APPSC GROUP 1 · 1000 TOPICS IN 100 DAYS

DAY 8

English Notes

Topics 71 to 80

Full teaching notes, 52 visual revision panels and source references.

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APPSC Group 1 Preparation Programme

Topics in Day 8

71 · Buddhism: life of the Buddha and core teachings

72 · Kandukuri Veeresalingam and social reform in Andhra

73 · Right to Equality: Articles 14 to 18

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Use the topic links above or the PDF bookmarks to move through the day.

DAY 8 · TOPIC 71

Buddhism: life of the Buddha and core teachings

1. Concept in one line

Siddhartha Gautama of the Sakya clan, the Buddha, taught a middle path to end suffering, set out in the four noble truths and the eightfold path. The examination asks for the persons, places and ages of his life, and for the exact terms of his teaching.

2. Revision notes

2.1 The setting

- NCERT: the mid-first millennium BCE is often regarded as a turning point in world history. It was the time of thinkers such as Mahavira and Gautama Buddha.
- **Sacrifice had grown elaborate.** At first sacrifices were performed collectively. Later, chiefs and kings had the rajasuya and the ashvamedha performed by Brahmana priests (NCERT).
- **A time of debate.** Buddhist texts mention as many as 64 sects or schools of thought. Teachers debated in the kutagarashala, literally a hut with a pointed roof (NCERT).
- **Shramana** (Pali: samana): one who labours or exerts himself for a higher or religious purpose. The word comes from the root shram. The shramana tradition includes Jainism, Buddhism, the Ajivikas, Ajnana and the Charvakas. The Buddha left home as a shramana.

- **Kingdoms of his time** (Vincent Smith): Magadha, ruled by Bimbisara from Rajagriha; Kosala, with its capital at Sravasti; the Vrijjian confederacy, with its capital at Vaisali; and the Sakya territory at the foot of the Nepal hills. The mahajanapadas and the rise of Magadha are taken up on other days.

2.2 The dates: what scholars say

No year of his life is fixed. Both the long and the short chronology say that he lived 80 years.

Reckoning	Dates	How it is worked out
Traditional long chronology (Sri Lanka and South-East Asia)	624 to 544 BCE	The Sri Lankan chronicles say he died 218 years before the coronation of Ashoka; here the coronation is placed in 326 BCE
Long chronology corrected by the Greek evidence on Ashoka	566 to 486 BCE	The same 218 years, counted from a coronation in about 268 BCE
Most historians of the early 20th century	563 to 483 BCE	About three years away from the corrected reckoning
Short chronology (Indian sources and their Chinese and Tibetan translations)	448 to 368 BCE	These sources say he died 100 years before the coronation of Ashoka (about 268 BCE)

Reckoning	Dates	How it is worked out
Most papers at a symposium of scholars in 1988	Death within 20 years on either side of 400 BCE	A date that falls between the long and the short chronology

- Vincent Smith, in an older standard history, puts the death "in or about the year 487 B.C."
- NCERT (Class XII) gives no year. It places his death in "c. fifth-fourth century BCE". The Class VI book says he was born about two and a half millennia ago. It notes that scholars differ widely on the precise year, and takes 560 BCE as an approximate year of birth.
- Britannica: he lived in northern India between the mid-6th and the mid-4th centuries BCE.
- For the examination: if the options are years, expect 563 BCE for the birth and 483 BCE for the death. If the question follows NCERT, the death is a century, not a year, and the birth is about 560 BCE.

2.3 Birth and family

- **Clan and father:** he belonged to the Sakya (Shakya) clan, whose capital was Kapilavastu. His father was Shuddhodana. NCERT calls the father a chief of the Sakya clan, and Britannica calls him a king. Scholars describe the Sakyas as probably an oligarchy or a small republic, in which Shuddhodana was an elected chief.

- **Birth:** his mother Maya (Maha Maya) gave birth to him in the garden of Lumbini, now in Nepal. His name at birth was Siddhartha (NCERT). Ashoka set up a pillar at Lumbini about 200 years after the time of the Buddha (NCERT).
- **Foster mother:** Maya died seven days after the birth. Her sister Mahapajapati Gotami (Sanskrit: Mahaprajapati) brought him up.
- **Wife and son:** he married Yashodhara at 16. Their son was Rahula.

2.4 From the great departure to the enlightenment

- **The four sights (at 29):** driven through the city in a chariot, he saw an old man, a sick man and a corpse, and then a mendicant who seemed to be at peace.
- **The great departure (mahabhinishkramana):** at 29 he left the palace, his wife and his son. His horse was Kanthaka.
- **Two teachers:** Alara Kalama and then Uddaka Ramaputta taught him meditation. He left both.
- **Austerities:** his search lasted six years. With a group of five ascetics he practised severe austerities and cut his food down to one pea a day. Then he gave up extreme self-mortification.
- **Sujata:** a village girl who offered him milk-rice after he gave up the austerities. Britannica tells the story of "a young woman", without her name.
- **Enlightenment:** after meditating for many days under a pipal tree at Bodh Gaya in Bihar, he attained enlightenment. The tree is called the Bodhi tree. Britannica places this on the full moon of May, six years after he left the palace, which makes him about 35. From then he was the Buddha, "the enlightened one" or "the awakened one".

2.5 The first sermon and the teaching years

- **First sermon:** he gave it in the deer park at Sarnath, near Varanasi, to his five former companions. He "set the wheel of the dharma in motion", so the event is called the dharmachakrapravartana. He taught the middle way, the four noble truths and the eightfold path.
- **The first five:** Kondanna, Bhaddiya, Vappa, Mahanama and Assaji. They became the first members of the sangha, the order of monks.
- **Teaching years:** he taught for about 45 years, moving from place to place. In the rainy season (mid-July to mid-October) he and his monks stayed in one place. The first rains were spent at Varanasi. Later he spent much of his time at Jetavana in Sravasti, a monastery given by the banker Anathapindika.

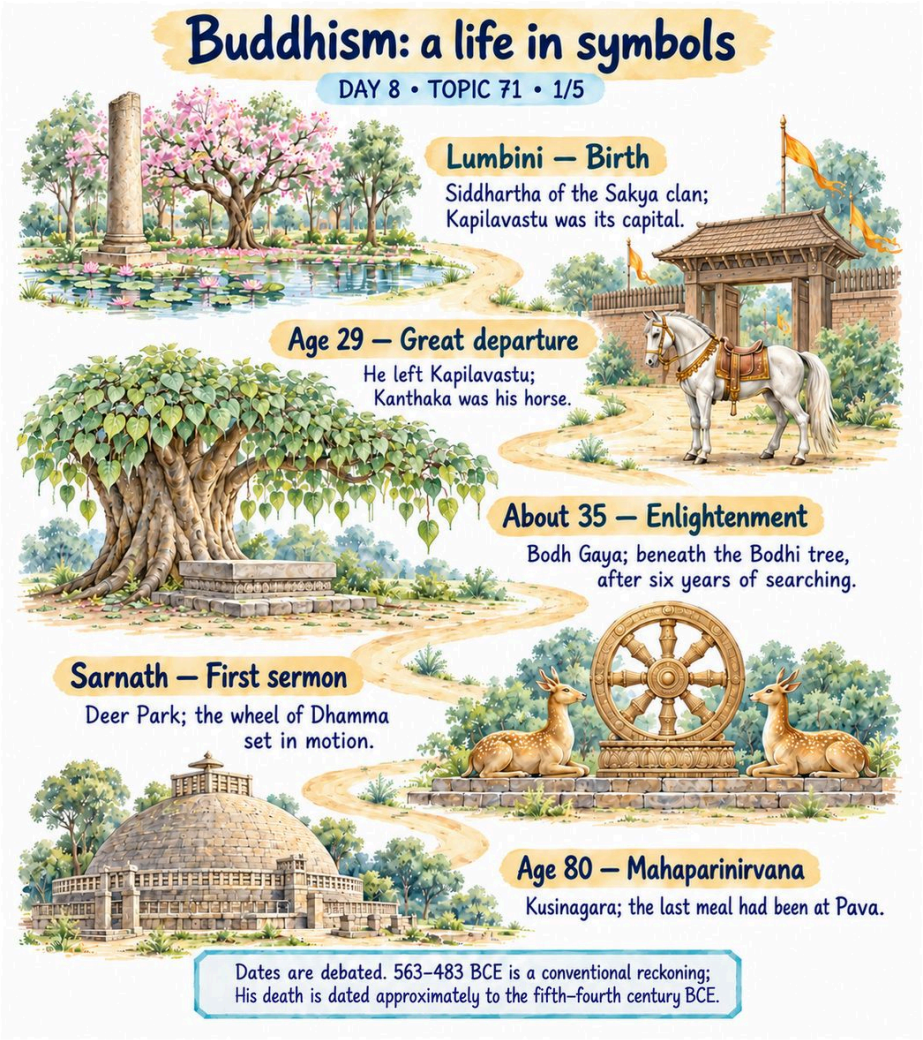
Disciple	Who he was	What he is remembered for
Kondanna (Kaundinya)	One of the five ascetics at Sarnath	The first to understand the teaching, and the first monk
Sariputta	A former follower of the sceptic Sanjaya Belatthiputta	One of the two chief disciples; foremost in wisdom; died shortly before the Buddha
Moggallana	Sariputta's childhood friend	The other chief disciple; known for his psychic powers

Disciple	Who he was	What he is remembered for
Ananda	A first cousin of the Buddha	His personal attendant; had the best memory; persuaded him to admit women
Upali	Born a barber	Master of the vinaya, the rules of monastic discipline
Mahakassapa	Born in a Brahmin family	Foremost in ascetic practices; led the sangha after the Buddha's death

- Assaji, one of the first five, converted Sariputta and Moggallana.
- At the council held after the Buddha's death, over which Mahakassapa presided, Ananda recited the discourses and Upali the discipline. The councils are a separate topic.
- **Kings:** Bimbisara of Magadha met him before the enlightenment and later gave him the Bamboo Grove (Veluvana) near Rajagriha. Ajatashatru, who by tradition put his father Bimbisara to death, later visited the Buddha and took refuge in him. Prasenajit (Pali: Pasenadi), king of Kosala with his capital at Sravasti, was a lay follower of the Buddha.
- **Women in the sangha:** at first only men were admitted. Mahapajapati Gotami asked for admission and was refused at first. Ananda pleaded for the women, and she became the first woman to be ordained as a bhikkhuni, a nun (NCERT).

2.6 The last days

- At 80 he accepted a meal from Cunda, a smith, at Cunda's mango grove in Pava. The dish is called sukaramaddava. Its meaning is disputed: the Theravada tradition generally takes it as pork, and the Mahayana tradition as a vegetarian dish.
- He fell ill soon after and died at Kusinagara (Pali: Kusinara; modern Kasia, Kushinagar). His death is called the mahaparinirvana (Pali: mahaparinibbana).
- NCERT gives his last words to his followers: "Be lamps unto yourselves as all of you must work out your own liberation."



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DAY 8 · TOPIC 71 · VISUAL REVISION 1

2.7 The core of the teaching

The four noble truths (first taught in the first sermon):

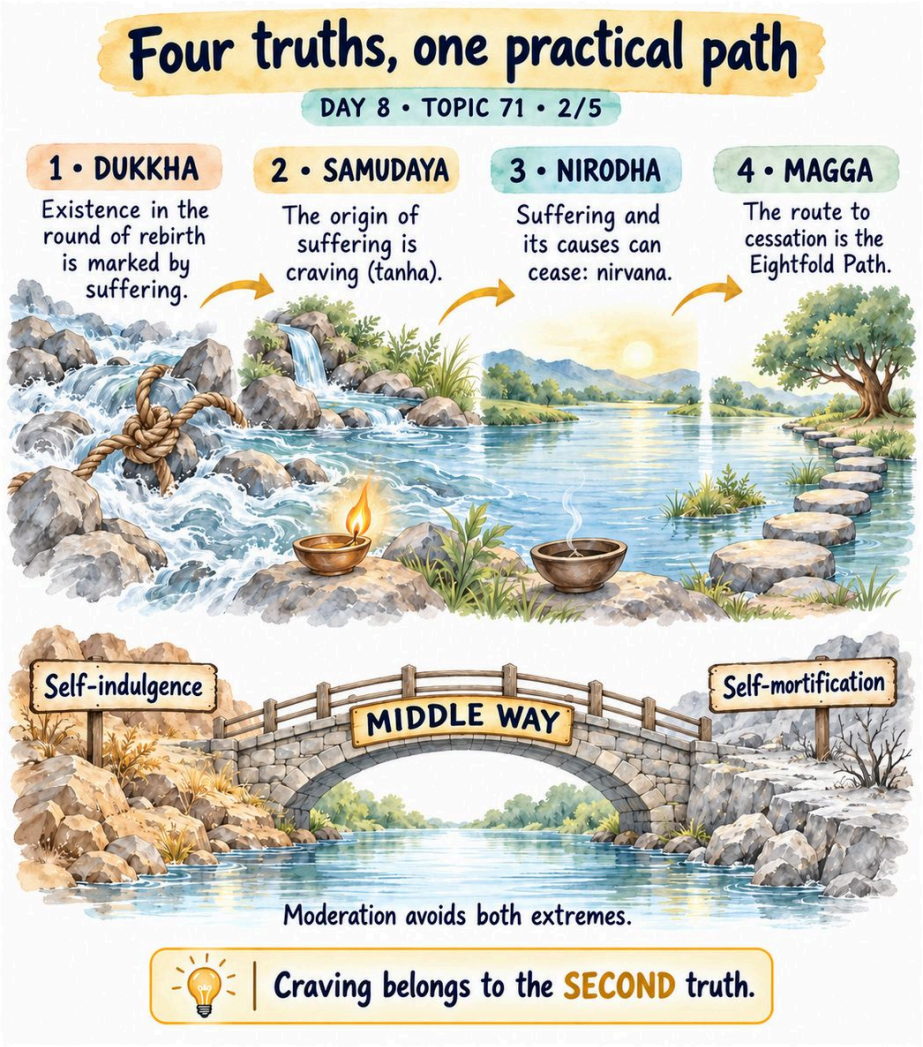
- First truth (dukkha): existence in the round of rebirth is marked by suffering.
- Second truth (samudaya): suffering has an origin, which is craving (tanha, literally "thirst").
- Third truth (nirodha): suffering can cease; the cessation is nirvana.
- Fourth truth (magga): there is a path to that cessation, the eightfold path.

The eightfold path, in three groups:

Group	Limbs of the path
Wisdom (panna)	Right view, right intention
Conduct (sila)	Right speech, right action, right livelihood
Concentration (samadhi)	Right effort, right mindfulness, right concentration

- **The middle path:** the way between two extremes, self-indulgence and self-mortification. NCERT calls it "the path of moderation between severe penance and self-indulgence".
- **The three marks of existence:** anicca (impermanence), dukkha (sorrow) and anatta (no self). NCERT: the world is transient and constantly changing; it is soulless, as there is nothing permanent or eternal in it; and sorrow is intrinsic to human existence.

- **Dependent origination (pratityasamutpada):** every state of body and mind arises in dependence on what went before. It is set out as twelve links, beginning with ignorance and ending with old age and death.
- **Karma and rebirth:** in karma, the intention (cetana) behind an act is what matters. Rebirth takes place although there is no permanent self: no soul or fixed substance passes from one life to the next.
- **Nirvana (Pali: nibbana):** literally "blowing out" or "quenching". NCERT explains it as the extinguishing of the ego and desire. It is the end of suffering and of its causes.
- NCERT (Class VI) adds that he saw ignorance (avidya) and attachment as the source of human suffering, and that he taught ahimsa, "non-hurting".



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2.8 What he set aside

- **The Vedas:** NCERT says Mahavira and the Buddha questioned the authority of the Vedas. The shramana culture of Greater Magadha, in the east, rejected Vedic authority and Vedic rituals, that is, the yajnas.
- **God:** NCERT: "In the earliest forms of Buddhism, whether or not god existed was irrelevant." He regarded the social world as made by human beings, and advised kings and gahapatis (masters of households) to be humane and ethical.
- **Metaphysical questions:** he declined to answer ten questions (the Sanskrit texts list fourteen). They ask whether the world is eternal, whether it is infinite, whether the life force is the same as the body, and whether a Buddha exists after death. His reason: such questions are not conducive to liberation. They are called avyakata, "undeclared".

Change, causation and liberation

DAY 8 • TOPIC 71 • 4/5



ANICCA

Impermanence: all conditioned things change.



DUKKHA

Suffering: existence is unsatisfactory.

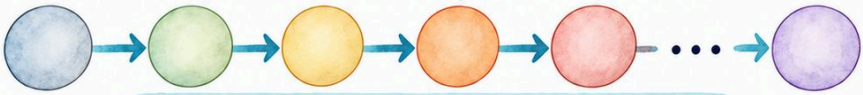


ANATTA

No permanent self.

DEPENDENT ORIGINATION

Body and mind arise in dependence on conditions.



Twelve links: ignorance → … → old age and death



KARMA

KARMA: intention (cetana) matters.



REBIRTH

REBIRTH: continuity without a permanent soul passing between lives.



NIRVANA

NIRVANA: the ending of suffering and its causes.

The Buddha questioned Vedic authority and ritual; liberation required personal effort.

2.9 Three jewels, five precepts, the sangha and the texts

- **Three jewels:** the Buddha, the Dhamma (the teaching) and the Sangha (the order). A Buddhist "goes for refuge" to each of the three.
- **Five precepts:** to abstain from killing, from taking what is not given, from sensual misconduct, from false speech and from intoxicants. They are the basic training for all Buddhists, lay people included. The ten precepts are ordinarily kept in full only by monks and nuns, who also follow the detailed monastic rules that elaborate the precepts further.
- **The sangha:** an order of monks (bhikkhus), who lived on alms, and later of nuns (bhikkhunis). NCERT lists those who joined: kings, wealthy men and gahapatis, and also workers, slaves and craftspeople. Inside the sangha all were equal. Decisions were taken by consensus, and by a vote if that failed.
- **Vinaya:** the code of conduct of the sangha. The Vinaya Pitaka holds these rules (NCERT).
- **Uposatha:** the fortnightly meeting of the monks, at the full moon and the new moon. They confess their offences to one another and recite the monastic code of 227 rules.
- **Texts:** none of his speeches were written down in his lifetime. His disciples compiled them after his death in the Tipitaka, "three baskets". Some of the oldest texts are in Pali; later ones are in Sanskrit (NCERT). NCERT adds that the stories of his teaching were narrated in the language spoken by ordinary people. The councils, sects and literature come on another day.

Refuge, discipline and disciples

DAY 8 • TOPIC 71 • 5/5



FIVE PRECEPTS

1. No killing
2. No taking what is not given
3. No sexual misconduct
4. No false speech
5. No intoxicants

Theravada novices observe **TEN** precepts.

Fully ordained monks and nuns follow the wider Vinaya discipline.



Kondanna – first to understand at Sarnath

Sariputta – chief disciple; wisdom

Ananda – cousin, attendant; recited discourses

Mahakassapa – presided at the first council

Upali – barber; master of Vinaya

Mahapajapati Gotami – foster mother; first bhikkhuni



The **Tipitaka** means 'three baskets'; the teachings were compiled after the Buddha's death.

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DAY 8 · TOPIC 71 · VISUAL REVISION 5

3. Extra section: the great events of his life in order, with their symbols in early art

Event · Birth

Age · At birth

Place · Lumbini

Symbol in early art · NCERT names none; guidebooks print "lotus and bull"

Event · The four sights and the great departure

Age · 29

Place · Kapilavastu

Symbol in early art · The horse (the riderless horse Kanthaka)

Event · Enlightenment

Age · About 35

Place · Bodh Gaya

Symbol in early art · The Bodhi tree, often shown with an empty seat

Event · First sermon

Age · About 35

Place · Sarnath

Symbol in early art · The wheel (NCERT)

Event · Mahaparinirvana

Age · 80

Place · Kusinagara

Symbol in early art · The stupa (NCERT)

- NCERT: many early sculptors did not show the Buddha in human form. The empty seat indicates his meditation, the wheel stands for the first sermon and the stupa represents the mahaparinibbana.
- The Bodhi tree, the wheel and the stupa recur at the major early sites of Sanchi, Bharhut, Amaravati, Bodh Gaya and Sarnath.
- The white elephant belongs to the story of Maya's dream: she dreamt that a white elephant had entered her womb.
- Human images of the Buddha became popular around the first century CE, at Mathura and Gandhara. Buddhist art and the stupas are taken up on another day.
- Ages to keep in order: marriage at 16, the great departure at 29, the enlightenment at about 35, death at 80.

4. Three common exam traps

1. **The place next door.** He was born at Lumbini, not at Kapilavastu, which was the Sakya capital. He attained enlightenment at Bodh Gaya but first taught at Sarnath. He took his last meal at Pava but died at Kusinagara.
2. **Treating 563 BCE and 483 BCE as settled.** They are one reckoning among several. The tradition of Sri Lanka gives 624 to 544 BCE, and most papers at the 1988 symposium put the death within 20 years of 400 BCE. NCERT gives the death only as a century, and takes 560 BCE as an approximate year of birth.
3. **Two women and two meals.** Maya was his mother and died seven days after the birth; her sister Mahapajapati Gotami brought him up and was later the first bhikkhuni. Sujata's milk-rice came before the enlightenment; Cunda's meal was the last one.

7. Sources

7.1 Sources

No. · S1

Source · NCERT, Themes in Indian History Part I (Class XII), Theme 4, "Thinkers, Beliefs and Buildings". https://ncert.nic.in/textbook/pdf/lehs104.pdf

Used for · The mid-first millennium BCE as a turning point; the growth of sacrifice (rajasuya, ashvamedha); 64 sects; the kutagarashala; Mahavira and the Buddha questioning the authority of the Vedas (pp. 84-85); the Buddha's death "c. fifth-fourth century BCE", no speeches written down in his lifetime, the Tipitaka, Pali and Sanskrit texts, the Vinaya Pitaka (p. 86); Siddhartha, son of a chief of the Sakya clan, the sights, enlightenment, "the Enlightened One" (pp. 89-90); anicca, anatta, dukkha, "the path of moderation between severe penance and self-indulgence", god "irrelevant", the stories narrated "in the language spoken by ordinary people" (p. 91); the social world, kings and gahapatis, individual effort, nibbana, the last words; the sangha, bhikkhus, bhikkhunis, Ananda's mediation, Mahapajapati Gotami as foster mother and first bhikkhuni, who joined, equality, consensus and vote (p. 92); Ashoka's pillar at Lumbini (p. 96); early sculptors not showing the Buddha in human form, the empty seat, the wheel and the stupa (p. 100); the tree as the symbol of an event in his life (pp. 100-101); the caption "An image of the Buddha from Mathura, c. first century CE" (p. 103); timeline entry "c. sixth century BCE" for Jainism and Buddhism (p. 110)

No. · S2

Source · NCERT, Exploring Society: India and Beyond (Class VI), Chapter 7, "India's Cultural Roots". https://ncert.nic.in/textbook/pdf/fees107.pdf

Used for · Born at Lumbini (today in Nepal) about two and a half millennia ago; scholars differ widely on the precise year of birth, and the book takes 560 BCE as an approximate year; the chariot ride at 29 and the four sights; leaving

the palace, wife and son; the pipal tree at Bodh Gaya; "enlightened" or "awakened" one; avidya and attachment as the source of suffering; ahimsa as "non-hurting"; the Sangha of bhikshus and bhikshunis; rituals (yajna)

No. · S3

Source · Encyclopaedia Britannica, "Buddha" (biography), sections "Birth and early life", "The enlightenment", "The first disciples", "The post-enlightenment period" and "The death of the Buddha". https://www.britannica.com/biography/Buddha-founder-of-Buddhism ; https://www.britannica.com/biography/Buddha-founder-of-Buddhism/Previous-lives ; https://www.britannica.com/biography/Buddha-founder-of-Buddhism/The-first-disciples

Used for · Born c. 6th to 4th century BCE at Lumbini near Kapilavastu; King Shuddhodana of the Shakya clan; Maha Maya, her dream of the white elephant, her death seven days after the birth; brought up by her sister Mahaprajapati; marriage at 16 to Yashodhara; Rahula; the four sights at 29; six years of search, the five ascetics, one pea a day; the meal given by a young woman; enlightenment on the full moon of May six years after leaving the palace; Bimbisara's offer before the enlightenment; the deer park at Sarnath outside Varanasi; "set the wheel of the dharma in motion"; the middle way between self-indulgence and self-mortification; the four truths and the eightfold path in the first sermon; the five as first members of the sangha; the rainy season retreat (mid-July to mid-October); Jetavana at Shravasti and the banker Anathapindika; Mahaprajapati and the order of nuns; the meal from the smith Chunda at 80; death at Kusinara (Kushinagar, modern Kasia)

No. · S4

Source · Encyclopaedia Britannica, "Four Noble Truths". https://www.britannica.com/topic/Four-Noble-Truths

Used for · The four truths in order (dukkha, samudaya, nirodha, magga); craving (tanha, "thirst") as the origin; cessation as nirvana; the path as the eightfold path; first set out in the first sermon; nirvana as a state in which suffering and its causes are absent

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No. · S5

Source · Encyclopaedia Britannica, "Eightfold Path". https://www.britannica.com/topic/Eightfold-Path

Used for · The names of the eight limbs in order: right view, intention, speech, action, livelihood, effort, mindfulness and concentration

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No. · S6

Source · Encyclopaedia Britannica, "uposatha". https://www.britannica.com/topic/uposatha

Used for · Fortnightly meetings of the monastic assembly at the full moon and the new moon; mutual confession and recitation of the 227-rule monastic code; the ten precepts ordinarily observed in full only by monks

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No. · S7

Source · Encyclopaedia Britannica, "Buddhism". https://www.britannica.com/topic/Buddhism

Used for · "A teacher who lived in northern India between the mid-6th and mid-4th centuries BCE"

No. · S8

Source · Vincent A. Smith, "The Dynasties Before Alexander", Chapter 2 of Volume 2 of a nine-volume history of India published in the first decade of the 20th century (text hosted by ibiblio). https://ibiblio.org/britishraj/Jackson2/chapter02.html

Used for · The death of the Buddha "in or about the year 487 B.C."; Bimbisara at Rajagriha; Kosala and its capital Sravasti; the Vrijjian confederacy and Vaisali; the Sakya territory at the foot of the Nepal hills; Ajatasatru's parricide by tradition, his visit to the Buddha and his taking refuge

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No. · S9

Source · Wikipedia, "The Buddha" (citing Reynolds and Hallisey 2005, Cousins 1996 and Schumann 2003 for the chronologies; Bechert, Cousins and Prebish for the 1988 symposium; Gombrich 1988 for the Sakya polity). https://en.wikipedia.org/wiki/The_Buddha

Used for · The long chronology (624 to 544 BCE), its corrected form (566 to 486 BCE), 563 to 483 BCE, the short chronology (448 to 368 BCE), the 1988 symposium; the Sakyas as probably an oligarchy or small republic and Suddhodana as an elected chief; Ashoka's pillar marking the birthplace; Alara Kalama and Uddaka Ramaputta; Sujata and the milk-rice; the pipal (Bodhi) tree at Bodh Gaya; the first rains at Varanasi; a teaching career of about 45 years; the Bamboo Grove near Rajagaha given by Bimbisara; Savatthi in his later years; Sariputta and Moggallana as followers of Sanjaya Belatthiputta, converted by Assaji; Ananda as cousin, and his plea for the ordination of women; Mahapajapati Gotami first refused; Upali the barber; Ajatashatru taking refuge

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No. · S10

Source · Wikipedia, "Buddhism". https://en.wikipedia.org/wiki/Buddhism

Used for · The grouping of the eightfold path under wisdom, moral conduct and concentration; anatta and rebirth without a soul or fixed substance; intention (cetana) in karma; nirvana as "blowing out, quenching"; dependent origination and its twelve links; the three marks of existence; the three jewels and the refuge formula; the five precepts as basic training for all Buddhists; vinaya as the code of conduct of the sangha

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No. · S11

Source · Wikipedia, "Ten principal disciples" (citing Hecker and Nyanaponika Thera 2003; Malalasekera 1937; Silk 2019; Gethin 2011; Clarke 2014; Mun-keat 2000; Gombrich 1995; Mrozik 2004; Eliade 1982; Keown 2004). https://en.wikipedia.org/wiki/Ten_principal_disciples

Used for · Sariputta as chief disciple, foremost in wisdom, who died shortly before the Buddha; Moggallana as the second chief disciple, his friendship with Sariputta and his psychic powers; Mahakassapa's Brahmin birth, ascetic practices, leadership after the Buddha's death and presiding at the first

council; Ananda as first cousin, attendant, of the best memory, reciting the discourses; Upali born a barber, his mastery of the vinaya and his reciting of the discipline

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No. · S12

Source · Wikipedia, "Kaundinya". https://en.wikipedia.org/wiki/Kaundinya

Used for · The five ascetics by name (Kaundinya, Bhaddiya, Vappa, Mahanama, Assaji); Kaundinya as the first to comprehend the teaching at Sarnath and the first bhikkhu

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No. · S13

Source · Wikipedia, "Cunda Kammaraputta". https://en.wikipedia.org/wiki/Cunda_Kammāraputta

Used for · Cunda the smith; the last meal at his mango grove in Pava on the way to Kusinagara; sukaramaddava and the dispute over its meaning; the illness that followed

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No. · S14

Source · Wikipedia, "Buddhist symbolism" (citing Karlsson for the three recurring symbols). https://en.wikipedia.org/wiki/Buddhist_symbolism

Used for · The riderless horse Kanthaka for the renunciation; the Bodhi tree with an empty seat; the Bodhi tree, wheel and stupa at Sanchi, Bharhut, Amaravati, Bodh Gaya and Sarnath; the white elephant of Maya's dream; human images from about the first century CE at Mathura and Gandhara

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No. · S15

Source · Wikipedia, "The unanswerable questions" (citing Majjhima Nikaya 63 and 72). https://en.wikipedia.org/wiki/The_unanswerable_questions

Used for · The ten undeclared questions of the Pali texts and the fourteen of the Sanskrit texts; the word avyakata; the reason given for not answering them

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No. · S16

Source · Wikipedia, "Sramana" (citing Monier-Williams for the word; Basham and Lochtefeld for the list of traditions; Bronkhorst for Greater Magadha). https://en.wikipedia.org/wiki/Śramaṇa

Used for · The meaning and root of shramana; the traditions counted as shramana; the Buddha leaving home as a shramana; the culture of Greater Magadha rejecting Vedic authority and rituals

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No. · S17

Source · GKToday, "Five Great Events of Buddha's Life" (first written 23 May 2013, modified 7 December 2022). https://www.gktoday.in/symbols-of-5-great-events-of-buddhas-life

Used for · The guidebook list of events and symbols: birth, lotus and bull; great departure (mahabhinishkramana), horse; enlightenment, Bodhi tree; first sermon (dharmachakra pravartana), wheel; death, stupa

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No. · S18

Source · Majjhima Nikaya 44, "Culavedalla Sutta: The Shorter Set of Questions-and-Answers", translated from the Pali by Thanissaro Bhikkhu (Access to Insight). https://www.accesstoinsight.org/tipitaka/mn/mn.044.than.html

Used for · The eightfold path under three heads: right speech, right action and right livelihood under virtue (sila); right effort, right mindfulness and right concentration under concentration (samadhi); right view and right resolve under discernment or wisdom (panna)

No. · S19

Source · Samyutta Nikaya 56.11, "Dhammacakkappavattana Sutta: Setting the Wheel of Dhamma in Motion", translated from the Pali by Thanissaro Bhikkhu (Access to Insight). https://www.accesstoinsight.org/tipitaka/sn/sn56/sn56.011.than.html

Used for · The first sermon, given at Varanasi in the game refuge at Isipatana to the group of five monks; the two extremes of sensual indulgence and self-affliction, and the middle way between them; the eight limbs of the path in order; craving in the second truth, the origination of suffering; Kondanna as the first to understand

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No. · S20

Source · Stanford Encyclopedia of Philosophy, "Buddha". https://plato.stanford.edu/entries/buddha/

Used for · Older dates of about 560 to 480 BCE, and the view of many scholars now that he died around 405 BCE; rebirth without a self that passes from life to life; intention as what counts in an action (karma); the chain of twelve links from ignorance to old age and death; the three characteristics (suffering, impermanence, non-self); the questions he declined to answer, and his reason

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No. · S21

Source · NCERT, An Introduction to Indian Art (Class XI), chapter "Arts of the Mauryan Period". https://ncert.nic.in/textbook/pdf/kefa103.pdf

Used for · The Buddha shown through symbols in the early phase of Buddhism; the Sarnath lion capital as a symbol of the dhammachakrapravartana, the first sermon; the birth, the renunciation, the enlightenment, the dhammachakrapravartana and the mahaparinibbana as the events shown in narrative art; no symbol named for the birth

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No. · S22

Source · Sarah E. Fraser, course page for Art History 240, "Introduction to Asian Art" (Northwestern University art history site). https://buddhist-art.arthistory.northwestern.edu/arthistory_240/buddhist-india-1.html

Used for · Sanchi, east gate, middle architrave: the Great Departure shown through symbols of the Buddha, an empty horse with a royal umbrella and footprints with wheels

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No. · S23

Source · Wikipedia, "Pasenadi" (citing Raychaudhuri 1972 for his succession and Upinder Singh 2016 for the marriage ties with Bimbisara). https://en.wikipedia.org/wiki/Pasenadi

Used for · Prasenajit (Pali: Pasenadi), king of Kosala with his capital at Shravasti; a lay follower of the Buddha

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No. · S24

Source · Encyclopaedia Britannica, "sila". https://www.britannica.com/topic/sila-Buddhism

Used for · Laymen observe the first five precepts at all times; the full ten precepts are normally observed only by monks or nuns, who also follow the detailed monastic rules (the patimokkha), a further elaboration of the precepts

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DAY 8 · TOPIC 72

Kandukuri Veeresalingam and social reform in Andhra

1. Concept in one line

Kandukuri Veeresalingam Pantulu (1848 to 1919) of Rajahmundry was a schoolmaster, journalist and writer who led social reform in the Telugu districts, above all the remarriage of widows and the education of women. The examination asks for his journals, the widow marriage of 1881 and the men behind it, his institutions and his books.

2. Revision notes

2.1 Life and career

- Born at Rajahmundry on 16 April 1848. Died at Madras (now Chennai) on 27 May 1919.
- He passed the Entrance (Matriculation) examination in 1870, according to the Government of India biography by D. Anjaneyulu (Publications Division, 1976). Wikipedia's page prints 1869.
- He chose teaching and turned away from clerical service under the Government.

Year	Post
1871	Junior assistant, Government District School, Rajahmundry

Year	Post
After that, for about two years	Headmaster, English school, Korangi
1874	Headmaster, Anglo-Vernacular School, Dowlaiswaram (Dhavaleswaram), near Rajahmundry. This is the place of the Godavari barrage, spelt Dowleswaram in Topic 74
1876	Junior Telugu assistant (Telugu pandit), Government School, Rajahmundry

- Later he lived for some years in Madras. He came back to Rajahmundry about 1905.
- His wife Rajyalakshmamma worked beside him; at one widow marriage she cooked for the guests herself.

Veeresalingam: reform in action

DAY 8 • TOPIC 72 • 1/5

Kandukuri Veeresalingam (1848–1919) combined teaching, journalism and literature to advance social reform in Andhra.



EDUCATION

Girls' schools and books for women.

PUBLIC DEBATE

Journals challenged harmful customs and corruption.

SOCIAL ACTION

Widow remarriage, widows' homes and reform associations.



1848
Born at Rajahmundry



1870s
Teaching and reform journalism



1881
Widow marriage at Rajahmundry



1919
Died at Madras



Rajyalakshmamma worked alongside him in the reform movement.

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DAY 8 | TOPIC 72 | 01

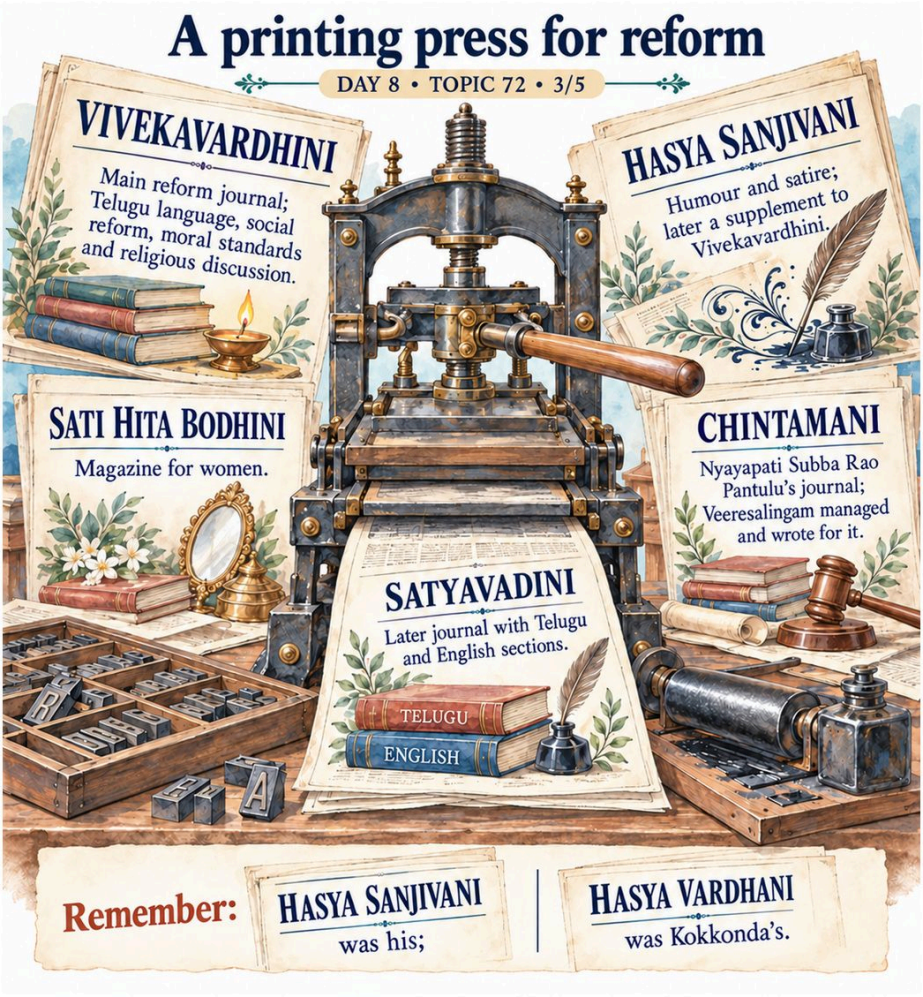
DAY 8 · TOPIC 72 · VISUAL REVISION 1

2.2 The journals he ran

Journal	What it was	Points to remember
Vivekavardhini	His main journal. He began it in 1874 as a monthly, at Dowlaiswaram	The name means "incentive to wisdom". The first issues were printed at Madras, at the press of Kokkonda Venkataratnam Pantulu's Andhra Bhasha Sanjivani. Then he set up his own press at Rajahmundry. In 1875 another paper, Vidvan Manoharini of Narasapur, merged with it. Soon after that he made it a fortnightly. It was suspended in 1890
Hasya Sanjivani	A humorous paper, started in July 1876	It was his answer to Kokkonda's humorous paper Hasya Vardhani. Later it became a supplement to Vivekavardhini
Sati Hita Bodhini (Satihitabodhini)	A magazine for women, started in 1883	Wikipedia's page calls it a monthly

Journal	What it was	Points to remember
Chintamani	A journal started in 1891 and sponsored by his friend Nyayapati Subba Rao Pantulu	It was printed at the Vivekavardhini press. Veeresalingam looked after it and wrote much of it. It was his friend's journal, not his own
Satyavadini	A journal of his later years, which came out on 1 March 1906	It had English and Telugu sections. It was as outspoken as Vivekavardhini

- **Year of Vivekavardhini:** 1874. Anjaneyulu's list of the landmarks of his life enters the start of the journal, as a monthly, under 1874. Wikipedia's page prints 1876, which is the year he went back to Rajahmundry.
- **Aims of Vivekavardhini (four):** to improve the Telugu language, to remove harmful customs, to raise moral standards and to explain true religious doctrine.
- **What it attacked:** nautch parties, the keeping of concubines, child marriage, the treatment of young widows, meaningless rituals, and bribery and irregular work in the local courts.



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DAY 8 | TOPIC 72 | 03

DAY 8 · TOPIC 72 · VISUAL REVISION 3

2.3 Social reform besides widow marriage

- **Nautch:** he attacked the parties of officials and lawyers at which professional dancing girls performed. After his campaign the patrons lost face and the custom lost respectability. It was ended later by legislation in the composite Madras State.
- **Child marriage:** he wrote against it in his journal, and his play Brahma Vivaham exposed child marriage and the marriage of young girls to old men.
- **Education of women:**
  - A girls' school at Dowlaiswaram, opened with local friends in 1874. The Government biography calls it the first of its kind in Andhra. Its headmaster was his friend Malladi Atchanna Sastri.
  - A girls' school at Innispeta in Rajahmundry, which the biography calls an important part of the town.
  - After his return about 1905, a girls' school named after Queen Victoria, in his ancestral house at Rajahmundry. It had nearly 50 pupils in the first year and about 150 in the second.
  - Books written for women: the novels Satyavati Charitra (1883) and Chandramati Charitramu (1884), and Stree Neeti Deepika ("lamp of morals for women").
  - His view: education is "as essential for women as for men".

2.4 Widow remarriage

- **Before him:** the first widow marriage in Bengal took place in 1856, largely through Ishwar Chandra Vidyasagar. The first in the Bombay Presidency took place in 1869, with the help of Mahadev Govind Ranade and others. An association started in Madras city about five years before his, with P. Chentsal Rao as secretary and

Dewan Bahadur R. Raghunatha Rao among its members, was short-lived. Anjaneyulu credits Rajahmundry with leading the way in the Madras Presidency.

- **1879:** Challapalli Bapaiah Pantulu suggested that he take up the remarriage of young widows. He gave his first lecture on it on 3 August 1879 at the Vijayanagaram Girls' School, Rajahmundry, and the second on 17 October 1879. At Kakinada opponents threw stones.
- **The Association:** with trusted friends he formed the Widow Remarriage Association (Stree Punarvivaha Samajam), probably the first body of its kind in Andhra. Anjaneyulu's list of the landmarks of his life enters its formation at Rajahmundry under 1880.
- **The marriages:** the first was performed at Rajahmundry on 11 December 1881. The second followed four days later and the third on 22 October 1882. On the third, Vidyasagar wrote from Calcutta to congratulate him. By the middle of 1884 he had completed ten marriages, two of them of Vaisya couples. Each cost at least Rs 1,000.

