

14. PHYSICS OF EMERGING TECHNOLOGIES

1 VSAQ = 2 MARKS

✍ CONCEPTS & DEFINITIONS ✍

1. **Physics is the language of nature:**

- 1.1 **Physics is everywhere** from falling apples to orbiting planets, physics explains the universe and also helps us invent new technologies.
- 1.2 **Physics drives innovation** the same laws of motion, energy, and matter are now being used to build machines, computers, and medical tools that were once only science fiction.

2. **AI(Artificial Intelligence) & ML(Machine Learning):**

- 2.1 **AI and ML in Physics** computers use artificial intelligence and machine learning to analyze huge amounts of scientific data and find patterns that humans would take many years.
- 2.2 **Gravitational waves:** AI was used by LIGO to detect gravitational waves in 2015 — ripples in space-time caused by massive cosmic events like black hole mergers.
- 2.3 **CERN and particle physics-** ML helps classify collision events and identify signatures of known particles at CERN.

3. **Physics in Robotics:**

- 3.1 **Robotics** — robots are built using mechanics, electromagnetism, and thermodynamics to mimic human and animal movement.
- 3.2 **Robot example** — Boston Dynamics' Spot (four-legged robot) uses dynamics, control theory, and Newton's laws to walk on rough terrain.
- 3.3 **Robots in industries** — robotics is used in manufacturing (assembling cars) and healthcare (surgical operations).

4. **Physics in Nanotechnology:**

- 4.1 **Nanotechnology** — science of manipulating matter at the atomic scale of 1 to 100 nanometers using quantum and classical physics.
- 4.2 **Quantum effects at nanoscale** — at this tiny scale, properties like conductivity and strength change dramatically due to quantum effects.
- 4.3 **Carbon nanotubes** — 50,000 times thinner than a human hair, stronger than steel, highly conductive, used in bendable smartphone screens.
- 4.4 **Nanotechnology applications** — targeted drug delivery in medicine, efficient solar cells in energy, and smaller faster transistors in computing.

5. **Physics in Quantum Technologies:**

- 5.1 **Quantum Technologies** — use quantum mechanics, superposition, entanglement, and wave-particle duality to build powerful devices.
- 5.2 **Quantum computers** — use qubits that exist in multiple states at once (superposition), unlike ordinary computers that use bits.
- 5.3 **Quantum supremacy** — Google's Sycamore solved in 200 seconds what would take a supercomputer 10,000 years (demonstrated in 2019).
- 5.4 **Quantum future** — quantum technologies will bring breakthroughs in cryptography, drug discovery, and materials science.

6. Fusion Energy:

- 6.1 Fusion Energy** — copies the sun's process of fusing atomic nuclei together to release huge amounts of energy.
- 6.2 Fission vs Fusion** — fission splits heavy atoms; fusion combines light atoms. Fusion is cleaner and produces minimal radioactive waste.
- 6.3 ITER** (International Thermonuclear Experimental Reactor) if successful, ITER will produce 10 times more energy than it consumes — a near-limitless clean energy source.

7. Advance Smart Nano materials Science:

- 7.1 Smart Materials** — advanced science designs materials with tailored properties by manipulating atomic and molecular structures.
- 7.2 Graphene** — a single layer of carbon atoms, 200 times stronger than steel, conducts electricity better than copper, used in touchscreens.
- 7.3 Carbon-based materials** — include Graphite, Graphene, Graphene oxide, SWCNT, MWCNT, Fullerene, and Nanodiamonds.
- 7.4 Smart materials applications** — lighter aircraft, durable medical implants, and efficient energy storage.

8. Space Technologies :

- 8.1 Space Technologies** — use orbital mechanics, electromagnetism, and thermodynamics to explore and utilize space.
- 8.2 Spacecraft guidance** — Newton's laws and Einstein's relativity guide spacecraft trajectories and communications.
- 8.3 Space technology benefits** — satellite communication, climate monitoring, and potential interplanetary colonization.

