portfolio; revised Bloom 2001; affective - Krathwohl; psychomotor - Dave; assess process skills by performance; textbook is one resource; Dale's cone runs from concrete to abstract; misconceptions need cognitive conflict, not telling; diagnostic test then remedial teaching; enrichment for quick learners; home language helps science learning.

Free practice questions: parikshasaathi.com/q/science-pedagogy/

Social Studies and its Pedagogy (Paper II)

Social Studies and its Pedagogy (Paper II)

What the exam asks: In CTET Paper II, candidates who choose the Social Studies/Social Science option answer 60 questions on it: 40 on content (history, geography, and social and political life at the level of Classes VI to VIII) and 20 on pedagogy. This topic carries both kinds of question. Pedagogy items are mostly classroom scenarios: a child says something, a teacher must choose a method, or an assessment item must be classified. The correct answer almost always reflects the NCF 2005 vision, which is constructivist, inquiry-based and child-centred, treats the textbook as one resource among many, and values critical thinking over memorisation. Options that praise lecturing, dictation, rote learning, punishment or a single correct viewpoint are nearly always wrong. For the content questions, revise the NCERT social science textbooks for Classes VI to VIII.

Nature and aims of social science: Social studies is the integrated school subject that draws on the social science disciplines of history, geography, political science, economics and sociology. NCF 2005 rejects the views that social science is a 'non-utility' subject, 'not scientific' or merely information to be memorised; it is a rigorous field of enquiry based on evidence and reasoning. Its aims are critical and creative thinking, informed and humane citizenship, understanding plurality, sensitivity to social and gender justice, and the habit of questioning and going beyond the textbook. Learning is meaning-making: children construct understanding from prior experience, and the teacher is a facilitator.

Classroom processes and discipline-specific skills: Discussions, debates, role play, mock parliament and mock elections, student councils (school as a democratic space), projects, field surveys of the local area, oral history interviews, newspapers, stories and biographies, and local history all move learning from the concrete and familiar to the abstract. In history, use timelines for chronology and duration, cause-and-effect questions, primary sources (inscriptions, coins, manuscripts, edicts, letters) versus secondary sources (textbooks, encyclopaedias), archaeological versus literary sources, and ask of every source who wrote it, for whom and why. Criticise James

Mill's Hindu-Muslim-British periodisation for defining periods by rulers' religion; 'history from below' recovers the lives of ordinary people. In geography, use the globe for accurate shape and position, maps and atlases for detail, scale (1:50,000 means 1 cm on the map is 500 m on the ground), directions, local field work and GIS, which layers spatial data. In civics, democracy should be lived, not memorised; in economics, begin with family budgets and the local market. Census data is secondary data collected every ten years.

Evaluation and problems in social science: Prefer source-based, map-based, open-ended and reflective questions ('If you were in the Constituent Assembly...') over date recall. Project work is assessed on process and product with a rubric. Values and attitudes are assessed through observation, anecdotal records and checklists under CCE. Learning indicators are observable behaviours showing that learning outcomes are being met. Handle controversial issues by presenting multiple viewpoints with evidence; use stereotyped textbook images as material for critical discussion; include every child, for example with tactile maps for a visually impaired learner. A good NCF 2005 textbook offers multiple perspectives, in-text questions, activities and links to the local context.

Examples

- Primary sources are from the period itself (edicts, coins, manuscripts, letters); secondary sources interpret them later (textbooks, encyclopaedias).
- Map scale 1:50,000 means 1 cm on the map equals 50,000 cm, that is 500 m, on the ground; a globe gives truer shape and size than any flat map.
- Social studies = the integrated school subject; social sciences = the parent disciplines (history, geography, political science, economics, sociology).
- Ask of every historical source: who wrote it, for whom, and why? An official British account of 1857 and a rebel proclamation describe the same events very differently.
- James Mill's 'Hindu-Muslim-British' periodisation is criticised for dividing history by the religion of rulers; 'history from below' looks at the lives of ordinary people.
- Democracy is lived, not memorised: a student council, class rules framed together and a mock parliament teach it better than definitions.
- Controversial issues (for example, reservation): present several viewpoints with evidence and let students reason; neither impose one 'correct' view nor avoid the topic.
- Assessment in social science: source-based, map-based, open-ended and reflective questions ('If you were in the Constituent Assembly...') test understanding better than recalling dates.
- Move from the concrete and familiar to the abstract: begin economics with family budgets and the local market, and history with a local fort or oral history from elders.
- In pedagogy scenario questions, the answer that keeps the child active, builds on prior knowledge, offers multiple perspectives and treats the textbook as one resource is usually the one consistent with NCF 2005.

> **Quick revision:** Social studies is integrated, social sciences are disciplines; primary vs secondary sources; Mill's periodisation criticised; scale 1:50,000 = 1 cm : 500 m; Census = secondary data every 10 years; values assessed by observation.

Early India: Sources, First Farmers, Harappan Cities, Mauryas and Guptas (Class VI History)

Sources and dates: Historians use manuscripts, books written by hand, usually on palm leaf or on the prepared bark of the birch (bhurja) tree; inscriptions, writings on hard surfaces such as stone or metal; and archaeology, the study of remains such as buildings, tools, pots, coins and bones. The name India comes from the Indus, called Sindhu in Sanskrit, while Bharata was the name of a group of people mentioned in the Rigveda. BCE (Before Common Era) dates count backwards, so 500 BCE is earlier than 300 BCE, and CE (Common Era) dates count forwards.

Hunter-gatherers and the first farmers: Bhimbetka in Madhya Pradesh has rock shelters with paintings, Hunsgi in Karnataka was a factory site where limestone tools were made, and ash in the Kurnool caves shows the use of fire. The Palaeolithic lasted from about 2 million to about 12,000 years ago; the Mesolithic, from about 12,000 to 10,000 years ago, is known for microliths, tiny stone tools fixed on handles; and the Neolithic began about 10,000 years

ago. As the climate warmed and grasslands spread, people began to domesticate plants and animals. At Mehrgarh, near the Bolan Pass in present-day Pakistan, people grew wheat and barley and reared sheep and goats; Burzahom in Kashmir had pit-houses, and Koldihwa in Uttar Pradesh gives early evidence of rice.

The Harappan cities: About 4700 years ago cities such as Harappa, Mohenjodaro, Kalibangan, Lothal and Dholavira grew up. Most had a smaller, higher citadel to the west and a larger lower town to the east, houses of baked bricks laid in an interlocking pattern, and covered drains. Mohenjodaro had the Great Bath, made watertight with a layer of natural tar; Kalibangan and Lothal had fire altars; and Harappa, Mohenjodaro and Lothal had storehouses. Lothal in Gujarat was a centre for making objects of stone, shell and metal, and Dholavira in the Rann of Kutch was divided into three parts and had large Harappan letters carved out of white stone. About 3900 years ago people began to leave the cities; drying rivers, deforestation and floods have been suggested, but no single reason explains every city.

Vedas, megaliths and the first kingdoms: The Rigveda, composed about 3500 years ago, has 1028 hymns (suktas) praising gods such as Agni, Indra and Soma; it was recited and heard, and written down much later. From about 3000 years ago people in the Deccan, south India, the north-east and Kashmir buried their dead under big stones called megaliths. About 2500 years ago some janapadas grew into fortified mahajanapadas whose rajas kept armies and collected taxes; bhaga, the tax on crops, was usually one-sixth of the produce. Magadha, with fertile land along the Ganga and the Son, elephant forests and iron ore, became the most powerful in about 200 years under rulers such as Bimbisara, Ajatasattu and Mahapadma Nanda. The Vajji, with its capital at Vaishali, was a gana or sangha ruled by an assembly of many rajas.

New questions and ideas: Siddhartha Gautama, the Buddha, born about 2500 years ago in the Sakya gana, attained enlightenment at Bodh Gaya, gave his first sermon at Sarnath and died at Kusinara. He taught in Prakrit, the language of ordinary people, that suffering comes from tanha (craving), and urged kindness to all living beings. Vardhamana Mahavira, a Lichchhavi prince and the 24th tirthankara of the Jainas, taught strict ahimsa; Jaina teachings were written down at Valabhi in Gujarat about 1500 years ago. The Upanishads record dialogues on atman, the individual soul, and brahman, the universal soul, and mention the learned woman thinker Gargi. Buddhist monks followed the rules of the Vinaya Pitaka, and brahmins described four ashramas: brahmacharya, grihastha, vanaprastha and samnyasa.

The first empire and distant lands: Chandragupta Maurya founded the Mauryan empire more than 2300 years ago with the help of Chanakya (Kautilya), whose ideas are in the Arthashastra; Megasthenes, a Greek ambassador at his court, described Pataliputra. His grandson Ashoka, horrified by the killing in the Kalinga war, gave up conquest and spread dhamma through inscriptions, mostly in Prakrit in the Brahmi script, through officials called dhamma mahamattas and through messengers to Syria, Egypt, Greece and Sri Lanka; his lion capital at Sarnath is India's national emblem. Roman pottery at Arikamedu near Puducherry and Chinese silk carried along the Silk Route show trade with distant lands. Mahayana Buddhism developed around the time of Kanishka and spread to Central Asia, China, Korea and Japan, and the Chinese pilgrim Xuan Zang studied at Nalanda.

New empires, culture and science: Harishena's prashasti on the Ashokan pillar at Allahabad praises Samudragupta, and Harshavardhana is known from Banabhatta's Harshacharita; the Chalukya king Pulakeshin II stopped Harsha at the Narmada. The iron pillar at Mehrauli in Delhi, made about 1500 years ago, is 7.2 m high, weighs over 3 tonnes and has not rusted. The stupa at Sanchi, the monolithic temples of Mahabalipuram and the Ajanta paintings show the art of the period. Aryabhata's Aryabhatiyam states that the earth rotates on its axis and explains eclipses, and the Tamil epics Silappadikaram and Manimekalai were composed about 1800 and 1400 years ago.

Examples

- Manuscripts were written on palm leaf or birch bark (bhurja); inscriptions on stone or metal; archaeology studies material remains such as tools, pots, coins and bones.
- Palaeolithic: about 2 million to 12,000 years ago; Mesolithic: 12,000 to 10,000 years ago (microliths); Neolithic: from about 10,000 years ago (farming, herding, polished tools).

- Mehrgarh (near the Bolan Pass): wheat, barley, sheep and goats; Burzahom (Kashmir): pit-houses; Koldihwa (Uttar Pradesh): rice; Hunsgi (Karnataka): limestone tool factory site.
- Harappan features: citadel and lower town, baked bricks, covered drains; Great Bath at Mohenjodaro; fire altars at Kalibangan and Lothal; Dholavira divided into three parts.
- Rigveda: about 3500 years ago, 1028 hymns, praises Agni, Indra and Soma; megalith burials began about 3000 years ago.
- Magadha: Bimbisara, Ajatasattu, Mahapadma Nanda; capital Rajagriha, later Pataliputra; the Vajji (Vaishali) was a gana or sangha ruled by an assembly; bhaga was one-sixth of the crop.
- Buddha: enlightenment at Bodh Gaya, first sermon at Sarnath, died at Kusinara; Mahavira was the 24th tirthankara; Jaina teachings were written down at Valabhi.
- Ashoka after the Kalinga war: dhamma, dhamma mahamattas, inscriptions mostly in Prakrit in the Brahmi script; the Sarnath lion capital is India's national emblem.
- Iron pillar at Mehrauli: about 1500 years old, 7.2 m high, over 3 tonnes, rust-free; Aryabhata's Aryabhatiyam explained eclipses and the earth's rotation.
- In class: build a class timeline in 'years ago' and BCE/CE, and let students examine pictures of coins and seals to ask what each source can and cannot tell us.

> **Quick revision:** Sources: manuscripts, inscriptions, archaeology; Mehrgarh early farming (wheat, barley); Harappan cities about 4700 years ago, decline about 3900; Rigveda 1028 hymns; mahajanapadas about 2500 years ago, Magadha strongest; Buddha (Bodh Gaya, Sarnath), Mahavira 24th tirthankara; Ashoka's dhamma after Kalinga; Harishena's prashasti of Samudragupta; Aryabhata; Mehrauli iron pillar.

Medieval India: New Kingdoms, Delhi Sultans, Mughals, Bhakti-Sufi Paths and Regional Cultures (Class VII History)

Sources and new kingdoms: For the period from about 700 to 1750, historians use inscriptions, coins, buildings, chronicles written in Persian and manuscripts copied by hand. Between the 7th and 12th centuries new dynasties rose, often from samantas, powerful landlords and warriors; the Rashtrakuta chief Dantidurga overthrew his Chalukya overlord and performed the hiranya-garbha ritual. The Gurjara-Pratiharas, Rashtrakutas and Palas fought for Kanauj in the tripartite struggle. Mahmud of Ghazni (997-1030) raided the subcontinent 17 times, plundering temples such as Somnath, and Al-Biruni, who came with him, wrote the Kitab al-Hind. The Chauhan ruler Prithviraja III defeated Sultan Muhammad Ghori in 1191 but lost to him in 1192.

The Cholas: Vijayalaya captured the Kaveri delta from the Muttaraiyar in the middle of the 9th century. Rajaraja I, king from 985, built the Rajarajeshvara temple at Thanjavur, and his son Rajendra I raided the Ganga valley, Sri Lanka and Southeast Asia and founded Gangaikondacholapuram. Chola bronzes were made by the lost-wax technique. Peasant settlements (ur) were grouped into nadu, and brahmadeya lands given to brahmanas were managed by a sabha; inscriptions at Uttaramerur in Tamil Nadu describe sabha members being chosen by lot from palm-leaf tickets drawn from a pot.

The Delhi Sultans: Delhi first became a capital under the Tomara Rajputs. The Sultanate had five dynasties: the early Turkish rulers (1206-1290), the Khaljis (1290-1320), the Tughluqs (1320-1414), the Sayyids (1414-1451) and the Lodis (1451-1526). Raziyya, daughter of Iltutmish, ruled from 1236 to 1240. Alauddin Khalji (1296-1316) built Siri as a garrison town against the Mongols, paid soldiers in cash and controlled prices; Muhammad Tughluq (1324-1351) shifted people to Daulatabad and issued a token currency. Commanders called muqtis held iqtas and paid soldiers from their revenue, and the land tax, kharaj, was about half the peasant's produce. Sher Shah Sur (1540-1545) defeated Humayun, and his administration became a model for Akbar.

