IAS WITH DR RAVI
AIM. PREPARE. ACHIEVE

APPSC GROUP 1 | 1,000 TOPICS IN 100 DAYS

DAY 23

Concept revision pictographs

English teaching sequence | Topics 221, 222, 223, 224, 225, 226, 227, 228, 229, 230

221	Non-Cooperation and Khilafat movements	2
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Full English/Telugu notes and 20 MCQs are provided separately.

Why non-cooperation could challenge colonial rule

British rule depended on Indian cooperation. Withdrawing that cooperation could weaken its authority.

The British could govern India only because many Indians supported their administration, institutions and economy. When people refused to cooperate, the structure became unstable.



A constructive path alongside

National education



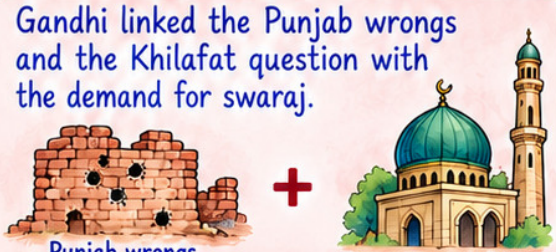
Khadi and spinning



Wider political participation



Gandhi linked the Punjab wrongs and the Khilafat question with the demand for swaraj.



Non-cooperation was intended to be nonviolent: refusing support is not the same as attacking people.

Non-cooperation: withdraw cooperation.

- Refuse titles and honours.
- Leave government schools.
- Boycott courts and councils.
- Boycott foreign goods.
- Peaceful and nonviolent method.

Civil disobedience: deliberately break unjust laws.

- Openly violate a law.
- Accept the legal penalty.
- Used against specific unjust laws.
- A distinct method of resistance.

Key events and progression

1919 Rowlatt agitation and Jallianwala Bagh



→ **1920** Congress accepts non-cooperation



→ **1921** Mass mobilisation



→ **February 1922** Suspension of the movement



Khilafat and swaraj: two grievances, a shared campaign

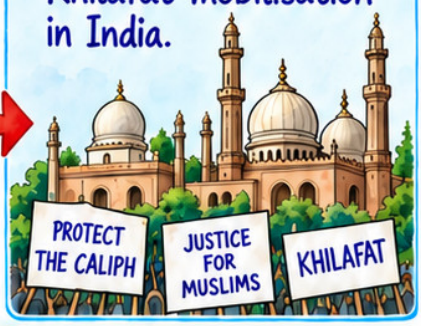
Ottoman defeat in the First World War (1914–1918)



Fear of harsh peace terms and loss of the Caliph's authority.



Khilafat mobilisation in India.



A Khilafat Committee was formed in Bombay in March 1919.

Muhammad Ali and Shaukat Ali were leading organisers.



The demands concerned:

- Muslim sacred places.
- Muslim sovereignty over former Ottoman territories.
- Sufficient territory for the Caliph.



Gandhi saw an opportunity for Hindu–Muslim unity against colonial rule.



KHILAFAT grievance + DEMAND for swaraj → Common non-cooperation programme.

Key dates

17 October 1919	19 March 1920	August 1920	1924
First Khilafat Day.	Second Khilafat Day.	Treaty of Sèvres.	Caliphate abolished.





Important contrast



1919 – 1922: Khilafat movement's main aim was to defend the Caliph's position.

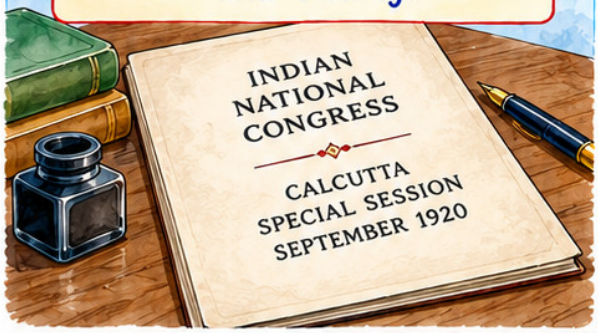
1924: The caliphate was abolished later, showing that the Khilafat issue had a different timeline from swaraj.



Calcutta accepts the idea; Nagpur consolidates it

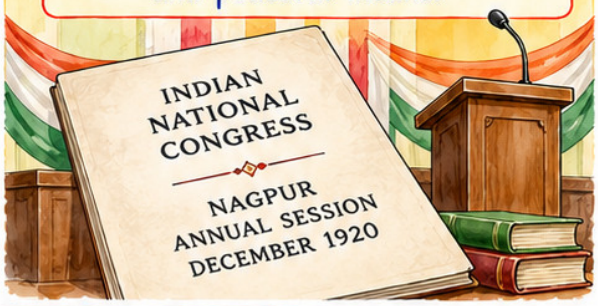
CALCUTTA
September 1920
Special session

Accepted non-cooperation in support of Khilafat and swaraj.



NAGPUR
December 1920
Annual session

Confirmed the non-cooperation programme. Changed the Congress objective to swaraj by legitimate and peaceful means.



Congress organisation

- Provincial committees based on linguistic regions
- Local branches
- Wider membership



Organisation helped carry the national message in people's mother tongues and expand beyond a narrow elite.



26 – 31 December 1920: Nagpur session.

Nagpur was presided over by C. Vijayaraghavachariar.

Annual membership fee: 4 annas.



Recall: Calcutta: acceptance of the programme. Nagpur: confirmation and organisational change.

Boycott worked only when alternatives grew

WITHDRAW COOPERATION

People refused to support British rule in many ways.

- Return official titles



- Leave government schools and colleges



- Boycott courts and councils



- Boycott foreign cloth



- Picket liquor shops



BUILD ALTERNATIVES

Boycott was effective only when people created their own alternatives.

- National institutions
- Khadi and spinning
- Local organisation



Examples of national institutions started during the movement

Gujarat Vidyapith
18 October 1920



Jamia Millia Islamia
29 October 1920, Aligarh



Kashi Vidyapith
10 February 1921, Banaras



Limits to the boycott



- Khadi could cost more than mill cloth.
- Alternative schools and institutions developed slowly.
- Economic costs made sustained boycott difficult.

Council elections were boycotted in most provinces; the Justice Party participated in Madras.



Tilak Swaraj Fund

One-crore-rupee target associated with the Bezwada programme of 1921; target recorded as met by 30 June.



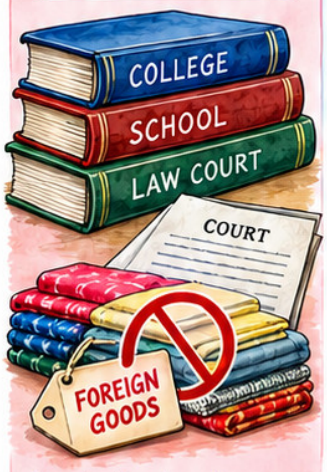
Boycott created real pressure only when people built alternatives.

One call for swaraj — different local meanings

Shared slogan: swaraj

Withdrawal from colonial institutions and foreign goods	Lower revenue, an end to begar and resistance to landlords	End to forest restrictions and support for khadi (along with armed struggle)	Freedom to leave plantations and end to restrictive laws

TOWNS



Students, teachers, lawyers and middle classes withdrew from colonial institutions and foreign-goods markets.

Main demand: Boycott colonial institutions and foreign goods.

AWADH



Baba Ramchandra's peasant movement sought lower revenue, an end to begar and resistance to oppressive landlords. The Oudh Kisan Sabha linked peasant grievances to wider mobilisation.

Main demand: Lower revenue, end to begar and resistance to oppressive landlords.

GUDEM HILLS, ANDHRA



Alluri Sitarama Raju opposed forest restrictions. He praised Gandhi and encouraged khadi, but favoured armed struggle: not every strand followed Gandhian nonviolence.

Main demand: End to forest restrictions and support for khadi (along with armed struggle).

ASSAM TEA PLANTATIONS



Workers sought freedom to leave plantations. The Inland Emigration Act of 1859 restricted departure without permission.

Main demand: Freedom to leave plantations and end to restrictive laws.

A mass movement joined different grievances; a shared slogan did not produce identical methods or goals.

Andhra: distinguish municipal taxes from forest dues

CHIRALA – PERALA

Issue: proposed municipality and heavier municipal taxation.

Leader: Duggirala Gopalakrishnayya, known as Andhra Ratna.

Method: residents left the town for Ramanagar, outside its limits, rather than accept the burden.



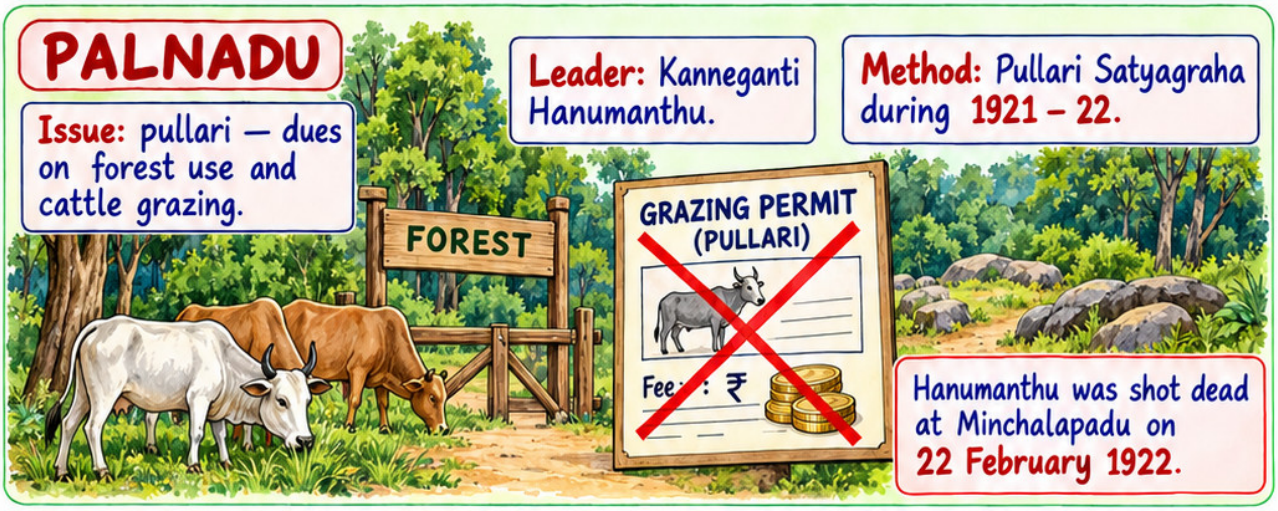
Gandhi visited Chirala on **6 April 1921** and advised a nonviolent struggle.

PALNADU

Issue: pullari — dues on forest use and cattle grazing.

Leader: Kanneganti Hanumanthu.

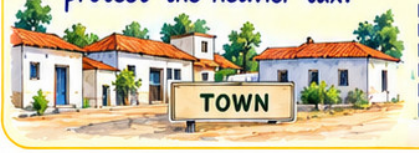
Method: Pullari Satyagraha during **1921 – 22.**

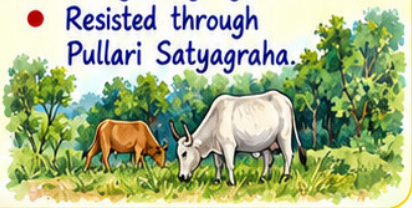


Hanumanthu was shot dead at Minchalapadu on **22 February 1922.**

Municipal tax ≠ forest grazing dues

Municipal tax (Chirala – Perala)	Forest grazing dues (Pullari, Palnadu)
Levied by a municipality on town residents.	Dues for forest use and cattle grazing.
Related to urban administration.	Related to forest access and grazing rights.
People left the town to protest the heavier tax.	Resisted through Pullari Satyagraha.





Gudem hills

Resistance to forest restrictions under **Alluri Sitarama Raju** — a different strand.



Chauri Chaura changed the course of the movement

1 February 1922

Gandhi warns the Viceroy about civil disobedience at Bardoli.



4 February 1922

Violent clash and burning of a police station at Chauri Chaura, Gorakhpur district, United Provinces.



Violence conflicts with nonviolent discipline.

12 February 1922

Bardoli resolution suspends civil disobedience; Gandhi begins a five-day fast.



25 February 1922

AICC in Delhi adopts the Bardoli resolutions with modifications.



10 March 1922

Gandhi arrested at Ahmedabad.



18 March 1922

Sentenced to six years for sedition.



February 1924

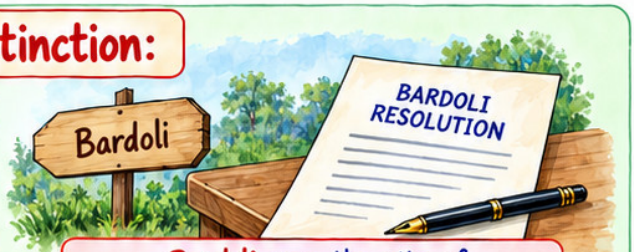
Released before completing the sentence.



Key distinction:



Chauri Chaura was the site of the violent incident.



Bardoli was the site of the suspension decision.

Withdrawal came before arrest, not because of the arrest.

A mass movement – and a debate over its limits

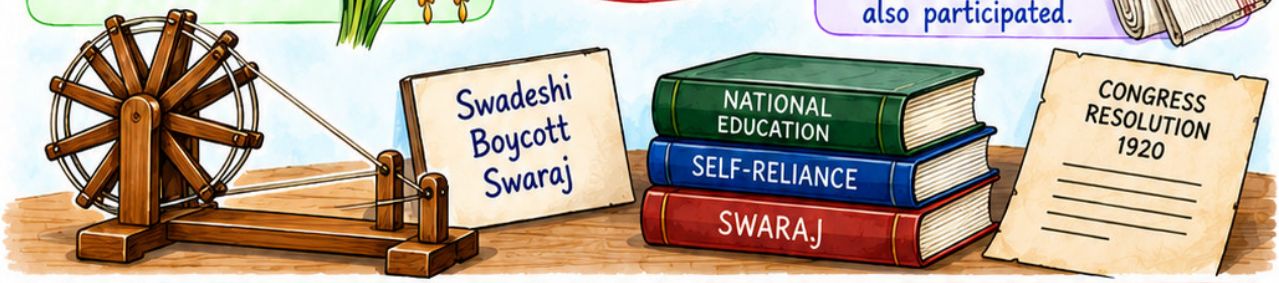
Students joined protests, boycott and national education.

Workers took part in strikes and supported the movement.

Peasants joined in many regions, linking local grievances to the national cause.

A wider national movement

Other groups including traders, women and various local associations, also participated.



ACHIEVEMENTS

- Expanded nationalism beyond a mainly middle-class base.
- Linked students, workers, peasants and other groups.
- Popularised khadi, boycott and national education.
- Connected local grievances with a national demand.

LIMITS

- Different groups understood swaraj differently.
- Some local actions became violent.
- Boycott required affordable alternatives.
- Sudden withdrawal disappointed many workers and leaders.

Caliphate abolished in 1924 – after Non-Cooperation ended.

Not every participating strand practised nonviolence.

C.R. Das and Motilal Nehru formed the Swaraj Party, **not Gandhi.**

1920
Congress programme



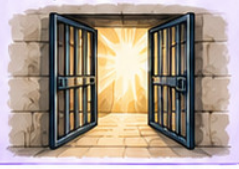
1921
mass action



February 1922
suspension



1924
Gandhi released and caliphate abolished



Mobilisation, method and discipline must be analysed together.

Why a handful of salt could challenge an empire

Salt was essential to rich and poor alike.



Salt is needed in every household, in every meal. It was a basic necessity for all, not a luxury.

Colonial law imposed a tax and a state monopoly over salt manufacture and sale.



The British controlled the production and sale of salt, and imposed a tax on it.

Even an everyday necessity became a visible symbol of colonial control.



People had to buy taxed salt under the colonial monopoly, showing how deeply colonial rule reached into daily life.

Universal necessity



Salt was needed by everyone.

Widely felt grievance



The salt tax affected rich and poor alike.

Simple act of defiance



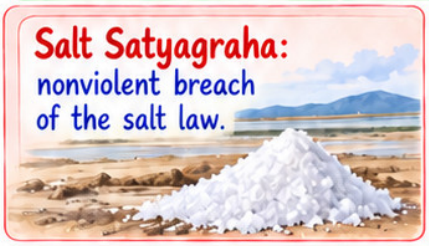
Making or collecting salt broke the law.

Mass participation



Salt Satyagraha:

nonviolent breach of the salt law.



Non-Cooperation:

refuse cooperation with colonial institutions.



Civil Disobedience:

deliberately violate unjust colonial laws.



Key events

December 1929:
Lahore Congress adopts Purna Swaraj under Jawaharlal Nehru.



26 January 1930:
Independence Day observed.



March–April 1930:
Salt March.

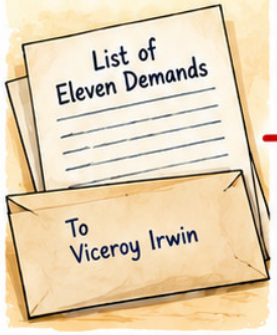


A modest material object carried a powerful political message.

From demands to Dandi: keep the sequence clear

31 January 1930

Eleven demands sent to Viceroy Irwin; abolition of the salt tax was a central demand.



2 March 1930

Gandhi's letter sets out grievances and gives notice of defiance of the salt laws.



12 March 1930

March begins at Sabarmati Ashram.



5 April 1930

Arrival at Dandi.



6 April 1930

Salt law broken at Dandi.



Letter of demands → Notice of defiance → March begins at Sabarmati → Arrival at Dandi → Salt law broken

Gandhi accompanied by **78 volunteers.**



Over **240 miles.**



24 days to reach Dandi.



The march converted preparation and publicity into a public act of civil disobedience.



Do not confuse arrival at Dandi with the following day's breach of the law.

5 April 1930: arrival at Dandi.
6 April 1930: salt law broken at Dandi.



Dates are milestones, not scale distances.

Breaking the salt law opened many fronts

People were asked not merely to withdraw cooperation, but to break colonial laws.

Civil Disobedience, 1930

Break the salt law and protest at salt factories.



Boycott foreign cloth.



Picket liquor shops.



Refuse revenue and chaukidari taxes.



Village officials resign.



Violate restrictive forest laws.





Women made salt, picketed shops and went to prison in large numbers.

Participation expanded, but Congress often still treated women's role as symbolic.





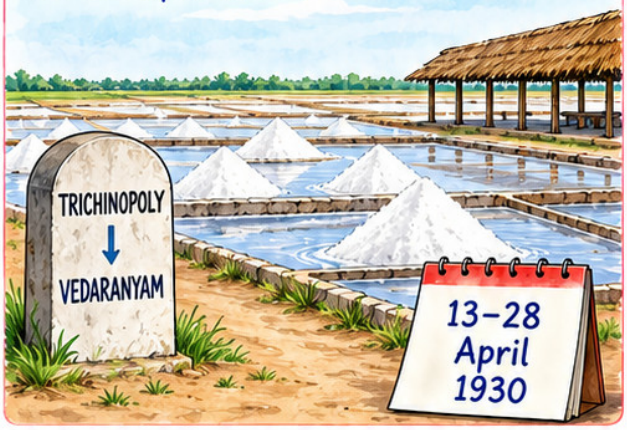
Shared national strategy → Different locally meaningful actions



Four centres – four different forms of resistance

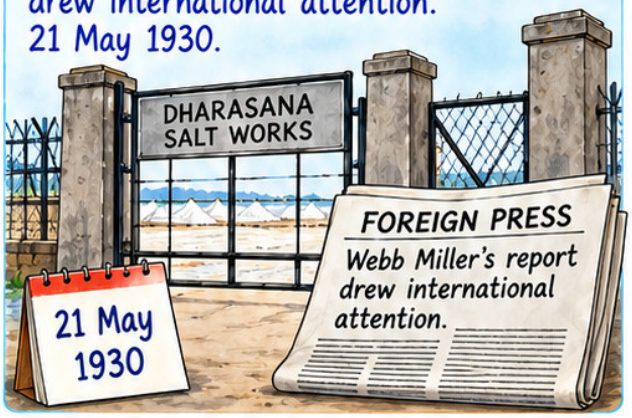
VEDARANYAM

C. Rajagopalachari led a march from Trichinopoly to Vedaranyam, 13–28 April 1930.



DHARASANA

After Gandhi's arrest, volunteers led by Sarojini Naidu faced police beatings without retaliating. Webb Miller's report drew international attention. 21 May 1930.



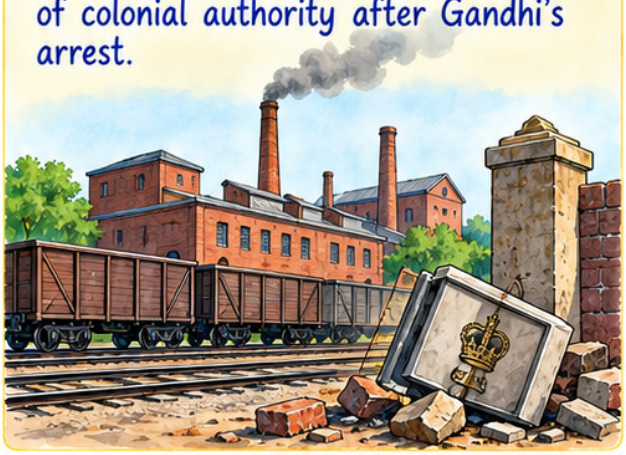
PESHAWAR

After Khan Abdul Ghaffar Khan's arrest in April, crowds faced firing. Soldiers of the Garhwal Rifles refused to fire on the crowds.



SHOLAPUR

Industrial workers attacked symbols of colonial authority after Gandhi's arrest.



These were not identical actions:

a salt march | nonviolent raid | refusal to fire | and worker unrest.

Different forms, but each was a form of resistance in the wider struggle for freedom.

Repression led to negotiation — not immediate independence

April 1930: Ghaffar Khan arrested.



Midnight, 4–5 May 1930: Gandhi arrested.



12 November 1930: First Round Table Conference opens without Congress participation.



26 January 1931: Gandhi and Congress leaders released.



5 March 1931: Gandhi–Irwin Pact.



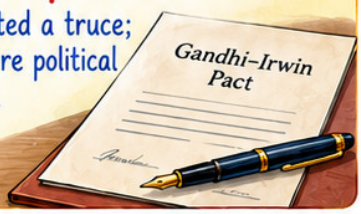
What did repression include?

Repression included arrests, police violence and restrictions on political action.



What did the pact achieve?

The pact created a truce; it did not secure political independence.



Negotiations after repression

Congress agreed to:

- suspend civil disobedience.
- participate in the Second Round Table Conference.



Government agreed to:

- withdraw repressive measures and allow specified concessions.



Sequence matters: the First Conference preceded the pact; Congress joined the Second.

12 November 1930: First Round Table Conference opens without Congress participation.



5 March 1931: Gandhi–Irwin Pact.



Congress participates in the Second Round Table Conference.



The Gandhi–Irwin Pact: concessions and boundaries

CONGRESS AGREED

- Call off civil disobedience.
- Attend the Second Round Table Conference.

5 March 1931



GOVERNMENT CONCESSIONS

- Release political prisoners except those guilty of violence.
- Withdraw ordinances and end prosecutions covered by the agreement.
- Restore confiscated property still in Government possession, subject to the settlement's reservations.
- Allow people near the coast to collect or make salt.
- Allow peaceful picketing of liquor and foreign-cloth shops.



LIMITS OF THE PACT

- ✗ Not a declaration of independence.
- ✗ Not a unconditional release of every prisoner.

MARCH 1931: KARACHI SESSION

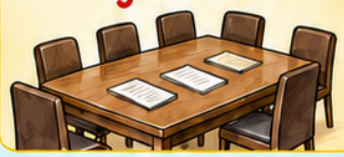
Congress session at Karachi, presided over by Vallabhbhai Patel, endorses the pact.

The resolution on fundamental rights includes a living wage and freedom of labour from serfdom.



Truce → Negotiations → Unresolved political questions







Three Round Table Conferences – Congress joined only one

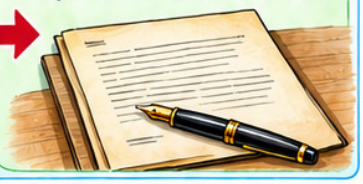
FIRST

Opened
12 November 1930

Congress absent.



5 March 1931:
Gandhi–Irwin Pact



SECOND

Opened
7 September 1931

Gandhi as sole Congress representative.



His claim that Congress represented all India was challenged by other political interests, including the Muslim League, Princes and B.R. Ambedkar.

Talks failed to produce agreement.



Civil disobedience resumed; Gandhi and Patel arrested.



THIRD

Opened
17 November 1932

Congress absent.



By 1934: movement lost momentum.



Sole Congress representative does not mean sole Indian representative.

Many political interests took part in the discussions:

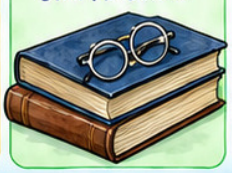
Muslim League



Princes



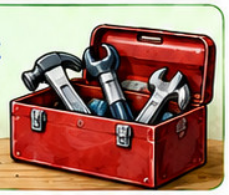
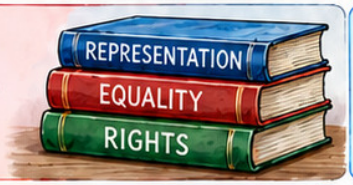
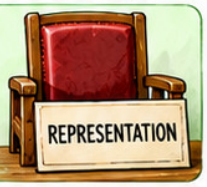
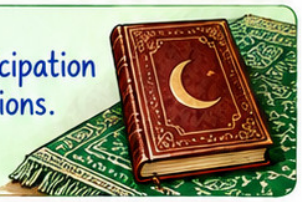
B.R. Ambedkar



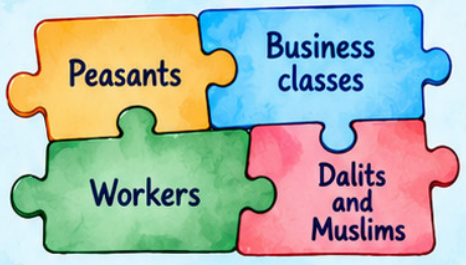
Other political interests



Who participated – and why support had limits

Group	Main concern	Limit
Rich peasants 	Falling crop prices and revenue burden.	Disappointed when revenue was not reduced in 1931. 
Poor peasants 	Rent relief.	Congress reluctant to support no-rent campaigns. 
Business classes 	Fewer colonial restrictions.	Support weakened after failed negotiations. 
Industrial workers 	Selective participation and workplace concerns.	Congress reluctant to include every labour demand. 
Dalits 	Representation and social equality.	Many leaders sought reserved seats or separate electorates. 
Muslims 	Alienation after the decline of Non-Cooperation and Khilafat.	Limited participation by large sections. 

Participation was neither uniform nor absent everywhere: avoid treating any community as a single bloc.



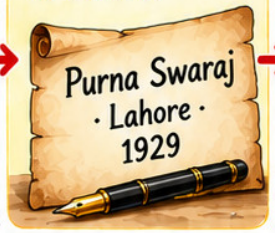
A national coalition can unite against colonial power while containing conflicting social demands.

