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To The Point

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GS Paper 3 – Science & Technology

1 DRDO's Major Leap: India Advances in Hypersonic Propulsion Technology

Context: The **Defence Research and Development Laboratory (DRDL)**, a key unit of **DRDO**, has successfully completed ground testing of an **Active-Cooled Scramjet Subscale Combustor**.

The test, conducted for over **1000 seconds**, marks a significant achievement towards developing indigenous **hypersonic weapon technology** in India.

Understanding Hypersonic Propulsion Technology:

Hypersonic propulsion is a cutting-edge domain focused on enabling vehicles to travel at speeds exceeding **Mach 5** (five times the speed of sound).

Applications:

- **Hypersonic cruise missiles**
- **Advanced aerospace systems**

What is a Mach Number?

A **Mach number** represents the ratio of the object's speed to the speed of sound. For instance, Mach 5 means five times faster than the speed of sound.

Key Features of Hypersonic Propulsion:

Air-Breathing Engines:

Hypersonic vehicles employ **Scramjet Engines** (**Supersonic Combustion Ramjet**) which **breathe atmospheric oxygen** for combustion, eliminating the need to carry onboard oxidizers. This significantly enhances the **efficiency** and **range** of hypersonic vehicles.

Scramjet Engine: The Core of Hypersonic Flight

What is a Scramjet?

A **Scramjet** is a type of **air-breathing engine** designed to operate efficiently at hypersonic speeds. Unlike conventional engines, it allows **supersonic combustion** of incoming air.

Key Differences: Scramjet vs Ramjet

- **Ramjet**: Slows down incoming air to **subsonic speeds** before combustion.
- **Scramjet**: Maintains **supersonic airflow** throughout the combustion process, enabling much higher speeds.

Working Principle:

- Utilizes the vehicle's **forward motion** to compress incoming air without using any **rotating compressors**.

India is now the **fourth country** — after the **USA**, **Russia**, and **China** — to successfully demonstrate **flight testing** of a Scramjet engine.

Importance of the Latest Scramjet Test:

Validation of Long-Duration Supersonic Combustion:

- The successful **1000-second test** confirms the **design reliability** and **efficiency** of India's scramjet technology.

- It builds upon the earlier **120-second test** held in **January**, showcasing continuous progress.

Boost to India's Hypersonic Missile Program:

- **Scramjet engines** enable **air-breathing propulsion**, reducing dependency on onboard oxidizers and significantly enhancing **missile range** and **payload capacity**.
- This successful test lays the groundwork for **full-scale flight testing** of **hypersonic cruise missiles** in the near future.

GS Paper 3 – Indian Economy

2 Overseas Remittances by Indians under LRS Drop by 29%

Context: Overseas remittances by Indian residents under the **Liberalised Remittance Scheme (LRS)** of the **Reserve Bank of India (RBI)** declined by **29%** to **$1,964.21 million** in **February 2025**, compared to **$2,768.89 million** in **January 2025**.

What is the Liberalised Remittance Scheme (LRS)?

- **LRS** is part of the **Foreign Exchange Management Act (FEMA), 1999**, which governs outward remittances from India.
- Under **LRS**, **resident individuals**, including minors, can **freely remit up to $250,000** per financial year for permissible **current or capital account transactions**.
- **Permitted purposes** include:
  - **Education abroad**
  - **Medical treatment overseas**
  - **Purchase of property**
  - **Investment in foreign stocks**

Recent Update:

The **Union Budget 2025** raised the threshold for collecting **Tax Collected at Source (TCS)** on LRS transactions from **7 lakh to 10 lakh**.

This move is expected to **boost outbound tourism**, **foreign education**, and **airline sectors** by reducing upfront tax burdens.

Reasons Behind the Decline:

1. Drop in Indian Students Abroad:

- A sharp decline of **at least 25%** was recorded in the number of **Indian students** receiving **study permits** in **Canada**, the **United States**, and the **United Kingdom** during **2024**.

2. Volatile Global Economy:

- Economic and market volatility led many individuals to **postpone or cancel** their **travel** and **investment plans**.

Understanding Remittances:

What are Remittances?

