

# Physics



**Short Note**  
**G-12**  
**Unit 1**  
**New**  
**curriculum!**  
**2017 E.C**

**AMBO IBSB**  
**SECONDARY**  
**SCHOOL**

## 1.1 Physics and other sciences

### Introduction

- Although there are many disciplines with a **special character** and **history** of their own, each discipline is dependent on and reinforces the other fields.
- Scientific disciplines do not have fixed borders.
- Each scientific field is benefited from advances in the other fields.
  - ✓ Important for the collaborative development of the disciplines, and its contribution for societal problem solving.

## 1.1.1 The Relationship Between Physics and Chemistry

### Overlaps between physics and chemistry

Physics and chemistry overlap when studying:

- ✓ systems involving matter composed of electrons and nuclei.
- ✓ fundamental laws governing matter.
- ✓ focus on the interaction between matter and energy

## Atomic and Subatomic Interactions

- ✓ Atomic and subatomic particle physics principles are crucial for understanding molecular bonding (covalent and ionic).

## Energy in Chemical Reactions

- ✓ Physics of heat energy determines the feasibility of chemical reactions.
- ✓ It explains the equilibrium composition of reaction systems.

## **Spectroscopy: A Bridge Between Physics and Chemistry**

- ✓ the study of interaction between **matter** and **electromagnetic radiation**.
- ✓ fundamental technique in both physics and chemistry **to examine matter at various wavelengths or frequencies**.
- ✓ Collaborative efforts between physicists and chemists have advanced these techniques.

## Exploring the Invisible World of Chemistry

**Question :** Chemistry studies minute entities like elements, atoms, molecules and ions which cannot be seen with your naked eyes.

How do chemists collect information, like composition, structure, properties, behavior and the changes they undergo during a reaction with other substances, from these minute invisible particles?

**Answer:** chemists collect information from these minute invisible particles using;

- ✓ Spectroscopy
- ✓ X-ray crystallography,
- ✓ chromatography
- ✓ microscopy, etc.

## Physics as the Foundation of Chemistry

- The study of physics underpins (support) our understanding of key concepts of chemistry like:
  - ✓ Atomic Structure – quantum mechanics
  - ✓ Molecular Structure - electromagnetism
  - ✓ X-ray Diffraction - x-rays
  - ✓ Radioactivity- nuclear physics
  - ✓ Periodic Properties of Elements - quantum physics
  - ✓ Valency and Chemical Bonds - quantum mechanics
  - ✓ Crystal Structure of Solids - solid state physics

## The Interdisciplinary Nature of Science

- ✓ Chemistry is deeply rooted in atomic and molecular physics.
- ✓ Understanding chemistry requires a strong foundation in physical principles.
- ✓ The collaboration between physicists and chemists continues to drive scientific progress.

### Summary

- ❖ Physics and chemistry are deeply interconnected.
- ❖ Atomic-level interactions and energy principles are crucial for both disciplines.
- ❖ Tools like spectroscopy demonstrate the practical overlap between the two sciences.