Person	Who he was	Part he played
Paida Ramakrishnayya (Pydah Ramakrishnaiah)	Merchant of Kakinada	He gave the money. Of the Rs 30,000 he promised, he gave Rs 10,000, then Rs 10,000 more, and left the last Rs 10,000 as a trust by his will. He died in 1886
Atmuri Lakshmi Narasimham	District Munsiff	He took a keen interest in the movement

Person	Who he was	Part he played
Basavaraju Gavarraju	Close friend, who had started an Association for Social Reform	He was Veeresalingam's "right-hand man" and a member of the Widow Remarriage Association. He died suddenly within two years of the marriages of 1884
Gogulapati Sriramulu	Bridegroom of the first marriage	He married the widow at Rajahmundry on 11 December 1881

- **Opposition:** the Sankaracharya of the Virupaksha Pitham sent letters of excommunication to disciples who had taken part. The orthodox, led by heads of maths, and the officials exposed in Vivekavardhini both bore him a grudge. After Gavarraju and Ramakrishnayya died, the Association was not very active for some years.
- **Widows' homes:** in Madras he first sheltered young widows in his own house, and then built a widows' home with a hostel and school on the outskirts of the city, out of his savings and donations. At Rajahmundry the Widows' Home became one of the institutions of the Hitakarini Samaj. When running the home left him in debt, the Maharaja of Pithapuram gave Rs 3,000 and a grant of Rs 60 a month, through Raghupati Venkataratnam Naidu.
- The law on widow remarriage is taken up in Topic 911.

The widow remarriage movement

DAY 8 • TOPIC 72 • 2/5



Veeresalingam organised the marriage;
Gogulapati Sriramulu was the bridegroom.



Paida Ramakrishnayya
Kakinada merchant;
financial support.



Atmuri Lakshmi Narasimham
District Munsiff;
supported the movement.

REFORM NEEDED
A NETWORK



Basavaraju Gavarraju
Close associate and organiser.



Gogulapati Sriramulu
Bridegroom at the first marriage.

A CHRONOLOGY OF THE MOVEMENT



1879 —
Public lectures →



1881 —
First marriage; second four days later →



1884 —
Ten marriages completed by mid-year

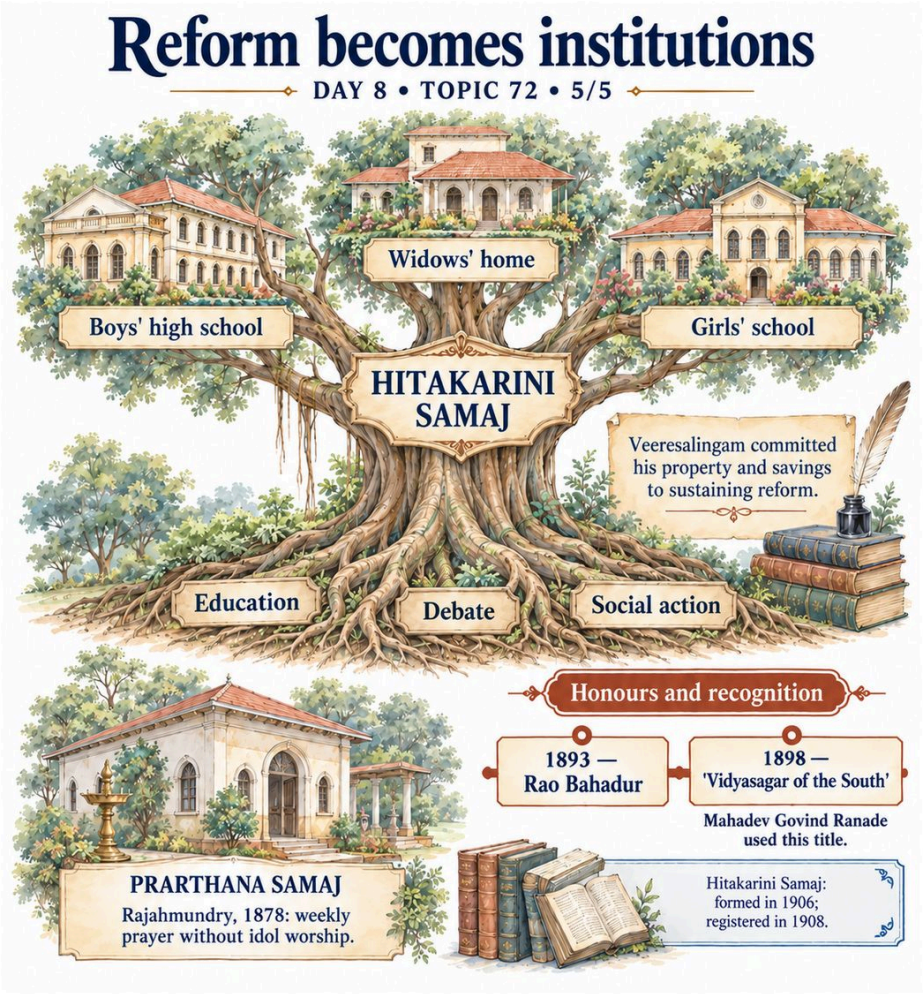
Earlier widow marriages had occurred in Bengal (1856) and the Bombay Presidency (1869).

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DAY 8 | TOPIC 72 | 02

2.5 Religion and institutions

- **Prarthana Samaj, Rajahmundry (1878):** about half a dozen young men formed it at his house. They met every week for prayer without idol worship. A visit by Pandit Sivanath Sastri of Calcutta in 1881 revived it. In 1897 a building for the Samaj and its library, put up at his own cost next to the town hall, was opened by Raghupati Venkataratnam Naidu. Wikipedia's page speaks of a Brahmo Mandir built at Rajahmundry in 1887.
- **Brahmo:** in Madras he was elected President of the South Indian Brahmo Samaj and of the Social Reform Society. In February 1906 he declared himself an Anushthanic Brahmo, that is, one who follows Brahmo rites in practice.
- **Town hall, Rajahmundry:** opened in October 1890 through his efforts, and "reputedly the first of its kind in the Andhra districts". He refused to have it named after himself.
- **Hitakarini Samaj:** formed in the middle of December 1906 and registered in 1908 (Anjaneyulu). It held three institutions: the Theistic High School for Boys (later the Veeresalingam High School), the Widows' Home, and a Lower Secondary School for Girls. When it was registered in 1908, he made a trust of his ancestral property and his life's savings, together worth more than Rs 40,000. Wikipedia's page gives 1908 for the Hitakarini school. The Samaj later published his works.



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DAY 8 | TOPIC 72 | 05

DAY 8 · TOPIC 72 · VISUAL REVISION 5

2.6 Literary work

Work	Kind	Points to remember
Rajasekhara Charitramu	Novel	It ran as a serial in 1878 and came out as a book in 1880. It was inspired by Oliver Goldsmith's The Vicar of Wakefield. The English translation, by the Rev. Hutchinson, is called Fortune's Wheel; The Times of London reviewed it in 1887
The travels of Satya Raja	Satire	It has two parts: Part I, Adumalayalamu, depicts an imaginary women-ruled land where women hold public offices; Part II is Lanka Dweepam
Prahasanams	Prose farces	He used them to reform wrongdoers through ridicule

Work	Kind	Points to remember
Plays	Three groups	Adaptations from English; translations from Sanskrit, such as Malavikagnimitram and Ratnavali; original mythological plays, such as Prahlada Natakam and Dakshina Gograhanam
Sweeya Charitramu	Autobiography	Two volumes, written from 1910 to 1913
Andhra Kavula Charitramu	Lives of the Telugu poets	Three parts: early poets from Nannayya (about 40), middle poets from Krishnadevaraya (about 60), modern poets (about 140). He published the first part in 1897

- **The first Telugu novel?** Rajasekhara Charitramu is usually described as the first Telugu novel (Sisir Kumar Das, Sahitya Akademi). Anjaneyulu notes two rival claimants: Kokkonda Venkataratnam's Mahasweta and Sri Ranga Raja Charitra (1872).
- Andhra Kavula Charitramu is "a history of Telugu literature, though the author dealt more with the lives of the poets than their poetry" (K. M. George, Sahitya Akademi).
- He wrote over a hundred volumes: essays, science books, and lives of Ram Mohun Roy and Vidyasagar among them.

- **Prose:** he is known as "Gadya Tikkana", the Tikkana of prose. He wrote some works in the classical (granthika) language so that scholars would accept them, but he argued for books in the spoken idiom.
- Popular lists call him the first Telugu novelist, autobiographer, historian of the poets and translator of science books. For the novel, remember the rival claimants.

Books that challenged society

DAY 8 • TOPIC 72 • 4/5

RAJASEKHARA CHARITRAMU

1878: serial → 1880: book

Inspired by
The Vicar of Wakefield.

English translation:
Fortune's Wheel.

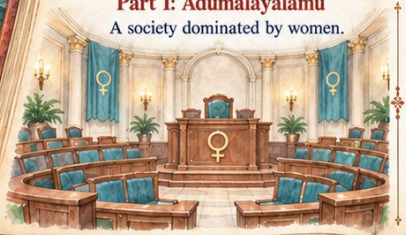
A landmark Telugu novel; claims to being 'first' have rivals.



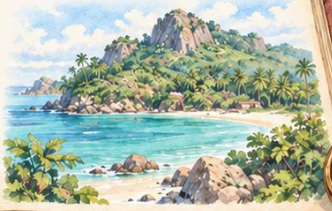
SATYARAJA PURVADESA YATRALU

Part I: Adumalayalamu

A society dominated by women.



Part II: Lanka Dweepamu



BRAHMA VIVAHAM

Play exposing child marriage and marriages of young girls to old men.



SWEEYA CHARITRAMU

Autobiography in two volumes, written 1910–1913.



Gadya Tikkana: a title honouring his Telugu prose.

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DAY 8 | TOPIC 72 | 04

DAY 8 · TOPIC 72 · VISUAL REVISION 4

2.7 Honours and names

- **Rao Bahadur:** the Government gave him this title in the New Year honours of 1893. It was rare for a schoolmaster, a poor Telugu pandit.
- **"The Vidyasagar of the South":** Ranade's words in 1898, when the Indian Social Conference met at Madras along with the session of the Indian National Congress.
- Wikipedia's page calls him the father of the Telugu renaissance movement. A 25 paise postage stamp was issued in his honour in 1974.

2.8 Reform in Andhra around him

- Brahmo ideas came to the Telugu districts from Bengal. Veeresalingam's own first contact with them, in 1867, was through the speeches of Keshub Chandra Sen. The Prarthana Samaj of 1878 at Rajahmundry and the South Indian Brahmo Samaj at Madras carried them.
- When he took up widow remarriage in 1879, the journals Purushartha Pradayini of Machilipatnam and Tattva Bodhini were in favour of open discussion of it.
- Raghupati Venkataratnam Naidu and Gurajada Apparao come in Topic 881, the Brahmo Samaj and Ram Mohun Roy in Topic 191, and Phule and Narayana Guru in Topic 501.

3. Extra section: chronology of Veeresalingam's life and work

Year	Event
1848	Born at Rajahmundry on 16 April
1870	Passes the Entrance (Matriculation) examination (1869 on Wikipedia's page)
1871	Begins teaching at the Government District School, Rajahmundry; then goes to Korangi as headmaster
1874	Headmaster at Dowlaiswaram; begins Vivekavardhini as a monthly and opens a girls' school there
1875	Vidvan Manoharini merges with Vivekavardhini
1876	Hasya Sanjivani starts in July; he returns to Rajahmundry as Telugu pandit
1878	Prarthana Samaj formed at his house; Rajasekhara Charitramu begins as a serial
1879	Lectures on widow remarriage on 3 August and 17 October
1880	Rajasekhara Charitramu comes out as a book

Year	Event
1881	Sivanath Sastri visits Rajahmundry; first widow marriage on 11 December, the second four days later
1882	Third widow marriage on 22 October
1883	Sati Hita Bodhini, a magazine for women, started
1884	Ten widow marriages completed by the middle of the year
1886	Paida Ramakrishnayya dies
1890	Vivekavardhini suspended; town hall opened in October
1891	Chintamani started; he looks after it for Nyayapati Subba Rao Pantulu
1893	Rao Bahadur in the New Year honours
1897	Building for the Prarthana Samaj opened; first part of Andhra Kavula Charitramu published
1898	Ranade calls him "the Vidyasagar of the South"
About 1905	Returns from Madras to Rajahmundry

Year	Event
1906	Declares himself an Anushthanic Brahmo in February; Satyavadini comes out on 1 March; Hitakarini Samaj formed in the middle of December
1908	Hitakarini Samaj registered; he makes a trust of his property and savings
1910 to 1913	Writes Sweeya Charitramu in two volumes
1919	Dies at Madras on 27 May

4. Three common exam traps

1. **"He performed the first widow marriage in India."** He did not. Widow marriages had taken place in Bengal in 1856 and in the Bombay Presidency in 1869. His was performed in December 1881, and the place was Rajahmundry, not Dowlaiswaram and not Madras. His claim is that Rajahmundry led the way in the Madras Presidency.
2. **Journals with look-alike names.** Hasya Sanjivani was his paper; Hasya Vardhani was the paper of his rival Kokkonda Venkataratnam Pantulu. Andhra Bhasha Sanjivani was also Kokkonda's, and Vivekavardhini was first printed at its press. Chintamani was the journal of Nyayapati Subba Rao Pantulu; Veeresalingam looked after it, but it was not his own.

3. **One event, two years.** Rajasekhara Charitramu is 1878 as a serial and 1880 as a book. Vivekavardhini began as a monthly at Dowlaiswaram in 1874; Wikipedia's page prints 1876, the year he went back to Rajahmundry. A statement that fixes a single year for such an event has to be read with care.

7. Sources

7.1 Sources

No. · S1

Source · D. Anjaneyulu, Kandukuri Veeresalingam (Builders of Modern India series), Publications Division, Ministry of Information and Broadcasting, Government of India, November 1976; Internet Archive scan and its full-text search. Chapters II to XV and the appendices, among them the list "Landmarks in the Life of Veeresalingam". https://archive.org/details/kandukuriveeresa00anja ; https://archive.org/stream/kandukuriveeresa00anja/kandukuriveeresa00anja_djvu.txt

Used for · Birth at Rajahmundry on 16 April 1848; death at Madras on 27 May 1919; Entrance examination in 1870; choice of teaching; posts of 1871, Korangi, 1874 and 1876; Rajyalakshmamma's part; Vivekavardhini (started as a monthly in 1874, meaning of the name, printing at the Andhra Bhasha Sanjivani press, own press, merger of Vidvan Manoharini in 1875, later a fortnightly, four aims, targets, suspension in 1890); Hasya Sanjivani (July 1876) and Hasya Vardhani; Sati Hita Bodhini as a magazine for women, started in 1883; Chintamani (1891, Nyayapati Subba Rao Pantulu); Satyavadini (1 March 1906); nautch and its later ending by legislation; Brahma Vivaham; girls' schools at Dowlaiswaram (1874, "the first of its kind in Andhra"), Innispeta and in his ancestral house, with pupil numbers; books for women with years; view on women's education; widow marriages in Bengal (1856) and Bombay (1869); the Madras association; Rajahmundry as forerunner; Challapalli Bapaiah Pantulu; lectures of 3 August and 17 October 1879; stones at Kakinada; Widow Remarriage Association and Stree Punarvivaha Samajam (formation at Rajahmundry entered under 1880 in the Landmarks list); first marriage on 11 December 1881 and the bridegroom Gogulapati Sriramulu; second marriage four days later; third on 22 October 1882 and Vidyasagar's letter; ten marriages by the middle of 1884; cost of each; Pydah Ramakrishnaiah's gifts, will and death in 1886; Atmuri Lakshmi Narasimham as District Munsiff; Basavaraju Gavarraju; the Sankaracharya's letters of excommunication; the two groups of opponents; widows' homes at Madras and Rajahmundry; the Maharaja of Pithapuram's gift; Prarthana Samaj

of 1878, Sivanath Sastri's visit in 1881 and the building of 1897; South Indian Brahmo Samaj and Social Reform Society at Madras; Anushthanic Brahmo in February 1906; town hall of October 1890; Hitakarini Samaj (mid-December 1906, registered 1908, three institutions, the trust of his property and savings of over Rs 40,000, later editions of his works); Rajasekhara Charitramu (1878, 1880, The Vicar of Wakefield, Fortune's Wheel, The Times in 1887, rival claimants); the travels of Satya Raja and Lanka Dweepam; prahasanams; three groups of plays and their titles; Sweeya Charitramu (two volumes, 1910 to 1913); over a hundred volumes; essays, science books and biographies; classical and spoken language; Rao Bahadur in the New Year honours of 1893; Ranade's words in 1898; return to Rajahmundry about 1905; his first contact with Brahmo ideas through the speeches of Keshub Chandra Sen (1867); Purushartha Pradayini and Tattva Bodhini

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No. · S2

Source · Wikipedia, "Kandukuri Veeresalingam" (citing Sisir Kumar Das, A History of Indian Literature 1800-1910: Western Impact, Indian Response, Sahitya Akademi, 1991, pp. 209-210, for the novel; and S. R. Vepachedu, "Kandukuri Veeresalingam, Father of Andhra Renaissance", for the widow marriage, the title of 1893 and "Gadya Tikkana"). https://en.wikipedia.org/wiki/Kandukuri_Veeresalingam

Used for · Death at Madras on 27 May 1919 (agreeing with S1); matriculation in 1869; Satihitabodhini as a monthly for women; Vivekavardhini dated 1876; Brahmo Mandir at Rajahmundry in 1887; Hitakarini school in 1908; Rajasekhara Charitramu described as the first Telugu novel; "Gadya Tikkana"; father of the Telugu renaissance movement; postage stamp of 25 paise in 1974; first widow marriage on 11 December 1881 and Rao Bahadur in 1893 (agreeing with S1)

No. · S3

Source · Wikipedia, "Andhra Kavula Charitramu" (citing K. M. George, Modern Indian Literature, an Anthology: Surveys and Poems, Sahitya Akademi, 1992, p. 403, and the Hitakarini Samajam editions of the work). https://en.wikipedia.org/wiki/Andhra_Kavula_Charitramu

Used for · Three parts of Andhra Kavula Charitramu and the number of poets in each; first part published by the author in 1897; K. M. George's description of the work; publication by the Hitakarini Samajam

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No. · S4

Source · eSamskriti, "Kandukuri Veeresalingam Pantulu" (a popular essay). https://www.esamskriti.com/essays/textfile/11_3733_4843.txt

Used for · The popular list of his "firsts" (novelist, autobiographer, historian of the poets, translator of science books)

No. · S5

Source · Wikipedia, "Rajasekhara Charitramu" (citing the translation itself: K. Veeresalingam, Fortune's Wheel, Elliot Stock, 1887; and M. K. Bhatnagar, Encyclopaedia of Literature in English, Atlantic Publishers, 2001, p. 742, for the link with Goldsmith). https://en.wikipedia.org/wiki/Rajasekhara_Charitramu

Used for · The English translation Fortune's Wheel (1887); serial in 1878 and book in 1880; The Vicar of Wakefield as the model; Sri Ranga Raja Charitra (1872) as an earlier Telugu novel

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No. · S6

Source · Kandukuri Veeresalingam, Satyaraja Purvadesa Yatralu, Part I, Adumalayalamu (primary text). https://te.wikisource.org/wiki/కందుకూరి_వీరేశలింగకృత_గ్రంథములు/సత్యరాజా_పూర్వదేశ_యాత్రలు-ప్రథమభాగము

Used for · Part I is Adumalayalamu; the women-ruled imaginary land belongs to this part

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Right to Equality: Articles 14 to 18

1. Concept in one line

Articles 14 to 18 of the Constitution form the Right to Equality: equality before the law, no discrimination on named grounds, equal opportunity in public employment, and the abolition of untouchability and of titles. The examination asks for the exact words and grounds of each clause, the amendment that inserted each special provision, and the leading judgments.

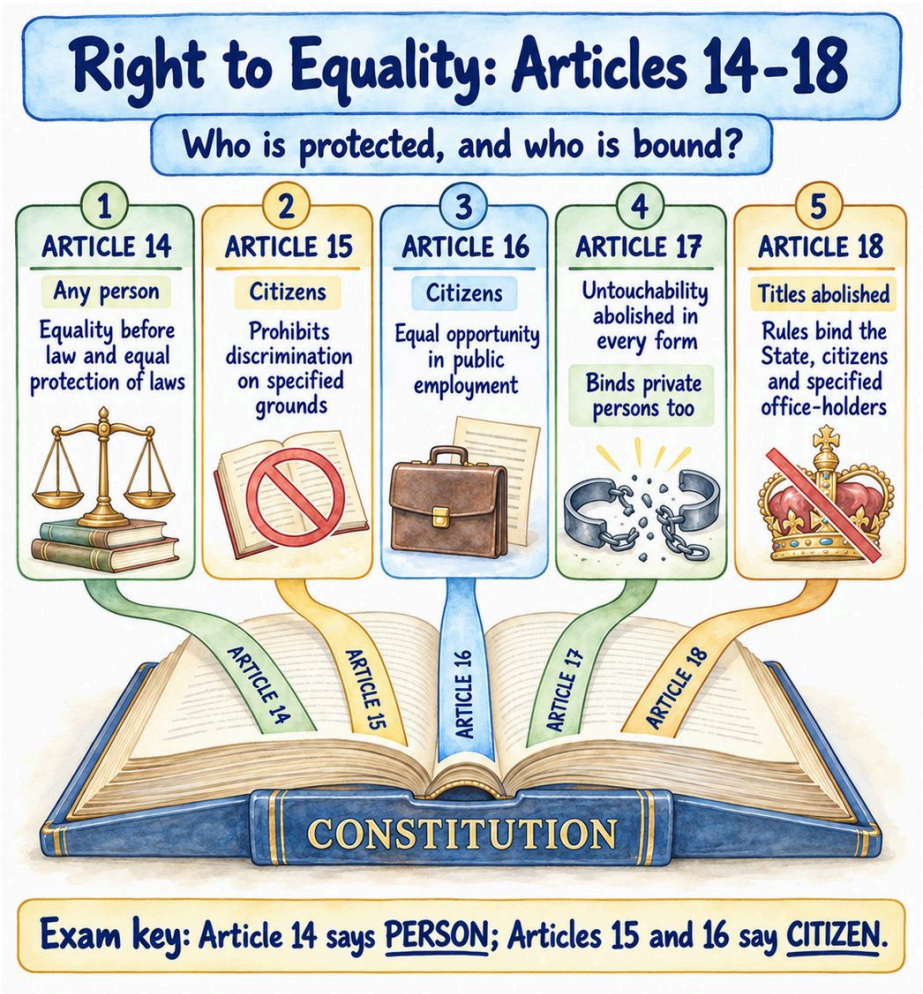
2. Revision notes

2.1 The five Articles at a glance

- In Part III the sub-heading "Right to Equality" stands above Article 14; the right runs from Article 14 to Article 18 (Topics 42 and 62). The wording below is that of the official text "as on 1st May, 2024" (Topic 42).
- "The State" in these Articles has the meaning that Article 12 gives it (Topic 62).

Article	Marginal heading	Whom the words name
14	Equality before law	"any person"

Article	Marginal heading	Whom the words name
15	Prohibition of discrimination on grounds of religion, race, caste, sex or place of birth	"any citizen"
16	Equality of opportunity in matters of public employment	"all citizens"
17	Abolition of Untouchability	No one is named: the practice is forbidden "in any form"
18	Abolition of titles	The State, citizens of India, and persons holding an office of profit or trust under the State (2.7)



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2.2 Article 14: the text and its two phrases

> The State shall not deny to any person equality before the law or the equal protection of the laws within the territory of India.

- **"any person":** the Article is not limited to citizens. In Basheshar Nath (decided on 19 November 1958; Topic 62) Chief Justice S.R. Das said that its object is "to secure to all persons, citizen or non-citizens, the equality of status and of opportunity referred to in the glorious preamble of our Constitution". He added: "The command of the Article is directed to the State."
- **Where the two phrases come from:** the same judgment says that Article 14 "combines the English doctrine of the rule of law and the equal protection clause of the 14th Amendment to the American Federal Constitution".

Phrase in Article 14	What the Supreme Court links it with	What follows from it
"equality before the law"	The English doctrine of the rule of law	In E.P. Royappa the Court placed equality with "the rule of law in a republic" and arbitrariness with "the whim and caprice of an absolute monarch"

Phrase in Article 14	What the Supreme Court links it with	What follows from it
"the equal protection of the laws"	The equal protection clause of the 14th Amendment to the Constitution of the United States	The law need not be the same for everybody, but the State may treat people differently only on a reasonable classification (2.3)

2.3 Article 14: reasonable classification, arbitrariness, and the usual exceptions

- Article 14 "forbids class legislation", but "it does not forbid reasonable classification for the purpose of legislation". The words are from D.S. Nakara v. Union of India (17 December 1982, five judges), which restates the settled rule.
- A classification must fulfil two conditions, both of them. The leading case that Nakara cites for them is Shri Ram Krishna Dalmia v. Shri Justice S.R. Tendolkar, reported in the Supreme Court Reports of 1959.

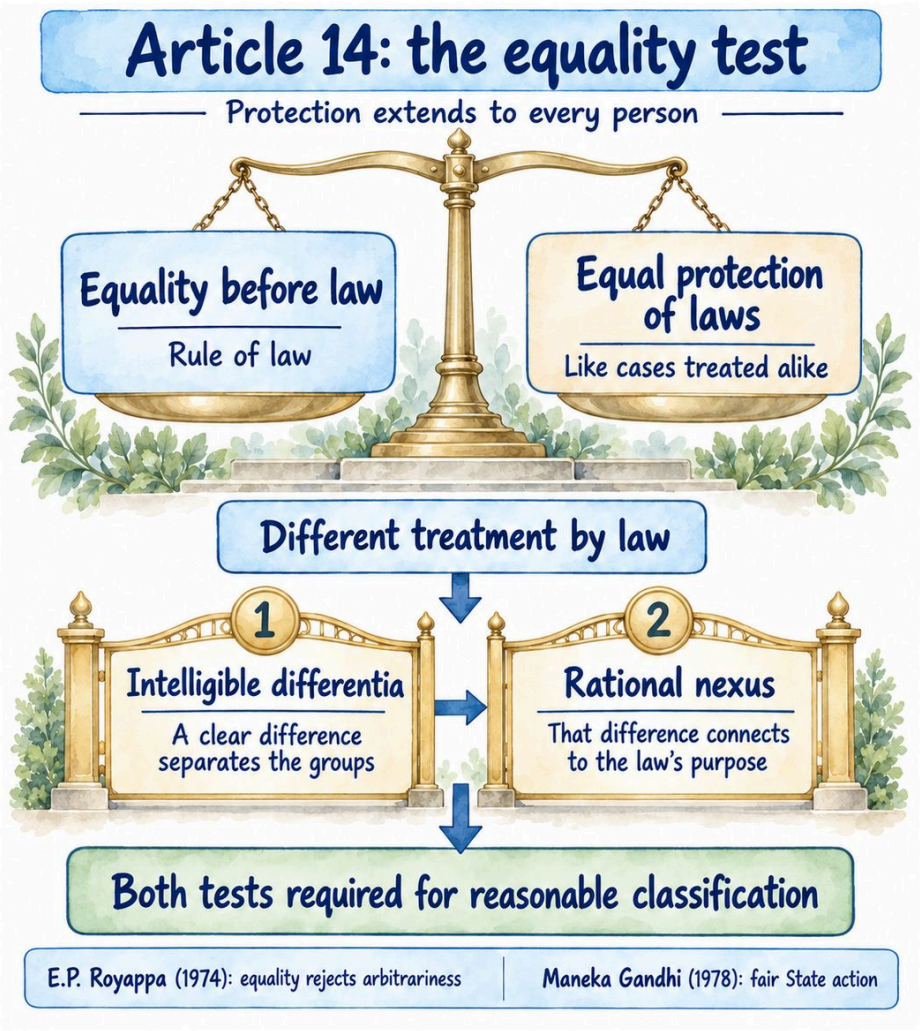
Condition	Words of the Court	In plain words
First	"the classification must be founded on an intelligible differentia which distinguishes persons or things that are grouped together from those that are left out of the group"	There must be a clear difference, one that can be understood, between those put in the group and those left out

Condition	Words of the Court	In plain words
Second	"that differentia must have a rational relation to the objects sought to be achieved by the statute in question"	That difference must be connected with the purpose of the law

- **Arbitrariness as the opposite of equality.** In E.P. Royappa v. State of Tamil Nadu (reported in 1974) the Court said: "From a positivistic point of view, equality is antithetic to arbitrariness." It called the two "sworn enemies". Maneka Gandhi v. Union of India (25 January 1978, seven judges) applied Royappa; Justice Bhagwati wrote there: "Article 14 strikes at arbitrariness in State action and ensures fairness and equality of treatment."
- **Provisions usually listed as exceptions to Article 14 include these four:**

Provision	What it says
Article 361	The President, or the Governor of a State, "shall not be answerable to any court for the exercise and performance of the powers and duties of his office". No criminal proceedings can be instituted or continued against either of them "during his term of office" (Topic 4)

Provision	What it says
Article 105	"No member of Parliament shall be liable to any proceedings in any court in respect of anything said or any vote given by him in Parliament or any committee thereof"
Article 194	"No member of the Legislature of a State shall be liable to any proceedings in any court in respect of anything said or any vote given by him in the Legislature or any committee thereof". It gives the members of a State Legislature the protection that Article 105 gives the members of Parliament
Article 31C	The protection is for a law giving effect to "the principles specified in clause (b) or clause (c) of article 39": such a law shall not "be deemed to be void on the ground that it is inconsistent with, or takes away or abridges any of the rights conferred by article 14 or article 19". The 42nd Amendment Act, 1976 widened this to "all or any of the principles laid down in Part IV", and the official text still prints those wider words. But a footnote of the official text records that the Supreme Court declared that section of the 42nd Amendment Act invalid in Minerva Mills, reported in 1980 (Topic 754)



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2.4 Article 15, clause by clause

Clause	What it says	Point to remember
(1)	The State shall not discriminate against any citizen "on grounds only of religion, race, caste, sex, place of birth or any of them"	Five grounds. Note the word "only"
(2)	On the same grounds, no citizen shall be subject to any disability, liability, restriction or condition with regard to (a) "access to shops, public restaurants, hotels and places of public entertainment", or (b) "the use of wells, tanks, bathing ghats, roads and places of public resort" maintained wholly or partly out of State funds or dedicated to the use of the general public	Unlike clause (1), it is not worded as a command to the State alone
(3)	The State may make "any special provision for women and children"	No footnote in the official text: it has stood since 1950

Clause	What it says	Point to remember
(4)	The State may make any special provision "for the advancement of any socially and educationally backward classes of citizens or for the Scheduled Castes and the Scheduled Tribes"	Added by the First Amendment Act, 1951, in force from 18 June 1951, soon after Champakam Dorairajan (Section 3)
(5)	For the same classes the State may make special provision "by law" on "their admission to educational institutions including private educational institutions, whether aided or unaided by the State". The minority educational institutions of Article 30(1) are kept out	Inserted by the 93rd Amendment Act, 2005, in force from 20 January 2006

Clause	What it says	Point to remember
(6)	The State may make special provision, including in admission to educational institutions, for "any economically weaker sections of citizens other than the classes mentioned in clauses (4) and (5)". Reservation under it is "in addition to the existing reservations and subject to a maximum of ten per cent. of the total seats in each category"	Inserted by the 103rd Amendment Act, 2019, in force from 14 January 2019

- **Explanation below clause (6):** for Articles 15 and 16, "economically weaker sections" (EWS) are such as the State notifies from time to time "on the basis of family income and other indicators of economic disadvantage".

2.5 Article 16, clause by clause

Clause	What it says	Point to remember
(1)	"There shall be equality of opportunity for all citizens in matters relating to employment or appointment to any office under the State."	It covers employment or office under the State, not private employment
(2)	No citizen shall, "on grounds only of religion, race, caste, sex, descent, place of birth, residence or any of them", be ineligible for, or discriminated against in respect of, any employment or office under the State	Seven grounds: the five of Article 15, and descent and residence

Clause	What it says	Point to remember
(3)	Parliament may by law prescribe, for a class or classes of employment under a State or Union territory, or under a local or other authority within it, "any requirement as to residence within that State or Union territory"	Only Parliament: under Article 35 the Legislature of a State "shall not have" this power. Parliament made the Public Employment (Requirement as to Residence) Act, 1957. It repealed the existing laws that required residence, and allowed such a requirement only for certain posts in certain areas, for a limited period (Topic 904)
(4)	The State may make "any provision for the reservation of appointments or posts in favour of any backward class of citizens which, in the opinion of the State, is not adequately represented in the services under the State"	No footnote in the official text: it has stood since 1950

Clause	What it says	Point to remember
(4A)	The State may make provision "for reservation in matters of promotion, with consequential seniority", in favour of the Scheduled Castes and the Scheduled Tribes which, in its opinion, are not adequately represented in the services	Inserted by the 77th Amendment Act, 1995, in force from 17 June 1995. The 85th Amendment Act, 2001 changed its words to bring in consequential seniority, with retrospective effect from 17 June 1995
(4B)	The State may treat the unfilled vacancies of a year, reserved under clause (4) or clause (4A), "as a separate class of vacancies to be filled up in any succeeding year or years". They are not counted with the vacancies of that later year "for determining the ceiling of fifty per cent. reservation"	Inserted by the 81st Amendment Act, 2000, in force from 9 June 2000

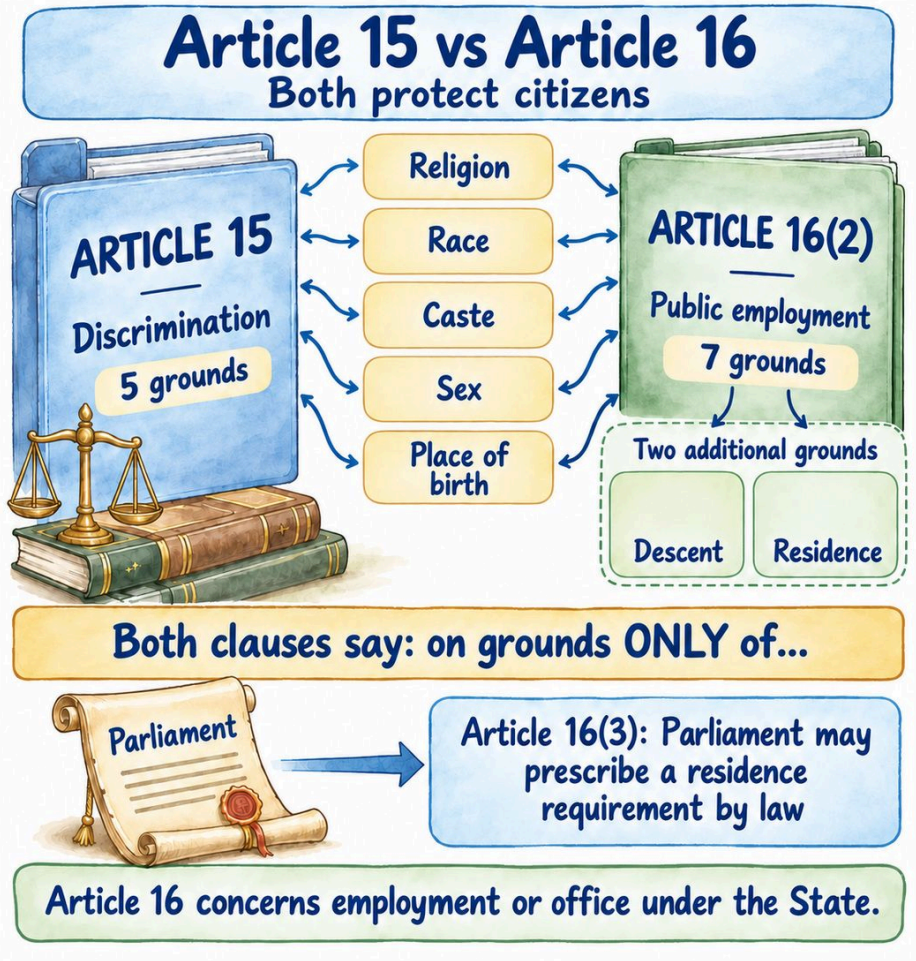
Clause	What it says	Point to remember
(5)	A law may require the holder of an office "in connection with the affairs of any religious or denominational institution", or a member of its governing body, to profess a particular religion or to belong to a particular denomination	Such a law is saved from the rest of the Article
(6)	The State may reserve appointments or posts for "any economically weaker sections of citizens other than the classes mentioned in clause (4)", "in addition to the existing reservation and subject to a maximum of ten per cent. of the posts in each category"	Inserted by the same 103rd Amendment Act, 2019, in force from 14 January 2019

Article 15 and Article 16 compared:

Point	Article 15	Article 16
Grounds	Five	Seven

Point	Article 15	Article 16
Words of the enabling clauses	"special provision"	"reservation of appointments or posts"
Backward classes, as worded in clause (4)	"socially and educationally backward classes of citizens", with the Scheduled Castes and the Scheduled Tribes	"any backward class of citizens" which is not adequately represented in the services under the State
EWS: the ceiling of 10 per cent	Of the total seats in each category	Of the posts in each category

- The leading judgments on these two Articles, and the amendments that answered them, are set out in order of time in Section 3.



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2.6 Article 17: abolition of untouchability

> "Untouchability" is abolished and its practice in any form is forbidden. The enforcement of any disability arising out of "Untouchability" shall be an offence punishable in accordance with law.

- The Article puts the word in quotation marks and does not define it.
- **It binds private persons too.** In People's Union for Democratic Rights v. Union of India (18 September 1982) the Court said: "there are certain fundamental rights conferred by the Constitution which are enforceable against the whole world and they are to be found inter alia in Articles 17, 23 and 24" (Topic 673; see also Topic 62).
- **Who makes the law that punishes:** under Article 35, Parliament, and not the Legislature of a State, has the power to make laws "for prescribing punishment for those acts which are declared to be offences under this Part".

Act of Parliament	What to remember
Protection of Civil Rights Act, 1955	It was enacted and notified on 8 May 1955 as the Untouchability (Offences) Act, and it came into force on 1 June 1955. It was renamed the Protection of Civil Rights Act, 1955 in the year 1976

Act of Parliament	What to remember
Scheduled Castes and the Scheduled Tribes (Prevention of Atrocities) Act, 1989	It aims to prevent offences of atrocities against members of the Scheduled Castes and the Scheduled Tribes. It provides for Special Courts to try such offences, and for the relief and rehabilitation of the victims

- The State Governments and the Union Territory Administrations are responsible for implementing both Acts.

2.7 Article 18: abolition of titles

Clause · (1)

Who is bound · The State

What is barred · Conferring any title, "not being a military or academic distinction"

Does the President's consent lift the bar? · No. Military and academic distinctions are simply outside the bar

Clause · (2)

Who is bound · A citizen of India

What is barred · Accepting "any title from any foreign State"

Does the President's consent lift the bar? · No. The clause makes no mention of consent

Clause · (3)

Who is bound · A person who is not a citizen of India, "while he holds any office of profit or trust under the State"

What is barred · Accepting any title from any foreign State

Does the President's consent lift the bar? · Yes. The bar is on accepting it "without the consent of the President"

Clause · (4)

Who is bound · Any person "holding any office of profit or trust under the State"

What is barred · Accepting "any present, emolument, or office of any kind from or under any foreign State"

Does the President's consent lift the bar? · Yes. Here too the bar is on accepting it "without the consent of the President"

Balaji Raghavan v. Union of India (15 December 1995, five judges; also cited by its law report of 1996):

- The question was whether the Bharat Ratna, the Padma Vibhushan, the Padma Bhushan and the Padma Shri are "titles" within Article 18(1). The Court held that these National Awards "do not amount to 'titles' within the meaning of Article 18(1)".
- They should not be used as suffixes or prefixes to the name. If that is done, "the defaulter should forfeit the National Award conferred on him or her".
- It was submitted to the Court that the words on military and academic distinctions had been used "by way of abundant caution". The judgment records this as an argument of counsel, not as the Court's own finding.

- The National Awards were formally instituted in January 1954, cancelled on 8 August 1977 and revived on 25 January 1980.

Article 18: titles and consent

Read the person, item and clause together

18(1) • The State

Cannot confer titles



Military and academic distinctions are excluded



18(2) • Indian citizen

Cannot accept a foreign-State title

No presidential-consent exception



18(3) • Non-citizen in an office of profit or trust under the State

Foreign-State title requires the President's consent



18(4) • Any holder of an office of profit or trust under the State

Foreign-State present, emolument or office requires the President's consent



Present



Emolument



Office



Bharat Ratna and Padma awards are not titles

Do not use them as a name's prefix or suffix

Balaji Raghavan (1995)

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DAY 8 | TOPIC 73 | 05

3. Extra section: judgments and amendments on Articles 15 and 16 in order of time, 1951 to 2024

Year	Judgment or amendment	What to remember
1951	State of Madras v. Champakam Dorairajan; 9 April 1951; seven judges	A Communal G.O. (Government Order) of Madras apportioned the seats in medical and engineering colleges among communities. The Court held it inconsistent with Article 29(2) and void under Article 13. It did not find it necessary to consider Articles 14 and 15
1951	First Amendment	Soon after that decision, Parliament inserted clause (4) in Article 15, in force from 18 June 1951

Year	Judgment or amendment	What to remember
1963	M.R. Balaji v. State of Mysore (the year is that of the law report)	The case was on Article 15(4). The Court said: "Speaking generally and in a broad way, a special provision should be less than 50%; how much less than 50% would depend upon the relevant prevailing circumstances in each case."