The Mughals: Babur defeated Ibrahim Lodi at Panipat in 1526 and Rana Sanga at Khanwa in 1527; Humayun lost to Sher Shah at Chausa (1539) and Kanauj (1540). Akbar (1556-1605) won the second battle of Panipat against Hemu in 1556 and ruled through mansabdars: zat fixed a mansabdar's rank and salary, sawar the number of cavalrymen he had to keep, and he was paid through revenue assignments called jagirs. Todar Mal surveyed crop yields and prices for 10 years (1570-1580) and fixed revenue in cash under the zabt system. In the ibadat khana at Fatehpur Sikri, from

1575, Akbar heard scholars of many faiths and developed the idea of sulh-i kul, universal peace; Abul Fazl wrote the Akbar Nama, whose third volume is the Ain-i Akbari.

Buildings and towns: Trabeate construction laid horizontal beams across columns; from the 12th century the arcuate style used arches, whose keystone carried the weight, and limestone cement. The Qutb Minar was built by Qutbuddin Aybak and Iltutmish; Humayun's tomb set the pattern of a central dome, a tall gateway (pishtaq) and the chahar bagh, a four-part garden, which Shah Jahan perfected in the Taj Mahal. The NCERT book says the Kandariya Mahadeva temple at Khajuraho was built in 999 by the Chandela king Dhangadeva, though most historians date it to about 1030, under the later Chandela king Vidyadhara. Hampi, capital of Vijayanagara, fell into ruin after its defeat by the Deccani sultans in 1565, and Surat, the main Mughal port for West Asia, was called the gate to Mecca because pilgrim ships sailed from it.

Tribes and devotional paths: Banjaras were trader-nomads whose caravans (tanda) carried grain, and Alauddin Khalji used them to supply Delhi. Rani Durgawati of the Gond kingdom of Garha Katanga resisted the Mughals (the NCERT book gives 1565; most historians date her last battle to 1564), and the Ahoms, who came from present-day Myanmar in the 13th century, were defeated by the Mughals in 1662. The 63 Nayanars (devotees of Shiva) and 12 Alvars (devotees of Vishnu) sang in Tamil between the 7th and 9th centuries; Shankara (8th century) taught Advaita, Ramanuja (11th century) Vishishtadvaita, and Basavanna led the Virashaiva movement in Karnataka in the 12th century. The saints of Maharashtra, such as Jnaneshwar, Namdev and Tukaram, worshipped Vitthala at Pandharpur. Chishti Sufis such as Muinuddin Chishti of Ajmer and Nizamuddin Auliya of Delhi met followers in khanqahs. Kabir rejected ritual and caste; Guru Nanak (1469-1539) started a langar at Kartarpur; Guru Arjan compiled the Adi Granth in 1604, and Guru Gobind Singh founded the Khalsa in 1699.

Regional cultures and the 18th century: Malayalam developed under the Chera kingdom of Mahodayapuram in the 9th century; at Puri, Anantavarman of the Ganga dynasty built the Jagannatha temple in the 12th century, and in 1230 Anangabhima III dedicated his kingdom to the deity; Kathak grew from temple storytellers (kathakas) and flourished under Wajid Ali Shah of Awadh. After Aurangzeb died in 1707, Nadir Shah sacked Delhi in 1739 and Ahmad Shah Abdali invaded north India five times between 1748 and 1761, while Awadh, Bengal and Hyderabad became virtually independent. The Sikh misls protected cultivators under the rakhi system for 20 per cent of the produce, and Ranjit Singh made Lahore his capital in 1799. The Marathas collected chauth (25 per cent of land revenue) and sardeshmukhi (9-10 per cent) but lost the third battle of Panipat in 1761.

Examples

- Tripartite struggle for Kanauj: Gurjara-Pratiharas, Rashtrakutas and Palas; Mahmud of Ghazni (997-1030) raided 17 times; Al-Biruni wrote the Kitab al-Hind.
- Prithviraja III Chauhan defeated Muhammad Ghori in 1191 but lost in 1192; Rajaraja I (Chola) became king in 985 and built the Rajarajeshvara temple at Thanjavur.
- Sultanate dynasties: early Turkish 1206-1290, Khalji 1290-1320, Tughluq 1320-1414, Sayyid 1414-1451, Lodi 1451-1526; Raziyya ruled 1236-1240.
- Alauddin Khalji: Siri, cash salaries, price control; Muhammad Tughluq: Daulatabad, token currency; iqta held by a muqti; kharaj was about half the produce.
- Mughal battles: Panipat 1526 (Babur defeats Ibrahim Lodi), Khanwa 1527 (Rana Sanga), Chausa 1539 and Kanauj 1540 (Sher Shah defeats Humayun), Panipat 1556 (Akbar's forces defeat Hemu).
- Mansabdari: zat = rank and salary, sawar = cavalrymen to be kept, pay through jagirs; Todar Mal's zabt; ibadat khana at Fatehpur Sikri (1575); sulh-i kul.
- Arcuate style: arch with a keystone; pishtaq and chahar bagh seen in Humayun's tomb and the Taj Mahal; Kandariya Mahadeva temple, Khajuraho: 999 and Dhangadeva in NCERT (most historians: about 1030, Vidyadhara).
- Bhakti and Sufi: 63 Nayanars (Shiva), 12 Alvars (Vishnu); Basavanna (Virashaiva); Vitthala at Pandharpur; Chishti khanqahs; Guru Nanak's langar at Kartarpur; Adi Granth 1604; Khalsa 1699.
- 18th century: Nadir Shah sacked Delhi in 1739; Abdali invaded five times between 1748 and 1761; chauth 25 per cent, sardeshmukhi 9-10 per cent; Sikh rakhi 20 per cent; Ranjit Singh's capital Lahore 1799.

- In class: compare a court chronicle and a temple inscription about the same king, and ask why each writer praised or blamed him, rather than only asking for dynasties and dates.

> **Quick revision:** Tripartite struggle for Kanauj; Mahmud of Ghazni 17 raids; Prithviraja III 1191 and 1192; Cholas: Rajaraja I 985, Uttaramerur sabha; Sultanate five dynasties 1206-1526; iqta, kharaj; Mughals: Panipat 1526, mansabdari, zabt, sulh-i kul; arcuate arches; Banjaras, Gonds, Ahoms; Nayanars, Alvars, Sufis, Kabir, Nanak; Kathak; Nadir Shah 1739; Panipat 1761.

Modern India: Company Rule, the Revolt of 1857, Social Reform and the National Movement (Class VIII History)

From trade to territory: The East India Company received a charter from Queen Elizabeth I in 1600 and set up its first factory on the banks of the Hugli in 1651. At Plassey in 1757 Robert Clive defeated Siraj-ud-daulah, Nawab of Bengal, largely because the forces of Mir Jafar never fought; after the Battle of Buxar in 1764 the Mughal emperor appointed the Company Diwan of Bengal in 1765, giving it the land revenue. Tipu Sultan of Mysore was killed defending Seringapatam in 1799, and the Marathas were crushed in the war of 1817-19. Under Lord Wellesley's subsidiary alliance, Indian rulers could not keep independent armies and had to pay for Company troops; under Lord Dalhousie's doctrine of lapse, states whose rulers died without a male heir were annexed, such as Satara (1848), Nagpur (1853) and Jhansi (1854), and Awadh was annexed in 1856 on the charge of misgovernment.

Ruling the countryside and the forests: The Permanent Settlement of 1793 under Lord Cornwallis made rajas and taluqdars zamindars who paid a revenue fixed permanently. In the mahalwari settlement devised by Holt Mackenzie in 1822 for the North Western Provinces, the village headman collected revenue for the whole village (mahal), while the ryotwari system, developed by Thomas Munro in the south, settled revenue directly with the cultivators (ryots). Indigo planters forced ryots into contracts; the indigo revolt of 1859 in Bengal led to the Indigo Commission of 1860, and Gandhi's visit to Champaran in 1917 began a movement against indigo planters. Forest laws made forests state property and restricted jhum (shifting) cultivation. Birsa Munda, born in the mid-1870s, led the Mundas against dikus (outsiders such as moneylenders and traders) and the British, and died in jail in 1900.

The revolt of 1857: Annexations, heavy land revenue, interference in customs and rumours that new cartridges were coated with the fat of cows and pigs angered sepoys, rulers and peasants. On 29 March 1857 Mangal Pandey attacked his officers at Barrackpore and was hanged; on 10 May sepoys at Meerut rebelled, marched to Delhi and proclaimed Bahadur Shah Zafar their leader. Leaders included Nana Saheb at Kanpur, Rani Lakshmibai at Jhansi, Begum Hazrat Mahal at Lucknow, Kunwar Singh at Arrah and Tantia Tope. The British recaptured Delhi in September 1857, and Bahadur Shah was exiled to Rangoon, where he died in 1862. An Act of 1858 transferred power from the Company to the British Crown, created a Secretary of State for India and gave the Governor-General the title of Viceroy.

Women, caste and reform: Raja Rammohun Roy founded the Brahmo Sabha, later the Brahmo Samaj, and campaigned against sati, which was banned in 1829. Ishwarchandra Vidyasagar's efforts led to the widow remarriage law of 1856, and Swami Dayanand Saraswati founded the Arya Samaj in 1875. Jyotirao Phule wrote Gulamgiri (1873) and, with Savitribai Phule, opened schools for girls; Rokeya Sakhawat Hossain started schools for Muslim girls in Patna and Calcutta. Sri Narayana Guru in Kerala preached one caste, one religion, one god for humankind; Periyar began the Self-Respect Movement; and in 1927 B.R. Ambedkar led the Mahad satyagraha for the right of Dalits to draw water from a public tank (the NCERT book describes his campaigns of 1927 to 1935 as temple entry movements). The Child Marriage Restraint Act was passed in 1929. Macaulay's minute of 1835 and Wood's Despatch of 1854 favoured English education, while Tagore founded his school at Santiniketan in 1901 so that children could learn in harmony with nature.

The national movement: The Indian National Congress was founded when 72 delegates met at Bombay in December 1885. Lord Curzon's partition of Bengal in 1905 sparked the Swadeshi movement and the rise of radicals such as Bal Gangadhar Tilak, Bipin Chandra Pal and Lala Lajpat Rai; the Muslim League was formed at Dacca in 1906. Gandhi returned from South Africa in 1915 and led movements at Champaran, Kheda and Ahmedabad. The Rowlatt Act of 1919 and the Jallianwala Bagh massacre at Amritsar on 13 April 1919 led to the Khilafat and Non-

Cooperation movements, which were withdrawn after violence at Chauri Chaura in February 1922. The Lahore Congress of 1929 adopted Purna Swaraj, and 26 January 1930 was observed as Independence Day; the Dandi March, begun on 12 March 1930, launched Civil Disobedience. The Congress formed ministries in 7 of 11 provinces in 1937. The Quit India movement began in August 1942 with the call 'Do or die', and India became independent on 15 August 1947, with Partition.

India after independence: The Constituent Assembly, of about 300 members, met between December 1946 and November 1949, with B.R. Ambedkar as chairman of the Drafting Committee; the Constitution came into force on 26 January 1950 with universal adult franchise. Potti Sriramulu fasted for a separate state for Telugu speakers and died after 58 days, on 15 December 1952; Andhra state was formed on 1 October 1953, and states were reorganised on linguistic lines in 1956. The Planning Commission was set up in 1950, and the Second Five Year Plan, from 1956, stressed heavy industry, such as the steel plant at Bhilai. Under Jawaharlal Nehru, India followed non-alignment, staying out of both Cold War blocs.

Examples

- Plassey 1757 (Clive defeats Siraj-ud-daulah; Mir Jafar's forces never fought); Buxar 1764; Diwani of Bengal to the Company 1765; Tipu Sultan killed at Seringapatam 1799.
- Subsidiary alliance: Lord Wellesley; doctrine of lapse: Lord Dalhousie, from Satara 1848 to Jhansi 1854; Awadh annexed in 1856 for 'misgovernment'.
- Permanent Settlement 1793 (Cornwallis, zamindars); mahalwari 1822 (Holt Mackenzie, village headman); ryotwari (Thomas Munro, cultivators directly).
- Indigo revolt 1859 and Indigo Commission 1860; Champaran 1917; Birsa Munda fought the dikus and the British and died in jail in 1900.
- 1857: Meerut, 10 May; Bahadur Shah Zafar proclaimed leader; Nana Saheb (Kanpur), Lakshmibai (Jhansi), Hazrat Mahal (Lucknow), Kunwar Singh (Arrah); the Act of 1858 transferred rule to the Crown.
- Reformers: Rammohun Roy (Brahmo Samaj; sati banned 1829), Vidyasagar (widow remarriage 1856), Dayanand (Arya Samaj 1875), Phule (Gulamgiri 1873), Sri Narayana Guru, Periyar, Ambedkar (Mahad satyagraha 1927; NCERT calls his 1927-1935 campaigns temple entry movements).
- Congress 1885 (72 delegates, Bombay); partition of Bengal 1905; Muslim League 1906; Jallianwala Bagh 13 April 1919; Chauri Chaura 1922; Purna Swaraj 1929; Dandi 1930; Quit India 1942.
- Constitution adopted 26 November 1949, in force 26 January 1950; Andhra state formed 1 October 1953 after Potti Sriramulu's death; states reorganised on linguistic lines in 1956.
- In class: give groups a British officer's account of 1857 and a rebel proclamation, and ask why one calls it a mutiny while the other speaks of defending faith, land and rulers.

> **Quick revision:** Company charter 1600; Plassey 1757, Buxar 1764, Diwani 1765; subsidiary alliance (Wellesley), doctrine of lapse (Dalhousie), Awadh 1856; Permanent Settlement 1793, mahalwari 1822, ryotwari; Birsa Munda; 1857 from Meerut, Act of 1858; reformers Rammohun, Vidyasagar, Phule, Narayana Guru, Ambedkar; Congress 1885, Bengal partition 1905, Purna Swaraj 1929, Quit India 1942; Constitution in force 26 January 1950; linguistic states 1956.

Planet Earth: Solar System, Globe, Motions, Maps, Landforms, Interior, Air and Water (Class VI-VII Geography)

The earth in the solar system: The solar system has the Sun, eight planets, their moons, asteroids and meteoroids; in 2006 the International Astronomical Union reclassified Pluto as a dwarf planet. From the Sun the planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. The earth, third from the Sun at about 150 million km, is called the blue planet because about two-thirds of its surface is water, and its shape, slightly flattened at the poles, is called a geoid. The Moon, about 384,400 km away, takes about 27 days both to go round the earth and to spin once on its axis, so we always see the same side.

Latitudes, longitudes and time: The equator (0°) divides the earth into the Northern and Southern Hemispheres. The Tropic of Cancer (23½° N), Tropic of Capricorn (23½° S), Arctic Circle (66½° N) and Antarctic Circle (66½° S)

mark the heat zones: the Torrid Zone between the tropics gets the overhead midday sun at least once a year, with the Temperate and Frigid Zones towards the poles. The Prime Meridian (0°) passes through Greenwich in London. The earth turns 360° in about 24 hours, so 15° of longitude equals one hour and 1° equals 4 minutes. Indian Standard Time is the local time of 82½° E, which passes near Mirzapur, and is 5 hours 30 minutes ahead of Greenwich Mean Time.

