AI BASICS: CPU, GPU AND TPU

What is a CPU (Central Processing Unit)?

- The **CPU** is a **general-purpose processor** that was developed in the **1950s** and can handle **a wide variety of tasks**.
- It functions like a **conductor in an orchestra**, coordinating the operations of all other computer parts like **GPUs, disk drives, and memory units**.
- A CPU contains **cores** — individual units that execute instructions. Early CPUs had **only one core**, but modern CPUs may contain **2 to 16 cores**.
- **Each core can handle one task at a time**, so a CPU's **multitasking capacity** depends on the **number of cores**.
- For everyday users, **2 to 8 cores** are usually sufficient, and CPUs are so efficient that users rarely notice that tasks are completed **sequentially, not simultaneously**.

What is a GPU (Graphics Processing Unit)?

- A **GPU** is a **specialised processor** designed to **perform many tasks simultaneously**, using a technique called **parallel processing**.
- Unlike CPUs, which process tasks **sequentially**, GPUs break down complex tasks into **thousands or millions of smaller problems**, solving them in **parallel**.
- Modern GPUs contain **thousands of cores**, making them far more suitable for **intensive computational tasks**.
- Initially developed for **rendering graphics** in gaming and animation, GPUs are now widely used in **machine learning and artificial intelligence**.
- GPUs have evolved into **general-purpose parallel processors**, making them a **key tool** in running **AI models** and handling large data operations.
- However, GPUs have **not replaced CPUs**, because certain operations are **better handled sequentially**, which is the **strength of CPUs**.

What is a TPU (Tensor Processing Unit)?

- A **TPU** is also a **type of ASIC (Application-Specific Integrated Circuit)**, meaning it is **built for a specific function** — in this case, **AI tasks**.
- First introduced by **Google in 2015**, TPUs are **specially designed hardware units** built **from the ground up** to handle **machine learning operations**.
- TPUs focus on processing **tensors** — the **multidimensional data arrays** used in AI model computations.
- They are optimised to **run neural networks efficiently**, enabling **faster training** and **execution of AI models** than GPUs or CPUs.
- For example, **training an AI model** that may take **weeks on a GPU** can often be completed in **hours using a TPU**.
- TPUs are used at the core of **Google's major AI services**, such as **Search, YouTube**, and **DeepMind's large language models**, illustrating their real-world application in high-scale AI infrastructure.

PM VIDYALAXMI SCHEME

- It is a **Central Sector Scheme** to provide **financial support to meritorious students** in their pursuit of **higher education.**

- **Eligibility**:
  - The scheme targets **students** who have **secured admission to** any of India's **top 860 Quality Higher Education Institutions (QHEIs), both private and governm**ent, as **ranked by the National Institutional Ranking Framewo**rk (NIRF).
  - **Students who receive any other** Central/State Government **Scholarship**, interest subvention plan, or fee reimbursement are **not eligible** for benefits under the PM Vidyalakshmi scheme.

- **Students who stop their studies** in between **or are dismissed** from the institution **on disciplinary or academic grounds are not eligible** for interest subvention or credit guarantee under this scheme.

- **How much loan can you avail under the PM Vidyalakshmi scheme?**
  - There is **no upper limit** on the amount of education loan you can get under the PM Vidyalakshmi scheme.
  - It will **depend on course fees and other fees charged by the QHEI** and other associated expenses like mess, hostel fees, other refundable and non-refundable fees of the institution, the cost of a reasonable-quality laptop, and a reasonable amount of living expenses required by the student during the course period.
- **Interest subvention:**
  - **A student** whose annual **family income is up to Rs 8 lakhs** and who is pursuing any course from QHEIs will be **eligible to get 3% interest subvention** for **education loans up to Rs 10 lakhs.**
  - If the education **loan amount is more than Rs 10 lakhs, interest subvention** will be **provided** for the disbursed total principal amount of loan **up to Rs 10 lakhs.**
- **Credit Guarantee:** When the **education loan** sanction amount is **up to Rs 7.5 lakhs, irrespective of family income**, the student will be **eligible for a credit guarantee** where **75% of outstanding default** will be covered by the government.