Year	Judgment or amendment	What to remember
1992	Indra Sawhney v. Union of India; 16 November 1992; nine judges	An Office Memorandum of 13 August 1990 had reserved 27 per cent of the vacancies in civil posts and services under the Government of India for the socially and educationally backward classes. The Court upheld it. Three rules: (i) reservations should not exceed 50 per cent, a rule treated as binding; (ii) the "creamy layer", the socially advanced section of a backward class, is kept out, and it is not identified by income alone; (iii) reservation under Article 16(4) "is confined to initial appointment and cannot extend to reservation in the matter of promotion", in the words in which M. Nagaraj later described this judgment

Year	Judgment or amendment	What to remember
1995	77th Amendment	Clause (4A) inserted in Article 16, in force from 17 June 1995
2000	81st Amendment	Clause (4B) inserted in Article 16, in force from 9 June 2000
2001	85th Amendment	The words of clause (4A) changed, with effect from 17 June 1995
2006	93rd Amendment Act, 2005	In force from 20 January 2006: clause (5) inserted in Article 15

Year	Judgment or amendment	What to remember
2006	M. Nagaraj v. Union of India; 19 October 2006; five judges	The amendments behind clauses (4A) and (4B) were challenged. The Court upheld them. It also said that an enabling provision may be valid and yet its exercise by the State in a given case may be arbitrary. Before reserving promotions the State must show, with quantifiable data, (i) the backwardness of the class, (ii) its inadequate representation, and (iii) that administrative efficiency is maintained

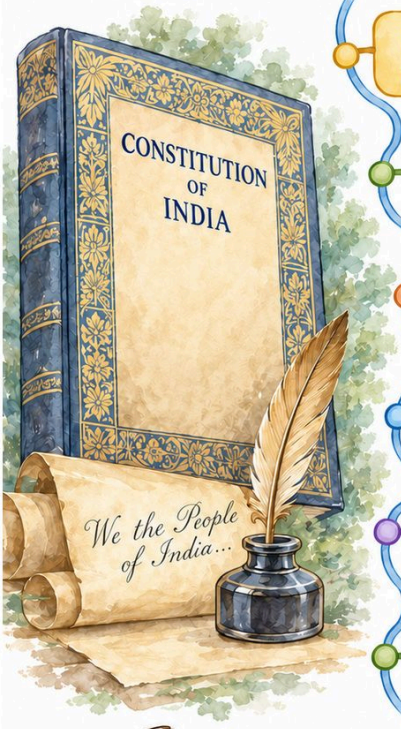
Year	Judgment or amendment	What to remember
2018	Jarnail Singh v. Lachhmi Narain Gupta; 26 September 2018; five judges, unanimous	Nagaraj need not go to a larger Bench of seven judges. But its condition on data to show the backwardness of the Scheduled Castes and the Scheduled Tribes is contrary to Indra Sawhney; the condition on inadequate representation stands. In reservation in promotions, the creamy layer exclusion extends to the Scheduled Castes and the Scheduled Tribes
2019	103rd Amendment	The President's assent on 12 January 2019; in force from 14 January 2019: clause (6) inserted in Article 15 and clause (6) in Article 16

Year	Judgment or amendment	What to remember
2022	Janhit Abhiyan v. Union of India; 7 November 2022; five judges, 3 to 2	The 103rd Amendment and the EWS reservations are constitutionally valid. Justice S.R. Bhat dissented, and Chief Justice U.U. Lalit joined him. A review petition was dismissed on 9 May 2023

Year	Judgment or amendment	What to remember
2024	State of Punjab v. Davinder Singh; 1 August 2024; seven judges, 6 to 1	Sub-classification within the Scheduled Caste and Scheduled Tribe categories is permissible, and the States have the power to make it. E.V. Chinnaiah (2004) had ruled that sub-classification within the Scheduled Castes was not permitted. Chief Justice D.Y. Chandrachud wrote the majority opinion; Justice Bela M. Trivedi dissented

- The pattern to notice: a judgment is often followed by an amendment. Champakam Dorairajan (1951) was followed by clause (4) of Article 15 in the same year. Indra Sawhney (1992) said that Article 16(4) does not reach promotions; clause (4A) came in 1995.
- Reservation is taken up in detail in Topic 592.

Reservation: amendment trail



1951 • 1st Amendment — Article 15(4): special provisions for SEBCs, SCs and STs

1995 • 77th Amendment — Article 16(4A): SC/ST promotion reservation

2000 • 81st Amendment — Article 16(4B): carry-forward reserved vacancies

2001 • 85th Amendment — Consequential seniority; effect from 17 June 1995

2005 • 93rd Amendment — Article 15(5): educational admissions; effective 2006

2019 • 103rd Amendment — Articles 15(6) and 16(6): EWS, maximum 10% additional reservation



Article 16(4): ordinarily a 50% ceiling, with narrowly justified extraordinary exceptions.

SEBCs: socially and educationally backward classes

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DAY 8 · TOPIC 73 · VISUAL REVISION 4

4. Three common exam traps

1. **"Person" and "citizen" are not the same word.** Article 14 protects "any person", so a person who is not a citizen can also claim it. Articles 15 and 16 speak only of citizens. Examiners exchange the two words. In the same way, do not assume that every Article of this group is a command to the State alone: the rights in Articles 17, 23 and 24 are enforceable "against the whole world".
2. **Five grounds in one Article, seven in the other.** Article 15 names religion, race, caste, sex and place of birth. Article 16(2) names these five and adds descent and residence. Both use the word "only" before the grounds. Residence has one more twist: a requirement of residence for jobs under a State or Union territory can be laid down only by a law of Parliament, not by a law of the State Legislature.
3. **Amendment numbers that sit close together.** Three Amendment Acts of 1995 to 2001 concern clauses (4A) and (4B) of Article 16, but only two of them inserted a clause: the 77th and the 81st. The 85th changed the words of a clause that was already there, and its change counts from the earlier date, 17 June 1995. In Article 15, the First Amendment and the 93rd added one clause each. The 103rd alone added a clause to both Articles, and its 10 per cent is a "maximum" that comes "in addition to" the existing reservations.

7. Sources

7.1 Sources

No. · S1

Source · Government of India, Ministry of Law and Justice, Legislative Department, The Constitution of India [As on 1st May, 2024], official text with footnotes (read from character 40,000 of the file's text onwards). https://cdnbbsr.s3waas.gov.in/s380537a945c7aaa788ccfcdf1b99b5d8f/uploads/2024/07/20240716890312078.pdf

Used for · Sub-heading "Right to Equality" above Article 14. The marginal headings and the full text of Article 14, Article 15 (clauses (1) to (6) and the Explanation), Article 16 (clauses (1), (2), (3), (4), (4A), (4B), (5) and (6)), Article 17 and Article 18 (clauses (1) to (4)). Footnotes: clause (4) of Article 15, "Added by the Constitution (First Amendment) Act, 1951, s. 2 (w.e.f. 18-6-1951)"; clause (5), "Ins. by the Constitution (Ninety-third Amendment) Act, 2005, s. 2 (w.e.f. 20-1-2006)"; clause (6), "Ins. by the Constitution (One Hundred and Third Amendment) Act, 2019, s. 2 (w.e.f. 14-1-2019)"; clause (4A) of Article 16, "Ins. by the Constitution (Seventy-seventh Amendment) Act, 1995, s. 2 (w.e.f. 17-6-1995)", and for the words "in matters of promotion, with consequential seniority, to any class", "Subs. by the Constitution (Eighty-fifth Amendment) Act, 2001, s. 2, for certain words (retrospectively) (w.e.f. 17-6-1995)"; clause (4B), "Ins. by the Constitution (Eighty-first Amendment) Act, 2000, s. 2 (w.e.f. 9-6-2000)"; clause (6) of Article 16, "Ins. by the Constitution (One Hundred and Third Amendment) Act, 2019, s. 3 (w.e.f. 14-1-2019)"; no footnote to Article 14, to clauses (1) to (3) of Article 15, to clauses (1), (2), (4) and (5) of Article 16, or to Articles 17 and 18. Article 31C, first sentence, with its footnotes: the words "all or any of the principles laid down in Part IV" substituted by section 4 of the Forty-second Amendment Act, 1976 for the words "the principles specified in clause (b) or clause (c) of article 39" (w.e.f. 3-1-1977); "Section 4 has been declared invalid by the Supreme Court in Minerva Mills Ltd. and Others Vs Union of India and Others, AIR 1980 SC 1789". Article 35, clause (a), sub-clauses (i) and (ii): "Parliament shall have,

and the Legislature of a State shall not have, power to make laws", for the matters under clause (3) of Article 16 and "for prescribing punishment for those acts which are declared to be offences under this Part"

No. · S2

Source · Supreme Court of India, Basheshar Nath v. The Commissioner of Income-Tax, Delhi and Rajasthan and Another, judgment of 19 November 1958, 1959 AIR 149, text on Indian Kanoon (opinion of S.R. Das, C.J.). https://indiankanoon.org/doc/761967/

Used for · Article 14 "combines the English doctrine of the rule of law and the equal protection clause of the 14th Amendment to the American Federal Constitution"; its object, "to secure to all persons, citizen or non-citizens, the equality of status and of opportunity referred to in the glorious preamble of our Constitution"; "The command of the Article is directed to the State"

No. · S3

Source · Supreme Court of India, D.S. Nakara and Others v. Union of India, judgment of 17 December 1982, 1983 AIR 130, 1983 SCR (2) 165, text on Indian Kanoon (judgment of the Court delivered by D.A. Desai, J.; five judges). https://future.indiankanoon.org/doc/1416283

Used for · "though Art. 14 forbids class legislation, it does not forbid reasonable classification for the purpose of legislation"; the two conditions of permissible classification, word for word, with the reference "see Shri Ram Krishna Dalmia v. Shri Justice S.R. Tendolkar & Others", cited in the headnote as [1959] S.C.R. 279; the words of E.P. Royappa v. State of Tamil Nadu, [1974] 2 S.C.R. 348: "From a positivistic point of view, equality is antithetic to arbitrariness" and "equality and arbitrariness are sworn enemies; one belongs to the rule of law in a republic while the other, to the whim and caprice of an absolute monarch"; the words of Maneka Gandhi on arbitrariness

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No. · S4

Source · Supreme Court of India, Maneka Gandhi v. Union of India, judgment of 25 January 1978, 1978 AIR 597, 1978 SCR (2) 621, text on Indian Kanoon. https://indiankanoon.org/doc/1766147/

Used for · Date; seven judges (M. Hameedullah Beg, C.J., Y.V. Chandrachud, P.N. Bhagwati, V.R. Krishna Iyer, N.L. Untwalia, S. Murtaza Fazal Ali and P.S. Kailasam, JJ.); "E.P. Royappa v. State of Tamil Nadu & Another [1974] 2 SCR 348 applied"; Bhagwati, J. (for himself, Untwalia and Murtaza Fazal Ali, JJ.): Article 14 "strikes at arbitrariness in State action and ensures fairness and equality of treatment"

No. · S5

Source · Centre for Law and Policy Research, Constitution of India website, "Article 361: Protection of President and Governors and Rajpramukhs" (text of the Article as in the Constitution of India 1950, Version 2). https://www.constitutionofindia.net/articles/article-361-protection-of-president-and-governors-and-rajpramukhs/

Used for · Article 361, clause (1), "The President, or the Governor or Rajpramukh of a State, shall not be answerable to any court for the exercise and performance of the powers and duties of his office"; clause (2), "No criminal proceedings whatsoever shall be instituted or continued against the President, or the Governor of a State, in any court during his term of office"

No. · S6

Source · Centre for Law and Policy Research, Constitution of India website, "Article 105: Powers, privileges, etc., of the Houses of Parliament and of the members and committees thereof". https://www.constitutionofindia.net/articles/article-105-powers-privileges-etc-of-the-houses-of-parliament-and-of-the-members-and-committees-thereof/

Used for · Article 105, clause (2): "No member of Parliament shall be liable to any proceedings in any court in respect of anything said or any vote given by him in Parliament or any committee thereof"

No. · S7

Source · India Code, The Public Employment (Requirement as to Residence) Act, 1957 (Act No. 44 of 1957), text with footnotes. https://www.indiacode.nic.in/bitstream/123456789/1429/3/a1957-44.pdf

Used for · Act number; the date printed under the title, 7th December, 1957; the long title, "An Act to make in pursuance of clause (3) of article 16 of the Constitution special provisions for requirement as to residence in regard to certain classes of public employment in certain areas and to repeal existing laws prescribing any such requirement"; section 2 (existing laws requiring residence "shall cease to have effect" and are repealed); section 3 (power to make rules for certain services and posts in named areas); section 5 (section 3 to cease to have effect after a fixed number of years)

No. · S8

Source · Supreme Court of India, Indra Sawhney and Others v. Union of India and Others, judgment of 16 November 1992, AIR 1993 SC 477, text on Indian Kanoon (judgment of B.P. Jeevan Reddy, J.; the first 100,000 characters of the page). https://indiankanoon.org/doc/1363234/

Used for · Date; nine judges; the Office Memorandum of 13 August 1990, "27% of the vacancies in civil posts and services under the Government of India shall be reserved for SEBC". Its account of the earlier cases: State of Madras v. Champakam Dorairajan, [1951] S.C.R. 525, seats "in the Medical and Engineering Colleges in the State of Madras were apportioned", "A Special Bench of Seven Judges heard the matter", "Soon after the said two decisions were rendered the Parliament intervened and in exercise of its constituent power, amended Article 15 by inserting Clause (4)"; M.R. Balaji v. State of Mysore, [1963] Suppl. 1 S.C.R. 439, "it can be stated in a general and broad way that they should be less than 50 per cent"

No. · S9

Source · Supreme Court of India, M. Nagaraj and Others v. Union of India and Others, judgment of 19 October 2006, (2006) 8 SCC 212, text on Indian Kanoon (judgment of S.H. Kapadia, J.; the first 100,000 characters of the page). https://indiankanoon.org/doc/102852/

Used for · Date; five judges (Y.K. Sabharwal, C.J.I., K.G. Balakrishnan, S.H. Kapadia, C.K. Thakker and P.K. Balasubramanyan, JJ.); the Seventy-seventh, Eighty-first, Eighty-second and Eighty-fifth Amendments under challenge; "'vesting of the power' by an enabling provision may be constitutionally valid and yet 'exercise of the power' by the State in a given case may be arbitrary". Its account of Indra Sawhney: reservation under Article 16(4) "is confined to

initial appointment and cannot extend to reservation in the matter of promotion"; "the rule of 50% laid down in Balaji was a binding rule and not a mere rule of prudence"

No. · S10

Source · Supreme Court Observer, "Plain English Summary of the Judgment", Jarnail Singh v. Lachhmi Narain Gupta (Reservation in Promotion). https://www.scobserver.in/reports/jarnail-singh-lacchmi-narain-reservation-in-promotion-plain-english-summary-of-the-judgment/

Used for · Judgment of 26 September 2018; five judges; "Justice Rohinton Nariman authored the unanimous judgment"; Nagaraj "does not need reconsideration by a larger seven-judge Bench"; the three conditions of Nagaraj (backwardness, inadequate representation, administrative efficiency) and the collection of quantifiable data; the backwardness condition "is contrary to the nine-judge Bench decision in Indra Sawhney"; the condition on inadequate representation "still stands"; "creamy layer exclusion extends to SC/STs"

No. · S11

Source · Supreme Court Observer, case page "EWS Reservation", Janhit Abhiyan v. Union of India. https://www.scobserver.in/cases/janhit-abhiyan-union-of-india-ews-reservation-case-background/

Used for · Judgment of 7 November 2022; five judges; "a 3-2 majority" (Justices Dinesh Maheshwari, B.M. Trivedi and J.B. Pardiwala); the dissent of Justice S.R. Bhat, joined by Chief Justice U.U. Lalit; the Court "declared that the Amendment and EWS Reservations were constitutionally valid"; the President's assent to the Amendment Act on 12 January 2019; the review petition dismissed on 9 May 2023; "the 50% ceiling for reservations established by the Supreme Court in Indra Sawhney (1992)"

No. · S12

Source · Supreme Court Observer, case page "Validity of Sub-Classification Within Reserved Categories", State of Punjab v. Davinder Singh. https://www.scobserver.in/cases/punjab-davinder-singh-scheduled-castes-preferential-treatment-case-background/

Used for · "On 1 August 2024, the top court upheld the validity of sub-classification" within the Scheduled Caste and Scheduled Tribe categories "in a 6:1 majority"; seven judges led by Chief Justice D.Y. Chandrachud; the majority opinion by the Chief Justice and the dissenting opinion of Justice Bela M. Trivedi; the power of the States; E.V. Chinnaiah (2004), which "ruled that sub-classification within the SC category was not permitted"

No. · S13

Source · Wikipedia, "Indra Sawhney & Others v. Union of India" (citing the judgment of 16 November 1992 on Indian Kanoon; Shalini Nair, The Indian Express, 18 April 2017; C. Basavaraju, Journal of the Indian Law Institute, volume 51, number 2, 2009, page 271). https://en.wikipedia.org/wiki/Indra_Sawhney_%26_Others_v._Union_of_India

Used for · A nine-judge Bench; the 27 per cent reservation for the backward classes in central government jobs held valid; the forward section of a backward class, "above a certain income", excluded (the creamy layer); "At no point should the reservation exceed 50%"; reservations not to be applied in promotions

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No. · S14

Source · Supreme Court of India, People's Union for Democratic Rights and Others v. Union of India and Others, judgment of 18 September 1982, 1982 AIR 1473, 1983 SCR (1) 456, text on Indian Kanoon (P.N. Bhagwati and Baharul Islam, JJ.; judgment by Bhagwati, J.). https://indiankanoon.org/doc/496663/

Used for · "But there are certain fundamental rights conferred by the Constitution which are enforceable against the whole world and they are to be found inter alia in Articles 17, 23 and 24"

No. · S15

Source · Government of India, Ministry of Social Justice and Empowerment, Department of Social Justice and Empowerment, "Scheme for Implementation of the Protection of Civil Rights Act, 1955 and the Scheduled Castes and the Scheduled Tribes (Prevention of Atrocities) Act, 1989" (scheme guidelines; no date printed). https://socialjustice.gov.in/writereaddata/UploadFile/48401709189291.pdf

Used for · The Untouchability (Offences) Act "enacted and notified on 08.05.1955"; "renamed as the Protection of Civil Rights {PCR} Act, 1955 in the year 1976"; the full name of the Act of 1989; its purpose, "to prevent commission of offences of atrocities against the members of the Scheduled Castes" and the Scheduled Tribes, with "Special Courts for the trial of such offences" and "relief and rehabilitation of the victims of such offences"; "Responsibility for implementation of the PCR Act and the PoA Act lies with State Governments and Union Territory Administrations"

No. · S16

Source · Supreme Court of India, Balaji Raghavan and S.P. Anand v. Union of India, judgment of 15 December 1995, [1995] Supp. 6 S.C.R. 694 (1995 INSC 900), text of the report as carried by Vaquill. https://app.vaquill.ai/cases/1995_INSC_900

Used for · Date; five judges (A.M. Ahmadi, C.J., Kuldip Singh, B.P. Jeevan Reddy, N.P. Singh and S. Saghir Ahmad, JJ.); the question whether the Bharat Ratna, Padma Vibhushan, Padma Bhushan and Padma Shri are "Titles" within Article 18(1); the awards "do not amount to 'titles' within the meaning of Article 18(1)"; not to be used as suffixes or prefixes; "If this is done, the defaulter should forfeit the National Award conferred on him or her"; "The National Awards were formally instituted in January, 1954"; cancelled by a notification of 8 August 1977; revived on 25 January 1980

No. · S17

Source · Earlier topics of this programme, read for consistency: Topic 62, "Article 12 and Article 13" (its sources include the official text in S1 and Basheshar Nath in S2); Topic 42, "Salient features of the Constitution" (its sources include the official text in S1 and NCERT, https://ncert.nic.in/textbook/pdf/keps207.pdf); Topic 4, "Governor"

Used for · Topic 62: Part III and the meaning of "the State" in Article 12; the Right to Equality beginning at Article 14; Basheshar Nath decided on 19 November 1958; Fundamental Rights against persons other than the State. Topic 42: the Right to Equality as Articles 14 to 18; the official text "as on 1st

May, 2024", which includes every amendment up to the 106th; the commencement of the Constitution on 26 January 1950. Topic 4: Article 361 and the Governor

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No. · S18

Source · Supreme Court of India, The State of Madras v. Srimathi Champakam Dorairajan, judgment of 9 April 1951, 1951 AIR 226, 1951 SCR 525, text on Indian Kanoon (judgment of the Court delivered by Das, J.). https://future.indiankanoon.org/doc/149321

Used for · Date; seven judges (Kania, C.J., Fazal Ali, Patanjali Sastri, Mehr Chand Mahajan, Mukherjea, S.R. Das and Vivian Bose, JJ.); the Communal G.O. on admissions to the Medical and Engineering Colleges of the State, with seats shared out by community; "the Communal G.O. being inconsistent with the provisions of article 29 (2) in Part III of the Constitution is void under article 13"; "we do not find it necessary to consider the effect of articles 14 or 15"

No. · S19

Source · Government of India, The Constitution of India, Part VI (The States), print carried on the website of the Ministry of External Affairs. https://www.mea.gov.in/Images/pdf1/Part6.pdf

Used for · Article 194, marginal heading "Powers, privileges, etc., of the Houses of Legislatures and of the members and committees thereof"; clause (2), "No member of the Legislature of a State shall be liable to any proceedings in any court in respect of anything said or any vote given by him in the Legislature or any committee thereof"

No. · S20

Source · Government of India, The Constitution of India, Part V (The Union), print carried on the website of the Ministry of External Affairs. https://www.mea.gov.in/Images/pdf1/Part5.pdf

Used for · Article 105, marginal heading "Powers, privileges, etc., of the Houses of Parliament and of the members and committees thereof"; clause (2), the protection of a member of Parliament from proceedings in any court for anything said or any vote given in Parliament or any committee thereof

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No. · S21

Source · Supreme Court Observer, journal article on the creamy layer in the Supreme Court's decisions, by Malavika Parthasarathy, 26 March 2022. https://www.scobserver.in/journal/creamy-layer-court-in-review/

Used for · Indra Sawhney (1992), nine judges: reservations for the backward classes upheld and the creamy layer to be excluded; such persons "as forward as any forward class member"; the exclusion not to rest on economic criteria alone; Jarnail Singh (2018) "extended the creamy layer principle to SC/STs in promotions"

No. · S22

Source · Supreme Court of India, Balaji Raghavan and S.P. Anand v. Union of India, judgment of 15 December 1995, 1996 AIR 770, 1996 SCC (1) 361, copy on the Supreme Court's website. https://api.sci.gov.in/judgment/judis/10166.pdf

Used for · Date; the citations of 1996; five judges, judgment by A.M. Ahmadi, C.J., with a separate concurring opinion of Kuldip Singh, J.; the question framed; "The National Awards do not amount to "titles" within the meaning of Article 18(1)"; "they should not be used as suffixes or prefixes"; the National Awards instituted in January 1954, cancelled on 8 August 1977 and revived on 25 January 1980; the words "by way of abundant caution" as a submission of counsel (paragraph 15) and as one of two views set out (paragraph 17)

No. · S23

Source · Supreme Court of India, M.R. Balaji and Others v. State of Mysore, judgment of 28 September 1962, 1963 AIR 649, 1962 SCR Supl. (1) 439, text on Indian Kanoon (five judges; judgment of the Court delivered by Gajendragadkar, J.). https://indiankanoon.org/doc/599701/

Used for · The order under challenge was made under Article 15(4) and reserved seats in the engineering and medical colleges of the State; "Speaking generally and in a broad way, a special provision should be less than 50%; how much less than 50% would depend upon the relevant prevailing circumstances in each case" (in the headnote and in the body of the judgment)

No. · S24

Source · Supreme Court of India, Jarnail Singh and Others v. Lachhmi Narain Gupta and Others, judgment of 26 September 2018, text on Indian Kanoon (Dipak Misra, C.J.I., Kurian Joseph, R.F. Nariman, Sanjay Kishan Kaul and Indu Malhotra, JJ.; judgment by R.F. Nariman, J.). https://indiankanoon.org/doc/190772988/

Used for · Paragraph 11, quoting paragraph 124 of M. Nagaraj: "Subject to the above, we uphold the constitutional validity of the Constitution (Seventy-seventh Amendment) Act, 1995; the Constitution (Eighty-first Amendment) Act, 2000; the Constitution (Eighty-second Amendment) Act, 2000 and the Constitution (Eighty-fifth Amendment) Act, 2001"

No. · S25

Source · Government of India, Ministry of Social Justice and Empowerment, "The Protection of Civil Rights Act, 1955 (22 of 1955)": the notifications bringing the Act into force and the Protection of Civil Rights Rules, 1977. https://socialjustice.gov.in/writereaddata/UploadFile/THE%20PROTECTION%20OF%20CIVIL%20RIGHTS%20ACT.pdf

Used for · Notification S.R.O. 1109 of 23 May 1955, under sub-section (3) of section 1 of the Untouchability (Offences) Act, 1955 (22 of 1955), appointing 1 June 1955 as the date on which the Act comes into force

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Irrigation: sources, major projects and micro-irrigation

1. Concept in one line

Irrigation is the supply of water to crops from wells, canals, tanks and other sources, and in 2022-23 it reached 55.8 per cent of India's gross cropped area. The exam asks for the terms, the share of each source, the size classes of projects, the big projects with their rivers and States, and the schemes with their years.

2. Revision notes

2.1 Why irrigation matters

- NCERT (Class XII): "Irrigation is needed because of spatio-temporal variability in rainfall in the country." Rain differs from place to place and from season to season, and Indian farming depends heavily on the monsoon (Topic 55).
- The Economic Survey 2025-26 calls access to assured water through irrigation "a key driver of agricultural productivity", and counts "limited access to irrigation and quality inputs" among the problems of the sector (Topic 63). Agriculture accounts for 89 per cent of surface water utilisation and 92 per cent of groundwater utilisation (NCERT).

2.2 The terms

Two sources recur below: MoSPI (the Ministry of Statistics and Programme Implementation) and LUS (Land Use Statistics, the yearly series of the Ministry of Agriculture and Farmers Welfare).

Term	Meaning	Point to remember
Net irrigated area (NIA)	The area irrigated in the year, from all sources. A field is counted once, however many times it is irrigated	It goes with net sown area (Topic 55)
Gross irrigated area (GIA)	A field is counted once for each crop season in which it is irrigated. GIA = NIA + area irrigated more than once	2010-11 (LUS, provisional): 63,601 + 25,759 = 89,360 thousand hectares, about 1.4 times NIA. It goes with gross cropped area
Command area	The area that a project and its canals are meant to serve	NCERT speaks of the “command area” of the Indira Gandhi Canal
Culturable command area (CCA)	The part of the command area that is fit for cultivation	Projects are classed by it (2.5). Some official texts spell it “cultivable”

Term	Meaning	Point to remember
Ultimate irrigation potential (UIP)	The largest area that could be irrigated in the end, when every possible source has been developed	139 million hectares as MoSPI prints it; the Economic Survey 2001-02 prints the reassessed potential as 139.89, that is, about 140. MoSPI's break-up: 64 from minor groundwater schemes and 17 from minor surface water schemes, which leaves about 58 for major and medium projects
Potential created and potential utilised	Potential created is the area that the works already built can irrigate. Potential utilised is the area actually irrigated from them	Utilisation falls short of creation. Command Area Development works are meant to raise it (2.9)

2.3 How much is irrigated: the figures with their dates

Measure	Figure	Source and date
GIA as a share of gross cropped area	41.7 per cent in 2001-02; 55.8 per cent in 2022-23	Economic Survey 2025-26

Measure	Figure	Source and date
NIA, all India	65,263 thousand hectares in 2011-12; 77,729 in 2020-21 (about 77.7 million hectares)	MoSPI for 2011-12; LUS, as printed in the Reserve Bank of India's Handbook of Statistics on Indian States (table dated 15 November 2023), for 2020-21
Irrigation coverage by crop	About 67 per cent for rice, about 26 per cent for pulses, below 15 per cent for millets	Economic Survey 2025-26 (as in Topic 55)
NCERT's lines	In Punjab, Haryana and western Uttar Pradesh more than 85 per cent of the net sown area is irrigated. For the country, the older line is that irrigation covers only about 33 per cent of the cultivated area (Topic 55)	NCERT Class XII

- So 44.2 per cent of the gross cropped area had no irrigation in 2022-23 (Topic 55).
- **Share of the net sown area:** a paper of the Press Information Bureau (PIB) of 29 August 2026 says that "only about 50% of the net sown area has irrigation facilities"; it gives no year for this figure.
- **States with the largest NIA in 2020-21 (thousand hectares):** Uttar Pradesh 14,334 (provisional), Madhya Pradesh 12,882 and Rajasthan 8,778; together they had about 46 per cent of the country's NIA. Telangana had 3,365 and Andhra Pradesh 2,936.

2.4 Sources of irrigation

The source-wise figures below are for 2011-12, the last year in MoSPI's Statistical Year Book. They are old figures: learn the order of the sources, and quote a share only with this year. The shares are shares of NIA, rounded to whole numbers.

Source	NIA in 2011-12 (thousand hectares)	Share	Where it matters most
Tube wells	29,408	45 per cent	Uttar Pradesh alone had one-third of the tube-well area. In Punjab, Rajasthan, Bihar and Uttar Pradesh the tube-well share is much higher than the canal share
Other wells	10,779	17 per cent	NCERT: wells and tube wells together irrigate 76.1 per cent of the net irrigated area of Punjab and 51.3 per cent of that of Haryana

Source	NIA in 2011-12 (thousand hectares)	Share	Where it matters most
Canals	16,017	25 per cent	Almost all are government canals. In the southern States the canal share is slightly larger than the tube-well share
Tanks	1,937	3 per cent	Tamil Nadu, Andhra Pradesh (then undivided) and Karnataka had 65 to 70 per cent of tank irrigation
Other sources	7,123	11 per cent	Every source other than the four above
Total	65,263	100 per cent	All India

The rows do not add up exactly to the totals, in area or in share, because the figures are rounded.

- **Wells lead.** Tube wells and other wells together irrigated 40,187 thousand hectares, about 62 per cent of NIA. Canals come next. Tanks have the smallest share of the four named sources.

2.5 Projects by size: major, medium and minor

Class	Culturable command area of the project
Major	More than 10,000 hectares
Medium	More than 2,000 hectares and up to 10,000 hectares
Minor	2,000 hectares or less

- The class depends on the CCA, not on the height of the dam, the storage or the cost.
- Exactly 2,000 hectares of CCA is minor; exactly 10,000 hectares is medium. The classification uses culturable command area, not dam height, storage or cost.

2.6 Major multipurpose and irrigation projects

NCERT (Class X): a dam is a barrier across flowing water. Dams are now called multi-purpose projects, because the stored water serves irrigation, electricity, water supply and flood control, among other uses. Jawaharlal Nehru called dams the “temples of modern India”.

Project	River	State or States	One fact
Bhakra Nangal	Sutlej (NCERT spells it Sutluj)	Bhakra Dam is in Bilaspur district, Himachal Pradesh; Nangal Dam is downstream, in Punjab	Bhakra is a concrete gravity dam about 226 m high; its reservoir is Gobind Sagar

Project	River	State or States	One fact
Hirakud	Mahanadi	Odisha	NCERT: it “integrates conservation of water with flood control”
Damodar Valley	Damodar	Jharkhand and West Bengal	Its main dams are Tilaiya, Konar, Maithon and Panchet Hill (NIOS, the National Institute of Open Schooling)
Nagarjuna Sagar	Krishna	Andhra Pradesh and Telangana: the river is the border here (Topic 45)	The dam is at Vijayapuri South; gross storage 312 TMC (thousand million cubic feet)
Srisailam	Krishna	Andhra Pradesh and Telangana; Srisailam is in Nandyal district (Topic 45)	Upstream of Nagarjuna Sagar; storage 216 TMC
Tungabhadra	Tungabhadra	Karnataka and Andhra Pradesh	The dam is at Hospet in Karnataka (Topic 45)

Project	River	State or States	One fact
Sardar Sarovar	Narmada	The dam is in Gujarat; the project covers Maharashtra, Madhya Pradesh, Gujarat and Rajasthan	NCERT: it will irrigate 18.45 lakh hectares in Gujarat
Indira Gandhi Canal	Sutlej and Beas water	It begins at the Harike barrage in Punjab and irrigates the Thar Desert of Rajasthan	Earlier called the Rajasthan Canal; launched on 31 March 1958; CCA 19.63 lakh hectares
Tehri	Bhagirathi	Tehri Garhwal district, Uttarakhand	A rock and earth-fill dam 260.5 m high, the tallest dam in India
Kosi	Kosi	Bihar; the project also serves Nepal	Its main work is the Kosi Barrage (NIOS)

Project	River	State or States	One fact
Polavaram	Godavari	Andhra Pradesh: at Polavaram, Eluru district. Polavaram district, formed on 31 December 2025, is the hill country upstream (Topic 45)	A national project (Topic 14), still under construction. On 13 July 2026 the Chief Minister said 89 per cent of the works were complete and promised completion by March 2027

- **Two pairs to keep apart.** Bhakra and Tehri are both high dams of the Himalayan States, but they stand on different rivers and are of different build: Bhakra is of concrete, Tehri of rock and earth. Hirakud and Sardar Sarovar are also mixed up: one is in Odisha and the other in Gujarat, on different rivers.

2.7 Andhra Pradesh in brief

- **The two deltas (Topic 45):** the Godavari delta canals take water from the Sir Arthur Cotton Barrage at Dowleswaram, and the Krishna delta canals from the Prakasam Barrage at Vijayawada. On the Krishna the storage dams (Srisailam, Nagarjuna Sagar, Pulichintala) stand above the barrage. On the Godavari, Polavaram is being built above the barrage, and its right bank canal links the Godavari with the Krishna.
- Andhra Pradesh is one of the three States that hold most of the country's tank irrigation (2.4), and one of the six States with the highest area under Per Drop More Crop in 2025-26 (2.8).

2.8 Micro-irrigation: drip and sprinkler

- **What it is:** water is carried under low pressure through a network of pipes and given in small discharges to each plant or near it (MoSPI's description of drip, micro-sprinkler and bubbler irrigation). NCERT calls these "water saving technologies (per drop more crop)".
- **Per Drop More Crop (PDMC):** the scheme that supports drip and sprinkler systems. Its assistance is 55 per cent for small and marginal farmers and 45 per cent for other farmers (Economic Survey 2025-26). It was a component of the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) from 2015-16 to 2021-22; since 2022-23 it has run under the Pradhan Mantri Rashtriya Krishi Vikas Yojana (PMRKVY), which these notes shorten to RKVY. The Ministry of Agriculture and Farmers Welfare answers for it.
- **Area covered:** PDMC had brought 115 lakh hectares under micro-irrigation, counted from its inception to July 2026; that is about 8.11 per cent of the net sown area (PIB, 29 August 2026). In 2025-26 the highest areas were recorded in six States: Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat and Rajasthan.
- **Micro Irrigation Fund (MIF):** a fund with NABARD (the National Bank for Agriculture and Rural Development), with an initial corpus of Rs 5,000 crore. States borrow from it, mostly to add a top-up subsidy of their own to PDMC. The Government of India gives the States an interest subvention of 2 per cent on these loans.

2.9 The schemes

Scheme	When, and who	What it does
Accelerated Irrigation Benefits Programme (AIBP)	Launched in 1996-97. The nodal Ministry is the water resources Ministry, now the Ministry of Jal Shakti	Central assistance to the States to speed up large projects that were beyond their resources. In 2015-16 it became one of the four components of PMKSY. In July 2016, 99 priority projects were picked, to be funded through a Long Term Irrigation Fund (LTIF) with NABARD, with an initial corpus of about Rs 20,000 crore
Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	Decided by the Cabinet Committee on Economic Affairs on 1 July 2015; in force from 2015-16. Three Ministries share it: Jal Shakti, Agriculture and Rural Development	Four components: (1) AIBP; (2) Har Khet Ko Pani, “water to every field”, which took in the minor irrigation schemes; (3) Per Drop More Crop, until 2021-22; (4) watershed development: the Integrated Watershed Management Programme of the Department of Land Resources was taken into PMKSY on 26 October 2015

Scheme	When, and who	What it does
Command Area Development (CAD)	From October 2013 its works were to go side by side with AIBP projects	Works such as lining of water courses, land levelling and warabandi (NCERT). The aim is to raise the utilisation of the potential created
Atal Bhujal Yojana (Atal Jal)	Launched by the Prime Minister on 25 December 2019	Better management of groundwater with the participation of the community, in seven States: Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh. NCERT, from the Annual Report 2022-23 of the Ministry of Jal Shakti: 8,220 water-stressed gram panchayats in 229 blocks of 80 districts
PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyaan)	Ministry of New and Renewable Energy; administrative approval dated 8 March 2019	Its link with irrigation is the solar pump. Its targets include 14 lakh stand-alone solar agriculture pumps and the solarisation of 35 lakh grid-connected agriculture pumps

2.10 Problems

- **Waterlogging and soil salinity in canal commands:** NCERT says that intensive irrigation and excessive use of water in the Indira Gandhi Canal command area caused both. Intensive irrigation is also increasing the salinity of the soil in Punjab, Haryana and western Uttar Pradesh.
- **Falling water tables:** groundwater utilisation is very high in Punjab, Haryana, Rajasthan and Tamil Nadu, and over-use has led to a decline of the groundwater table there (NCERT). Over-withdrawal has also raised the fluoride in groundwater in Rajasthan and Maharashtra, and arsenic in parts of West Bengal and Bihar.

Covered on other days: water use efficiency and PMKSY in detail (Topic 893), the Green Revolution (Topic 185), the rivers of Andhra Pradesh (Topic 45), hydro power (Topic 926) and inter-State river water disputes.

3. Extra section: a chronology of irrigation projects and schemes, 1948 to 2026

Year or date	What happened
1948	Kanwar Sain conceived the canal that became the Indira Gandhi Canal
31 March 1958	The canal project, then the Rajasthan Canal, was launched
Early 1960s	Irrigation began in Stage I of the canal: Ganganagar, Hanumangarh and northern Bikaner; CCA 5.53 lakh hectares

Year or date	What happened
1967	Nagarjuna Sagar Dam (the year given in the list of dams)
1981	Srisailam Dam (the year given in the list of dams)
Mid-1980s	Irrigation began in Stage II of the canal: Bikaner, Jaisalmer, Barmer, Jodhpur, Nagaur and Churu; CCA 14.10 lakh hectares
1996-97	AIBP was launched; its inception is dated October 1996
October 2013	CAD works were to go side by side with AIBP projects
1 July 2015	The Cabinet Committee on Economic Affairs decided on PMKSY; in 2015-16 AIBP became one of its four components
26 October 2015	The Integrated Watershed Management Programme was taken into PMKSY
July 2016	99 priority projects were picked; LTIF with NABARD, initial corpus about Rs 20,000 crore
25 December 2019	Atal Bhujal Yojana was launched
2022-23	Per Drop More Crop moved from PMKSY to RKVY

Year or date	What happened
29 July 2025	The Lok Sabha was told of MIF projects in eight States, with Rs 4,709.06 crore sanctioned
13 July 2026	Polavaram: 89 per cent of the works said to be complete; completion promised by March 2027

How to read it:

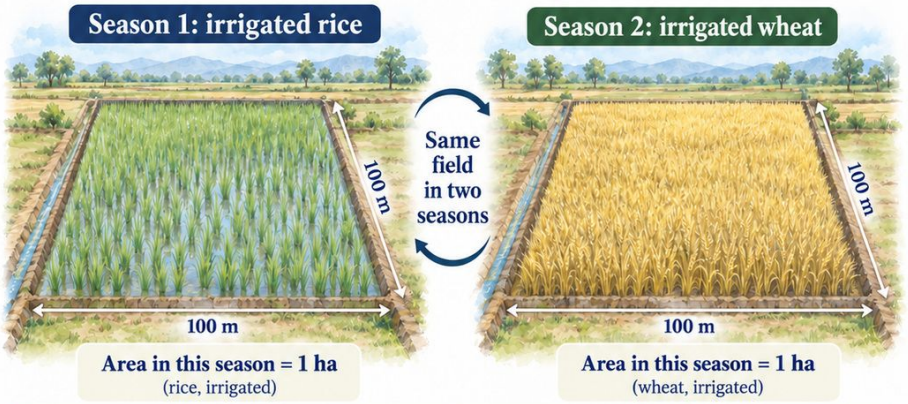
- The early entries are single big projects. The entries after 1996 are schemes, mostly for finishing old projects and for using water better.
- AIBP is older than PMKSY by almost twenty years. PMKSY did not start it; PMKSY took it in.
- The newest steps (Atal Bhujal Yojana, Per Drop More Crop, MIF) are about groundwater and about saving water on the farm, not about new dams.

4. Three common exam traps

1. **Quoting an irrigation share without its base and its year.** 55.8 per cent (2022-23) is the gross irrigated area as a share of the gross cropped area. It is not a share of the net sown area, and it is not NCERT's "about 33 per cent of the cultivated area", which is an older textbook line. The shares of wells, canals and tanks are shares of the net irrigated area, and the source-wise figures here are those of 2011-12. Tanks are the smallest of the named sources (3 per cent), although they matter in Tamil Nadu, Andhra Pradesh and Karnataka.

2. **Placing a project by the land it waters and not by its headworks.** The Indira Gandhi Canal irrigates the desert of Rajasthan, but it begins at the Harike barrage in Punjab. Sardar Sarovar Dam stands in Gujarat, though the project covers four States. Bhakra and Nangal are two different dams, in two different States. Nagarjuna Sagar and Srisailam stand on the same river. Polavaram's right bank canal runs towards the Krishna, yet the project is on the Godavari.
3. **Mixing up the two NABARD funds and the home of Per Drop More Crop.** The Long Term Irrigation Fund (initial corpus about Rs 20,000 crore) is for the 99 priority major and medium projects. The Micro Irrigation Fund (initial corpus Rs 5,000 crore) is for drip and sprinkler irrigation. Per Drop More Crop began inside PMKSY but has run under RKVY since 2022-23, and the Ministry of Agriculture and Farmers Welfare answers for it, not the Ministry of Jal Shakti. Atal Bhujal Yojana is a groundwater scheme for seven States; it builds no dams or canals.

One field, two ways to count



Net irrigated area (NIA) = 1 ha
Count land **once** for NIA
(total area irrigated at least once in a year).

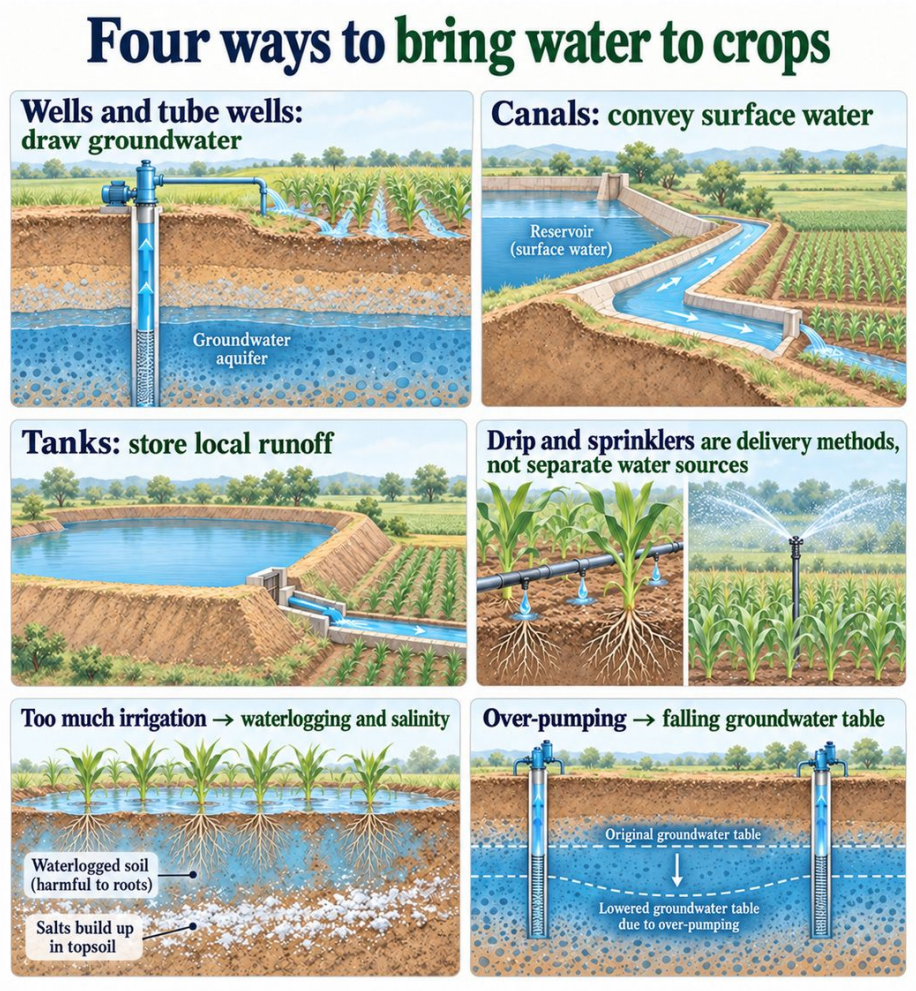
Gross irrigated area (GIA) = 2 ha
Count **each** irrigated crop season for GIA
(sum of area under all irrigated crops in a year).