Motions of the earth: Rotation on the axis takes about 24 hours and causes day and night. The axis makes an angle of 66½° with the plane of the orbit. Revolution round the Sun along an elliptical orbit takes 365¼ days, so every fourth year is a leap year of 366 days, with 29 days in February. Tilt and revolution cause the seasons: on 21 June the Sun is overhead at the Tropic of Cancer and the Northern Hemisphere has its longest day (summer solstice); on 22 December it is overhead at the Tropic of Capricorn (winter solstice in the north); and on 21 March and 23 September it is overhead at the equator, so day and night are equal everywhere (equinoxes).

Maps: A map represents the earth or a part of it on a flat surface, drawn to scale. Physical maps show natural features, political maps show countries, states and cities, and thematic maps show one theme such as rainfall or roads; a globe is a true model of the earth but cannot show much detail. Every map has three components: distance (shown by the scale), direction and symbols, and a large-scale map shows a small area in detail. Conventional colours are used: blue for water, brown for mountains, yellow for plateaus and green for plains. A sketch has no scale, while a plan is a large-scale drawing of a small area.

Realms and major landforms: The earth has four realms: the lithosphere, hydrosphere, atmosphere and biosphere, where land, water and air meet to support life. Asia is the largest continent and Australia, an island continent, the smallest; the Pacific is the largest ocean and holds the Mariana Trench, nearly 11 km deep. Air is about 78 per cent nitrogen and 21 per cent oxygen. Fold mountains may be young (Himalayas, Alps) or old (Aravalli, Urals); block mountains, such as the Vosges, form where large areas break and are displaced vertically; and volcanic mountains include Kilimanjaro and Fujiyama. The Tibet plateau is the highest, at 4,000 to 6,000 m, and the Chota Nagpur plateau is rich in minerals.

Inside the earth and the changing surface: The crust is about 35 km thick under continents, of silica and alumina (sial), and about 5 km under oceans, of silica and magnesium (sima). The mantle extends to about 2,900 km, and the core, of nickel and iron (nife), has a radius of about 3,500 km. Igneous rocks form when molten magma cools (granite, basalt), sedimentary rocks form from deposited layers and may hold fossils, and metamorphic rocks form under heat and pressure (clay to slate, limestone to marble). Endogenic forces cause volcanoes and earthquakes, which start at the focus below the epicentre and are recorded by a seismograph. Exogenic forces wear the surface by weathering and erosion: rivers form meanders, ox-bow lakes and deltas, sea waves form arches and stacks, glaciers leave moraines and wind builds sand dunes.

Air, water and natural vegetation: Weather occurs in the troposphere, on average 13 km high; the stratosphere, up to 50 km, holds the ozone layer; meteorites burn up in the mesosphere; and the ionosphere helps radio transmission. Weather is the day-to-day state of the atmosphere, and climate its average over many years. Winds are permanent (trade winds, westerlies, easterlies), seasonal (monsoons) or local (the loo). About 97.3 per cent of the earth's water is in the salty oceans. Tides rise twice a day, with spring tides at full moon and new moon, and fishing grounds are rich where warm and cold currents meet, as the Gulf Stream and the Labrador Current do near Newfoundland. Vegetation depends on temperature and moisture: forests, grasslands, thorny bushes in deserts, and mosses and lichens in the tundra.

Examples

- Planets from the Sun: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune; Pluto became a dwarf planet in 2006; Venus is called the earth's twin.
- Tropic of Cancer 23½° N, Tropic of Capricorn 23½° S, Arctic Circle 66½° N, Antarctic Circle 66½° S; the Torrid Zone lies between the two tropics.
- 1° of longitude = 4 minutes and 15° = 1 hour; Indian Standard Time is based on 82½° E and is 5 hours 30 minutes ahead of Greenwich Mean Time.

- Solstices: 21 June (Sun overhead at the Tropic of Cancer) and 22 December (overhead at the Tropic of Capricorn); equinoxes: 21 March and 23 September.
- Map components: distance (scale), direction, symbols; colours: blue water, brown mountains, yellow plateaus, green plains; a sketch has no scale, a plan is large-scale.
- Crust: about 35 km under continents (sial) and about 5 km under oceans (sima); mantle to about 2,900 km; core of nickel and iron (nife).
- Rocks: igneous (granite, basalt), sedimentary (sandstone; may hold fossils), metamorphic (clay to slate, limestone to marble).
- Atmosphere: troposphere (average 13 km, weather), stratosphere (ozone, aeroplanes), mesosphere (meteorites burn up), thermosphere (ionosphere), exosphere.
- Temperate grasslands: prairies (North America), pampas (South America), steppes (Central Asia), velds (South Africa), downs (Australia); tropical grasslands are savannas.
- In class: use a torch and a tilted ball to show day and night and the seasons, and draw a plan of the classroom to scale before moving on to atlas maps.

> **Quick revision:** 8 planets, Pluto a dwarf planet since 2006; earth third from the Sun, a geoid; tropics at 23½°, polar circles at 66½°; 1° = 4 minutes, IST at 82½° E (5 hours 30 minutes ahead of GMT); rotation 24 hours, revolution 365¼ days; solstices 21 June and 22 December, equinoxes 21 March and 23 September; map = scale, direction, symbols; crust sial and sima, core nife; troposphere 13 km; 97.3 per cent of water in oceans.

Resources and Development: Land, Soil, Water, Minerals, Agriculture, Industries and People (Class VIII Geography)

What makes a resource: Anything that can satisfy a need and has utility is a resource, and time and technology turn things into resources: fast-flowing water became a resource when people learned to make hydroelectricity. Resources are natural, human-made (buildings, machines, technology) or human (people, whose knowledge and skills create other resources). Natural resources are renewable (sunlight, wind, forests) or non-renewable (coal, petroleum, minerals); ubiquitous (air) or localised (copper, iron ore); actual (quantity known and in use) or potential (not used now, such as the uranium found in Ladakh); and biotic or abiotic. Sustainable development means using resources so that present needs are met while future generations are also taken care of, by respecting all forms of life, conserving the earth's diversity and minimising the depletion of natural resources.

Land and soil: Land covers only about 30 per cent of the earth's surface, and its use depends on soil, climate, topography, water, population and technology. Soil forms from the weathering of parent rock and is shaped by climate, relief, flora and fauna, and time; deforestation, overgrazing and the overuse of chemical fertilisers degrade it. Conservation methods include mulching (covering bare ground with organic matter), contour barriers, rock dams that slow running water, terrace farming, intercropping, contour ploughing and shelter belts of trees. Landslides can be reduced by hazard mapping, retention walls, vegetation cover and surface drainage.

Water, vegetation and wildlife: Only about 2.7 per cent of the earth's water is fresh; nearly 70 per cent of that is frozen in ice sheets and glaciers, and only about 1 per cent of freshwater is fit for human use. Water is conserved through rainwater harvesting, lined canals, drip and sprinkler irrigation, and keeping rivers free of sewage and industrial waste. Natural vegetation depends mainly on temperature and moisture, and wildlife is threatened by habitat loss, poaching and pollution. Conservation tools include national parks, wildlife sanctuaries and biosphere reserves, social forestry, the tree-planting festival Vanamahotsava, and CITES, an international agreement that controls trade in endangered species of wild animals and plants.

Minerals and power: A mineral is a naturally occurring substance with a definite chemical composition. Metallic minerals are ferrous (iron ore, manganese, nickel) or non-ferrous (copper, lead, gold); non-metallic minerals include limestone, mica and gypsum. Minerals are extracted by open-cast mining near the surface, shaft mining from deep layers, drilling and quarrying. Conventional sources of power are firewood and the fossil fuels, coal (called buried sunshine), petroleum (black gold) and natural gas, along with hydel power. Non-conventional sources are solar, wind,

nuclear, geothermal and tidal energy and biogas; nuclear power uses uranium and thorium, and the monazite sands of Kerala are rich in thorium.

Agriculture: Economic activities are primary (agriculture, fishing, mining), secondary (manufacturing) and tertiary (services). A farm is a system of inputs (seeds, fertilisers, machinery, labour), processes (ploughing, sowing, irrigation, harvesting) and outputs (crops, wool, dairy). Subsistence farming feeds the farmer's family: intensive subsistence farming on small plots, shifting cultivation (slash and burn, called jhumming in north-east India, milpa in Mexico, roca in Brazil and ladang in Indonesia and Malaysia) and nomadic herding. Commercial farming produces for sale, as in commercial grain farming, mixed farming and plantations of tea, coffee, rubber or sugarcane. Rice needs high temperature, high humidity, rainfall and clayey alluvial soil; wheat needs moderate temperature and rainfall and well-drained loamy soil; millets grow on less fertile, sandy soils; cotton needs high temperature, light rainfall, 210 frost-free days and bright sunshine, on black and alluvial soils; and jute, the golden fibre, needs heavy rainfall and a humid climate.

Industries: Industries are classified by raw material (agro-based, mineral-based, marine-based, forest-based), by size (small-scale, large-scale) and by ownership (private, public, joint, and cooperative, owned by producers or workers, such as milk producers' unions). Location depends on raw material, land, water, labour, power, capital, transport and market. The Tata Iron and Steel Company (TISCO) began in 1907 at Sakchi, now Jamshedpur, near the confluence of the Subarnarekha and Kharkai rivers, close to iron ore, coal and water. India's first successful cotton textile mill was set up in Mumbai in 1854; Ahmedabad is called the Manchester of India and Osaka the Manchester of Japan; and Bengaluru is a leading information technology centre. On 3 December 1984 methyl isocyanate gas leaked from the Union Carbide pesticide factory at Bhopal.

Human resources: People are the greatest resource, because their knowledge and skills turn nature into resources, and education and health make them more productive. More than 90 per cent of the world's people live on about 30 per cent of the land surface, crowded in plains and river valleys and sparse in deserts, high mountains and very cold regions. Population density is the number of people per square kilometre. Population changes through births, deaths and migration; the natural growth rate is the difference between the birth rate and the death rate. A population pyramid shows the age and sex composition, and a broad base means many children and a high birth rate. The sex ratio is the number of females per 1000 males; India's was 943 at Census 2011.

Examples

- Resources by development: actual (known and used) and potential (not used now, such as uranium in Ladakh); by distribution: ubiquitous (air) and localised (copper, iron ore).
- Soil conservation: mulching, contour barriers, rock dams, terrace farming, intercropping, contour ploughing and shelter belts.
- Only about 2.7 per cent of the earth's water is fresh, nearly 70 per cent of that is frozen, and only about 1 per cent of freshwater is fit for human use.
- CITES: the Convention on International Trade in Endangered Species of Wild Fauna and Flora, an international agreement controlling trade in endangered animals and plants.
- Ferrous minerals: iron ore, manganese, nickel; non-ferrous: copper, lead, zinc, gold; non-metallic: limestone, mica, gypsum; coal is called buried sunshine and petroleum black gold.
- Shifting cultivation is called jhumming in north-east India, milpa in Mexico, roca in Brazil and ladang in Indonesia and Malaysia.
- Cotton: high temperature, light rainfall, 210 frost-free days, bright sunshine, black and alluvial soils; jute is the golden fibre; rice needs clayey alluvial soil.
- TISCO, Jamshedpur, 1907 (Subarnarekha-Kharkai confluence); first successful cotton mill in Mumbai, 1854; Ahmedabad is the Manchester of India, Osaka the Manchester of Japan.
- Bhopal gas tragedy, 3 December 1984: methyl isocyanate leaked from the Union Carbide pesticide factory.
- In class: let students list the resources of their own locality (wells, shops, workshops, farms, people's skills) and classify them as natural, human-made or human before using textbook examples.

Quick revision: Resource = utility, created by time and technology; natural, human-made, human; actual and potential (uranium in Ladakh); sustainable development; land about 30 per cent of the surface; soil conservation by mulching, terraces, shelter belts; 2.7 per cent of water fresh; CITES; ferrous and non-ferrous minerals; coal buried sunshine; jhumming; cotton 210 frost-free days; TISCO 1907; Bhopal 1984; sex ratio 943 (Census 2011).

Social and Political Life (Class VI-VII): Diversity, Local Government, Livelihoods, Equality, Gender, Media and Markets

Diversity and discrimination: India's diversity of languages, religions, food, dress and work grows out of different geographical settings and histories; the class VI book compares Ladakh, a cold desert where people rear goats for pashmina wool, with Kerala, where the spice trade brought Jewish and Arab traders and, later, the Portuguese under Vasco da Gama, and where Chinese fishing nets called cheena-vala are still used. NCERT credits Jawaharlal Nehru with coining the phrase unity in diversity and quotes his book The Discovery of India on the nature of Indian unity. A prejudice is judging others negatively or as inferior; a stereotype fixes one image on a whole group, as in the idea that girls are not good at science; and discrimination is acting on prejudice, for example refusing to rent a house to someone because of religion. The Constitution forbids discrimination on grounds of religion, race, caste, sex or place of birth (Article 15) and abolishes untouchability (Article 17).

Government and democracy: A government makes and enforces decisions at three levels: local, state and national. In a monarchy the ruler decides and need not explain; in a democracy people give power to the government through elections and can question it. Under universal adult franchise every citizen aged 18 and above may vote, whatever their wealth, caste, religion, education or gender. Key elements of democracy are participation (through elections, protests, petitions and the media), the peaceful resolution of conflict, and equality and justice. Women in many countries had to struggle for the vote, as the suffrage movement did in Britain and the United States.

Panchayati Raj and administration: The Gram Sabha is a meeting of all adults living in the area of a panchayat whose names are on the voters' list; it approves plans and keeps the Gram Panchayat answerable. The Gram Panchayat has elected ward members (panch) and a president (sarpanch), and a secretary, appointed by the government and not elected, who calls meetings and keeps records. Panchayati Raj has three levels: the Gram Panchayat (village), the Panchayat Samiti or Janpad Panchayat (block) and the Zila Parishad (district). The 73rd Amendment of 1992 reserved one-third of seats for women and listed 29 subjects in the Eleventh Schedule; the 74th Amendment covers municipalities, with 18 subjects in the Twelfth Schedule. The patwari measures land and keeps land records, the tehsildar hears disputes, and the police record complaints in a First Information Report (FIR). The Hindu Succession Amendment Act 2005 gave daughters an equal share in family agricultural land. In cities, ward councillors are elected, while the Municipal Commissioner is appointed.