Salt Satyagraha: a revision chain, not isolated dates

1928: Simon Commission arrives without an Indian member.



December 1929: Purna Swaraj at Lahore.



26 January 1930: Independence Day.



12 March – 6 April 1930: march and breach of salt law.



5 March 1931: Gandhi–Irwin Pact.



September 1931: Second Round Table Conference.



January 1932: struggle resumed.



By 1934: momentum declines.



Key outcomes of the Salt Satyagraha



Salt made colonial rule's daily impact visible.



Women entered nationalist activity in large numbers.

The campaign attracted international attention and challenged colonial legitimacy.



Three precision cues



78 volunteers accompanied Gandhi: count Gandhi separately.



Arrival 5 April; salt-law breach 6 April.



Congress attended Second, not First or Third Conference.

A useful comparison

Non-Cooperation Movement withdraws support.



Civil Disobedience Movement breaks an unjust law.



Union executive: power and responsibility

Recall:
The President is elected indirectly by an electoral college and removed only by impeachment. This topic is about his powers.

Article 53(1): Executive power of the Union

The executive power of the Union is vested in the President and is exercised by him either directly or through officers subordinate to him, in accordance with the Constitution.



President
Head of the Union executive

May seek reconsideration once

Aid and advice

Acts in accordance with advice

Article 74(1): Council of Ministers

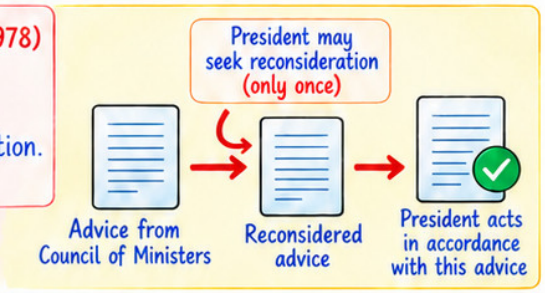
There is a Council of Ministers with the Prime Minister at the head to aid and advise the President, who "shall, in the exercise of his functions, act in accordance with such advice".



Council of Ministers
headed by the Prime Minister
Aids and advises the President

Proviso to Article 74(1) (Inserted by 44th Amendment Act, 1978)

In force from 20 June 1979: the President may require the Council of Ministers to reconsider its advice, and he shall act in accordance with the advice tendered after that reconsideration. So, the President can send the advice back only once.



Article 74(2): No judicial inquiry

The question whether any, and if so what, advice was tendered by Ministers to the President "shall not be inquired into in any court".



Shamsher Singh v. State of Punjab

(23 August 1974, seven judges)

The President, like the Governor, is a formal head who acts on the aid and advice of the Council of Ministers.



Article 75: Council of Ministers

- The Council of Ministers is collectively responsible to the House of the People (75(3)).

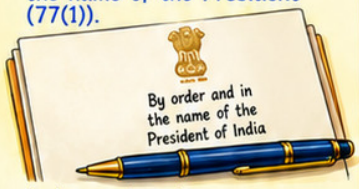


Lok Sabha
(House of the People)

- A Minister who for six consecutive months is not a member of either House ceases to be a Minister at the end of that period (75(5)).

Article 77: Executive action in the name of the President

- All executive action of the Government of India is expressed to be taken in the name of the President (77(1)).



- Orders made in his name are authenticated as his rules lay down, and an authenticated order cannot be called in question on the ground that the President did not make or execute it (77(2)).

Article 78: Duties of the Prime Minister

The Prime Minister must:

(a) communicate to the President all decisions of the Council of Ministers on the administration of the Union and on proposals for legislation;

(b) furnish such information on these as the President may call for; and

(c) if the President so requires, submit for the Council's consideration any matter decided by a Minister but not considered by the Council.

Who appoints whom?

Key constitutional appointments by the President

Office	Article	What the text says
Prime Minister	75(1)	Appointed by the President.
Other Ministers	75(1)	Appointed by the President on the advice of the Prime Minister.
Attorney-General for India	76(1)	The President appoints a person qualified to be appointed a Judge of the Supreme Court.
Comptroller and Auditor-General (CAG)	148(1)	Appointed by the President by warrant under his hand and seal.
Governor of a State	155	Appointed by the President by warrant under his hand and seal.
Judges of the Supreme Court	124(2)	Appointed by the President by warrant after consultation with Judges he considers necessary; for a Judge other than the Chief Justice, the Chief Justice of India is always consulted.
Judges of a High Court	217(1)	Appointed by the President by warrant after consultation with the Chief Justice of India, the Governor of the State and, for a Judge other than the Chief Justice, the Chief Justice of that High Court.
Chief Election Commissioner and other Election Commissioners	324(2)	Appointed by the President, "subject to the provisions of any law made in that behalf by Parliament".
Finance Commission	280(1)	Constituted by the President at the expiration of every fifth year, or earlier if he considers it necessary.
Chairman and members of the Union Public Service Commission (UPSC)	316(1)	Appointed by the President.

Diplomatic and military powers

Diplomatic powers



International treaties and agreements are negotiated and concluded on behalf of the President, who sends and receives diplomats.

Military powers (Article 53(2))



The supreme command of the Defence Forces of the Union is vested in the President, and its exercise is regulated by law.

Mercy powers: scope, not personal discretion

Article 72(1)

The President has the power to grant pardons, reprieves, respites or remissions of punishment, or to suspend, remit or commute the sentence of any person convicted of any offence, in three kinds of case:



1. All cases where the punishment or sentence is by a Court Martial.
2. All cases where the sentence is for an offence against a law on a matter to which the executive power of the Union extends.
3. All cases where the sentence is a sentence of death.

Forms of mercy and their meaning

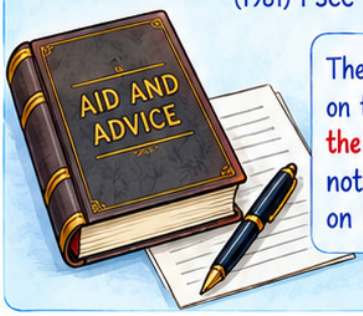
Pardon	Completely forgives the offence and removes the punishment.
Commutation	Substitutes a less severe sentence for the original sentence.
Remission	Reduces the period of the sentence without changing its character.
Respite	Awards a lesser sentence due to special circumstances (e.g. health).
Reprieve	Temporarily postpones the execution of a sentence, especially a sentence of death.

President (Article 72) vs Governor (Article 161)

Point	President (Article 72)	Governor (Article 161)
Words of the power	Pardons, reprieves, respites, remissions; suspend, remit or commute	The same words
Offences covered	Against a law on a matter to which the executive power of the Union extends.	Against a law on a matter to which the executive power of the State extends.
Court Martial	Covered, clause (1)(a)	Not mentioned in Article 161
Sentence of death	Covered in all cases, clause (1)(c)	Article 72(3) saves the Governor's power to suspend, remit or commute it.

Maru Ram v. Union of India

11 November 1980 | five judges
(1981) 1 SCC 107



The power is exercised on the aid and advice of the Council of Ministers, not by the President on his own.

Kehar Singh v. Union of India

16 December 1988 | five judges
AIR 1989 SC 653



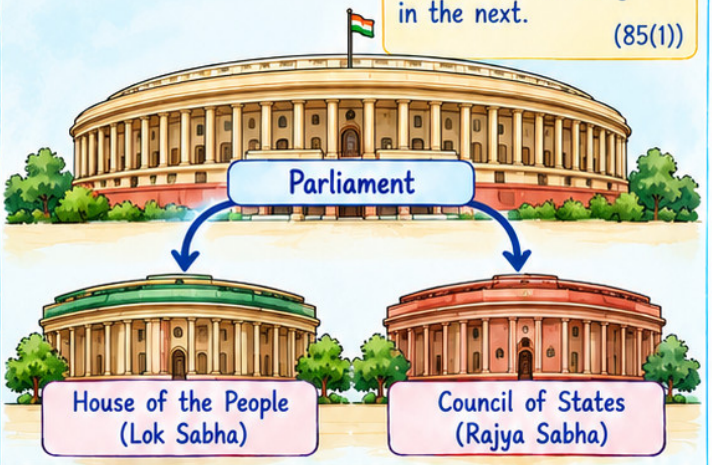
- The President may examine the evidence on record and reach a different conclusion, without amending or superseding the judicial record.
- The petitioner has no right to an oral hearing.
- Judicial review of the order is limited (within the bounds set in Maru Ram).

Summoning Parliament and resolving a deadlock

Article 85 : Summoning, prorogation and dissolution

The President **summons** each House of Parliament.

Six months shall not intervene between the last sitting in one session and the first sitting in the next. (85(1))



The President may **prorogue** either House or both, and **dissolve** the House of the People. (85(2))

Meaning of key terms (Article 85)

Summoning



The President issues a summons to each House to meet for a session.

Prorogation



The President brings a session to an end without dissolving the House. The House can be summoned again later.

Dissolution (of Lok Sabha)



The President dissolves the House of the People (Lok Sabha). A general election is held and a new Lok Sabha is constituted.

Article 108 : Joint sitting to resolve a deadlock

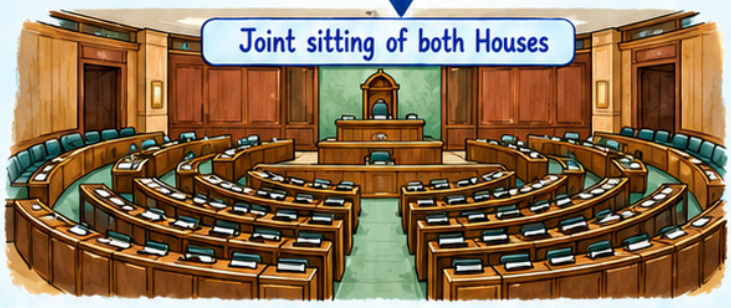
If, after one House has passed a Bill, the other House:

(a) **rejects** the Bill, or

(b) the Houses have **finally disagreed** on amendments, or

(c) more than **six months** pass without the other House passing the Bill.

The President may notify his intention to **summon a joint sitting** of both Houses.



Important exceptions



A joint sitting **cannot** be held for a Money Bill.

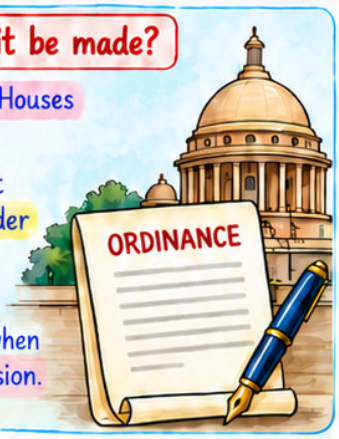


There is **no joint sitting** for a Constitution Amendment Bill either. Under **Article 368(2)** each House must pass it separately by the special majority.

An Ordinance is temporary law

Article 123(1): When can it be made?

- At any time except when both Houses of Parliament are in session.
- If the President is satisfied that "circumstances exist which render it necessary" for him to take immediate action.
- So, an Ordinance can be made when at least one House is not in session.



Condition: At least one House is not in session



Lok Sabha | Rajya Sabha

Ordinance can be made when at least one House is not in session.

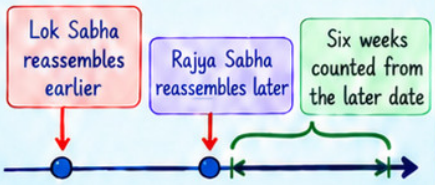
Article 123(2): Force and effect, laying and lapse



- An Ordinance has the same force and effect as an Act of Parliament.
- It must be laid before both Houses of Parliament.
- It ceases to operate at the expiration of six weeks from the reassembly of Parliament.
- It may cease earlier if both Houses pass resolutions disapproving it.
- The President may withdraw it at any time.

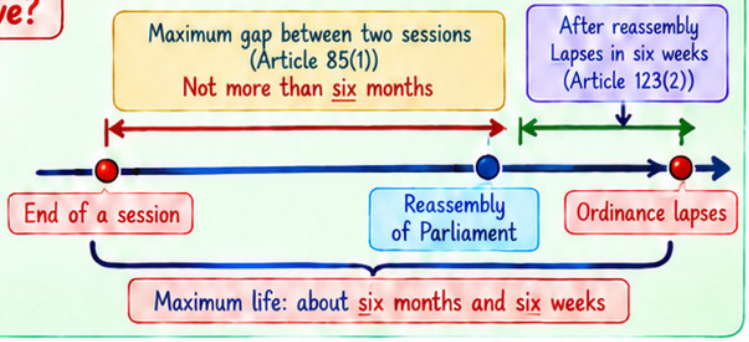
Explanation to Article 123(2)

- If the two Houses are summoned to reassemble on different dates, the six weeks are counted from the later of those dates.



How long can an Ordinance live?

- Under Article 85(1), not more than six months can pass between two sessions of Parliament.
- The Ordinance lapses six weeks after the reassembly of Parliament.
- So, an Ordinance can last at most about six months and six weeks.



Article 123(3): Void in certain cases



- An Ordinance is void if it makes a provision that Parliament could not validly enact.

Krishna Kumar Singh v. State of Bihar

(2 January 2017, seven judges, 5:2)



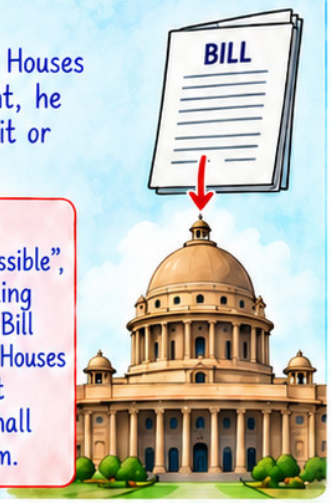
- Re-promulgation is "a fraud on the Constitution".
- Laying an Ordinance before the Legislature is a mandatory obligation.
- The ordinance powers under Articles 123 and 213 are not immune from judicial review.

Assent, return and withholding: different actions

Article 111

When a Bill passed by both Houses is presented to the President, he declares that he assents to it or that he withholds assent.

Proviso (not a Money Bill): he may instead, "as soon as possible", return it with a message asking the Houses to reconsider the Bill or any of its provisions. If the Houses pass it again, with or without amendment, the President shall not withhold assent therefrom.



The names of the vetoes

The Constitution does not use the word "veto". Polity textbooks and notes name three:

- **Absolute veto** — Withholding assent to the Bill.
- **Suspensive veto** — Returning the Bill for reconsideration.
- **Pocket veto** — Not acting on the Bill at all.

President's options under Article 111

Bill passed by both Houses and presented to the President

- **Ordinary Bill (not a Money Bill)** → Assent / Withhold assent (absolute veto) / Return with message (suspensive veto) → If returned and passed again by both Houses (with or without amendment) → President shall not withhold assent therefrom.
- **Money Bill** → Assent / Withhold assent (absolute veto) → Cannot be returned for reconsideration under the proviso.
- **Constitution Amendment Bill** → Must give assent. → After the Constitution (Twenty-fourth Amendment) Act, 1971, the President cannot withhold assent or return such a Bill.

Pocket veto of 1986

President Zail Singh neither assented to nor returned the Indian Post Office (Amendment) Bill, 1986, which both Houses had passed.



State Bills (Articles 200 and 201)

The Governor may:

- assent to a Bill,
- withhold assent, or
- reserve a Bill for the consideration of the President (Article 200).



On a reserved Bill the President declares that he assents or withholds assent (Article 201). For a non-Money Bill, he may direct the Governor to return it for reconsideration.

Time limits and the 2025 opinions



- **Two-judge opinion (8 April 2025)** → Set time limits, including three months for the President. / Treated 10 Bills as assented.
- **Five-judge Constitution Bench opinion (20 November 2025)** → Neither the Governor nor the President can be bound by judicially fixed timelines. / There is no "deemed assent". / No fixed judicial timeline does not mean unreviewable delay.

Which Bill can be sent back?

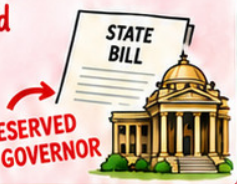
The President's options on each kind of Bill

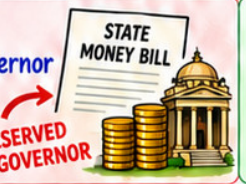
Kind of Bill	Assent	Withhold assent	Return for reconsideration
Ordinary Bill passed by Parliament (Article 111)	✓ Yes	✓ Yes	✓ Yes, once; if passed again, with or without amendment, he must assent.
Money Bill passed by Parliament (Article 111)	✓ Yes	✓ Yes	✗ No: the proviso covers only a Bill that is not a Money Bill.
Constitution Amendment Bill (Article 368(2), after the 24th Amendment)	✓ He must assent.	✗ No.	✗ No.
State Bill reserved by the Governor, not a Money Bill (Article 201)	✓ Yes	✓ Yes	✓ He may direct the Governor to return it; the Legislature reconsiders within six months, and the Bill comes back to him.
State Money Bill reserved by the Governor (Article 201)	✓ Yes	✓ Yes	✗ No.











What the table shows

1. The return of a Bill is the "suspensive veto" of the textbooks; it is available only for a Bill that is not a Money Bill.



2. For a Bill of Parliament, the return can be used once. For a reserved State Bill that is passed again, Article 201 does not oblige him to assent.



3. Withholding is the "absolute veto". It is open for every kind of Bill except a Constitution Amendment Bill.



4. No fixed presidential deadline is specified in these Articles. Prolonged inaction may still face judicial scrutiny.

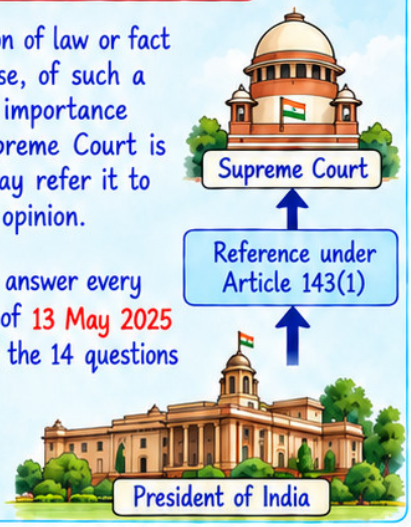


Seeking the Court's advice; emergencies under review

Advisory jurisdiction (Article 143)

Article 143(1): if a question of law or fact has arisen or is likely to arise, of such a nature and of such public importance that the opinion of the Supreme Court is expedient, the President may refer it to the Supreme Court for its opinion.

The Court is not bound to answer every question. On the Reference of 13 May 2025 it declined to answer two of the 14 questions (Questions 12 and 14).



Emergency powers (in outline)

The Constitution gives the President the following emergency powers:

Article 352 (Proclamation of Emergency)	War, external aggression or armed rebellion.
Article 356 (President's Rule in a State)	S.R. Bommai v. Union of India (11 March 1994, nine judges) held a Proclamation under Article 356 open to judicial review.
Article 360 (Financial Emergency)	Threat to financial stability or credit.

The President as on 25 October 2026

Droupadi Murmu is the President of India (President's Secretariat, as on 25 October 2026). She was sworn in as the 15th President on 25 July 2022.



Three common exam traps

1 Treating the three vetoes as words of the Constitution.

"Absolute", "suspensive" and "pocket" veto are textbook labels. The text speaks only of assenting, withholding assent and returning a Bill.

- A Money Bill cannot be returned.
- A Constitution Amendment Bill must be assented to after the 24th Amendment.
- The pocket veto exists only because no time limit is written; Zail Singh used it in 1986.

2 "An Ordinance lasts for six months."

The rule of Article 123 is six weeks from the reassembly of Parliament.
Six months is the longest gap allowed between two sessions under Article 85.
Together they give the outer limit of about six months and six weeks.

Between sessions: at most 6 months → Parliament reassembles → Ordinance lapses 6 weeks later

An approximate outer limit, not a fixed term.

- Making the same Ordinance again and again is a fraud on the Constitution (Krishna Kumar Singh, 2017).

3 "The President decides mercy petitions and Ministers' advice as he pleases."

- He can send the advice of the Council of Ministers back only once, under the proviso added by the 44th Amendment in 1978; after that he must act on it.
- Mercy petitions too are decided on the advice of the Council of Ministers (Maru Ram).
- Kehar Singh adds that he may look at the evidence himself, but the petitioner cannot demand an oral hearing.



A Budget is an estimate — not a result

A Budget is a forward-looking estimate of the government's expected receipts and planned expenditure for a financial year. It is **not** the actual money received or actually spent. Actual outcomes are known only after the financial year is over.



From estimate to Parliamentary authorization

Finance Ministry prepares the Budget using revenue projections and expenditure needs.



Annual Financial Statement



- Estimated receipts (revenue + capital)
- Estimated expenditure (spending)

Article 112

The President causes the annual statement to be laid before both Houses for every financial year.



Parliament authorizes spending and taxes through the applicable legislative process.

Demands for grants

Ministry-wise demands for expenditure are discussed and voted in the Lok Sabha.



Appropriation Bill

Seeks Parliament's authorization to withdraw funds from the Consolidated Fund of India.



Finance Bill

Seeks to impose, amend or repeal taxes and related provisions.



Key terms and timing

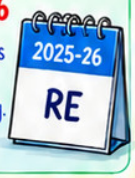
Budget Speech

Presented on 1 February 2026.



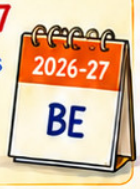
RE 2025-26

Revised Estimates for the financial year then running.



BE 2026-27

Budget Estimates for the coming financial year.



Actuals

Recorded outcomes after the period.



Always retain the **year** AND the **estimate label**.

Three funds mentioned in the Constitution

Consolidated Fund of India

Holds government revenues, borrowings and loan recoveries. Expenditure from this Fund requires Parliamentary authorization.



Public Account of India

Holds money received in trust, such as provident funds, small savings and other similar deposits.



Contingency Fund of India

Provides advances for urgent, unforeseen spending, pending Parliamentary approval.



Sources: Constitution, Articles 112–117; Union Budget 2026–27.

Four budget heads: follow the money

Revenue receipts

Tax revenue net to Centre + non-tax revenue.



BE 2026-27
₹35,33,150 crore

Capital receipts

Loan recoveeries + other receipts + borrowings and other liabilities.



BE 2026-27
₹18,14,165 crore

Revenue expenditure

Expenditure not creating assets for the Union. Interest, subsidies and grants.

BE 2026-27
₹41,25,494 crore



Capital expenditure

Acquiring assets, investments, loans and advances.

BE 2026-27
₹12,21,821 crore



Key comparisons to remember

Loan RECOVERED



Capital receipt.

Loan GIVEN



Capital expenditure.

Borrowing



Capital receipt, not revenue income.

Union grant → State builds school



Grant from Union (Government of India)

State builds school (Government of State)

The State owns the asset. The Union classifies its grant as **REVENUE** expenditure.

Grants for creation of capital assets:
₹4,92,702 crore in BE 2026-27.

Classify by the nature of the transaction—not by whether it sounds useful.

Source: Budget at a Glance 2026-27.

Receipts: separate income from borrowing



Total receipts
₹ 53,47,315
(All amounts in ₹ crore, BE 2026-27)

Revenue receipts
₹ 35,33,150

- **Net tax receipts** ₹ 28,66,922
- **Non-tax revenue** ₹ 6,66,228

Capital receipts
₹ 18,14,165

- **Loan recoveries** ₹ 38,397
- **Other receipts** ₹ 80,000
- **Borrowings and other liabilities** ₹ 16,95,768

Non-debt capital receipts
= 38,397 + 80,000
= ₹ 1,18,397

From gross tax to net tax

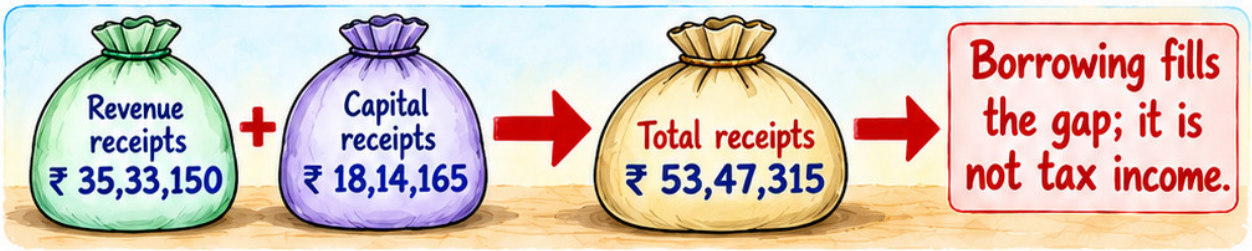
Gross tax receipts	₹ 44,04,086
− Less: States' share	₹ 15,26,255
− Less: NCCD transfer	₹ 10,910
→ Published net to Centre	₹ 28,66,922

Note: Published rounded entries differ by ₹ 1 crore when subtracted; retain the official net figure.

Disinvestment under other receipts

Disinvestment proceeds are recorded under other receipts, a capital-receipt head — not non-tax revenue.

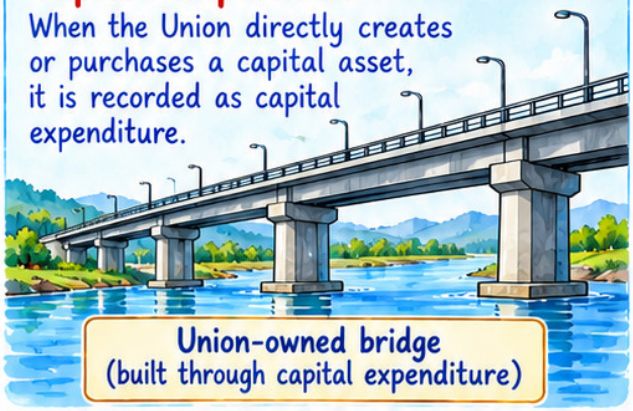




Capital spending: who owns the asset?

Union acquires asset → capital expenditure

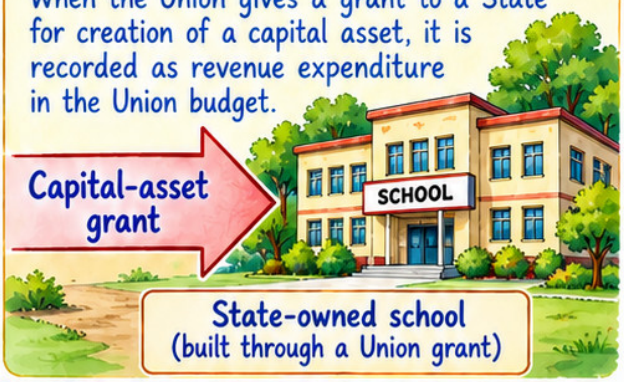
When the Union directly creates or purchases a capital asset, it is recorded as capital expenditure.



Union-owned bridge
(built through capital expenditure)

Union gives capital-asset grant → Union revenue expenditure

When the Union gives a grant to a State for creation of a capital asset, it is recorded as revenue expenditure in the Union budget.



State-owned school
(built through a Union grant)

Union expenditure in BE 2026-27

(All amounts in ₹ crore)

Revenue expenditure	+	Capital expenditure	=	Total expenditure
41,25,494		12,21,821		53,47,315

Revenue expenditure includes (among others):

Interest payments	Grants for creation of capital assets
14,03,972	4,92,702

These are parts of revenue expenditure, not the entire amount.