Irrigation intensity = GIA ÷ NIA × 100
2 ÷ 1 × 100 = 200%



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Drip or sprinkler?

DRIP

Small discharges near plant roots



SPRINKLER

Sprays water over the crop and soil



Per Drop More Crop
supports drip and sprinkler systems

Since 2022–23:
under RKVY

Assistance rates

Small & marginal farmers: **55%**

Other farmers: **45%**

Source: Economic Survey 2025–26; PIB, 29 August 2026

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Irrigation schemes: read the timeline

1974–75 — **Command Area Development:** use created irrigation potential



1996–97 — **AIBP:** speed up unfinished major and medium projects



2015–16 — **PMKSY:** irrigation and water-use framework



2019 — **Atal Bhujal Yojana:** community groundwater management



2022–23 — **Per Drop More Crop** moves to RKVY





LTIF: major and medium priority projects; initial corpus about **₹20,000 crore**

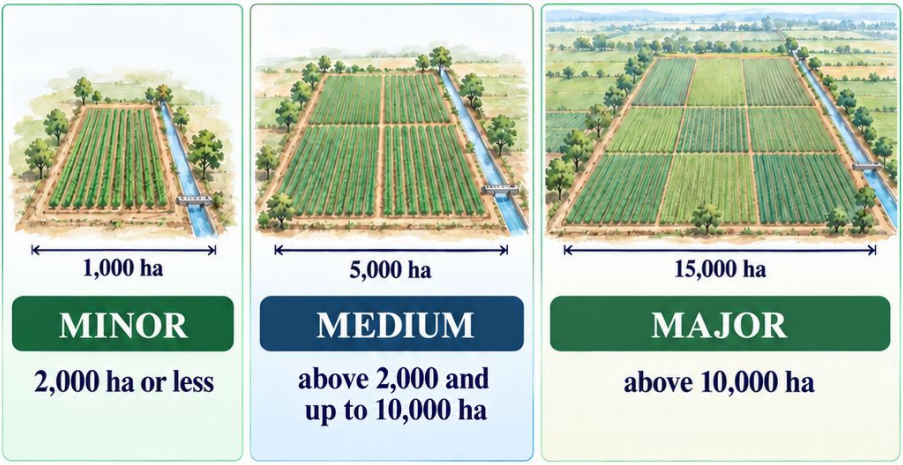


MIF: micro-irrigation; initial **₹5,000 crore** plus **₹5,000 crore** augmentation approved in 2024

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Size classes use culturable command area



Classify using culturable command area (CCA)

1,000 ha → minor	5,000 ha → medium	15,000 ha → major

CCA = culturable command area

Classify by cultivable area served, not dam height, cost or storage.



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Humidity, clouds and forms of condensation

1. Concept in one line

Humidity is the water vapour held in the air, and condensation is the change of that vapour into water droplets or ice crystals, which we see as dew, frost, fog and clouds. The examination asks for the measures of humidity, the conditions for each form of condensation and the marks of each cloud type.

2. Revision notes

2.1 Water vapour in the atmosphere

- Water vapour varies from 0 to 4 per cent by volume of the atmosphere (NCERT). It may be 4 per cent of the air in the warm and wet tropics and less than 1 per cent in the dry and cold areas of deserts and polar regions (Day 2, Topic 15).
- It decreases with altitude, and also from the equator towards the poles.
- Water is present in the atmosphere in three forms: gaseous, liquid and solid.
- The moisture comes from water bodies through evaporation and from plants through transpiration. There is a continuous exchange of water between the atmosphere, the oceans and the continents.

- **Why it matters:** water vapour absorbs parts of the insolation and preserves the heat radiated by the earth, so it acts like a blanket. It also contributes to stability and instability in the air, and every form of condensation and precipitation comes from it.

2.2 Humidity and its three measures

Humidity is the amount of water vapour in the air (Britannica). It is stated in three ways.

Measure	What it is	Unit	Point to remember
Absolute humidity	The actual amount of water vapour present in the atmosphere: the weight of water vapour per unit volume of air (NCERT)	Grams per cubic metre	It differs from place to place on the surface of the earth
Specific humidity	The mass of water vapour in a unit mass of moist air (Britannica)	Grams of vapour per kilogram of air	It does not vary as the temperature or pressure of a body of air changes, as long as no moisture is added or removed. NCERT's chapter does not define it

Measure	What it is	Unit	Point to remember
Relative humidity	The percentage of moisture present in the atmosphere as compared to its full capacity at a given temperature (NCERT)	Per cent	It changes when the temperature changes, even if the amount of vapour stays the same

- The ability of the air to hold water vapour depends entirely on its temperature (NCERT). An increase in temperature increases this capacity.
- So, with the same amount of vapour, relative humidity falls when the air is warmed and rises when the air is cooled.
- An illustration with round figures: a parcel of air holds 10 g of vapour and can hold 20 g at its present temperature, so its relative humidity is 50 per cent. Cool it until it can hold only 10 g: the relative humidity is now 100 per cent, though no vapour was added.
- **Saturated air:** air containing moisture to its full capacity at a given temperature. Its relative humidity is 100 per cent.
- **Dew point:** the temperature at which saturation occurs in a given sample of air.
- **Where it is high and low:** relative humidity is greater over the oceans and least over the continents (NCERT).

2.3 Evaporation and latent heat

- Evaporation is the process by which water is transformed from the liquid to the gaseous state. Heat is the main cause of evaporation (NCERT).
- **Latent heat of vaporisation:** the amount of heat energy required to convert a unit mass of a liquid into vapour without a change in temperature.
- In the heat budget (Day 3, Topic 25), 19 of the 34 units that the earth's surface passes to the atmosphere go through latent heat of condensation: evaporation at the surface and condensation in the air together carry heat upwards.

Factor (NCERT)	Effect on evaporation
Temperature	A rise in temperature increases the capacity of the air to absorb and retain water, so evaporation increases
Moisture already in the air	If the moisture content is low, the air can absorb and retain more moisture: the drier the air, the more it takes up
Movement of air	Moving air replaces the saturated layer with the unsaturated layer. The greater the movement of air, the greater is the evaporation

2.4 Condensation and what it needs

- Condensation is the transformation of water vapour into water. It is caused by the loss of heat (NCERT).

- **First need, cooling to the dew point:** when air is cooled to its dew point it becomes saturated. With further cooling the excess water vapour condenses into liquid form.
- **Second need, something to condense on:** in free air, condensation results from cooling around very small particles called hygroscopic condensation nuclei. Particles of dust, smoke and salt from the ocean are particularly good nuclei because they absorb water (the hygroscopic nuclei of Day 2, Topic 15). Condensation also takes place when moist air comes in contact with some colder object.
- NCERT lists three conditions in which condensation takes place: (i) when the temperature of the air is reduced to the dew point with its volume remaining constant; (ii) when both the volume and the temperature are reduced; (iii) when moisture is added to the air through evaporation. The most favourable condition is the decrease in air temperature.
- **How air is cooled aloft:** clouds are formed when relatively moist air rises. The lower pressure at higher levels lets it expand, and it cools adiabatically until its temperature falls below the dew point (Britannica; the adiabatic process of Day 6, Topic 56).
- **Sublimation and deposition:** sublimation is the direct change from solid to gas; deposition is the direct change from gas to solid. Frost can form by deposition of water vapour as ice on a cold surface.

2.5 Forms of condensation: dew, frost, fog and mist

After condensation, the water vapour or moisture in the atmosphere takes one of these forms: dew, frost, fog and clouds (NCERT). The forms are classified on the basis of temperature and location.

Point	Dew	Frost
What is deposited	Water droplets	Minute ice crystals instead of water droplets
Where	On the cooler surfaces of solid objects such as stones, grass blades and plant leaves	On cold surfaces
Dew point	Above the freezing point	At or below the freezing point (0°C)
Ideal conditions	Clear sky, calm air, high relative humidity, and cold and long nights	The same as for dew, except that the air temperature must be at or below the freezing point. NCERT speaks here of white frost

- **Fog** is a cloud with its base at or very near to the ground. It forms when the temperature of an air mass holding a large quantity of water vapour falls all of a sudden: condensation then takes place on fine dust particles. NCERT calls fogs mini clouds.
- **Smog:** in urban and industrial centres smoke provides plenty of nuclei. Fog mixed with smoke is described as smog (see Day 4, Topic 36).

Point	Fog	Mist
Horizontal visibility at the earth's surface	Less than 1 km	At least 1 km

Point	Fog	Mist
Where it is common (NCERT)	Where warm currents of air come in contact with cold currents	Over mountains, as the rising warm air up the slopes meets a cold surface
Appearance near the ground	A whitish veil; the air usually feels damp	A fairly thin, greyish veil; a lighter obscuration by suspended droplets

- Fog and mist are distinguished by horizontal visibility near the ground. This definition does not prescribe a universal ranking of their moisture content.
- The India Meteorological Department (IMD) grades fog as shallow, moderate, dense and very dense. A paper from the IMD in its journal MAUSAM (2012) gives the limits: shallow fog, visibility below 1,000 m but not below 500 m; moderate fog, below 500 m but not below 200 m; dense fog, below 200 m but not below 50 m; very dense fog, below 50 m. The IMD's press release of 19 December 2025 keeps to these limits: it prints "dense fog (visibility 50-199 m)", and where visibility is below 50 m it writes "dense to very dense fog".

2.6 Cloud forms and names

A cloud is a visible collection of tiny water droplets, ice crystals, or both, suspended in the atmosphere. Cloud names describe characteristic forms.

Name	Characteristic appearance
Cirrus	Thin, detached clouds with a feathery appearance

Name	Characteristic appearance
Cumulus	Cotton-wool-like heaps, often in separate patches with flat bases
Stratus	Layered clouds covering large portions of the sky

Nimbus / nimbo: a rain-bearing name element, as in nimbostratus and cumulonimbus. Nimbus alone is not one of the ten modern cloud genera. Typical levels and vertical development are explained in section 2.7.

2.7 Clouds by height, and the ten genera

The ten cloud genera can be grouped by their typical levels and vertical development. The levels overlap and vary with latitude; they are not rigid, mutually exclusive height bands.

Typical level or development	Cloud genera	Qualification
High	Cirrus, cirrostratus, cirrocumulus	Typical high-level genera
Middle	Altostratus, altocumulus, nimbostratus	Altostratus can extend higher. Nimbostratus commonly extends through more than one level; its base may descend into the low level.
Low	Stratocumulus, stratus	Typical low-level layers
Low bases with vertical development	Cumulus, cumulonimbus	Their tops may reach middle or high levels.

The ten genera: cirrus, cirrocumulus, cirrostratus, altocumulus, altostratus, nimbostratus, stratocumulus, stratus, cumulus and cumulonimbus. The names and forms introduced in section 2.6 help in identifying these genera. Nimbus alone is not a genus.

2.8 Precipitation in brief

- After the condensation of water vapour, the release of moisture is known as precipitation (NCERT).
- **Rainfall:** precipitation in the form of water. **Snowfall:** when the temperature is lower than 0°C, precipitation takes place as fine flakes of snow.
- **Sleet:** frozen raindrops and refrozen melted snow-water. It comes when a layer of air above the freezing point lies over a subfreezing layer near the ground: the raindrops solidify and reach the ground as small pellets of ice, not bigger than the raindrops.
- **Hailstones:** drops of rain that, after release by the clouds, solidify into small rounded solid pieces of ice. They are formed by rainwater passing through colder layers, and have several concentric layers of ice one over the other.
- Types of rainfall and its world distribution come on Day 11 (Topic 106).

3. Extra section: the ten cloud genera, what each looks like and what it brings

Use appearance, typical level and precipitation together to identify a cloud. The levels below are a grouping guide, with the overlap and vertical-extent qualifications in section 2.7.

Genus (abbreviation)	Typical level or development	What it looks like	What it brings, or what to note
Cirrus (Ci)	High	Delicate white filaments; thin, detached and feathery	Always composed of ice crystals
Cirrocumulus (Cc)	High	A patchy sheet of very small grains or ripples	Predominantly ice crystals, and short-lived
Cirrostratus (Cs)	High	A transparent, whitish veil that can cover the whole sky. It is never thick enough to stop objects on the ground from casting shadows	A halo is nearly always produced around the sun or the moon
Altocumulus (Ac)	Middle	A patchy sheet or layer of rounded masses or rolls	A corona appears when its edge or a thin patch of it passes in front of the sun or the moon
Altostratus (As)	Middle	A grey or bluish sheet. The sun shows as if through ground glass. Objects on the ground cast no shadows	No halo. Sometimes streaks of rain hang from it (virga), and at times they reach the ground as very light precipitation

Genus (abbreviation)	Typical level or development	What it looks like	What it brings, or what to note
Nimbostratus (Ns)	Middle; often extends into other levels	A dark grey layer, thick enough throughout to blot out the sun. Low, ragged clouds often lie beneath it	Steady rain or snow. Rain lasting a day or longer usually comes from this cloud (Britannica)
Stratocumulus (Sc)	Low	A grey or whitish patchy sheet or layer with dark rounded masses or rolls, often like a honeycomb	Its small elements are regularly arranged
Stratus (St)	Low	A generally grey layer with a uniform base. The outline of the sun stays clear when seen through it	Drizzle, ice prisms or snow grains, if the layer is thick enough
Cumulus (Cu)	Low base; vertical development	Detached, dense clouds with sharp outlines, rising like mounds, domes or towers; the top is often like a cauliflower. The sunlit parts are brilliant white and the base is dark and horizontal	Over land it grows on clear days: it appears in the morning, grows, and dissolves towards evening. Sometimes it gives showers (Britannica)

Genus (abbreviation)	Typical level or development	What it looks like	What it brings, or what to note
Cumulonimbus (Cb)	Low base; extensive vertical development	Heavy and dense, like a mountain or a huge tower. The top is nearly always flattened into the shape of an anvil	The thunderstorm cloud: showers of rain, snow or hail, and a common sign of a thunderstorm (thunderstorms come on Day 90, Topic 894)

How to tell the look-alikes apart:

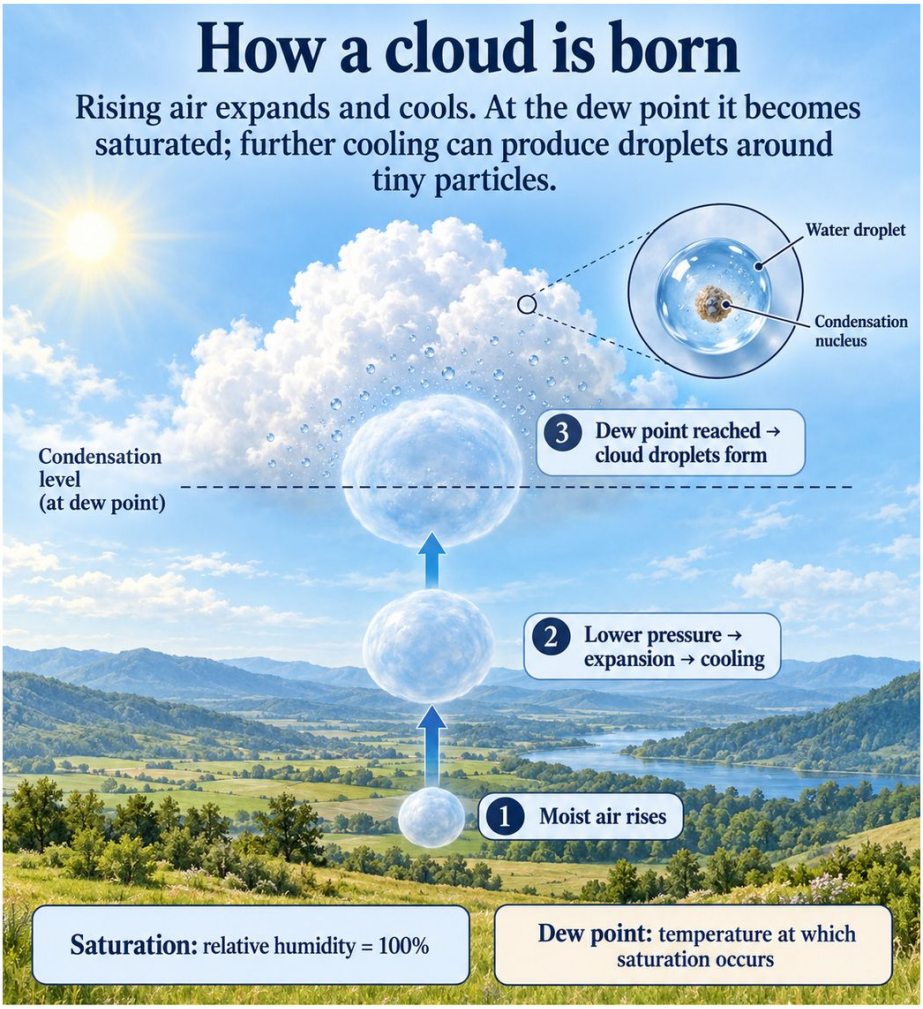
- Cirrostratus and altostratus are both sheets. The high one is transparent, lets shadows form and gives a halo. The middle one is grey or bluish, hides shadows and gives no halo.
- Nimbostratus and cumulonimbus both carry “nimbus” in the name. The first is a layer that rains steadily for long hours. The second is a tower that gives showers, hail and thunder.
- Stratus and nimbostratus are both grey layers. Stratus gives no more than drizzle, ice prisms or snow grains, and the sun’s outline can still be seen through it. Nimbostratus gives steady rain or snow and blots out the sun.

4. Three common exam traps

1. **“All three measures of humidity are percentages.”** Only relative humidity is a percentage: it compares the vapour present with the full capacity of the air at that temperature. Absolute humidity is a weight in a volume (grams per cubic metre), and specific humidity is

a mass in a mass (grams per kilogram). So a high relative humidity does not by itself mean a large amount of vapour. In the same way, latent heat of vaporisation is an amount of heat, not a temperature.

2. **Distinguish fog and mist by visibility.** Fog reduces horizontal visibility near the ground to below 1 km; in mist it is at least 1 km. Do not infer a fixed moisture-content ranking from these names. Fog is a cloud at or very near the ground; smog is fog mixed with smoke, not a fifth form of condensation.
3. **Do not treat cloud groups as rigid height bands.** There are ten genera; nimbus alone is not one of them. Nimbostratus is commonly grouped at the middle level but can extend into other levels, with a base that may descend into the low level. Cumulus and cumulonimbus have low bases and variable vertical extent.

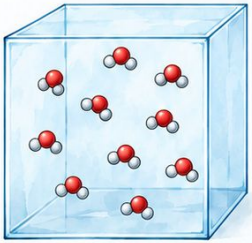


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Humidity: three different measures

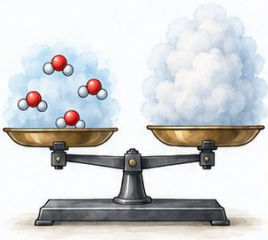
Absolute humidity



Mass of vapour per volume of air

g/m³

Specific humidity



Mass of vapour per mass of moist air

g/kg

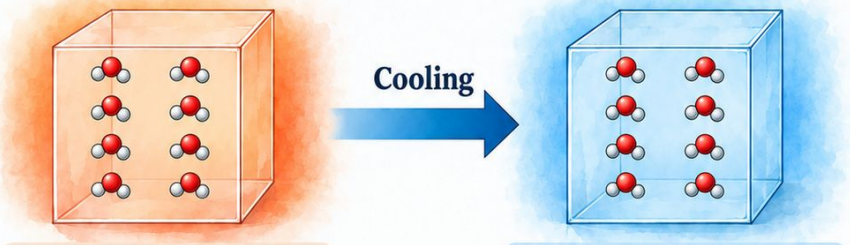
Relative humidity



Vapour present compared with saturation at the same temperature

%

Same vapour, different temperature



Lower relative humidity

Higher relative humidity

Cooling raises RH until saturation; warming lowers RH, if moisture is unchanged.

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Dew, frost, fog and mist

Dew



- Liquid water on a cool surface
- Dew point above 0°C

Frost



- Ice crystals on a freezing-cold surface
- Vapour → ice is deposition

Fog



- Cloud at or near the ground
- Visibility below 1 km

Mist



- Horizontal visibility at least 1 km

Fog and mist are suspended droplets that reduce horizontal visibility near the ground.

Dew and frost form on surfaces. Fog and mist suspend droplets in air.

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Read the clouds



Cirrus

High, thin and feathery
Ice crystals



Stratus

Layered blanket
May give drizzle



Cumulus

Cotton-like heaps
Flat base; vertical growth



Cumulonimbus

Tall thunderstorm cloud
Heavy showers, thunder or hail



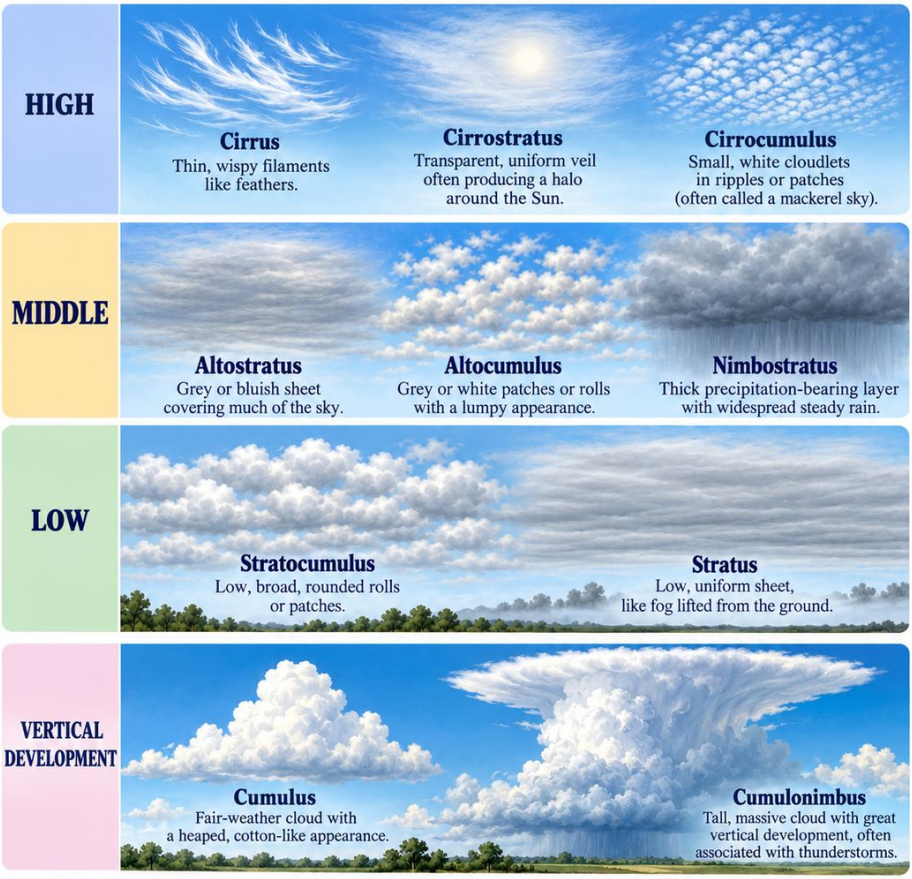
Layered rain cloud: nimbostratus → steady rain or snow

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Ten cloud genera at a glance

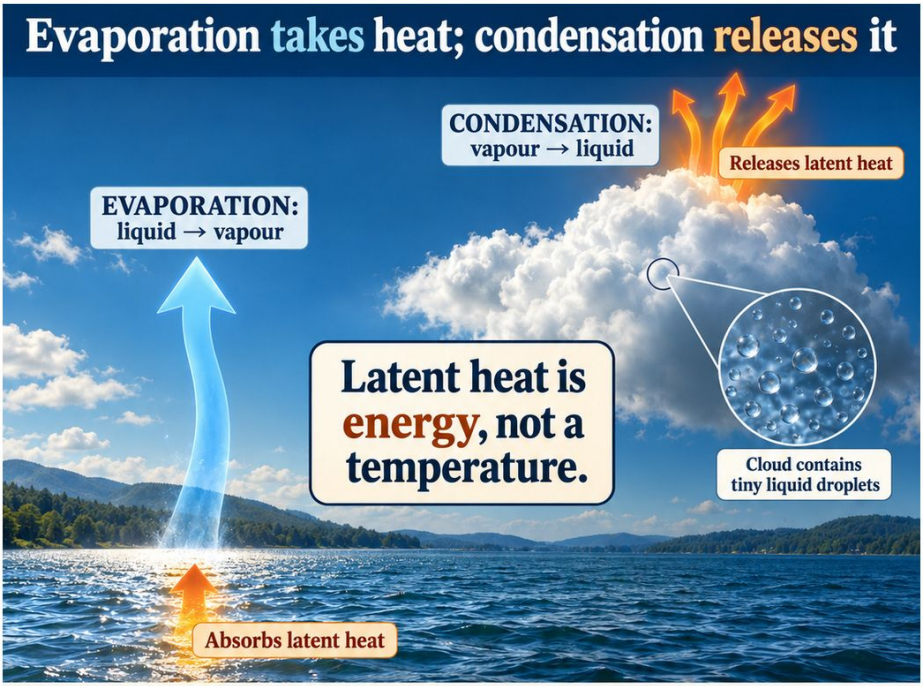
Typical levels and vertical development

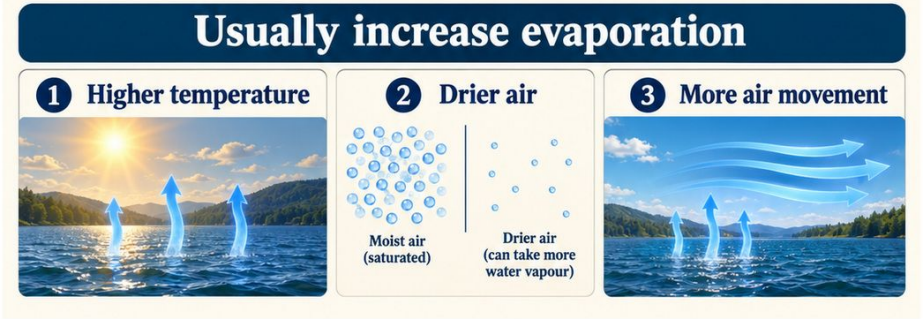


- Nimbostratus commonly spans several levels; its base may descend into the low level.
- Cumulus and cumulonimbus have low bases; their tops may reach higher levels.
- Levels overlap and vary with latitude. This grouping guide is not a height scale.

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Source references

S1

NCERT, Fundamentals of Physical Geography (Class XI), Chapter 10, “Water in the Atmosphere”, reprint 2026-27. https://www.ncert.nic.in/textbook/pdf/kegy210.pdf

Used for · Water vapour from 0 to 4 per cent by volume; three forms of water; evaporation and transpiration; continuous exchange of water; absolute humidity and its unit; the ability of the air to hold water vapour depending on temperature; relative humidity, greater over the oceans and least over the continents; saturated air; dew point; evaporation, heat as its main cause, latent heat of vaporisation, the effect of temperature, moisture content and movement of air; condensation, loss of heat, hygroscopic condensation nuclei (dust, smoke and salt from the ocean), contact with a colder object, the three conditions and the most favourable one; the forms of condensation and their classification by temperature and location; dew and frost with their conditions; fog as a cloud with its base at or very near to the ground, smog, fogs as mini clouds; definition of a cloud and cloud appearance; precipitation, rainfall, snowfall, sleet and hailstones

S2

NCERT, Fundamentals of Physical Geography (Class XI), Chapter 10, “Water in the Atmosphere”, text of an earlier printing as reproduced on the SATHEE portal (sathee.iitk.ac.in). https://sathee.iitk.ac.in/ncert-books/class-11/geography/fundamental-of-physical-geography/chapter-10-water-in-the-atmosphere

Used for · Excess water vapour condensing into liquid form; the absolute humidity differing from place to place; particles of dust, smoke and salt as good nuclei because they absorb water; fog forming when the temperature of an air mass falls all of a sudden; smoke in urban and industrial centres providing nuclei

S3

NCERT, Fundamentals of Physical Geography (Class XI), Chapter 7, “Composition and Structure of Atmosphere”, reprint 2026-27. https://www.ncert.nic.in/textbook/pdf/kegy207.pdf

Used for · Water vapour as a variable gas that decreases with altitude and from the equator towards the poles; 4 per cent in the warm and wet tropics and less than 1 per cent in the dry and cold areas of deserts and polar regions; absorbing parts of the insolation and preserving the earth’s radiated heat, like a blanket; contributing to stability and instability in the air; dust and salt particles as hygroscopic nuclei

S4

World Meteorological Organization, International Cloud Atlas (2017 edition), “Genera”. https://cloudatlas.wmo.int/en/clouds-genera.html

Used for · “Consideration of the most typical forms of clouds leads to the recognition of ten genera”; the names and abbreviations of the ten genera

S5

World Meteorological Organization, International Cloud Atlas (2017 edition), “Fog” and “Fog compared with Mist”. https://cloudatlas.wmo.int/en/fog.html ; https://cloudatlas.wmo.int/en/fog-compared-with-mist.html

Used for · Fog when microscopic droplets reduce horizontal visibility at the earth’s surface to less than 1 km, and mist when they do not; mist taken in practice as “light fog”; fog a whitish veil in which the air usually feels damp, moist or wet; mist a fairly thin, greyish veil

S6

NOAA, JetStream, “Ten Basic Clouds” (page updated 28 March 2023), giving the definitions of the WMO’s International Cloud Atlas. https://www.noaa.gov/jetstream/clouds/ten-basic-clouds

Used for · The appearance of each of the ten clouds; cirrus always composed of ice crystals, cirrocumulus predominantly ice crystals and short-lived; the halo of cirrostratus and its shadows; the corona of altocumulus; altostratus showing the sun as if through ground glass, with no halo, no shadows, virga and very light precipitation; nimbostratus as a dark grey layer with falling rain or snow, blotting out the sun, with low ragged clouds beneath, placed with the mid-level clouds and often wrongly called a low-level cloud; stratus with drizzle, ice prisms or snow grains and the sun’s outline; stratocumulus and its regularly arranged elements; stratus listed with the low clouds; cumulus developing vertically and its daily growth over land; cumulonimbus as the thunderstorm cloud with an anvil top; cumulus and cumulonimbus listed with the low clouds

S7

Encyclopaedia Britannica, “cloud”. https://www.britannica.com/science/cloud-meteorology

Used for · Clouds formed when relatively moist air rises, expands and cools adiabatically below the dew point; mean heights of high clouds (13 to 5 km), middle clouds (7 to 2 km) and low clouds (2 to 0 km); cumulonimbus extending through all three heights; steady rain lasting a day or longer usually produced by nimbostratus; cumulus sometimes yielding showers; cumulonimbus as a common sign of a thunderstorm, with showers of rain, snow or hail

S8

Encyclopaedia Britannica, “specific humidity”. https://www.britannica.com/science/specific-humidity

Used for · Specific humidity as the mass of water vapour in a unit mass of moist air; grams of vapour per kilogram of air; not varying as the temperature or pressure of a body of air changes, as long as moisture is not added or removed

S9

Encyclopaedia Britannica, “humidity”. https://www.britannica.com/science/humidity

Used for · Humidity as the amount of water vapour in the air

S10

Encyclopaedia Britannica, “sublimation”. https://www.britannica.com/science/sublimation-phase-change

Used for · Sublimation as the conversion of a substance from the solid to the gaseous state without its becoming liquid; dry ice; the phase diagram showing sublimation and deposition between solid and gas

S11

India Meteorological Department, Ministry of Earth Sciences, Press Release of 19 December 2025. https://internal.imd.gov.in/press_release/20251219_pr_4567.pdf

Used for · Dense fog as visibility of 50 to 199 m; dense to very dense fog as visibility below 50 m

S12

India Meteorological Department, Regional Meteorological Centre, Guwahati, “Fog Forecast for Guwahati Airport”. https://mausam.imd.gov.in/guwahati/mcdata/guwahatifog.pdf

Used for · The four grades of fog used by the IMD: shallow, moderate, dense and very dense

S13

World Meteorological Organization, International Cloud Atlas (2017 edition), “Nimbostratus (Ns)”, definition. https://cloudatlas.wmo.int/en/nimbostratus-ns.html

Used for · Nimbostratus as a grey, often dark cloud layer made diffuse by more or less continuously falling rain or snow; thick enough throughout to blot out the sun; low, ragged clouds frequently below the layer

S14

NCERT, Fundamentals of Physical Geography (Class XI), Chapter 8, “Solar Radiation, Heat Balance and Temperature”, reprint 2026-27. https://ncert.nic.in/textbook/pdf/kegy208.pdf

Used for · Of the 51 units absorbed by the earth’s surface, 34 units absorbed by the atmosphere: 6 directly, 9 through convection and turbulence and 19 through latent heat of condensation

S15

NOAA, National Weather Service, Weather Forecast Office Louisville, page on humidity. https://www.weather.gov/lmk/humidity

Used for · With the same amount of water vapour, air has a higher relative humidity if it is cooler and a lower relative humidity if it is warmer; relative humidity highest in the early morning and lowest in the afternoon when the amount of vapour does not change

S16

Rajendra Kumar Jenamani (India Meteorological Department, New Delhi), "Development of intensity based fog climatological information system (daily and hourly) at IGI airport, New Delhi for use in fog forecasting and aviation", MAUSAM, vol. 63, no. 1 (2012), pp. 89-112. https://mausamjournal.imd.gov.in/index.php/MAUSAM/article/download/1459/1287/5456

Used for · The visibility limits of the four grades of fog: shallow fog below 1,000 m but not below 500 m; moderate fog below 500 m but not below 200 m; dense fog below 200 m but not below 50 m; very dense fog below 50 m

S17

World Meteorological Organization, International Cloud Atlas, section 2.2.1.2, Useful concepts, Table 6 and explanatory paragraphs. https://cloudatlas.wmo.int/en/useful-concepts.html

Used for · Typical cloud levels; nimbostratus in the middle-level group with multi-level extent; low bases of cumulus and cumulonimbus; overlap and variation with latitude.

S18

World Meteorological Organization, "Classifying clouds". https://public.wmo.int/world-meteorological-day-2017/classifying-clouds

Used for · Cloud-name elements and characteristic forms; nimbus / nimbo means rain-bearing.

S19

NOAA National Weather Service, “Clouds: How do they form?”. https://www.weather.gov/source/zhu/ZHU_Training_Page/clouds/cloud_development/clouds.htm

Used for · Solid-to-gas sublimation and gas-to-solid deposition; latent heat as energy transferred in a change of state.

S20

NOAA National Weather Service, “Dew and frost development”. https://www.weather.gov/source/zhu/ZHU_Training_Page/fog_stuff/Dew_Frost/Dew_Frost.htm

Used for · Frost can form by deposition, with water vapour passing directly to solid ice on a cold surface.

Nuclear energy in India: three-stage programme and power plants

1. Concept in one line

India plans its nuclear power in three stages, so that its limited uranium leads step by step to its large thorium: pressurised heavy water reactors first, fast breeder reactors next, thorium reactors last. The examination asks for the reactor and fuel of each stage, the organisations with their years, and the power stations with their States.

2. Revision notes

Topic 47 explained fissile and fertile materials, the moderator, the coolant, first criticality and the reactor types. MWe means megawatts of electrical output; MWt means megawatts of heat.

2.1 Why three stages

- India holds limited uranium reserves but one of the largest thorium reserves in the world (Press Information Bureau, PIB, 7 April 2026).
- The figures of the Department of Atomic Energy (DAE): its Atomic Minerals Directorate (AMD) had established 4,23,222 tonnes of uranium oxide in the ground, in 47 deposits, by 30 June 2024; 2,52,220 tonnes of it lie in Andhra Pradesh, nearly all at Tummalapalle (reply in the Lok Sabha, 31 July 2024). Thorium is

found in the mineral monazite: the AMD has established 13.07 million tonnes of monazite (reply in the Lok Sabha, 9 August 2023).

- Thorium-232 is fertile, not fissile: it cannot keep a chain reaction going by itself. In a reactor it absorbs a neutron and changes into uranium-233, which is fissile.
- So thorium cannot be the starting fuel. The plan first burns natural uranium, which leaves plutonium in the spent fuel (the used fuel taken out of a reactor). It then burns that plutonium in breeder reactors, which make more fuel than they use. Only after that does it turn to thorium. Each stage makes the fuel of the next.
- **Homi Bhabha:** the PIB calls Dr Homi Jehangir Bhabha the architect of India's nuclear programme and says that he first conceived the three-stage plan. Published accounts say he presented it in November 1954 and that the Government formally adopted it in 1958. His life is a separate topic.

2.2 The three stages compared

Stage · First

Reactor type · Pressurised heavy water reactor (PHWR)

Fuel · Natural uranium

Moderator and coolant · Heavy water is both the moderator and the coolant

What it makes for the next stage · Plutonium-239, which is recovered by reprocessing the spent fuel

Position in the cited 2026 sources · In commercial use: 20 PHWR units stand in the list of the Nuclear Power Corporation of India Limited (NPCIL)

Stage · Second

Reactor type · Fast breeder reactor (FBR)

Fuel · Mixed oxide (MOX) of uranium and plutonium

Moderator and coolant · No moderator; the coolant is liquid sodium

What it makes for the next stage · More plutonium-239, from a blanket of uranium-238; later, uranium-233 from a blanket of thorium-232

Position in the cited 2026 sources · A test reactor attained first criticality in October 1985; the 500 MWe prototype did so on 6 April 2026

Stage · Third

Reactor type · Thorium-based reactors; the design made to demonstrate them is the Advanced Heavy Water Reactor (AHWR)

Fuel · Thorium with uranium-233

Moderator and coolant · In the AHWR: heavy water as moderator, boiling light water as coolant

What it makes for the next stage · Uranium-233 from thorium; the AHWR is designed to be self-sustaining in uranium-233

Position in the cited 2026 sources · Not yet in commercial use: there is a small research reactor, and the AHWR is still a design

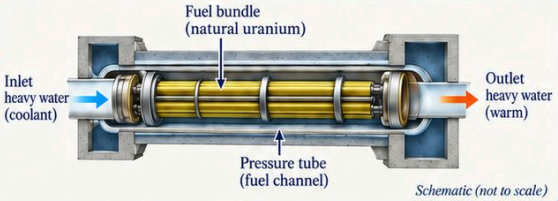
- **Fast Breeder Test Reactor (FBTR):** at the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, Tamil Nadu. It is cooled by sodium, gives 40 MWt (13.2 MWe), and attained first criticality in October 1985. Its fuel is a mixed carbide, not the mixed oxide of the prototype.

- **Prototype Fast Breeder Reactor (PFBR):** 500 MWe, at Kalpakkam. IGCAR designed it; Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) built it. Its plutonium is recovered from the spent fuel of the PHWRs. It attained first criticality at 8.25 pm on 6 April 2026, after the Atomic Energy Regulatory Board (AERB) had reviewed the safety of the plant's systems and given its clearance. The official reply of 29 July 2026 confirms this first-criticality milestone; it does not establish grid connection or commercial operation.
- **Next fast breeders:** the Government has approved pre-project activities for two more, FBR-1 and FBR-2 (2 × 500 MWe), at Kalpakkam (reply in the Rajya Sabha, 29 January 2026). That reply names them separately: they are not in its count of 17 reactors, given in 2.6.
- **KAMINI:** a research reactor of IGCAR at Kalpakkam. It gives only 30 kWt, attained first criticality on 29 October 1996, and is fuelled by uranium-233.
- **AHWR:** a 300 MWe design of the Bhabha Atomic Research Centre (BARC), of the vertical pressure tube type. Its fuel is thorium mixed with uranium-233 and thorium mixed with plutonium, as mixed oxides. BARC calls it a gateway to thorium technology. The World Nuclear Association (WNA), in a list updated on 15 July 2026, shows it as "proposed".

India's three-stage nuclear plan

1 PHWR

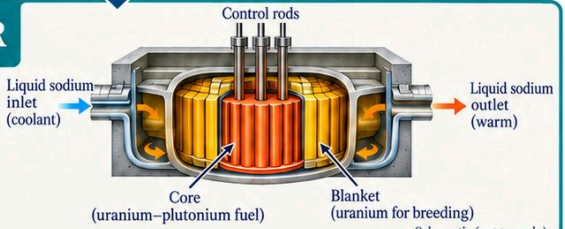
- Natural uranium
- Heavy water: moderator + coolant



Plutonium recovered from spent fuel

2 FAST BREEDER

- Uranium–plutonium fuel
- Liquid sodium coolant; no moderator



Build fissile fuel; enable thorium use

3 THORIUM PATHWAY

- Thorium-232 → uranium-233
- Thorium is fertile; uranium-233 is fissile



Stage 3 is a development pathway, not a commercial thorium fleet.

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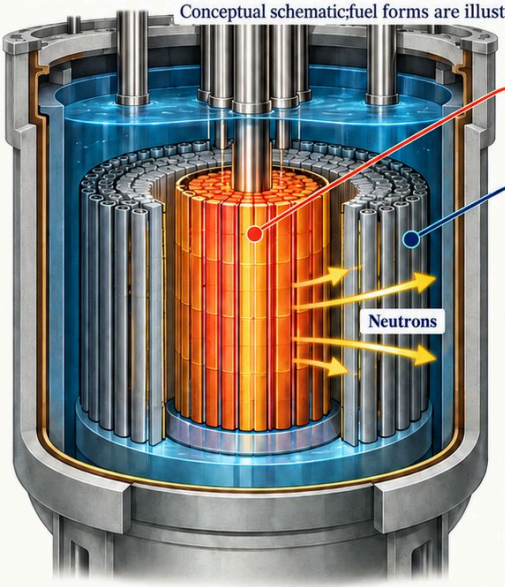
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DAY 8 | TOPIC 76 | 01

DAY 8 · TOPIC 76 · VISUAL REVISION 1

Inside a breeder: fuel and blanket

Conceptual schematic;fuel forms are illustrative, not to scale



PFBR core: uranium–plutonium mixed oxide (MOX)

Uranium-238 blanket

Breeding new fissile fuel



Uranium-238 ⟶ plutonium-239

Coolant: liquid sodium

No moderator

PFBR: mixed oxide fuel



- Uranium–plutonium mixed oxide (MOX)
- Fast breeder reactor
- Surrounded by uranium-238 blanket to breed more fuel

FBTR: mixed carbide fuel



- Uranium–plutonium mixed carbide (MC)
- Fast breeder test reactor
- Demonstrated breeder technology

KAMINI: uranium-233 fuel



- Uranium-233 fuel
- Small research reactor
- Supports thorium fuel cycle research

Thorium is not the PFBR's present core fuel.