Livelihoods and equality: Most rural families depend on farming as small farmers or landless labourers, often in debt, and many city workers are self-employed, like street vendors, or casual workers without security, while permanent workers get a regular salary, medical facilities and paid leave. Every vote has equal value, but inequality continues, as Omprakash Valmiki's autobiography Joothan shows for caste. The Midday Meal scheme, first introduced in Tamil Nadu, spread after the Supreme Court in 2001 asked all state governments to begin it within six months; it raised enrolment and made children of all castes eat together. In the United States, Rosa Parks's refusal in 1955 to give up her bus seat to a white man is seen as the start of the civil rights movement.

The state government and health: Each state is divided into constituencies, each electing a Member of the Legislative Assembly (MLA), and the party that wins more than half the seats forms the government; in NCERT's example of Himachal Pradesh, whose Assembly had 68 seats when the book was written, that meant at least 35 seats. The Chief Minister and ministers head departments and answer to the Assembly, and the Governor is appointed by the Central Government (formally, by the President). On health, the books contrast costly private care with public services meant for all; in Hakim Sheikh's case the Supreme Court held that the failure of government hospitals to give timely treatment violated the right to life under Article 21, and in 1996 Kerala gave 40 per cent of its state budget to panchayats to plan for local needs.

Gender, media and markets: Margaret Mead's study of the Samoan Islands in the 1920s showed that children grow up very differently in different societies, so the roles of boys and girls are made by society, not fixed by nature. Housework and care work, done mostly by women, are unpaid and undervalued, and working women carry a double burden. Rashsundari Devi, born in 1800, wrote Amar Jiban, the first known autobiography by an Indian woman. The women's movement works by campaigning, raising awareness, protesting and showing solidarity, which led to the Protection of Women from Domestic Violence Act 2005 and the Supreme Court's 1997 guidelines against sexual harassment at the workplace. Mass media need money and technology, so business and government can influence them; a balanced report gives all points of view. Goods reach us through a chain of markets, from producers to wholesalers and retailers; the story of a shirt, from cotton grown by Swapna in Kurnool through the Erode cloth market to buyers in the United States, shows that those with money and power gain the most.

Examples

- Prejudice = judging others negatively; stereotype = one fixed image of a whole group; discrimination = acting on prejudice; Article 15 forbids discrimination, Article 17 abolishes untouchability.
- Universal adult franchise: every citizen aged 18 and above votes; the key elements of democracy are participation, peaceful resolution of conflict, and equality and justice.
- Gram Sabha = all adult voters of the panchayat area; sarpanch and panch are elected; the panchayat secretary is appointed by the government, not elected.
- Three tiers: Gram Panchayat (village), Panchayat Samiti or Janpad Panchayat (block), Zila Parishad (district); 73rd Amendment 1992, one-third seats for women, 29 subjects.
- Patwari measures land and keeps land records; tehsildar hears disputes; the Hindu Succession Amendment Act 2005 gave daughters equal rights in agricultural land.
- Midday Meal: first introduced in Tamil Nadu; in 2001 the Supreme Court told all state governments to begin it within six months.
- State government: MLAs from constituencies, majority party forms the government, Chief Minister heads it, Governor appointed by the Centre; NCERT's example: Himachal Pradesh, 68 seats when the book was written, 35 for a majority.
- Women's movement methods: campaigning, raising awareness, protesting, showing solidarity; Rashsundari Devi's Amar Jiban; Rokeya Sakhawat Hossain's Sultana's Dream (1905).
- Chain of markets: producer, wholesaler, retailer; weekly haats, neighbourhood shops, malls; 'A Shirt in the Market' (Kurnool to Erode to the USA) shows unequal gains.
- In class: hold a mock Gram Sabha in which students play the sarpanch, the secretary, women members and villagers and decide how to spend funds on drinking water.

> **Quick revision:** Diversity, prejudice, stereotype, discrimination; Articles 15 and 17; universal adult franchise at 18; Gram Sabha, Gram Panchayat, Panchayat Samiti, Zila Parishad; 73rd and 74th Amendments; patwari, tehsildar, FIR; Midday Meal (Tamil Nadu, 2001 order); MLA, Chief Minister, Governor; Margaret Mead, double burden, Rashsundari Devi; balanced media; chain of markets.

Constitution, Secularism, Parliament, Judiciary and Marginalisation (Class VIII Social and Political Life)

The Indian Constitution: A constitution states a nation's ideals, sets the rules of government, limits the misuse of power and protects minorities from domination by the majority. India's Constituent Assembly of about 300 members drafted it between December 1946 and November 1949, with Dr B.R. Ambedkar as chairman of the Drafting Committee. Its key features are federalism, the parliamentary form of government, the separation of powers, Fundamental Rights and secularism. The Fundamental Rights are equality (Articles 14-18), freedom (19-22), against exploitation (23-24, banning trafficking, forced labour and child labour), freedom of religion (25-28), cultural and educational rights (29-30) and constitutional remedies (32). NCERT calls them the conscience of the Constitution, while the Directive Principles guide governments towards social and economic justice. Article 21A, added by the 86th Amendment in 2002, makes free and compulsory education for children aged 6 to 14 a Fundamental Right.

Understanding secularism: Secularism means separating religion from the State, so that no religious community dominates another, no members dominate others within the same community, and the State neither enforces a religion nor takes away religious freedom. The Indian State has no official religion. It keeps its distance from religion (government schools cannot promote any one religion, and under Article 28 no religious instruction is given in institutions wholly maintained by the State), practises non-interference (Sikhs need not wear helmets, as the turban is central to their faith) and intervenes to end discrimination, as in abolishing untouchability. In the United States, by contrast, religion and the State are kept strictly apart and neither may interfere in the other's affairs. The word secular was added to the Preamble by the 42nd Amendment in 1976.

Parliament and laws: Parliament consists of the President, the Lok Sabha and the Rajya Sabha. Lok Sabha members are elected directly from constituencies, and the party or coalition with a majority forms the government, with its leader as Prime Minister. Parliament selects the national government, controls, guides and informs it, and makes laws; in Question Hour members question ministers, and the Opposition holds the government to account. Most Rajya Sabha members are elected by the elected members of the state legislative assemblies, and 12 are nominated by the President. A bill becomes law when both Houses pass it and the President gives assent. The rule of law means no one is above the law, unlike under the colonial Sedition Act of 1870, which let the British arrest critics without due trial. Citizens shape laws too, as women's groups did for the Protection of Women from Domestic Violence Act 2005.

The judiciary: Courts resolve disputes, carry out judicial review (striking down laws that violate the Constitution) and uphold the law and Fundamental Rights; the separation of powers keeps them independent. The Supreme Court in New Delhi was set up on 26 January 1950, the first High Courts in 1862 at Calcutta, Bombay and Madras, and below them are the district courts. Under the appellate system a person can appeal to a higher court: in the Sudha Goel case the High Court acquitted the accused in 1983, but in 1985 the Supreme Court convicted Laxman and his mother. Criminal law deals with offences such as theft or dowry harassment, begins with an FIR and can lead to jail; civil law deals with matters such as land, rent or divorce and begins with a petition. Public Interest Litigation, developed in the early 1980s, lets anyone approach the High Court or Supreme Court for people whose rights are violated, even by letter. Article 22 protects arrested persons, and Article 39A provides free legal aid.

Understanding marginalisation: To be marginalised is to be pushed to the fringes of society because of language, customs, religion, poverty or low social status. Adivasis, literally original inhabitants, were 8.6 per cent of India's population at Census 2011, and many lost lands and forests to mines, dams and forest laws. The Sachar Committee, set up in 2005, found that Muslims lagged behind in literacy, school attendance and public employment. Dalit, meaning broken, is a term that people of castes once treated as untouchable use for themselves. Safeguards include the Fundamental Rights, reservation in education and government jobs, the Scheduled Castes and Scheduled Tribes (Prevention of Atrocities) Act 1989, the 1993 Act banning the employment of manual scavengers (the Safai Karmachari Andolan filed a PIL in 2003 to enforce it), and the Forest Rights Act 2006.

Public facilities and social justice: Public facilities such as water, sanitation, health care, electricity, public transport and schools must reach everyone; the right to water is recognised as part of the right to life under Article 21. Laws on minimum wages, worker safety and the environment protect people only if they are enforced. On the night of 2-3 December 1984 methyl isocyanate gas leaked from the Union Carbide plant at Bhopal, and more than 8,000 people died within three days; in 1989 the company settled for 470 million dollars, far less than the 3 billion dollars claimed. Since then courts have held that the right to life includes the right to a pollution-free environment.

Examples

- Fundamental Rights: equality (14-18), freedom (19-22), against exploitation (23-24), freedom of religion (25-28), cultural and educational (29-30), constitutional remedies (32).
- Key features of the Constitution: federalism, parliamentary government, separation of powers, Fundamental Rights, secularism; Ambedkar chaired the Drafting Committee.
- Article 21A (86th Amendment, 2002): free and compulsory education for children aged 6 to 14; Article 24 bans employing children under 14 in factories and mines.

- Indian secularism: distance (no religion promoted in government schools, Article 28), non-interference (Sikh helmet exemption), intervention (untouchability abolished); 'secular' added to the Preamble in 1976.
- Parliament: President, Lok Sabha and Rajya Sabha; Question Hour lets members question ministers; 12 Rajya Sabha members are nominated by the President.
- Judiciary: dispute resolution, judicial review, upholding the law; first High Courts 1862 (Calcutta, Bombay, Madras); Supreme Court from 26 January 1950; PIL from the early 1980s.
- Criminal law begins with an FIR and can lead to jail; civil law begins with a petition (land, rent, divorce) and seeks relief such as compensation.
- Safeguards against marginalisation: SC and ST (Prevention of Atrocities) Act 1989, ban on manual scavenging 1993, Forest Rights Act 2006; Sachar Committee (2005) on Muslims.
- Bhopal gas tragedy, 2-3 December 1984: methyl isocyanate from the Union Carbide plant; more than 8,000 dead within three days; settlement of 470 million dollars in 1989.
- In class: run a mock Parliament with a Question Hour on the school's water supply, then ask students which Fundamental Right each question relates to.

> **Quick revision:** Constituent Assembly 1946-49; key features: federalism, parliamentary form, separation of powers, Fundamental Rights, secularism; Article 21A (2002); Indian secularism: distance, non-interference, intervention; Parliament: Lok Sabha, Rajya Sabha, Question Hour; rule of law and the Sedition Act of 1870; judiciary: judicial review, appeals, PIL; marginalisation: Adivasis, Muslims, Dalits; Atrocities Act 1989; Bhopal 1984.

Nature of Social Science, NCF 2005 and Classroom Processes: Critical Thinking, Discussion and Debate

What social science is: Social science studies human society: how people live together, earn a living, use resources, govern themselves and change over time. History studies change over time through evidence; geography, places and the relation between people and their environment; political science, power, government and citizenship; economics, the production, distribution and consumption of goods and services; and sociology and anthropology, groups, institutions and cultures. In school, social studies is the integrated subject that combines these disciplines. NCF 2005 places environmental studies (EVS) at the primary stage, social studies drawn from history, geography, political science and economics in classes VI to VIII, and the social sciences as distinct disciplines at the secondary stage.

NCF 2005 on the social sciences: NCF 2005 and its position paper on teaching the social sciences reject the view that the subject is non-utilitarian, merely informative and to be memorised for examinations, and treat it as a rigorous field of enquiry. Issues are to be presented from the perspective of marginalised groups, and gender justice and sensitivity to the concerns of Scheduled Castes, Scheduled Tribes and minorities should inform every part of the subject. Concepts are to be understood rather than facts lined up, and linked to the lived experiences of children and communities. Disciplinary markers are kept while interdisciplinary themes such as water are encouraged. The social sciences carry a normative responsibility to widen the popular base for values such as freedom, trust, mutual respect and respect for diversity. History should include ordinary people, women, tribes and workers, and the textbook is one resource among many.

From civics to political science: In the colonial period civics was taught to stress obedience and loyalty to the government. The NCF 2005 position paper recommended replacing it with political science, which treats children as thinking citizens who ask how power works, who is left out and how democracy can be deepened; NCERT's upper primary books are therefore called Social and Political Life. Students learn about the Gram Sabha by role-playing one and about equality by examining real lives, not by memorising definitions. The aims are critical and creative thinking, informed and humane citizenship, respect for plurality, empathy for the deprived, concern for the environment and the habit of questioning.

Developing critical thinking: Critical thinking means asking questions, examining evidence, recognising bias and reaching reasoned judgements. A teacher builds it by comparing two accounts of the same event, asking whose voice is missing from a textbook picture, analysing advertisements and news reports, asking how we know and what

the evidence is, and setting open-ended questions. Bloom's taxonomy (Benjamin Bloom, 1956; revised by Anderson and Krathwohl in 2001 as remember, understand, apply, analyse, evaluate and create) helps her move from recall to higher-order questions. Constructivism underlies NCF 2005: Piaget held that children build knowledge through assimilation and accommodation; Vygotsky, that learning happens through social interaction, with teachers and abler peers scaffolding the child within the zone of proximal development; and Bruner proposed discovery learning and a spiral curriculum, in which a concept such as government is revisited in greater depth, from the panchayat in class VI to Parliament in class VIII.

Discussion: A good discussion starts from an open question connected to children's lives, such as whether the village should spend its funds on a road or a school. The teacher sets ground rules (listen, take turns, respect others, disagree with ideas rather than persons), draws in quiet children, girls and children from marginalised groups, keeps the talk tied to evidence, and summarises the different positions without declaring her own view the only right one. Brainstorming, think-pair-share and small-group methods such as the jigsaw, in which each member masters one part and teaches it to the group, let every child in a large class take part.

Debate, role play and simulation: A debate is a structured argument for and against a motion, such as whether big dams do more good than harm, in which students gather evidence, speak in turn and answer the other side; it builds reasoning and respect for opposing views. Role play and dramatisation let children enter a situation, such as a Gram Sabha meeting or a farmer's visit to a moneylender. Simulations such as a mock parliament with a Question Hour, a mock election or a mock court show how institutions work, and a student council lets democracy be lived in school. Case studies and narratives, used widely in the NCERT books, carry abstract ideas through real lives.

Handling sensitive issues: Caste, religion, gender, reservation and communal conflict arise naturally in social science. The teacher should create a safe and respectful classroom, present multiple perspectives with evidence, use the values of the Constitution as the common frame, correct factual errors and stereotypes, and neither impose a personal view nor avoid the topic. Children's languages and local knowledge are resources, and a question that challenges the textbook should be welcomed as a chance to investigate. In CTET scenarios, the option that keeps children active, builds on their experience and develops their own reasoning is usually the right one.

