1.Quantum Computing: Overcoming the Noise Barrier

Source: *The Hindu*
Subject: Science & Technology | Quantum Technology

Why in News?

- India's **National Quantum Mission (NQM)** is accelerating research to develop **practical and fault-tolerant quantum computers**, with the biggest challenge being **quantum noise (decoherence)** and error correction.

Key Developments and Significance

- It has launched the **National Quantum Mission (2023)** with an outlay of **₹6,003.65 crore** to make India a global leader in **Quantum Technologies & Applications** by **2030–31**.
- It uses **qubits** instead of classical bits, enabling **superposition** and **entanglement** for exponentially faster computation.
- It has the potential to revolutionise **drug discovery, molecular simulation, cryptography, logistics optimisation, climate modelling, financial modelling and Artificial Intelligence**.
- It has attracted significant investments from companies such as **Google, IBM and Microsoft** to develop **fault-tolerant quantum computers**.
- It is expected to deliver commercially useful quantum computing applications during this decade as error correction technologies mature.

Challenges in Quantum Computing

- It suffers from **decoherence (quantum noise)**, where interaction with the environment destroys fragile quantum states.
- It has **high error rates (0.1%–1%)**, making current quantum computers unreliable for complex computations.
- It requires **extreme cooling, isolation and sophisticated hardware**, increasing development costs.
- It depends on **quantum error correction**, where multiple physical qubits are combined to create stable **logical qubits**.

- It faces challenges in scaling quantum processors while maintaining stability and computational accuracy.

National Quantum Mission (NQM)

- It was **approved in April 2023** with a budget of **₹6,003.65 crore** for the period **2023-24 to 2030-31**.
- It aims to position India as a **global hub for Quantum Technologies** and strengthen **Atmanirbhar Bharat** in critical technologies.
- It focuses on **Quantum Computing, Quantum Communication, Quantum Sensing & Metrology, and Quantum Materials & Devices**.
- It aims to develop **intermediate-scale quantum computers**, establish **2,000 km Quantum Key Distribution (QKD)** networks, advance quantum sensors and develop indigenous quantum materials.
- It is implemented through four **Thematic Hubs** led by **IISc Bengaluru, IIT Madras-C-DOT, IIT Bombay and IIT Delhi**.

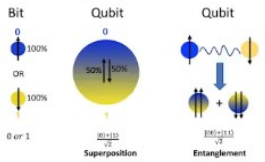
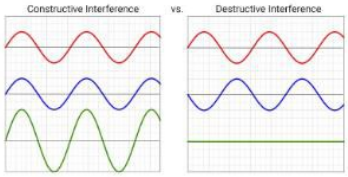
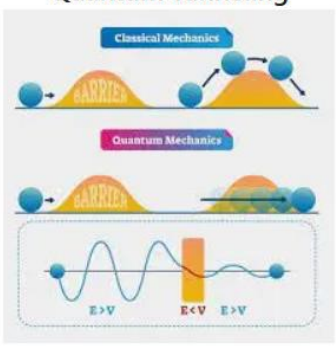
Way Forward

- It requires development of **fault-tolerant quantum computers** through advanced error-correction techniques.
- It needs greater investment in **indigenous quantum hardware, semiconductor fabrication and cryogenic technologies**.
- It should strengthen collaboration among **academia, industry, startups and research institutions**.
- It requires creation of a skilled **quantum workforce** and expansion of India's quantum innovation ecosystem.
- It should integrate quantum technologies with **cybersecurity, defence, healthcare and advanced manufacturing** to strengthen technological competitiveness.

About Quantum Computing

Quantum computing is an area of computer science that uses the principles of quantum theory at the atomic and subatomic levels. It uses subatomic particles, such as electrons or photons. Classical computers, which include smartphones and laptops, encode information in binary “bits” that can either be 0s or 1s. In a

quantum computer, the basic unit of memory is a quantum bit or qubit. Quantum bits, or qubits, allow the subatomic particles to exist in more than one state at the same time.

Key principle	Description
Superposition 	- The fundamental principle that enables the power of quantum computing is '**quantum superposition**'. - Unlike traditional bits used in classical computers that can exist in only one state **(either 0 or 1),** quantum bits or '**qubits**' can exist in a superposition of 0 and 1 simultaneously.
Quantum Entanglement 	- Quantum Entanglement is where **quantum particles interact physically** in ways such that the quantum state of each cannot be described independently. - Measuring one particle instantaneously affects the others even over long distances. - This enables quantum systems to **exhibit correlations** stronger than any possible classical behaviour.
Quantum Interference 	- The **wave-like** characteristics of quantum particles cause interference effects between different probability states that can result in **constructive or destructive interference** analogous to the interference effects seen in waves. • This effect is harnessed in **quantum algorithms.**
Quantum Tunneling 	- Quantum tunnelling refers to the **ability of particles to tunnel through barriers** when according to classical physics they do not have enough energy to do so. • This principle is critical for the functioning of quantum computer hardware like **quantum dots.**

Key Principles of Quantum Computing

UPSC Prelims MCQ

Q. With reference to Quantum Computing, consider the following statements:

1. Quantum computers use qubits that can exist in multiple states simultaneously through superposition.
2. Decoherence refers to the loss of quantum information due to interaction with the surrounding environment.
3. The National Quantum Mission was approved in 2023 to promote quantum technologies in India.