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DAY 8 | TOPIC 76 | 02

2.3 Light water reactors: outside the three stages

- The three stages rest on PHWRs, fast breeders and thorium reactors. A light water reactor is none of these: it uses enriched uranium, and ordinary water is its moderator and its coolant (Topic 47). Such reactors add capacity by the side of the three stages.
- Four stand in NPCIL's list of plants under operation: Tarapur 1 and 2, which are boiling water reactors (BWR) of 160 MWe each (commercial operation began in 1969), and Kudankulam 1 and 2, which are pressurised water reactors (PWR) of the Russian VVER design, 1,000 MWe each (commercial operation began in 2014 and 2017).

2.4 The organisations

Organisation	Set up, and where	What it does
Atomic Energy Commission (AEC)	First set up in August 1948, in the Department of Scientific Research; set up again within the DAE by a Government resolution of 1 March 1958	It has full executive and financial powers. The Secretary of the DAE is its Chairman ex officio (Dr Ajit Kumar Mohanty, as on 10 October 2026)
Department of Atomic Energy (DAE)	3 August 1954, by a Presidential Order	It was set up under the direct charge of the Prime Minister. The research centres, industrial units and undertakings below belong to it

Organisation	Set up, and where	What it does
NPCIL	A public sector undertaking of the DAE; Mumbai	It builds and runs the nuclear power stations: 24 units
BHAVINI	A public sector undertaking of the DAE; Kalpakkam; created in 2003	It was created to build and run the PFBR and later fast breeder reactors
BARC	A research centre of the DAE; Mumbai	Research and reactor design: the AHWR and the 200 MWe Bharat Small Modular Reactor
IGCAR	A research centre of the DAE; Kalpakkam; set up on 30 April 1971 as the Reactor Research Centre and renamed in 1985	Fast reactor research: the FBTR, KAMINI and the design of the PFBR
AERB	Constituted on 15 November 1983 by the President, under the Atomic Energy Act, 1962; office in Mumbai	The safety regulator. Its mission is that the use of ionising radiation and nuclear energy should cause no undue risk to health and the environment
Uranium Corporation of India Limited (UCIL)	Incorporated on 4 October 1967; a public sector undertaking of the DAE; Jaduguda, Jharkhand	It mines and processes uranium

Organisation	Set up, and where	What it does
Nuclear Fuel Complex (NFC)	An industrial unit of the DAE; Hyderabad	It makes the fuel assemblies for the power reactors
Heavy Water Board (HWB)	An industrial unit of the DAE; Mumbai	It produces heavy water, the moderator and coolant of the PHWRs

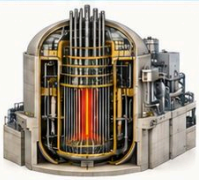
Who does what in nuclear energy?

Institutions and roles

RESEARCH AND DESIGN



BARC
reactor design and research



IGCAR
fast-reactor research; PFBR design

BUILD AND OPERATE



NPCIL
nuclear power stations



BHAVINI
PFBR and fast breeders

SUPPLIES



UCIL
uranium mining and processing



NFC
fuel assemblies



Heavy Water Board
heavy water

AERB

Safety regulator

Responsible to AEC



IGCAR designs. BHAVINI builds and operates. AERB regulates.

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DAY 8 | TOPIC 76 | 03

DAY 8 · TOPIC 76 · VISUAL REVISION 3

2.5 Commercial nuclear power stations (official capacity snapshot: 30 July 2026)

Station (NPCIL's short name) · Tarapur (TAPS)

State · Maharashtra

Reactor type · BWR (units 1 and 2) and PHWR (units 3 and 4)

Units and capacity · 2 × 160 MWe + 2 × 540 MWe = 1,400 MWe

Station (NPCIL's short name) · Rawatbhata (RAPS)

State · Rajasthan

Reactor type · PHWR

Units and capacity · Six units, numbered 2 to 7 (unit 1 is under extended shutdown and is not in the list): 200 + 4 × 220 + 700 = 1,780 MWe

Station (NPCIL's short name) · Kalpakkam (MAPS)

State · Tamil Nadu

Reactor type · PHWR

Units and capacity · 2 × 220 MWe = 440 MWe

Station (NPCIL's short name) · Narora (NAPS)

State · Uttar Pradesh

Reactor type · PHWR

Units and capacity · 2 × 220 MWe = 440 MWe

Station (NPCIL's short name) · Kakrapar (KAPS)

State · Gujarat

Reactor type · PHWR

Units and capacity · 2 × 220 MWe + 2 × 700 MWe = 1,840 MWe

Station (NPCIL's short name) · Kaiga (KGS)

State · Karnataka

Reactor type · PHWR

Units and capacity · 4 × 220 MWe = 880 MWe

Station (NPCIL's short name) · Kudankulam (KKNPS)

State · Tamil Nadu

Reactor type · PWR (VVER)

Units and capacity · 2 × 1,000 MWe = 2,000 MWe

Station (NPCIL's short name) · Total

State · Six States

Reactor type · 20 PHWRs, 2 BWRs and 2 PWRs

Units and capacity · 24 units, 8,780 MWe

- The M in MAPS stands for Madras: the station at Kalpakkam is the Madras Atomic Power Station. The R in RAPS stands for Rajasthan.
- Tamil Nadu has two stations, so the seven stations stand in six States.

- Two names begin alike: Kakrapar is in Gujarat and Kaiga is in Karnataka. Two stations lie inland in the north: Narora is in Uttar Pradesh and Rawatbhata is in Rajasthan.

Nuclear stations: names and States



Tarapur	Maharashtra	BWR + PHWR
Rawatbhata	Rajasthan	PHWR
Kalpakkam (MAPS)	Tamil Nadu	PHWR
Narora	Uttar Pradesh	PHWR
Kakrapar	Gujarat	PHWR
Kaiga	Karnataka	PHWR
Kudankulam	Tamil Nadu	PWR

NPCIL operating fleet • October 2026

24 units • 8,780 MWe

20 PHWR + 2 BWR + 2 PWR

Kakrapar = Gujarat | Kaiga = Karnataka

PFBR is not included in this NPCIL total.

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DAY 8 · TOPIC 76 · VISUAL REVISION 4

2.6 Under construction, and the newer sites

A reply in the Rajya Sabha on 29 January 2026 counted 17 reactors (13,100 MWe) under implementation: 7 under construction and 10 in pre-project activities. The first six rows below make up that dated 17-reactor programme; the status and expected dates below incorporate official updates of 29 July 2026 where specified. Expected commissioning dates are targets, not completed milestones.

Site · Rawatbhata (unit 8)

State · Rajasthan

Reactors · 1 × 700 MWe PHWR

Position, with date · Advanced commissioning stage; expected in 2026 (reply of 29 July 2026)

Site · Kudankulam (units 3 to 6)

State · Tamil Nadu

Reactors · 4 × 1,000 MWe VVER

Position, with date · Under construction; expected dates: unit 3, June 2027; unit 4, June 2028; unit 5, June 2029; unit 6, March 2030 (29 July 2026 reply)

Site · Gorakhpur

State · Haryana

Reactors · 4 × 700 MWe PHWR

Position, with date · Units 1 and 2: about six years from first concrete, after ground-improvement work (29 July 2026 reply); units 3 and 4: pre-project activities in the January reply

Site · Kaiga (units 5 and 6)

State · Karnataka

Reactors · 2 × 700 MWe PHWR

Position, with date · January: pre-project activities; construction confirmed by 29 July 2026; expected dates June 2031 / June 2032. WNA records first concrete in March 2026

Site · Mahi Banswara

State · Rajasthan

Reactors · 4 × 700 MWe PHWR

Position, with date · In pre-project activities in the 29 January 2026 reply. The builder is ASHVINI, a joint venture of NPCIL and NTPC

Site · Chutka

State · Madhya Pradesh

Reactors · 2 × 700 MWe PHWR

Position, with date · In pre-project activities in the 29 January 2026 reply

Site · Jaitapur

State · Maharashtra

Reactors · 6 × 1,650 MWe, planned in cooperation with France; the design is the EPR

Position, with date · "In principle" approval of the Government (reply in the Lok Sabha, 31 July 2024); no construction recorded (WNA, 15 July 2026)

Site · Kovvada, in Srikakulam district

State · Andhra Pradesh

Reactors · 6 × 1,208 MWe, planned in cooperation with the United States; the design is the AP1000 of Westinghouse

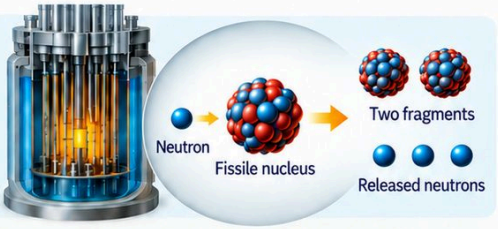
Position, with date · "In principle" approval of the Government (same reply of 31 July 2024). NPCIL allotted the site to Westinghouse in June 2016; no construction recorded (WNA, 15 July 2026)

Criticality is a milestone

1

First criticality

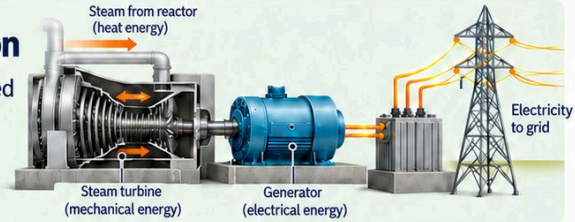
A self-sustaining controlled chain reaction.



2

Grid connection

Electricity first supplied to the grid.



3

Commercial operation

Plant enters commercial service.



PFBR, Kalpakkam
500 MWe design capacity

First criticality:
6 April 2026

First criticality is distinct from commercial operation.

2.7 Capacity, share and targets

- **Installed capacity:** 8,780 MWe (8.78 GW) in 24 units, reported on 30 July 2026. This is the figure of Topic 47. The PFBR is not in this count.
- **Share:** nuclear stations generated 56,681 million units in 2024-25, which was 3.1 per cent of India's electricity generation. The share has stayed at around 3 per cent (PIB, 7 April 2026).
- **Targets:** The April 2026 projection was 22.38 GW by 2031-32; the July 2026 roadmap expresses it as about 22 GW. The aim is 100 GW by 2047.
- **Nuclear Energy Mission:** announced in the Union Budget of February 2025, with ₹20,000 crore for small modular reactors (SMRs). At least five SMRs of Indian design are to be in operation by 2033. BARC leads the 200 MWe Bharat Small Modular Reactor (BSMR-200); another design is the 55 MWe SMR-55.
- **Bharat Small Reactors (BSRs):** these are different from the BSMR. They are to be closely based on the 220 MWe PHWR. They were included in the Union Budget of July 2024, and NPCIL has called for proposals (WNA, 15 July 2026).

2.8 Uranium, the opening of 2008, and the law

- **Uranium mining:** UCIL works the mine at Jaduguda in Jharkhand (mine opened in 1967, mill in 1968). Tummalapalle in Andhra Pradesh began commercial production in June 2012.
- **Before 2008:** India is not a party to the Non-Proliferation Treaty (NPT). In a joint statement of 18 July 2005 with the United States, India agreed to separate its civil and military nuclear facilities and to place the civil ones under the safeguards of the International Atomic Energy Agency (IAEA).

- **In 2008:** the IAEA's Board approved the safeguards agreement in August. The Nuclear Suppliers Group (NSG) gave India a waiver on 6 September, which let India get civil nuclear technology and fuel from other countries. The India-United States civil nuclear agreement, called the 123 Agreement, was signed on 10 October 2008.
- **The law:** the Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India (SHANTI) Act, 2025 (Act 39 of 2025) received the President's assent on 20 December 2025; by its section 1 it comes into force on the date that the Central Government notifies, and it is taken up in a separate topic.

3. Extra section: chronology, 1948 to 2026

Date	Event
August 1948	The AEC is first set up, in the Department of Scientific Research
3 August 1954	The DAE is set up by a Presidential Order
November 1954	Bhabha presents the three-stage plan (published accounts)
1 March 1958	A Government resolution sets up the AEC within the DAE. The three-stage plan is formally adopted in the same year (published accounts)
4 October 1967	UCIL is incorporated
28 October 1969	Tarapur 1 and 2 begin commercial operation

Date	Event
30 April 1971	The Reactor Research Centre is set up at Kalpakkam; it is renamed IGCAR in 1985
15 November 1983	The AERB is constituted
October 1985	The FBTR attains first criticality
29 October 1996	KAMINI attains first criticality
2003	BHAVINI is created
2008	The IAEA's Board approves the safeguards agreement in August; NSG waiver on 6 September; 123 Agreement signed on 10 October
31 December 2014	Kudankulam 1 begins commercial operation
30 June 2023	Kakrapar 3, of 700 MWe, begins commercial operation
15 April 2025	Rawatbhata 7, of 700 MWe, begins commercial operation
20 December 2025	The SHANTI Act, 2025 receives the President's assent
6 April 2026	The PFBR attains first criticality

How to read the table:

- The bodies came in this order: AEC (1948), DAE (1954), UCIL (1967), the centre at Kalpakkam (1971), AERB (1983), BHAVINI (2003).

- The stations in NPCIL's list began commercial operation in this order: Tarapur 1 and 2 (28 October 1969), Rawatbhata 2 (1 April 1981), Kalpakkam 1 (27 January 1984), Narora 1 (1 January 1991), Kakrapar 1 (6 May 1993), Kaiga 2 (16 March 2000) and Kudankulam 1 (31 December 2014).
- The reactors at Kalpakkam that belong to the second and third stages came in this order: FBTR (1985), KAMINI (1996), PFBR (2026).

4. Three common exam traps

1. **Taking thorium for a fuel that is already in use.** Thorium is fertile. It gives no power until a reactor has changed it into a fissile material. In the official capacity list reported on 30 July 2026, no commercial power station of India runs on thorium: all 24 units in NPCIL's list are uranium-fuelled PHWRs, BWRs and PWRs. The light water reactors among them are not a "stage" at all.
2. **Taking first criticality for commercial operation, and BHAVINI for NPCIL.** The PFBR has attained first criticality; that is the start of a controlled chain reaction, not the start of commercial supply. It is BHAVINI's reactor, so it is not among NPCIL's 24 units and not inside the 8,780 MWe. IGCAR designs and researches; BHAVINI builds and runs; the AERB only regulates.
3. **Being misled by names and years.** The Gorakhpur project is in Haryana, not in Uttar Pradesh. The power station at Kalpakkam is called Madras (MAPS), and Kalpakkam also holds IGCAR and BHAVINI, which are separate bodies. The AEC (1948) is older than the DAE (1954), though the AEC as it stands today rests on the resolution of 1958. The BSR (a small PHWR) is not the BSMR (a small modular reactor).

7. Sources

7.1 Sources

No. · S1

Source · Nuclear Power Corporation of India Limited (NPCIL), "Plants Under Operation" (seen on 10 October 2026). https://www.npcil.nic.in/content/302_1_AllPlants.aspx

Used for · The 24 units with place, State, reactor type, capacity and date of commercial operation; total installed capacity of 8,780 MWe; the count of 20 PHWRs, 2 BWRs and 2 PWRs; the short names TAPS, RAPS, MAPS, NAPS, KAPS, KGS and KKNPS

No. · S2

Source · NPCIL, "Projects Under Construction" (seen on 10 October 2026). https://www.npcil.nic.in/content/297_1_ProjectsUnderConstruction.aspx

Used for · Project names: Rajasthan Atomic Power Project 7 and 8, Kudankulam Nuclear Power Project 3 and 4 and 5 and 6, Gorakhpur Haryana Anu Vidhyut Pariyojna 1 and 2, Kaiga Atomic Power Project 5 and 6

No. · S3

Source · Press Information Bureau, "A New Chapter in India's Nuclear Journey" (7 April 2026). https://static.pib.gov.in/WriteReadData/specificdocs/documents/2026/apr/doc202647841801.pdf

Used for · Limited uranium and one of the largest thorium reserves in the world; Bhabha as architect of the programme and of the three-stage plan; the three stages; natural uranium in PHWRs; plutonium from the first stage as fuel of the second; uranium-233 bred from thorium for the third; PFBR of 500 MWe, built by BHAVINI, technology of IGCAR, MOX fuel, plutonium recovered from the spent fuel of PHWRs, blanket of uranium-238; capacity of 8.78 GW; 56,681

million units and 3.1 per cent in 2024-25; "around 3%"; 22.38 GW by 2031-32; 100 GW by 2047; Nuclear Energy Mission, ₹20,000 crore, five SMRs by 2033; BSMR-200 and SMR-55; the SHANTI Act and limited private participation

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No. · S4

Source · Department of Atomic Energy, "Prototype Fast Breeder Reactor at Kalpakkam, Tamil Nadu attains first criticality" (7 April 2026). https://dae.gov.in/prototype-fast-breeder-reactor-at-kalpakkam-tamil-nadu-attains-first-criticality

Used for · First criticality at 8.25 pm on 6 April 2026; clearance of the safety systems by the AERB; design by IGCAR; built and commissioned by BHAVINI, a public sector undertaking of the DAE; MOX fuel; uranium-238 blanket changing into plutonium-239; later thorium-232 blanket for uranium-233; liquid sodium coolant

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No. · S5

Source · Department of Atomic Energy, "History". https://dae.gov.in/history/

Used for · DAE set up on 3 August 1954 by a Presidential Order, under the direct charge of the Prime Minister; AEC set up by the resolution of 1 March 1958, with full executive and financial powers

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No. · S6

Source · Department of Atomic Energy, "Atomic Energy Commission" (seen on 10 October 2026). https://dae.gov.in/atomic-energy-commission/

Used for · AEC first set up in August 1948 in the Department of Scientific Research; resolution of 1 March 1958; the Secretary of the DAE, Dr Ajit Kumar Mohanty, as Chairman ex officio

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No. · S7

Source · Department of Atomic Energy, "Units". https://dae.gov.in/units/

Used for · BARC and IGCAR as research centres; NFC and HWB under industries; NPCIL, BHAVINI and UCIL as public sector undertakings of the DAE

No. · S8

Source · Department of Atomic Energy, "Activities" (page last updated 14 September 2023). https://dae.gov.in/activities/

Used for · Places: BARC, NPCIL and HWB at Mumbai; IGCAR and BHAVINI at Kalpakkam; NFC at Hyderabad; UCIL at Jaduguda; production of heavy water and fabrication of nuclear fuel assemblies for power plants among the activities of the DAE

No. · S9

Source · Press Information Bureau release of the Department of Atomic Energy, "Parliament Question: Expansion Projects" (reply in the Rajya Sabha, 29 January 2026), as mirrored by GlobalSecurity.org. https://www.globalsecurity.org/wmd/library/news/india/2026/india-260129-india-pib04.htm

Used for · 17 reactors of 13,100 MW under implementation, 7 under construction and 10 in pre-project activities; Rawatbhata 7 and 8, Kudankulam 3 to 6, Gorakhpur (Haryana) 1 to 4, Kaiga 5 and 6, Chutka (Madhya Pradesh), Mahi Banswara (Rajasthan) with capacities and expected years; ASHVINI as a joint venture of NPCIL and NTPC; FBR-1 and FBR-2 of 2 × 500 MWe at Kalpakkam

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No. · S10

Source · Department of Atomic Energy, "Acts and Rules" (seen on 10 October 2026). https://dae.gov.in/acts-rules/

Used for · The SHANTI Act, 2025 listed with the Atomic Energy Act, 1962 and the Civil Liability for Nuclear Damage Act, 2010

No. · S11

Source · The Gazette of India, Extraordinary, Part II, Section 1, No. 63 (21 December 2025): the Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India Act, 2025, as placed on the DAE website. https://cdnbbsr.s3waas.gov.in/s35b8e4fd39d9786228649a8a8bec4e008/uploads/2026/06/20260605195774330.pdf

Used for · Title of the Act; Act No. 39 of 2025; President's assent on 20 December 2025; section 1(2) on commencement by notification

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No. · S12

Source · World Nuclear Association, "Nuclear Power in India" (updated 15 July 2026). https://world-nuclear.org/information-library/country-profiles/countries-g-n/india

Used for · Kudankulam reactors as VVER units; AHWR of 300 MWe listed as proposed; Gorakhpur, Mahi Banswara, Chutka and Kaiga 5 and 6 as 700 MWe PHWRs; first concrete at Kaiga 5 and 6 in March 2026; Jaitapur (Maharashtra) with six EPR units proposed; Kovvada (Srikakulam district, Andhra Pradesh) with six AP1000 units proposed, site allotted to Westinghouse by NPCIL in June 2016; Kudankulam's reactors as standing apart from the three-stage plan; Rawatbhata unit 1 shut down since 2004; Jaduguda mine (1967) and mill (1968); Tummalapalle, first commercial production in June 2012; Bharat Small Reactors based on the 220 MWe PHWR, in the budget of July 2024, with NPCIL's call for proposals; NSG agreement of September 2008

No. · S13

Source · Wikipedia, "India's three-stage nuclear power programme" (citing M. V. Ramana, 2007, for November 1954; Woddi, Charlton and Nelson, 2009, for 1958; the Ministry of External Affairs for heavy water; S. K. Jain, 2009, for the second stage). https://en.wikipedia.org/wiki/India%27s_three-stage_nuclear_power_programme

Used for · Bhabha's presentation of the plan in November 1954 and its formal adoption in 1958; PHWRs fuelled by natural uranium, with heavy water as moderator and coolant, giving plutonium-239 as a by-product; MOX fuel of the second stage and the thorium blanket; thorium and uranium-233 in the third stage

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No. · S14

Source · Department of Atomic Energy, "Press Release" list (seen on 10 October 2026). https://dae.gov.in/category/press-release/

Used for · DAE press-release archive; the dated first-criticality confirmation is in S2 and S26

No. · S15

Source · Department of Atomic Energy, "UCIL Celebrates Diamond Jubilee Year, Marks Six Decades of India's Uranium Mining and Processing Capability" (6 October 2026). https://dae.gov.in/ucil-celebrates-diamond-jubilee-year-marks-six-decades-of-indias-uranium-mining-and-processing-capability/

Used for · UCIL incorporated on 4 October 1967; a public sector enterprise under the DAE; uranium mining and processing; Jaduguda in Jharkhand

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No. · S16

Source · Atomic Energy Regulatory Board, "About Us". https://www.aerb.gov.in/english/about-us

Used for · AERB constituted on 15 November 1983 by the President under the Atomic Energy Act, 1962; its mission; office at Mumbai

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No. · S17

Source · Bhabha Atomic Research Centre, "Advanced Heavy Water Reactor (AHWR)". https://www.barc.gov.in/randd/ahwr.html

Used for · AHWR as a 300 MWe, vertical pressure tube type, boiling light water cooled and heavy water moderated reactor; its fuel; self-sustaining in uranium-233; "gateway"; large thorium deposits and limited uranium reserves

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No. · S18

Source · Wikipedia, "Indira Gandhi Centre for Atomic Research" (citing the PIB releases "IGCAR Foundation Day, April 30, 2022" and "IGCAR Celebrates 40 Years of Fast Breeder Test Reactor's First Criticality"; Usha and others, "Research reactor KAMINI", Nuclear Engineering and Design, 2006; the IGC Newsletter, October 2004). https://en.wikipedia.org/wiki/Indira_Gandhi_Centre_for_Atomic_Research

Used for · Reactor Research Centre set up on 30 April 1971 and renamed in 1985; FBTR: sodium-cooled, 40 MWt, 13.2 MWe, mixed carbide fuel, first criticality in October 1985; KAMINI: 30 kWt, uranium-233 fuel, first criticality on 29 October 1996; BHAVINI created in 2003 to build and operate the PFBR and later fast breeder reactors

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No. · S19

Source · Wikipedia, "India-United States Civil Nuclear Agreement" (citing the White House joint statement of 2005; IAEA, "IAEA Board Approves India-Safeguards Agreement", 1 August 2008; S. Varadarajan, 8 September 2008; the US State Department, 10 October 2008). https://en.wikipedia.org/wiki/India%E2%80%93United_States_Civil_Nuclear_Agreement

Used for · Joint statement of 18 July 2005; separation of civil and military facilities and IAEA safeguards; approval by the IAEA's Board in August 2008; NSG waiver of 6 September 2008 and what it allowed; signing of the 123 Agreement on 10 October 2008; India not a party to the NPT

No. · S20

Source · R. R. Ramanarayanan and others (Indira Gandhi Centre for Atomic Research, Kalpakkam), paper on the KAMINI reactor in a conference volume of the International Atomic Energy Agency. https://www-pub.iaea.org/mtcd/publications/pdf/csp_004c/pdffiles/008.pdf

Used for · KAMINI as a uranium-233 fuelled research reactor of 30 kWt at IGCAR, Kalpakkam; first criticality on 29 October 1996

No. · S21

Source · Indira Gandhi Centre for Atomic Research, page on the Fast Breeder Test Reactor. https://www.igcar.gov.in/rfg/fbtrintro.html

Used for · FBTR at IGCAR, Kalpakkam; first criticality in October 1985; plutonium-uranium carbide fuel

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No. · S22

Source · Lok Sabha, Unstarred Question No. 1409, answered on 31 July 2024 (Department of Atomic Energy). https://eparlib.nic.in/bitstream/123456789/2978517/1/AU1409_E9F4CS.pdf

Used for · Sites given "in principle" approval: Jaitapur (Maharashtra), 6 × 1,650 MW, in cooperation with France; Kovvada (Andhra Pradesh), 6 × 1,208 MW, in cooperation with the United States; Rawatbhata unit 1 under extended shutdown

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No. · S23

Source · Lok Sabha, Unstarred Question No. 1559, answered on 31 July 2024 (Department of Atomic Energy). https://eparlib.nic.in/bitstream/123456789/2978684/1/AU1559_kKTw7x.pdf

Used for · 4,23,222 tonnes of uranium oxide in the ground in 47 deposits, established by the Atomic Minerals Directorate as on 30 June 2024; 2,52,220 tonnes in Andhra Pradesh, of which 2,49,459 tonnes at Tummalapalle

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No. · S24

Source · Lok Sabha, Starred Question No. 293, answered on 9 August 2023 (Department of Atomic Energy). https://eparlib.nic.in/bitstream/123456789/2504240/1/AS293.pdf

Used for · Monazite as a mineral of thorium and the rare earths; 13.07 million tonnes of monazite in the ground, established by the Atomic Minerals Directorate

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No. · S25

Source · Department of Atomic Energy / PIB, Nuclear Power Generation Capacity, 29 July 2026. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2291078&lang=1&reg=1

Used for · June 2026 project status and unit-specific expected commissioning dates; roadmap

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No. · S26

Source · Department of Atomic Energy / PIB, Nuclear Energy Mission, 29 July 2026. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2291090&lang=1&reg=1

Used for · Kaiga 5 and 6 construction; PFBR first criticality confirmed

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No. · S27

Source · Department of Atomic Energy / PIB, Generation of Nuclear Power, 30 July 2026. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2291837&lang=2&reg=48

Used for · 24 commercial reactors and 8,780 MW capacity snapshot

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No. · S28

Source · Department of Atomic Energy / PIB, Enhancing Nuclear Energy, 30 July 2026. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2291831&lang=2&reg=48

Used for · About 22 GW by 2031-32 and 100 GW by 2047 roadmap

Prominent Indian scientists: Raman, J.C. Bose, S.N. Bose, Saha and Ramanujan

1. Concept in one line

C.V. Raman, Jagadish Chandra Bose, Satyendra Nath Bose, Meghnad Saha and Srinivasa Ramanujan, all born between 1858 and 1894, did pioneering work in physics and mathematics. The examination asks who did what, where and in which year, and which institution, journal, honour or national day goes with each.

2. Revision notes

2.1 The five at a glance

Scientist · C.V. Raman

Born · 7 November 1888, Tiruchirappalli

Died · 21 November 1970, Bangalore

Field · Physics: light and sound

Best known for · Raman effect (1928)

Fellow of the Royal Society (FRS) · 1924

Scientist · Jagadish Chandra Bose (J.C. Bose)

Born · 30 November 1858, Mymensingh, now in Bangladesh

Died · 23 November 1937, Giridih

Field · Physics and plant physiology

Best known for · Millimetre-wave wireless experiments (1894 to 1896); the crescograph

Fellow of the Royal Society (FRS) · 1920

Scientist · Satyendra Nath Bose (S.N. Bose)

Born · 1 January 1894, Calcutta (now Kolkata)

Died · 4 February 1974, Calcutta

Field · Theoretical physics

Best known for · Bose-Einstein statistics (1924)

Fellow of the Royal Society (FRS) · 1958

Scientist · Meghnad Saha

Born · 6 October 1893, Seoratali village near Dhaka

Died · 16 February 1956, New Delhi

Field · Astrophysics

Best known for · Thermal ionisation equation (1920)

Fellow of the Royal Society (FRS) · 1927

Scientist · Srinivasa Ramanujan

Born · 22 December 1887, Erode

Died · 26 April 1920, aged 32

Field · Mathematics

Best known for · Partitions, infinite series, mock theta functions

Fellow of the Royal Society (FRS) · 1918

- S.N. Bose and Saha were classmates at Presidency College, Calcutta. J.C. Bose was one of their teachers there.
- Sources differ on where Ramanujan died. The Royal Society's obituary notice, written by G.H. Hardy, and Britannica give Kumbakonam; the Oxford Dictionary of National Biography gives Madras. Remember the date and the age.

2.2 C.V. Raman (1888 to 1970)

- **Education and posts:** BA (1904) and MA (1907) from Presidency College, Madras. He joined the Indian Finance Department in 1907 and was posted at Calcutta as Assistant Accountant General. While in service he did experiments in the laboratory of the Indian Association for the Cultivation of Science (IACS), Calcutta. He became Palit Professor of Physics at Calcutta University in 1917. In 1933 he moved to the Indian Institute of Science (IISc), Bangalore, as its first Indian director, and was professor there till 1948.
- **Main work:** (a) The Raman effect, discovered on 28 February 1928 with K.S. Krishnan and announced to the press the same day. When light passes through a transparent material, a small part of the scattered light comes out with a changed wavelength. The Nobel Prize in Physics 1930 was given "for his work on the scattering of light and for the discovery of the effect named after

him". (b) The colour of the sea: on a voyage home from England in 1921 he concluded that the blue of the sea comes from the scattering of light by the water itself, and not from the reflection of the sky, which was Lord Rayleigh's explanation. (c) Sound: he worked on instruments of the violin family and made the first scientific studies of the tabla and the mridangam.

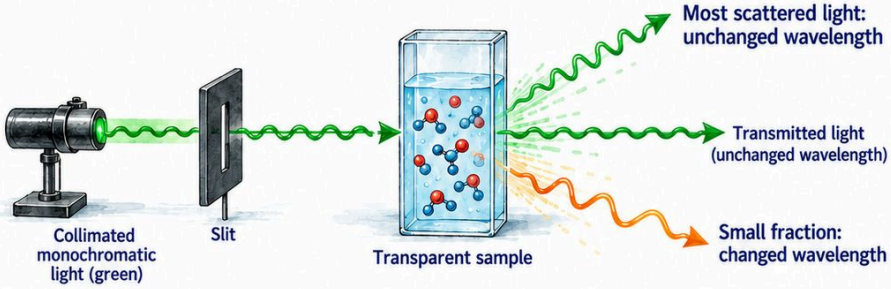
- **Instruments, books and institutions:** he founded the Indian Journal of Physics (1926) and the Indian Academy of Sciences at Bangalore (1934), of which he was President till 1970. He set up the Raman Research Institute, Bangalore, with his own funds and was its Director from 1948. Give 1948 for this institute; Wikipedia's article has 1948 in one place and 1949 in another.
- **Honours:** FRS (1924); knighthood (1929); Nobel Prize in Physics (1930); first National Professor (1947); Bharat Ratna (1954); Lenin Peace Prize (1957).
- **Facts examiners like:** he was the first Asian to receive a Nobel Prize in any science. National Science Day, 28 February, marks the discovery of the Raman effect. The Government of India declared the day in 1986 and it was first observed on 28 February 1987.

C.V. Raman: light tells a story

DAY 8 • TOPIC 77 • 1/5

RAMAN EFFECT • 28 FEBRUARY 1928

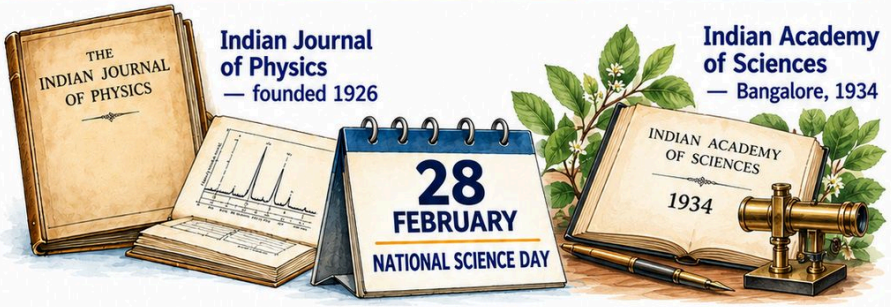
At IACS, Calcutta, Raman and K.S. Krishnan observed a small fraction of scattered light with a changed wavelength.



1928 — Discovery at Calcutta

1930 — Nobel Prize in Physics

1933 — Moved to IISc, Bangalore



Indian Journal of Physics — founded 1926

Indian Academy of Sciences — Bangalore, 1934

IAS WITH DR RAVI
AIM. PREPARE. ACHIEVE

@iaswithdrravi

DAY 8 | TOPIC 77 | 01

DAY 8 · TOPIC 77 · VISUAL REVISION 1

2.3 Jagadish Chandra Bose (1858 to 1937)

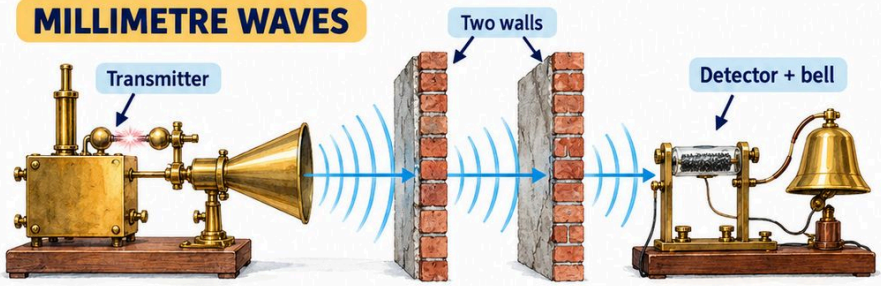
- **Education and posts:** he studied at St Xavier's College, Calcutta, and took the BA of Calcutta University in 1879. He then joined Christ's College, Cambridge, and took a BA from Cambridge and a BSc from London University (1884). He joined Presidency College, Calcutta, in 1885 and taught physics there till he retired in 1915. As an Indian his pay was fixed at one-third of that of the European professors, and in protest he took no salary for the first 3 years.
- **Main work:** (a) Wireless: from 1894 he produced and studied very short radio waves, about 5 mm in wavelength, called millimetre waves. In 1895 at Calcutta he sent waves of 60 GHz over 23 metres, through two walls, and with them rang a bell and set off gunpowder. (b) Plants: he showed with instruments that plants respond to stimuli such as temperature, chemicals, gases and electricity.
- **Instruments, books and institutions:** for the wave experiments he built, among other things, a spark transmitter, a coherer (a detector), a polariser and a horn antenna. His crescograph measures the growth of a plant by magnifying the movement of its tip up to 10,000 times (Banglapedia speaks of ten million times). Books: Response in the Living and Non-Living (1902) and The Nervous Mechanism of Plants (1926). He founded the Bose Institute at Calcutta in 1917 and directed it till his death.
- **Honours:** knighthood (1917 in Wikipedia, 1916 in Banglapedia); FRS (1920); President of the Indian Science Congress (1927).
- **Facts examiners like:** (a) Patents: he was against patenting and described his inventions openly. One United States patent of 1904, for a detector, was taken in his name because a friend

pressed him. (b) Place in the history of radio: in September 2012 the Institute of Electrical and Electronics Engineers (IEEE) placed a Milestone plaque at Presidency College, Kolkata. The IEEE calls his work of 1894 to 1896 "the first millimeter-wave communication system in the world". (c) Science fiction: his Bengali story Niruddesher Kahini (1896) was enlarged as Palatak Tuphan in his book Abyakta (1921). He is regarded as the father of Bengali science fiction.

J.C. Bose: waves and plant growth

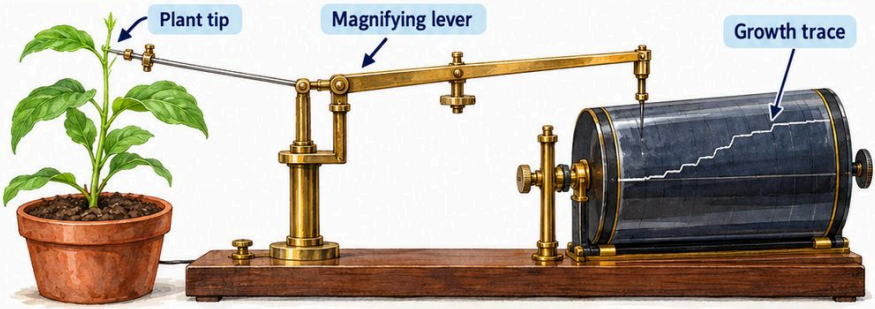
DAY 8 • TOPIC 77 • 2/5

MILLIMETRE WAVES



1895 demonstration: **60 GHz** over **23 metres**, through two walls.
He developed millimetre-wave instruments and detectors.

CRESCOGRAPH



Magnifies tiny growth movements so plant responses to stimuli can be measured.

Presidency College, Calcutta: taught physics	Bose Institute: founded 1917	FRS: 1920

Exam cue: J.C. Bose studied plants and radio waves; S.N. Bose developed quantum statistics.

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DAY 8 | TOPIC 77 | 02

DAY 8 · TOPIC 77 · VISUAL REVISION 2

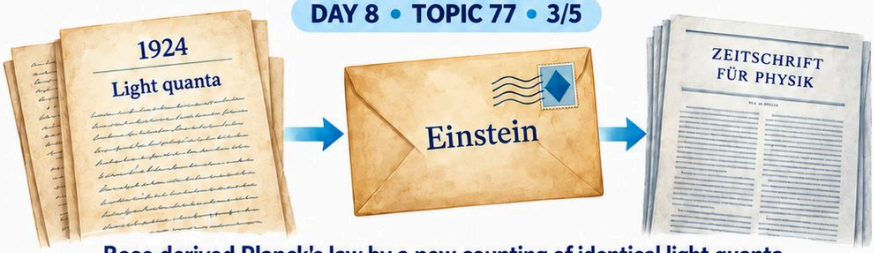
2.4 Satyendra Nath Bose (1894 to 1974)

- **Education and posts:** at Presidency College, Calcutta, he stood first in the BSc (1913) and in the MSc in mixed mathematics (1915); Saha stood second. He was a lecturer in physics at the Science College of Calcutta University from 1916 to 1921. In 1921 he joined the University of Dhaka as Reader in physics and taught there till 1945. He then taught at Calcutta till 1956, and was Vice-Chancellor of Visva-Bharati from 1956 to 1958.
- **Main work:** (a) In 1924 he wrote the paper "Planck's Law and the Hypothesis of Light Quanta". In it he derived Planck's law of radiation by a new way of counting identical particles of light, without using classical physics. The Philosophical Magazine did not accept it. He sent it to Albert Einstein, who translated it into German and had it published in the Zeitschrift für Physik in 1924. Einstein then extended the method to atoms. (b) What grew out of it: the method is called Bose-Einstein statistics. The particles that follow it are called bosons, a name given by Paul Dirac after Bose. Einstein's extension predicted the Bose-Einstein condensate: when a gas of such atoms is cooled to a very low temperature, all the atoms gather in the lowest possible energy state. It was first produced in a laboratory in 1995, and the Nobel Prize in Physics 2001 went to Eric Cornell, Wolfgang Ketterle and Carl Wieman for achieving it.
- **Instruments, books and institutions:** in 1919 he and Saha brought out the first book in English of Einstein's papers on relativity. The S.N. Bose National Centre for Basic Sciences, Kolkata (1986), is named after him. It came up after his death.
- **Honours:** Padma Vibhushan (1954); FRS (1958); National Professor (1959), a post he held for 15 years.

- **Facts examiners like:** he was nominated for the Nobel Prize (1956, 1959 and 1962) but was never awarded it.

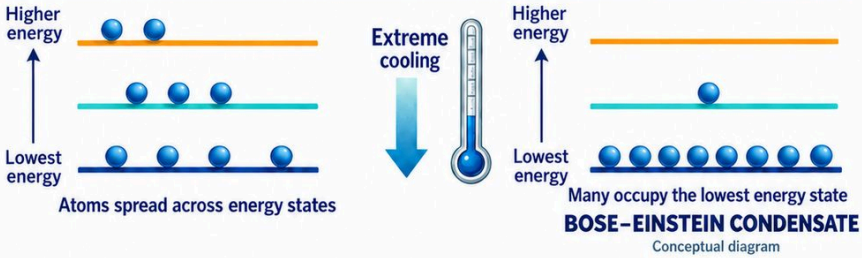
S.N. Bose: a new way to count

DAY 8 • TOPIC 77 • 3/5



Bose derived Planck's law by a new counting of identical light quanta.
Einstein translated his paper and extended the method to atoms.

BOSE–EINSTEIN STATISTICS



BOSE–EINSTEIN CONDENSATE
Conceptual diagram

1924 Bose's paper → **1995** Condensate first produced → **2001** Nobel Prize for Cornell, Ketterle and Wieman



'Boson' was named by Paul Dirac after Bose.



University of Dhaka: taught physics, 1921–1945.



Final exam cue: S.N. Bose did not receive a Nobel Prize.