Examples

- Social studies = the integrated school subject; social sciences = the disciplines, such as history, geography, political science, economics, sociology and anthropology.
- NCF 2005: social science is a rigorous field of enquiry, not a non-utility subject for memorising; teach concepts, not lists of facts.
- NCF 2005: present issues from the perspective of marginalised groups; gender justice and sensitivity to SC, ST and minority concerns should inform all of social science.
- Civics, linked in colonial times with obedience and loyalty, was to be replaced by political science; NCERT's upper primary books are called Social and Political Life.
- Revised Bloom's taxonomy (Anderson and Krathwohl, 2001): remember, understand, apply, analyse, evaluate, create.
- Bruner's spiral curriculum: government is studied as the panchayat in class VI, the state government in class VII and Parliament in class VIII.
- Discussion ground rules: listen, take turns, respect others, disagree with ideas not persons; the teacher facilitates and summarises, she does not impose.
- Simulations: mock parliament with Question Hour, mock election, mock court, student council; role play of a Gram Sabha meeting.
- Sensitive issues (caste, religion, reservation): present multiple perspectives with evidence and use constitutional values as the frame; neither impose a view nor avoid the topic.
- Jigsaw method: each member of a group masters one part and teaches it to the others, making every child responsible for the group's learning.

Quick revision: Social science = study of society through history, geography, political science, economics, sociology; NCF 2005: rigorous not non-utility, concepts not facts, perspective of the marginalised, gender justice, normative values, textbook one resource; civics replaced by political science; critical thinking; Bloom revised 2001; Piaget, Vygotsky (ZPD, scaffolding), Bruner (spiral); discussion, debate, role play, mock parliament.

Enquiry and Sources in Social Science: Primary and Secondary Sources, Projects, Field Trips, Maps and Timelines

The enquiry approach: In the enquiry (inquiry) approach students investigate a question as a historian or geographer would: they ask a question, gather evidence, analyse it, and reach and share a conclusion they can defend. John Dewey's problem-solving or reflective thinking method follows similar steps: sensing a problem, defining it, forming hypotheses, collecting data and testing the hypotheses to reach a conclusion. A question such as why many young people from our village move to cities can be explored through a survey, interviews and Census tables. Social science relies on empirical evidence, information gained by observation and experience that others can check, and the teacher guides the enquiry instead of handing over conclusions.

Primary and secondary sources: Primary sources were produced at the time by people who took part in or witnessed events: inscriptions, coins, manuscripts, letters, diaries, official records, photographs, artefacts and eyewitness testimony. Secondary sources are later accounts that interpret primary sources, such as textbooks, encyclopaedias and later biographies. Historians also group sources as archaeological (monuments, inscriptions studied in epigraphy, coins studied in numismatics, pottery and tools) and literary (religious and secular texts and travellers' accounts, such as those of Megasthenes, Xuan Zang, Al-Biruni and Ibn Battuta). In geography and civics, primary data is collected first-hand through surveys, interviews, questionnaires and observation, and secondary data comes from published sources such as Census reports. Whether a source is primary depends on the question: a textbook written in the 1950s is secondary for the Mauryas but primary for how history was taught in the 1950s. Oral history, such as interviewing grandparents about Partition or migration, brings ordinary voices into class.

Weighing evidence: Every source has an author, an audience and a purpose. Students should ask who made it, when, for whom and why, check it against other sources (corroboration), separate fact from opinion and notice what is left out. A prashasti written by a court poet praises the king; British officials called 1857 a mutiny while many Indian writers later called it a war of independence; a court chronicle may ignore peasants. Historical thinking also involves chronology, cause and consequence, continuity and change, and empathy for people of the past. History is an interpretation built on evidence, so historians can disagree, and a claim without evidence is weak.

Project work: William Heard Kilpatrick set out the project method in 1918, building on Dewey's ideas, and defined a project as a wholehearted purposeful activity proceeding in a social environment. Its classic steps are purposing, planning, executing and judging. Good social science projects are real and local: the history of the school or locality, the water sources of the village and who controls them, how the weekly haat works, the work of the gram panchayat, or a family tree showing changes in occupation over three generations. Projects build research, cooperation and presentation skills, and are assessed on both process and product with a rubric shared with students in advance.

Field trips: A field trip links the classroom to the world. Before the visit the teacher sets objectives linked to the lesson, arranges permission and safety, finds out what children already know and prepares a worksheet of questions; during the visit students observe, take notes, sketch and interview people; afterwards they discuss, write reports, make displays and connect what they saw to the textbook. Suitable places include a panchayat or municipal office, a post office, a police station, a bank, a local market, a museum, a monument, a farm or a factory, and community members such as a farmer or an elected representative can be invited as resource persons.

Using maps and globes: Map skills include orientation, using the scale, reading symbols and the legend, and interpreting what a pattern shows. They are built step by step: a sketch of the classroom, a plan of the school drawn to scale, a map of the neighbourhood, and then district, state, country and world maps in the atlas, with the globe for the true shape and position of continents. In history, outline maps are used to mark the extent of empires, trade routes or the sites of Ashoka's inscriptions; thematic maps of rainfall, crops or population density help students see

distributions and ask why. Satellite images and Geographic Information Systems (GIS) extend these skills, and tactile maps with raised features include visually impaired learners.

Timelines and documents: Timelines build a sense of chronology and duration. Children can begin with a timeline of their own life or family, move to local and national events, and learn to count backwards in BCE and to work out centuries: 1857 falls in the 19th century, and the year 2000 is the last year of the 20th century. Documents bring evidence into class: newspapers, government reports, Census tables, extracts from the Constitution, letters, photographs, advertisements and political cartoons. Guiding questions help students read them: what does it say, who produced it, when, why, and what is missing. Museums, archives such as the National Archives of India in New Delhi, libraries and documentaries are further sources, and information from the internet must be checked for reliability.

Examples

- Primary sources: from the time itself (inscriptions, coins, letters, diaries, official records, eyewitness accounts); secondary sources: later interpretations (textbooks, encyclopaedias, later biographies).
- Epigraphy is the study of inscriptions and numismatics the study of coins; both are archaeological sources.
- Primary data is collected first-hand by survey, interview, questionnaire or observation; secondary data comes from published sources such as Census reports.
- Questions to ask of any source: who made it, when, for whom, why, and what is left out; then corroborate it with other sources.
- Dewey's problem-solving method: sense the problem, define it, form hypotheses, collect data, test and conclude.
- Kilpatrick's project method (1918): a wholehearted purposeful activity proceeding in a social environment; steps: purposing, planning, executing, judging.
- Field trip: set objectives and a worksheet before, observe and record during, discuss and report after the visit.
- Map skills in order: classroom sketch, school plan to scale, neighbourhood map, then atlas maps; the globe for true shape and position; tactile maps for visually impaired learners.
- Timeline facts: 1857 is in the 19th century; 2000 is the last year of the 20th century; BCE years count backwards.
- Oral history: interviewing elders about Partition, migration or changes in farming brings ordinary people's experiences into history lessons.

> **Quick revision:** Enquiry: question, evidence, analysis, conclusion; Dewey's problem-solving method; primary and secondary sources and data; epigraphy, numismatics; who, when, for whom, why; corroboration; Kilpatrick's project method (1918): purposing, planning, executing, judging; field trip before, during and after; map skills from classroom plan to atlas; timelines, BCE, centuries; documents, cartoons, archives; oral history.

Evaluation and Problems of Teaching Social Science: CCE, Open-Ended and Source-Based Questions, Rote Learning

CCE under the RTE Act: The RTE Act 2009 requires comprehensive and continuous evaluation (CCE) of the child's understanding of knowledge and ability to apply it (Section 29), and says that no child shall be required to pass any board examination till the completion of elementary education (Section 30). Continuous means that assessment is part of everyday teaching, not only an end-of-term event; comprehensive means it covers both scholastic areas (knowledge, understanding and skills) and co-scholastic areas (attitudes, values, interests, life skills and participation). Formative assessment, or assessment for learning, happens during teaching to find out what children have understood and to give feedback; summative assessment, or assessment of learning, sums up achievement at the end of a unit or term; and assessment as learning means children reflect on their own learning through self-assessment and peer assessment.

Tools of assessment: Social science learning is assessed through observation, anecdotal records (short factual notes on significant incidents in a child's behaviour), checklists, rating scales, rubrics (criteria with described levels of performance), portfolios (a collection of a child's work over time showing progress), projects, assignments, oral questions, quizzes, map work, group work, debates and role plays. Values and attitudes such as respect for diversity, cooperation and empathy cannot be measured by a written test; they are judged through observation and

anecdotal records over time. Feedback should be descriptive, telling the child what was done well and what to improve, rather than only a mark or grade, and children should not be labelled or compared with one another.

Kinds of questions: Closed questions have one correct answer and test recall, such as asking in which year the Battle of Plassey was fought. Open-ended questions allow many valid answers and are judged on reasoning, such as asking why the Company wanted the Diwani of Bengal, or what you would do as a member of the Gram Sabha if the village well dried up. Source-based questions give an extract from an inscription, a proclamation, a letter or a newspaper and ask what it tells us, who wrote it and why; map-based questions ask students to locate places, use the scale or interpret a distribution; and picture, cartoon and data-based questions use a photograph, a cartoon, a table or a graph. Reflective questions ask students to imagine themselves in a situation, as the Imagine boxes in NCERT's history books do. Mapping questions to Bloom's levels ensures that a test asks students to analyse, evaluate and create, not only to remember.

Rote learning and how to avoid it: Social science is often memorised as names, dates and definitions because the syllabus is seen as a list of facts, examinations reward recall, lessons are lectures or dictation, the textbook is treated as the only authority and concepts are cut off from life. The Yash Pal Committee's report Learning Without Burden (1993) identified the burden of non-comprehension as the real load on children. Remedies are to teach concepts through children's experience and local examples; to use stories, case studies, timelines and concept maps; to ask why and how questions; to encourage projects and discussion; and to revisit concepts in a spiral. NEP 2020 calls for assessment to shift from summative tests of rote memorisation to regular, formative, competency-based assessment that tests higher-order skills such as analysis, critical thinking and conceptual clarity, with a holistic, 360-degree progress card.

Common problems and remedies: Social science is often seen as dull and less useful than science; the syllabus is heavy with information; many schools lack maps, globes, atlases and other aids; classes are large; content such as ancient empires, latitudes or federalism feels abstract and distant; teaching is teacher-centred; and sensitive topics make teachers hesitant. Children also bring misconceptions, such as believing that the Sun goes round the earth, that the government means only the Prime Minister, or that tribal people are backward. Remedies include moving from the known to the unknown, the concrete to the abstract and the local to the global; making low-cost aids such as clay models of landforms; using group work in large classes; inviting community resource persons; using ICT and documentaries; and correcting misconceptions by creating cognitive conflict with evidence rather than simply telling the right answer.

Diagnosis, remediation and inclusion: When many children make the same error, such as misreading a map scale, a diagnostic test identifies the exact difficulty and remedial teaching addresses it with new examples and activities. A teacher can tackle a recurring classroom problem through action research: identify the problem, analyse its causes, plan an intervention, try it out and evaluate the result. Assessment must also be inclusive: tactile maps, oral answers, extra time or a scribe help children with disabilities, as the Rights of Persons with Disabilities Act 2016 and the inclusive vision of the RTE Act require, and questions should be free of gender, caste and regional stereotypes. In CTET items, prefer the option that uses assessment to improve learning rather than to rank, punish or label children.

Examples

- RTE Act 2009: Section 29 requires comprehensive and continuous evaluation; Section 30 says no board examination till the completion of elementary education.
- Formative = assessment for learning (during teaching, with feedback); summative = assessment of learning (end of unit or term); assessment as learning = self-assessment and peer assessment.
- Anecdotal record = short factual note on a significant incident; portfolio = collection of work over time showing progress; rubric = criteria with performance levels.
- Values and attitudes (empathy, cooperation, respect for diversity) are assessed by observation and anecdotal records, not by paper-pencil tests.
- Closed question: 'In which year was the Battle of Plassey fought?'; open-ended question: 'Why do you think the Company wanted the Diwani of Bengal?'

- Source-based question: give an extract from an Ashokan inscription and ask what it reveals about dhamma and why the king had it carved in public places.
- Yash Pal Committee report Learning Without Burden (1993): the real burden on children is non-comprehension.
- NEP 2020: move from rote memorisation to regular, formative, competency-based assessment of higher-order skills; a holistic 360-degree progress card.
- Action research: identify a classroom problem, analyse its causes, plan and try an intervention, evaluate; a teacher uses it to solve her own class's recurring difficulty.
- Misconceptions are corrected by creating cognitive conflict with evidence (a globe, a torch, a source), not by repeating the correct answer.

> **Quick revision:** CCE (RTE Act Section 29): continuous and comprehensive, scholastic and co-scholastic; formative and summative; tools: observation, anecdotal records, checklists, rating scales, rubrics, portfolios; open-ended, source-based and map-based questions; Learning Without Burden 1993; NEP 2020 competency-based assessment and 360-degree progress card; problems: abstract content, rote learning, few aids; remedies: local, concrete, activity, action research.

Free practice questions: parikshasaathi.com/q/science-social-pedagogy/

Revision sheet

Every lesson's quick-revision box in one place, for the last read before the exam.