Effective capital expenditure

Add the asset-creation grants to direct capital expenditure to see total spending on creation of capital assets.

12,21,821	+	4,92,702	=	17,14,523
Capital expenditure		Asset-creation grants (in revenue expenditure)		Effective capital expenditure

Comparison: RE 2025-26 and BE 2026-27

(All amounts in ₹ crore)

Item	RE 2025-26	BE 2026-27
Capital expenditure	10,95,755	12,21,821
Asset-creation grants	3,08,151	4,92,702
Effective capital expenditure	14,03,906	17,14,523



Effective capex adds the asset-creation grants to direct capital expenditure; it does not change the grant's accounting classification.

Source: Budget at a Glance 2026-27.

Four deficits – one worked budget

All figures BE 2026-27 (₹ crore)

1 Revenue deficit

Gap on the revenue account.

Measures the excess of revenue expenditure over revenue receipts. It shows the gap in day-to-day operations.



Revenue expenditure: 41,25,494 − Revenue receipts: 35,33,150 =

Revenue deficit
= 41,25,494 − 35,33,150
= **5,92,344**

2 Effective revenue deficit

Removes the asset-creation grant component.

Measures the revenue deficit after adjusting for grants given for creation of capital assets. It shows the underlying gap in revenue account.

Revenue deficit: 5,92,344 − Grants for creation of capital assets: 4,92,702 =

Effective revenue deficit
= 5,92,344 − 4,92,702
= **99,642**

3 Fiscal deficit

Overall borrowing requirement.

Measures the excess of total expenditure over non-debt receipts. It shows how much the government needs to borrow.

Total expenditure: 53,47,315 − Non-debt receipts

Non-debt receipts:
- Revenue receipts: 35,33,150
- \+ Recovery of loans: 38,397
- \+ Other receipts: 80,000

Non-debt receipts = 35,33,150 + 38,397 + 80,000
= 36,51,547

Fiscal deficit
= 53,47,315 − 36,51,547
= **16,95,768**

4 Primary deficit

Deficit excluding interest on past borrowing.

Measures the fiscal deficit after removing interest payments. It shows the extent of deficit due to current operations.

Fiscal deficit: 16,95,768 − Interest payments: 14,03,972 =

Primary deficit
= 16,95,768 − 14,03,972
= **2,91,796**

Check with budget financing

Fiscal deficit (₹ crore): 16,95,768 ⟷ Should be equal to ⟷ Borrowings and other liabilities (₹ crore): 16,95,768

! Do not subtract all capital receipts: that would wrongly include borrowing.

Source: Budget at a Glance 2026-27.

Deficit is a flow; debt is a stock

Fiscal deficit: borrowing requirement over one year

Fiscal deficit is total expenditure minus total receipts excluding debt capital receipts. It measures the government's overall borrowing requirement for the year.

Debt: outstanding liabilities accumulated over time

Debt is the total outstanding liabilities of the government, built up from past borrowings. It is a stock at a point in time.



Key fiscal indicators (% of GDP)

Indicator	RE 2025-26 (% of GDP)	BE 2026-27 (% of GDP)
Fiscal deficit	4.4	4.3
Revenue deficit	1.5	1.5
Effective revenue deficit	0.6	0.3
Primary deficit	0.8	0.7
Central Government debt	56.1	55.6

Target timeline for debt ratio

Budget 2025-26 indicated target → Budget 2026-27 recalls target → 50 ± 1% of GDP by 2030-31

From 2026-27, annual fiscal deficits are set to keep the debt ratio on a declining path.

This is a target, NOT an achievement.

FRBM framework: historical statutory targets

The FRBM framework included statutory targets of:

- fiscal deficit 3% by 31 March 2021
- Central Government debt 40% by 31 March 2025.

These old target dates are NOT the current debt-anchor endpoint.

Budget GDP denominator

BE 2026-27 GDP:

₹3,93,00,393 crore

How they relate

Fiscal deficit (flow) → Adds to debt → Debt (stock)

Each year's borrowing (deficit) increases the total outstanding debt.

Keeping annual fiscal deficits under control helps put the debt ratio on a declining path towards 50 ± 1% of GDP by 2030-31.

Source: Budget Speech 2026-27 ¶92-94; FRBM 2026-27.

One rupee in; one rupee out

Where it comes from (paise)

Borrowings and other liabilities	24
Income tax	21
Corporation tax	18
GST and other taxes	15
Non-tax revenue	10
Union excise duties	6
Customs	4
Non-debt capital receipts	2
Total	**100**

Where it goes (paise)

States' share of taxes	22
Interest payments	20
Central sector schemes	17
Defence	11
Centrally sponsored schemes	8
Finance Commission and other transfers	7
Other expenditure	7
Major subsidies	6
Civil pension	2
Total	**100**

Largest incoming share:
Borrowings and other liabilities
24 paise

₹ 1 RUPEE

Largest outgoing share:
States' share of taxes
22 paise
Not interest payments (20 paise).

These paise figures are the official Budget chart.
Do not treat this chart's denominator as only Union revenue receipts.

Source: Budget at a Glance 2026-27.

Budget tools ask different questions

Gender budget lens: Who benefits?

Classifies provisions in schemes based on the extent of benefit to women and girls.

Part A
100%
provision for women and girls.



100%

Part B
30 – 99%
provision for women and girls.



30 – 99%

Part C
below 30%
provision for women and girls.



below 30%

Gender Budget allocations

BE 2026-27
₹ 5,00,878.73 crore

RE 2025-26
₹ 3,97,884.98 crore



Budget Estimate (BE) 2026-27

Revised Estimate (RE) 2025-26

Outcome chain: from spending to results

OOMF 2026-27 covers major schemes with outlay ₹ 500 crore or more; it links spending to measurable results.



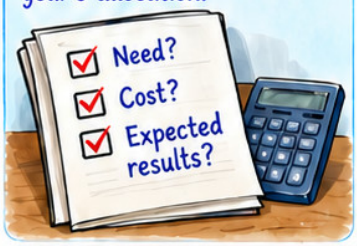
Outlay
Money allocated for a scheme.

Outputs
Goods and services delivered, e.g. schools built, books provided.

Outcomes
Changes achieved, e.g. improved learning opportunities.

Zero-based budgeting

Justify each expense afresh from a zero base. Every activity must be examined for its need, cost and expected results, rather than assuming the previous year's allocation.



Vote on account

Article 116(1)(a) provides for a vote on account, which is an advance grant for expenditure during part of a year, to meet government expenses until the full Budget is passed.



Interim budget

A temporary financial plan presented near elections to meet government expenses until a new government presents a full Budget. It is not a constitutional term.



Supplementary grant

Article 115(1)(a) provides for a supplementary grant when the authorized amount for a service is insufficient and additional funds are required during the year.



Contingency Fund

Article 267 provides for a Contingency Fund with a corpus of ₹ 30,000 crore to meet urgent and unforeseen expenditure, pending approval by the Parliament.



Urgent and unforeseen expenditure pending approval.

2017: key Budget changes

Railway and General Budgets merged
The first combined Budget of independent India.







Presentation advanced to 1 February.

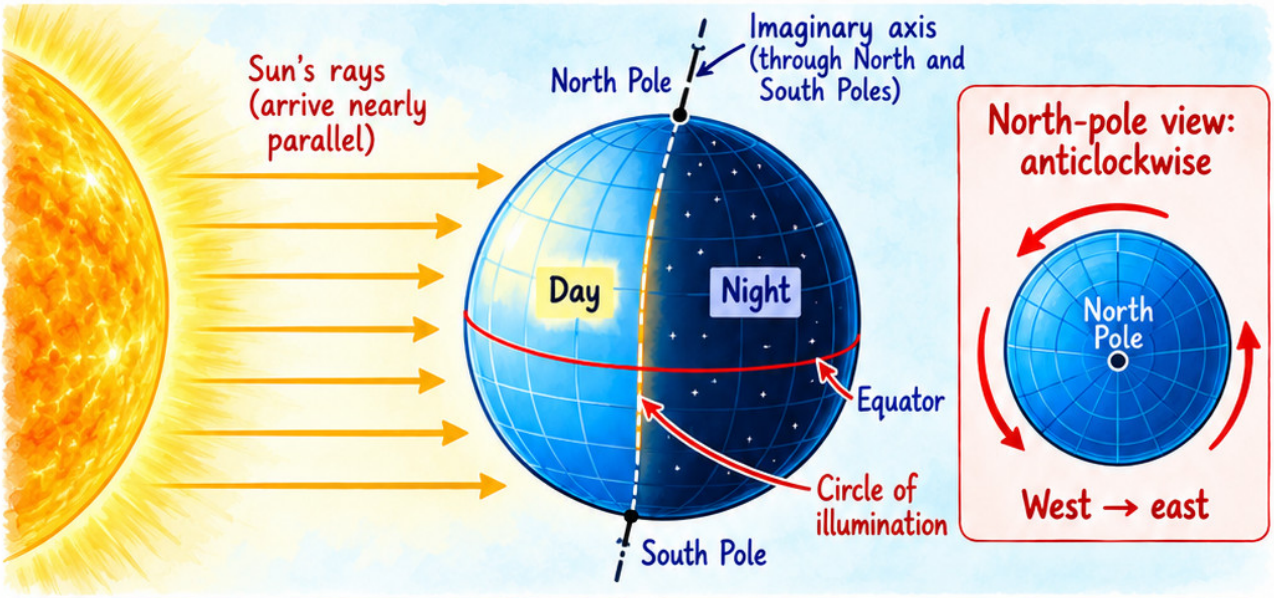


Plan / Non-Plan classification discontinued.

Source: Union Budget 2026-27, Statement 13, Key to Budget Documents; Budget Speech 2017.

Rotation: Earth turns from west to east

A spin on the axis — not a journey around the Sun

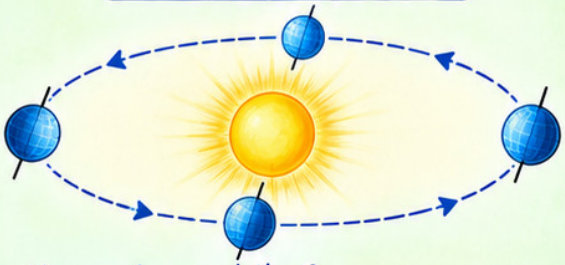


ROTATION



- Spin on its axis.
- About 24 hours for a mean solar day.
- Produces day and night.

REVOLUTION



- Movement around the Sun.
- About 365.2 days.
- Together with axial tilt, produces seasons.

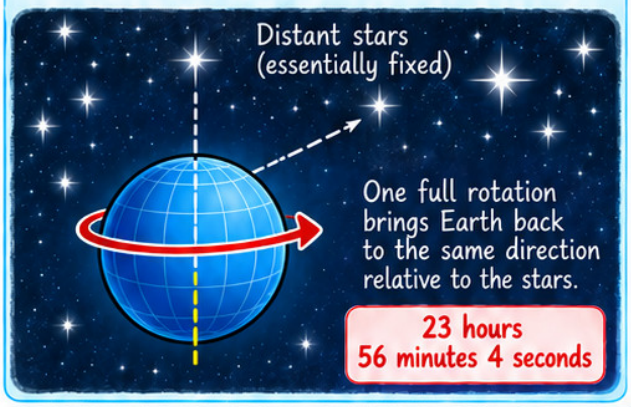
Earth turns eastward → the Sun appears to move westward across the sky.



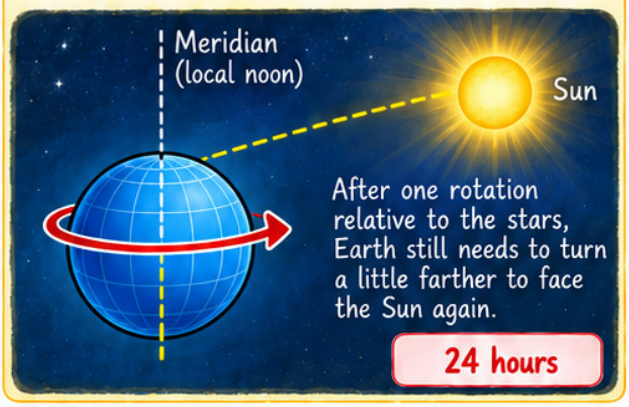
Rotation and revolution are different motions.

Two clocks for one turning Earth

Sidereal day: one rotation relative to distant stars — **23 hours 56 minutes 4 seconds.**



Mean solar day: average interval between successive solar transits of the same meridian — **24 hours.**





Why the extra rotation?

360° ÷ 365.2
≈ 1° of orbital advance per day

↓

About 1° extra rotation to face the Sun again

↓

About 4 extra minutes
(1° is 1/360 of a full rotation, so 24 h ÷ 360 ≈ 4 min per degree)

Comparison of the two days

Item	Sidereal day	Mean solar day
Reference	Distant stars	Sun (same meridian)
Period	23 hours 56 minutes 4 seconds	24 hours
What it measures	One rotation relative to stars	Average interval between successive solar transits of the same meridian
Length (rounded)	23 h 56 m 4 s (≈ 23.9345 h)	24 h (= 24.0000 h)

⚠ Important trap

24 hours is the mean solar day, not the sidereal rotation period.

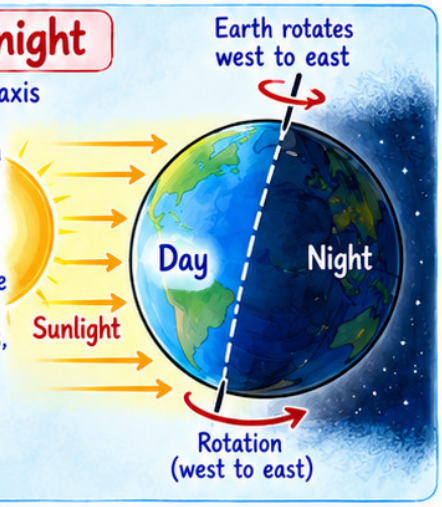
A sidereal day is shorter by about 4 minutes because Earth moves about 1° along its orbit each day and must turn a little farther to face the Sun again.

Rotation changes the sky, time and Earth's shape

1. Day and night

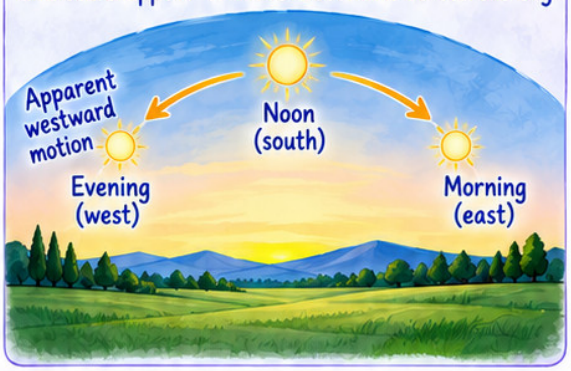
Earth rotates on its axis from west to east. Places facing the Sun have daylight, while places facing away have night.

Most places experience a daily sunrise and sunset. Near the poles, there are periods of continuous daylight (polar day) or continuous darkness (polar night).



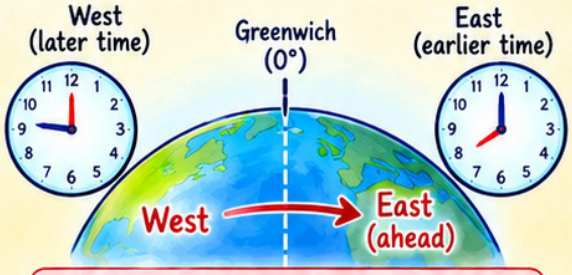
2. Apparent sky motion

Because Earth rotates eastward, the Sun, Moon and stars appear to move westward across the sky.



3. Local time

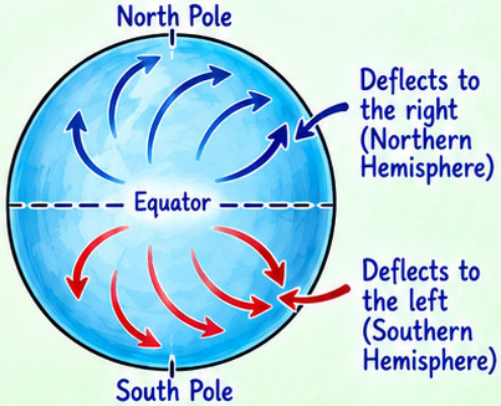
Earth rotates 360° in 24 hours.
So, 360° ÷ 24 hours = 15° per hour
= 1° per 4 minutes.
Places to the east experience local time earlier than places to the west.



15° per hour = 1° per 4 minutes

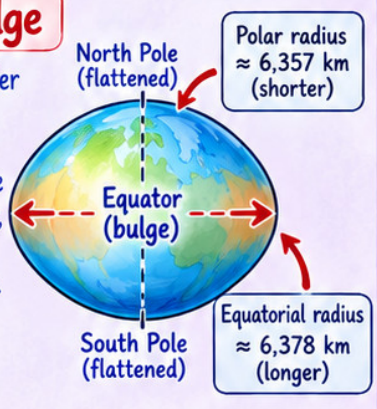
4. Coriolis effect

Due to Earth's rotation, moving air and water are deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.



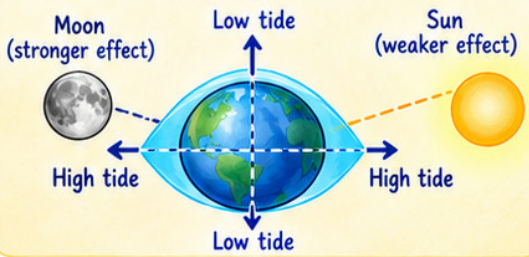
5. Equatorial bulge

Earth's rotation causes a wider equator and flatter poles. Centrifugal effect due to rotation reduces the effective pull of gravity at the equator, so the equatorial radius is larger than the polar radius.



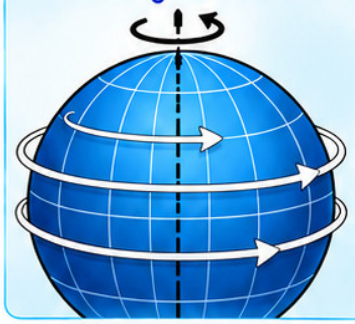
6. Tides

Tides are chiefly caused by the gravitational pull of the Moon and the Sun on Earth's oceans. They are not caused by Earth's rotation alone. Tidal friction gradually slows Earth's rotation.



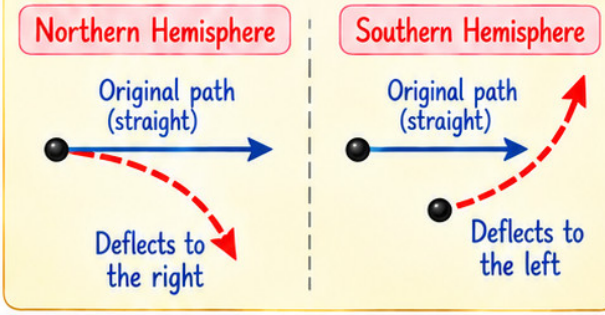
Rightward deflection does NOT mean a clockwise cyclone

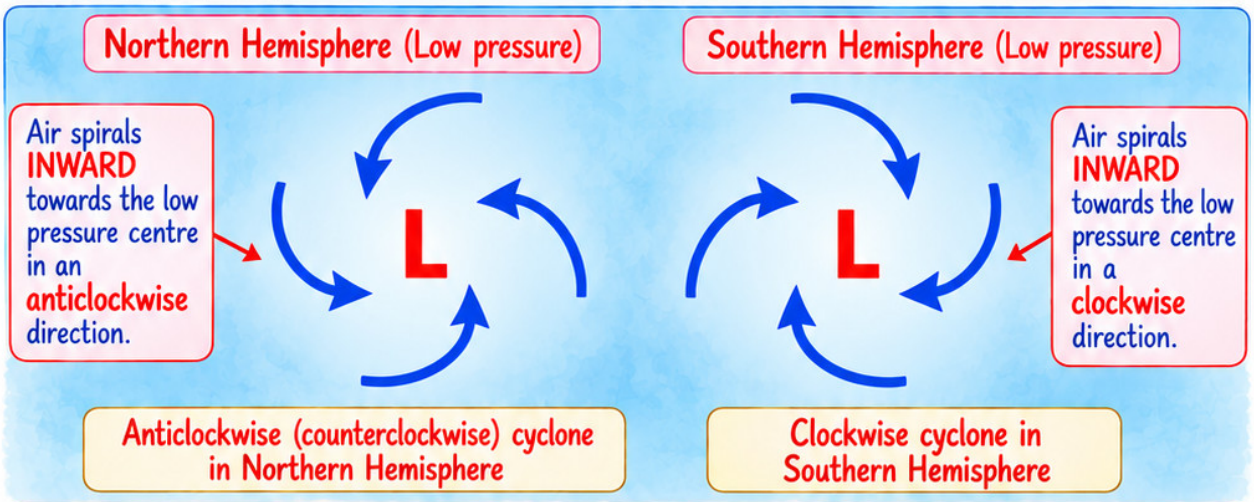
Coriolis effect is a apparent effect of viewing motion from rotating Earth.



Objects moving on Earth appear to deflect due to Earth's rotation (we are in a rotating frame of reference).

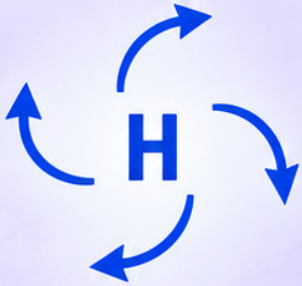
Deflection: right in the north; left in the south.





Inflow toward low pressure + Coriolis deflection → anticlockwise northern cyclones; clockwise southern cyclones.

Northern high pressure



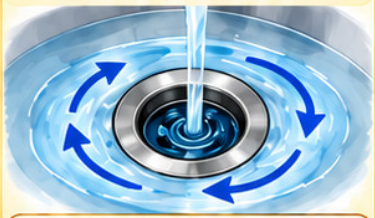
Northern high pressure: clockwise outward circulation.

Horizontal Coriolis effect is zero at the equator and strongest at the poles; it increases with moving-air speed.

Latitude dependence follows sin(latitude).

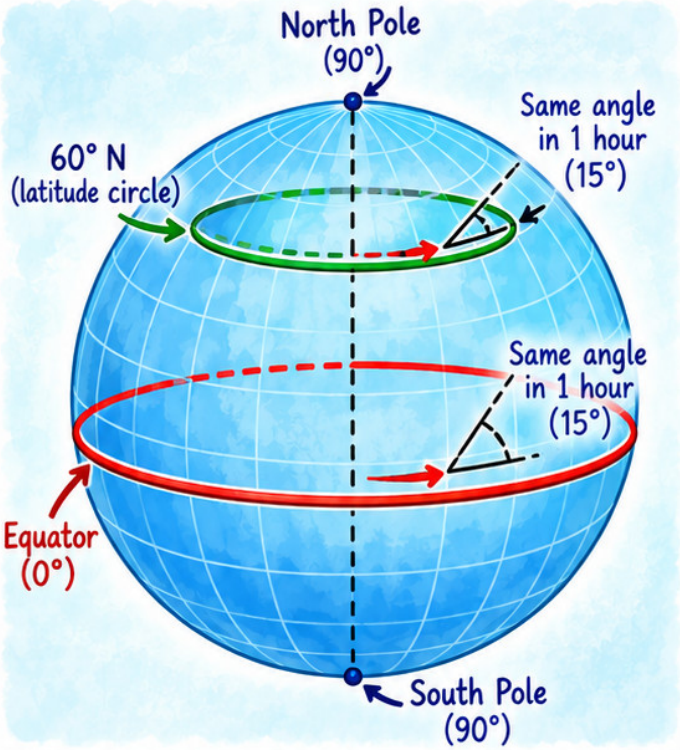
Tropical cyclones rarely form within 5° of the equator: Coriolis effect is too weak.

A sink drain is not a reliable hemisphere test.



Direction of water swirl in a sink depends on local conditions (shape, flow rate, obstruction), not on the hemisphere.

Same angular speed – different ground speeds



Angular speed: about 15° per hour everywhere.

The Earth rotates 360° in about 24 hours, so the angular speed is about 15° per hour at all latitudes.

Linear speed decreases toward the poles because latitude circles get smaller.

Everyone on Earth has the same angular speed, but the distance covered in 1 hour depends on the size of the latitude circle. The circle is largest at the equator and gets smaller toward the poles, so the ground (linear) speed decreases.

Formula for linear speed

$$v = 1{,}670 \times \cos(\text{latitude}) \text{ km/h}$$

(approximate)

Here, **1,670 km/h** is the linear speed at the equator. "latitude" is the absolute value in degrees (0° to 90°).

Worked examples

Latitude (°)	cos(latitude)	Linear speed (km/h)
0°	1	about 1,670 km/h
30°	0.866	about 1,446 km/h
45°	0.707	about 1,181 km/h
60°	0.5	about 835 km/h
90°	0	zero

Example

At 60°:

$1{,}670 \times 0.5 = 835$ km/h

So, the linear speed at 60° latitude is about 835 km/h.

Note

Equator travels about 40,075 km in about 24 hours.

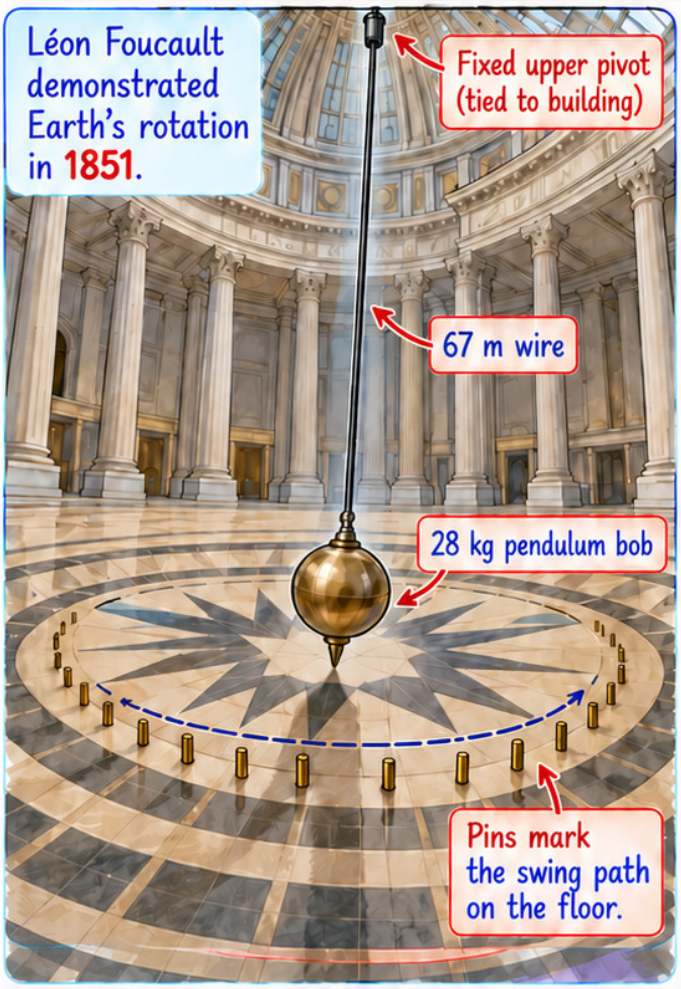
These speeds are rounded teaching approximations.