9. Medical Physics :

- 9.1 Medical Physics** — applies physics principles like radiation, acoustics, and electromagnetism to diagnose and treat diseases.
- 9.2 MRI** — Magnetic Resonance Imaging uses nuclear magnetic resonance to create detailed images of organs without surgery or invasive procedures.
- 9.3 MRI principle** — atomic nuclei align with a magnetic field and emit radio waves when disturbed; relies on quantum mechanics and electromagnetic theory.
- 9.4 Medical physics tools** — X-rays, ultrasound for diagnostics; radiation therapy for treatment — saving millions of lives.

10. Biophysics :

- 10.1 Biophysics** — applies physics to understand biological systems from molecules to organisms using mechanics, thermodynamics, and electromagnetism.
- 10.2 DNA discovery** — the double helix structure of DNA was discovered using X-ray diffraction, a physics technique grounded in wave optics.
- 10.3 Biophysics today** - helping design drugs for diseases like Alzheimer's.
- 10.4 Biophysics future** — drives personalized medicine, synthetic biology, and bioengineering.

11. Photonics :

- 11.1 Photonics** — the study of light (photons) rooted in electromagnetism and quantum optics.
- 11.2 Photonics technologies** — lasers, fiber optics, and solar cells are all based on photonics principles.
- 11.3 Fiber optic cables** — transmit internet data using total internal reflection (Snell's law and wave optics); a single cable carries terabytes of data per second.
- 11.4 Photonics applications** — telecommunications, laser surgeries, and renewable energy — shaping a light-driven future.

For better concept clarity refer **PHYSI BEATS P.No: 272**

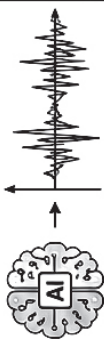
1. PHYSICS IS THE LANGUAGE OF NATURE

- Physics explains the universe from falling apples to orbiting planets.
- Laws of motion, energy & matter are used to build modern machines, computers & medical tools.



2. AI & ML

- AI & ML analyze huge scientific data and find patterns quickly.
- AI was used by LIGO (2015) to detect gravitational waves.



3. PHYSICS IN ROBOTICS

- Robots are built using mechanics, electromagnetism & thermodynamics to mimic movement.
- Example: Boston Dynamics' Spot uses dynamics & Newton's laws to walk on rough terrain.



4. PHYSICS IN NANOTECH

- Manipulating matter at atomic scale (1–100 nm) using quantum & classical physics.
- Carbon nanotubes are extremely strong, highly conductive, used in smartphone screens.



5. QUANTUM TECHNOLOGIES

- Use quantum mechanics: superposition, entanglement & wave-particle duality.
- Quantum computers use qubits in multiple states; Google's Sycamore (2019) showed quantum supremacy.



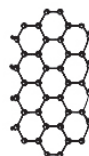
6. FUSION ENERGY

- Fusion energy copies the sun's process of fusing atomic nuclei to release huge energy.
- ITER aims to produce 10 times more energy than it consumes — a clean energy source.



7. ADV. SMART NANO MATERIALS

- Smart materials are designed by manipulating atomic & molecular structures.
- Graphene is 200× stronger than steel and conducts electricity better than copper.



8. SPACE TECHNOLOGIES

- Use orbital mechanics, electromagnetism & thermodynamics to explore space.
- Enable satellite communication, climate monitoring & future interplanetary colonization.



9. MEDICAL PHYSICS

- Applies radiation, acoustics & electromagnetism to diagnose & treat diseases.
- MRI uses nuclear magnetic resonance to create detailed images without surgery.



10. BIOPHYSICS

- Applies physics to understand biological systems from molecules to organisms.
- DNA structure was discovered using X-ray diffraction; helps in drug design.



11. PHOTONICS

- Study of light (photons) based on electromagnetism & quantum optics.
- Fiber optic cables use total internal reflection to transmit data at high speed.



14. PHYSICS OF EMERGING TECHNOLOGIES



KEY TAKEAWAY

Physics is the foundation of all modern and emerging technologies — from tiny nanoparticles to the farthest galaxies — improving our lives today and shaping a smarter, healthier and sustainable future.