Child Development and Pedagogy	Growth quantitative, development qualitative and lifelong; cephalocaudal head-to-toe, proximodistal centre-outwards; Piaget: sensorimotor, pre-operational, concrete, formal; assimilation vs accommodation; Vygotsky ZPD, scaffolding, MKO; Kohlberg 3 levels 6 stages; Erikson 6-12 industry vs inferiority; IQ = MA/CA x 100; Gardner 8 intelligences; Skinner negative reinforcement increases behaviour; Bandura Bobo doll; Maslow self-actualisation at top; formative = assessment for learning; NCF 2005 (Yash Pal) 5 principles; RTE 2009: 6-14 years, Art 21A, 25% EWS, PTR 30:1.
Growth and Development: Concept, Principles and Stages of Childhood	Growth quantitative and stops, development qualitative and lifelong; development = maturation + learning; continuous, sequential, general to specific, cumulative; cephalocaudal head to toe, proximodistal centre outwards; same sequence, different rates; heredity x environment; infancy 0-2, early childhood 2-6, later childhood 6-12 (gang age), adolescence 12-18 (storm and stress, Stanley Hall); Piaget: development precedes learning; Vygotsky: learning leads development.
Heredity, Environment and Socialisation: Nature, Nurture and the Teacher's Role	Heredity = genes on 46 chromosomes (23 pairs), fixed at conception, sets potential; environment = prenatal, physical, social, cultural; Galton (1869) heredity, Locke tabula rasa and Watson environment; development = heredity x environment; family primary agent, school, peers, media secondary; hidden curriculum; Bronfenbrenner micro, meso, exo, macro, chrono; Baumrind: authoritative best; home knowledge and languages are resources (NCF 2005).
Piaget's Theory of Cognitive Development: Schema, Four Stages and Classroom Use	Piaget (Swiss, 1896-1980), genetic epistemology, clinical method, child as little scientist; schema, assimilation, accommodation, equilibration; sensorimotor 0-2 object permanence; pre-operational 2-7 egocentrism, animism, centration, irreversibility; concrete operational 7-11 conservation, reversibility, seriation, classification; formal operational 11+ hypothetico-deductive; horizontal decalage; concrete materials and cognitive conflict; critique: underestimated children, neglected culture.
Vygotsky and Bruner: ZPD, Scaffolding, Modes of Representation and Discovery Learning	Vygotsky (1896-1934): social constructivism, culture and language as tools, social plane then individual plane; ZPD = actual vs potential level; scaffolding temporary and faded (Wood, Bruner, Ross 1976); MKO; private speech becomes inner speech; learning leads development; Bruner (1915-2016): enactive, iconic, symbolic modes; discovery learning; spiral curriculum; The Process of Education 1960.
Moral and Personality Development: Kohlberg, Gilligan and Erikson	Piaget: heteronomous (consequences) to autonomous (intentions); Kohlberg (Heinz dilemma, reasoning not answer): pre-conventional (1 punishment, 2 exchange), conventional (3 good boy-nice girl, 4 law and order), post-conventional (5 social contract, 6 universal principles); invariant order; Gilligan 1982 ethic of care; Erikson 8 psychosocial stages: initiative vs guilt 3-6, industry vs inferiority 6-12, identity vs role confusion in adolescence.
Theories of Learning: Pavlov, Thorndike, Skinner, Kohler's Insight and Constructivism	Learning = relatively permanent change from experience; Pavlov classical conditioning (UCS, UCR, CS, CR, extinction, spontaneous recovery, generalisation); Watson Little Albert 1920; Thorndike trial and error, laws of readiness, exercise, effect; Skinner operant: positive and negative reinforcement increase, punishment decreases, variable ratio most lasting, shaping, programmed instruction; Kohler insight (Sultan); Gestalt whole more than parts; constructivism (NCF 2005).
Intelligence, Creativity and Individual Differences: IQ, Gardner, Sternberg and Diversity	Individual differences from heredity x environment, diversity a resource; Binet-Simon 1905 mental age; Stern 1912 IQ = MA/CA, Terman Stanford-Binet 1916 x 100; Wechsler deviation IQ mean 100, SD 15; Gardner 1983 eight intelligences (naturalist added later); Sternberg analytical, creative, practical; EI Salovey-Mayer 1990, Goleman 1995; Guilford divergent thinking: fluency, flexibility, originality, elaboration; differentiated instruction; RPwD Act 2016, 21 disabilities.

Language and Thought, and Gender as a Social Construct in the Classroom	Piaget: thought precedes language, egocentric speech; Vygotsky: thought and speech merge around 2 years, private then inner speech, language shapes thought; Chomsky LAD, universal grammar, overgeneralisation; Skinner Verbal Behavior 1957; Bruner LASS; Sapir-Whorf; RTE: mother tongue as far as practicable; NEP 2020: home language till Grade 5; sex biological, gender social construct; stereotypes and roles; rotate duties, mixed groups, counter-examples.
Assessment for Learning: Formative Assessment, CCE, Rubrics and Bloom's Taxonomy	Assessment of (summative), for (formative), as (self and peer, metacognition) learning; Scriven 1967; diagnostic then remedial; CCE = continuous + comprehensive (scholastic, co-scholastic), NPE 1986, NCF 2005, RTE Sections 29 and 30; 2019 amendment: exams in Classes 5 and 8; portfolio, rubric, anecdotal record; Bloom 1956, revised 2001: remember, understand, apply, analyse, evaluate, create; NEP 2020: competency-based, holistic progress card, PARAKH.
How Children Learn and Why They Fail: Motivation, Emotion and Child-Centred Education	Intrinsic over extrinsic motivation; overjustification; Deci-Ryan autonomy, competence, relatedness; Maslow 1943 physiological, safety, belonging, esteem, self-actualisation; Yerkes-Dodson optimum arousal; Learning Without Burden 1993; RTE Section 17 no physical punishment; much 'failure' is the system's; Pygmalion effect 1968; SLDs in RPwD Act 2016; Rousseau Emile 1762, Pestalozzi, Froebel kindergarten, Montessori 1907, Dewey 1916, Kilpatrick project method; teacher as facilitator.
Environmental Studies (EVS) and its Pedagogy (Paper I)	EVS = integrated science + social science + environmental education, separate subject from class III; NCF 2005 six themes: Family and Friends, Food, Shelter, Water, Travel, Things We Make and Do; sub-themes of Family and Friends: Relationships, Work and Play, Animals, Plants; NCERT textbook: Looking Around; principles: known to unknown, concrete to abstract, local to global, learning by doing; CCE tools: portfolio, anecdotal record, checklist, rubric; ants follow smell; clove = flower bud; coconut dispersed by water; Konkan Railway Roha-Thokur; Chipko 1973 Uttarakhand.
Family and Friends in NCERT EVS: Relationships, Work and Play, Animals and Plants	Family and Friends: only theme with sub-themes (Relationships, Work and Play, Animals, Plants); families differ and change (birth, marriage, moving for work); inherited vs learnt features; ears seen outside = hair + young ones; elephant herd led by oldest female; Anita Kushwaha, Bihar, honeybees; Kalbeliya, four poisonous snakes, Wildlife Act 1972; Amrita and the Bishnois of Khejadli (363, 1730); Valley of Flowers (Uttarakhand), itr of Kannauj; girls' kabaddi; dignity of labour; inclusive family activities.
Food, Water and Shelter in EVS: Food Habits, Water Sources and Conservation, Houses in Different Regions	Food comes from plants and animals, habits differ by region, climate, age and custom; cooking: boiling, frying, roasting, steaming; tastes and saliva; Beaumont and Alexis St. Martin (1822); keeping food by drying, salt, sugar, oil; rain is the main source of fresh water; stepwells, Ghadsisar, kund or tanka; Anopheles malaria, Ross 1897 and 1902; Aedes dengue; Dead Sea; houses differ by climate and materials: stilt (Assam), mud walls (Rajasthan), sloping roofs (Himachal, Kerala), rebo (Changpa).
Travel, and Things We Make and Do: Transport, Communication, Maps, Crafts and Work	Travel: land, water, air; fuel vs animal or human power; Going to School (bamboo bridge, trolley, vallam in Kerala); Omana's train journey Ahmedabad to Kerala; petrol and diesel are limited; communication: letter, postcard, 6-digit PIN (1972), gestures and sign language; maps: own space first, top view, symbols, key; Things We Make and Do: pottery, weaving, ikat of Pochampalli, Golconda fort; Wahida; migration and displacement; dignity of every occupation.
Concept and Scope of EVS: Integrated EVS, NCF 2005 and the Six Themes	EVS = natural, social and cultural environment as one whole; integrated (science + social science + environmental education); classes I-II through language and maths, III-V separate (Looking Around), VI onwards split; EE infused (NCF 2005, Habitat and Learning); Tbilisi 1977 five objectives; six themes in a spiral; syllabus columns: Questions, Key Concepts, Resources, Activities; RTE Section 29; NEP 2020 preparatory stage; NCF-SE 2023 The World Around Us.
Learning Principles in EVS: Prior Knowledge, Learning from Surroundings, Questioning and Children's Ideas	Children bring prior knowledge; constructivism (Piaget: assimilation, accommodation, equilibration; Vygotsky: ZPD, scaffolding; Ausubel: prior knowledge matters most); maxims known to unknown, concrete to abstract, local to global; concrete operational stage 7-11; learning from surroundings and community; value children's questions; open, divergent and probing questions with wait time; misconceptions: elicit, create cognitive conflict, test, discuss; respect home language and diversity.

Approaches and Activities in EVS: Activity, Inquiry, Field Trips, Surveys, Experiments, Stories and Drama	Activity-based (learning by doing with a purpose); experiential (Kolb cycle); inquiry and Bruner's discovery; 5E and POE; field trip before, during, after; survey from many sources with tally and graphs; project (Kilpatrick: purposing, planning, executing, judging); experiments by children, demonstration only if unsafe; discussion, think-pair-share; stories, role play and drama for empathy; NEP 2020 experiential, arts- and sports-integrated, storytelling.
EVS Teaching Material and Aids: Local Environment, Textbooks, Worksheets and the Teacher as Facilitator	Local environment is EVS's first resource; realia, nature corner, school garden, weather chart; charts, models, maps, globe, ICT; low-cost and no-cost aids from waste; community people and places; Looking Around has 24, 27 and 22 chapters, conversational, true stories, open questions, What we have learnt (class V), diversity, no rote definitions; worksheets for observing and recording, graded; teacher as facilitator and co-learner.
Assessment in EVS (CCE, Indicators, Portfolios) and Common Problems in Teaching EVS	CCE (RTE Section 29(2)(h)): continuous during teaching, comprehensive across skills and values; formative = for learning, summative = of learning, self and peer = as learning; NCERT 2008 indicators: observation and reporting, discussion, expression, explanation, classification, questioning, analysis, experimentation, concern for justice and equality, cooperation; tools: observation, checklist, rating scale, rubric, anecdotal record, portfolio; descriptive feedback, no labelling; problems: rote, splitting, textbook only, large classes, language.
Inclusive Education and Children with Special Needs	Inclusion: school adapts to child; integration: child adapts to school; segregation: special schools. SLD = dyslexia (reading), dysgraphia (writing), dyscalculia (maths), dyspraxia (motor). Renzulli: ability, task commitment, creativity. UDL (CAST): representation, action/expression, engagement. Braille 6 dots, Louis Braille (France); Taylor frame for maths. Kothari 1964-66 common school; IEDC 1974; NPE 1986; Salamanca 1994 (UNESCO); PWD Act 1995 (7); SSA zero rejection; NCF 2005; UNCRPD 2006, India 2007; RTE 2009 25%; RPwD 2016: 21 categories, 40% benchmark, Sec 17.
Segregation, Integration and Inclusion: Models of Disability and the Salamanca Statement	Exclusion; segregation = special school; integration = child adjusts to school; inclusion = school adapts to child; medical model = deficit in person; charity model = pity; social model = barriers in society (Michael Oliver); rights model = UNCRPD 2006, Art 24; ICF 2001 biopsychosocial; normalisation, Nirje 1969; IEDC 1974; Salamanca 7-10 June 1994, Spain + UNESCO, 92 governments; Jomtien 1990; Articles 14, 15, 21A, 41; NCF 2005: diversity is a resource.
Law and Policy for Inclusion: RPwD Act 2016, RTE Act 2009, Samagra Shiksha and NEP 2020	PWD Act 1995: 7 disabilities, 3% posts and seats; RPwD Act 2016 (in force 19 April 2017): 21 disabilities, benchmark 40%; Sec 16 duties of schools; Sec 17 survey every 5 years, free aids to 18, scribe, extra time; Sec 31 free education 6-18; Sec 32: 5% higher education seats, 5 years age relaxation; Sec 34: 4% posts; RTE 2009 (6-14), 2012 amendment: home-based education; Samagra Shiksha 2018-19 = SSA + RMSA + TE; NEP 2020 Ch 6: SEDGs, Gender-Inclusion Fund, SEZs, ISL.
Learning Disabilities, ADHD and Autism: Signs a Teacher Sees and Classroom Strategies	SLD: neurological, average or higher intelligence, difficulty in one area; dyslexia = reading (b/d), dysgraphia = writing, dyscalculia = maths, dyspraxia = movement (DCD); VAKT, Fernald, Orton-Gillingham; ADHD: inattention, hyperactivity, impulsivity, not an SLD but often co-occurs; autism (Kanner 1943): social communication + repetitive behaviour, visual timetable, echolalia; slow learner: slow in all subjects, not an RPwD category; learning difficulty often temporary; teacher observes and refers, never labels.
Visual, Hearing and Locomotor Disabilities: Braille, Indian Sign Language and Classroom Changes	Visual: blindness and low vision; signs: squinting, holding the book close; front seat, say aloud what you write, large print, tactile maps, JAWS/NVDA, Taylor frame, Cranmer abacus; Braille: Louis Braille, 1824, 6 dots, 63 patterns, slate and stylus, World Braille Day 4 January; deaf 70 dB, hard of hearing 60-70 dB; face the class, U-shaped seating; ISL has own grammar, ISLRTC 2015; total communication; hearing aid, cochlear implant, FM system; locomotor: ramps, wide doors, wheelchairs, callipers.
Gifted, Creative and Disadvantaged Learners: Identifying and Supporting Them Without Labels	Gifted: Renzulli three rings (ability, task commitment, creativity), Gardner MI, Terman IQ studies; identify from several sources; twice-exceptional; enrichment = broader/deeper, acceleration = faster, curriculum compacting; Enrichment Triad; JNV under NPE 1986; creativity: Guilford divergent thinking; Torrance fluency, flexibility, originality, elaboration; Wallas 1926 four stages; disadvantaged: first-generation, migrant, linguistic minorities; Art 350A; NCF 2005 multilingualism; KGBV 2004; difference not deficit; no labels.