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2.5 Meghnad Saha (1893 to 1956)

- **Education and posts:** he passed the ISc from Dhaka College (1911) and took honours in mathematics at Presidency College, Calcutta. He was Lecturer at the College of Science, Calcutta (1916), Professor of Physics at the University of Allahabad (1923) and Palit Professor at Calcutta University (1938).
- **Main work:** (a) Science: the thermal ionisation equation of 1920. It links the look of a spectrum with the temperature of the source of light, so the spectrum of a star can be used to find the star's temperature. It explained the classes of stellar spectra, and in the form improved by E.A. Milne it is basic to all work on stellar atmospheres. (b) Public work: he was a member of the National Planning Committee (1938). He was the chief architect of river planning in India and prepared the original plan of the Damodar Valley Project. He was chairman of the Calendar Reform Committee, set up in 1952 under the Council of Scientific and Industrial Research (CSIR); its report is of 1955. The national calendar, based on the Saka era, came into official use on 22 March 1957, which was 1 Chaitra 1879 Saka.
- **Instruments, books and institutions:** he founded the journal Science and Culture in 1935. He helped to found the National Academy of Science (1930) and the National Institute of Sciences of India (1935), now the Indian National Science Academy (INSA). He was instrumental in creating the Institute of Nuclear Physics at Calcutta: the institute's own history dates its founding to 1949, formal inauguration by Irène Joliot-Curie to 11 January 1950 (its Foundation Day), and autonomy to 1951. After Saha's death in 1956 it was renamed the Saha Institute of Nuclear Physics, Kolkata.
- **Honours:** FRS (1927); President of the Indian Science Congress (1934).

- **Facts examiners like:** he was elected to the first Lok Sabha from Calcutta North West in the first general election. The Election Commission's report calls it the general election of 1951, and Britannica and Banglapedia also give 1951. He sat in the Lok Sabha from 1952 until his death. Britannica and Banglapedia call him an independent; Wikipedia's election table for the seat lists him under the Revolutionary Socialist Party.

Meghnad Saha: reading the stars

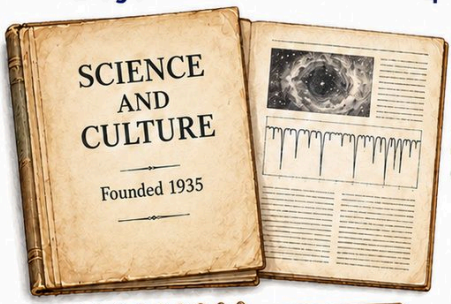
DAY 8 • TOPIC 77 • 4/5

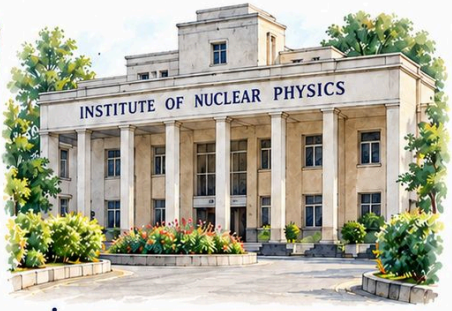
THERMAL IONISATION • 1920

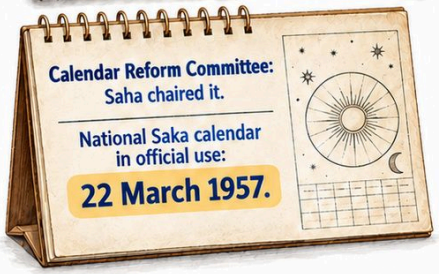
Ionisation depends on temperature and electron density.
Saha's equation helps explain stellar spectra.



Starlight — Spectrum — Clues to the stellar atmosphere







- 1949 — Founded
- 11 Jan 1950 — Building inaugurated
- 1951 — Became autonomous

Now the Saha Institute of Nuclear Physics, Kolkata.

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DAY 8 | TOPIC 77 | 04

DAY 8 · TOPIC 77 · VISUAL REVISION 4

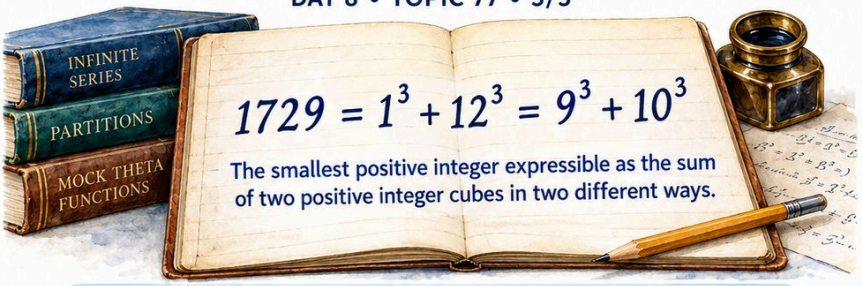
2.6 Srinivasa Ramanujan (1887 to 1920)

- **Education and posts:** born at Erode, he grew up at Kumbakonam. He failed the First Arts (FA) examination at Pachaiyappa's College, Madras, and did not obtain a degree there. Cambridge later awarded him a BA by research in 1916. He taught himself from G.S. Carr's Synopsis, a book of about 5,000 theorems. In March 1912 he was taken as an accounts clerk in the Madras Port Trust on 30 rupees a month. He wrote to G.H. Hardy of Cambridge on 16 January 1913, sailed from Madras on 17 March 1914 and worked at Cambridge for nearly 5 years. He returned to India in 1919.
- **Main work:** (a) Partitions, that is, the ways of writing a positive integer as a sum of positive integers. With Hardy he gave in 1918 a formula for the approximate number of partitions of a large number. (b) Infinite series, among them series for π that close in on its value very fast. (c) Mock theta functions, found in the last year of his life and described in a letter to Hardy in January 1920. (d) 1729: Hardy said that the number of his taxi, 1729, seemed dull. Ramanujan replied that it is the smallest number that can be written as the sum of two cubes in two different ways: $1729 = 1^3 + 12^3 = 9^3 + 10^3$.
- **Instruments, books and institutions:** he left nearly 3,900 results, mostly identities and equations. Most of them are in 3 notebooks. A fourth, a sheaf of 87 loose pages known as the "lost notebook", was found again by George Andrews in 1976.
- **Honours:** FRS (2 May 1918), the second Indian to be elected, after Ardaseer Cursetjee (1841); Fellow of Trinity College, Cambridge (October 1918), the first Indian to be elected.

- **Facts examiners like:** National Mathematics Day is 22 December, his birthday. Prime Minister Manmohan Singh declared it on 26 December 2011 at Madras University, and declared 2012 the National Mathematics Year. The SASTRA Ramanujan Prize and the ICTP Ramanujan Prize, both for young mathematicians, carry his name. Robert Kanigel's book The Man Who Knew Infinity (1991) tells his life; the film of the same name came in 2015.

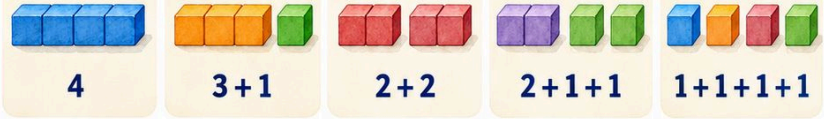
Ramanujan: patterns in numbers

DAY 8 • TOPIC 77 • 5/5



Infinite series • Partitions • Mock theta functions

PARTITIONS

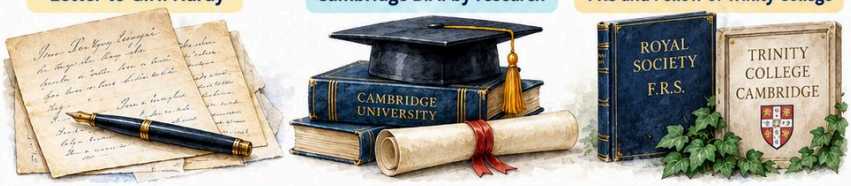


A partition writes a positive integer as a sum of positive integers; order does not create a new partition.

1913 — Letter to G.H. Hardy

1916 — Cambridge B.A. by research

1918 — FRS and Fellow of Trinity College



He failed FA at Pachaiyappa's College; he later earned the Cambridge degree.

22 DECEMBER • NATIONAL MATHEMATICS DAY

His birthday; 2012 was National Mathematics Year.

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DAY 8 | TOPIC 77 | 05

2.7 Who started what: journals, bodies and institutes

Journal, body or institute · Indian Association for the Cultivation of Science (IACS), Calcutta

Year · 1876

Who · Mahendralal Sircar

Point to remember · The first research institute founded in India. Raman did his experiments here; he did not found it

Journal, body or institute · Indian Journal of Physics

Year · 1926

Who · Raman

Point to remember · His paper on the new effect, "A new radiation", appeared in it on 31 March 1928

Journal, body or institute · National Academy of Science

Year · 1930

Who · Saha helped to found it

Point to remember · It is not Raman's academy of 1934

Journal, body or institute · Indian Academy of Sciences, Bangalore

Year · 1934

Who · Raman

Point to remember · It was inaugurated on 31 July 1934 with 65 Founding Fellows

Journal, body or institute · Science and Culture (journal)

Year · 1935

Who · Saha

Point to remember · It wrote on the Damodar Valley, drought and famine, and research on rivers

Journal, body or institute · National Institute of Sciences of India

Year · 1935

Who · Saha was among the founders

Point to remember · It is now the Indian National Science Academy (INSA)

3. Extra section: a chronology from 1858 to 2012

Year	Event
1858	J.C. Bose is born at Mymensingh (30 November)

Year	Event
1876	Mahendralal Sircar founds the IACS at Calcutta
1885	J.C. Bose joins Presidency College, Calcutta
1887 and 1888	Ramanujan is born at Erode (22 December 1887); Raman is born at Tiruchirappalli (7 November 1888)
1893 and 1894	Saha is born (6 October 1893); S.N. Bose is born (1 January 1894)
1894 to 1896	J.C. Bose does his millimetre-wave experiments; the demonstration with the bell and the gunpowder is of 1895
1913 and 1914	Ramanujan writes to Hardy (16 January 1913) and sails for England (17 March 1914)
1916	Cambridge awards Ramanujan a BA by research
1917	J.C. Bose founds the Bose Institute; Raman becomes Palit Professor at Calcutta University
1918	Ramanujan becomes FRS (2 May) and Fellow of Trinity College (October)
1920	Saha gives the thermal ionisation equation; J.C. Bose becomes FRS; Ramanujan dies (26 April)

Year	Event
1921	Raman studies the colour of the sea on his voyage; S.N. Bose joins the University of Dhaka
1924	S.N. Bose sends his paper to Einstein; Raman becomes FRS
1926 and 1927	Raman founds the Indian Journal of Physics (1926); Saha becomes FRS (1927)
1928	Raman discovers the Raman effect at Calcutta (28 February)
1930	Raman receives the Nobel Prize in Physics; the National Academy of Science, which Saha helped to found, is set up
1933 and 1934	Raman moves to the IISc, Bangalore (1933) and founds the Indian Academy of Sciences (1934)
1935	Saha founds Science and Culture; the National Institute of Sciences of India is founded
1937	J.C. Bose dies at Giridih (23 November)
1948	Raman becomes Director of the Raman Research Institute

Year	Event
1949, 1950 and 1951	Institute of Nuclear Physics founded (1949); inaugurated on 11 January 1950; granted autonomy in 1951
1952	Saha takes his seat in the Lok Sabha; the Calendar Reform Committee is set up with Saha as chairman
1954	Raman receives the Bharat Ratna; S.N. Bose receives the Padma Vibhushan
1956 and 1957	Saha dies (16 February 1956); the national calendar comes into official use (22 March 1957)
1958 and 1959	S.N. Bose becomes FRS (1958) and National Professor (1959)
1970 and 1974	Raman dies (21 November 1970); S.N. Bose dies (4 February 1974)
1976	George Andrews finds Ramanujan's "lost notebook"
1986 and 1987	National Science Day is declared (1986) and first observed (28 February 1987); the S.N. Bose National Centre is set up (1986)
1995 and 2001	The Bose-Einstein condensate is produced (1995); the Nobel Prize in Physics is given for it (2001)

Year	Event
2011 and 2012	National Mathematics Day is declared (26 December 2011); 2012 is the National Mathematics Year; the IEEE Milestone plaque for J.C. Bose is placed (September 2012)

4. Three common exam traps

1. **The two national days.** National Science Day (28 February) marks the day on which the Raman effect was discovered in 1928. It is not Raman's birthday (7 November), and it is not the day of his Nobel Prize (1930). National Mathematics Day (22 December) is Ramanujan's birthday. It was declared in December 2011, but the National Mathematics Year was 2012.
2. **Bodies with similar names.** The IACS at Calcutta (1876) was founded by Mahendralal Sircar; Raman worked in it but did not found it. The Indian Academy of Sciences (Bangalore, 1934) is Raman's. The National Institute of Sciences of India (1935), now INSA, is the body that Saha helped to found. The Bose Institute (1917) was founded by J.C. Bose. The S.N. Bose National Centre for Basic Sciences (1986) only carries S.N. Bose's name; it came up after his death.
3. **Honours given to the wrong man.** In 1954 Raman received the Bharat Ratna and S.N. Bose the Padma Vibhushan. Raman received the Nobel Prize (1930). S.N. Bose was nominated but never received it; the Prize of 2001 went to three others for producing the Bose-Einstein condensate. J.C. Bose was against patents, yet one United States patent of 1904 stands in his name, so "he never held a patent" is wrong.

7. Sources

7.1 Sources

No. · S1

Source · The Nobel Foundation, "Sir Chandrasekhara Venkata Raman: Biographical" (Nobel Prize in Physics 1930). https://www.nobelprize.org/prizes/physics/1930/raman/biographical/

Used for · Raman: birth (7 November 1888, Tiruchirappalli) and death (21 November 1970); Presidency College, Madras, BA 1904 and MA 1907; Indian Finance Department 1907; research in the laboratory of the IACS at Calcutta; Palit Chair of Physics at Calcutta University, 1917; professor at the IISc, Bangalore, 1933 to 1948; Director of the Raman Research Institute from 1948, "established and endowed by himself"; Indian Journal of Physics founded 1926; Indian Academy of Sciences; theory of instruments of the violin family; discovery of 28 February 1928; FRS 1924; knighted 1929; Nobel Prize 1930

No. · S2

Source · Wikipedia, "C. V. Raman" (its references include S. Bhagavantam's memoir in the Biographical Memoirs of Fellows of the Royal Society, 1971; Raman's note "The colour of the sea", Nature, 1921; the American Chemical Society's landmark booklet; and the Nobel Foundation's pages). https://en.wikipedia.org/wiki/C._V._Raman

Used for · Death at Bangalore; Assistant Accountant General at Calcutta, 1907; IACS as the first research institute founded in India, 1876, by Mahendralal Sircar; voyage of 1921 and the colour of the sea against Lord Rayleigh's explanation; tabla and mridangam; K.S. Krishnan; announcement to the press on 28 February 1928; "A new radiation" in the Indian Journal of Physics, 31 March 1928; what the effect is; wording of the Nobel citation; first Asian to receive a Nobel Prize in the sciences; first Indian director of the IISc, 1933; Raman Research Institute given as 1948 and as 1949; first National Professor, 1947; Bharat Ratna 1954; Lenin Peace Prize 1957

No. · S3

Source · Indian Academy of Sciences, "History". https://www.ias.ac.in/About_IASc/History/

Used for · Academy founded in 1934 by C.V. Raman; inaugurated on 31 July 1934 at Bengaluru with 65 Founding Fellows; Raman as President, 1934 to 1970

No. · S4

Source · Wikipedia, "National Science Day". https://en.wikipedia.org/wiki/National_Science_Day

Used for · The day marks the discovery of the Raman effect on 28 February 1928; declared by the Government of India in 1986; first observed on 28 February 1987

No. · S5

Source · Encyclopaedia Britannica, "Jagadish Chandra Bose". https://www.britannica.com/biography/Jagadish-Chandra-Bose

Used for · J.C. Bose: born 30 November 1858, Mymensingh, Bengal (now in Bangladesh); died 23 November 1937, Giridih; physicist and plant physiologist

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No. · S6

Source · Wikipedia, "Jagadish Chandra Bose" (its references include Banglapedia; Mukherji's biography; D.T. Emerson, "The work of Jagadis Chandra Bose: 100 years of mm-wave research", 1997). https://en.wikipedia.org/wiki/Jagadish_Chandra_Bose

Used for · Joined Presidency College, Calcutta, in January 1885; pay at one-third and three years without salary; research begun in 1894; wavelength of about 5 mm; United States patent of 1904 for a detector and his view of patents; books of 1902 and 1926; Bose Institute, 1917, directed till his death; knighthood 1917; FRS 1920; Indian Science Congress 1927; Niruddesher Kahini (1896), Palatak Tuphan, Abyakta (1921), father of Bengali science fiction; among the teachers of S.N. Bose and Saha

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No. · S7

Source · Banglapedia (Asiatic Society of Bangladesh), "Bose, Sir Jagadish Chandra". https://en.banglapedia.org/index.php/Bose,_Sir_Jagadish_Chandra

Used for · St Xavier's School and College; BA of Calcutta University, 1879; Christ's College, Cambridge; BA of Cambridge and BSc of London, 1884; retirement in 1915; crescograph magnifying by a factor of ten million; Bose Institute, 1917; knighted 1916; FRS 1920

No. · S8

Source · Engineering and Technology History Wiki (IEEE), "Milestones: First Millimeter-wave Communication Experiments by J.C. Bose, 1894-96". https://ethw.org/Milestones:First_Millimeter-wave_Communication_Experiments_by_J.C._Bose,_1894-96

Used for · Demonstration of 1895: 60 GHz, 23 metres, two walls, bell and gunpowder; spark transmitter, coherer, polariser, horn antenna; "the first millimeter-wave communication system in the world"; Milestone plaque at Presidency College, Kolkata, September 2012

No. · S9

Source · Wikipedia, "Crescograph" (its references include J.C. Bose and G. Das, "Researches on growth and movement in plants by means of the high magnification crescograph", Proceedings of the Royal Society of London, Series B, 1919). https://en.wikipedia.org/wiki/Crescograph

Used for · The crescograph as a device for measuring growth in plants; movement of the tip of a plant; magnification of up to 10,000 times; experiments with temperature, chemicals, gases and electricity

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No. · S10

Source · Encyclopaedia Britannica, "Satyendra Nath Bose". https://www.britannica.com/biography/Satyendra-Nath-Bose

Used for · S.N. Bose: born 1 January 1894, Calcutta; died 4 February 1974, Calcutta; taught at the University of Dacca (1921 to 1945) and at Calcutta (1945 to 1956); paper of 1924, "Planck's Law and the Hypothesis of Light Quanta"; Bose-Einstein statistics

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No. · S11

Source · Wikipedia, "Satyendra Nath Bose" (its references include J. Mehra's memoir in the Biographical Memoirs of Fellows of the Royal Society, 1975, and S. Mahanti's Vigyan Prasar biography). https://en.wikipedia.org/wiki/Satyendra_Nath_Bose

Used for · Presidency College, BSc 1913 and MSc 1915, first place, Saha second; lecturer at the Science College, 1916 to 1921; Reader in physics at Dhaka, 1921; derivation of Planck's law; Philosophical Magazine; Einstein's translation and the Zeitschrift für Physik; extension to atoms and the Bose-Einstein condensate, produced in 1995; bosons named by Dirac; book of 1919 with Saha; Padma Vibhushan 1954; Visva-Bharati 1956 to 1958; FRS 1958; National Professor 1959 for 15 years; Nobel nominations of 1956, 1959 and 1962; S.N. Bose National Centre, 1986

No. · S12

Source · The Nobel Foundation, "The Nobel Prize in Physics 2001". https://www.nobelprize.org/prizes/physics/2001/summary/

Used for · Eric A. Cornell, Wolfgang Ketterle and Carl E. Wieman; "for the achievement of Bose-Einstein condensation in dilute gases of alkali atoms"

No. · S13

Source · Encyclopaedia Britannica, "Meghnad N. Saha". https://www.britannica.com/biography/Meghnad-N-Saha

Used for · Saha: born 6 October 1893, Seoratali, near Dacca; died 16 February 1956, New Delhi; thermal ionisation equation of 1920, its use for stellar spectra and temperature, Milne's form; Professor of Physics at Allahabad, 1923; Calcutta, 1938; Institute of Nuclear Physics; Science and Culture founded in 1935; elected to Parliament in 1951 as an independent; FRS 1927

No. · S14

Source · Wikipedia, "Meghnad Saha" (its references include S. Banerjee, "Meghnad Saha: Physicist and nationalist", Physics Today, 2016; D.S. Kothari's memoir in the Biographical Memoirs of Fellows of the Royal Society, 1960; the Statistical Report on General Elections, 1951). https://en.wikipedia.org/wiki/Meghnad_Saha

Used for · Classmate of S.N. Bose; National Academy of Science, 1930; chief architect of river planning and the original plan of the Damodar Valley Project; Calcutta North West; member of the Lok Sabha from 1952 to his death; Indian Science Congress 1934; relation of stellar spectral classes to temperature

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No. · S15

Source · Banglapedia (Asiatic Society of Bangladesh), "Saha, Meghnad". https://en.banglapedia.org/index.php/Saha,_Meghnad

Used for · ISc from Dhaka College, 1911; honours in mathematics at Presidency College; Lecturer at the College of Science, 1916; Palit Professor, 1938; National Institute of Sciences of India, 1935, later the Indian National Science Academy; subjects taken up by Science and Culture; National Planning Committee, 1938; independent candidate in 1951

No. · S16

Source · Wikipedia, "Saha Institute of Nuclear Physics". https://en.wikipedia.org/wiki/Saha_Institute_of_Nuclear_Physics

Used for · Institute named after and founded by Meghnad Saha; at Kolkata; the institutional chronology is supplied by S29

No. · S17

Source · Wikipedia, "Indian national calendar" (its references include M.N. Saha and others, Report of the Calendar Reform Committee, CSIR, 1955, and S.K. Chatterjee, Indian Calendric System, 1998). https://en.wikipedia.org/wiki/Indian_national_calendar

Used for · Calendar Reform Committee of 1952 under the CSIR, Saha as chairman, report of 1955; national calendar on the Saka era; official use from 1 Chaitra 1879 Saka, 22 March 1957

No. · S18

Source · Encyclopaedia Britannica, "Srinivasa Ramanujan". https://www.britannica.com/biography/Srinivasa-Ramanujan

Used for · Ramanujan: born 22 December 1887, Erode; died 26 April 1920, Kumbakonam, aged 32

No. · S19

Source · Wikipedia, "Srinivasa Ramanujan" (its references include R. Kanigel, The Man Who Knew Infinity, 1991, and G.H. Hardy, Ramanujan: Twelve Lectures, 1940). https://en.wikipedia.org/wiki/Srinivasa_Ramanujan

Used for · Kumbakonam; Pachaiyappa's College; Carr's Synopsis; Madras Port Trust, March 1912, 30 rupees; letter of 16 January 1913; sailing on 17 March 1914; nearly five years at Cambridge; return in 1919; partitions formula of 1918; series for π; mock theta functions and the letter of January 1920; nearly 3,900 results; the 1729 story; notebooks and the "lost notebook" found by George Andrews in 1976; FRS on 2 May 1918 after Ardaseer Cursetjee (1841); Fellow of Trinity College in October 1918; SASTRA and ICTP Ramanujan Prizes; Kanigel's book (1991) and the film (2015); Madras given as the place of death in the fact box

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No. · S20

Source · Wikipedia, "National Mathematics Day (India)" (its references are the Prime Minister's Office text of the speech at Chennai and The Hindu, 27 December 2011). https://en.wikipedia.org/wiki/National_Mathematics_Day_(India)

Used for · 22 December declared National Mathematics Day by Prime Minister Manmohan Singh on 26 December 2011 at Madras University; 2012 as the National Mathematics Year

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No. · S21

Source · Press Information Bureau, Ministry of Science and Technology, "National Science Day (28 February)", 28 February 2024. https://static.pib.gov.in/WriteReadData/specificdocs/documents/2024/feb/doc2024228314801.pdf

Used for · In 1986 the National Council for Science and Technology Communication asked the Government of India to designate 28 February as National Science Day, and the Government accepted; first celebrated on 28 February 1987; the day commemorates the discovery of the Raman effect, made in the laboratory of the IACS, Kolkata; Nobel Prize of 1930

No. · S22

Source · MacTutor History of Mathematics Archive, University of St Andrews, "Srinivasa Aiyangar Ramanujan". https://mathshistory.st-andrews.ac.uk/Biographies/Ramanujan/

Used for · Ramanujan: born 22 December 1887, Erode; died 26 April 1920; Pachaiyappa's College and the First Arts examination; Madras Port Trust from 1 March 1912; letter to Hardy, January 1913; sailing on 17 March 1914; FRS on 2 May 1918; Fellow of Trinity College in October 1918; return to India in 1919

No. · S23

Source · G.H. Hardy, obituary notice of Srinivasa Ramanujan in the Royal Society's "Obituary Notices of Fellows Deceased" (copy in the MacTutor archive). https://mathshistory.st-andrews.ac.uk/RS/ramanujan_rs.pdf

Used for · Death at Kumbakonam on 26 April 1920; Fellow of the Royal Society, 1918; first letter to Hardy on 16 January 1913

No. · S24

Source · R. Kanigel, "Ramanujan, Srinivasa", Oxford Dictionary of National Biography, Oxford University Press, 2004 (copy in the MacTutor archive). https://mathshistory.st-andrews.ac.uk/DNB/Ramanujan.html

Used for · Birth at Erode on 22 December 1887; death in Madras on 26 April 1920; clerk in the Madras Port Trust, 1912; Fellow of the Royal Society, 1918; return to India in 1919

No. · S25

Source · Wikipedia, "Boson" (its references are the notes on Dirac's lecture "Developments in Atomic Theory", Paris, 6 December 1945, and G. Farmelo, The Strangest Man, 2009). https://en.wikipedia.org/wiki/Boson

Used for · The term "boson" coined by Paul Dirac for the particles that obey Bose-Einstein statistics

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No. · S26

Source · Wikipedia, "Calcutta North West Lok Sabha constituency" (its reference is the Election Commission of India, "General Elections, India, 1951: Constituency Wise Detailed Results"). https://en.wikipedia.org/wiki/Calcutta_North_West_Lok_Sabha_constituency

Used for · Saha as the member for the seat from 1952; listed under the Revolutionary Socialist Party; the Election Commission's report titled as the general elections of 1951

No. · S27

Source · The Nobel Foundation, press release, "The Nobel Prize in Physics 2001", 9 October 2001. https://www.nobelprize.org/prizes/physics/2001/press-release/

Used for · Einstein's prediction that a gas of such atoms, cooled to a very low temperature, would gather in the lowest possible energy state; the state first achieved in 1995

No. · S28

Source · Institute of Mathematical Sciences, Srinivasa Ramanujan biography. https://www.imsc.res.in/~rao/ramanujan.html

Used for · Cambridge BA by research, 1916

No. · S29

Source · Saha Institute of Nuclear Physics, official institutional history and RTI disclosure. https://www.saha.ac.in/web/administration-right-to-information

Used for · Founded in 1949; formal inauguration and Foundation Day, 11 January 1950; autonomy in 1951; renamed after Saha's death

DAY 8 · TOPIC 78

Number series: difference and ratio patterns

1. Concept in one line

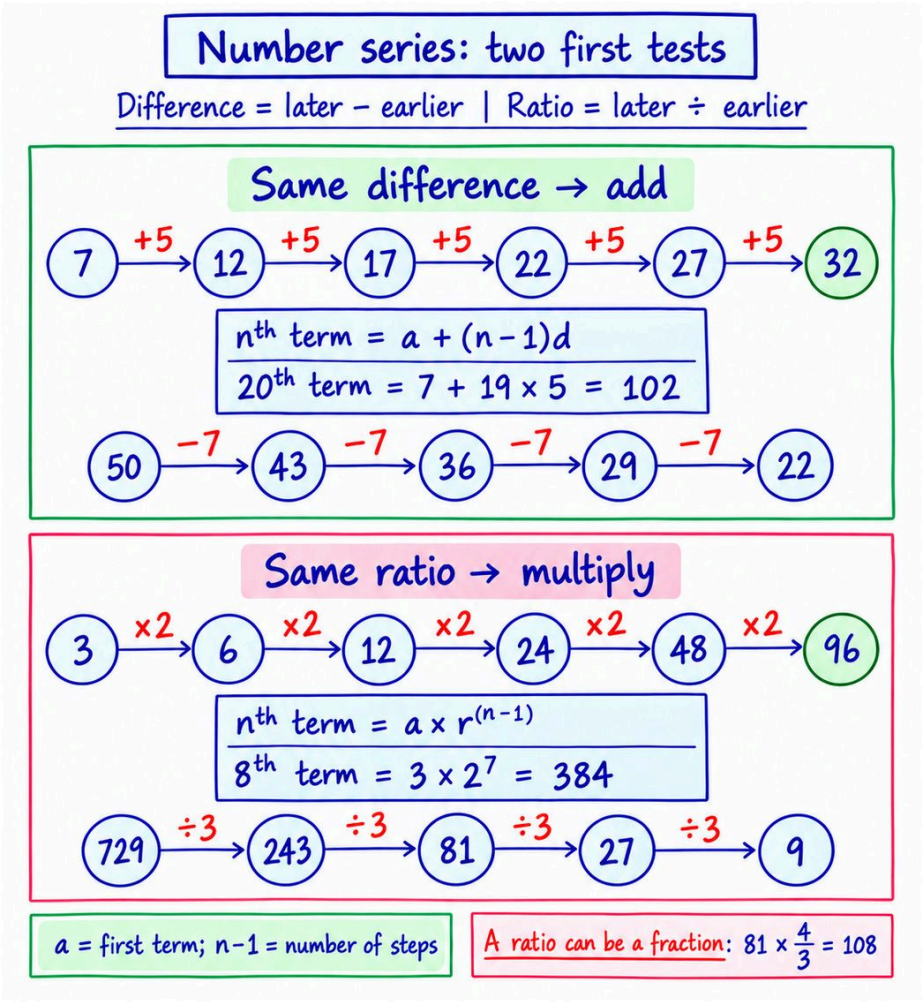
A number series is a list of numbers written in order by one rule; in a difference pattern the rule shows when neighbouring terms are subtracted, and in a ratio pattern it shows when they are divided. The examination gives a few terms and asks for the next term, or for a missing term inside the series.

2. Revision notes

2.1 What a number series question asks

- A number series is a list of numbers written in a fixed order by one rule. Each number in the list is a term. The rule is not stated; you find it from the terms that are given.
- School textbooks call such a list a sequence and keep the word "series" for the sum of its terms. Reasoning papers call the list itself a number series, and these notes do the same.
- Two kinds of question are covered here. "Find the next term": the gap is at the end. "Find the missing term": the gap, shown by a question mark, is inside the series.

- A step is the move from one term to the term after it. Two measures of a step are used throughout:
  - the difference of a step = later term - earlier term. It is negative when the series falls. In a falling series the size of a negative difference is called a drop: a difference of -7 is a drop of 7.
  - the ratio of a step = later term ÷ earlier term. It is less than 1 when the series falls.
- Look at three things first:
  1. Direction: does the series rise, fall, or go up and down?
  2. Speed: does it move by about the same amount at every step, or faster and faster?
  3. Size: by how much does each term differ from the term before it?
- All the series in this topic are made of positive numbers. Numbers of four or more digits are written without commas (1080, not 1,080), because commas separate the terms.
- Other days cover: series built on squares, cubes and primes; alternating and mixed series; finding the wrong term; letter series; alpha-numeric series.



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DAY 8 | TOPIC 78 | 01

DAY 8 · TOPIC 78 · VISUAL REVISION 1

2.2 Difference patterns: a constant difference (arithmetic series)

- Every term is got by adding the same number to the term before it. The fixed number is the common difference, d. Such a series is an arithmetic series; textbooks call it an arithmetic progression (AP).
- d can be positive (the series rises) or negative (the series falls).
- 7, 12, 17, 22, 27: every difference is +5. The next term is 32.
- 50, 43, 36, 29: every difference is -7. The next term is 22.
- **nth term = a + (n - 1) × d**, where a is the first term. From the 1st term to the nth term there are n - 1 steps.
- The 20th term of 7, 12, 17, ... is 7 + 19 × 5 = 102. The 8th term of 50, 43, 36, ... is 50 + 7 × (-7) = 1.
- To find the place of a term: n = (term - a) ÷ d + 1. In 7, 12, 17, ... the number 102 stands at (102 - 7) ÷ 5 + 1 = 20, so it is the 20th term.

2.3 Difference patterns: differences that form a pattern

- When the differences are not equal, read the differences as a series of their own. They are the first differences. The differences of the first differences are the second differences.
- If the second differences are all equal, the first differences rise or fall by a constant. Then:
  - next first difference = last first difference + second difference;
  - next term = last term + next first difference.

• The common cases:

The first differences are · The natural numbers

Series · 4, 5, 7, 10, 14

First differences · +1, +2, +3, +4

Second difference · +1

Next term · 14 + 5 = 19

The first differences are · The even numbers

Series · 3, 5, 9, 15, 23

First differences · +2, +4, +6, +8

Second difference · +2

Next term · 23 + 10 = 33

The first differences are · The odd numbers

Series · 6, 9, 14, 21, 30

First differences · +3, +5, +7, +9

Second difference · +2

Next term · 30 + 11 = 41

The first differences are · The multiples of one number

Series · 6, 11, 21, 36, 56

First differences · +5, +10, +15, +20

Second difference · +5

Next term · 56 + 25 = 81

The first differences are · Any other list that rises by a constant

Series · 2, 5, 12, 23, 38

First differences · +3, +7, +11, +15

Second difference · +4

Next term · 38 + 19 = 57

The first differences are · Differences that get smaller, in a rising series

Series · 10, 34, 54, 70, 82

First differences · +24, +20, +16, +12

Second difference · -4

Next term · 82 + 8 = 90

The first differences are · Drops that get bigger, in a falling series

Series · 90, 88, 84, 78, 70

First differences · -2, -4, -6, -8

Second difference · -2

Next term · 70 - 10 = 60

- Keep the signs. A second difference is also "later minus earlier". From +24 to +20 it is -4. From -2 to -4 it is -2.
- The first differences can also be the squares, the cubes or the primes (another day), or can themselves be multiplied at every step (see 2.7).

2.4 How to set out a difference table

1. Write the series in one row, with space between the terms.
2. Under each step write its first difference: later term minus earlier term, with its sign. In the table below each difference stands under the later term of its step.
3. If that row is constant, stop. If it is not, write the second differences under it in the same way.
4. Stop when a row is constant, or is a list you know. Go down one more row only if you must (example B in Section 3 needs three rows of differences).
5. Build back up. Write the next number of the lowest row, add it to the last number of the row above, and go on up to the series.

Row · Series

1st term · 2

2nd term · 5

3rd term · 12

4th term · 23

5th term · 38

Next · 38 + 19 = 57

Row · First differences

1st term ·

2nd term · +3

3rd term · +7

4th term · +11

5th term · +15

Next · 15 + 4 = 19

Row · Second differences

1st term ·

2nd term ·

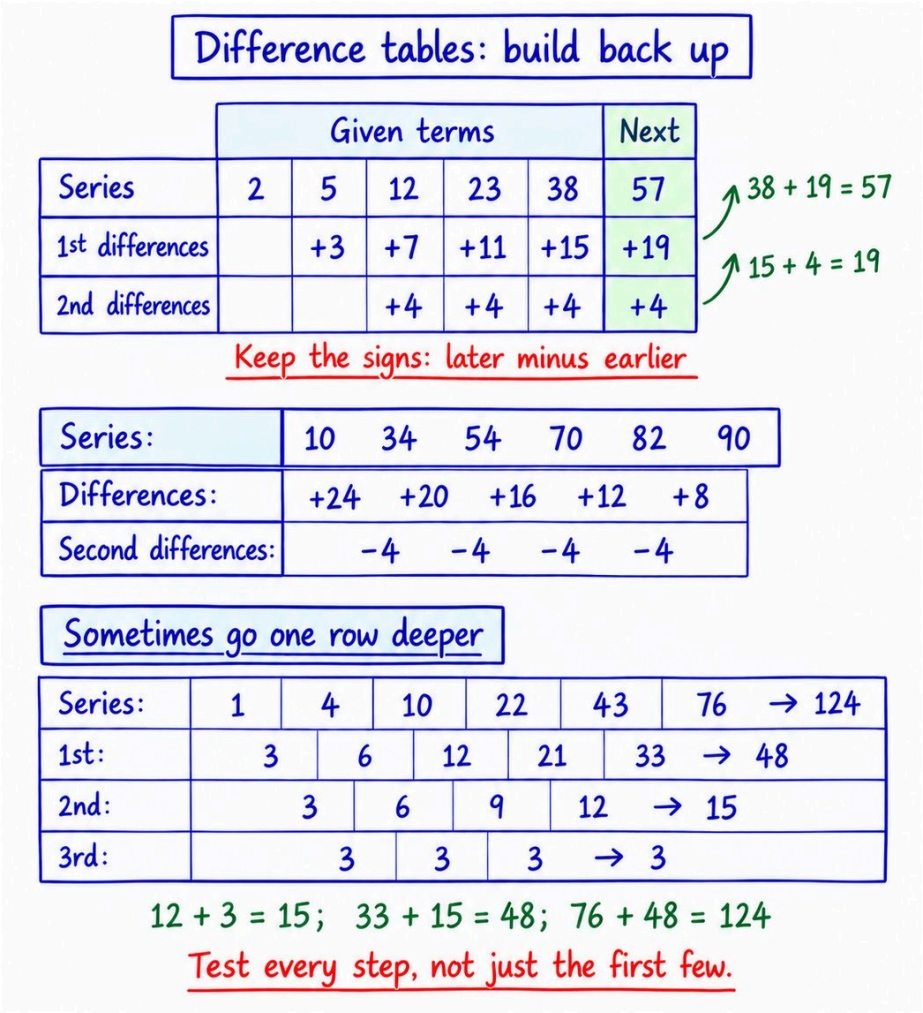
3rd term · +4

4th term · +4

5th term · +4

Next · 4

- Do not call a row constant on one entry. You need at least two equal entries, and three are safer. Four terms give three first differences and only two second differences.
- Test the rule on every term that is given, not only on the first few.



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DAY 8 | TOPIC 78 | 02

2.5 Ratio patterns: a constant ratio (geometric series)

- Every term is got by multiplying the term before it by the same number. The fixed number is the common ratio, r. Such a series is a geometric series; textbooks call it a geometric progression (GP).
- 3, 6, 12, 24, 48: every ratio is 2. The next term is 96.
- **nth term = $a \times r^{n-1}$**, that is, a multiplied by r, n - 1 times. The 8th term of 3, 6, 12, ... is $3 \times 2^7 = 3 \times 128 = 384$.
- **A ratio less than 1 gives a falling series.** 729, 243, 81, 27: every ratio is 1/3, and the next term is 9. Similarly, in 96, 48, 24, 12 every ratio is 1/2 (each term is half of the term before), and the next term is 6.
- **The ratio can also be a fraction more than 1.** 81, 108, 144, 192: 108/81 = 4/3, 144/108 = 4/3 and 192/144 = 4/3. The next term is $192 \times 4/3 = 256$.
- To find a ratio, write the later term over the earlier term as a fraction and reduce it to lowest terms. Do not expect a whole number.

2.6 Ratio patterns: a multiplier that changes

- The multiplier of a step is the number by which a term is multiplied to give the next term. It is the ratio of that step. In these series the multipliers themselves form a simple list.

The multiplier · Rises by 1 at every step

Series · 2, 2, 4, 12, 48

Multipliers · ×1, ×2, ×3, ×4

Next term · 48 × 5 = 240

The multiplier · Rises by a half at every step

Series · 16, 8, 8, 12, 24

Multipliers · ×0.5, ×1, ×1.5, ×2

Next term · 24 × 2.5 = 60

The multiplier · Falls by 1 at every step

Series · 3, 18, 90, 360, 1080

Multipliers · ×6, ×5, ×4, ×3

Next term · 1080 × 2 = 2160

The multiplier · Is a divisor that rises by 1 at every step

Series · 720, 720, 360, 120, 30

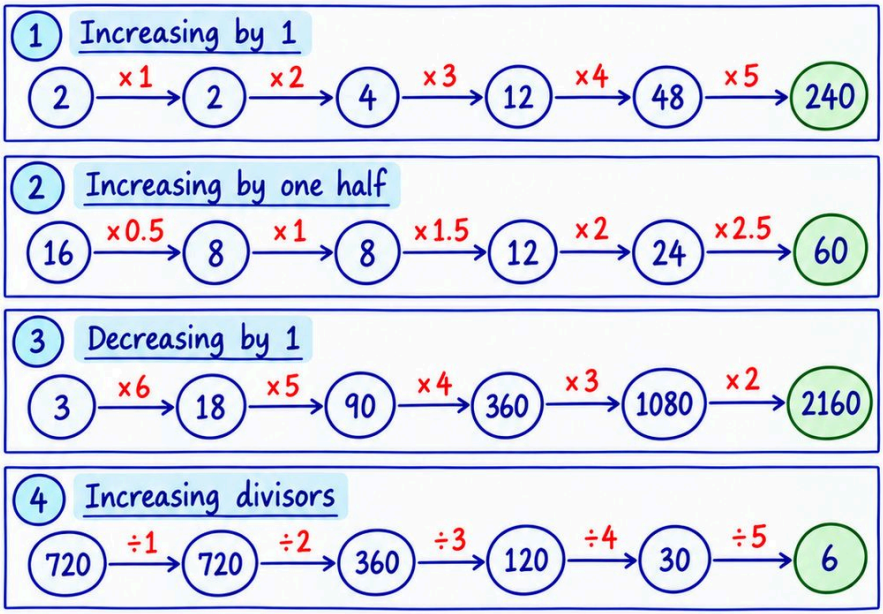
Multipliers · ÷1, ÷2, ÷3, ÷4

Next term · 30 ÷ 5 = 6

- With ×1 a term is repeated (2, 2). With ×0.5 followed by larger multipliers the series falls first and then rises (16, 8, 8, 12). A repeated term, or a fall followed by a rise, often points to a changing multiplier.

Changing multipliers

Read the operation labels as a sequence



Test differences AND ratios

Changing ratios can still have a clear difference pattern.