## 1.1.2 Relation of Physics and Biology

❖ Exploring the Intersection of Physical Laws and Living Systems

**Question:**

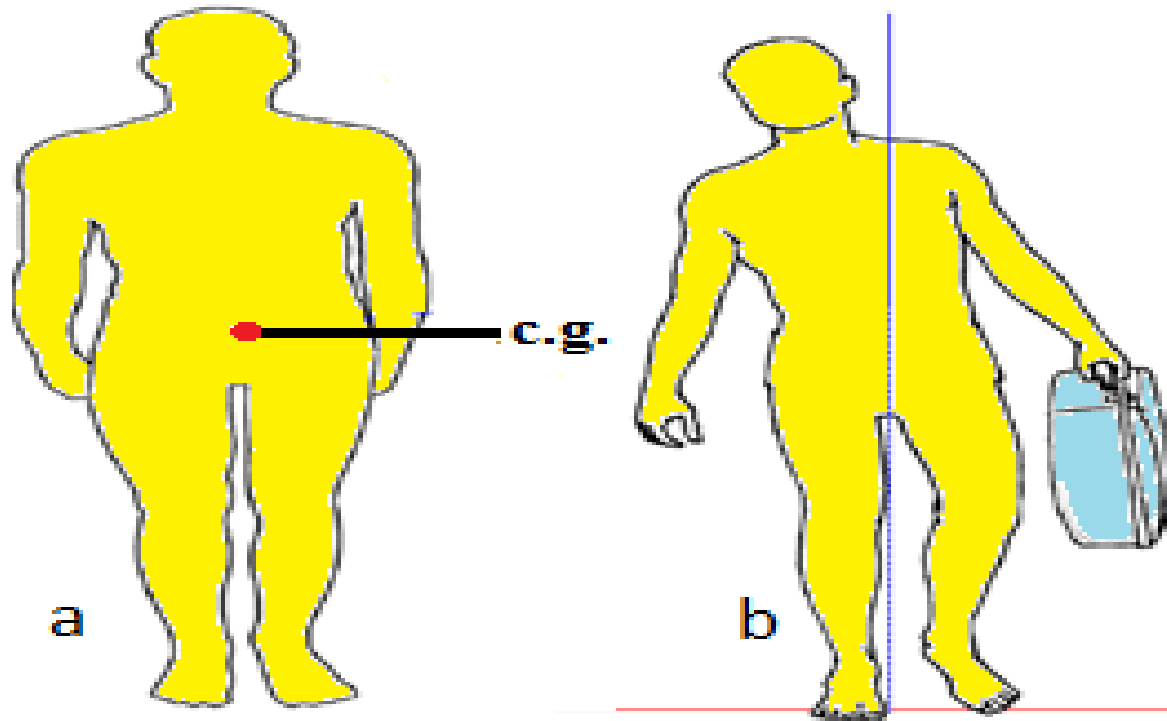
Can you list some Physics concepts in our body?

**Answer:** To understand how life works, like;

- ✓ **mechanics** of human motion
- ✓ **fluid dynamics** of blood flow
- ✓ **acoustics** of sound production, and
- ✓ **electricity** in the nervous system.

## 1. Newtonian Mechanics:

- ✓ explains **animal movement**, stability, and **balance**.
- ✓ describes how **athletes** and **animals**, like cheetahs, achieve speed.
- ✓ stability depends on the **center of mass** and **base support**.
  - *A person falls when the center of gravity moves beyond the feet*
  - *Stability increases with a wider base & lower center of gravity.*



**Figure 1.1** (a) Center of gravity of a freely standing person  
 (b) A person carrying unbalanced load stands bending

**Discussion Question**

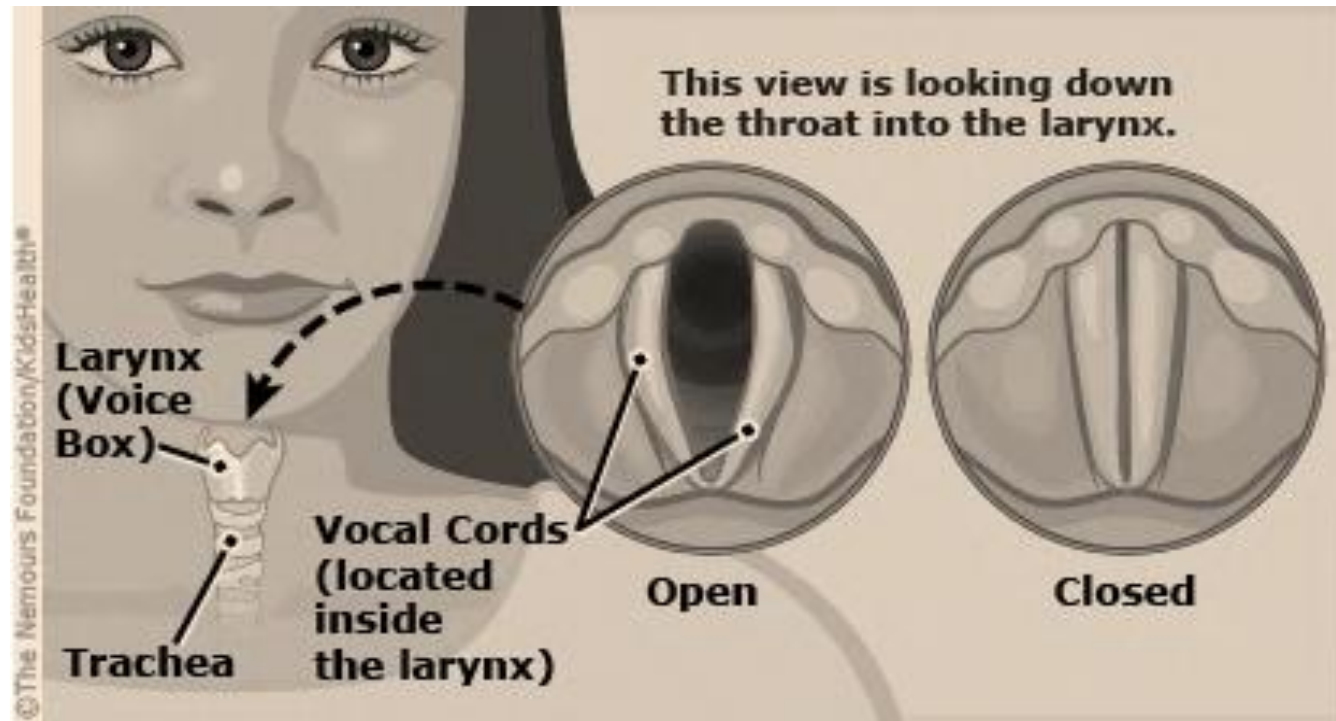
1. Why is it difficult to stand on one foot compared to two?
2. Why are we more stable when **lying down** than **standing**?