CHINA'S RARE EARTH CURBS DISRUPT GLOBAL ELECTRONICS SUPPLY CHAIN

China has effectively halted global exports of key rare earth elements (REEs) and magnets, including yttrium and dysprosium, following its April 4 announcement in retaliation to U.S. tariffs.

While the move targets the U.S., the absence of a licensing regime has disrupted shipments to all countries, impacting industries reliant on REEs like defense, aviation, and electronics.

Rare Earth Elements (REEs)

- These are a group of 17 chemically similar elements, including 15 lanthanides plus scandium and yttrium.
- Despite their name, they are relatively abundant in the Earth's crust but are rarely found in concentrated, economically exploitable forms.
- **Significance of REEs**
    - **Critical for Modern Technology**
        - REEs are essential in the manufacturing of high-tech devices like smartphones, electric vehicles, wind turbines, LED lights, and flat-screen TVs.
    - **Defense and Aerospace Use**
        - They are used in precision-guided missiles, jet engines, radar systems, and other military equipment.
    - **Green Energy Transition**
        - Vital for clean energy technologies such as solar panels, batteries, and permanent magnets in wind turbines and electric vehicles.
    - **Strategic Importance**
        - Due to their wide applications and limited global suppliers (especially China's dominance), REEs are considered strategically important for national security and economic stability.
- **Challenges**
    - Mining and refining are environmentally damaging.
    - Global supply is heavily concentrated, with China refining over 85% of REEs, creating vulnerability for other nations.

Global Supply Crunch Looms

- With China producing the majority of the world's REEs, the current export halt is expected to spark a global supply crunch, particularly impacting the U.S., Japan, Vietnam, and Germany.

Limited Impact on India

- India is expected to face minimal disruption from China's REE export curbs due to its relatively low domestic consumption, despite a gradual rise in demand.

India Explores Andaman Seabed for Rare Earths

- In a parallel move, India launched an auction in November for seven seabed blocks in the Andaman Sea.
- These blocks are rich in polymetallic nodules and crusts, which may contain valuable heavy rare earth elements.

STATUS OF BIRTH AND DEATH REGISTRATIONS IN INDIA

Gaps in Registration

- RGI issued a circular on March 17 noting that around 10% of births and deaths in India are still not registered.
- While 90% registration has been achieved, the goal of 100% universal registration remains unmet.
- **Legal Provisions and Penalties**
  - The Registration of Birth and Death (**RBD**) Act, 1969—amended in 2023—makes it mandatory to register all births and deaths.
  - Under **Section 23(2),** registrars who are negligent in performing their duties may face fines, which have been increased from ₹50 to up to ₹1,000.

Responsibility for Registration Under the Civil Registration System (CRS)

- Under the Civil Registration System (CRS), governed by the RGI, government hospitals act as registrars for births and deaths.
- Private hospitals are required to report such events to the designated registrar so that certificates can be issued to the families.

- **Role of State Authorities and Departments**
  - The RBD Act empowers the RGI to coordinate with Chief Registrars appointed by State governments.
  - Registration duties vary across States:
    - **Health Departments** manage registration in States/UTs like Assam, Chandigarh, Haryana, Lakshadweep, Meghalaya, Odisha, Punjab, Sikkim, and the Andaman & Nicobar Islands.
    - **Panchayat Departments** handle it in Kerala.
    - **Directorate of Economics and Statistics** manages it in Bihar.
- **Centralised Digital Registration System**
  - Following the 2023 amendment to the RBD Act (effective from October 1, 2023), all births and deaths in India must be **digitally** registered through the Centre's Civil Registration System portal.
  - Chief Registrars and Registrars are mandated to share this data with the Central database maintained by the RGI.
  - This ensures uniformity, transparency, and seamless integration across government services.

Centralised Portal for Birth and Death Registration

- **Foundation for NPR and NRC**
  - The centralized registration system feeds into the National Population Register (NPR), which has a database of 119 crore residents.
  - The NPR, updated in 2015, is seen as a precursor to the National Register of Citizens (NRC).
  - Each resident's information is linked through a unique registration number, connecting documents like Aadhaar and birth certificates — starting from birth, thereby creating a unified digital identity trail.