Trap

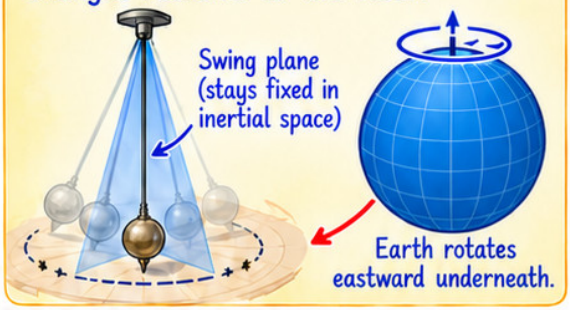
Use **cosine** for surface linear speed, not sine.

Foucault's pendulum: the floor turns beneath the swing

Léon Foucault demonstrated Earth's rotation in **1851**.

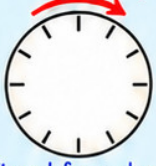


The swing plane stays approximately fixed in inertial space while Earth rotates underneath; its direction changes relative to the floor.



Relative to the floor:
clockwise in the Northern Hemisphere;
anticlockwise in the Southern Hemiisphere.

Northern Hemisphere



Viewed from above the local floor.
Clockwise precession of the swing plane (relative to the floor).

Southern Hemisphere



Viewed from above the local floor.
Anticlockwine precession of the swing plane (relative to the floor).

Precession rate = Earth's rotation rate × sin(latitude)

Pole: fastest
About one full turn per sidereal day.



Latitude = 90°
sin 90° = 1 → full rate

Paris: about one full turn in **32 hours**



Latitude ≈ 49°
sin 49° ≈ 0.75 → 24 / 0.75 ≈ 32 hours

Equator: no precession of the swing plane



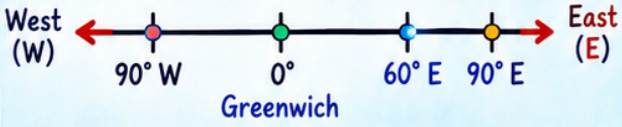
Latitude = 0°
sin 0° = 0 → no precession

Surface linear speed (due to Earth's rotation) uses **COSINE** of latitude.

Foucault precession (of the swing plane) uses **SINE** of latitude.

Longitude becomes time in four clear steps

Longitude tells us how far a place is east or west of the Prime Meridian (0°).



Key idea

As Earth rotates 360° in 24 hours, 15° of longitude corresponds to 1 hour and 1° corresponds to 4 minutes of local solar time.

360° in 24 hours → 15° in 1 hour → 1° in 4 minutes

EAST → AHEAD → ADD

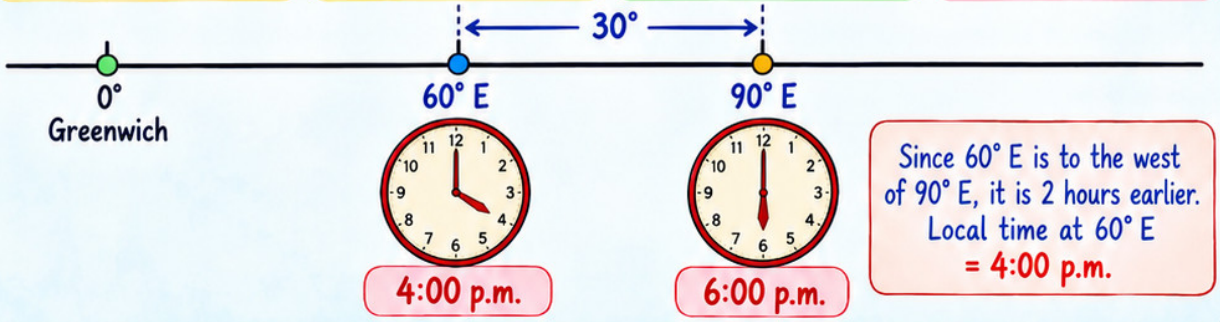
Places to the east have later local time. Add the time difference.

WEST → BEHIND → SUBTRACT

Places to the west have earlier local time. Subtract the time difference.

Example 1: At 90° E, local time is 6:00 p.m. Find local time at 60° E.

1. Same side of Greenwich: subtract longitudes.
2. 90° − 60° = 30°.
3. 30° × 4 minutes = 120 minutes = 2 hours.
4. 60° E is west of 90° E: subtract 2 hours → 4:00 p.m.



Since 60° E is to the west of 90° E, it is 2 hours earlier. Local time at 60° E = 4:00 p.m.

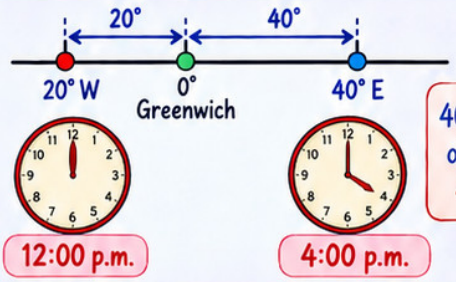
Example 2: Opposite sides of Greenwich

Find the time difference between 20° W and 40° E.

Separation = 20° + 40° = 60°.

Time difference = 60° × 4 minutes = 240 minutes = 4 hours.

The eastern place (40° E) is ahead by 4 hours.



40° E is ahead of 20° W by 4 hours.

These are local solar-time calculations, not political time-zone rules.

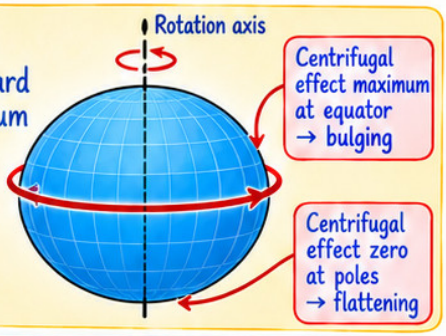
Indian Standard Time uses 82°30′ E.

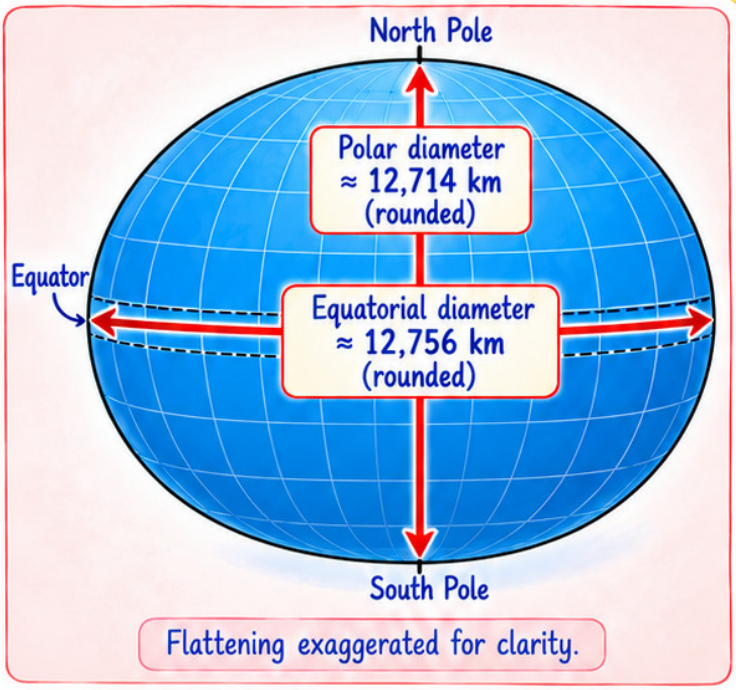
Why Earth's diameter is about 43 km larger at the equator

Earth is not a perfect sphere. It is an oblate sphere, slightly flattened at the poles and bulging at the equator due to its rotation.

Rotation causes bulging

As Earth rotates, the outward centrifugal effect is maximum at the equator and zero at the poles. This makes the equatorial region bulge and the polar region flatten.





Flattening exaggerated for clarity.

NASA source radii

NASA equatorial radius: **6,378.137 km**
NASA polar radius: **6,356.752 km**

Calculate the difference

Difference in radii = 6,378.137 − 6,356.752
= **21.385 km**

Difference in diameters = 2 × 21.385
= **42.77 km**

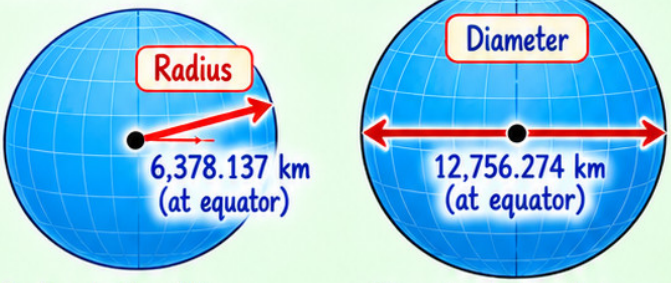
About 43 km.

Using rounded diameters

Rounded diameters:
Equatorial diameter: about **12,756 km**
Polar diameter: about **12,714 km.**

Subtracting rounded values gives 42 km; use exact source radii before rounding the final result.

Radius vs diameter



Radius is the distance from the centre to the surface.

Diameter is the distance across the Earth through the centre (2 × radius).

Flattening value

Flattening (f) describes how much Earth is flattened at the poles.

Flattening = 0.003353 ≈ 1/298

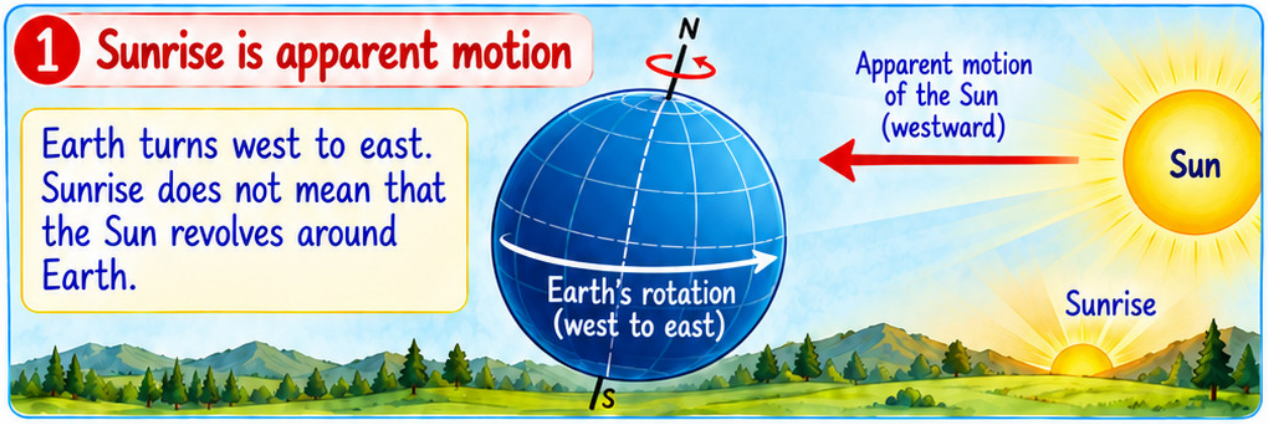
This small flattening value means Earth is very close to a sphere, but the equatorial bulge is large enough to make the diameter about 43 km greater at the equator.

Rotation contributes to equatorial bulging and polar flattening.

Three rotation traps — reason through the mechanism

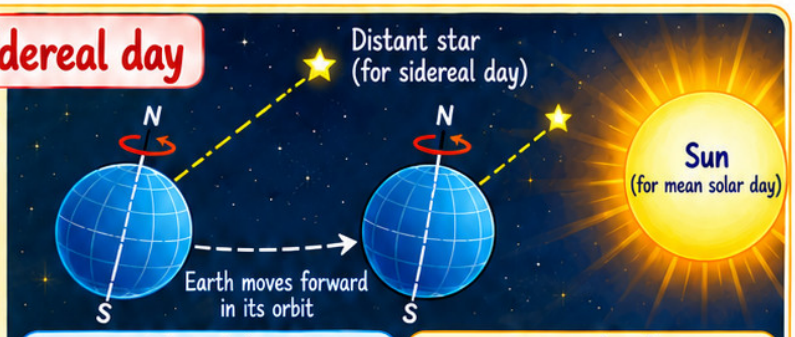
1 Sunrise is apparent motion

Earth turns west to east. Sunrise does not mean that the Sun revolves around Earth.



2 24 hours is not the sidereal day

Sidereal day: 23 h 56 min 4 s.
Mean solar day: 24 h.
Orbital advance requires a little extra turn to face the Sun again.



Sidereal day
23 h 56 min 4 s
(one rotation relative to distant stars)

Mean solar day
24 h
(successive returns of the Sun to the meridian)

3 Right deflection, anticlockwise cyclone

Air flows inward toward low pressure. Deflection is to each parcel's right, producing anticlockwise circulation in the north.

Air moves toward a LOW → Each parcel deflects to its own RIGHT in the north. → Together: ANTICLOCKWISE circulation

its own right

Comparison

- Northern low: anticlockwise
- Southern low: clockwise

Direction → reference frame → mechanism • understand these • before memorising a diagram.

Resources, reserves and potential are not the same

What do they mean?

Resource: total naturally occurring quantity that may be useful in future.

Reserve: part of the resource that is known with reasonable certainty to be economically and technically recoverable with current technology.

Potential: theoretical capacity or possibility (e.g. solar or wind) that may be harnessed in future.

Coal: geological resources

The Ministry of Coal counts coal as geological resources, in three classes by how well they have been explored: measured, indicated and inferred.

Its count covers seams 0.90 m thick and more, down to a depth of 1,200 m.

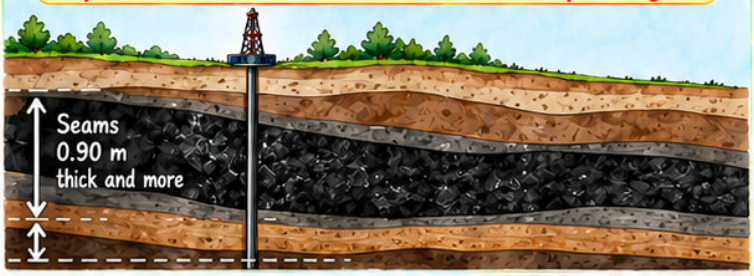
Petroleum: estimated reserves

The petroleum figures that MoSPI (the Ministry of Statistics and Programme Implementation) publishes are estimated reserves.

The Ministry of Petroleum and Natural Gas (MoPNG) sometimes speaks of "reserves and resources" together.

Coal resource classification (by level of exploration)

Exploration-confidence classes—not depth layers

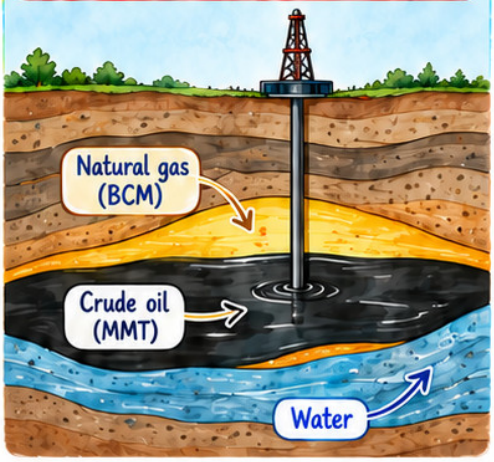


Measured
Well explored. Higher level of certainty about quantity and quality.

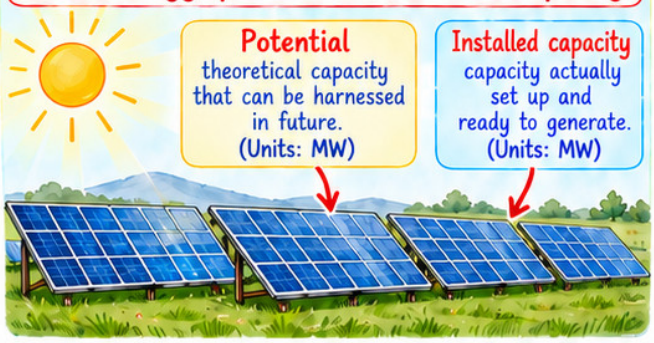
Indicated
Moderately explored. Reasonable level of certainty.

Inferred
Less explored. Lower level of certainty. May become measured or indicated with further exploration.

Petroleum: reserves in a reservoir



Solar energy: potential and installed capacity



Same term, different meanings

Aspect	Coal	Petroleum	Solar
What is reported	Geological resources	Estimated reserves (MoSPI)	Potential and installed capacity
Classes / categories	Measured, indicated, inferred	Reserves (sometimes discussed with resources by MoPNG)	Potential vs installed
Units used	MT or MMT	MMT (oil) or BCM (natural gas)	MW

So, a figure must always be read with its label, its date and the body that gives it.

Coal and lignite: read the resource label

What are coal and lignite?

Coal is a combustible geological resource formed from ancient plant remains over millions of years. Lignite is a lower-rank brown coal with lower carbon content and higher moisture than higher-rank coals.



Classification of coal resources

Coal geological resources are classified as:

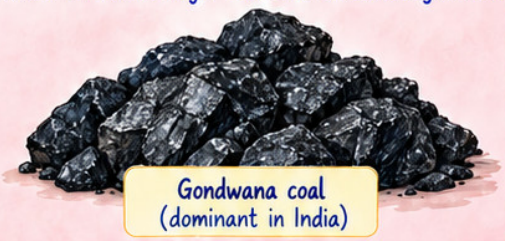
Measured	High level of geological confidence in quantity and quality.
Indicated	Moderate level of geological confidence.
Inferred	Lower level of geological confidence based on limited information.

How coal is formed?



Gondwana coal dominates

Most of India's coal resources are Gondwana coals, which form the major share of the country's coal.



Coking coal and steel making

Coking coal has special properties and is used in steel production.



State highlights



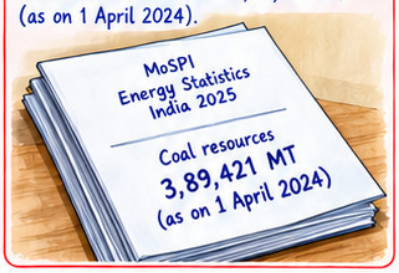
Odisha leads coal resources in India.



Tamil Nadu leads lignite resources in India.

Coal resource estimate (MoSPI)

As per MoSPI Energy Statistics India 2025, India's coal resources are 3,89,421 MT (as on 1 April 2024).



Singareni Collieries Company Limited (SCCL)

Coal in Telangana is mined by Singareni Collieries Company Limited (SCCL).



SCCL is owned by Government of Telangana (51%) and Government of India (49%).

Singareni is in Telangana, not Andhra Pradesh.

Coal and lignite: rank comparison

Feature	Coal (higher rank)	Lignite (lower rank)
Colour	Black	Brown
Carbon content	Higher	Lower
Moisture content	Lower	Higher
Energy content	Higher	Lower

From resource to power: potential vs installed capacity

Coal and lignite resources (potential) → Mining and supply → Thermal power plants (installed capacity) → Electricity supply for development

Oil and gas: offshore is a separate category

Estimated reserves of crude oil and natural gas (MoSPI, Energy Statistics India 2025, as on 1 April 2024)

Region or State	Crude oil (MMT)	Share	Natural gas (BCM)	Share
Western Offshore	213.26	31.76%	342.29	31.28%
Assam	145.41	21.66%	164.51	15.03%
Rajasthan	131.50	19.59%	63.55	5.81%
Gujarat (onshore)	118.86	17.70%	55.46	5.07%
Eastern Offshore	40.67	6.06%	263.34	24.07%
Tamil Nadu	8.54	1.27%	36.57	3.34%
Andhra Pradesh	7.69	1.15%	59.27	5.42%
Coal-bed methane (West Bengal, Madhya Pradesh, Jharkhand)	–	–	73.61	6.73%
All India	**671.40**	100%	**1,094.19**	100%

Offshore is a separate category

Offshore reserves are counted separately. Do not add them to a coastal State's onshore reserves.



Largest estimated reserves

Crude oil reserves
Western Offshore
213.26 MMT
(31.76%)

Natural gas reserves
Western Offshore
342.29 BCM
(31.28%)

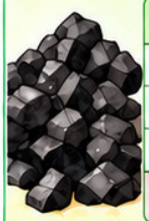
Second place differs

Crude oil second place
Assam
145.41 MMT
(21.66%)

Natural gas second place
Eastern Offshore
263.34 BCM
(24.07%)

Coal-bed methane (CBM) is listed separately

MoSPI lists CBM under three coal-bearing States. West Bengal has the largest share, about 60% of CBM.



State	Gas (BCM)	Share of CBM
West Bengal	44.37	60.3%
Madhya Pradesh	24.38	33.1%
Jharkhand	4.86	6.6%
Total (CBM)	73.61	100%

Other estimated reserves

Other crude oil reserves are in Arunachal Pradesh, Nagaland, Tripura and West Bengal.

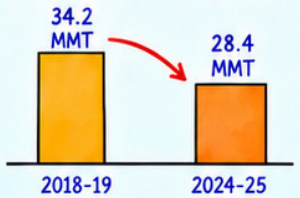
The rest of the gas is in Arunachal Pradesh, Nagaland and Tripura.

Tripura alone has 28.18 BCM of gas.

West Bengal's conventional gas row is zero; all its gas is coal-bed methane.

Falling output of crude oil

Domestic crude oil production fell from 34.2 MMT in 2018-19 to 28.4 MMT in 2024-25 (a Standing Committee of Parliament, as PRS gives it).



Uranium and monazite: Andhra Pradesh relevance

Uranium

- Uranium is a naturally occurring chemical element used in nuclear fuel.
- Atomic Minerals Directorate (AMD) had established 4,23,222 tonnes of uranium oxide (U_3O_8) in the ground, in 47 deposits, as on June 2024 (reply in the Lok Sabha, 31 July 2024).



Uranium ore



U_3O_8: resource quantity reported as uranium oxide

State-wise uranium resources (as on June 2024)

State	U_3O_8 (tonnes)	Share (worked out)
Andhra Pradesh	2,52,220	59.6 per cent
Jharkhand	98,967	23.4 per cent
Meghalaya	23,268	5.5 per cent
Telangana	18,550	4.4 per cent
Rajasthan	16,531	3.9 per cent

The YSR Tummalapalle group in Andhra Pradesh holds 2,49,459 tonnes, the largest single deposit in the list.



YSR Tummalapalle group (Andhra Pradesh)

Monazite and thorium

- Thorium is found in the mineral monazite, a mineral of the rare earths and thorium.
- The AMD has established 13.07 MT of monazite in the ground (reply in the Lok Sabha, 9 August 2023).



Monazite (sand grains)

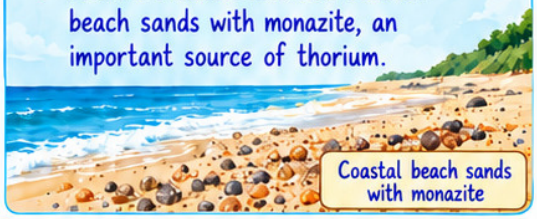
It occurs in coastal beach sands in parts of Kerala, Tamil Nadu, Odisha, Andhra Pradesh, Maharashtra and Gujarat, and inland in parts of Jharkhand, West Bengal and Tamil Nadu.



Beach sand containing monazite

Significance for Andhra Pradesh

- Andhra Pradesh has 2,52,220 tonnes of U_3O_8, about 59.6 per cent of the country's established resources.
- The YSR Tummalapalle group (2,49,459 tonnes) is the largest single uranium deposit.
- Andhra Pradesh also has coastal beach sands with monazite, an important source of thorium.



Coastal beach sands with monazite

Uranium and monazite resources: different materials and units

Uranium resources



4,23,222 tonnes of U_3O_8, as on June 2024.

Limited uranium resources underpin the rationale for India's three-stage nuclear programme.

Different materials and units—never compare these numbers as if they measure the same substance.

Monazite resources

13.07 million tonnes (MT), as reported 9 August 2023.

Monazite contains thorium; resource quantity is not the amount of thorium alone.



Potential is not installed capacity

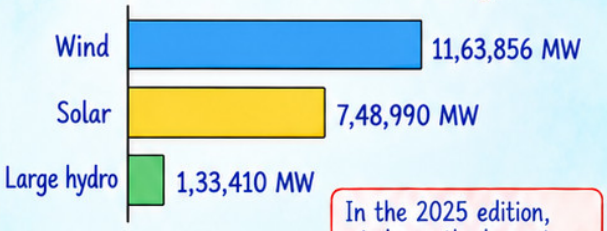
Potential means the total feasible resource estimated using studies, not the amount of power already installed or generating now.



Renewable and hydro potential (MoSPI)

Source	Potential, 31 March 2024 (Energy Statistics India 2025)	Potential, 31 March 2025 (Energy Statistics India 2026)
Solar	7,48,990 MW	33,43,378 MW
Wind, at 150 m height	11,63,856 MW	11,63,856 MW
Large hydro	1,33,410 MW	1,33,410 MW
Total, all sources	21,09,655 MW	47,04,043 MW

2025 edition: wind is the largest

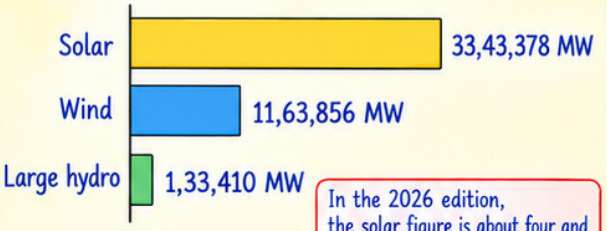


Total: 21,09,655 MW

In the 2025 edition, wind was the largest item (about 55 per cent).

Selected sources; total also includes other sources.

2026 edition: solar dominates



Total: 47,04,043 MW

In the 2026 edition, the solar figure is about four and a half times larger, and solar makes up about 71 per cent.

Selected sources; total also includes other sources.

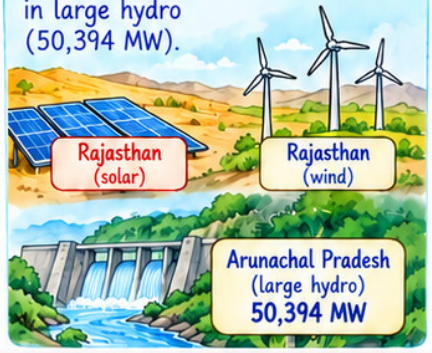
Solar potential revised by new assessment

New assessment by the National Institute of Solar Energy (NISE), an autonomous institute of the MNRE: about 3,343 GWp of ground-mounted solar potential, against the earlier estimate of 2014 of 749 GWp (PIB, 23 September 2025).



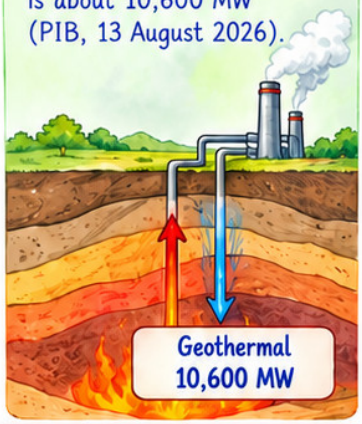
State with highest potential in 2025 edition

Rajasthan leads in both solar and wind. Arunachal Pradesh leads in large hydro (50,394 MW).