Which of the statements given above are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Answer: (d)

UPSC Mains Question (15 Marks)

"Quantum computing has the potential to transform strategic sectors, but overcoming quantum noise and achieving fault-tolerant systems remain major technological challenges." Discuss in the context of India's National Quantum Mission.

2.India-Indonesia Joint Restoration of Prambanan Temple

Source: *The Hindu*
Subject: International Relations | Art & Culture

Why in News?

- India and Indonesia have jointly launched the **restoration of the UNESCO World Heritage-listed Prambanan Temple** in Yogyakarta, with the **Archaeological Survey of India (ASI)** leading the conservation work from the Indian side, reflecting the deep civilisational and cultural ties between the two countries.

Key Highlights and Significance

- It marks a major cultural cooperation initiative under the **India-Indonesia Comprehensive Strategic Partnership**.
- It strengthens India's **cultural diplomacy** and supports the objectives of the **Act East Policy**.
- It reinforces the shared **Hindu-Buddhist civilisational heritage** linking India and Southeast Asia.
- It demonstrates India's expertise in **heritage conservation**, following restoration projects at **Angkor Wat (Cambodia)** and **Mỹ Sơn (Vietnam)**.
- It enhances bilateral cooperation in **archaeology, conservation, tourism and cultural exchanges**.

About the Restoration Project

- It is being implemented jointly by the **Archaeological Survey of India (ASI)** and Indonesian heritage authorities.
- It focuses on restoring the **Perwara (companion shrines)** surrounding the main temple complex.
- It adopts the **Anastylosis technique**, involving reconstruction using original stones wherever possible.
- It integrates **digital mapping, Artificial Intelligence (AI)** and modern conservation technologies to improve restoration accuracy.
- It aims to preserve the site's structural integrity while maintaining its historical authenticity.

About Prambanan Temple

- It is a **9th-century Hindu temple complex** located in **Yogyakarta, Indonesia**.
- It is dedicated to the **Trimūrti—Brahma (Creator), Vishnu (Preserver) and Shiva (Destroyer)**.
- It is the **largest Hindu temple complex in Indonesia**.
- It was designated a **UNESCO World Heritage Site in 1991**.
- It depicts episodes from the **Ramayana and Mahabharata**, reflecting the spread of Indian culture across Southeast Asia.

Way Forward

- It requires expanding India-Indonesia cooperation in **heritage conservation, archaeology and museum management**.
- It should promote **cultural tourism, academic exchanges and joint archaeological research**.
- It needs greater use of **digital technologies** for preservation of heritage monuments.
- It should strengthen India's role in preserving **shared Asian cultural heritage** through international partnerships.

About Archaeological Survey of India (ASI)

- **Established:** 1861
- **Founder:** Alexander Cunningham
- **Ministry:** Ministry of Culture
- **Headquarters:** New Delhi
- **Functions:** Conservation of protected monuments, archaeological excavations, heritage preservation and implementation of the **Ancient Monuments and Archaeological Sites and Remains (AMASR) Act, 1958**.

UPSC Prelims MCQ

Q. With reference to the Prambanan Temple, consider the following statements:

1. It is the largest Hindu temple complex in Indonesia.
2. It is dedicated to the Trimūrti—Brahma, Vishnu and Shiva.
3. It was declared a UNESCO World Heritage Site in 1991.

Which of the statements given above are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Answer: (d)

UPSC Mains Question (15 Marks)

"Shared cultural heritage has emerged as an important pillar of India's diplomacy in Southeast Asia." Discuss with reference to the India-Indonesia collaboration for the restoration of the Prambanan Temple.

3.Wayanad Tunnel Landslide: A Man-Made Disaster?

Source: *The Hindu*
Subject: Environment | Disaster Management | Infrastructure

Why in News?

- The **Kerala Government** has suspended the **₹2,134.5-crore Anakkampoyil-Kalladi-Meppadi twin-tunnel project** in **Wayanad** after a fatal landslide at the construction site, raising concerns over **environmental compliance, slope stability and infrastructure development in the ecologically fragile Western Ghats**.