Inclusive Classroom Practice: UDL, Differentiated Instruction, Peer Learning, IEPs and Assessment	UDL (CAST, Rose and Meyer): engagement, representation, action and expression; universal design from architecture (Ronald Mace); differentiation (Tomlinson): content, process, product, environment by readiness, interest, profile; ZPD and scaffolding; cooperative learning (Johnson and Johnson, 5 elements); jigsaw (Aronson 1971); peer tutoring, think-pair-share, buddy system; IEP (USA 1975), team-made, measurable goals; person-first language, high expectations; accommodation vs modification; CCE, portfolios; NEP 2020 360-degree progress card.
Language Pedagogy (Language I and Language II)	Krashen: acquisition (subconscious) vs learning; monitor; natural order; input i+1; affective filter; Chomsky: LAD and universal grammar; Skinner: imitation and reinforcement; Vygotsky: social interaction, ZPD; Piaget: egocentric speech; stages: cooing, babbling, holophrastic, telegraphic; NCF 2005: multilingualism is a resource, home language as medium; three-language formula: Kothari Commission, NPE 1968; CLT: communicative competence, fluency over accuracy; error (systematic) vs mistake (slip); interlanguage (Selinker), fossilisation; BICS vs CALP (Cummins); skimming = gist, scanning = detail; process writing; inductive grammar in context.
Language Acquisition and Learning: Krashen, Chomsky, Skinner, Vygotsky and Piaget	Krashen: acquisition (subconscious) vs learning (conscious); monitor edits output; over-, under- and optimal users; input i+1; silent period; affective filter; Skinner, Verbal Behavior 1957: imitation, reinforcement; Chomsky 1959 review: LAD, universal grammar, poverty of stimulus, competence vs performance; Vygotsky: social, private (3-7), inner speech; Piaget: egocentric speech, collective monologue; Bruner: LASS; Lenneberg 1967: critical period; Genie.
Principles of Language Teaching, Multilingualism and the Role of the Home Language	Known to unknown, oral before written, meaning before form, integrated skills; NCF 2005: language across the curriculum, multilingualism a resource, strategy and goal (Agnihotri focus group); Cummins: interdependence; three-language formula: 1961, Kothari 1964-66, NPE 1968, NPE 1986, NEP 2020 (two of three native); Article 350A; RTE Section 29(2)(f); NEP 2020: mother tongue till Grade 5, preferably 8; NCF-FS 2022; translanguaging (Cen Williams, García).
Listening and Speaking: Developing Oral Language in the Classroom	Oral language before literacy; listening (receptive) and speaking (productive) are both active; hearing is not listening; pre-, while- and post-listening; TPR, read-aloud, listen and draw, dictation; show-and-tell, storytelling, role play, debates, information gap; pair work, wait time; fluency before accuracy; Halliday's seven functions; recast, clarification, self-correction; accept dialect, no ridicule.
Reading: Readiness, Phonics and Whole Language, Types of Reading and Comprehension	Reading is meaning-making (NCF 2005); bottom-up, top-down, interactive; schema theory; readiness: oral language, phonological awareness, concepts about print; emergent literacy (Marie Clay); phonics vs whole language (Goodman 1967), balanced literacy; Hindi: synthetic vs analytic methods; loud, silent, intensive, extensive; skimming = gist, scanning = detail; pre-, during, post-reading; literal, inferential, evaluative; print-rich classroom, big books.
Writing: Stages of Development, Process Writing and Feedback That Helps	Writing: most demanding productive skill; NCF 2005 against copying and memorised answers; stages: scribbling, drawing, mock letters, letter strings, invented spelling, conventional; Gentry 1982: precommunicative, semiphonetic, phonetic, transitional, correct; process writing (Graves): pre-writing, drafting, revising, editing, publishing; controlled, guided, free; creative vs functional; feedback: ideas first, specific, portfolios, dialogue journals.
Teaching Grammar and Vocabulary: Inductive and Deductive Methods, Grammar in Context	Implicit grammar known before school; prescriptive vs descriptive grammar; deductive: rule to example, teacher-centred, grammar-translation; inductive: example to rule, learner-centred, preferred; grammar in context; Hymes: communicative competence; Canale and Swain 1980: grammatical, sociolinguistic, strategic; Canale 1983: discourse; receptive vs productive vocabulary; collocations; realia, word webs, word walls, prefixes and suffixes, guessing from context.
Methods and Materials: Grammar-Translation to Task-Based Teaching, Textbooks and Language Games	Anthony 1963: approach, method, technique; grammar-translation: classical, deductive, translation, speaking neglected; direct method: target language only, inductive, Berlitz 1878; audio-lingual: Army method, behaviourism, pattern drills; structural approach; CLT: 1970s, Wilkins 1976, information gap, facilitator; TBLT: Prabhu's Bangalore Project 1979-84, Willis 1996; Silent Way (Gattegno), Suggestopedia (Lozanov), CLL (Curran); textbook one resource; children's literature; language games.

Assessment in Language, Reading and Writing Difficulties and Remedial Teaching	Assess ability not memory: unseen passages, open tasks; all four skills; for, as and of learning; running records (Clay), miscue analysis (Goodman), cloze (Taylor 1953), rubrics, portfolios; RTE Section 29(2)(h): CCE; NEP 2020: 360-degree progress card; Corder 1967: error (systematic) vs mistake (slip); interlingual vs intralingual; dyslexia, dysgraphia (RPwD Act 2016); remedial: diagnose first, multisensory VAKT (Fernald); Labov: difference not deficit.
Mathematics Pedagogy	NCF 2005: mathematisation of thought; narrow aim numeracy, higher aim mathematical thinking; Position Paper problems: fear and failure, curriculum, assessment, teacher preparation; Piaget concrete operational 7-11, conservation of number; Bruner enactive-iconic-symbolic; Van Hiele visualisation, analysis, informal deduction, deduction, rigour; Dienes perceptual and mathematical variability; Polya understand, plan, carry out, look back; errors are systematic windows into thinking, diagnose first; 1/5 > 1/3 and 0.25 > 0.7 are whole-number reasoning; equals sign is a balance; Herbart 5 steps, 5E model.
Nature of Mathematics: Logic, Patterns, Inductive and Deductive Reasoning	Mathematics is abstract, logical, precise, symbolic, hierarchical and cumulative, the science of patterns; truth by proof; induction: examples to rule, gives a conjecture; deduction: rule to example, gives certainty; one counterexample disproves; Euclid: axioms to theorems; Piaget concrete operational 7-11, formal from 11; NCF 2005 goal: mathematisation of the child's thought; Position Paper: all can and all need to learn mathematics; Wheeler: knowing how to mathematise matters more than knowing a lot of mathematics.
Place of Mathematics in the Curriculum: Aims, NCF 2005 Position Paper and NEP 2020	Values: utilitarian, disciplinary, cultural, aesthetic, social; NCF 2005 narrow aim numeracy, higher aim mathematical thinking; curriculum ambitious, coherent, important; Position Paper problems: fear and failure, curriculum, crude assessment, teacher support; recommendations: higher aims, success for all, assess mathematisation, teacher resources; NEP 2020 FLN mission, 5+3+3+4; NIPUN Bharat 2021: FLN by end of Grade 3 by 2026-27.
Language of Mathematics, Word Problems and Community Mathematics	Mathematics has symbols, vocabulary and grammar; order matters (8 – 5 is '5 less than 8'); symbols after action and talk; key-word tricks fail; Newman: reading, comprehension, transformation, process skills, encoding; problem posing; Hindi names say ones first (सतावन 57); multilingualism is a resource; ethnomathematics (D'Ambrosio); Brazilian street vendors study 1985; build on home and market mathematics.
How Children Learn Number, Place Value and Geometry	Pre-number: classification, class inclusion, seriation, one-to-one correspondence, conservation (number at about 6-7, horizontal décalage); rote vs rational counting; subitising; place value: face value vs place value, grouping in tens, zero as placeholder; proportional models (bundles, Dienes) before abacus and money; Van Hiele 5 levels, sequential, instruction-dependent, 5 phases; space: topological, projective, Euclidean; 3D before 2D.
Teaching Approaches and Materials: CPA, Play-Way, Manipulatives and Problem Solving	CPA from Bruner: objects, pictures, symbols, linked both ways; play-way: Froebel gifts, Montessori materials, Caldwell Cook 1917; activity-based learning by doing (Dewey); Dienes blocks for place value, abacus, Cuisenaire rods (Gattegno), geoboard, tangram 7 pieces; Polya 1945: understand, plan, carry out, look back; problem vs exercise; Kilpatrick project method 1918; discover the rule before stating it.
Errors and Misconceptions in Arithmetic, Fractions, Decimals and Geometry	Slip vs systematic error vs misconception; buggy algorithms (Brown and Burton 1978); 47 + 38 = 715 and 503 − 168 = 435 show weak place value; 618 ÷ 6 = 13 drops a zero; 1/2 + 1/3 = 2/5; fractions need equal parts; longer-is-larger and shorter-is-larger decimals; ruler read from 1; tilted square; longer arms; 2a + 3b = 5ab; error analysis: pattern, hypothesis, test, interview, cognitive conflict; errors are information.
Diagnostic and Remedial Teaching in Mathematics: Slow and Gifted Learners	Diagnosis: what and why, often an earlier gap; tools: observation, error analysis, interview, diagnostic test (sub-skills, untimed, no ranking) vs achievement test; remedial cycle: identify, diagnose, plan, teach, re-assess; a different method in small steps; RTE Act Section 4 special training; dyscalculia in RPwD Act 2016; peer tutoring (Vygotsky, NEP 2020); slow learners: more time; gifted: enrichment and acceleration.

Evaluation in Mathematics: CCE, Open-Ended Questions, Rubrics and Maths Anxiety	Scriven 1967: formative (for learning) vs summative (of learning); assessment as learning; RTE Act Section 29(2)(h) CCE; CCE tools; Skemp 1976 instrumental vs relational understanding; assess understanding, not only procedure; Position Paper: assess mathematisation; open-ended questions, low floor and high ceiling; portfolios show growth; rubrics analytic and holistic; maths anxiety, MARS 1972, causes and remedies; NEP 2020 360-degree progress card, PARAKH.
Mathematics, Classes I-V (Paper I)	Paper I maths: 15 content + 15 pedagogy at class I-V level. Place value vs face value; Indian commas, 1 lakh = 1,00,000; round using the next digit. Regroup in + and -, check by the inverse. 23 × 15 = 230 + 115. Dividend = divisor × quotient + remainder, remainder < divisor; keep quotient zeros. Factors are limited, multiples endless. Equivalent fractions: same multiplier top and bottom; like fractions compare by numerator. ₹ 25.05 = ₹ 25 and 5 paise. Cube: 6 faces, 12 edges, 8 vertices. 1 m = 100 cm, 1 kg = 1,000 g, 1 L = 1,000 mL, 1 h = 60 min. Area is not perimeter. Read the pictograph key; magic square sum 15.
Numbers and Place Value: Lakhs, Expanded Form, Indian and International Systems, Roman Numerals	Pre-number ideas: matching, sorting, seriation; the last number said gives how many (cardinality); place value = digit × value of its place, face value = the digit, place value of 0 is 0; 99,999 + 1 = 1,00,000; Indian periods of 3, 2, 2 digits, international 3, 3, 3; 10 lakh = 1 million, 1 crore = 10 million; compare from the left; Roman I, V, X, L, C, D, M, only I, X, C subtract, 99 = XCIX.
Addition and Subtraction: Regrouping, Properties, Estimation and Word Problems	Addition: putting together or adding on; subtraction: take away, compare or missing part; carry when a column reaches 10 (368 + 475 = 843); borrow across zeros (802 - 357 = 445, not 555); addition is commutative and associative with identity 0, subtraction is not; 845 + 238 = 1,083 gives 1,083 - 238 = 845; estimate by rounding (6,800 - 2,200 = 4,600); picture the problem, do not trust key words.
Multiplication and Division: Tables, Long Methods, Remainders, Factors, HCF and LCM	Multiplication: equal groups, repeated addition, arrays; division: sharing or grouping, the inverse of multiplication; 236 × 47 = 11,092; 2,437 ÷ 12 = 203 remainder 1; remainder < divisor, round up or down as the situation needs; × is commutative, associative, distributive; ÷ 0 has no meaning; prime has exactly 2 factors, 1 is neither, 2 the only even prime; HCF for largest equal parts, LCM for together again; HCF × LCM = product.
Fractions and Decimals at Primary Level: Equivalent Fractions, Comparing, Adding and Money	Fraction = equal parts; denominator = equal parts in the whole, numerator = parts taken; 1/8 < 1/5; 2/5 of 30 = 12; equivalent fractions: multiply or divide both terms by the same non-zero number, 18/24 = 3/4; like fractions: compare and add the numerators only (2/7 + 3/7 = 5/7); 1 mm = 0.1 cm, 1 paisa = ₹ 0.01; 0.5 > 0.45; ₹ 45.50 + ₹ 28.75 = ₹ 74.25.
Measurement: Length, Weight, Capacity, Time and Money in Standard and Non-standard Units	Compare, then non-standard units, then standard units, then convert; 10 mm = 1 cm, 100 cm = 1 m, 1,000 m = 1 km; 1 kg = 1,000 g, 1 quintal = 100 kg; 1 L = 1,000 mL; larger to smaller unit multiply, smaller to larger divide; 60 s = 1 min, 60 min = 1 h, 24 h = 1 day; leap year 366 days, century years only if divisible by 400; 10:40 a.m. to 2:15 p.m. = 3 h 35 min; ₹ 1 = 100 paise; bill = rate × quantity.
Geometry and Shapes: Solids, Plane Figures, Symmetry, Tangrams, Perimeter, Area and Nets	Solids before plane shapes; face, edge, vertex; cube 6 faces, 12 edges, 8 vertices; triangular prism 5, 9, 6; square pyramid 5, 8, 5; F + V - E = 2; diameter = 2 × radius; right angle 90 degrees, acute less than 90, obtuse between 90 and 180; symmetry lines: square 4, non-square rectangle 2, equilateral triangle 3, circle infinite; tangram 7 pieces; perimeter = boundary, area = unit squares, they vary independently; a cube has 11 nets.
Patterns and Data Handling: Number and Shape Patterns, Tally Marks, Pictographs and Bar Graphs	Patterns: copy, extend, create, describe the rule; a repeating pattern has a core; 3, 7, 11 ... has 10th term 39; squares 1, 4, 9, 16; triangular numbers 1, 3, 6, 10; number grid: right +1, down +10; calendar: down +7, a 3 by 3 block = 9 × middle date; data: question, collect, tally in 5s, pictograph with a key, bar graph with equal widths and a scale; read, compare, total, decide.
Volume, Capacity and Everyday Mathematics: Counting Cubes and Learning from Real Life	Volume: space taken up, counted in unit cubes; capacity: what a container holds, in L and mL; 1 cubic cm = 1 mL; 4 × 3 × 2 = 24 cubes; 3 × 3 × 3 = 27; painted cube 8, 12, 6, 1; displacement 400 to 550 mL = 150 cubic cm; everyday problems: read, choose the operation, keep units, check sense; Math-Magic (NCF 2005): play, real contexts, spiral; Joyful Mathematics (NCF-FS 2022): play in the Foundational Stage.