Geothermal potential

Geothermal potential is about 10,600 MW (PIB, 13 August 2026).



Potential vs installed capacity



Potential

Total feasible resource estimated through studies

e.g. 7,48,990 MW (Solar in 2024)
33,43,378 MW (Solar in 2025)
11,63,856 MW (Wind)
1,33,410 MW (Large hydro)

≠

Installed capacity

Actual installed nameplate capacity to generate electricity at a point of time. It is a part of the potential and is generally much smaller than the total potential. Actual generation depends on utilisation and conditions.

Import dependence: compare like with like

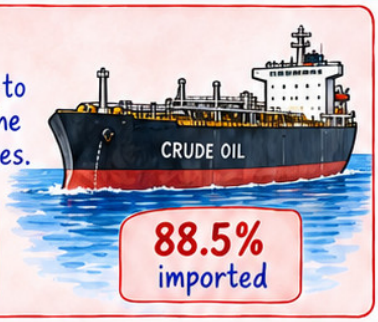
2.6 How far India depends on imports

The dependence differs across fuels. Always note the year and source along with the figure.

Crude oil

India imports close to 88.5 per cent of the crude oil it consumes.

MoPNG document on PIB, 5 July 2026 (no year stated).



88.5% imported

Natural gas

46 per cent of the gas consumed was imported, up from 28 per cent in 2011-12.

2023-24 (PPAC data, as PRS gives it).



28% 2011-12 → 46% 2023-24

Coal

Imports fell by 7.9 per cent, from 264.53 MT to 243.62 MT, while production was 1,047.52 MT.

2024-25 (Ministry of Coal, PIB, 27 May 2025; Annual Report 2025-26).



264.53 MT imports → 243.62 MT imports

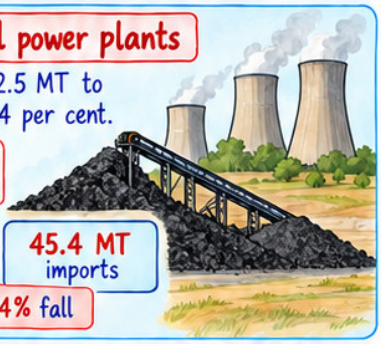
7.9% fall

1,047.52 MT production

Coal for thermal power plants

Imports fell from 62.5 MT to 45.4 MT, about 27.4 per cent.

2024-25 to 2025-26 (PIB, 13 August 2026).



62.5 MT imports → 45.4 MT imports

about 27.4% fall

Coking coal

The Ministry of Coal says coking coal and high-grade thermal coal are in short supply within the country's reserves.

Ministry of Coal, PIB, 27 May 2025.



Suppliers of crude oil

In 2023-24 the top three suppliers of oil to India were Russia, Iraq and Saudi Arabia.

Ministry of Commerce data, as PRS gives it (2023-24).



Coking coal share in resources

Coal is the opposite case to oil: most of it is mined at home, and its imports are falling. The gap is in coking coal, which is only about 9.4 per cent of the Gondwana resources.



9.4% of Gondwana resources (coking coal)

2.8 Why import dependence matters

The import bill

Crude oil makes up 85 per cent of India's petroleum imports by value.

PPAC data, as PRS gives it.



85% of India's petroleum imports (by value)

The current account

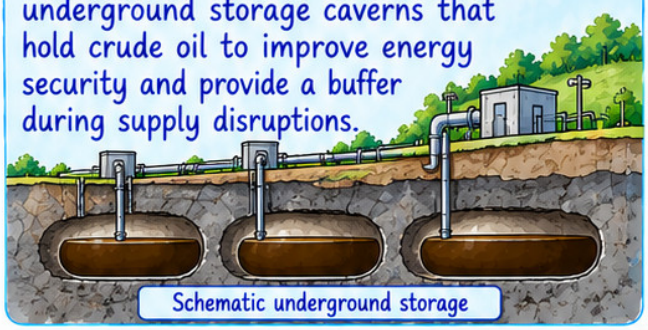
Petroleum, oil and lubricants (POL) are counted under goods in the current account. A larger oil bill widens the merchandise trade deficit and so puts pressure on the current account.

Higher oil import bill
↓
Wider merchandise trade deficit
↓
Pressure on current account

- PPAC is the Petroleum Planning and Analysis Cell of the MoPNG.
- The crude oil figures differ by period and by source. A PRS note also cites a Standing Committee report of December 2023 that put crude oil import dependence at about 85 per cent.

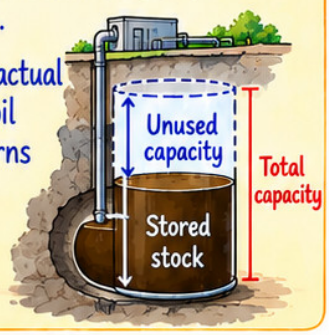
Strategic reserves: capacity is not stored stock

Strategic petroleum reserves are underground storage caverns that hold crude oil to improve energy security and provide a buffer during supply disruptions.



Capacity is the maximum amount that can be stored.

Stored stock is the actual quantity of crude oil present in the caverns at a given time.



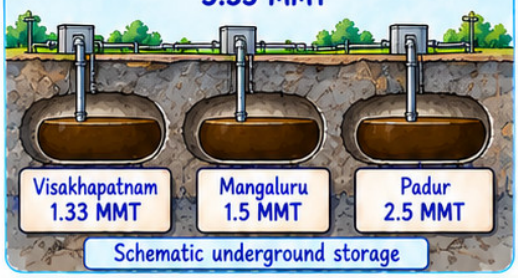
Strategic petroleum reserve facilities in India

Facility	Capacity (MMT of crude oil)	Status
Visakhapatnam	1.33	Built
Mangaluru	1.5	Built
Padur	2.5	Built
Total built	**5.33**	Built through Indian Strategic Petroleum Reserves Limited (ISPRL), a special purpose vehicle.
Chandikhol (Odisha)	4	Approved in July 2021, on the public-private partnership model.
Padur (Karnataka), second facility	2.5	Approved in July 2021, on the same model.

Built, stored and approved capacity

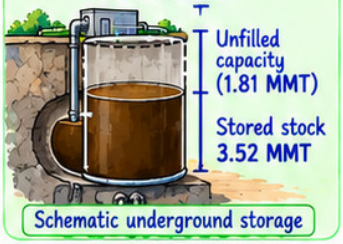
Built facilities (3)

Total capacity
5.33 MMT



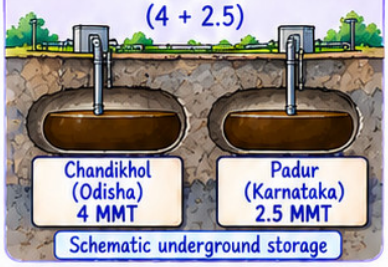
Actual stock in March 2025

Caverns held
3.52 MMT
of crude oil.



Approved additional facilities

Total approved capacity
6.5 MMT
(4 + 2.5)



Built capacity
5.33 MMT

Stored in March 2025
3.52 MMT
(less than capacity)

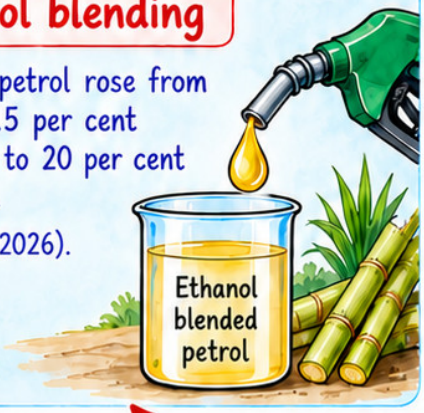
Approved additional capacity
(July 2021)
6.5 MMT

Reducing dependence needs several routes

Measures to reduce dependence

1. Ethanol blending

- Ethanol in petrol rose from less than 1.5 per cent in 2013-14 to 20 per cent in 2025-26. (PIB, 5 July 2026).



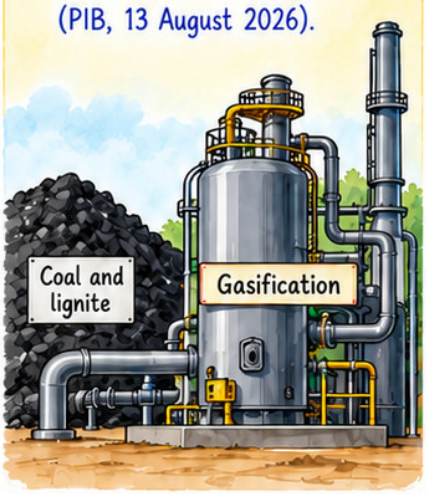
2. Compressed biogas (CBG)

- SATAT scheme (October 2018).
- GOBARdhan, the National Circular Bioenergy Scheme, approved on 6 August 2026 with ₹23,731 crore for 2026-27 to 2035-36. (PIB, 13 August 2026).



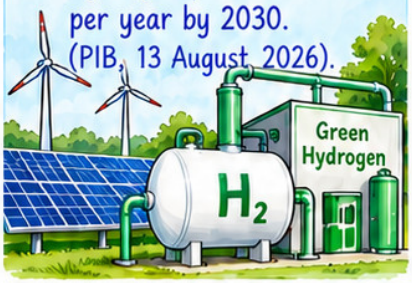
3. Coal gasification

- A target of 100 MT of coal and lignite gasified by 2030.
- A scheme of ₹37,500 crore approved in May 2026. (PIB, 13 August 2026).



4. National Green Hydrogen Mission

- ₹19,744 crore, approved in January 2023.
- Target: 5 MMT of green hydrogen production per year by 2030. (PIB, 13 August 2026).



5. More exploration at home

- "Samudra Manthan", the National Offshore Exploration Programme, approved on 31 July 2026 with ₹84,084 crore. (PIB, 13 August 2026).



Multiple routes strengthen energy security

Use renewable and alternative fuels (Ethanol, CBG, Green Hydrogen) → Convert domestic resources (Coal gasification) → Explore new sources at home (Offshore) → Broader fuel mix reduces import dependence → Stronger and more resilient energy security

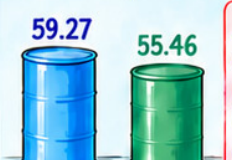
Andhra Pradesh: gas, atomic minerals and a reserve

Energy and mineral resources of Andhra Pradesh

Resource	Where	Figure and date	What to remember
Oil and gas of the KG basin 	The Krishna and Godavari river basins, onshore and offshore.	Estimated onshore reserves, 1 April 2024: **7.69 MMT of crude oil and 59.27 BCM of gas.**	The offshore part of the basin is counted in the **Eastern Offshore (263.34 BCM of gas)**, not in the Andhra Pradesh row.
KG-D6 block 	Deep water of the KG basin.	Operated by **Reliance Industries.**	Its first discoveries were **Dhirubhai-1, 2 and 3.**
Uranium 	YSR Tummalapalle group.	**2,49,459 tonnes** of U_3O_8 (June 2024).	The largest single deposit in the DAE's list; Andhra Pradesh holds **2,52,220 tonnes** in all.
Monazite (thorium) 	Coastal beach sands.	Part of India's **13.07 MT** (2023 reply).	Andhra Pradesh is one of six States with coastal monazite.
Strategic petroleum reserve 	Visakhapatnam.	Capacity: **1.33 MMT**	The smallest of the three built facilities.

Compare Andhra Pradesh's resource categories carefully

Onshore natural gas
(BCM, 1 April 2024)



Andhra Pradesh's onshore gas (59.27 BCM) is larger than Gujarat's (55.46 BCM).

Onshore crude oil
(MMT, 1 April 2024)



Andhra Pradesh's onshore crude oil (7.69 MMT) is much smaller than Gujarat's (118.86 MMT).

Coal

Singareni Collieries is in Telangana, not Andhra Pradesh.

Key points to remember



Andhra Pradesh is strong in **gas** and in **atomic minerals.**



Andhra Pradesh is **weak in coal.**



It has major atomic minerals — **uranium** (YSR Tummalapalle) and **monazite (thorium).**

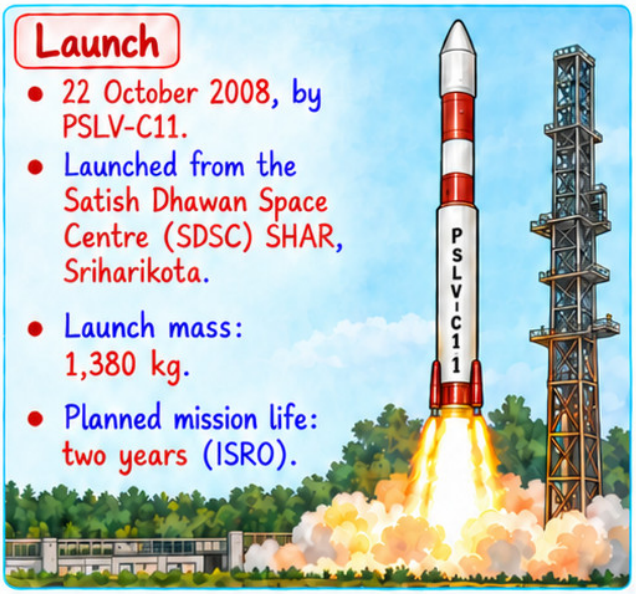


It has onshore oil and gas in the **KG basin** and a **strategic petroleum reserve** at Visakhapatnam.

Chandrayaan-1: an orbiting observatory

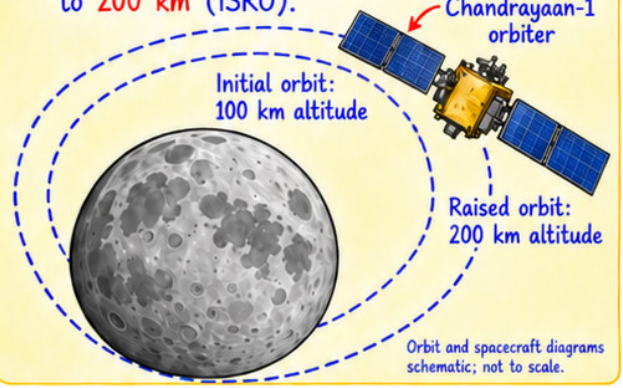
Launch

- 22 October 2008, by PSLV-C11.
- Launched from the Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota.
- Launch mass: 1,380 kg.
- Planned mission life: two years (ISRO).



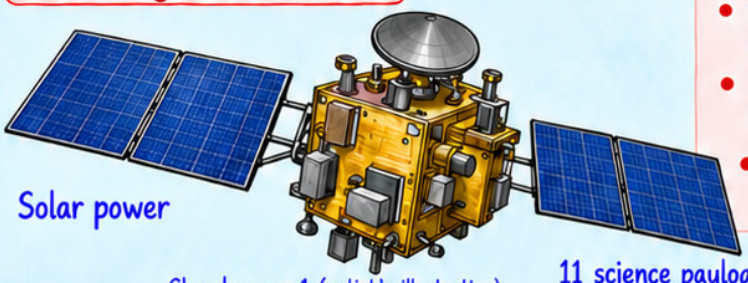
Orbit

- Chandrayaan-1 worked from an orbit 100 km above the lunar surface.
- In May 2009, the orbit was raised to 200 km (ISRO).



Orbit and spacecraft diagrams schematic; not to scale.

Chandrayaan-1 orbiter



Chandrayaan-1 (artist's illustration)

- Carried 11 scientific instruments (payloads) in total.
- Five were from India (ISRO) and six were from foreign space agencies.
- The foreign instruments came from the USA, the UK, Germany, Sweden and Bulgaria.

11 Instruments (Payloads)

Indian instruments (5)

No.	Instrument (Abbreviation)	Main purpose (name)
1	Terrain Mapping Camera (TMC)	Mapping the lunar terrain
2	Hyper Spectral Imager (HySI)	Imaging in multiple wavelengtts to study surface composition
3	Lunar Laser Ranging Instrument (LLRI)	Laser ranging studies of the Moon
4	High Energy X-ray Spectrometer (HEX)	Study of high energy X-rays from the Moon
5	Moon Impact Probe (MIP)	A probe released from the orbiter to study the lunar surface and exosphere

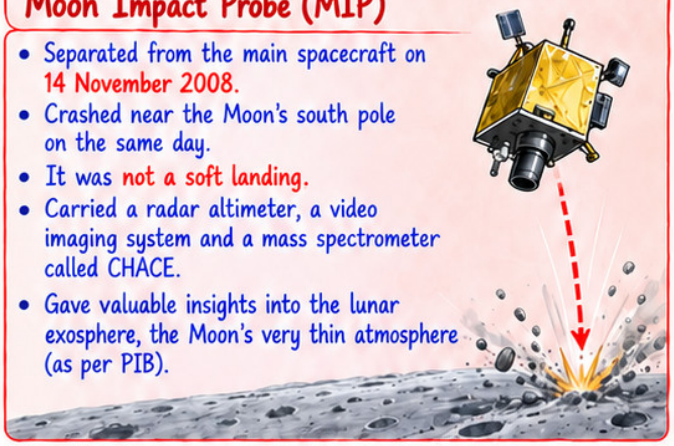
Foreign instruments (6)

No.	Instrument (Abbreviation)	Main purpose (name)
1	Chandrayaan-1 X-ray Spectrometer (CIXS)	Study of X-rays from the Moon
2	Near Infrared Spectrometer (SIR-2)	Near-infrared spectroscopy of the lunar surface
3	Sub keV Atom Reflecting Analyzer (SARA)	Study of energetic neutral atoms around the Moon
4	Miniature Synthetic Aperture Radar (Mini SAR)	Radar imaging of the lunar surface
5	Moon Mineralogy Mapper (M3)	Mapping lunar minerals (NASA instrument)
6	Radiation Dose Monitor (RADOM)	Measurement of radiation dose in lunar orbit

Impact is not a soft landing; water is not a lake

Moon Impact Probe (MIP)

- Separated from the main spacecraft on 14 November 2008.
- Crashed near the Moon's south pole on the same day.
- It was not a soft landing.
- Carried a radar altimeter, a video imaging system and a mass spectrometer called CHACE.
- Gave valuable insights into the lunar exosphere, the Moon's very thin atmosphere (as per PIB).



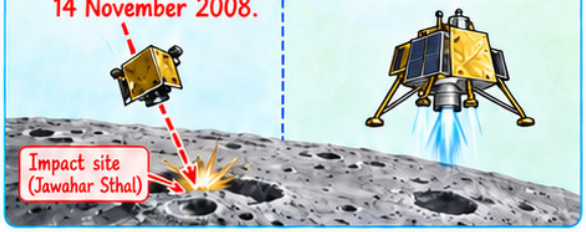
Impact vs Soft landing

MIP : Impact

- Deliberate crash.
- Not a soft landing.
- Crashed near the south pole on 14 November 2008.

Soft landing (comparison)

- Slows down gently.
- Lands intact on surface.
- Designed to operate after landing.



Instruments on MIP

Radar altimeter



Measured altitude above the surface.

Video imaging system



Captured images during the descent and impact.

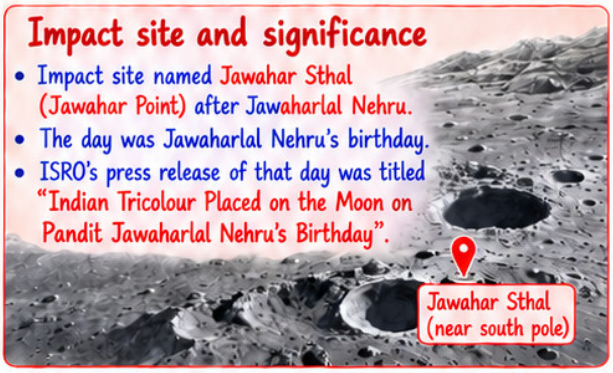
CHACE



Mass spectrometer that studied the lunar exosphere (very thin atmosphere).

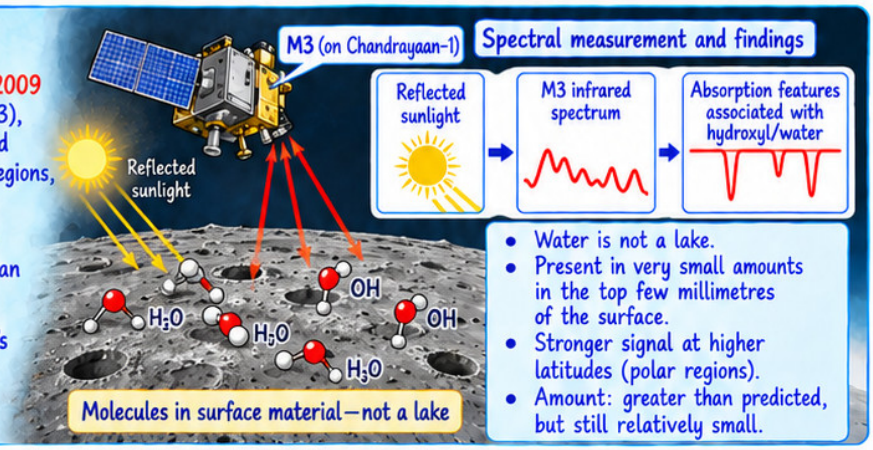
Impact site and significance

- Impact site named Jawahar Sthal (Jawahar Point) after Jawaharlal Nehru.
- The day was Jawaharlal Nehru's birthday.
- ISRO's press release of that day was titled "Indian Tricolour Placed on the Moon on Pandit Jawaharlal Nehru's Birthday".



Water on the Moon

- NASA announced on 24 September 2009 that its Moon Mineralogy Mapper (M3), carried on Chandrayaan-1, had found water molecules in the Moon's polar regions, and hydroxyl in the lunar soil.
- Water was in the top few millimetres of the surface, in amounts "greater than predicted, but still relatively small".
- The signal was stronger at the Moon's higher latitudes.



Confirmation by other missions

Cassini spacecraft



Data from Cassini's VIMS instrument agreed with M3.

EPOXI spacecraft



EPOXI confirmed the findings.

How each body words it

ISRO	Chandrayaan-1 confirmed the presence of water molecules on the Moon.
PIB	Speaks of evidence of water molecules and hydroxyl.
NASA	The instrument that made the observation was NASA's Moon Mineralogy Mapper (M3).

Mission end

- After more than 3,400 orbits, communication was lost on 29 August 2009.
- The mission ended (ISRO).

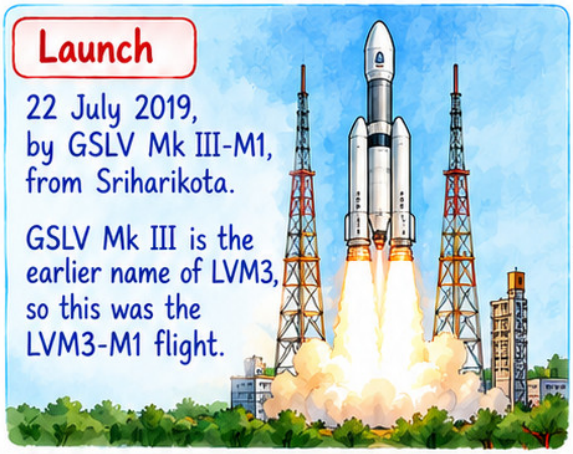


Chandrayaan-2: three parts, different outcomes

Launch

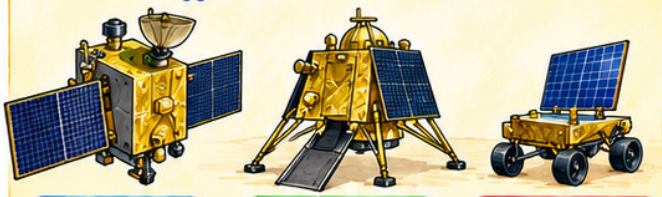
22 July 2019, by GSLV Mk III-M1, from Sriharikota.

GSLV Mk III is the earlier name of LVM3, so this was the LVM3-M1 flight.



Three parts of Chandrayaan-2

Chandrayaan-2 had an orbiter, the Vikram lander and the Pragyan rover.



Orbiter — in lunar orbit (still working)

Vikram lander — attempted landing (lost contact)

Pragyan rover — intended to roam on the Moon

Instruments on board

Orbiter - 8 instruments



1. CLASS
2. XSM
3. DFSAR
4. IIRS
5. ChACE-2
6. TMC-2
7. Dual frequency radio science experiment
8. Orbiter High Resolution Camera

Vikram lander - 4 instruments



1. ILSA
2. ChaSTE
3. RAMBHA-LP
4. Laser retroreflector array

Pragyan rover - 2 instruments

1. LIBS
2. APXS



Vikram: contact lost during descent

Contact with the Vikram lander was lost during the descent, on 7 September 2019 by Indian time (6 September by Universal Time).



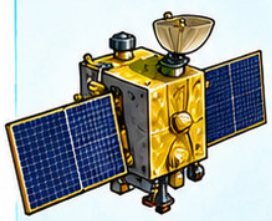
What happened to Vikram

In November 2019 the Government told the Lok Sabha that Vikram had made a hard landing within 500 m of its designated landing site, because the reduction in velocity in the second phase of descent was more than the designed value.

↓

Later estimates from satellite images put the spot about 600 m from the target.

Orbiter: still working



- The Government said in the same reply that all eight orbiter instruments were working.
- The orbiter's life had been extended to seven years, thanks to a precise launch and precise orbital manoeuvres.
- PIB (June 2026) says it works from an altitude of 100 km and has given some of the highest-resolution images of the lunar surface.

Tiranga Point

On 26 August 2023 the Prime Minister announced that the place where the Chandrayaan-2 lander crash-landed would be known as Tiranga Point, a reminder that failure is not the end.



Chandrayaan-3: the successful landing architecture

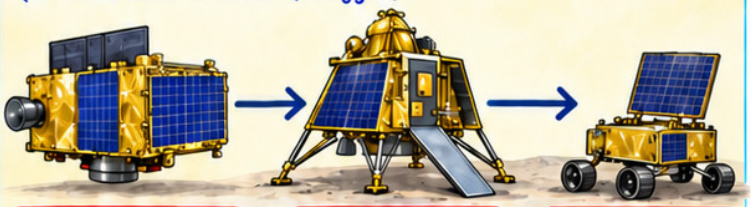
1. Launch



Date: 14 July 2023
Time: 14:35 IST
Vehicle: LVM3-M4
From: Second Launch Pad, SDSC SHAR.

2. Three parts of Chandrayaan-3

The mission has a Propulsion Module, a Lander Module (Vikram) and a rover (Pragyan).



- Propulsion Module (1 instrument)
- Lander Module (Vikram) (4 instruments)
- Rover (Pragyan) (2 instruments)

3. Scientific instruments

Lander Module (Vikram) – 4 instruments

- ChaSTE – to measure the thermal properties of the lunar surface near the south pole.
- ILSA – to measure lunar seismic activity.
- RAMBHA-LP – to study the plasma environment near the Moon.
- NASA's laser retroreflector array – for precise distance measurements between the Moon and Earth.



Rover (Pragyan) – 2 instruments

- APXS – to determine the elemental composition of lunar soil and rocks.
- LIBS – to estimate the elemental composition of lunar soil and rocks using laser-induced breakdown spectroscopy.