Key Highlights and Concerns

- It resulted in **three deaths and several missing workers** after heavy monsoon rainfall triggered a landslide at the construction site.
- It was caused by the accumulation of **over one lakh cubic metres of excavated debris**, despite repeated warnings from district authorities.
- It ignored directives issued by the **District Disaster Management Authority (DDMA)** to reduce debris height and suspend construction until safe disposal of excavated soil.
- It exposed deficiencies in **construction safety, environmental safeguards and project monitoring**.
- It highlighted the vulnerability of **large infrastructure projects** in the **landslide-prone Western Ghats**.

Environmental and Governance Issues

- It has been described as a **man-made disaster** due to **unscientific dumping of excavation debris**, leading to slope instability and soil failure.
- It demonstrated the failure of temporary engineering measures such as **retaining structures and tarpaulin covers** under intense monsoon conditions.
- It raised concerns over compliance with conditions imposed during **environmental and judicial clearances**.

- It renewed demands to review approvals granted by the **State Environment Impact Assessment Authority (SEIAA)**.
- It highlighted the need for stronger implementation of **Disaster Risk Reduction (DRR)** principles in infrastructure planning.

Way Forward

- It requires **scientific excavation and debris management** in all hill infrastructure projects.
- It needs strict implementation of **Environmental Impact Assessment (EIA)** conditions and independent safety audits.
- It should strengthen **slope stabilisation, drainage management and early warning systems** in landslide-prone areas.
- It requires integrating **geological risk assessment, climate resilience and disaster management** into infrastructure planning.
- It should ensure greater accountability of executing agencies and regular monitoring by environmental and disaster management authorities.

About the Western Ghats

The Western Ghats formed through tectonic events shaping the faulted edges of the Deccan Plateau. It is formed by the subduction of the Arabian basin and tilting of the eastern and north-eastern region.

- The Ghats are block mountains formed due to downwarping of land towards the Arabian Sea.
- Scholars suggest they are not true mountains but represent the western faulted edge of the Deccan Plateau.
- Their uplifted edges create steep western cliffs and gentler eastern slopes.
- This ancient terrain influences drainage, monsoon interception, soil formation, and biodiversity across peninsular India.
- The Ghats contain varied rock systems: basalt, charnockite, granite gneiss, metamorphic gneiss, khondalite and leptynite.
- Several important passes cut across the Western Ghats, enabling connectivity between coastal and inland regions like: Thal Ghat, Amba Ghat, Bhor Ghat, etc

UPSC Prelims MCQ

Q. With reference to the Western Ghats, consider the following statements:

1. The Western Ghats are recognised as a UNESCO World Heritage Site.

2. They are one of the world's biodiversity hotspots.
3. Major peninsular rivers such as the Godavari and Krishna originate in the Western Ghats.

Which of the statements given above are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Answer: (d)

UPSC Mains Question (15 Marks)

"Infrastructure development in ecologically fragile regions must balance economic needs with environmental sustainability and disaster resilience." Discuss with reference to the Wayanad tunnel landslide.

4.Right to be Forgotten (RTBF)

Source: *The Hindu*
Subject: Polity & Governance | Fundamental Rights | Data Protection

Why in News?

- The **Delhi High Court**, in **Laksh Vir Singh Yadav v. Union of India**, laid down principles governing the **Right to be Forgotten (RTBF)** under **Article 21**, balancing **privacy, dignity, freedom of expression and the principle of open justice**.

Key Highlights and Significance

- It recognises the **Right to be Forgotten** as an integral part of the **Right to Privacy under Article 21**.
- It allows individuals to seek **erasure or de-indexing of personal information** that is no longer relevant, causes disproportionate harm and serves no overriding public interest.
- It balances **privacy rights** with **freedom of speech and expression under Article 19(1)(a)** and the principle of **open justice**.

- It directs that in judicial records **only the names of parties may be masked**, while the factual record remains available.
- It provides a **structured proportionality test** for deciding requests relating to removal of digital information.

Legal Framework and Challenges

- It originated from the **2014 Google Spain (Mario Costeja González) judgment** of the **Court of Justice of the European Union (CJEU)**.
- It is codified under **Article 17 of the European Union's General Data Protection Regulation (GDPR)** as the **Right to Erasure**.
- It derives constitutional protection in India from the **K.S. Puttaswamy v. Union of India (2017)** judgment, which recognised **privacy as a Fundamental Right**.
- It is only partially recognised under the **Digital Personal Data Protection (DPDP) Act, 2023**, which provides a limited consent-based right to erasure but does not specifically address judicial records.
- It faces implementation challenges due to archived content, mirror websites, social media platforms and the absence of a fully operational **Data Protection Board**.