INDIA, RISING POWER DEMAND AND THE 'HYDROGEN FACTOR'

The Necessity of Electrification and Hydrogen Integration

- The **bulk of current fossil fuel usage is for purposes beyond electricity generation**, notably in providing heat and essential molecules in industrial processes.
- For instance, **carbon from coal is a critical component in steel production**, while hydrogen derived from natural gas is vital in manufacturing ammonia, a key input in fertiliser production.
- **Transitioning to a net-zero economy** mandates **replacing these fossil-derived molecules with cleaner alternatives.**
- In this context, **hydrogen becomes indispensable**, not just as an energy carrier but also as a feedstock substitute in industrial operations.
- **In steel manufacturing, for example, hydrogen can substitute carbon**, enabling a cleaner reduction of iron ore.
- Similarly, **widespread electrification must be complemented by strategic deployment of hydrogen,** especially where direct electrification is impractical or inefficient.

Rising Power Demand and the Role of Nuclear Energy

- Forecasts by energy researchers indicate **a significant increase in power demand as India progresses toward a developed,** net-zero economy.
- While **solar, wind, and hydroelectric power are critical components** of the energy mix, **they alone cannot meet the growing electricity requirements.**
- **Nuclear energy**, with its capability to provide stable and continuous power, **becomes an essential complement.**
- Recognising this, **the Indian government has set an ambitious goal of achieving 100 GW of installed nuclear capacity by 2047.**
- The **Nuclear Power Corporation of India Limited (NPCIL) is actively working to realise this vision** through the deployment of Pressurised Heavy Water Reactors (PHWRs).

Challenges in Balancing Low-Carbon Energy Sources

- **The Challenge of Grid Stability in a Low-Carbon Future**
  - As nations transition toward low-carbon energy systems, **one of the most pressing operational challenges is balancing electricity supply and demand** in real time.
  - In a fossil fuel-dominated system**, this balancing act is relatively straightforward**, conventional coal or gas-fired plants can be ramped up or down as needed to match demand.
  - However, **in a system dominated by low-carbon sources** like solar, wind, hydro, and nuclear, **maintaining grid stability becomes far more complex.**
- **Intermittency and Operational Constraints of Renewables**
  - **Solar and wind energy,** while environmentally sustainable, **are inherently intermittent and variable.**
  - **Solar generation peaks during the day and drops to zero at night**, while wind patterns are less predictable and can vary by region and season.
  - **Hydroelectric power is more consistent but is constrained by geography** and seasonality.
  - **Nuclear energy, on the other hand, provides a stable and continuous source of power but is typically designed to operate best at a constant**, "base load" output rather than being flexed to follow demand fluctuations.

Conclusion

- **The road to a net-zero economy is complex** and multifaceted, requiring a coordinated transformation of energy generation, industrial practices, and policy frameworks.
- **Electrification, coupled with the strategic use of hydrogen, holds the key** to decarbonizing end-use sectors.
- **Nuclear power, with its base-load stability, must be integrated into the energy mix** to meet growing demand.

ETALIN HYDROELECTRIC PROJECT

- It is a **3,097 MW** hydropower project planned in the **Dibang Valley of Arunachal Pradesh.**
- It is one of the largest hydropower projects proposed in the country in terms of installed capacity.
- EHEP is proposed to be developed as a **combination of two run-of-the-river schemes.**
- The project proposes the construction of t**wo concrete gravity dams**, 101.5 metres and 80 metres high, on the **Dri and Tangon rivers**, which are **tributaries of the Dibang**
- The project area **falls under the "richest bio-geographical province of the Himalayan zone"** and "one of the **mega biodiversity hotspots** of the world".
- The **project area** is **dominated by indigenous** populations belonging to **Idu-Mishmi tribes.**
- The project is being executed through the Etalin Hydro Electric Power Company Limited, a joint venture company of Jindal Power Limited and Hydro Power Development Corporation of Arunachal Pradesh Limited (a Govt. of Arunachal Pradesh Undertaking) with an **ownership stake of 74% and 26%, respectively.**