1, 4, 9, 16, 25

Differences: 3, 5, 7, 9

Second differences: 2, 2, 2

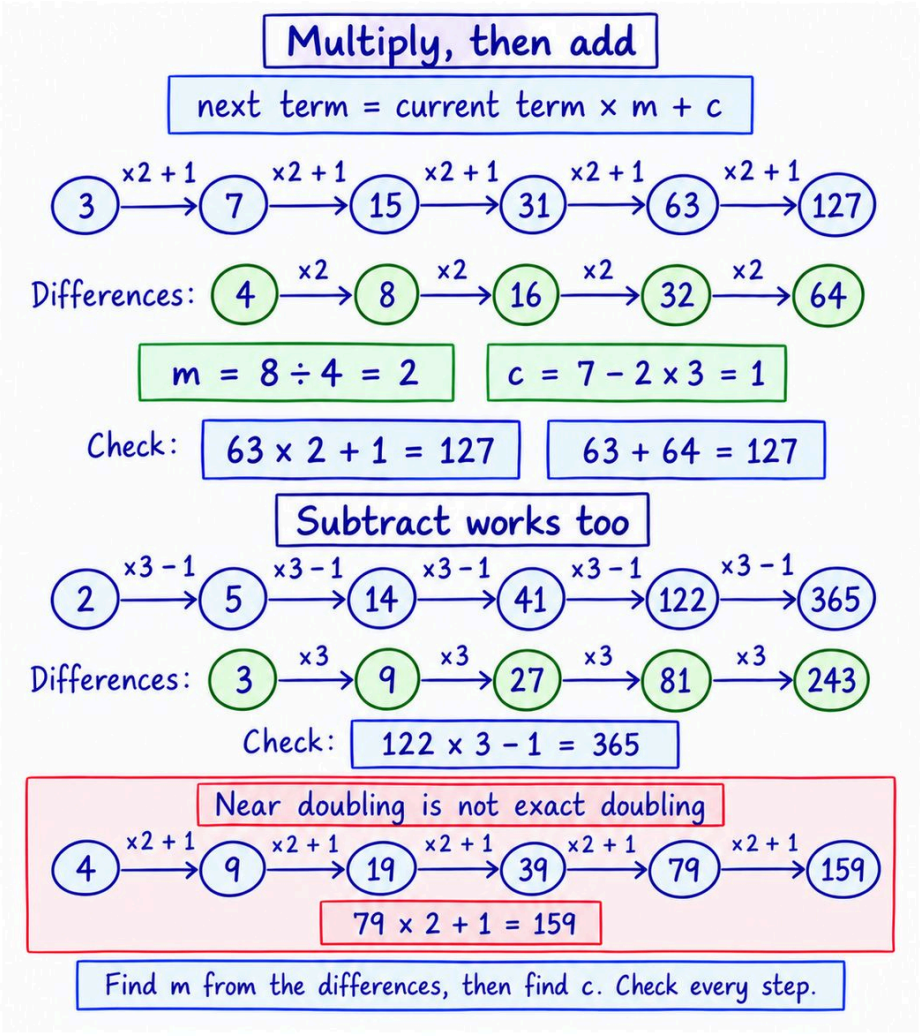
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DAY 8 | TOPIC 78 | 03

2.7 "Multiply and add": the bridge between the two families

- Rule: next term = term × m + c, where m and c are fixed. When c is negative it is "multiply and subtract".
- ×2 + 1: 3, 7, 15, 31, 63. The next term is 63 × 2 + 1 = 127.
- ×3 - 1: 2, 5, 14, 41, 122. The next term is 122 × 3 - 1 = 365.
- Two clues to this rule:
  - When m is more than 1 and the series rises, the ratios are not equal, but they move closer and closer to one number, m, without reaching it. For 3, 7, 15, 31, 63 they are 7/3, 15/7, 31/15 and 63/31: about 2.33, 2.14, 2.07 and 2.03.
  - The first differences form a geometric series whose ratio is m: 4, 8, 16, 32 (ratio 2) for the first series; 3, 9, 27, 81 (ratio 3) for the second.
- To find the rule: m is the ratio of the first differences; c = second term - m × first term (7 - 2 × 3 = 1). Test m and c on every step.
- So "differences that double" and "multiply by 2, then add or subtract" are one series seen in two ways. 5, 7, 11, 19, 35 has the differences +2, +4, +8, +16, and its rule is also ×2 - 3. The next term is 35 + 32 = 67, or 35 × 2 - 3 = 67.



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2.8 Difference pattern or ratio pattern: look at how the differences grow

What to look at	Difference pattern	Ratio pattern
How the differences grow	By adding: they are equal, or they change by the same amount at every step (+3, +7, +11, +15)	By multiplying: with a constant ratio each difference is the difference before it multiplied by that ratio (+3, +6, +12, +24); with a changing multiplier the differences follow no steady rule of their own
Later term ÷ earlier term	Usually a different fraction at every step, with no simple list (5/2, 12/5, 23/12)	The same number at every step, or a simple list (×1, ×2, ×3)
The rows of the difference table	The row of first differences or of second differences is constant (rarely, a later row)	No row of differences becomes constant: for 3, 6, 12, 24, 48 the first differences are 3, 6, 12, 24 and the second differences are 3, 6, 12

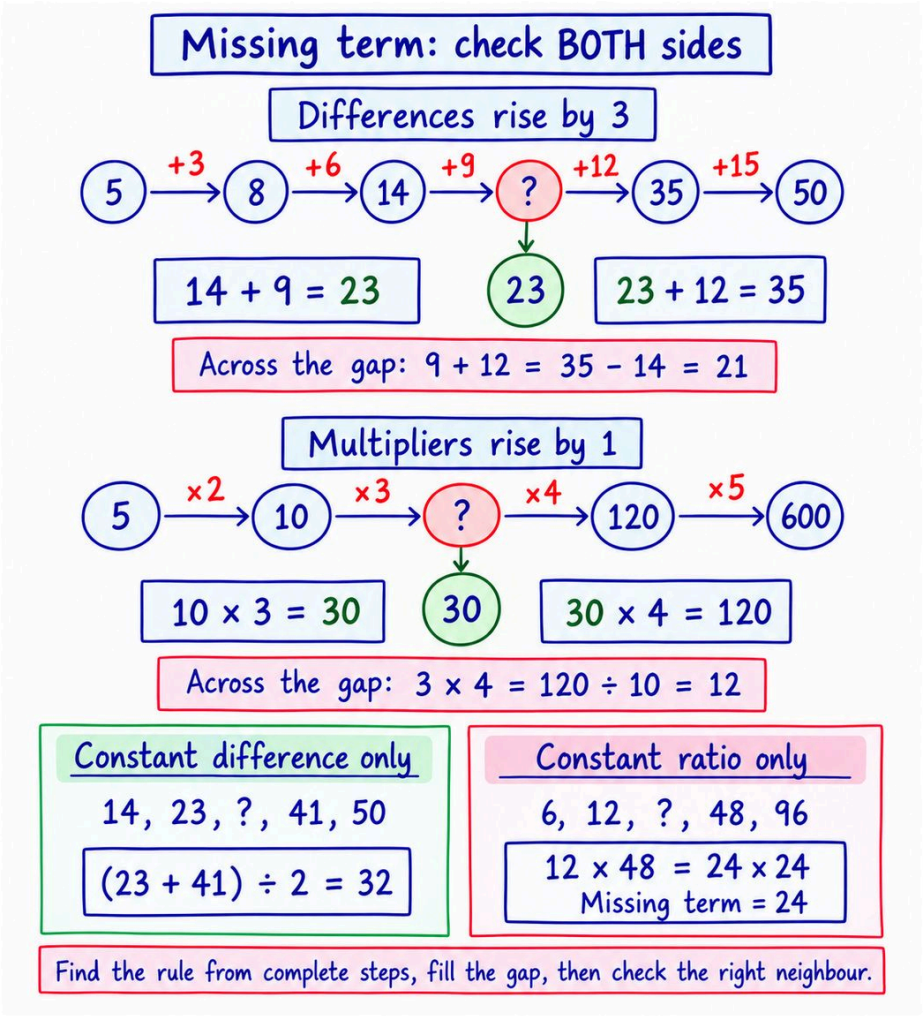
What to look at	Difference pattern	Ratio pattern
First test to try	The difference table	Dividing each term by the term before it

- A rough guide to where to start: if each term is about double the term before it, or more (about half, or less, in a falling series), divide first. Otherwise subtract first. It is only a guide: 81, 108, 144, 192 has the ratio 4/3, and its differences 27, 36, 48 show it, because each is 4/3 of the difference before.
- When unsure, test in this order: first differences, second differences, ratios, multiply and add.

2.9 Finding a term inside the series

- The missing term is tied to both of its neighbours. The step into the gap and the step out of the gap must both obey the rule.
- A complete step is a step whose two terms are both given. Method:
  1. Find the rule from the complete steps on the left and on the right of the gap.
  2. Fill the gap from the left.
  3. Check with the right: the term you filled in must lead to the next given term.
- Across the gap there are two unknown steps. In a difference pattern their two differences add up to (term after the gap - term before the gap). In a ratio pattern their two multipliers multiply to (term after the gap ÷ term before the gap).

- **Difference pattern:** 5, 8, 14, ?, 35, 50. Complete steps: +3 and +6 on the left, +15 on the right. Differences that rise by 3 are +3, +6, +9, +12, +15. Fill: 14 + 9 = 23. Check: 23 + 12 = 35. Across the gap: 9 + 12 = 21 = 35 - 14.
- **Ratio pattern:** 5, 10, ?, 120, 600. Complete steps: ×2 on the left, ×5 on the right. The multipliers are ×2, ×3, ×4, ×5. Fill: 10 × 3 = 30. Check: 30 × 4 = 120. Across the gap: 3 × 4 = 12 = 120 ÷ 10.
- Two shortcuts, each for one kind of series only:
  - Constant difference: the missing term is the average of its two neighbours. 14, 23, ?, 41, 50: (23 + 41) ÷ 2 = 32.
  - Constant ratio: the missing term multiplied by itself is equal to the product of its two neighbours, because three neighbouring terms are in continued proportion (Topic 59). 6, 12, ?, 48, 96: 12 × 48 = 576 = 24 × 24, so the missing term is 24.
- Use a shortcut only after the complete steps have shown which kind of series it is.
- When options are given, put each option in the gap. Only the right one fits on both sides.



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DAY 8 · TOPIC 78 · VISUAL REVISION 5

3. Extra section: the common patterns in one table, and worked examples

A. The common patterns, with one example each

No. · 1

Pattern · Constant difference, rising series

Rule of the example · +7 at every step

Example · 9, 16, 23, 30, 37

Next term · 37 + 7 = 44

No. · 2

Pattern · Constant difference, falling series

Rule of the example · -11 at every step

Example · 95, 84, 73, 62, 51

Next term · 51 - 11 = 40

No. · 3

Pattern · Differences that rise by a constant

Rule of the example · +3, +6, +9, +12

Example · 8, 11, 17, 26, 38

Next term · 38 + 15 = 53

No. · 4

Pattern · Differences that fall by a constant

Rule of the example · +20, +16, +12, +8

Example · 12, 32, 48, 60, 68

Next term · 68 + 4 = 72

No. · 5

Pattern · Constant ratio, rising series

Rule of the example · ×3 at every step

Example · 4, 12, 36, 108, 324

Next term · 324 × 3 = 972

No. · 6

Pattern · Constant ratio, falling series

Rule of the example · ×1/2 at every step

Example · 480, 240, 120, 60, 30

Next term · 30 × 1/2 = 15

No. · 7

Pattern · Multiplier that rises by 1

Rule of the example · ×3, ×4, ×5, ×6

Example · 1, 3, 12, 60, 360

Next term · 360 × 7 = 2520

No. · 8

Pattern · Multiplier that rises by a half

Rule of the example · ×0.5, ×1, ×1.5, ×2

Example · 12, 6, 6, 9, 18

Next term · 18 × 2.5 = 45

No. · 9

Pattern · Multiply and add

Rule of the example · ×2 + 3 at every step

Example · 1, 5, 13, 29, 61

Next term · 61 × 2 + 3 = 125

No. · 10

Pattern · Multiply and subtract

Rule of the example · ×3 - 2 at every step

Example · 2, 4, 10, 28, 82

Next term · 82 × 3 - 2 = 244

B. A series that needs three rows of differences

Find the next term: 1, 4, 10, 22, 43, 76, ?

- First differences: +3, +6, +12, +21, +33. The start (3, 6, 12) looks like doubling, but the next difference is 21, not 24. There is no rule yet.
- Second differences: +3, +6, +9, +12. They rise by 3. The third differences are +3, +3, +3.

- Build back up: the next second difference is 12 + 3 = 15. The next first difference is 33 + 15 = 48. The next term is 76 + 48 = 124.
- Answer: 124.

C. The nth term, and the place of a term

In the series 8, 15, 22, 29, ..., find the 25th term. Which term of the series is 148?

- Every difference is +7, so d = 7 and a = 8.
- 25th term = 8 + 24 × 7 = 8 + 168 = 176.
- Place of 148: (148 - 8) ÷ 7 + 1 = 20 + 1 = 21. So 148 is the 21st term.

D. Difference or ratio?

Find the next term: 4, 8, 14, 22, 32, ?

- The first step looks like ×2. But the ratios are 2, 7/4, 11/7 and 16/11: a different fraction at every step.
- First differences: +4, +6, +8, +10. They rise by 2.
- The next first difference is 12. The next term is 32 + 12 = 44.
- Answer: 44.

E. Multiply and add

Find the next term: 4, 9, 19, 39, 79, ?

- Ratios: 9/4, 19/9, 39/19 and 79/39, about 2.25, 2.11, 2.05 and 2.03. They move closer and closer to 2 without reaching it.
- First differences: +5, +10, +20, +40. They form a geometric series with ratio 2. So m = 2, and c = 9 - 2 × 4 = 1.

- Test: 4 × 2 + 1 = 9; 9 × 2 + 1 = 19; 19 × 2 + 1 = 39; 39 × 2 + 1 = 79.
- The next term is 79 × 2 + 1 = 159. By the differences: 79 + 80 = 159.
- Answer: 159. Plain doubling gives 158, which is wrong.

F. A missing term in a series with a constant ratio

Find the missing term: 48, 72, ?, 162, 243

- Complete steps: 72 ÷ 48 = 3/2 on the left and 243 ÷ 162 = 3/2 on the right. The ratio is constant: 3/2.
- Fill: 72 × 3/2 = 108. Check: 108 × 3/2 = 162.
- Shortcut: 72 × 162 = 11664 = 108 × 108.
- Answer: 108. The average of the neighbours, (72 + 162) ÷ 2 = 117, is wrong here: the differences 24 and 81 of the complete steps are not equal, so this is not a constant-difference series.

4. Three common exam traps

1. **Fixing the rule from the first step alone.** A series that starts 3, 6 may go on by +3 (9, 12), by ×2 (12, 24) or by differences that grow (+3, +5, +7 gives 11, 18). One step fits many rules. Find the rule from at least three steps and test it on every term. In example B the differences start 3, 6, 12 like a doubling, and the fourth difference breaks that reading.
2. **Counting n steps for the nth term.** From the 1st term to the nth term there are n - 1 steps, not n. The 20th term of 7, 12, 17, ... is 7 + 19 × 5 = 102, not 7 + 20 × 5 = 107. The 8th term of 3, 6, 12, ... is $3 \times 2^7 = 384$, not $3 \times 2^8 = 768$.

3. **Reading "nearly double" as "double".** In 3, 7, 15, 31, 63 every term is a little more than twice the term before it. Plain doubling gives 126 as the next term; the rule is ×2 + 1 and the next term is 127. When the ratios come closer and closer to one number without reaching it, test "multiply and add": the first differences 4, 8, 16, 32 settle it.

7. Sources

7.1 Sources

No. · S1

Source · NCERT, Mathematics, Class X, Chapter 5 "Arithmetic Progressions" (reprint 2026-27), Sections 5.2 and 5.3. https://ncert.nic.in/textbook/pdf/jemh105.pdf

Used for · Each number in the list is called a term; an arithmetic progression is a list in which each term is obtained by adding a fixed number to the preceding term; that number is the common difference and can be positive, negative or zero; the nth term is a + (n - 1)d

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No. · S2

Source · NCERT, Mathematics, Class XI, Chapter 8 "Sequences and Series" (reprint 2026-27), Sections 8.2, 8.3, 8.4, 8.4.1 and 8.4.3. https://ncert.nic.in/textbook/pdf/kemh108.pdf

Used for · The numbers of a sequence are its terms; "series" is the sum expression associated with a sequence; a geometric progression has non-zero terms and a constant ratio between consecutive terms, called the common ratio (2, 4, 8, 16 has the ratio 2); the nth term is a multiplied by r to the power n - 1; the geometric mean of two positive numbers is the square root of their product (2 and 8 give 4)

No. · S3

Source · Wikipedia, "Arithmetic progression" (the page's references include BBC Bitesize, "Linear sequences", and Weisstein, "Arithmetic progression", MathWorld). https://en.wikipedia.org/wiki/Arithmetic_progression

Used for · In an arithmetic progression the difference from any succeeding term to its preceding term remains constant; that constant is the common difference

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No. · S4

Source · Wikipedia, "Geometric progression" (citing Young, Precalculus, John Wiley & Sons, 2010, p. 966; Hall and Knight, Higher Algebra, p. 39). https://en.wikipedia.org/wiki/Geometric_progression

Used for · Each term after the first is found by multiplying the previous one by a fixed number, the common ratio; 2, 6, 18, 54 has the ratio 3 and 10, 5, 2.5, 1.25 has the ratio 1/2; the terms grow in size when the ratio is more than 1 and shrink towards zero when it is less than 1

No. · S5

Source · Wikipedia, "Difference engine", section "Method of differences". https://en.wikipedia.org/wiki/Difference_engine

Used for · The difference table: a column of values, a column of the differences of neighbouring values and a column of the differences of those differences; for a quadratic expression the second differences are constant (2, 1, 4, 11, 22 gives -1, 3, 7, 11 and then 4, 4, 4); the next value is found by adding back up the columns (22 + 15 = 37)

HCF and LCM

1. Concept in one line

The highest common factor (HCF) of two or more numbers is the largest number that divides each of them exactly, and their least common multiple (LCM) is the smallest number that each of them divides exactly. The exam asks you to find both quickly, and to use the links between them: the relation between two numbers, their HCF and their LCM, co-prime numbers, and numbers given through a ratio.

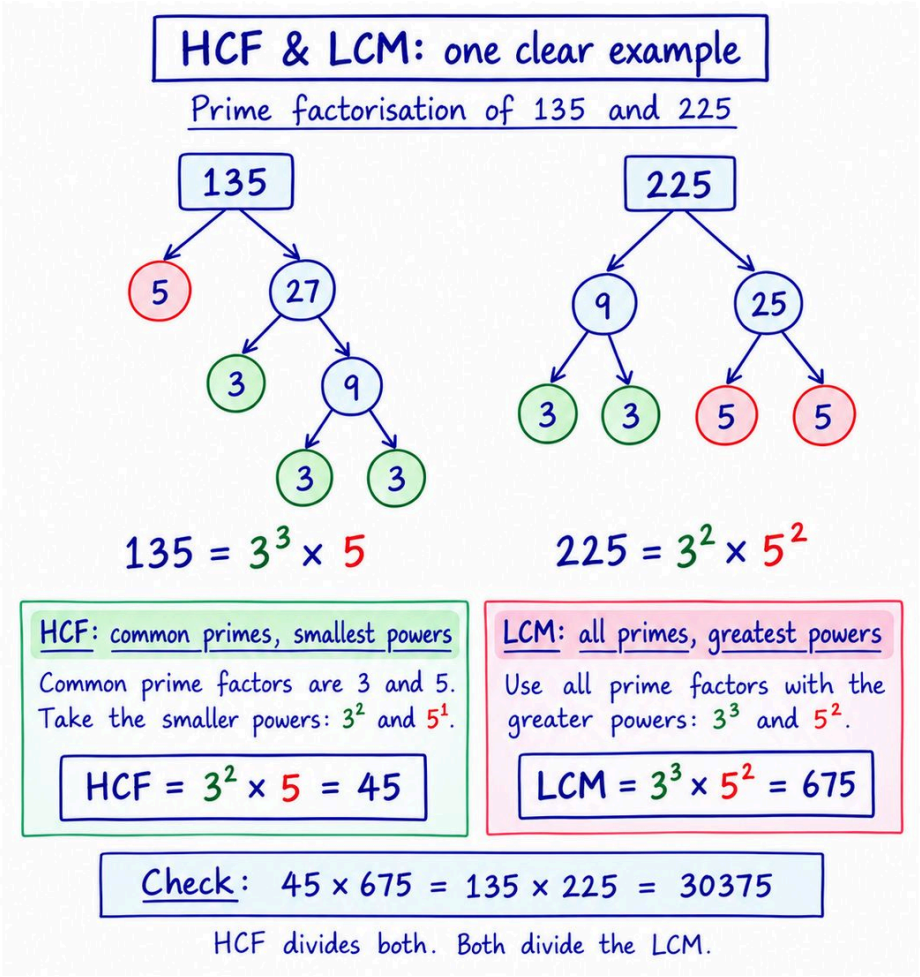
2. Revision notes

2.1 Factors, multiples and the two names

- A factor of a number divides it exactly, that is, leaves no remainder. The number is then a multiple of that factor: $48 = 6 \times 8$, so 6 is a factor of 48, and 48 is a multiple of 6 (Topics 39 and 49).
- A number has a limited number of factors: the smallest is 1 and the largest is the number itself. It has an unlimited number of multiples: the smallest is the number itself.
- **HCF.** NCERT Class VI: "The Highest Common Factor (HCF) of two or more given numbers is the highest (or greatest) of their common factors." It is also known as the greatest common divisor (GCD). These notes use the name HCF throughout.

- **LCM.** The LCM of two or more given numbers is the lowest (or smallest, or least) of their common multiples. NCERT Class VI expands LCM as "Lowest Common Multiple"; "least common multiple", the name used in Topics 39 and 49, means the same thing.
- In this topic "number" means a natural number.

Point	HCF	LCM
Meaning	The largest number that divides each of the given numbers exactly	The smallest number that each of the given numbers divides exactly
Size	Never larger than the smallest of the given numbers	Never smaller than the largest of the given numbers
From the prime factorisations	Product of the lowest power of each common prime	Product of the highest power of every prime that appears
When two numbers are co-prime (no common factor other than 1)	1	Their product
When one number is a multiple of the other	The smaller number	The larger number
Example: 12 and 18	6	36



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DAY 8 | TOPIC 79 | 01

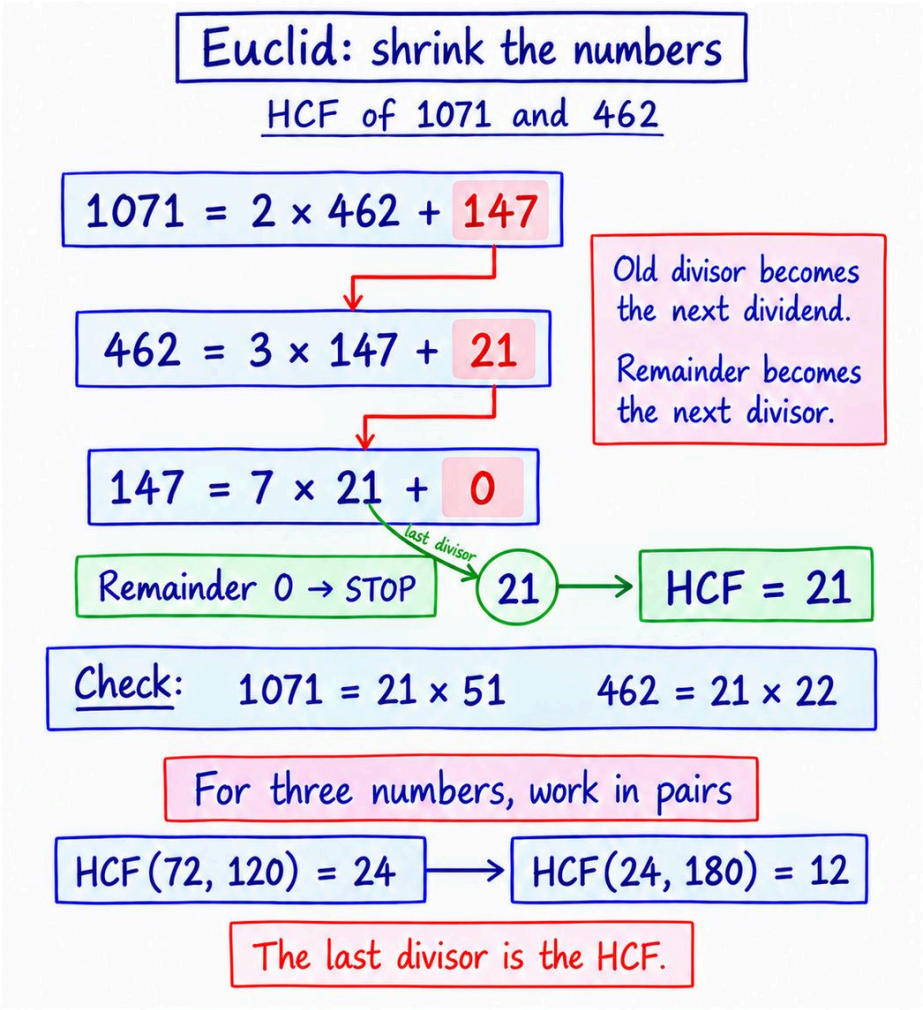
DAY 8 · TOPIC 79 · VISUAL REVISION 1

2.2 HCF: three methods

1. **Listing factors.** The factors of 12 are 1, 2, 3, 4, 6 and 12. The factors of 16 are 1, 2, 4, 8 and 16. The common factors are 1, 2 and 4, so the HCF is 4.
2. **Prime factorisation.** Write each number as a product of primes (Topic 39). NCERT Class X gives the HCF as the "Product of the smallest power of each common prime factor in the numbers". $72 = 2^3 \times 3^2$ and $120 = 2^3 \times 3 \times 5$. The common primes are 2 and 3, so the HCF is $2^3 \times 3 = 24$. A prime that is missing from any one of the numbers (here 5) is left out. If no prime is common, the HCF is 1.
3. **Division method (Euclid's algorithm).** Divide the larger number by the smaller. Then divide the divisor by the remainder. Go on in this way until the remainder is 0. The last divisor is the HCF.

- Example: $1{,}071 = 2 \times 462 + 147$; $462 = 3 \times 147 + 21$; $147 = 7 \times 21 + 0$. So the HCF of 1,071 and 462 is 21.
- Why it works: a number that divides two numbers exactly also divides their difference exactly (Topic 49). The remainder is what is left when the smaller number is subtracted from the larger as many times as possible, so every common factor of the two numbers divides the remainder too. The larger number, in turn, is a multiple of the smaller number plus the remainder, so every common factor of the smaller number and the remainder divides the larger number too. Each step therefore keeps the same common factors and makes the numbers smaller.
- The method is named after Euclid, who described it in his Elements (about 300 BCE). It suits large numbers that are hard to factorise.

- **Three numbers, prime factorisation.** A prime counts only if it is in all three numbers. $20 = 2^2 \times 5$, $28 = 2^2 \times 7$ and $36 = 2^2 \times 3^2$, so the HCF is $2^2 = 4$.
- **Three numbers, division method.** Find the HCF of any two of them, and then the HCF of that result and the third number. For 72, 120 and 180: the HCF of 72 and 120 is 24, and the HCF of 24 and 180 is 12. So the HCF of the three is 12.



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2.3 LCM: three methods

1. **Listing multiples.** The multiples of 12 are 12, 24, 36, 48, ... and the multiples of 18 are 18, 36, 54, ... The first multiple common to both lists is 36, so the LCM is 36.
2. **Prime factorisation.** NCERT Class X gives the LCM as the "Product of the greatest power of each prime factor, involved in the numbers". $24 = 2^3 \times 3$ and $90 = 2 \times 3^2 \times 5$, so the LCM is $2^3 \times 3^2 \times 5 = 360$. Every prime is taken, whether it is common or not. For three numbers the rule is the same: $40 = 2^3 \times 5$, $48 = 2^4 \times 3$ and $45 = 3^2 \times 5$, so the LCM is $2^4 \times 3^2 \times 5 = 720$.
3. **Common division (ladder) method.** Write the numbers in a row. Divide by the smallest prime that divides at least one of them exactly, and bring down unchanged any number that it does not divide exactly. Repeat until every number has become 1. The LCM is the product of all the divisors.

Step · Start

First number · 20

Second number · 25

Third number · 30

Step · Divide by 2

First number · 10

Second number · 25

Third number · 15

Step · Divide by 2

First number · 5

Second number · 25

Third number · 15

Step · Divide by 3

First number · 5

Second number · 25

Third number · 5

Step · Divide by 5

First number · 1

Second number · 5

Third number · 1

Step · Divide by 5

First number · 1

Second number · 1

Third number · 1

- LCM of 20, 25 and 30 = 2 × 2 × 3 × 5 × 5 = 300.
- A shorter form of the same method: stop as soon as no two of the numbers left have a common factor other than 1, and multiply the divisors by the numbers left. The answer is the same.

- The divisors must be primes. For 4 and 6, dividing by 4 and then by 6 gives $4 \times 6 = 24$, but the LCM is 12.
- The ladder gives the LCM, not the HCF. For the HCF, divide only by a prime that divides every number exactly, and multiply only those divisors: for 20, 25 and 30 that is one division by 5, so the HCF is 5.
- For three or more numbers the LCM can also be found in steps: the LCM of 40 and 48 is 240, and the LCM of 240 and 45 is 720.

LCM: climb down the ladder

Find the LCM of 20, 25 and 30

2	20	25	30
2	10	25	15
3	5	25	15
5	5	25	5
5	1	5	1
	1	1	1

Multiply

25 stays 25

Stop when all are 1

LCM = 2 × 2 × 3 × 5 × 5 = 300

300 ÷ 20 = 15

300 ÷ 25 = 12

300 ÷ 30 = 10

HCF uses a different test

Divide only by a prime common to EVERY number.

20, 25, 30 ÷ 5 → 4, 5, 6

HCF = 5

LCM ladder: divide at least one; carry others unchanged.

2.4 The relation: HCF × LCM = product of the two numbers

- NCERT Class X: for any two positive integers a and b, HCF (a, b) × LCM (a, b) = a × b.
- **Why it holds.** For each prime, the HCF takes the lower of the two powers and the LCM takes the higher. Between them they take both powers, which is exactly what the product a × b contains. $6 = 2 \times 3$ and $20 = 2^2 \times 5$: the HCF is 2 and the LCM is $2^2 \times 3 \times 5 = 60$, and $2 \times 60 = 120 = 6 \times 20$.
- **Three ways to use it.** LCM = product ÷ HCF. HCF = product ÷ LCM. Other number = HCF × LCM ÷ given number.
- Example: $96 = 2^5 \times 3$ and $404 = 2^2 \times 101$, so the HCF is 4 and the LCM is $96 \times 404 \div 4 = 9{,}696$.
- **It does not hold in general for three numbers.** For 6, 72 and 120 the HCF is 6 and the LCM is 360. HCF × LCM = 2,160, but the product of the three numbers is 51,840.
- For three numbers the relation holds only when every two of them are co-prime: 8, 9 and 25 have the HCF 1 and the LCM $1{,}800 = 8 \times 9 \times 25$. An HCF of 1 for the three together is not enough: 2, 3 and 4 have the HCF 1, but their LCM is 12 and their product is 24.

2.5 Special cases, and facts that always hold

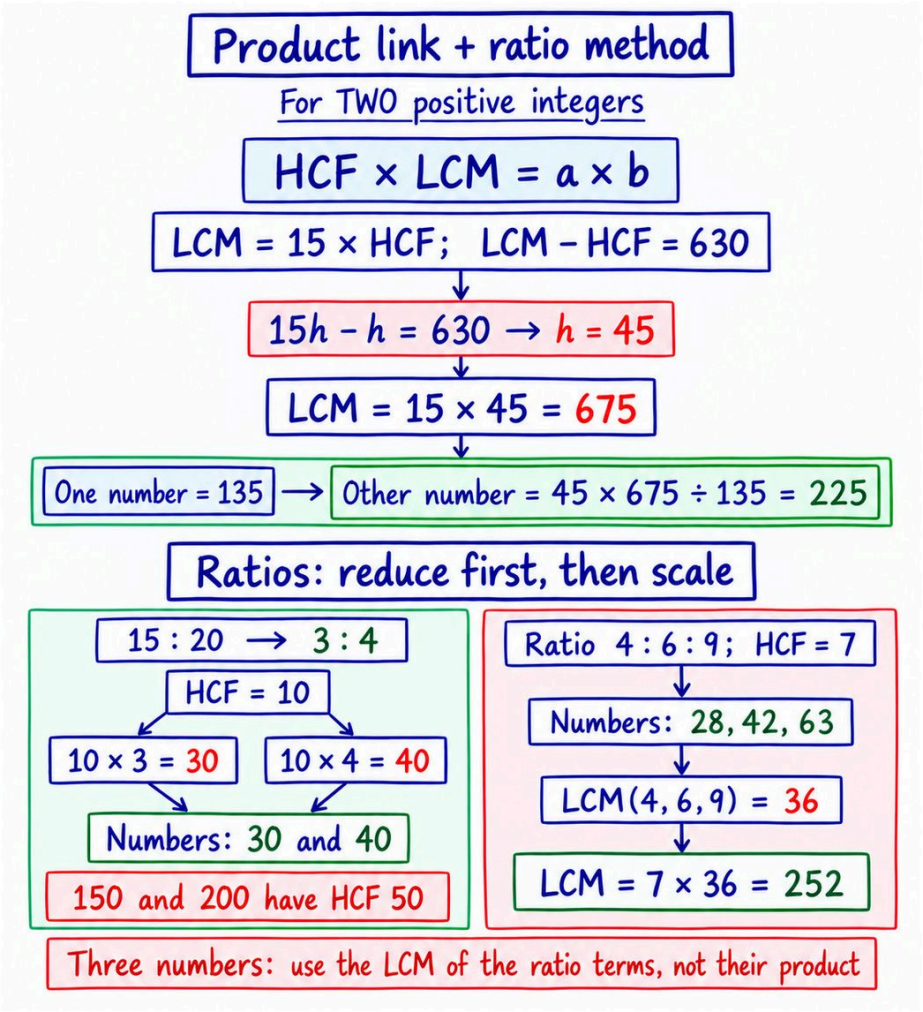
- **Co-prime numbers** have the HCF 1 (Topic 39), so their LCM is their product: for 8 and 15 it is 120. Any two different primes are co-prime, and so are any two consecutive natural numbers.
- **When one number is a multiple of the other,** the HCF is the smaller number and the LCM is the larger: for 15 and 45 they are 15 and 45.

- **The HCF always divides the LCM exactly.** The HCF is a factor of each number, and each number is a factor of the LCM. So no two numbers can have the HCF 8 and the LCM 60, because 8 does not divide 60 exactly.
- Every common factor of the numbers is a factor of their HCF, and every common multiple is a multiple of their LCM. The common factors of 72 and 120 are the factors of 24: 1, 2, 3, 4, 6, 8, 12 and 24.
- The HCF of two numbers divides their difference exactly. The HCF of 91 and 104 must divide 13, so it is 1 or 13; as 91 = 13 × 7, it is 13.
- If every number is multiplied by k, the HCF and the LCM are both multiplied by k: 12 and 18 give 6 and 36; 120 and 180 give 60 and 360.

2.6 Numbers given by a ratio

- Dividing two numbers by their HCF leaves two co-prime numbers: 48 ÷ 16 = 3 and 80 ÷ 16 = 5. So two numbers whose HCF is h are h × a and h × b, where a and b are co-prime. Their ratio in its simplest form (Topic 59) is a : b, and their LCM is h × a × b.
- It follows that LCM ÷ HCF = a × b, the product of the two co-prime terms.
- If the ratio is not in its simplest form, reduce it first.
- **Three numbers.** If the ratio a : b : c is in its simplest form (the three terms together have no common factor other than 1) and the HCF is h, the numbers are h × a, h × b and h × c. Their LCM is h × (the LCM of a, b and c). It equals h × a × b × c only when every two of the terms are co-prime.

Given	Working	Result
Ratio 3 : 5, HCF 16	Numbers: 16 × 3 and 16 × 5	48 and 80; LCM = 16 × 3 × 5 = 240
Ratio 3 : 5, LCM 225	h × 3 × 5 = 225, so h = 15	45 and 75; HCF = 15
Ratio 15 : 20, HCF 10	Simplest form 3 : 4; numbers: 10 × 3 and 10 × 4	30 and 40 (150 and 200 have the HCF 50)
Ratio 2 : 3 : 4, HCF 5	Numbers: 10, 15 and 20; the LCM of 2, 3 and 4 is 12	LCM = 5 × 12 = 60 (5 × 2 × 3 × 4 = 120 is wrong)



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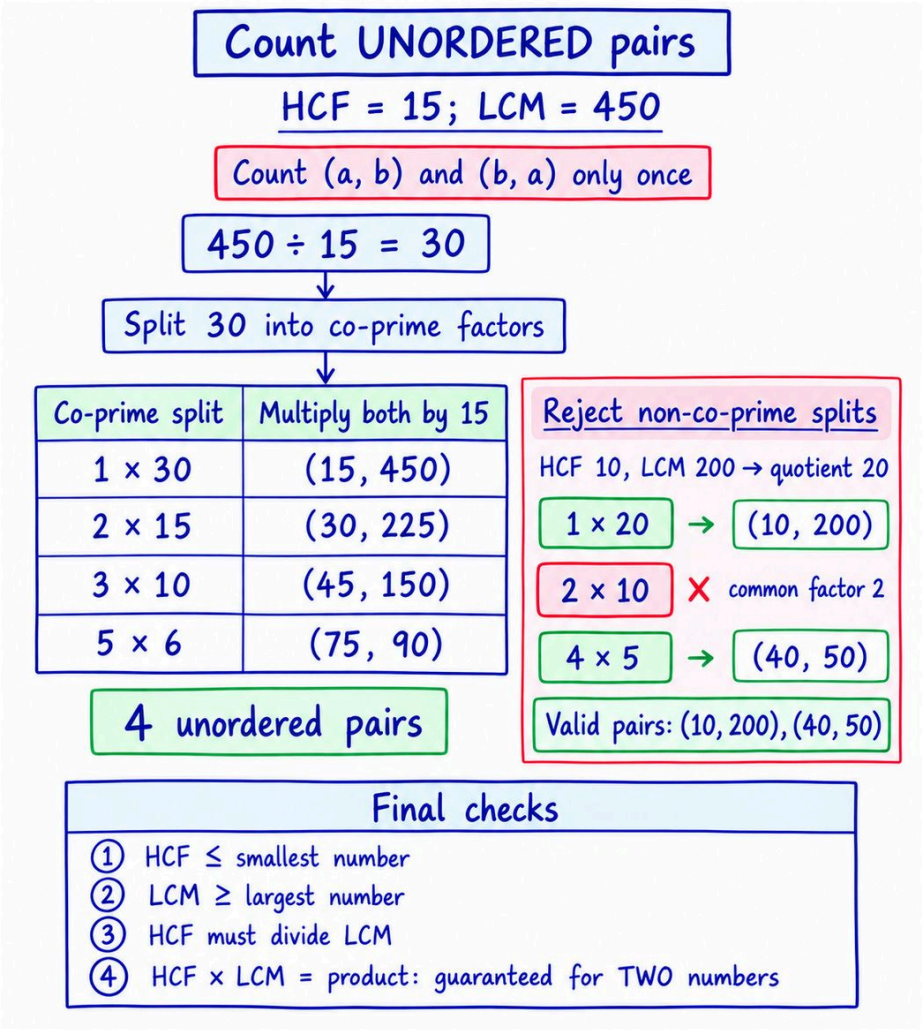
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2.7 How many pairs have a given HCF and LCM

- Divide the LCM by the HCF, and count the ways of writing the quotient (the answer of the division) as a product of two co-prime numbers. Each way gives one pair of numbers.
- Example: HCF 10 and LCM 200. The quotient is 200 ÷ 10 = 20 = 1 × 20 = 4 × 5. The split 2 × 10 does not count, because 2 and 10 are not co-prime. So there are two pairs: 10 and 200, and 40 and 50. The pair 20 and 100 fails: its HCF is 20.



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2.8 Quick checks on an answer

- The HCF divides every one of the given numbers exactly, and is not larger than the smallest of them.
- Every one of the given numbers divides the LCM exactly, and the LCM is not smaller than the largest of them.
- The HCF divides the LCM exactly.
- For two numbers, HCF × LCM equals their product.

Other days cover word problems on bells, tiles and remainders (Topic 649) and the HCF and LCM of fractions and decimals (Topic 879). Divisibility rules were covered in Topic 49.

3. Extra section: worked examples

A. HCF and LCM of two numbers

1. **84 and 120 by prime factorisation.** $84 = 2^2 \times 3 \times 7$ and $120 = 2^3 \times 3 \times 5$. HCF $= 2^2 \times 3 = 12$. LCM $= 2^3 \times 3 \times 5 \times 7 = 840$. Check: $12 \times 840 = 10{,}080 = 84 \times 120$.
2. **943 and 851 by the division method.** $943 = 1 \times 851 + 92$; $851 = 9 \times 92 + 23$; $92 = 4 \times 23 + 0$. The HCF is 23. The LCM is $943 \times 851 \div 23 = 41 \times 851 = 34{,}891$.

B. Three numbers

1. **HCF of 943, 851 and 1,081.** The HCF of the first two is 23 (example 2). Now $1{,}081 = 47 \times 23 + 0$, so the HCF of 23 and 1,081 is 23. The HCF of the three numbers is 23.
2. **LCM and HCF of 18, 24 and 40.** $18 = 2 \times 3^2$, $24 = 2^3 \times 3$ and $40 = 2^3 \times 5$. LCM $= 2^3 \times 3^2 \times 5 = 360$. HCF $= 2$. Here HCF × LCM $= 720$, but the product of the three numbers is 17,280.

3. **LCM of 12, 15 and 20 by the ladder.** Divide by 2: 6, 15, 10. Divide by 2: 3, 15, 5. Divide by 3: 1, 5, 5. Divide by 5: 1, 1, 1. LCM = 2 × 2 × 3 × 5 = 60.

C. Using the relation

1. **The HCF of two numbers is 13 and their LCM is 455. One number is 65. Find the other.** Other number = 13 × 455 ÷ 65 = 91. Check: 65 = 13 × 5 and 91 = 13 × 7.
2. **The LCM of two numbers is 20 times their HCF, and the sum of the HCF and the LCM is 315. One number is 60. Find the other.** Let the HCF be h. Then the LCM is 20h, and h + 20h = 21h = 315, so h = 15 and the LCM is 300. Other number = 15 × 300 ÷ 60 = 75. Check: 60 = 15 × 4 and 75 = 15 × 5, and 4 × 5 = 20.
3. **Can two numbers have the HCF 14 and the LCM 300?** No: 300 = 14 × 21 + 6, so 14 does not divide 300 exactly.

D. Ratios

1. **Two numbers are in the ratio 5 : 7 and their LCM is 420.** h × 5 × 7 = 420, so h = 12. The numbers are 60 and 84, and their HCF is 12.
2. **Three numbers are in the ratio 3 : 4 : 6 and their LCM is 180.** The LCM of 3, 4 and 6 is 12, so h × 12 = 180 and h = 15. The numbers are 45, 60 and 90, and their HCF is 15. Dividing 180 by 3 × 4 × 6 = 72 would not even give a whole number.