Propulsion Module – 1 instrument

- SHAPE – Measures spectral and polarimetric properties of Earth from lunar orbit; helps study signatures of habitable planets.



The lander and rover were designed to work for one lunar daylight, about 14 Earth days.

4. Landing on the Moon

Date: 23 August 2023
Time: about 6 p.m. IST (ISRO had announced the powered descent for about 17:45 IST).
Location: near the south pole, at about 69° south.



5. Significance

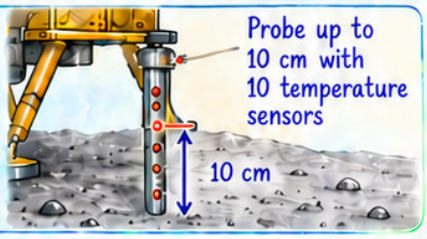
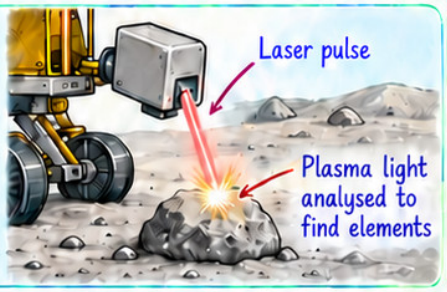
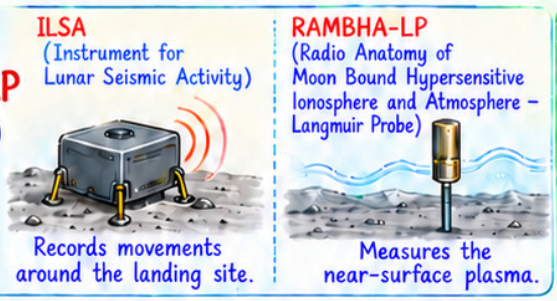
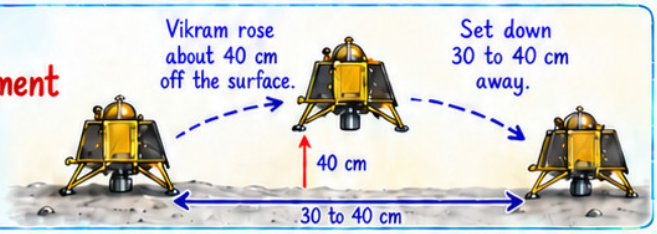
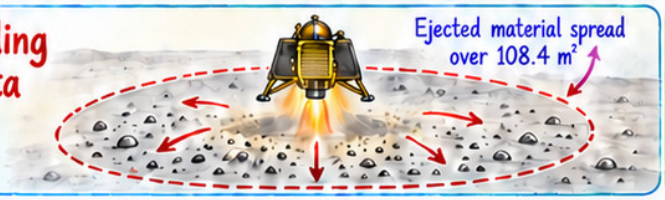
According to PIB, this made India the fourth nation, after the United States, Russia and China, to soft-land on the Moon, and the first country to soft-land near the Moon's south pole.

6. Statio Shiv Shakti

On 26 August 2023, at the ISRO Telemetry Tracking and Command Network (ISTRAC) in Bengaluru, the Prime Minister announced that the place where Vikram and Pragyan landed would be called the Shiv Shakti point (Statio Shiv Shakti), and that 23 August would be celebrated as National Space Day.



What did the instruments actually measure?

Date (2023)	Instrument or event	Finding (ISRO)
27 August	**ChaSTE** (Chandra's Surface Thermophysical Experiment) (on the lander) 	• A probe went up to 10 cm into the soil with 10 temperature sensors and gave the temperature profile of the topsoil. • ISRO calls it the first such profile for the lunar south pole.
28 August	**LIBS** (Laser-Induced Breakdown Spectroscopy) (on the rover) 	• Confirmed sulphur on the surface near the south pole through in-situ measurements, which orbiter instruments could not do. • It also found aluminium, calcium, iron, chromium and titanium, and later manganese, silicon and oxygen.
30 August	**APXS** (Alpha Particle X-ray Spectrometer) (on the rover) 	• Detected minor elements, including sulphur. • ISRO noted that LIBS on the same rover had also confirmed sulphur.
31 August	**ILSA and RAMBHA-LP** (on the lander) 	• ILSA recorded movements around the landing site. • RAMBHA-LP measured the near-surface plasma.
4 September (announced)	**Hop experiment** 	• Vikram rose about 40 cm off the surface and set down 30 to 40 cm away. • The lander and rover were then put in sleep mode.
27 October (report)	**Landing ejecta** 	• About 2.06 tonnes of lunar epiregolith were thrown up and spread over 108.4 m² (NRSC/ISRO).

The mission continued beyond the landing

After the lunar day

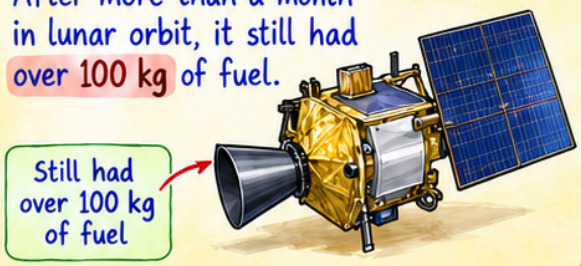
On 22 September 2023 ISRO said efforts to establish communication with the lander and the rover were under way.

In Topic 177, the mission was recorded as not operational.



The Propulsion Module came back

After more than a month in lunar orbit, it still had over 100 kg of fuel.



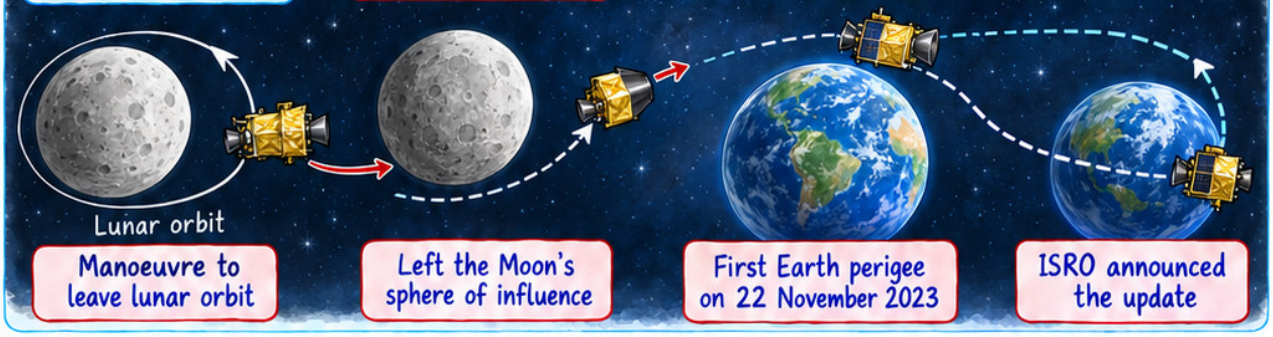
Journey after the lunar mission

13 October 2023
ISRO used the propulsion module to move it out of lunar orbit (manoeuvre).

10 November 2023
The propulsion module left the Moon's sphere of influence.

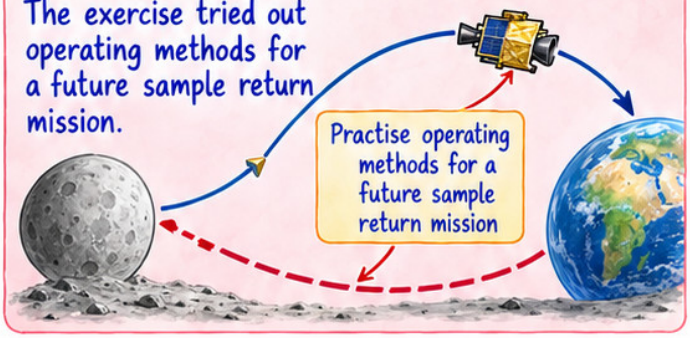
22 November 2023
It passed its first Earth perigee.

4 December 2023
ISRO announced this on 4 December 2023.



Purpose of the exercise

The exercise tried out operating methods for a future sample return mission.

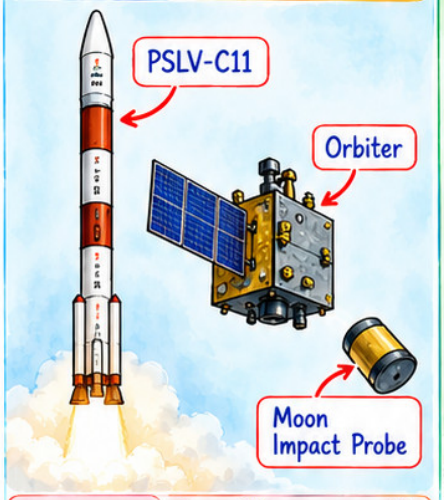
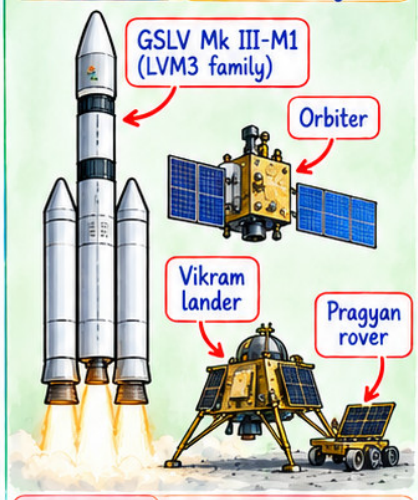
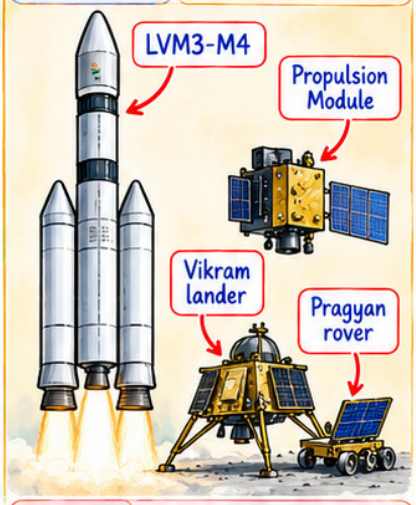
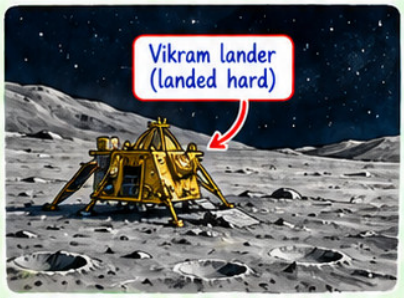
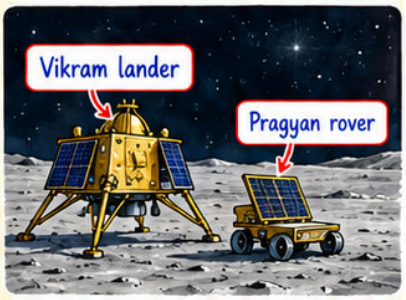


SHAPE kept observing the Earth

The SHAPE payload on the propulsion module continued to observe the Earth during its journey back.



Three missions: compare spacecraft, launcher and result

	Chandrayaan-1	Chandrayaan-2	Chandrayaan-3
Launch date and vehicle	22 October 2008 PSLV-C11	22 July 2019 GSLV Mk III-M1 (LVM3 family)	14 July 2023 LVM3-M4
			
Parts	One orbiting spacecraft, which released the Moon Impact Probe.	Orbiter, Vikram lander, Pragyan rover.	Vikram lander, Pragyan rover, Propulsion Module.
Instruments	11 (five Indian, six foreign)	Eight on the orbiter, four on the lander, two on the rover.	Four on the lander, two on the rover, one on the Propulsion Module.
			
Main result	Water molecules and hydroxyl seen by NASA's M3.	Orbiter still studying the Moon; lander's hard landing.	Soft landing near the south pole on 23 August 2023; sulphur confirmed on the surface.
Point named	Jawahar Sthal (probe's impact site).	Tiranga Point (lander's crash site).	Statio Shiv Shakti (landing site).

Chandrayaan-1 found water molecules and hydroxyl. → **Chandrayaan-2** built on the experience; orbiter continues to study. → **Chandrayaan-3** achieved a successful soft landing near the south pole.

Sample return and polar exploration are planned

What comes next

India is planning the next phase of lunar exploration. Chandrayaan-4 will focus on bringing samples back from the Moon. Chandrayaan-5 (LUPEX) will explore the Moon's polar region with India and Japan working together. These are planned missions, not completed launches.

Chandrayaan-4 (Sample return)

- **Approved:** 18 September 2024 (Union Cabinet).
- **Outlay:** Rs 2,104.06 crore.
- **Objective:** Develop and demonstrate technologies to land on the Moon, collect samples, return to Earth and analyse the samples on Earth.
- **Launch vehicles:** Cost covers two launch vehicle missions of LVM3.
- **Responsibility:** ISRO for spacecraft and the launch, with industry and academia taking part.
- **Target completion:** within 36 months of the approval (PMO release, 18 September 2024).

Timeline for Chandrayaan-4

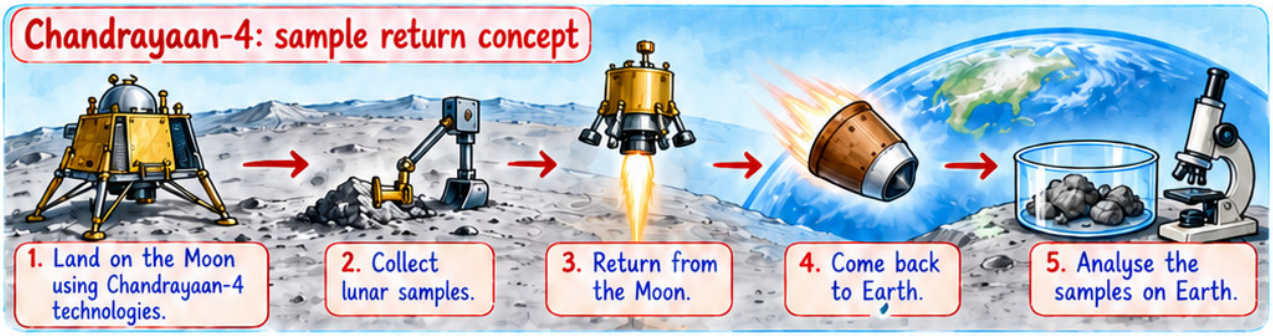
PIB backgrounder (June 2026): planned year 2027.

ISRO (April 2025): indicates 2027-28.

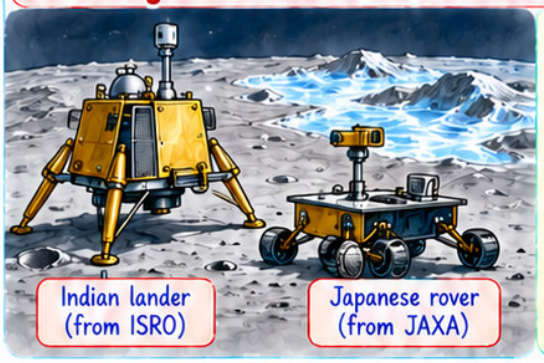
Not a firm date. Mission is planned.



Chandrayaan-4: sample return concept



Chandrayaan-5 / LUPEX (Lunar Polar Exploration)



- **Name:** Chandrayaan-5 / LUPEX (Lunar Polar Exploration) mission.
- **Partners:** India (ISRO) and Japan (JAXA).
- **Configuration:** Indian lander with a Japanese rover.
- **Objective:** Explore the Moon's polar region and search for lunar water and ice.
- **Launch vehicle:** To be launched on Japan's H3 rocket.

Timeline for Chandrayaan-5 / LUPEX

PIB backgrounder (June 2026): 2027-28.

JAXA mission page (checked 30 October 2026): launch no earlier than 2028.

This is a planned mission, not a completed launch.



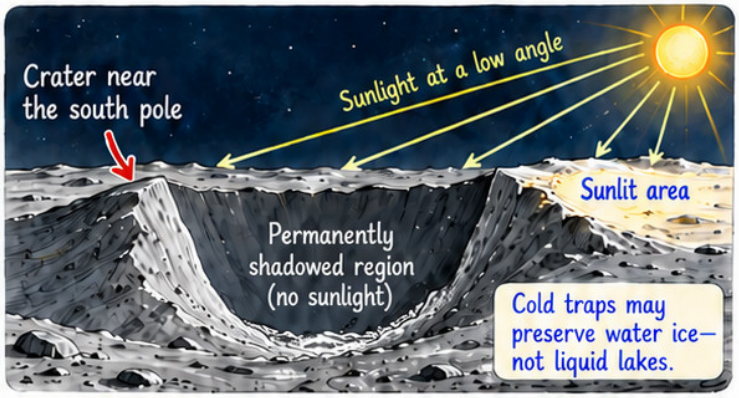
Wider vision for India's space programme

Chandrayaan-4 (sample return)	Chandrayaan-5 / LUPEX (polar exploration)	Bharatiya Antariksh Station	Indian landing on the Moon
Planned year **2027** (PIB June 2026)	No earlier than **2028** (JAXA, checked 30 October 2026)	Target year **2035** (Cabinet note)	Target year **2040** (Cabinet note)

Near the south pole is not at the pole

Why the south pole?

- PIB says LUPEX will explore water and other volatile materials in the **permanently shadowed regions near** the lunar south pole, that is, places where sunlight never falls.
- NASA's M3 had already found the water signal stronger at **higher latitudes.**



National Space Day

23 Aug 2023 — Chandrayaan-3 landed near the lunar south pole on 23 August 2023.

26 Aug 2023 — Government declared 23 August as National Space Day on 26 August 2023.

2024 — First National Space Day was observed in 2024.

2025 — ISRO describes the celebration of 2025, held in New Delhi, as the second National Space Day.



Chandrayaan-3 landed near the south pole on 23 August 2023.

Near the pole ≠ at the pole

Chandrayaan-3 landed at about **69° south latitude.**

The geographic lunar south pole is **90° south.**

Polar exploration investigates cold traps and volatile materials.

69° S — Chandrayaan-3 (about 69° S)

Near the pole (but not at the pole)

90° S — Geographic south pole (90° S)

Latitude (south)

Three common exam traps

1 "India's first landing on the Moon came with Chandrayaan-1."



- Chandrayaan-1 was an **orbiting** mission, not a landing.
- It is remembered for the **evidence of water.**
- The **first Indian soft landing** was Chandrayaan-3's, near the south pole, on 23 August 2023.
- Credit the water finding correctly: the spacecraft was ISRO's, but the instrument that saw the water was NASA's.

2 Mixing up names.

GSLV Mk III-M1 (Chandrayaan-2) and LVM3-M4 (Chandrayaan-3) are the same family of rocket, since LVM3 was earlier called GSLV Mk III.

GSLV Mk III (earlier name) Chandrayaan-2 = LVM3 (same family) Chandrayaan-3

GSLV Mk II is a different launcher.

Chandrayaan-2 and Chandrayaan-3 both had a lander named Vikram and a rover named Pragyan, so always ask "which mission?".

Vikram-S and Vikram-I are different things again: Skyroot's private rockets.

3 Treating planned as done, or an announcement as the first observance.

Chandrayaan-4 — PIB June 2026 plan: 2027 — not a firm date. Not yet launched.

Chandrayaan-5 (LUPEX): Joint mission with Japan. JAXA lists launch no earlier than2028.

23 Aug 2023 — National Space Day was declared in 2023 and first observed in 2024.

Chandrayaan-3 launched on 14 July 2023 → Chandrayaan-3 landed on 23 August 2023

A question on the landing wants the second date.

Decode letters into positions

1. WHAT A LETTER SERIES QUESTION ASKS

- A letter series is a list of terms written in a fixed order by one rule. A term may be one letter (C, F, I, L) or a group of letters (ACE, GIK, MOQ). The rule is not stated; you find it from the terms that are given.
- Three kinds of question are covered here.

Find the next term
The gap is at the end.
C, F, I, L, ...

Find the missing term
The gap is inside the series.
C, F, ?, L

Fill in the blanks
A string of letters with gaps, in which a block of letters repeats.
A_ _ A_ _ A_ _

- Position questions ask for the letter at a given place: counted from either end of the alphabet, counted from a given letter, or counted from either end of a given word.

2. THE POSITION TABLE AND THE REVERSE TABLE

Letter	From A	From Z	Letter	From A	From Z
A	1	26	N	14	13
B	2	25	O	15	12
C	3	24	P	16	11
D	4	23	Q	17	10
E	5	22	R	18	9
F	6	21	S	19	8
G	7	20	T	20	7
H	8	19	U	21	6
I	9	18	V	22	5
J	10	17	W	23	4
K	11	16	X	24	3
L	12	15	Y	25	2
M	13	14	Z	26	1

- In every row the two numbers add up to 27.
- In every row the second letter is 13 places after the first.
- A to M are 1 to 13; N to Z are 14 to 26.
- The opposite of a letter in one half is always in the other half.

3. THE EJOTY PATTERN

E, J, O, T, Y are five letters 5 places apart.

E	J	O	T	Y
5	10	15	20	25
	+5	+5	+5	+5

Count from the nearest of these five.
R is two places before T.
T = 20, so R = 20 − 2 = 18.

4. OPPOSITE LETTERS ADD UP TO 27

The opposite of a letter is the letter at 27 minus its position.

Opposite position = 27 − position

Opposite of H:
H = 8, so opposite = 27 − 8 = 19, which is S.

Opposite of Q:
Q = 17, so opposite = 27 − 17 = 10, which is J.

Opposite pairs

A–Z B–Y C–X D–W E–V F–U G–T
H–S I–R J–Q K–P L–O M–N

5. TWO HALVES OF THE ALPHABET

First half: A to M
Positions 1 to 13

A	B	C	D	E	F	G	H	I	J	K	L	M
1	2	3	4	5	6	7	8	9	10	11	12	13

Second half: N to Z
Positions 14 to 26

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
14	15	16	17	18	19	20	21	22	23	24	25	26

The opposite of a letter in one half is always in the other half.
M and N are the two neighbours in the middle.

6. WORKED EXAMPLES ON LETTER SERIES

1 Find the next term (one letter)
The letters increase by 3 positions each time.

C	F	I	L	?
3	6	9	12	15
	+3	+3	+3	+3

15 corresponds to O. Next term = O.

2 Find the missing term (one letter)
The letters decrease by 2 positions each time.

Q	O	M	?	I
17	15	13	11	9
	−2	−2	−2	−2

11 corresponds to K. Missing term = K.

3 Find the next term (group of letters)
Each term consists of three letters increasing by 2 positions.

ACE	GIK	MOQ	?
1 3 5	7 9 11	13 15 17	19 21 23
	+6	+6	+6

Next term = SUW.

4 Going round the alphabet
Add or subtract and wrap with 26.

Forward 4 from X:
X = 24
24 + 4 = 28
28 − 26 = 2
which is B.

Back 4 from C:
C = 3
3 − 4 = −1
−1 + 26 = 25
which is Y.

Wrap with 26; find opposite positions with 27 − p.

From the end or to the side?

1 THE ALPHABET AND ITS POSITIONS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

Left end is A ← To the left (towards A) | To the right (towards Z) → Right end is Z

2 USEFUL FORMULAS WITH THE ALPHABET (A TO Z)

What is asked	Formula	Worked example
The kth letter from the left of the alphabet	The letter at position k.	18th from the left: position 18 is **R**.
The kth letter from the right of the alphabet	The letter at position $27 - k$.	18th from the right: $27 - 18 = 9$, position 9 is **I**.
The kth letter to the right of a letter at position p	The letter at position $p + k$.	4th to the right of K (11): $11 + 4 = 15$, position 15 is **O**.
The kth letter to the left of a letter at position p	The letter at position $p - k$.	4th to the left of K (11): $11 - 4 = 7$, position 7 is **G**.
The kth letter from the right in a word of n letters	The letter at position $n + 1 - k$ (from the left).	In PLANET (6 letters), 2nd from the right: $6 + 1 - 2 = 5$th from the left, position 5 is **E**.

3 WORKED EXAMPLES

a 18th letter from the left

The 18th letter from the left is the letter at position 18.

P	Q	R	S	T
16	17	18	19	20

So, the 18th letter from the left is **R**.

b 18th letter from the right

Use position $27 - k$.
$27 - 18 = 9$.
The letter at position 9 is **I**.

G	H	I	J	K
7	8	9	10	11

c 4th letter to the right of K

K is at position 11. Use $p + k$.
$11 + 4 = 15$.
The letter at position 15 is **O**.

M	N	O	P	Q
13	14	15	16	17

d 4th letter to the left of K

K is at position 11. Use $p - k$.
$11 - 4 = 7$.
The letter at position 7 is **G**.

E	F	G	H	I
5	6	7	8	9

4 POSITION IN A WORD

2nd letter from the right in PLANET

The word PLANET has 6 letters.
Use position $n + 1 - k$.
$n = 6$, $k = 2$
$6 + 1 - 2 = 5$.
The 2nd letter from the right is the 5th from the left.

P	L	A	N	E	T
1	2	3	4	5	6

So, the 2nd letter from the right in PLANET is **E**.

5 IMPORTANT POINTS

1 Count steps, not letters.

The letter you start from is not counted.
The 1st letter to the right of K is L.

1st	2nd	3rd	4th	
K	L	M	N	O
11	12	13	14	15

2 Work inside out.

Find the 5th letter to the left of the 9th letter from the right.

First: 9th from the right → $27 - 9 = 18$ (R).
Then: 5th to the left → $18 - 5 = 13$ (M).
So, the required letter is **M**.

3 Use 27 for the alphabet, $n + 1$ for a word.

The number 27 belongs to the alphabet only, because it has 26 letters.
For a word or string of n letters, use $n + 1$.

6 ADDING TO $n + 1$

A letter's position from the left and from the right of a string always add up to $n + 1$.

If a letter is 4th from the left and 9th from the right, then the string has $4 + 9 - 1 = 12$ letters.

7 REPEATING PATTERNS

The string abcc is repeated four times.

a	b	c	c	a	b	c	c	a	b	c	c	a	b	c	c
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Position 1 → a Position 10 → b
Position 5 → a Position 15 → c

Recognise the pattern, then check every term

1. THE LETTER POSITIONS

A	B	C	D	E	F	G	H	I	J	K	L	M
1	2	3	4	5	6	7	8	9	10	11	12	13

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
14	15	16	17	18	19	20	21	22	23	24	25	26

The position of a letter is its place in the alphabet. The opposite letter has position 27 minus the position.

A ⇔ Z, B ⇔ Y, C ⇔ X, ...
A + Z = 27, B + Y = 27, ...

2. KINDS OF LETTER SERIES (with worked examples)

1 Equal steps forward

Every step is the same number of places towards Z.

C, F, I, L, ? (+3)

+3 +3 +3 +3

C	F	I	L	O
3	6	9	12	15

Each step is +3, so the next letter is O (15).

2 Equal steps backward

Every step is the same number of places towards A.

Z, W, T, ? (−3)

−3 −3 −3

Z	W	T	Q
26	23	20	17

Each step is −3, so the next letter is Q (17).

3 Increasing steps

The step grows by the same amount each time.

A, C, F, J, ?

+2 +3 +4 +5

A	C	F	J	O
1	3	6	10	15

The steps are +2, +3, +4, +5. So the next letter is O (15).