- **Remittances** refer to the **electronic transfer of money** to individuals, often **family members**, residing in another country.
- Typically sent by those employed in **blue-collar** or **skilled jobs** overseas.

Why are Remittances Important?

- They provide a **significant source of income** for many countries.
- Help **stabilize economies**, support **local consumption**, and even **finance national trade deficits**.

Modes of Remittance Transfer:

- **Banks**

- **Money Transfer Operators**
- **Digital Platforms**

Types of Remittances:

Type	Description
Inward Remittance	Funds transferred **into India** from abroad.
Outward Remittance	Funds transferred **from India** to another country.

India's Remittance Landscape:

Overall Growth:

- **India's remittances** more than **doubled**, rising from **$55.6 billion in 2010-11** to **$118.7 billion in 2023-24** — a **trickle turning into a flood**.

Contribution by Countries:

- **United States and United Kingdom**: Together accounted for **40%** of India's inward remittances in **FY24**, up from **26%** in **FY17**.
- **United States**: Emerged as the **top source**, contributing **nearly 28%** in **FY24**.
- **United Arab Emirates (UAE)**: Still the **second-largest** contributor with **19.2%**, driven mainly by Indian migrants in **construction**, **healthcare**, **hospitality**, and **tourism** sectors.
- **Singapore**: Saw an **increase** in its share to **6.6%** in **FY24**, the **highest** since **FY17**.

State-wise Distribution:

- **Maharashtra**, **Kerala**, and **Tamil Nadu** received **half of all remittances**.
- Other states like **Haryana**, **Gujarat**, and **Punjab** had **smaller shares** (below 5%).

Size of Remittances:

- **28.6%** of remittances were **above 5 lakh**.
- **40.6%** of remittances were **16,500 or less**.

GS Paper 3 – Defence Technology

3 Hydrogen Bomb Innovation: A Game-Changer for Modern Warfare

Context: Chinese researchers have reportedly tested a **new hydrogen bomb** that uses **magnesium hydride** to sustain a **fireball** — achieving a thermonuclear reaction **without using traditional nuclear materials**.

What is a Hydrogen Bomb?

A **Hydrogen Bomb**, or **Thermonuclear Bomb**, traditionally operates through a **two-stage detonation process**:

- **Primary Stage (Fission Trigger)**: Uses **fissile material** such as **uranium-235** or **plutonium-239** to generate immense **heat and pressure**.
- **Secondary Stage (Fusion Reaction)**: Under extreme conditions, **hydrogen isotopes** (**deuterium** and **tritium**) undergo **fusion**, releasing an energy yield **many times greater** than a pure fission bomb.

What is a Fissile-Free Hydrogen Bomb?

China's breakthrough represents a **fissile-free thermonuclear device**. Instead of relying on fission, **alternative ignition systems** are used:

- **Inertial Confinement Fusion (ICF)**: High-powered **lasers** compress and heat a small pellet of **hydrogen isotopes** to initiate **fusion**.
- **Magnetic Compression (Z-pinch Systems)**: **Magnetic fields** rapidly compress plasma to achieve the **high pressure** needed for **fusion** reactions.

Key Difference: No **uranium** or **plutonium** is required, making it **technically non-nuclear** under traditional definitions.

Key Concerns Arising from this Innovation:

1. Legal Loopholes:

- **Nuclear treaties** like the **Nuclear Non-Proliferation Treaty (NPT)** and **Comprehensive Test Ban Treaty (CTBT)** focus on **fissile material**.
- **Fissile-free devices** could **bypass treaty restrictions**, **undermining global arms control efforts**.

2. Ease of Development:

- **Fusion fuels** like **deuterium** and **tritium** are **less regulated** compared to fissile materials.
- **Fusion technologies** are **embedded in civilian research** (e.g., energy programs), making **dual-use activities** harder to monitor.

3. Proliferation Risk:

- **Rogue states** or **terror groups** could exploit the **new pathway** to build powerful weapons **without conventional nuclear infrastructure**.

4. Asymmetric Warfare Implications:

- Compact, **high-yield**, and **non-radioactive** bombs could be:
  - Used in **covert operations**.
  - Deployed in **gray-zone warfare** tactics.

- **Smuggled** across borders.
- **Disguised** as industrial accidents.