Mathematics, Classes VI-VIII (Paper II)	Paper II maths: 20 content + 10 pedagogy at class VI-VIII level. Indian periods: lakh, crore; 1 million = 10 lakh. Place value = digit × value of its place. Roman: repeat at most 3 times; only I, X, C subtract. Divisibility: 3 and 9 by digit sum, 4 by last two digits, 8 by last three, 11 by alternate sums. HCF lowest powers, LCM highest; HCF × LCM = product. Whole numbers not closed under subtraction; $-(-a) = +a$. Divide fractions by the reciprocal. $a^m \times a^n = a^{m+n}$, $a^{-m} = 1/a^m$. Proportion a : b = c : d when ad = bc. Triangle 180°, quadrilateral 360°. Rectangle: area lb, perimeter 2(l + b). Mean, median, mode.
Number System: Integers, Rational Numbers, Divisibility, HCF and LCM	Natural numbers are whole numbers, whole numbers are integers, integers are rational; whole numbers not closed under subtraction, integers not under division; rational p/q with $q \neq 0$, standard form has a positive denominator and no common factor; reciprocal of $-7/9$ is $-9/7$; 25 primes up to 100, 1 neither prime nor composite; rule for 11: alternate digit sums differ by 0 or a multiple of 11; HCF lowest powers, LCM highest; HCF × LCM = product for two numbers only; with remainder r use HCF of (numbers − r) or LCM + r.
Fractions, Decimals, Exponents and Powers, Squares and Cubes	To divide by a fraction multiply by its reciprocal; compare unlike fractions by cross-multiplying; decimal places in a product add up; $a^m \times a^n = a^{m+n}$, $(a^m)^n = a^{mn}$, $a^0 = 1$, $a^{-m} = 1/a^m$; standard form $k \times 10^n$ with $1 \leq k < 10$; squares end in 0, 1, 4, 5, 6 or 9; sum of first n odd numbers = n^2; $2m$, $m^2 - 1$, $m^2 + 1$ is a triplet; square roots by pairing prime factors and cube roots by grouping them in threes; $1{,}729 = 1^3 + 12^3 = 9^3 + 10^3$.
Algebra: Expressions, Linear Equations, Identities and Factorisation	Variable takes different values; terms, coefficients, like terms; only like terms add; subtracting an expression changes every sign; linear equation: same operation on both sides, clear fractions with the LCM, check by substitution; identity true for all values; $(a \pm b)^2 = a^2 \pm 2ab + b^2$, $(a + b)(a - b) = a^2 - b^2$, $(x + a)(x + b) = x^2 + (a + b)x + ab$; factorise by common factor, regrouping, identities or two numbers with product q and sum p.
Ratio, Proportion, Percentage, Profit and Loss, Simple and Compound Interest	Ratio: same kind, same unit, no unit of its own; a : b :: c : d when ad = bc; unitary method finds one unit first; percentage change on the original value; profit and loss per cent on CP, discount per cent on MP, overheads added to CP; SI = PRT/100; $A = P(1 + R/100)^n$, CI = A − P; half-yearly: rate halved, periods doubled; 2-year CI − SI = $P(R/100)^2$; direct proportion: x/y constant; inverse: xy constant.
Geometry: Lines, Angles, Parallel Lines, Triangles and Congruence	Complementary 90°, supplementary 180°; linear pair 180°; vertically opposite angles equal; with parallel lines, corresponding and alternate angles equal, same-side interior angles add to 180°; triangle angle sum 180°; exterior angle = sum of interior opposite angles; any two sides > third; $h^2 = a^2 + b^2$; triplets 3-4-5, 5-12-13, 8-15-17, 7-24-25; congruence by SSS, SAS, ASA, RHS, never AAA.
Geometry: Quadrilaterals, Circles, Symmetry, Constructions and Solid Shapes	Polygon angle sum (n − 2) × 180°, exterior angles 360°, regular polygon exterior angle 360°/n; parallelogram: opposite sides and angles equal, adjacent angles add up to 180°, diagonals bisect; rhombus diagonals perpendicular, rectangle diagonals equal, square both; diameter = 2r, longest chord; lines of symmetry: square 4, equilateral triangle 3, rectangle 2, circle infinite; rotation angle = 360°/order; ruler-compass angles 60°, 120°, 90°, 30°, 45°; Euler F + V − E = 2.
Mensuration: Perimeter, Area, Surface Area and Volume (Cube, Cuboid, Cylinder)	Rectangle P = 2(l + b), A = lb; circle $C = 2\pi r$, $A = \pi r^2$; parallelogram bh; triangle 1/2 bh; rhombus 1/2 d_1d_2; trapezium 1/2 (a + b)h; path = outer − inner area; cuboid TSA 2(lb + bh + hl), walls 2h(l + b); cube $6a^2$; cylinder CSA $2\pi rh$, TSA $2\pi r(r + h)$; volumes lbh, a^3, $\pi r^2 h$; 1 L = 1,000 cm^3, 1 m^3 = 1,000 L; doubling the edge of a cube: area ×4, volume ×8.
Data Handling: Mean, Median, Mode, Graphs and Probability	Range = highest − lowest; value on an upper class limit goes to the next interval; mean = sum ÷ number; median = middle value after ordering (mean of middle two if even); mode = most frequent value; adding k to every value adds k to the mean, median and mode; bar graph has gaps, histogram none; pie-chart angle = value ÷ total × 360°, 1% = 3.6°; probability = favourable ÷ total equally likely outcomes, from 0 to 1; P(not E) = 1 − P(E).
Science and its Pedagogy (Paper II)	Science is product + process; knowledge is tentative and empirical; NCF 2005 validity: cognitive, content, process, historical, environmental, ethical; scientific temper = Art 51A(h); observation uses senses, inference explains; 5E = Engage, Explore, Explain, Elaborate, Evaluate; heuristic = Armstrong, project = Kilpatrick, concept map = Novak; Bloom revised top = Create; diagnostic test precedes remedial teaching; add acid to water.

Food and the World of the Living: Nutrition, Cells, Microorganisms, Reproduction and Adolescence	Carbohydrates and fats give energy, proteins build the body, vitamins and minerals protect; A night blindness, B1 beriberi, C scurvy, D rickets, iodine goitre, iron anaemia; photosynthesis in leaves through stomata and chlorophyll; Cuscuta parasite, pitcher plant insectivorous; small intestine about 7.5 m with villi; Hooke saw cells in 1665; Lactobacillus curd, Fleming penicillin, Jenner vaccine; ovary becomes fruit; adolescence 11-19 years; XY male.
Materials: Separation, Physical and Chemical Changes, Acids and Bases, Fibres, Metals, Fuels and Combustion	Winnowing, sedimentation, decantation, filtration, evaporation; physical change forms no new substance, chemical change does; rusting needs oxygen and water, galvanisation is a zinc coat; blue litmus turns red in acid, turmeric red in base; ant sting has formic acid; acid + base gives salt + water; silkworm egg-larva-pupa-moth; thermoplastic vs thermosetting; metals malleable and ductile; coke, coal tar, coal gas; ignition temperature; outer flame zone hottest.
Moving Things, People and Ideas: Measurement, Motion, Force, Pressure and Friction	1 m = 100 cm, 1 km = 1000 m; rectilinear, circular and periodic motion; speed = distance / time in m/s or km/h; pendulum time period constant for a given length; force is a push or pull that can change speed, direction or shape; contact (muscular, friction) and non-contact (magnetic, electrostatic, gravitational) forces; pressure = force / area; liquid pressure rises with depth; static > sliding > rolling friction; lubricants and ball bearings reduce friction.
How Things Work: Electric Current and Its Effects, Magnets, Light and Sound	Cell: positive metal cap, negative metal disc; a closed circuit lights the bulb; conductors vs insulators; heating effect in heater and fuse, MCB; Oersted 1820, magnetic effect; electromagnet in crane and bell; iron, nickel, cobalt magnetic; repulsion is the sure test; angle of incidence = angle of reflection; plane mirror image virtual, erect, laterally inverted; concave for dentists, convex for rear view; persistence 1/16 s; pitch-frequency, loudness-amplitude; electroplate the object at the negative terminal.
Natural Phenomena and Natural Resources: Winds, Lightning, Earthquakes, the Solar System, Water, Forests and Pollution	Wind blows from high to low pressure; cyclone eye is calm; lightning from charge separation in clouds, conductor protects, squat but never lie flat; earthquakes from plate movement, Richter scale, Bhuj 2001; light year is a distance; Pole Star seems fixed; eight planets, Venus brightest, Jupiter largest; Aryabhata 1975; 71% of the surface is water, World Water Day 22 March; acid rain causes marble cancer; Ganga Action Plan 1985; Project Tiger 1973; Pachmarhi Biosphere Reserve.
Nature and Structure of Science: Process, Body of Knowledge, Aims and Scientific Attitude	Science = body of knowledge + process; fact, concept, law, theory, hypothesis; knowledge empirical, tentative, verifiable; basic and integrated process skills; NCF 2005: true to the child, to life and to science; upper primary learns through familiar experience, hands-on design and activities, not diluted secondary science; six validities: cognitive, content, process, historical, environmental, ethical; scientific temper Art 51A(h), 42nd Amendment 1976; National Science Day 28 February.
Approaches to Teaching Science: Inquiry, Discovery, Experiment, 5E Model, Projects and Concept Maps	Inquiry: question, plan, evidence, explain, share; structured, guided, open; discovery = Bruner, heuristic = Armstrong; experiment changes one variable against a control; 5E (BSCS): Engage, Explore, Explain, Elaborate, Evaluate; project method = Kilpatrick 1918; problem solving = Dewey; POE turns demonstration into inquiry; concept map = Novak, based on Ausubel; integrated and thematic teaching; low-cost improvised apparatus.
Evaluation, Text Materials and Remedial Teaching in Science	CCE = RTE Act 2009, Section 29(2)(h); formative is assessment for learning, summative of learning; anecdotal record, checklist, rating scale, rubric, portfolio; revised Bloom 2001; affective - Krathwohl; psychomotor - Dave; assess process skills by performance; textbook is one resource; Dale's cone runs from concrete to abstract; misconceptions need cognitive conflict, not telling; diagnostic test then remedial teaching; enrichment for quick learners; home language helps science learning.
Social Studies and its Pedagogy (Paper II)	Social studies is integrated, social sciences are disciplines; primary vs secondary sources; Mill's periodisation criticised; scale 1:50,000 = 1 cm : 500 m; Census = secondary data every 10 years; values assessed by observation.
Early India: Sources, First Farmers, Harappan Cities, Mauryas and Guptas (Class VI History)	Sources: manuscripts, inscriptions, archaeology; Mehrgarh early farming (wheat, barley); Harappan cities about 4700 years ago, decline about 3900; Rigveda 1028 hymns; mahajanapadas about 2500 years ago, Magadha strongest; Buddha (Bodh Gaya, Sarnath), Mahavira 24th tirthankara; Ashoka's dhamma after Kalinga; Harishena's prashasti of Samudragupta; Aryabhata; Mehrauli iron pillar.

Medieval India: New Kingdoms, Delhi Sultans, Mughals, Bhakti-Sufi Paths and Regional Cultures (Class VII History)	Tripartite struggle for Kanauj; Mahmud of Ghazni 17 raids; Prithviraja III 1191 and 1192; Cholas: Rajaraja I 985, Uttaramerur sabha; Sultanate five dynasties 1206-1526; iqta, kharaj; Mughals: Panipat 1526, mansabdari, zabt, sulh-i kul; arcuate arches; Banjaras, Gonds, Ahoms; Nayanars, Alvars, Sufis, Kabir, Nanak; Kathak; Nadir Shah 1739; Panipat 1761.
Modern India: Company Rule, the Revolt of 1857, Social Reform and the National Movement (Class VIII History)	Company charter 1600; Plassey 1757, Buxar 1764, Diwani 1765; subsidiary alliance (Wellesley), doctrine of lapse (Dalhousie), Awadh 1856; Permanent Settlement 1793, mahalwari 1822, ryotwari; Birsa Munda; 1857 from Meerut, Act of 1858; reformers Rammohun, Vidyasagar, Phule, Narayana Guru, Ambedkar; Congress 1885, Bengal partition 1905, Purna Swaraj 1929, Quit India 1942; Constitution in force 26 January 1950; linguistic states 1956.
Planet Earth: Solar System, Globe, Motions, Maps, Landforms, Interior, Air and Water (Class VI-VII Geography)	8 planets, Pluto a dwarf planet since 2006; earth third from the Sun, a geoid; tropics at 23½°, polar circles at 66½°; 1° = 4 minutes, IST at 82½° E (5 hours 30 minutes ahead of GMT); rotation 24 hours, revolution 365¼ days; solstices 21 June and 22 December, equinoxes 21 March and 23 September; map = scale, direction, symbols; crust sial and sima, core nife; troposphere 13 km; 97.3 per cent of water in oceans.
Resources and Development: Land, Soil, Water, Minerals, Agriculture, Industries and People (Class VIII Geography)	Resource = utility, created by time and technology; natural, human-made, human; actual and potential (uranium in Ladakh); sustainable development; land about 30 per cent of the surface; soil conservation by mulching, terraces, shelter belts; 2.7 per cent of water fresh; CITES; ferrous and non-ferrous minerals; coal buried sunshine; jhumming; cotton 210 frost-free days; TISCO 1907; Bhopal 1984; sex ratio 943 (Census 2011).
Social and Political Life (Class VI-VII): Diversity, Local Government, Livelihoods, Equality, Gender, Media and Markets	Diversity, prejudice, stereotype, discrimination; Articles 15 and 17; universal adult franchise at 18; Gram Sabha, Gram Panchayat, Panchayat Samiti, Zila Parishad; 73rd and 74th Amendments; patwari, tehsildar, FIR; Midday Meal (Tamil Nadu, 2001 order); MLA, Chief Minister, Governor; Margaret Mead, double burden, Rashsundari Devi; balanced media; chain of markets.
Constitution, Secularism, Parliament, Judiciary and Marginalisation (Class VIII Social and Political Life)	Constituent Assembly 1946-49; key features: federalism, parliamentary form, separation of powers, Fundamental Rights, secularism; Article 21A (2002); Indian secularism: distance, non-interference, intervention; Parliament: Lok Sabha, Rajya Sabha, Question Hour; rule of law and the Sedition Act of 1870; judiciary: judicial review, appeals, PIL; marginalisation: Adivasis, Muslims, Dalits; Atrocities Act 1989; Bhopal 1984.
Nature of Social Science, NCF 2005 and Classroom Processes: Critical Thinking, Discussion and Debate	Social science = study of society through history, geography, political science, economics, sociology; NCF 2005: rigorous not non-utility, concepts not facts, perspective of the marginalised, gender justice, normative values, textbook one resource; civics replaced by political science; critical thinking; Bloom revised 2001; Piaget, Vygotsky (ZPD, scaffolding), Bruner (spiral); discussion, debate, role play, mock parliament.
Enquiry and Sources in Social Science: Primary and Secondary Sources, Projects, Field Trips, Maps and Timelines	Enquiry: question, evidence, analysis, conclusion; Dewey's problem-solving method; primary and secondary sources and data; epigraphy, numismatics; who, when, for whom, why; corroboration; Kilpatrick's project method (1918): purposing, planning, executing, judging; field trip before, during and after; map skills from classroom plan to atlas; timelines, BCE, centuries; documents, cartoons, archives; oral history.
Evaluation and Problems of Teaching Social Science: CCE, Open-Ended and Source-Based Questions, Rote Learning	CCE (RTE Act Section 29): continuous and comprehensive, scholastic and co-scholastic; formative and summative; tools: observation, anecdotal records, checklists, rating scales, rubrics, portfolios; open-ended, source-based and map-based questions; Learning Without Burden 1993; NEP 2020 competency-based assessment and 360-degree progress card; problems: abstract content, rote learning, few aids; remedies: local, concrete, activity, action research.

Pariksha Saathi is an independent project, not affiliated with any recruitment body or government department. Notes for every subject: parikshasaathi.com/downloads/