4 Alternate series

Two series are written by turns: one on the odd places, the other on the even places.

A, M, C, N, E, ?

Odd places: A, C, E (+2, +2)

Even places: M, N, ? (+1, +1)

The next even-place letter after N is O.

5 Letter groups

Each group is made by one rule; the groups change from one to the next by another rule.

ABC, BCD, CDE, ?

ABC	BCD	CDE	DEF
1 2 3	2 3 4	3 4 5	4 5 6

- Inside each group: consecutive letters (+1, +1).
- From group to group: first letter moves +1. So the next group is DEF.

6 Pairs moving in opposite directions

The first letter moves forward, the second moves backward.

AZ, BY, CX, ?

A	Z	B	Y	C	X	D	W
1	26	2	25	3	24	4	23

- First letters: A, B, C, D, (each +1).
- Second letters: Z, Y, X, W (each −1).

Each pair adds up to 27. So the next pair is **DW**.

7 Skips by squares or primes

The positions are squares (1, 4, 9, 16, 25) or primes (2, 3, 5, 7, 11, 13).

A, D, I, P, ? (squares)

A	D	I	P	Y
1	4	9	16	25

+3 +5 +7 +9

These are square positions. The differences are 3, 5, 7, 9 (odd numbers rising by 2). So the next letter is Y (25).

8 Repeating pattern with blanks

A block of letters repeats; you fill the gaps so that the block repeats exactly.

a _ c a _ c a b _ a b _ (block abc)

a	b	c	a	b	c	a	b	c	a	b	c
1	2	3	4	5	6	7	8	9	10	11	12

Here the block is **abc** (length 3).

The completed 12-letter string is

abc	abc	abc	abc

Check the entire repeated block.

Going round the alphabet

In a forward series, if the position passes 26, subtract 26.

X + 4 = 28, and 28 − 26 = 2, so the letter is **B**.

In a backward series, if the position falls below 1, add 26.

C − 4 = −1, and −1 + 26 = 25, so the letter is **Y**.

3. THE METHOD IN FOUR STEPS

1 Write the positions.

Put the position under every letter. For letter groups, write the positions of each group.

C	F	I	L
3	6	9	12

2 Find the differences.

Subtract each position from the next. If the differences show no pattern, look at the odd places and the even places separately, test the sum of 27, and test squares and primes.

C	F	I	L
3	6	9	12

+3 +3 +3

3 State the rule and check every term.

The rule must fit every given term, not only the first two or three.

Rule: each step is +3.

Check: 3 → 6 → 9 → 12 (all +3).

4 Apply the rule and go round where needed.

Then check the answer against the rule once more, and check the letters near A and Z.

C	F	I	L	O
3	6	9	12	15

+3 +3 +3 +3

Next letter is O (15). Check: 12 + 3 = 15.

Equal steps and increasing steps

1. EQUAL STEPS, WITH GOING ROUND

In some analogies, each term is obtained by moving the same number of steps forward in the alphabet. After Z, we go round and continue from A.

Alphabet positions (reminder)

A	B	C	D	E	F	G	H	I	J	K	L	M
1	2	3	4	5	6	7	8	9	10	11	12	13

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
14	15	16	17	18	19	20	21	22	23	24	25	26

WORKED EXAMPLE 1: P, T, X, ?, F

The letters P, T, X, ?, F are in a sequence with the same step each time.
The positions of the given letters are:

P	+4	T	+4	X	+4	?	+4	F
16		20		24		28		6

Each step is +4.
From X (24), the next position is 24 + 4 = 28.
Since there are 26 letters, we go round: 28 − 26 = 2.
Position 2 corresponds to the letter B.
Check the next step: 2 + 4 = 6, which is F. So the missing term is B.

Thus the completed sequence with positions is:

P	T	X	B	F
16	20	24	2	6

2. INCREASING STEPS

In some analogies, the amount added increases by 1 at each step.
The differences form an increasing sequence: +1, +2, +3, +4, ...

WORKED EXAMPLE 2: A, B, D, G, K, ?

The letters A, B, D, G, K, ? are in a sequence with increasing steps.
The positions of the given letters are:

A	+1	B	+2	D	+3	G	+4	K	+5	?
1		2		4		7		11		16

The differences between consecutive terms are:
+1 (1 to 2), +2 (2 to 4), +3 (4 to 7), +4 (7 to 11).
So the next step is +5.
11 + 5 = 16, and position 16 corresponds to the letter P.
Hence the missing term is P.

Thus the completed sequence with positions is:

A	B	D	G	K	P
1	2	4	7	11	16

3. REPEATING PATTERN: A B C C A B C C A B C C A B C C

The block A B C C is repeated again and again.
Each block has 4 letters. The positions are:

A	B	C	C	A	B	C	C	A	B	C	C	A	B	C	C
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Required positions:
- Position 1 → A
- Position 5 → A
- Position 10 → B
- Position 15 → C

Split alternating and grouped series

1. ALPHABET NUMERICAL VALUES

Write the position of each letter in the English alphabet.

A	B	C	D	E	F	G	H	I	J	K	L	M
1	2	3	4	5	6	7	8	9	10	11	12	13

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
14	15	16	17	18	19	20	21	22	23	24	25	26

The reverse value can be found using 27 − (position).

Letter	Position	Reverse value (27 − position)
A	1	26 (Z)
B	2	25 (Y)
C	3	24 (X)
⋮	⋮	⋮
Z	26	1 (A)

2. ALTERNATE SERIES (SPLIT INTO TWO SERIES)

Example 1 B, Z, D, X, F, V, ?

1st	2nd	3rd	4th	5th	6th	7th
B (2)	Z (26)	D (4)	X (24)	F (6)	V (22)	? (?)

Odd positions (1st, 3rd, 5th, ...)

B (2) →+2→ D (4) →+2→ F (6)

The letters in odd places increase by 2 each step.

Even positions (2nd, 4th, 6th, ...)

Z (26) →−2→ X (24) →−2→ V (22)

The letters in even places decrease by 2 each step.

The 7th term is at an odd position, so it continues the odd-position rule.
6 + 2 = 8, which corresponds to the letter H.

7th term = H

3. LETTER GROUPS (GROUPED SERIES)

Example 2 ACE, GIK, MOQ, ?

Step 1: Find the pattern inside each group.
In each group the letters are 2 places apart.

A	C	E		G	I	K		M	O	Q
1	3	5		7	9	11		13	15	17
+2	+2			+2	+2			+2	+2	

Step 2: Find how the groups change.
Look at the first letter of each group:

A (1) →+6→ G (7) →+6→ M (13) →+6→ S (19)

The first letter increases by 6 each time.
So the next group starts with S (19).

Step 3: Write the next group.
Starting with S (19), the next two letters are 2 places apart:

S (19) →+2→ U (21) →+2→ W (23)

Next group = SUW

Opposite pairs and backward squares

LETTER POSITIONS AND OPPOSITES

The letters A to Z are numbered from 1 to 26.

A	B	C	D	E	F	G	H	I	J	K	L	M
1	2	3	4	5	6	7	8	9	10	11	12	13

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
14	15	16	17	18	19	20	21	22	23	24	25	26

Opposite letters are symmetrical about the middle of the alphabet. Their positions add to 27.

If a letter is at position n, its opposite is at position 27 − n.

A (1) ↔ Z (26) 1 + 26 = 27
B (2) ↔ Y (25) 2 + 25 = 27
C (3) ↔ X (24) 3 + 24 = 27
D (4) ↔ W (23) 4 + 23 = 27

DRILL 5 : Pairs moving in opposite directions

BY , DW , FU , ?

Each pair consists of two letters. The first letters move forward by 2 positions (2, 4, 6, ...) and the second letters move backward by 2 positions (25, 23, 21, ...).

Step 1 : Write the positions

Pair	1st letter		2nd letter	
	Letter	Position	Letter	Position
BY	B	2	Y	25
DW	D	4	W	23
FU	F	6	U	21

Step 2 : Find the next pair

First letters : +2
6 + 2 = 8
Position 8 is **H**.

Second letters : − 2
21 − 2 = 19
Position 19 is **S**.

So the next pair is **H S**

Step 3 : Check the opposite property

8 + 19 = 27, so H and S are opposite letters, just like every other pair.

DRILL 6 : Squares, backward

Y , P , I , D , ?

The letters correspond to perfect squares taken in reverse order.

Step 1 : Write the positions and squares

Letter	Y	P	I	D
Position	25	16	9	4
Square	5^2	4^2	3^2	2^2

Step 2 : Find the next term

The next square is $1^2 = 1$.
Position 1 is **A**.

So the next letter is **A**

Step 3 : Check using differences

Differences between positions:
25 − 16 = 9, 16 − 9 = 7, 9 − 4 = 5.
The differences are −9, −7, −5, so the next difference is −3.
Hence 4 − 3 = 1, which is the position of A.

Repeating blocks and word positions

WORKED EXAMPLE 1 : Repeating pattern with blanks

Fill the blanks in the following repeating pattern.

_ b c c _ b c c a _ c c a b _ c

The string is formed by repeating the same block of letters. Find the missing letters by identifying the block and using the positions of the blanks.

Step 1 Find the repeating block

The string has 16 places. Try the block **abcc**, which is 4 letters long.

a b c c	a b c c	a b c c	a b c c
1 – 4	5 – 8	9 – 12	13 – 16

Step 2 Locate the blanks

The blanks are at the 1st, 5th, 10th and 15th places. In the repeated block these positions contain:

Position	Which block	Letter
1	1st place of abcc	a
5	1st place of abcc	a
10	2nd place of abcc	b
15	3rd place of abcc	c

Step 3 Write the completed string

Filling the blanks with **a**, **a**, **b** and **c** gives

a	b	c	c	a	b	c	c	a	b	c	c	a	b	c	c
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

This is the block **abcc** repeated four times.

Check

The completed string is **abcc abcc abcc abcc**, exactly the same block repeated four times. Each of the other possible fills would break the repeating block at least once, so the only completion is the one above.

WORKED EXAMPLE 2 : Position in a word and in the alphabet

(i) In the word EXAMINATION, which letter is the 4th from the right?

Step 1 Write the letters with positions from the left.

1	2	3	4	5	6	7	8	9	10	11
E	X	A	M	I	N	A	T	I	O	N

Step 2 Convert to a left position.

EXAMINATION has 11 letters. The 4th from the right is the (11 + 1 – 4) = 8th from the left. The 8th letter is **T**.

Answer: T

(ii) Which letter of the alphabet is the 7th to the right of the 15th letter from the left?

Step 1 Write the alphabet with positions.

Letter	A	B	C	D	E	F	G	H	I	J	K	L	M
Position	1	2	3	4	5	6	7	8	9	10	11	12	13

Letter	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Position	14	15	16	17	18	19	20	21	22	23	24	25	26

Step 2 Find the required position.

The 15th letter from the left is **O**. Moving 7 letters to the right gives position 15 + 7 = 22. The 22nd letter is **V**.

Answer: V

Reverse position rule

The position from the right is 27 minus the position from the left. For example, 1st from right = 26th from left, 2nd from right = 25th from left, and so on.

Right position = 27 – Left position

Three traps that shift the answer

LETTER POSITIONS RECAP

A	B	C	D	E	F	G	H	I	J	K	L	M
1	2	3	4	5	6	7	8	9	10	11	12	13

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
14	15	16	17	18	19	20	21	22	23	24	25	26

Reverse position

B is 2nd from the left and 25th from the right: 27 − 2 = 25.
Its opposite letter is Y, at position 25 from the LEFT.

COMMON SLIPS IN SHORT

Slip	What goes wrong	Correct way
26 minus instead of 27 minus	The opposite of B is wrongly taken as X at 24.	Opposite position = 27 − 2 = 25, so opposite letter is Y.
Subtracting 27 when going round	Z + 2 is taken as 28 − 27 = 1 (A).	After Z comes A, then B. So 28 − 26 = 2, which is B.
"From the right" mixed with "to the right"	The 3rd from the right is taken as 3 (C).	Use 27 − 3 = 24. So the 3rd from the right is 24 (X).
27 used for a word	In a word of 8 letters, 3rd from the right is taken as 27 − 3.	For a word of 8 letters use 8 + 1 − 3 = 6. So it is the 6th from the left.
A blank-filling series cut into wrong blocks	The blanks are filled so that a short block repeats only in part.	Find the block length first, then check the whole string.

THREE COMMON EXAM TRAPS

1 Counting the starting letter

"The 5th letter to the right of H"

Start from H and move five places to the right. Do not count H itself.

H is at position 8.
Move 5 places: I, J, K, L, M.
8 + 5 = 13.
Position 13 is M.

2 Reading two series as one

In D, W, F, U, H, S, ?
the differences jump about.

Take the terms by turns.

Odd places:
D, F, H, ...
4 → 6 → 8
+2 +2
Next is 10, which is J.

Even places:
W, U, S, ...
23 → 21 → 19
−2 −2
Next would be 17 (Q).

So the next term in the original series is J.

3 Fixing the rule from the first few terms

A, B, D, ? fits two rules.

Rule 1: +1, +2, so +3 next.

A	B	D	G
1	2	4	7
	+1	+2	+3

Rule 2: positions double.

A	B	D	H
1	2	4	8
	×2	×2	×2

Both rules fit the first three terms. Only a fourth term decides, so test the rule on every term that is given before you choose.

The mean balances the deviations

1. WHAT WE ALREADY HAVE

Mean of a set of values

$$\text{Mean} = \frac{\text{sum of all the values}}{\text{number of values}}$$

Sum = mean × number of values.

Average speed

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

It is not the simple average of the speeds.

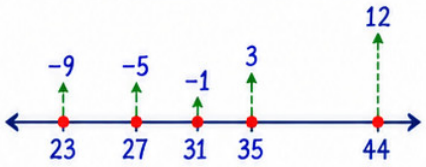
2. THE SUM OF THE DEVIATIONS IS ZERO

The deviation of a value from a number a is value − a. The sum of the deviations of all the values from their mean is zero.

Example: 23, 27, 31, 35, 44
Sum = 23 + 27 + 31 + 35 + 44 = 160
Mean = 160 ÷ 5 = 32

Value	23	27	31	35	44
Deviation from 32	23 − 32 = −9	27 − 32 = −5	31 − 32 = −1	35 − 32 = 3	44 − 32 = 12
Sum of deviations	−9 − 5 − 1 + 3 + 12 = 0				

Deviations shown on a number line



3. EFFECTS OF CHANGING EVERY VALUE

Adding k to every value

If each value is increased by k, the mean also increases by k.

Add 5 to 23, 27, 31, 35, 44:

23 → 28, 27 → 32, 31 → 36, 35 → 40, 44 → 49

New sum = 28 + 32 + 36 + 40 + 49 = 185

New mean = 185 ÷ 5 = 37 = 32 + 5

Multiplying every value by k

If each value is multiplied by k, the mean also becomes k times the mean.

Multiply by 3:

23 → 69, 27 → 81, 31 → 93, 35 → 105, 44 → 132

New sum = 69 + 81 + 93 + 105 + 132 = 480

New mean = 480 ÷ 5 = 96 = 3 × 32

Subtracting or dividing

Subtracting k from every value lowers the mean by k.

Dividing every value by k (k not zero) divides the mean by k. These are the same rules used the other way round.

Subtract 5: new mean = 32 − 5 = 27

Divide by 3: new mean = $32 \div 3 = \frac{32}{3}$

4. SUMMARY TABLE

Change made to every value	Effect on the mean	Check with 23, 27, 31, 35, 44 (mean 32)
Nothing; deviations from the mean are taken	The deviations add up to 0	−9 − 5 − 1 + 3 + 12 = 0
k is added	The mean rises by k	Add 5: new mean 37
Multiplied by k	The mean becomes k times	Multiply by 3: new mean 96

5. THE DEVIATION METHOD

The mean of the deviations from a number a is (mean − a). Hence

mean = a + (mean of the deviations)

Example: 23, 27, 31, 35, 44
Take a = 30 (convenient number).

Value	23	27	31	35	44
Deviation from 30	−7	−3	1	5	14

Mean of deviations = (−7 − 3 + 1 + 5 + 14) ÷ 5 = 10 ÷ 5 = 2

Mean = 30 + 2 = 32

Works for any a

If we take a = 32 (the mean), the deviations are −9, −5, −1, 3, 12 and their mean is 0. So mean = 32 + 0 = 32.

Large numbers, small deviations

KEY IDEA : ASSUMED-MEAN (DEVIATION) METHOD

- Choose a convenient number a, the assumed mean, near the middle of the data. A is usually taken as one of the class marks or a value close to the centre.
- Find each deviation $d = x - a$ for every value x.
- Add all the deviations. Then

$$\text{Mean} = a + \frac{\text{sum of the deviations}}{\text{number of values}}$$

Why it helps?

- When the numbers are large and close to each other, the deviations are small, so calculations become easier.
- The mean obtained is exactly the same as with the usual method.

WORKED EXAMPLE : RAW DATA

Find the mean of 2,486, 2,512, 2,495, 2,508 and 2,519 using the assumed-mean method. Take $a = 2{,}500$.

Value x	Deviation $d = x - 2{,}500$	Calculation
2,486	2,486 − 2,500 = −14	−14
2,512	2,512 − 2,500 = 12	12
2,495	2,495 − 2,500 = −5	−5
2,508	2,508 − 2,500 = 8	8
2,519	2,519 − 2,500 = 19	19
	Sum of deviations Σd	20

Steps to find the mean

1. Choose $a = 2{,}500$ (near the middle of the data).
2. Find all deviations $d = x - 2{,}500$.
3. Add the deviations: $\Sigma d = 20$.
4. $$\text{Mean} = a + \frac{\Sigma d}{n}$$
$$= 2{,}500 + \frac{20}{5}$$
$$= 2{,}500 + 4$$
$$= 2{,}504$$

EXAMPLE : FREQUENCY DISTRIBUTION

Find the mean of the following data using the assumed-mean method. Take $a = 50$.

Value x	Frequency f	Deviation $d = x - 50$	fd
40	3	−10	−30
45	5	−5	−25
50	8	0	0
55	6	5	30
60	4	10	40
	$\Sigma f = 26$		$\Sigma fd = 15$

Steps and calculation

1. Choose $a = 50$.
2. Find $d = x - 50$ and then fd for each value.
3. Add to get $\Sigma f = 26$ and $\Sigma fd = 15$.
4. $$\text{Mean} = a + \frac{\Sigma fd}{\Sigma f}$$
$$= 50 + \frac{15}{26}$$
$$= 50 + 0.5769\ldots$$
$$= 50.5769\ldots \approx 50.58$$

Frequency means count people — not rows

KEY IDEA

For a frequency table the formula is

$$\text{Mean} = a + \frac{\Sigma fd}{\Sigma f}$$

- a is any chosen value (usually a class mark).
- f is the frequency (count of people).
- $d = x - a$ (deviation from a).
- Σ means "the sum of".
- Σf is the total frequency.

WORKED EXAMPLE 1 Daily wages of 40 workers

Daily wage x (rupees)	Workers f	$d = x - 700$	$f \times d$
600	5	−100	−500
650	9	−50	−450
700	12	0	0
750	8	50	400
800	6	100	600
Total	40		50

$$\text{Mean} = 700 + \frac{50}{40} = 700 + 1.25 = \underline{701.25} \text{ rupees.}$$

CHECK BY DIRECT METHOD

Find the total of $f \times x$ and divide by the total frequency 40.

x (rupees)	f	$f \times x$
600	5	3,000
650	9	5,850
700	12	8,400
750	8	6,000
800	6	4,800
Total	40	28,050

$$\text{Mean} = \frac{\text{total of } f \times x}{\text{total frequency}} = \frac{28{,}050}{40}$$
$$= \underline{701.25} \text{ rupees.}$$

Both methods give the same mean: 701.25 rupees.

Any number can serve as a

Take $a = 600$ (first class mark) and get the same mean.
Then $d = x - 600$.
Here $\Sigma fd = 4050$ and $\Sigma f = 40$.
$\text{Mean} = 600 + \frac{4050}{40} = 600 + 101.25 = \mathbf{701.25}$ rupees.
A value near the centre only keeps the deviations small.

THREE COMMON MISTAKES (AND HOW TO AVOID THEM)

1 Forgetting to add a back

Wrong: $\text{Mean} = \frac{\Sigma fd}{\Sigma f} = \frac{50}{40}$
$= 1.25$ (missing a).

Correct: $\text{Mean} = 700 + \frac{50}{40}$
$= \underline{701.25}$ rupees.

2 Dividing by number of rows

Wrong: $50 \div 5 = 10$
(using 5 rows).

Correct: divide by total frequency 40.
$\text{Mean} = 700 + \frac{50}{40} = \underline{701.25}$.

3 Losing a minus sign

If -50 is written as $+50$, then Σfd becomes
$-500 + 450 + 0 + 400 + 600$
$= 950$ (wrong).

Keep the $-$ sign.
Correct $\Sigma fd = 50$.

Step-deviation and grouped estimates

1. Step-deviation method in a line

When all the deviations have a common factor h, take $u = (x - a) \div h$.

$$\text{Mean} = a + h \times (\Sigma fu \div \Sigma f)$$

Here, a is an assumed mean, h is the common factor, u is the step-deviation, f is the frequency.

2. Worked example : Wages of workers

Wages (x) ₹	Frequency f	$d = x - 700$	$u = d \div 50$	fu
600	5	−100	−2	−10
650	9	−50	−1	−9
700	12	0	0	0
750	8	50	1	8
800	6	100	2	12
Total	**40**			**1**

Here $a = 700$, $h = 50$. $\Sigma f = 40$, $\Sigma fu = 1$.

$$\text{Mean} = 700 + 50 \times (1 \div 40) = 700 + 1.25 = 701.25$$

Do not forget to multiply by h.

3. Grouped data and class mark

When data are grouped into class intervals, each class interval is represented by its class mark, the average of its upper and lower limits.

$$\text{Class mark} = (\text{Lower limit} + \text{Upper limit}) \div 2$$

For example, the class mark of 10 – 25 is $(10 + 25) \div 2 = 17.5$.

The frequency of each class is assumed to be centred at its class mark.

4. Worked example : Marks of 30 students

Class interval	Class mark x	Frequency f	$d = x - 47.5$	$u = d \div 15$	fd	fu
10 – 25	17.5	2	−30	−2	−60	−4
25 – 40	32.5	3	−15	−1	−45	−3
40 – 55	47.5	6	0	0	0	0
55 – 70	62.5	8	15	1	120	8
70 – 85	77.5	6	30	2	180	12
85 – 100	92.5	5	45	3	225	15
Total		**30**			**435**	**29**

(i) Direct method

$$\text{Mean} = \Sigma fx \div \Sigma f = 1860 \div 30 = 62$$

(ii) Assumed mean method

$$\text{Mean} = a + (\Sigma fd \div \Sigma f) = 47.5 + (435 \div 30) = 47.5 + 14.5 = 62$$

(iii) Step-deviation method

$$\text{Mean} = a + h \times (\Sigma fu \div \Sigma f) = 47.5 + 15 \times (29 \div 30) = 47.5 + 14.5 = 62$$

All three methods (direct, assumed mean and step-deviation) give the same mean.
The grouped mean is an approximation because of the class-mark assumption.
For the same 30 marks taken as raw data, the mean is 59.3.

5. Summary of the three methods for grouped data

Method	Formula	Key idea
Direct method	$\text{Mean} = \Sigma fx \div \Sigma f$	Use class marks x and frequencies f directly.
Assumed mean method	$\text{Mean} = a + (\Sigma fd \div \Sigma f)$	Take a convenient assumed mean a and deviations $d = x - a$.
Step-deviation method	$\text{Mean} = a + h \times (\Sigma fu \div \Sigma f)$	When all deviations have a common factor h, take $u = (x - a) \div h$.

Combine totals, not averages

KEY IDEA

$$\text{Combined mean} = \frac{n_1 \times \text{mean}_1 + n_2 \times \text{mean}_2 + \ldots}{n_1 + n_2 + \ldots}$$

It is the total of all the values ÷ the total count, so each group's mean is weighted by its size.

WHAT IT MEANS

- Multiply each group's mean by the number of items in that group to get the total.
- Add the totals and the counts.
- Divide to get the combined mean.

WORKED EXAMPLE 1 : Two groups

Group	Number of students (n)	Mean mark	Total mark (n × mean)
A	40	62	40 × 62 = 2,480
B	60	72	60 × 72 = 4,320
Total	100	–	2,480 + 4,320 = 6,800

Combined mean

$$= \frac{2,480 + 4,320}{100}$$

$$= \frac{6,800}{100}$$

$$= 68$$

Why 67 is wrong

The simple average of the two means is (62 + 72) ÷ 2 = 67, but the groups are of different sizes, so it does not give the correct combined mean.

WORKED EXAMPLE 2 : Three groups

Group	Number (n)	Mean	Total (n × mean)
A	15	50	15 × 50 = 750
B	25	60	25 × 60 = 1,500
C	20	70	20 × 70 = 1,400
Total	60	–	750 + 1,500 + 1,400 = 3,650

Combined mean

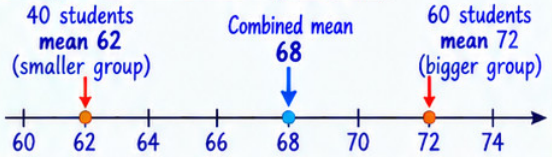
$$= \frac{3,650}{60}$$

$$= 60.83 \text{ (to 2 d.p.)}$$

POSITION OF THE COMBINED MEAN

- The combined mean always lies between the smallest and the largest group mean.
- With two groups of different sizes and different means, it lies nearer to the mean of the bigger group.
- It equals the simple average of the means only if the groups are of equal size.

Example : nearer to the bigger group



The combined mean 68 lies between 62 and 72 and is nearer to 72 because the second group is larger (60 students).

EQUAL SIZES : THEN SIMPLE AVERAGE WORKS

Two groups of equal size, 30 each, with means 50 and 70.

$$\text{Combined mean} = \frac{30 \times 50 + 30 \times 70}{30 + 30}$$

$$= \frac{1,500 + 2,100}{60}$$

$$= \frac{3,600}{60} = 60$$

When the groups are equal in size, the combined mean is the simple average: (50 + 70) ÷ 2 = 60.

ANOTHER EXAMPLE : Arithmetic mean of runs

A batsman scores 34 runs in 5 innings and 48 runs in 7 innings. Find the arithmetic mean of runs per inning overall.

$$\text{Combined mean} = \frac{5 \times 34 + 7 \times 48}{5 + 7}$$

$$= \frac{170 + 336}{12}$$

$$= \frac{506}{12} = 42.17 \text{ (to 2 d.p.)}$$

New total divided by new count

KEY RULE

New mean = New total ÷ New count

Whatever change is made (add, remove, replace or correct), first find the new total and the new count, then divide.