## 2. Fluid Dynamics:

- ✓ Concepts like viscosity, continuity and turbulence governs blood circulation and pressure in multicellular organisms.
- ✓ Soft-bodied animals use fluid principles, like Pascal's law, for movement

### 3. Sound Waves:

- ✓ Sound produced by **vibrating vocal cords**.
- ✓ **Sound waves** propagate through air and are interpreted by the brain.



**Figure 1.2** Sound wave generating organ in human being.

#### 4. Electricity:

- ❖ Electrical signals control **muscle movement** and **nervous system communication**.
- ❖ **Neurons** transmit information via electrical pulse
- ❖ The **brain stores & processes** information through electrical signals.
- ❖ **Sharks** have specialized organs sensitive to electric field in water.
  - ✓ *electric field detect prey & might communicate.*

#### 5. Optical Physics:

- ❖ Light is crucial for **vision** and **photosynthesis**.
- ❖ Optics covers the **function of eyes, light-based processes in organisms**, and **devices like microscopes and telescopes**.

### 1.1.3 Relation of Physics and Astronomy

#### Astrophysics:

- ✓ Studies the physics of astronomical objects like stars, planets, galaxies, and the Universe.
- ✓ Focuses on properties, life cycles, and interactions of these objects.

#### 1. Newton's Laws of Motion and Astronomy:

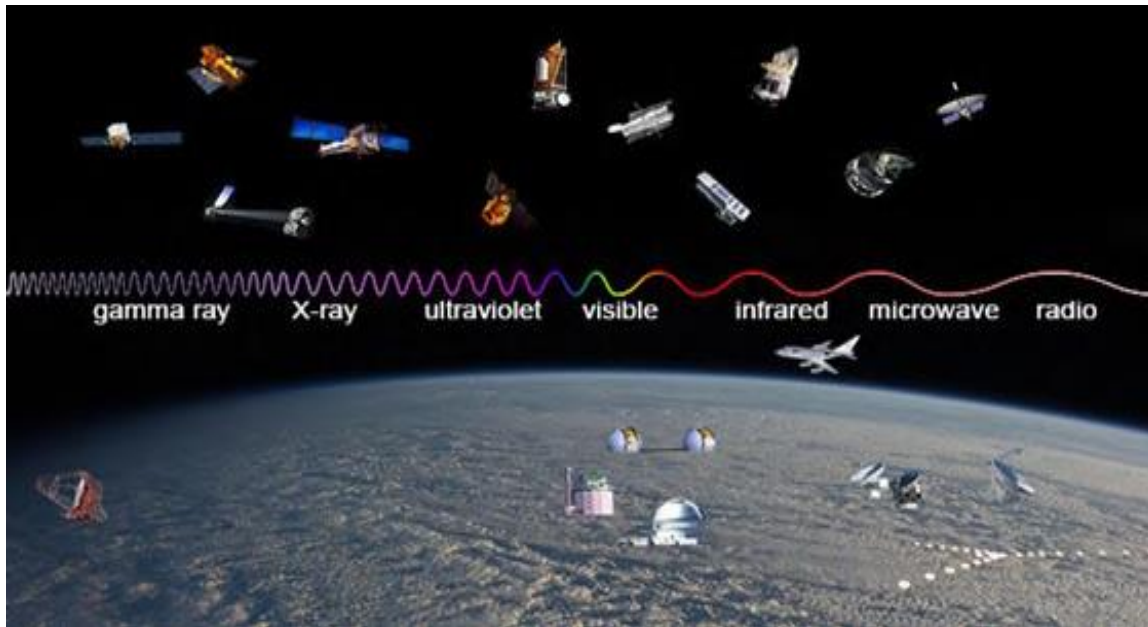
- ✓ Newton's law of gravitation explains the motion of celestial bodies.
- ✓ Kepler's Laws of planetary motion were derived using Newton's laws.
- ✓ Centripetal and centrifugal forces help understand orbital motions (e.g., planets around the Sun).