Way Ahead:

Redefining International Law:

- **Update the CTBT** to explicitly ban **non-fissile thermonuclear tests**.
- **Rethink definitions** of nuclear weapons based on **energy yield**, not merely **material composition**.

Strengthening Verification Mechanisms:

- Establish a **Fusion Weapons Verification Body (FWVB)** under the **International Atomic Energy Agency (IAEA)**, similar to the **Organisation for the Prohibition of Chemical Weapons (OPCW)**.

India's Strategic Response:

- **India**, guided by its **credible minimum deterrence** doctrine, must address the **emerging strategic uncertainties**.
- **Invest** in technologies that can **detect non-radiological fusion detonations** to safeguard national security.

GS Paper 1 – Geography

4 Yellowstone Supervolcano: Latest Discovery and Its Implications

Context: A **"breathing" cap of magma** has been discovered inside the **Yellowstone supervolcano**, according to a **new study**.
This discovery could help scientists **better predict** when Yellowstone might **erupt next**.

About the Yellowstone Supervolcano:

Location:

- Lies **beneath Yellowstone National Park**, in the **western United States**.
- Recognized as one of the **largest active volcanic systems** in the world.

What is it?

- **Yellowstone** is a **caldera** — a **large crater** formed after the collapse of land following a major volcanic eruption.
- It is part of an **active supervolcanic system**, continuously monitored for activity.

Size of the Caldera:

- Measures about **55 x 72 kilometers** (**34 x 45 miles**).

Formation of the Caldera:

- Formed when **pyroclastic material** explosively ejected from the volcano, **partly emptying the magma chamber**.
- As the **magma chamber emptied**, the **roof collapsed**, creating a **bowl-shaped depression** in the ground.

Eruption History:

Yellowstone has experienced **three colossal eruptions** at the **Yellowstone hotspot**:

Event	Approximate Time
1st Major Eruption	**2.1 million years ago**
2nd Major Eruption	**1.3 million years ago**
3rd Major Eruption	**640,000 years ago**

- Two of these eruptions released such massive amounts of material that Yellowstone earned its status as a **supervolcano**.

What is a Supervolcano?

- A **supervolcano** is defined as a volcano that has erupted **more than 1,000 cubic kilometers** of deposits in a single event.
- **Supervolcanic eruptions** are extremely rare but **catastrophically powerful**.

Potential Impact of Another Eruption:

- A future **supervolcanic eruption** at Yellowstone could:
    - **Blanket North America** in **ash**.

- Areas near the hotspot could be buried under **more than one meter** of debris.

Climate Effects:

- **Supervolcanoes** release significant amounts of **sulfur dioxide** into the atmosphere during eruptions.
- **Sulfur dioxide** forms **aerosols** that **block sunlight**, leading to **global cooling** for several years.
- This cooling effect would eventually **fade** as the sulfur dioxide **washes out** of the atmosphere.

GS Paper 1 – Geography

5 Zero Shadow Day (ZSD): A Fascinating Celestial Event

Context: The **Cosmology Education and Research Training Center (COSMOS)** in **Mysuru**, under the **Indian Institute of Astrophysics**, recently observed **'Zero Shadow Day'**.

What is Zero Shadow Day?

Zero Shadow Day (ZSD) is a unique **celestial phenomenon** where **no shadow** of any **vertical object** is seen at a particular location.

Why does it happen?

- It occurs when the **Sun is exactly overhead** at noon.
- On this day, the **Sun's declination** becomes **equal to the latitude** of the location.
- As the **Sun crosses the local meridian**, its rays **fall exactly vertically** on objects, **eliminating their shadows**.

Scientific Explanation:

- Due to the **tilt of Earth's axis** and its **revolution around the Sun**, the **angle of sunlight** hitting Earth changes throughout the year.
- This change in the Sun's angle affects **shadow lengths and directions**.
- When the Sun is exactly overhead, shadows **disappear briefly**, creating the **Zero Shadow Day** effect.

When Does Zero Shadow Day Occur?

- **ZSD happens twice a year** for locations between the **Tropic of Cancer** and the **Tropic of Capricorn**.
- It corresponds to:
    - **Uttarayan** (when the Sun moves **northward**).
    - **Dakshinayan** (when the Sun moves **southward**).