FOUR SITUATIONS

	Example	Working	New mean
1 A value is added The count increases by 1.	The mean of 24 values is 35. A value 60 is added.	New total = 24 × 35 + 60 = 840 + 60 = 900 New mean = 900 ÷ 25 = 36	**36**
2 A value is removed The count decreases by 1.	The mean of 15 values is 42. The value 70 is removed.	New total = 15 × 42 − 70 = 630 − 70 = 560 New mean = 560 ÷ 14 = 40	**40**
3 A value is replaced The count does not change.	The mean of 10 values is 56. A value 38 is replaced by 68.	New total = 10 × 56 − 38 + 68 = 560 − 38 + 68 = 590 New mean = 590 ÷ 10 = 59	**59**
4 A misread value is corrected The count does not change.	A value was wrongly taken as 38. The correct value is 68.	Correct total = Wrong total − wrong value + right value. The count stays the same.	Found using new total ÷ same count.

CHANGE IN MEAN

When a value is replaced or corrected, the count does not change. So the mean changes by

New mean = Old mean + (new value − old value) ÷ count

In the example above:

56 + (68 − 38) ÷ 10
= 56 + 30 ÷ 10
= 56 + 3 = 59.

ADDED VALUE FROM MEANS

The value that was added can be found in the same way.

Added value = New total − Old total

Example:
Mean of 24 values is 35.
New mean after adding a value is 36. Find the added value.

Old total = 24 × 35 = 840
New total = 25 × 36 = 900
Added value = 900 − 840 = 60.

IMPORTANT POINTS

- When a value is added, the count increases by 1. Divide by the new count.
- When a value is removed, the count decreases by 1. Divide by the new count.
- When a value is replaced or corrected, the count does not change.
- The rule never changes: new mean = new total ÷ new count.

Equally spaced values: pair the ends

KEY IDEA: ARITHMETIC PROGRESSION

An **arithmetic progression** (A.P.) is a list in which each term is got by adding the same fixed number, the common difference, to the one before it. The common difference may be positive, negative or zero.

$a \rightarrow a + d \rightarrow a + 2d \rightarrow a + 3d \rightarrow \cdots$

SUM AND MEAN OF AN A.P.

If an A.P. has n terms with first term a and last term l, then

$$\text{Sum} = n \times (a + l) \div 2$$

So the **mean** = **sum** ÷ n

$$\text{Mean} = (a + l) \div 2$$

WORKED EXAMPLES

	Sequence	Mean	Check (using sum)
1	Consecutive numbers 38 to 44 (7 numbers)	The middle number, 41	(38 + 44) ÷ 2 = 41 Sum = 287, 287 ÷ 7 = 41
2	Consecutive numbers 21 to 26 (6 numbers)	The average of the two middle numbers, 23.5	(21 + 26) ÷ 2 = 23.5
3	The progression 7, 11, 15, ..., 47 (11 terms)	(first + last) ÷ 2 = (7 + 47) ÷ 2 = 27	Sum = 297, 297 ÷ 11 = 27
4	The first n natural numbers 1, 2, ..., n	(n + 1) ÷ 2	n = 20 : sum = 210 210 ÷ 20 = 10.5 = 21 ÷ 2
5	The first n odd numbers 1, 3, ..., (2n − 1)	(1 + 2n − 1) ÷ 2 = n	n = 15 : 1 to 29 sum = 225, 225 ÷ 15 = 15

SUM OF SPECIAL SEQUENCES

Sum of the first n natural numbers

$$1 + 2 + 3 + \ldots + n = n(n+1) \div 2$$

Sum of the first n odd numbers

$$1 + 3 + 5 + \ldots + (2n - 1) = n \times n = n^2$$

GAUSS PAIRING 1 TO 100

$1 + 100 = 101$
$2 + 99 = 101$
$3 + 98 = 101$
⋮
$50 + 51 = 101$

There are 50 pairs, each with sum 101.

Total sum = 50 × 101 = 5050.

Mean = 5050 ÷ 100 = 50.5 = (1 + 100) ÷ 2.

USE THE RULE ONLY WHEN EQUALLY SPACED

The numbers 2, 3, 10 are not equally spaced.

$$\text{Mean} = (2 + 3 + 10) \div 3 = 15 \div 3 = 5.$$

Using only the ends gives (2 + 10) ÷ 2 = 6, which is incorrect.

Ages and runs: track the denominator

KEY IDEAS

Ages

- After t years, every age rises by t. So the mean age of the same people also rises by t.
- If a new member joins, use new total of ages ÷ new count.

Runs

- The arithmetic mean of runs per innings is total runs ÷ number of innings.
- This is not the standard cricket batting average, which uses dismissals in the denominator. Here we use innings.

WORKED EXAMPLE 1 : Ages

Five years ago the mean age of a family of 4 was 24 years. Since then a child was born and is now 2 years old. Find the present mean age.

Original 4 people: present mean 29 years; total age 116 years

Child 2

Total age = 116

2

Total = 118

Present mean = 118 ÷ 5 = 23.6 years.

Solution:

1. Five years ago, mean = 24 for 4 people.
   Total age five years ago = 4 × 24 = 96.
2. After 5 years, each of the same 4 people is 5 years older, so their total age = 96 + 4 × 5 = 96 + 20 = 116.
3. A new child has joined and is now 2 years old. Present total age = 116 + 2 = 118.
4. Present number of people = 5.
   Present mean age = 118 ÷ 5 = **23.6 years.**

WORKED EXAMPLE 2 : Runs

A cricketer has an average of 42 runs per innings after 11 innings. If he wants his average to be 45 after 12 innings, how many runs does he need to score in the 12th innings?

Innings	Total runs	Average
After 11 innings	11 × 42 = 462	42
After 12 innings	12 × 45 = 540	45

Solution:

1. Total runs after 11 innings = 11 × 42 = 462.
2. Required total runs after 12 innings = 12 × 45 = 540.
3. Runs needed in 12th innings = 540 − 462 = 78.

He needs to score **78 runs** in the 12th innings.

Deviations in two worked settings

1. RAW DATA BY DEVIATIONS

Find the mean of 63, 68, 71, 74 and 79 using deviations. Take $a = 70$.

Step 1 : Find deviations from $a = 70$.

x	$d = x - 70$
63	$63 - 70 = -7$
68	$68 - 70 = -2$
71	$71 - 70 = 1$
74	$74 - 70 = 4$
79	$79 - 70 = 9$
Σd	$-7 - 2 + 1 + 4 + 9 = 5$

Step 2 : Apply the deviation formula.

$$\text{Mean} = a + \frac{\Sigma d}{n}$$

Here, $a = 70$, $\Sigma d = 5$, $n = 5$.

$$\text{Mean} = 70 + \frac{5}{5}$$

$$= 70 + 1 = \boxed{71.}$$

Step 3 : Check by direct method.

Sum of the observations:

$63 + 68 + 71 + 74 + 79 = 355.$

$$\text{Mean} = \frac{355}{5} = \boxed{71.}$$

2. STEP-DEVIATION ON A FREQUENCY TABLE

Find the mean marks using step-deviation method from the following frequency distribution. Take $a = 35$ and $h = 5$.

x	f	$u = \frac{x - 35}{5}$	$f \times u$
25	6	$(25 - 35)/5 = -2$	-12
30	10	$(30 - 35)/5 = -1$	-10
35	14	$(35 - 35)/5 = 0$	0
40	12	$(40 - 35)/5 = 1$	12
45	8	$(45 - 35)/5 = 2$	16
Total	$N = 50$	—	$\Sigma fu = 6$

Step 1 : Apply the step-deviation formula.

$$\text{Mean} = a + h\,\frac{\Sigma fu}{N}$$

Here, $a = 35$, $h = 5$, $\Sigma fu = 6$, $N = 50$.

$$\text{Mean} = 35 + 5 \times \frac{6}{50}$$

$$= 35 + \frac{30}{50} = 35 + 0.6 = \boxed{35.6.}$$

Step 2 : Check by the direct method.

Compute Σfx :

$25 \times 6 + 30 \times 10 + 35 \times 14 + 40 \times 12 + 45 \times 8$

$= 150 + 300 + 490 + 480 + 360 = 1{,}780.$

$$\text{Mean} = \frac{1{,}780}{50} = \boxed{35.6.}$$

Groups, removal and replacement

1 THREE GROUPS

Sections of 30, 25 and 45 students have means 58, 64 and 70. Find the combined mean of all 100 students. Also compare with the simple average of the three means.

When groups have different numbers, use the total of each group.
The simple average of the means gives equal weight to each group and is wrong unless the group sizes are the same.

Step 1 Find the total of each group

Group	Number of students	Mean	Total (number × mean)
1	30	58	30 × 58 = 1,740
2	25	64	25 × 64 = 1,600
3	45	70	45 × 70 = 3,150
Total	100	–	1,740 + 1,600 + 3,150 = 6,490

Step 2 Find the combined mean

$$\text{Combined mean} = \frac{\text{Total}}{\text{Total number}} = \frac{6,490}{100} = 64.9$$

Step 3 Compare with simple average

Simple average of the three means
= (58 + 64 + 70) ÷ 3
= 192 ÷ 3 = 64

This is 64, which is not the correct combined mean because the groups have different numbers of students.

2 REMOVING A VALUE

The mean of 9 values is 50. One value, 82, is removed.
Find the new mean of the remaining 8 values.

Step 1 Find the original total

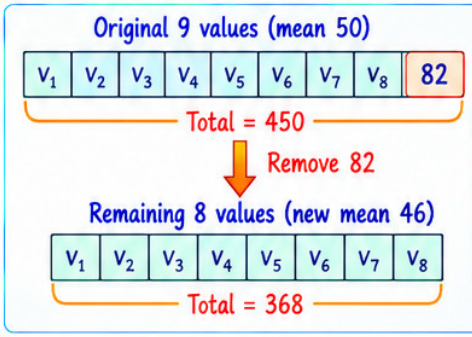
Total of 9 values = 9 × 50 = 450

Step 2 Subtract the removed value

New total = 450 − 82 = 368
New number of values = 8

Step 3 Find the new mean

New mean = 368 ÷ 8 = **46**



Removing a value reduces the total and the number of values, so the mean changes.

3 REPLACING A VALUE

The mean weight of 12 players is 64 kg. A player of 58 kg is replaced by one of 82 kg. Find the new mean weight.
The number of players stays the same.

Step 1 Find the original total

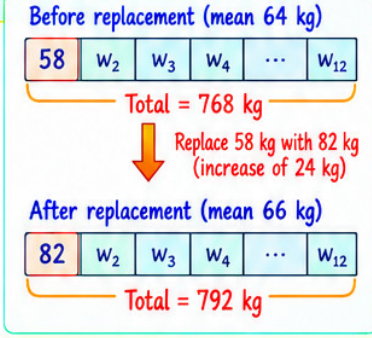
Total weight = 12 × 64 = 768 kg

Step 2 Change in total due to replacement

The new player is 24 kg heavier (82 − 58 = 24).
So the total weight increases by 24 kg.

Step 3 Find the new mean

New total = 768 + 24 = 792 kg
New mean = 792 ÷ 12 = **66 kg**



Replacing a value changes the total by the difference between the new and old values, but the number of values stays the same.

Sequences and a runs-per-innings mean

1. A PROGRESSION

Find the mean of
13, 17, 21, ..., 89.

13 17 21 ... 85 89

+4 +4 +4

1 Number of terms

$n = (89 - 13) \div 4 + 1$
$= 76 \div 4 + 1$
$= 19 + 1 = 20$

It is an arithmetic progression with first term 13, last term 89 and common difference 4.

2 Mean of an arithmetic progression

Mean = (first term + last term) ÷ 2
= (13 + 89) ÷ 2
= 102 ÷ 2 = **51**.

3 Check using the sum

Sum of 20 terms = 20 × 51 = 1,020.
Mean = 1,020 ÷ 20 = 51.

2. NATURAL AND ODD NUMBERS

(a) Mean of the first 50 natural numbers

The natural numbers are 1, 2, 3, ..., 50.

1 2 3 ... 48 49 50

Mean = (first term + last term) ÷ 2
= (1 + 50) ÷ 2
= 51 ÷ 2 = 25.5.

The numbers are equally spaced around the middle value 25.5, so the mean is 25.5.

(b) Mean of the first 40 odd numbers

The first 40 odd numbers are 1, 3, 5, ..., 79.

1 3 5 ... 75 77 79

Mean = (first term + last term) ÷ 2
= (1 + 79) ÷ 2
= 80 ÷ 2 = 40.

There are 40 numbers, each with mean 40, so their sum is 40 × 40 = 1,600.

3. RUNS: A NEW ARITHMETIC MEAN

A batter's arithmetic mean of runs per innings after 15 innings is 38. She scores 86 in the 16th innings. Find the new average.

Innings	Total runs	Mean (runs per innings)
First 15	15 × 38 = 570	38
16th	86	–
New total	570 + 86 = 656	–
New mean	656 ÷ 16	41

1 Total runs after 16 innings

15 × 38 + 86 = 570 + 86 = 656.

2 New mean

656 ÷ 16 = **41**.

The new arithmetic mean of runs per innings is 41.

Check weights, counts and the assumed mean

KEY IDEAS

Weighted mean
When groups have different sizes, use the total method.

$$\text{Mean} = \frac{\text{total of values}}{\text{total number}}$$

Change in count
After a value is added or removed, divide by the new count.

new total → new count

Assumed mean
The mean of the deviations is only the gap from the assumed mean.

Mean = a + (mean of deviations)

COMMON TRAPS AT A GLANCE

Trap	Wrong working	Right working
Averaging averages	40 students at 62, 60 at 72 : (62 + 72) ÷ 2 = 67	(2,480 + 4,320) ÷ 100 = 68
Forgetting to change the count	15 values, mean 42, 70 removed : 560 ÷ 15	560 ÷ 14 = 40
Not adding a back	Wages : 50 ÷ 40 = 1.25	700 + 1.25 = 701.25
Averaging speeds	(40 + 70 + 35) ÷ 3	Total distance ÷ total time

THREE COMMON EXAM TRAPS

1 Averaging averages
When two groups have different means, the mean of the two together is the simple average of their means only if the groups are of equal size.

Example : 10 workers earn on average 300 rupees a day and 30 others earn 500. Find the mean for all 40.

Group	Number	Mean	Total amount
First	10	300	10 x 300 = 3,000
Second	30	500	30 x 500 = 15,000
Together	40	–	3,000 + 15,000 = 18,000

Mean for all 40
18,000 ÷ 40
= 450

Not 400.

2 Forgetting to change the count
After a value is added or removed, divide the new total by the new count.
When a value is replaced or corrected, the count stays the same.

Example (addition) :
The mean of 6 values is 20.
A value 34 is added.
New total = 6 x 20 + 34
= 120 + 34 = 154
New mean = 154 ÷ 7 = 22

Example (removal) :
15 values have mean 42.
A value 70 is removed.
Original total = 15 x 42 = 630
New total = 630 − 70 = 560
New mean = 560 ÷ 14 = 40

3 Leaving the deviation method half done
The mean of the deviations is only the gap from the assumed mean.
Add a back to get the actual mean.

Example : The deviations from a = 60 have mean −2.

Mean = a + (mean of deviations)
= 60 + (−2) = 58

So the mean is 58, not −2 and not 62.

APCNF: a community-managed farming system

Government of Andhra Pradesh

Department of Agriculture and Cooperation

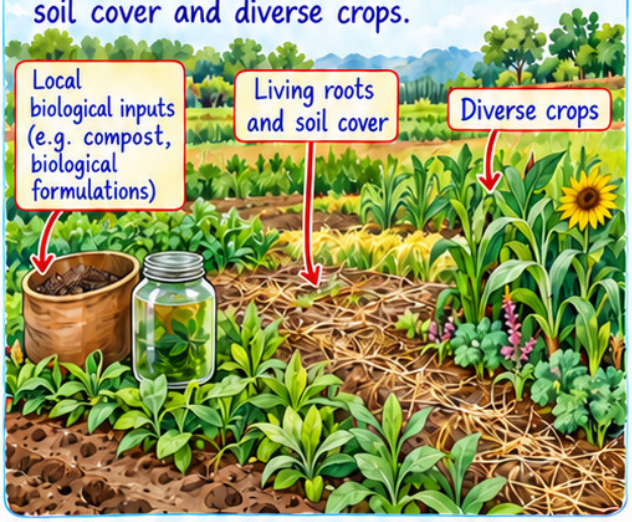
Rythu Sadhikara Samstha (RySS)

RySS is a not-for-profit organisation fully owned by the State Government.

Andhra Pradesh Community-managed Natural Farming (APCNF)

What is community-managed natural farming?

Natural farming replaces synthetic inputs with local biological inputs, living roots, soil cover and diverse crops.



Women-led implementation

APCNF is women-led. Extension works through women's self-help groups (SHGs) and their federations, and farmer-to-farmer learning.

Women's self-help groups (SHGs) ↔ Federations of SHGs ↔ Farmer-to-farmer learning

Community networks for knowledge sharing and wider adoption

Official webpage snapshot (viewed 25 October 2026)

28	districts
662	mandals
8,168	Gram Panchayats
1,773,432	farmers
926,387	hectares

Website snapshot—not a dated census or a claim that every farm has completed transition.

Key dates

- 2015–16: Launch wording on homepage
- 2016: Government mandate

Source

APCNF official programme and Andhra Pradesh pages.

Nine principles work as one farming system

1 Living crops and roots throughout the year

Keep the soil covered with living plants and active roots in all seasons.

2 Diverse crops, with trees where possible

Grow a mix of crops, including cereals, pulses, oilseeds, vegetables and trees where possible.

3 Residue cover when living plants are absent

Keep crop residues, leaves or mulches on the soil surface when living plants are absent.



4 Minimum soil disturbance and reduced tillage

Disturb the soil as little as possible and reduce tillage to protect soil structure, organisms and roots.

5 Farmers' own seeds, preferably indigenous

Use and conserve farmers' own seeds, preferably indigenous and locally adapted varieties.

6 Integrate animals into the farm

Integrate animals such as cattle, goats or poultry to recycle nutrients, provide manure and support farm biodiversity.

7 Biological stimulants support soil biology

Use biological preparations such as Jeevamrutham to stimulate useful soil microbes.

8 Agronomic practices and botanical preparations manage pests

Use crop rotation, trap crops, intercropping, beneficial plants and botanical preparations to manage pests.

9 Avoid synthetic fertilisers, pesticides, herbicides and weedicides

Do not use synthetic fertilisers, pesticides, herbicides or weedicides.



Crop diversity guidance varies across APCNF pages; adapt to local conditions.

APCNF: nine universal principles.

Know the input — and the job it performs

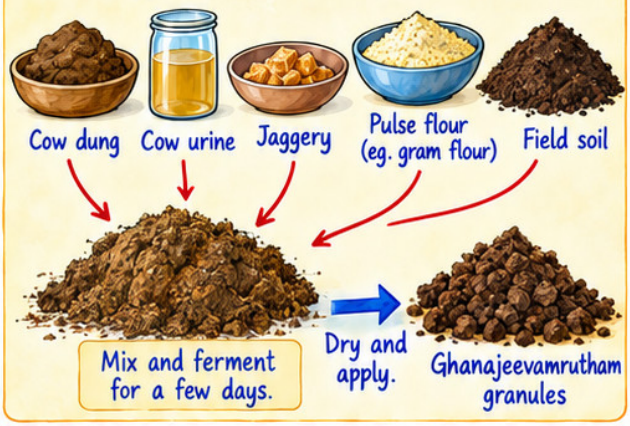
1. Beejamrutham: seed treatment before sowing.

Cow dung + cow urine + lime + chemical-free soil + water → coat / treat seeds; supports microbial activity and seedling establishment.



2. Ghanajeevamrutham: solid biological input.

Cow dung + cow urine + jaggery + pulse flour + field soil → ferment, dry and apply; enriches soil biology.



3. Dravajeevamrutham: liquid microbial stimulant.

Similar ingredients fermented in water → apply to stimulate useful soil microbes. APCNF describes fermentation over 24 – 48 hours.



4. Kashayams and botanical extracts: local plant preparations for pest management.

Use local plants such as neem, chilli and garlic. Combine with good agronomic practices and traps.



These inputs have different jobs:

Seed treatment (Beejamrutham)
Coats seeds and supports microbial activity and seedling establishment.

≠

Soil biological stimulant (Ghanajeevamrutham / Dravajeevamrutham)
Enriches and stimulates soil biology.

≠

Pest-management preparation (Kashayams and botanical extracts)
Helps manage pests; use with good agronomic practices and traps.

⚠ These are programme-described practices, not a universal dosage recipe; use local technical guidance.

Source: APCNF official natural farming inputs.

Soil cover links dry sowing to living roots

Pre-monsoon dry sowing (PMDS) places seeds in dry soil before the monsoon, covers them with crop residues and establishes a diverse living cover when moisture supports germination.

1 Prepare pelleted seeds
Seeds are coated with clay or organic materials to protect them and aid sowing.

2 Sow several species in dry soil before the monsoon
Broadcast or place pelleted seeds in dry soil. Use a mix of grasses, legumes and other suitable species.

3 Cover with crop-residue mulch
Spread crop residues such as straw, leaves or plant biomass over the sown area.

4 Establish diverse living cover when moisture supports germination
Seeds germinate and grow into a mix of plants that keep the soil covered with living roots.



Why mulch is important
Mulching keeps soil covered, moderates temperature, conserves moisture and feeds soil organisms.

Types of mulch

Living mulch: growing plants



- Continues to cover the soil as it grows.
- Adds fresh organic matter through roots and leaves.
- Supports diverse soil organisms.

Residue mulch: crop remains or organic cover



- Uses crop residues such as straw, leaves or biomass.
- Shields soil from direct sun and wind.
- Slowly decomposes and feeds soil organisms.

Planning cycle for PMDS



Source information
APCNF describes pelleted seeds remaining viable for up to 6 months and systems allowing up to 3 harvests a year; these are practice descriptions, not guarantees for every farm.

NMNF: read approval, targets and continuation separately

National Mission on Natural Farming (NMNF)

Standalone Centrally Sponsored Scheme to promote natural farming across the country.



Ministry of Agriculture and Farmers Welfare

Nodal ministry for overall policy, funding, guidelines, coordination and monitoring.



Cabinet approval: 25 November 2024

Approval for the mission with a defined programme outlay and targets.



Programme outlay (through 2025–26)

Original outlay ₹2,481 crore through 2025–26 = Centre ₹1,584 crore + States ₹897 crore.



Total ₹2,481 crore

- Centre ₹1,584 crore
- States ₹897 crore

Approved mission targets – not achievements



15,000 clusters



1 crore farmers



7.5 lakh hectares



10,000 Bio-input Resource Centres



about 2,000 model demonstration farms



18.75 lakh farmers trained



30,000 Krishi Sakhis/ community resource persons

Implementation flow (illustrative)

Bio-input Resource Centres (BRCs)



Supply bio-inputs and technical support at the local level.

→

Farmer training



Train farmers on natural farming practices.

→

Model demonstration farms



Showcase practical models on farmers' fields.

→

Adoption at scale



Farmers adopt natural farming in clusters.

Monitoring, certification and branding



- Simple certification / common branding.
- Geo-tagged online monitoring to track implementation.

Important continuation



The original funding period does NOT mean the mission ended: PIB 18 June 2026 refers to an approved Annual Action Plan for 2026–27.

Sources: Cabinet 25 November 2024; PIB 18 June 2026.

Natural and organic: similar aims, different scheme routes

Natural farming



- Uses locally available resources.
- On-farm biomass recycling (e.g. crop residues, farm waste).
- Livestock integration.
- Biological inputs, including on-farm cow-based formulations.
- Diverse crops and cropping systems.
- Synthetic chemical inputs excluded.

Organic farming



- May use on-farm or off-farm organic inputs (e.g. compost, vermicompost, bio-fertilisers, organic manures).
- Promoted through separate government schemes.
- Avoids synthetic chemical inputs and focuses on organic production standards and certification.

Key differences between natural farming and organic farming

Aspect	Natural farming	Organic farming
Main idea	Ecological, low-cost, locally available resources with on-farm recycling.	Certified organic production using approved organic inputs.
Input source	Locally available, on-farm biomass.	May use on-farm or off-farm organic inputs.
Livestock role	Integrated with cropping system.	May include livestock, not essential.
Diversity of crops	Emphasises diverse crops and cropping systems.	Supports crop diversification as per organic standards.
Synthetic chemicals	Excluded.	Excluded.
Scheme support	BPKP (up-scaled into NMNF).	PKVY and MOVCDNER.
Focus of support	Cluster formation, capacity building, handholding, certification and residue analysis.	Support for organic inputs, capacity building and value chain development.

Scheme flow and details

BPKP (Bharatiya Prakritik Krishi Paddhati) → Up-scaled into **NMNF** (National Mission on Natural Farming)



PKVY → Paramparagat Krishi Vikas Yojana

MOVCDNER → Mission Organic Value Chain Development for North Eastern Region

BPKP (historical support)

- Support: ₹12,200 per hectare over 3 years.
- Purpose: Cluster formation, capacity building, handholding, certification and residue analysis.

PKVY

- Support: ₹31,500 per hectare over 3 years.
- Within this, ₹15,000 DBT for organic inputs.
- Purpose: Support for organic inputs, capacity building and organic farming.

MOVCDNER

- Support: ₹32,500 per hectare over 3 years.
- Purpose: Support for organic inputs.
- As per 3 December 2024 Lok Sabha reply.

Important caution
Do not mistake the PKVY input component ₹15,000 for the total ₹31,500 package.

Source
Press Information Bureau and Lok Sabha replies dated 3 December 2024 and 17 December 2024.

Separate a milestone, a target and an outcome

Milestone
10 November 2016

G.O. Rt. No. 764 mandates RySS to advance natural farming; pilot 615 Gram Panchayats and 40,000 farmers.



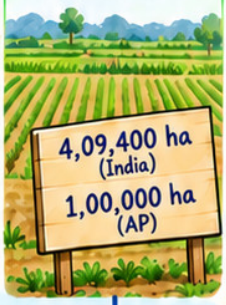
Target
June 2018

State announced target to convert 60 lakh farmers and achieve 100% natural farming by 2024 — historical target, NOT proof of achievement.



Outcome
4 February 2022

BPKP historical coverage 4,09,400 hectares nationally, including 1,00,000 hectares in AP.



Milestone
25 November 2024

Cabinet approves NMNF.



Award
2024

Gulbenkian Prize for Humanity.



Award
2026

Food Planet Prize; winner amount USD 1.5 million.



2016 — 2018 — 2022 — 2024 — 2024 — 2026

Evidence ladder: build stronger claims

1. Programme description
What is planned and how it will be implemented.



2. Measured farm results
Data from fields on yield, income, cost, soil health etc.



3. Independent comparison
Compare with similar farms without the programme.



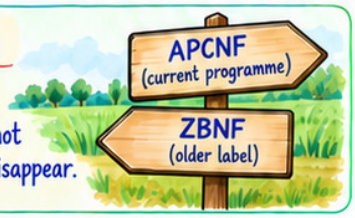
Do not over-interpret claims
A programme claim is not a guarantee of yield or income. Compare crop, season, soil, baseline, sample and measurement method before generalising.



About awards
Awards recognise a programme; they do not prove every stated farm outcome.



Programme names and meaning
APCNF is the current programme name; ZBNF is an older label. Zero budget does not mean that labour, land or all farming costs disappear.



Sources
- APCNF official milestones.
- PIB 2022.
- Food Planet Prize official.