## 2. Physics of Electromagnetic Waves and Astronomy:

- ✓ Astronomers study **radiation from space objects** to understand stars, distances, and the Universe's formation.
- ✓ **Telescopes** detect various parts of the electromagnetic spectrum (radio, infrared, optical, etc.).
- ✓ **False colors** in astronomical images represent wavelengths that are not visible to the human eye.
- ✓ Light is used to measure distances of astronomical objects (inverse square law).

$$\text{apparent brightness} \propto \frac{\text{true brightness}}{\text{distance}^2}$$

- ✓ Astronomers also used **light year** as an alternate astronomical distance measuring unit.
  - ❖ A **light year** is the distance that light travels in one year.



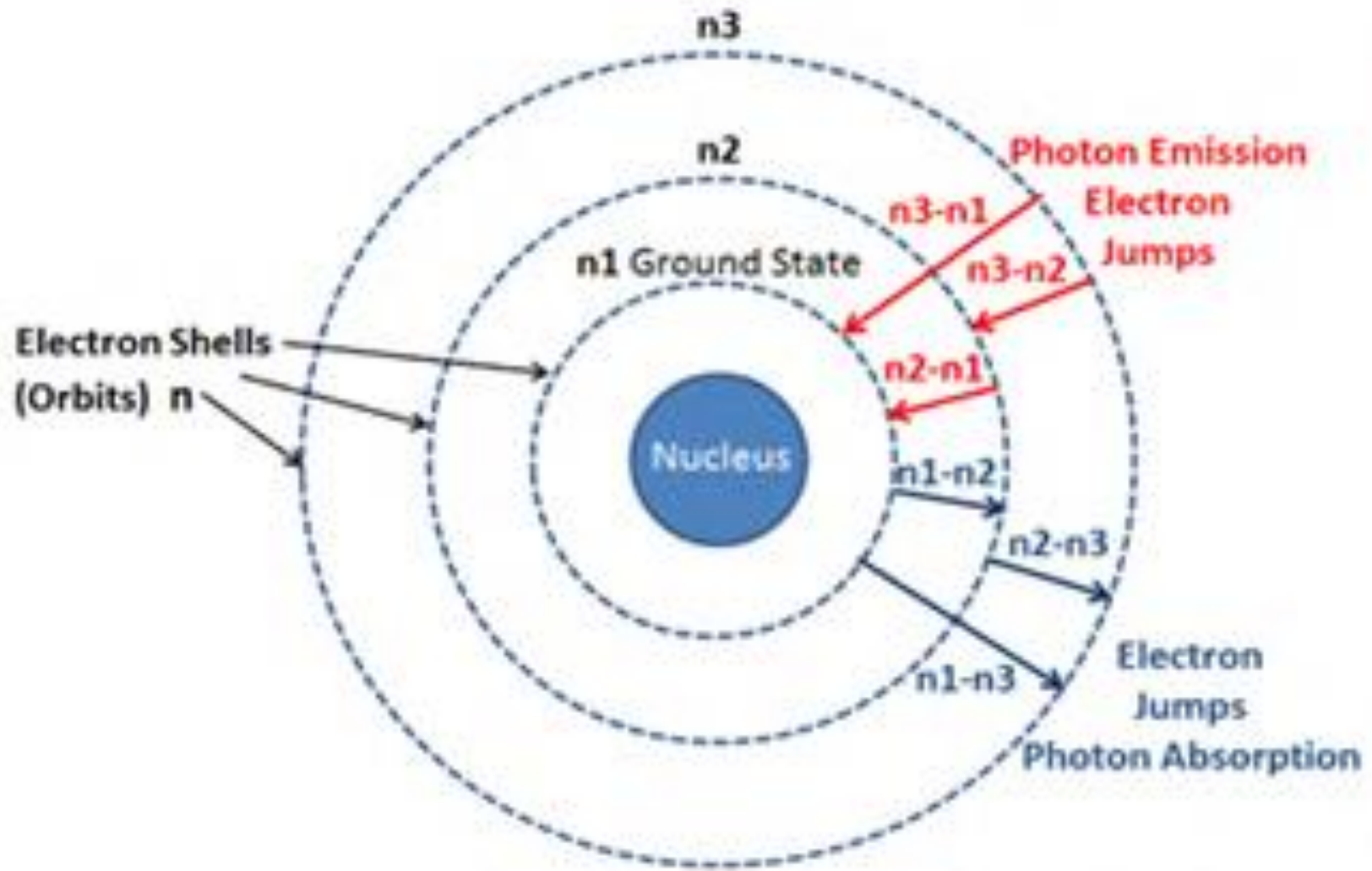
**Figure 1.3** Detection of different components of electromagnetic radiation by telescope