Duration: The exact "zero shadow" moment lasts for **a fraction of a second**, but the visible effect can persist for about **one to one-and-a-half minutes**.

Where Can It Be Observed in India?

- ZSD can be seen in regions **south of Bhopal**, covering a wide range of Indian states, including:

Region	States/UTs
Southern and Western India	**Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Goa, Maharashtra**
Eastern India	**Odisha, Jharkhand, West Bengal, Tripura, Mizoram**
Union Territories	**Andaman & Nicobar Islands, Puducherry, Daman & Diu, Dadra & Nagar Haveli**
Central India	**Chhattisgarh, Southern parts of Madhya Pradesh**
Western India	**Most of Gujarat**

Zero Shadow Day is a **remarkable reminder** of the **dynamic relationship** between **Earth and the Sun**, and how **simple observations** can reveal profound truths about **our planet's movements**.

GS Paper 3 – Environment and climate change

6 Climate Crisis and Gender-Based Violence: Urgent Call to Action

Context: A **report** released by the **UN Spotlight Initiative** highlights a growing crisis: **climate change is worsening gender-based violence (GBV)**, particularly in **vulnerable communities**.

The **report predicts** that by **2100**, climate change could be responsible for **1 in 10 cases of intimate partner violence (IPV)** if urgent action is not taken.

Understanding the UN Spotlight Initiative:

The **Spotlight Initiative** is a **global partnership** between the **European Union (EU)** and the **United Nations (UN)**, dedicated to **eliminating violence against women and girls (VAWG)** worldwide.

Key Findings from the UN Report on Climate and Gender-Based Violence:

Climate Change Intensifies GBV:

- A **1°C rise in temperature** results in a **4.7% increase** in **intimate partner violence (IPV)**.
- With **2°C of warming**, **40 million more women and girls** could face IPV annually by **2090**. This number more than doubles with **3.5°C of warming**.
- Limiting the temperature increase to **1.5°C** could reduce IPV rates from **24%** to **14%** by **2060**.

Disaster-Induced Violence & Underreporting:

- In **2023**, **93.1 million people** faced climate disasters, and **423 million women** suffered IPV.
- **Heatwaves** caused a **28% rise** in **femicide**. Post-disaster situations often lead to an increase in **child marriage**, **human trafficking**, and **sexual exploitation**.
- Gender-based violence is described as a **"shadow pandemic"**, with **one in three women** globally experiencing **physical, sexual, or psychological abuse**, and only **7%** of survivors reporting the incidents.

Vulnerable Groups at Highest Risk:

- **Women in poverty**, **informal settlements**, **agriculture**, **Indigenous communities**, **those with disabilities**, the **elderly**, and **LGBTQ+ individuals** are at **higher risk** of GBV due to limited support systems.
- **Women advocating for environmental rights** face **harassment**, **violence**, **abduction**, and **even murder**.

Huge Gap in Gender-Climate Funding:

- Only **0.04%** of **climate-related development assistance** focuses on **gender equality**, signaling a massive gap in addressing GBV within climate action.

Key Recommendations from the UN Report:

Integrating GBV in Climate Policy:

- It is crucial to **mainstream GBV prevention** into all climate policies and programs at the **local, national**, and **global** levels, with an increase in **gender-focused climate funding**.

Prioritize Women's Safety and Leadership:

- **Ensure women** are central to **climate solutions** as both **leaders** and **beneficiaries**.
- **Acknowledge and address** GBV as a **barrier to climate resilience**, making it a core part of **sustainable development** efforts.

Supporting Women's Movements:

- Strengthen the capacity of **civil society organizations** and **women's movements**, such as the **Pacific Feminist Community of Practice**, to ensure **gender justice** is central to **global climate platforms** like **COP27**.

Adopting International Best Practices:

- Implement **gender-responsive programs** as seen in **Vanuatu**, **Liberia**, and **Mozambique**, linking **gender justice** with **climate resilience**.
- Key measures include:
  - **Retraining former FGM practitioners** in **climate-smart agriculture**.
  - **Embedding GBV services** in **disaster response**.
  - Deploying **mobile health clinics** in **climate-affected areas**.