Way Forward

- It requires a comprehensive statutory framework defining the scope and limitations of the **Right to be Forgotten**.
- It needs operationalisation of the **Data Protection Board** under the **DPDP Act, 2023**.
- It should establish a transparent mechanism involving **digital platforms, regulators and courts** for deciding erasure requests.
- It must balance **individual privacy, public interest, transparency and freedom of expression** through proportionality.
- It requires stronger accountability mechanisms for digital intermediaries to ensure timely compliance.

About the Right to be Forgotten (RTBF)

- **Meaning:** Right of an individual to seek removal, de-indexing or erasure of personal information from public access where continued availability is unjustified.
- **Constitutional Basis (India): Article 21 (Right to Life and Personal Liberty)**.
- **Related Fundamental Right: Article 19(1)(a)** (Freedom of Speech and Expression).

- **Landmark Indian Judgment: K.S. Puttaswamy v. Union of India (2017)**.
- **Major Delhi HC Judgment: Laksh Vir Singh Yadav v. Union of India**.
- **International Basis: Article 17 of the EU General Data Protection Regulation (GDPR)**.

UPSC Prelims MCQ

Q. With reference to the Right to be Forgotten, consider the following statements:

1. It is recognised as part of the Right to Privacy under Article 21 of the Constitution.
2. Article 17 of the European Union's General Data Protection Regulation (GDPR) codifies the Right to Erasure.
3. The Digital Personal Data Protection Act, 2023 explicitly provides for the removal of judicial records under the Right to be Forgotten.

Which of the statements given above are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Answer: (a)

UPSC Mains Question (15 Marks)

"The Right to be Forgotten reflects the growing importance of informational privacy in the digital age. Discuss the constitutional basis of this right in India and examine the challenges in balancing privacy with transparency and freedom of expression."

5.Pinaka Long-Range Guided Rocket

Source: *The Hindu*
Subject: Science & Technology | Defence

Why in News?

- The **Defence Research and Development Organisation (DRDO)** successfully conducted the **flight test of the Pinaka Long-Range Guided Rocket** from the

Integrated Test Range (ITR), Chandipur, validating its **minimum strike range of 60 km** with high precision.

Key Highlights and Significance

- It validated the **user-defined minimum strike range of 60 km** with high accuracy.
- It demonstrated **precision strike capability** through successful in-flight manoeuvres.
- It confirmed the capability of a **common launcher** to fire different variants of the Pinaka rocket system.
- It strengthens the **Indian Army's long-range artillery firepower** and operational flexibility.
- It reinforces **Atmanirbhar Bharat** through indigenous development of advanced rocket artillery systems.

About Pinaka Multi-Barrel Rocket Launcher (MBRL)

- It is an **indigenously developed Multi-Barrel Rocket Launcher (MBRL)** designed by **DRDO** for the Indian Army.
- It was developed to replace the **Russian BM-21 Grad** rocket launcher system.
- It consists of a **launcher vehicle, loader-cum-replenishment vehicle, fire control system and command post vehicle**.
- It can fire a **salvo of 12 rockets in about 44 seconds**, providing rapid area saturation.
- It is capable of operating in **all-weather conditions** with high mobility and quick deployment.

Variants and Capabilities

- **Pinaka Mk-I:** It has a strike range of about **38–40 km** and is currently in service.
- **Pinaka Guided (Mk-II):** It has a strike range of about **60–75 km** with improved navigation and guidance systems.
- **Pinaka Extended Range (ER):** It has a strike range of up to **90 km**, featuring enhanced propulsion and aerodynamics.
- It supports multiple warhead types, including **High Explosive (HE), incendiary and anti-tank munitions**.
- It significantly enhances India's **deep strike capability, battlefield mobility and indigenous defence manufacturing**.

Way Forward

- It requires accelerated induction of advanced **Pinaka variants** into the Indian Army.
- It needs greater indigenous development of **guided munitions, propulsion systems and precision guidance technologies**.
- It should expand export opportunities under **Defence Exports and Atmanirbhar Bharat** initiatives.
- It requires integration with advanced **surveillance, targeting and network-centric warfare systems**.
- It should strengthen collaboration between **DRDO, private industry and the armed forces** for next-generation artillery systems.

UPSC Prelims MCQ

Q. With reference to the Pinaka Multi-Barrel Rocket Launcher (MBRL), consider the following statements:

1. It is an indigenously developed rocket artillery system designed by DRDO.
2. It was developed to replace the BM-21 Grad rocket launcher in the Indian Army.
3. The latest guided variant has enhanced precision and an extended strike range compared to the original version.

Which of the statements given above are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Answer: (d)

UPSC Mains Question (15 Marks)

"Indigenous artillery systems such as the Pinaka Multi-Barrel Rocket Launcher have significantly enhanced India's self-reliance and conventional military capability." Discuss.