**Figure 1.4** Entoto space observatory telescope

### 3. Physics of Atoms and Astronomy:

- ✓ Atomic astrophysics links atomic physics with astronomical observations.
- ✓ Light emission and absorption by atoms reveal compositions, temperatures, and motions of stars.
- ✓ Atomic transitions (electron jumps) result in emission or absorption of photons.
- ✓ Emitted light helps determine the physical properties of astronomical objects.



**Figure 1.5** The Bohr atomic structure and electron transitions

## 1.1.4 Relation of Physics with Geology

### Earth Science :

- ✓ Earth science studies various components of Earth, including lava, mountains, valleys, atmosphere, and the Earth's core.

### Geology :

- ✓ Geology is a branch of Earth science focused on Earth's solid and liquid matter and processes affecting them.

### Physics in Geology:

- ✓ Physics concepts like force, optics, atomic structure, and electromagnetic radiation are essential to understanding geological processes.

### Applications in Geology:

- ✓ Physics is used to study the properties of rocks and minerals, such as electrical properties, density, magnetization, and elasticity.

### Geological Methods:

- ✓ Geologists analyze rock and mineral properties through excavation or by sending waves from the Earth's surface.

### Specialization in Geology:

- ✓ Geology has many branches, leading geologists to specialize in areas such as mineralogy, which focuses on the composition and structure of minerals.

## Economic Applications:

- ✓ Geological knowledge aids in detecting and assessing economically valuable geological deposits, like ores, fossil fuels, and groundwater reservoirs.



**Figure 1.6** Mineralogists focus on all kinds of minerals.

## 1.1.5 Physics and Engineering

➤ Fundamental physics concepts like mechanics, thermodynamics, electromagnetism and nuclear physics are essential across all engineering branches (e.g., civil, mechanical, electrical, chemical).

### 1. Civil Engineering:

- ✓ Uses physics principles (**forces**, **fluid pressure**, **gravity**) to design and construct infrastructure (e.g., skyscrapers, bridges, roads).



**Figure 1.7** Civil Engineering in (a) Suspension Bridge (Hedase Bridge) (b) Building construction (Africa Union Head Quarter, Addis Ababa) (c) Transportation Engineering (Gotera interchange road)

## 2. Mechanical Engineering:

- ✓ Applies physics concepts (**mechanics**, **thermodynamics**, **aerodynamics**) to create reliable mechanical systems (e.g., engines, vehicles, robotics).



**Figure 1.8** Mechanical engineering design

### 3. Electrical Engineering:

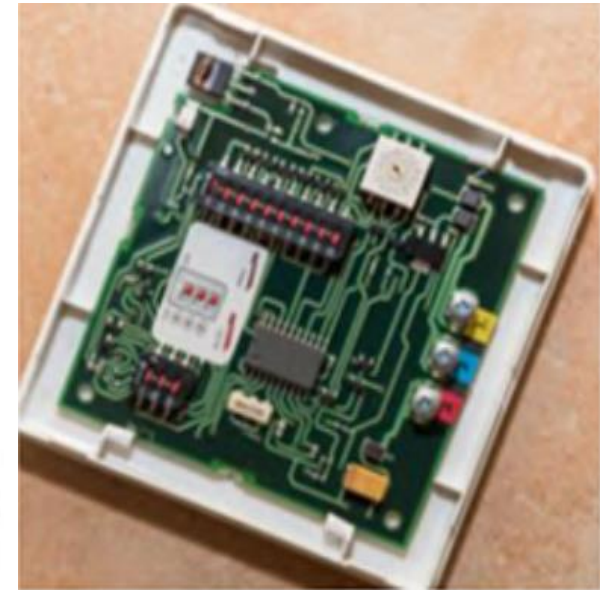
- ✓ Involves designing electrical circuits and systems, requiring knowledge of **electromagnetism**, **mechanics**, and **thermodynamics**.