E. Counting pairs

1. **How many pairs of numbers have the HCF 15 and the LCM 450?** 450 ÷ 15 = 30 = 1 × 30 = 2 × 15 = 3 × 10 = 5 × 6, and in each split the two numbers are co-prime. So there are four pairs: 15 and 450, 30 and 225, 45 and 150, 75 and 90.

4. Three common exam traps

1. **Mixing up the two rules of prime factorisation.** For the HCF take only the primes common to all the numbers, each with its lowest power. For the LCM take every prime, each with its highest power. A quick test catches the slip: the HCF cannot be larger than the smallest number, and the LCM cannot be smaller than the largest. An "HCF" of 360 for 24 and 90 is really their LCM.
2. **Using "HCF × LCM = product" for three numbers.** The relation is true for any two numbers. For three numbers it fails unless every two of them are co-prime: for 6, 72 and 120 it gives 2,160 against a product of 51,840. And three numbers whose HCF is 1 need not be co-prime two by two (2, 3 and 4).
3. **Forgetting that the two terms must be co-prime.** The numbers h × a and h × b have the HCF h only when a and b are co-prime. So a ratio such as 15 : 20 must be reduced before the HCF is multiplied in: with the HCF 10 the numbers are 30 and 40, not 150 and 200. For the same reason 20 and 100 are not a pair with the HCF 10 and the LCM 200: their HCF is 20.

7. Sources

7.1 Sources

No. · S1

Source · NCERT, Mathematics, Class VI, Chapter 3 "Playing with Numbers" (the textbook used before Ganita Prakash), read on the SATHEE portal of IIT Kanpur. Sections 3.2 (Factors and Multiples), 3.7 (Highest Common Factor), 3.8 (Lowest Common Multiple) and "What have we discussed?". https://sathee.iitk.ac.in/ncert-books/class-06/mathematics/chapter-03-playing-with-numbers/

Used for · A factor as an exact divisor; every factor is at most the number and every multiple is at least the number; the number of factors is finite and the number of multiples is not; the definition "The Highest Common Factor (HCF) of two or more given numbers is the highest (or greatest) of their common factors", also known as the Greatest Common Divisor (GCD); the name "Lowest Common Multiple (LCM)" and its meaning as the lowest (or smallest or least) of the common multiples; the HCF of 12 and 16 by listing common factors; the HCF of 20, 28 and 36 by prime factorisation; the LCM of 12 and 18 by listing multiples; the LCM of 24 and 90 and of 40, 48 and 45 by prime factorisation (each prime taken the maximum number of times it occurs); the division method for the LCM, with the example 20, 25 and 30

No. · S2

Source · NCERT, Mathematics, Class X (reprint 2026-27), Chapter 1 "Real Numbers", Section 1.2 "The Fundamental Theorem of Arithmetic": the text after Example 2, Examples 2, 3 and 4, and the remark after Example 4. https://ncert.nic.in/textbook/pdf/jemh101.pdf

Used for · HCF as the "Product of the smallest power of each common prime factor in the numbers"; LCM as the "Product of the greatest power of each prime factor, involved in the numbers"; "for any two positive integers a and b, HCF (a, b) × LCM (a, b) = a × b"; 6 and 20 (HCF 2, LCM 60); 96 and 404 (HCF

4, LCM found as 96 × 404 ÷ 4); 6, 72 and 120 (HCF 6, LCM 360) and the remark that the product of three numbers is not equal to the product of their HCF and LCM

No. · S3

Source · Wikipedia, "Euclidean algorithm" (citing Weil 1983, Number Theory, pp. 4-6; Knuth, The Art of Computer Programming, Vol. 2, p. 318; Ore 1948, pp. 47-48; Stark 1978, p. 21). https://en.wikipedia.org/wiki/Euclidean_algorithm

Used for · The algorithm is named after Euclid, who described it in his Elements (c. 300 BC); the larger number is replaced by its remainder on division by the smaller, and the work stops at a zero remainder; the worked example 1071 = 2 × 462 + 147, 462 = 3 × 147 + 21, 147 = 7 × 21 + 0; the HCF of three numbers found by taking the HCF of pairs; two numbers whose greatest common divisor is 1 are co-prime

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No. · S4

Source · Wikipedia, "Greatest common divisor" (citing Long 1972, Elementary Introduction to Number Theory, p. 33; Pettofrezzo and Byrkit 1970, Elements of Number Theory, p. 34; Hardy and Wright 1979, An Introduction to the Theory of Numbers, p. 20). https://en.wikipedia.org/wiki/Greatest_common_divisor

Used for · "Highest common factor (HCF)" and "greatest common divisor (GCD)" as names of the same thing; every common divisor of two numbers is a divisor of their greatest common divisor; gcd(a, b) × lcm(a, b) = a × b; multiplying both numbers by m multiplies the greatest common divisor by m; dividing two numbers by their greatest common divisor leaves co-prime numbers; the greatest common divisor is unchanged when one number is replaced by the difference or by the remainder

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No. · S5

Source · Wikipedia, "Least common multiple" (citing Hardy and Wright 1979, An Introduction to the Theory of Numbers, § 5.1, p. 48; Long 1972, pp. 39 and 41; Pettofrezzo and Byrkit 1970, pp. 56 and 58). https://en.wikipedia.org/wiki/Least_common_multiple

Used for · "Least common multiple", "lowest common multiple" and "smallest common multiple" as names of the same thing; the LCM as the smallest positive integer divisible by each of the numbers; the LCM by listing multiples and by taking the highest power of each prime

Current affairs: COP30, the UN Climate Summit at Belém (2025)

1. Concept in one line

COP30, the thirtieth Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), met at Belém in Brazil in November 2025 and adopted a set of decisions called the Belém Political Package. The examination asks about the three climate treaties, what the Belém decisions say on finance, adaptation, just transition and fossil fuels, India's targets, and the earlier COPs.

2. Revision notes

2.1 The Convention, the Protocol and the Agreement

Treaty · UNFCCC (the Convention)

Adopted · The text was adopted in 1992 and opened for signature at the Earth Summit in Rio the same year

Entered into force · 21 March 1994

What to remember · One of the three "Rio Conventions", with the UN Convention on Biological Diversity and the UN Convention to Combat Desertification. Its aim is to stabilise greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system". The UNFCCC website, as seen on 10 October 2026, counts 198 Parties: 197 States and 1 regional economic integration organisation

Treaty · Kyoto Protocol

Adopted · 11 December 1997, at COP3

Entered into force · 16 February 2005

What to remember · The Parties to the Protocol first met in 2005 at Montreal. The Doha Amendment to the Protocol was adopted in 2012

Treaty · Paris Agreement

Adopted · 12 December 2015, at COP21 in Paris

Entered into force · 4 November 2016

What to remember · A legally binding international treaty on climate change. The UNFCCC website says that 195 Parties adopted it at COP21 in 2015, and counts 194 Parties to the Agreement as of 27 January 2026. The United States of America gave notice of withdrawal from the Agreement, and the United Nations treaty notice (depositary notification) said that the withdrawal would take effect on 27 January 2026

How the Paris Agreement works:

- **Temperature goal:** to hold the increase in the global average temperature to "well below 2°C above pre-industrial levels" and to pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels".
- **Nationally determined contribution (NDC):** each country's national climate action plan. The UNFCCC website says that countries have been submitting NDCs since 2020. Some NDCs are older than that: India's first NDC is of 2015 (2.7). The Agreement works on a five-year cycle, and each successive NDC is meant to show a higher degree of ambition than the one before it. The NDCs of the round that began in 2025 carry targets up to 2035.
- **Transparency:** from 2024, countries report on the action they have taken and on their progress. These reports are called biennial transparency reports.
- **Global stocktake:** an assessment of the collective progress of all countries towards the long-term goals. The first global stocktake concluded at COP28 in Dubai in December 2023.

One conference, three numbers:

- **COP** is the Conference of the Parties to the Convention. COP1 met at Berlin in 1995.
- **CMP** is the meeting of the Parties to the Kyoto Protocol.
- **CMA** is "the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement".
- At Belém the three met together as COP30, CMP20 and CMA7, along with the 63rd sessions of the two subsidiary bodies: the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI). The main Belém decisions in 2.3 are decisions of CMA7.

2.2 COP30 at a glance

Point	Detail
Official name	UN Climate Change Conference, Belém, November 2025
Place	Belém, in the State of Pará, Brazil, in the Amazon region. The Brazilian presidency noted that this was the first time a COP was held in a rainforest, in a region "considered essential to the planet's climate balance"
Dates	Scheduled for 10 to 21 November 2025. The closing plenaries were held on Saturday, 22 November 2025

Point	Detail
President of COP30	André Corrêa do Lago. Brazil holds the COP presidency until November 2026
Leaders' meeting	The Belém Climate Summit, convened by President Luiz Inácio Lula da Silva of Brazil for 6 and 7 November 2025, came before the COP
Participation	More than 40,000 participants, as UN Climate Change (the UNFCCC secretariat) reports
Outcome	The Belém Political Package. The presidency counted 29 decisions, approved by consensus



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DAY 8 | TOPIC 80 | 01

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2.3 What the negotiated decisions say

The lead political decision is titled "Global Mutirão: Uniting humanity in a global mobilization against climate change". In this table, adaptation means coping with the effects of climate change, and a just transition is one that is equitable and inclusive.

Subject	Decision	What it says
Adaptation finance	Global Mutirão	It "calls for efforts to at least triple adaptation finance by 2035", in the context of the finance decision of COP29
Finance goals	Global Mutirão	It stresses the need to stay on a pathway towards at least USD 300 billion a year for developing countries by 2035, with developed countries taking the lead. It reaffirms the call to scale up finance to at least USD 1.3 trillion a year by 2035. It sets up a two-year work programme on climate finance, including Article 9, paragraph 1 of the Paris Agreement (Article 9 is the Agreement's article on finance)

Subject	Decision	What it says
Implementation	Global Mutirão	It launches the Global Implementation Accelerator, a voluntary initiative guided by the presidencies of COP30 and COP31, and the Belém Mission to 1.5, guided by the presidencies of COP29, COP30 and COP31
Temperature	Global Mutirão	It reaffirms the Paris temperature goal and resolves to limit "both the magnitude and the duration of any temperature overshoot". It recalls that the 1.5°C path needs emissions 43% lower by 2030 and 60% lower by 2035 than in 2019, and net zero carbon dioxide emissions by 2050

Subject	Decision	What it says
Fossil fuels	Global Mutirão	The word "fossil" does not occur in the decision. It refers by name to the "United Arab Emirates Consensus" of the Dubai conference, but it does not repeat that conference's call on fossil fuels (2.8)

Subject	Decision	What it says
Trade	Global Mutirão	Measures taken to combat climate change, "including unilateral ones", should not be "a means of arbitrary or unjustifiable discrimination" or a disguised restriction on international trade. A dialogue on trade and climate action is to be held at the 64th, 66th and 68th sessions of the subsidiary bodies, with the World Trade Organization (WTO), UNCTAD (the United Nations body for trade and development) and the International Trade Centre, followed by a high-level event in 2028

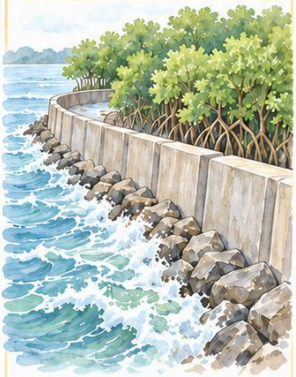
Subject	Decision	What it says
Adaptation indicators	Global goal on adaptation	It adopts the Belém Adaptation Indicators: 59 indicators, covering 11 targets (seven thematic and four dimensional) under the United Arab Emirates Framework for Global Climate Resilience. They are voluntary, non-prescriptive and non-punitive. They are "not intended to serve as a basis for comparison among Parties", create no new financial obligations, and cannot be made a condition for developing countries to get funds. A two-year process, the "Belém-Addis vision on adaptation", is to work out guidance on using them

Subject	Decision	What it says
Just transition	United Arab Emirates just transition work programme	It "decides to develop a just transition mechanism" to enhance international cooperation, technical assistance, capacity-building and knowledge-sharing. The subsidiary bodies, at their June 2026 sessions, are to recommend a draft decision on how to operationalise it, for CMA8 in November 2026
Gender	Belém gender action plan	It runs from 2026 to 2034, with 27 activities and 98 deliverables

Belém: negotiated outcomes

Final adopted CMA7 decisions

ADAPTATION FINANCE



Efforts to at least **triple finance by 2035**

No standalone baseline specified

BELÉM ADAPTATION INDICATORS

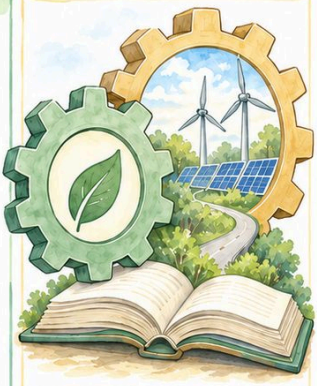
59 indicators

11 targets

- Voluntary
- Non-prescriptive
- Non-punitive

- No ranking of Parties
- No new financial obligations
- No funding conditionality

JUST TRANSITION



Decision to develop a mechanism

Cooperation • technical assistance • capacity-building • knowledge-sharing

Sources: Decisions 1/CMA.7, 12/CMA.7 and 2/CMA.7

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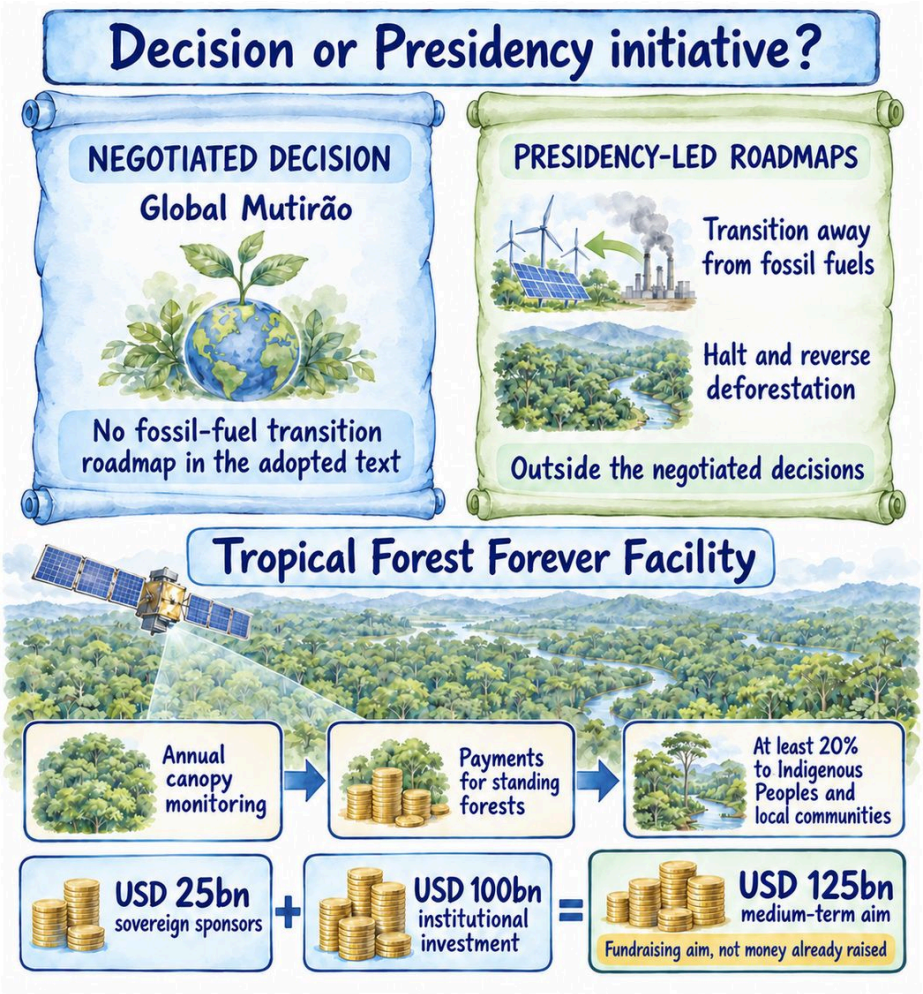
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2.4 Launched by the presidency, outside the negotiated text

Initiative	What it is	Status
Tropical Forests Forever Facility (TFFF)	A fund to pay tropical forest countries for keeping their forests standing. Payments are to be based on yearly satellite measurement of forest canopy cover. At least 20% of the payments are to go to Indigenous Peoples and local communities. The medium-term aim is a fund of USD 125 billion: USD 25 billion from sovereign sponsors and USD 100 billion from institutional investors. The World Bank is its trustee and interim host	Launched by President Lula at the leaders' summit in Belém. At the launch, 53 countries endorsed its declaration and over USD 5.5 billion was announced. At the close of COP30 the presidency reported over USD 6.7 billion and the endorsement of 63 countries
Two road maps of the presidency	The Forest and Climate Roadmap, on how to halt and reverse deforestation, and the Transitioning Away From Fossil Fuels Roadmap	Announced by the COP30 President as "Presidency-led initiatives". They are not decisions of the COP

Initiative	What it is	Status
Baku to Belém Roadmap to 1.3T	A document on scaling up climate finance for developing countries to USD 1.3 trillion a year by 2035	Prepared by the presidencies of COP29 and COP30 and released before COP30. The CMA only "takes note of" it



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2.5 The new round of NDCs

- UN Climate Change published its 2025 NDC Synthesis Report in October 2025 and an update at the start of COP30.
- The update covered 86 NDCs from 113 Parties, which accounted for 69% of global greenhouse gas emissions in 2019.
- If fully implemented, these NDCs would bring total global greenhouse gas emissions to around 12% below the 2019 level by 2035. Set this against the 60% cut by 2035 that the 1.5°C path needs (2.3).
- At the close of COP30 the presidency said that over 122 countries had submitted new or updated NDCs. India's new NDC came after Belém (2.7).

2.6 India at Belém

- **National Statement:** delivered at the High-Level Segment on 17 November 2025 by the Union Minister for Environment, Forest and Climate Change, Shri Bhupender Yadav. He said COP30 should be remembered as a "COP of Implementation" and a "CoP of Delivery on Promises".
- **On developed countries:** they "must reach net zero far earlier than current target dates" and deliver "new, additional, and concessional climate finance at a scale of trillions, not billions".
- **On India's record:** the emissions intensity of GDP had fallen by over 36% since 2005, and non-fossil sources made up more than half of the installed electric power capacity, a target reached five years ahead of 2030.
- **On the NDC:** India would declare its revised NDC up to 2035 and submit its first Biennial Transparency Report.

- **At the closing plenary, 22 November 2025:** India welcomed the progress on the global goal on adaptation, thanked the presidency for the focus on Article 9.1, and called the just transition mechanism "a significant milestone". On unilateral trade-restrictive climate measures, India said that they hurt developing countries, go against equity and common but differentiated responsibilities and respective capabilities (CBDR-RC), and "cannot continue to be brushed under the carpet".

2.7 India's targets: 2030, 2035 and 2070

Target · Cut in the emissions intensity of GDP from the 2005 level

First NDC (2015), for 2030 · 33 to 35%

Updated NDC (August 2022), for 2030 · 45%

NDC for 2031 to 2035 · 47% by 2035

Progress, as official releases state · A 36% reduction between 2005 and 2020. The target of the first NDC was met 11 years ahead of schedule

Target · Share of non-fossil fuel-based resources in cumulative installed electric power capacity

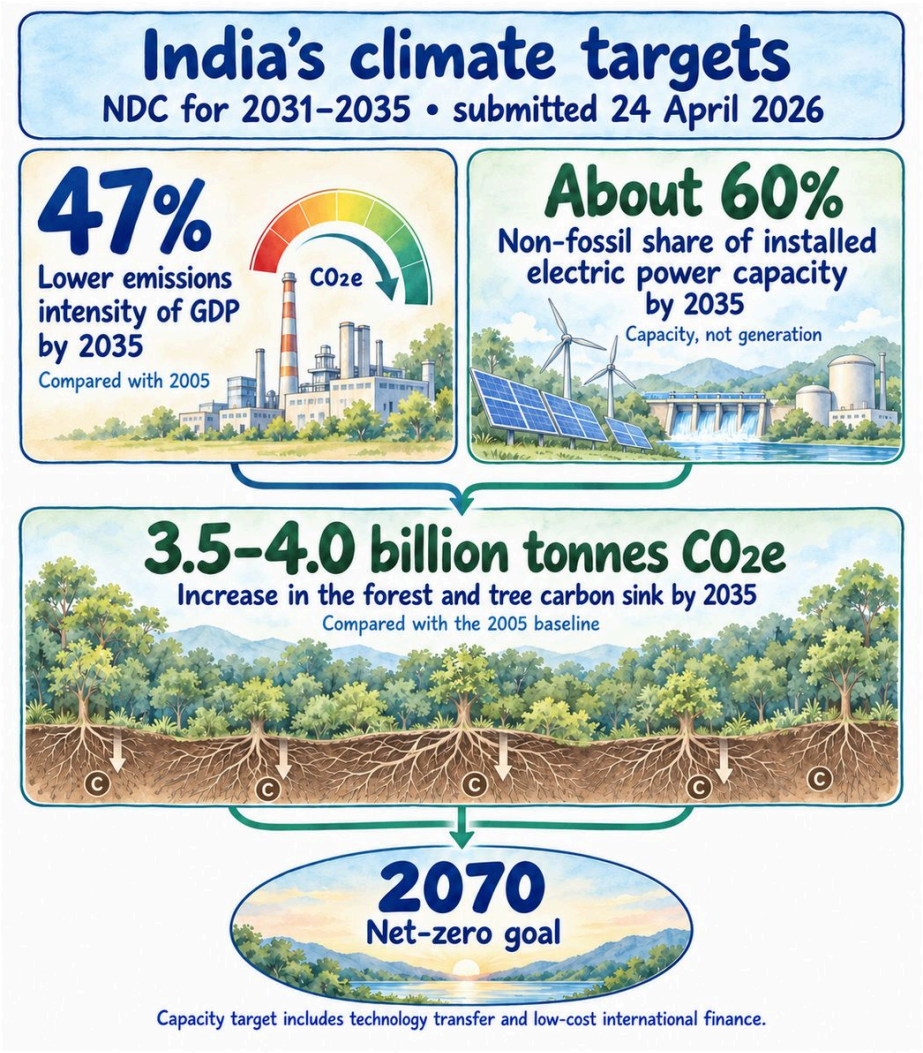
First NDC (2015), for 2030 · 40%

Updated NDC (August 2022), for 2030 · 50%

NDC for 2031 to 2035 · 60% by 2035

Progress, as official releases state · The 40% target was met 9 years ahead of schedule. The share was 52.57% in February 2026

- The NDC for 2031 to 2035 also aims to create a carbon sink of 3.5 to 4.0 billion tonnes of CO2 equivalent through forest and tree cover by 2035, compared with the 2005 baseline. The NDC records an additional 2.29 billion tonnes of CO2 equivalent created during 2005 to 2021. These are increases relative to the baseline, not the total forest carbon stock.
- The Union Cabinet, chaired by the Prime Minister, approved this NDC for communication to the UNFCCC; the approval was announced on 25 March 2026. The NDC document on the UNFCCC website is dated April 2026. It words the capacity target as "about 60 percent", just as the updated NDC of August 2022 said "about 50 percent" for 2030.
- The long-term goal stays the same: net zero by 2070.



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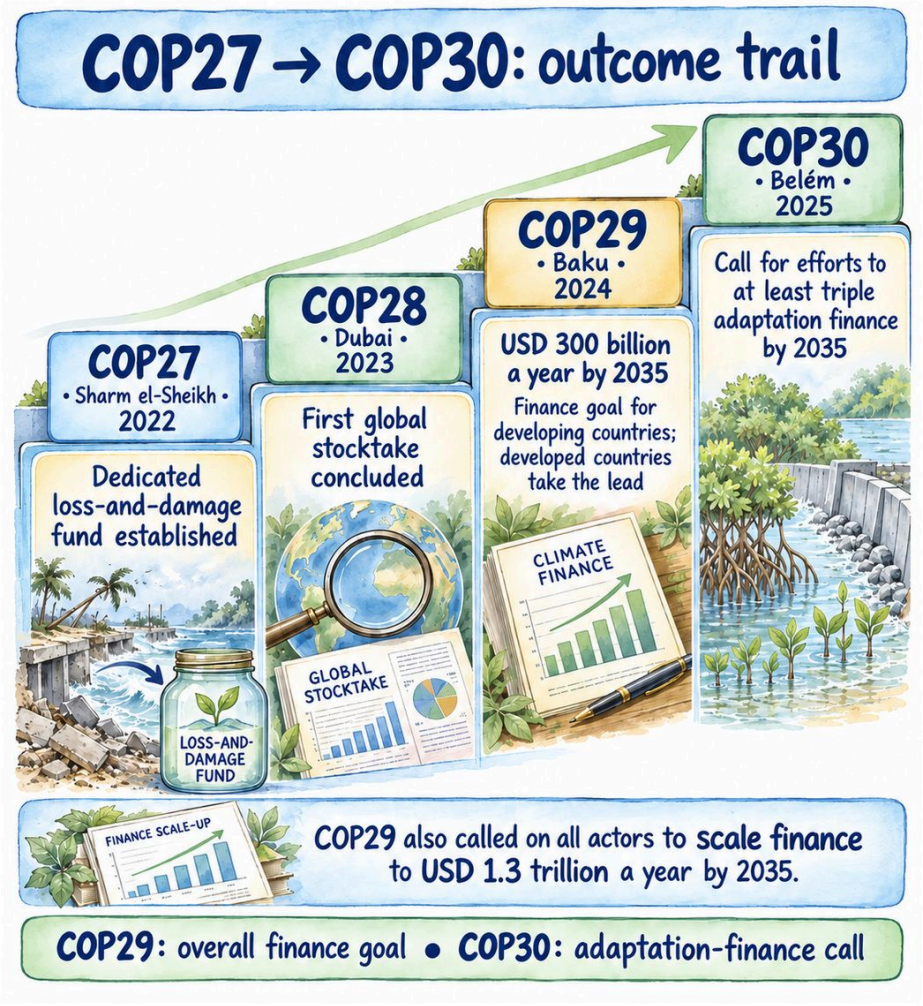
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2.8 Earlier COPs to link with Belém

COP	Place and date	Known for
COP21	Paris, 2015	The Paris Agreement was adopted on 12 December 2015
COP26	Glasgow, 2021	The Glasgow Climate Pact. For the first time, nations were called upon to accelerate efforts towards the "phasedown of unabated coal power" and the "phase-out of inefficient fossil fuel subsidies". The words differ: phasedown for coal power, phase-out for the subsidies
COP27	Sharm el-Sheikh; closed on 20 November 2022	Agreement to establish new funding arrangements and a dedicated fund for loss and damage (the harm caused by climate change) in developing countries. The cover decision was the Sharm el-Sheikh Implementation Plan

COP	Place and date	Known for
COP28	Dubai; closed on 13 December 2023	The first global stocktake concluded. It called on Parties to work towards tripling renewable energy capacity and doubling energy efficiency improvements by 2030, and for "the transition away from fossil fuels in energy systems" in a just, orderly and equitable manner. The loss and damage fund was operationalised on the first day

COP	Place and date	Known for
COP29	Baku, Azerbaijan; closed on 24 November 2024	The New Collective Quantified Goal on Climate Finance (NCQG): finance to developing countries to triple, from the earlier goal of USD 100 billion a year to USD 300 billion a year by 2035. All actors are also to work together to scale up finance from public and private sources to USD 1.3 trillion a year by 2035. The final building blocks of the rules for carbon markets under Article 6 of the Paris Agreement were agreed
COP30	Belém; closed on 22 November 2025	The Global Mutirão decision, the Belém Adaptation Indicators and the decision to develop a just transition mechanism (2.3)



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2.9 What comes next (position on 10 October 2026)

- **COP31, with CMP21 and CMA8:** Antalya, Türkiye, from 9 to 20 November 2026, as the UNFCCC website states.
- **The arrangement between Türkiye and Australia:** Türkiye hosts the conference and holds the office of COP31 President, for which Murat Kurum has been nominated. Chris Bowen of Australia is the President of Negotiations. Fiji, Tuvalu and Australia are partners for the Pre-COP ministerial meeting and a leaders' event in the Pacific, listed for 5 to 8 October 2026.
- **COP32:** Ethiopia, in 2027.
- COP31 will be over before the examination. Read its outcome when it comes.

3. Extra section: timeline from Rio to Antalya, and Belém in figures

Date	Event
1992	Text of the UNFCCC adopted; opened for signature at the Earth Summit in Rio
21 March 1994	The Convention enters into force
1995	COP1 at Berlin
11 December 1997	Kyoto Protocol adopted at COP3
16 February 2005	Kyoto Protocol enters into force; its Parties meet for the first time in the same year, at Montreal

Date	Event
12 December 2015	Paris Agreement adopted at COP21
4 November 2016	Paris Agreement enters into force
20 November 2022	COP27 closes at Sharm el-Sheikh
13 December 2023	COP28 closes at Dubai
24 November 2024	COP29 closes at Baku
October 2025	2025 NDC Synthesis Report published
6 and 7 November 2025	Belém Climate Summit of leaders; the Tropical Forests Forever Facility is launched there
10 November 2025	Scheduled opening of COP30
17 November 2025	India's National Statement at the High-Level Segment
22 November 2025	Closing plenaries of COP30; India's closing statement
25 March 2026	Cabinet approval of India's NDC for 2031 to 2035 announced
June 2026	Sessions of the subsidiary bodies named in the Belém decisions for the just transition mechanism and for the first trade dialogue
9 to 20 November 2026	COP31 at Antalya, as scheduled on 10 October 2026
2027	COP32, Ethiopia

Figure	What it stands for
30, 20 and 7	The numbers of the COP, the CMP and the CMA at Belém
59	Belém Adaptation Indicators
29	Decisions in the Belém package, by the presidency's count
More than 40,000	Participants at COP30
86 NDCs from 113 Parties	Coverage of the updated NDC synthesis; 69% of global emissions of 2019
Around 12%	Fall in global emissions by 2035 from the 2019 level, if those NDCs are fully implemented
43% and 60%	Cuts from the 2019 level needed by 2030 and by 2035 for the 1.5°C path
2026 to 2034	Period of the Belém gender action plan
USD 125 billion	Medium-term aim of the Tropical Forests Forever Facility
1 billion and 1 trillion	1 billion is 100 crore; 1 trillion is 1 lakh crore

4. Three common exam traps

1. **One conference, three numbers; and "adopted" is not "entered into force".** The COP is counted under the Convention, the CMP under the Kyoto Protocol and the CMA under the Paris Agreement. So the Paris Agreement's meeting carries a much smaller number than the COP held with it. Each treaty also has two years that examiners exchange: the Convention has 1992 and 1994, the Kyoto Protocol has 1997 and 2005, and the Paris Agreement has 2015 and 2016.
2. **The leaders' summit is not the COP, and a launch is not a decision.** The leaders met on 6 and 7 November 2025 at the Belém Climate Summit; the COP itself was scheduled from 10 to 21 November and closed a day later, on 22 November. The Tropical Forests Forever Facility was launched by Brazil at the leaders' summit. It is a fund outside the UNFCCC decisions, and USD 125 billion is its aim, not the money already announced.
3. **At COP31 the host and the head of the negotiations come from two different countries.** As on 10 October 2026, Türkiye hosts COP31 at Antalya and holds the office of COP31 President, while Chris Bowen of Australia is the President of Negotiations and the Pre-COP events are in the Pacific. "Australia hosts COP31" is wrong. COP32 goes to Ethiopia in 2027.

7. Sources

7.1 Sources

No. · S1

Source · UN Climate Change (UNFCCC secretariat), conference page "UN Climate Change Conference - Belém, November 2025". https://unfccc.int/cop30

Used for · Official name; scheduled dates 10 to 21 November 2025; sessions COP 30, CMP 20, CMA 7, SBSTA 63 and SBI 63; closing plenaries on Saturday, 22 November 2025

No. · S2

Source · UN Climate Change, "Belém Political Package" (list of the decisions adopted at Belém, with links). https://unfccc.int/cop30/belem-political-package

Used for · The name "Belém Political Package"; the list of decisions (Global Mutirão, United Arab Emirates just transition work programme, global goal on adaptation, gender action plan and others)

No. · S3

Source · UN Climate Change Quarterly Update: Q4 2025. https://unfccc.int/about-us/reports-highlights/quarterly-updates/un-climate-change-quarterly-update-q4-2025

Used for · More than 40,000 participants; summary of the Belém outcomes; Baku to Belém Roadmap released by the two presidencies before COP30; gender action plan 2026 to 2034 (27 activities, 98 deliverables); NDC Synthesis Report of October 2025 and its update (86 NDCs, 113 Parties, 69%, around 12% below 2019 by 2035); COP31 roles of Türkiye and Australia; COP32 in Ethiopia in 2027

No. · S4

Source · Conference of the Parties serving as the meeting of the Parties to the Paris Agreement, seventh session, "Global Mutirão: Uniting humanity in a global mobilization against climate change", proposal by the President, FCCC/PA/CMA/2025/L.24, 22 November 2025. https://unfccc.int/sites/default/files/resource/cma2025_L24E.pdf (document page: https://unfccc.int/documents/654389)

Used for · Title, body and date of the decision; tripling of adaptation finance by 2035; USD 300 billion and USD 1.3 trillion; "takes note of" the Baku to Belém Roadmap; work programme on climate finance; Global Implementation Accelerator; Belém Mission to 1.5; temperature goal, overshoot, 43% and 60%; absence of the word "fossil"; United Arab Emirates Consensus; unilateral measures and the trade dialogues; date of entry into force of the Paris Agreement

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No. · S5

Source · Earlier version of the same text, marked "Version 21/11/2025 3:00". https://unfccc.int/sites/default/files/resource/Mutir%C3%A3o_cop30.pdf

Used for · Cross-check that the word "fossil" is absent in both versions

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No. · S6

Source · Conference of the Parties serving as the meeting of the Parties to the Paris Agreement, seventh session, "Global goal on adaptation", FCCC/PA/CMA/2025/L.25, 22 November 2025. https://unfccc.int/sites/default/files/resource/cma2025_L25E.pdf (document page: https://unfccc.int/documents/653890)

Used for · Adoption of the Belém Adaptation Indicators; the 11 targets; voluntary, non-prescriptive, non-punitive; not a basis for comparison; no new financial obligations; Belém-Addis vision on adaptation; United Arab Emirates Framework for Global Climate Resilience

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No. · S7

Source · Conference of the Parties serving as the meeting of the Parties to the Paris Agreement, seventh session, "United Arab Emirates just transition work programme", FCCC/PA/CMA/2025/L.14, 21 November 2025. https://unfccc.int/sites/default/files/resource/cma2025_L14E.pdf (document page: https://unfccc.int/documents/653888)

Used for · Decision to develop a just transition mechanism; its purpose; the steps set for June 2026 and November 2026

No. · S8

Source · COP30 Brazilian presidency, "COP30 approves Belém Package". https://cop30.br/en/news-about-cop30/cop30-approves-belem-package1

Used for · Name of the COP30 President; 29 decisions by consensus; 59 indicators; the two Presidency-led road maps; TFFF figures at the close (over USD 6.7 billion, 63 countries); over 122 countries with new or updated NDCs; Brazil's presidency until November 2026

No. · S9

Source · COP30 Brazilian presidency, "Over USD 5.5 billion Announced for Tropical Forest Forever Facility as 53 Countries Endorse the Historic TFFF Launch Declaration". https://cop30.br/en/news-about-cop30/over-usd-5-5-billion-announced-for-tropical-forest-forever-facility-as-53-countries-endorse-the-historic-tfff-launch-declaration

Used for · Launch of the TFFF at the leaders' summit; how it pays; 20% share; USD 125 billion aim; World Bank as trustee and interim host

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No. · S10

Source · COP30 Brazilian presidency, "The Climate Summit will take place in Belém on 6 and 7 November". https://cop30.br/en/news-about-cop30/the-climate-summit-will-take-place-in-belem-on-6-and-7-november

Used for · Belém Climate Summit of 6 and 7 November 2025, convened by President Lula; COP30 dates; first COP held in a rainforest

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No. · S11

Source · Press Information Bureau (Ministry of Environment, Forest and Climate Change), "Union Environment Minister, Shri Bhupender Yadav delivers India's National Statement at UNFCCC CoP30 High-Level Segment, at Belém, Brazil", 18 November 2025, Release ID 2191067. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2191067

Used for · India's National Statement of 17 November 2025: finance, net zero of developed countries, technology, India's record, revised NDC and Biennial Transparency Report, net zero by 2070

No. · S12

Source · Press Information Bureau (Ministry of Environment, Forest and Climate Change), "India Welcomes Key Outcomes at UNFCCC CoP30; Reaffirms Commitment to Equity, Climate Justice and Global Solidarity", 23 November 2025, Release ID 2193076. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2193076

Used for · India's statement at the closing plenary of 22 November 2025: adaptation, Article 9.1, just transition mechanism, unilateral trade-restrictive climate measures

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No. · S13

Source · Press Information Bureau (Cabinet), "Cabinet approves India's Nationally Determined Contribution (2031-2035) to be communicated to the United Nations Framework Convention on Climate Change", 25 March 2026, Release ID 2245209. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2245209&reg=3&lang=1

Used for · Targets for 2035 (47%, 60%, 3.5 to 4.0 billion tonnes); targets of the 2015 NDC and when they were met; 36% reduction from 2005 to 2020; 52.57% in February 2026; 2.29 billion tonnes by 2021; net zero by 2070

No. · S14

Source · UN Climate Change, "The Paris Agreement". https://unfccc.int/process-and-meetings/the-paris-agreement

Used for · Adoption on 12 December 2015 at COP21 by 195 Parties; entry into force on 4 November 2016; 194 Parties as of 27 January 2026; temperature goal; five-year cycle; NDCs; transparency from 2024; global stocktake

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No. · S15

Source · UN Climate Change, "What is the United Nations Framework Convention on Climate Change?". https://unfccc.int/process-and-meetings/what-is-the-united-nations-framework-convention-on-climate-change

Used for · Entry into force on 21 March 1994; 198 Parties; the three Rio Conventions; the aim of the Convention

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No. · S16

Source · UN Climate Change, "History of the Convention". https://unfccc.int/process/the-convention/history-of-the-convention

Used for · 1992 (text adopted, opened for signature at Rio); 1995, COP 1 at Berlin; December 1997, Kyoto Protocol adopted at COP 3; 2005, entry into force and first meeting at Montreal; 2012, Doha Amendment

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No. · S17

Source · UN Climate Change, press release "COP27 Reaches Breakthrough Agreement on New 'Loss and Damage' Fund for Vulnerable Countries", 20 November 2022. https://unfccc.int/news/cop27-reaches-breakthrough-agreement-on-new-loss-and-damage-fund-for-vulnerable-countries

Used for · COP27: closing date; funding arrangements and dedicated fund for loss and damage; transitional committee; Sharm el-Sheikh Implementation Plan; first global stocktake to conclude at COP28

No. · S18

Source · UN Climate Change, press release "COP28 Agreement Signals 'Beginning of the End' of the Fossil Fuel Era", 13 December 2023. https://unfccc.int/news/cop28-agreement-signals-beginning-of-the-end-of-the-fossil-fuel-era

Used for · COP28 at Dubai: closing date; first global stocktake; renewable energy and energy efficiency by 2030; transition away from fossil fuels; loss and damage fund operationalised on the first day; dates fixed for COP30

No. · S19

Source · UN Climate Change, press release "COP29 UN Climate Conference Agrees to Triple Finance to Developing Countries, Protecting Lives and Livelihoods", 24 November 2024. https://unfccc.int/news/cop29-un-climate-conference-agrees-to-triple-finance-to-developing-countries-protecting-lives-and

Used for · COP29 at Baku, Azerbaijan: closing date; New Collective Quantified Goal on Climate Finance (USD 300 billion and USD 1.3 trillion a year by 2035); carbon markets under Article 6

No. · S20

Source · UN Climate Change, conference page for COP31. https://unfccc.int/cop31

Used for · Antalya, Türkiye, 9 to 20 November 2026; CMP 21 and CMA 8; Murat Kurum nominated as President of COP31; Chris Bowen as President of Negotiations; Pre-COP in the Pacific, 5 to 8 October 2026

No. · S21

Source · Government of India, two NDC documents on the UNFCCC website: "India's Updated First Nationally Determined Contribution Under Paris Agreement (2021-2030)", August 2022 submission to UNFCCC, https://unfccc.int/sites/default/files/NDC/2022-08/India%20Updated%20First%20Nationally%20Determined%20Contrib.pdf ; "India's Nationally Determined Contribution (2031-2035)", April 2026, https://unfccc.int/sites/default/files/2026-04/INDIA%20NDC%202031-35.pdf

Used for · Updated NDC of August 2022: 45% by 2030 from the 2005 level, and "about 50 percent" of cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. NDC for 2031 to 2035: 47%, "about 60 percent" and 3.5 to 4.0 billion tonnes by 2035; the date April 2026; net zero by 2070

No. · S22

Source · The institute's current affairs file: Insights "Current Affairs 30", November 2025, "COP30 - UN Climate Summit 2025", page 153, and "COP30 Draft Outcome", page 151

Used for · Selection of the item only. The facts in the notes are taken from the official sources listed in this table

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No. · S23

Source · UN Climate Change, page on the Kyoto Protocol. https://unfccc.int/kyoto_protocol

Used for · Kyoto Protocol adopted on 11 December 1997 and in force from 16 February 2005; Doha Amendment adopted on 8 December 2012

No. · S24

Source · UN Climate Change, page on the Glasgow Climate Pact and the key outcomes of COP26. https://unfccc.int/process-and-meetings/the-paris-agreement/the-glasgow-climate-pact-key-outcomes-from-cop26

Used for · COP26 at Glasgow (2021): the Glasgow Climate Pact; that nations were called upon for the first time to act on unabated coal power and inefficient fossil fuel subsidies

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No. · S25

Source · COP30 Brazilian presidency, page about COP30. https://cop30.br/en/about-cop30

Used for · Belém in the State of Pará; the Amazon

No. · S26

Source · United Nations, depositary notification C.N.71.2025.TREATIES-XXVII.7.d, "Paris Agreement, Paris, 12 December 2015. United States of America: Withdrawal", 27 January 2025. https://treaties.un.org/doc/Publication/CN/2025/CN.71.2025-Eng.pdf

Used for · Withdrawal of the United States of America from the Paris Agreement, to take effect on 27 January 2026

No. · S27

Source · Conference of the Parties serving as the meeting of the Parties to the Paris Agreement, third session, Decision 1/CMA.3, "Glasgow Climate Pact", in FCCC/PA/CMA/2021/10/Add.1. https://unfccc.int/sites/default/files/resource/cma2021_10_add1_adv.pdf

Used for · Paragraph 36 of the Glasgow Climate Pact: "phasedown of unabated coal power" and "phase-out of inefficient fossil fuel subsidies"