(a)



(b)



(c)

**Figure 1.9** Areas electrical engineering concerns (a) electrical system for installation and maintenance (b) Electric power transmission and management (c) Electric circuit

#### 4. Chemical Engineering:

- ✓ Focuses on chemical processes and production, relying on **physical chemistry** and **thermodynamics** to ensure efficiency and effectiveness.



**Figure 1.10** Some chemical Engineering products (a) plastics (b) petroleum products (c) detergents and (d) paints

## Technology Generating New Physics

### Interconnection of Physics and Technology:

- ✓ Physics provides the foundational principles for technology.
- ✓ Technological advancements enable new scientific discoveries.

### Role of Science and Engineering:

- ✓ Science seeks to understand the natural world using technology.
- ✓ Engineering applies scientific discoveries to create solutions for societal challenges.

### Impact of Technology on Physics:

- ✓ Technological innovations can lead to new physics concepts.

Examples include:

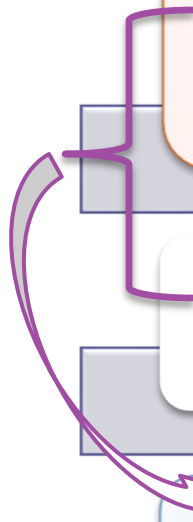
- ❖ Rocket technology facilitating space measurements.
- ❖ X-ray technology enhancing studies of atomic structure and spectral analysis.

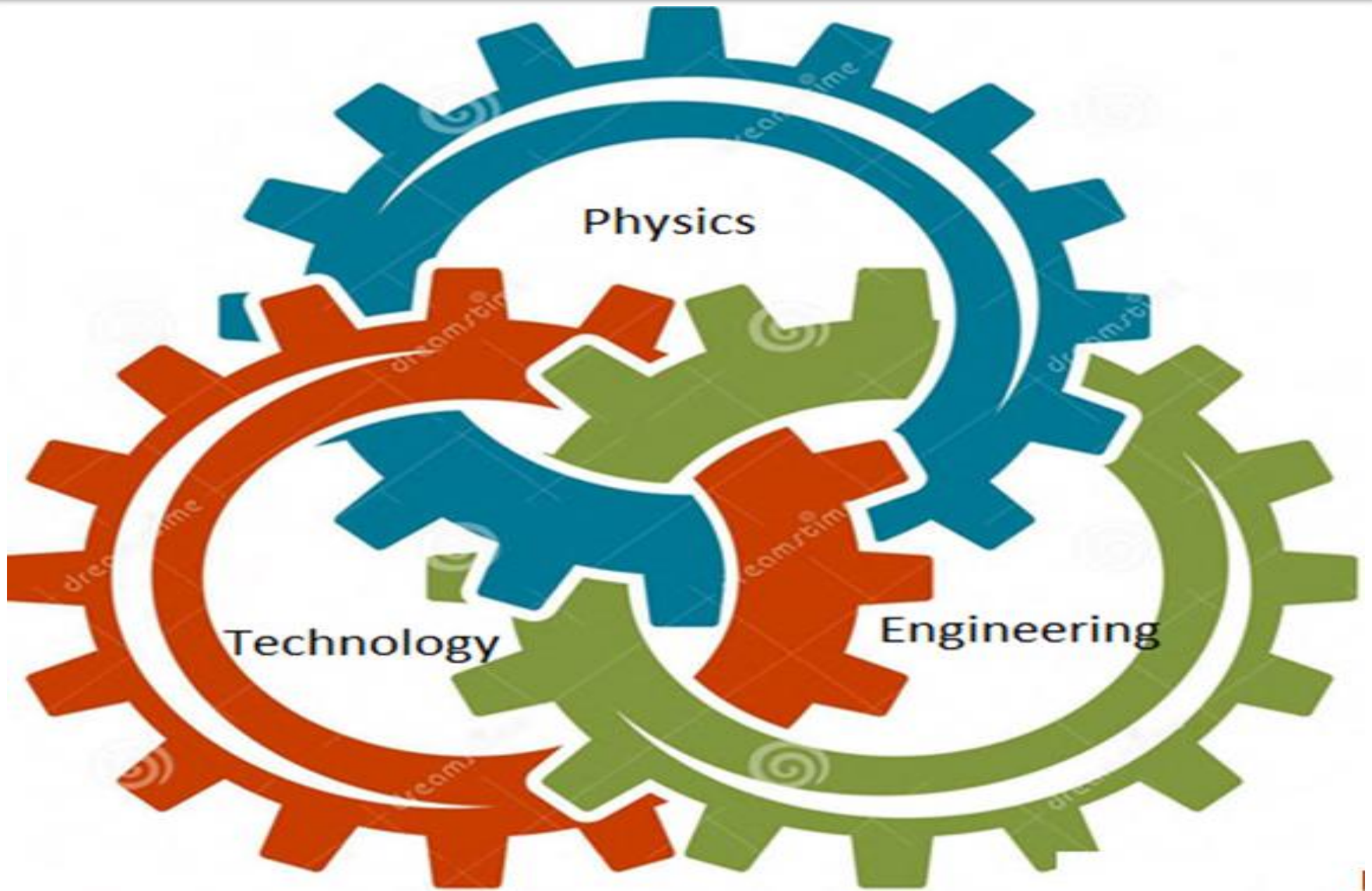
**Physics:** provides the theoretical knowledge



**Technology:** applies this knowledge in practical ways

**Engineering:** brings it all together to create solutions that enhance our lives





**Figure 1.11** Interrelation of physics, engineering and technology

### 1.1.6 Medical Physics:

- **Definition:** Medical physics is a branch of physics focused on the application of physics principles in medical **diagnosis** and **treatment** of abnormal tissues.
- **Historical Background:** The field was revolutionized by the discovery of X-rays by **Wilhelm Conrad Roentgen** in **1895**, which paved the way for medical imaging techniques.

### Medical Imaging Techniques

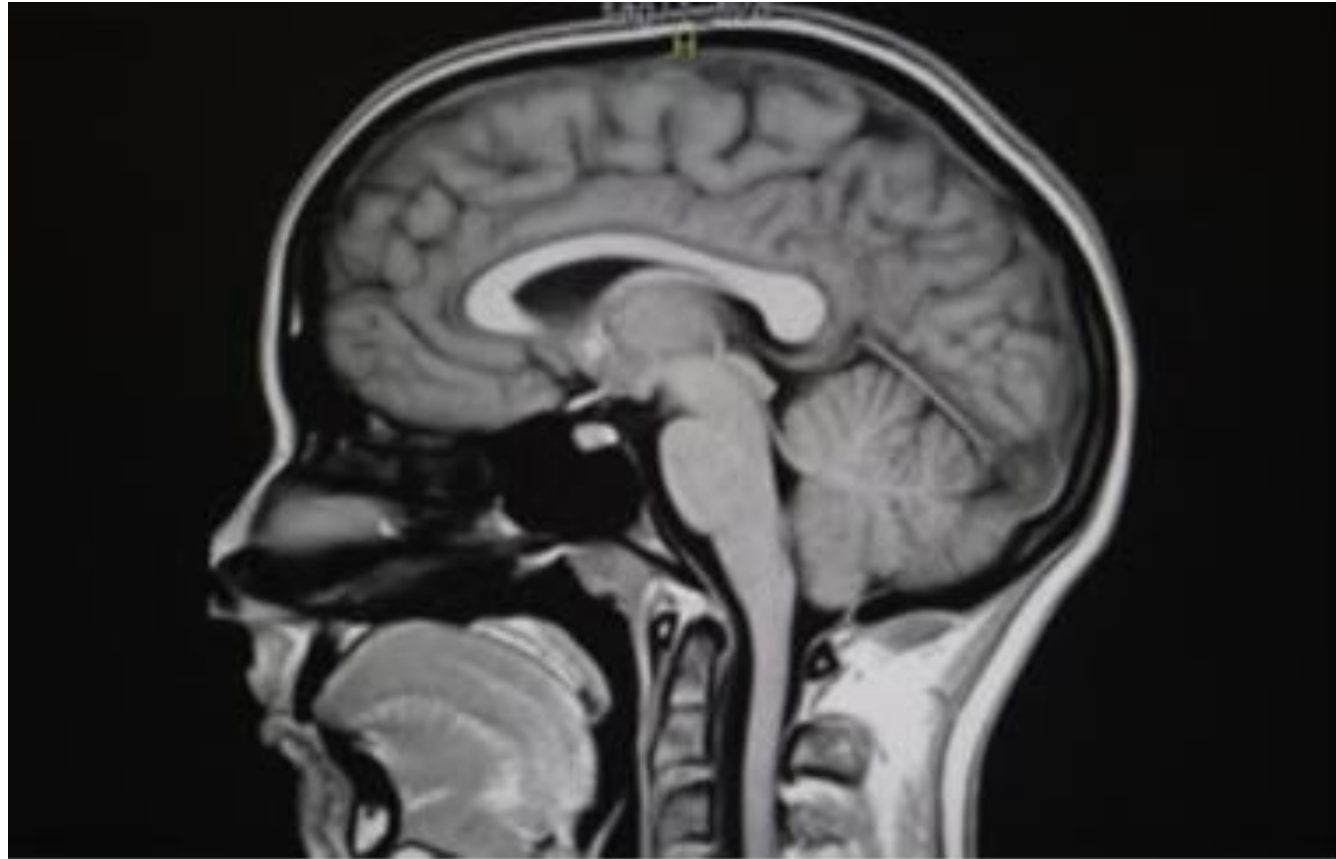
**Purpose:** Medical imaging technologies are used to view the human body for **diagnosing**, **monitoring**, or **treating** medical conditions.

## Types of Techniques:

- ✓ **Electromagnetic**: Includes optical, X-ray, MRI, and thermography.
- ✓ **Acoustic**: Includes ultrasound.
- ✓ **Chemical and Electrical**: Used in various imaging processes.

## Magnetic Resonance Imaging (MRI)

- ❖ **Principle**: MRI is based on the principle of magnetic resonance, which involves the absorption or emission of electromagnetic radiation by electrons or atomic nuclei in response to magnetic fields.
- ❖ **Historical Context**: The concept was first described by Felix Bloch and Edward Purcell in 1946, with imaging applications developed by Paul Lautenberg and Peter Mansfield.



**Figure 1.12** An MRI image of the brain. The MRI technique yields detailed visualization of soft tissue structures with a resolution of about 0.5 mm

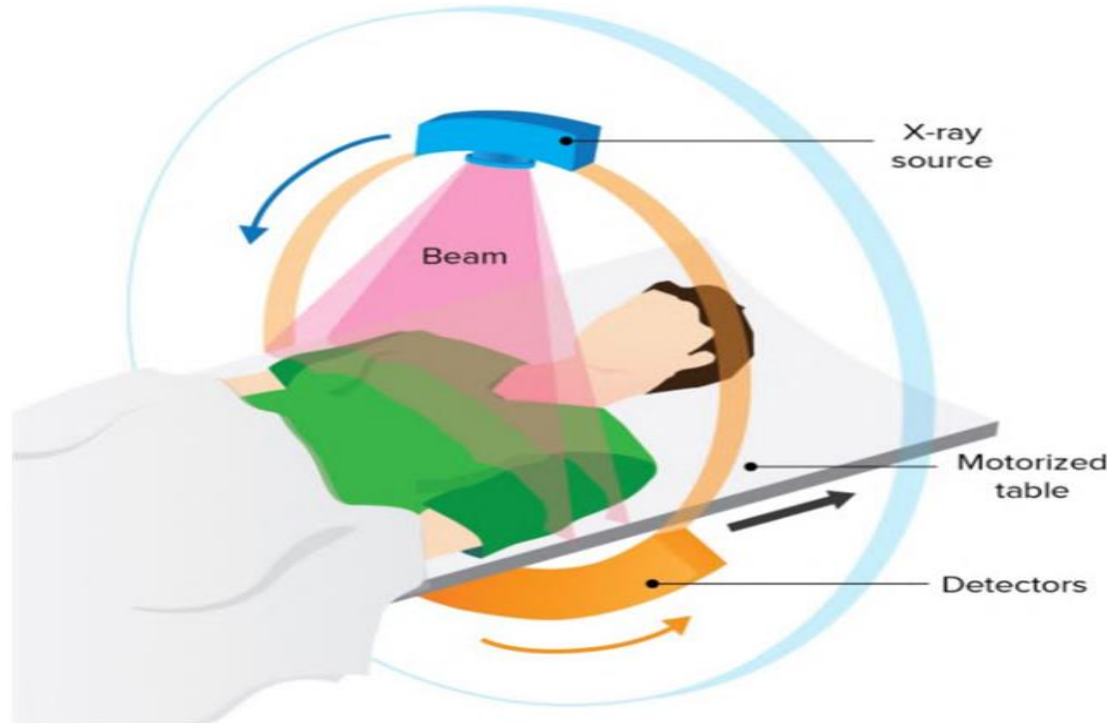
**Mechanism:**

- ✓ MRI relies on the abundance of protons in the body, primarily from water molecules.
- ✓ Protons align with a magnetic field in the MRI scanner.
- ✓ When disturbed by a current pulse, they release energy as they return to alignment.
- ✓ The energy released varies by tissue type, creating a detailed image

**X-Ray Computed Tomography (CT Scan)**

- ❖ **Principle:** X-ray imaging is based on the absorption of X-rays as they pass through different tissues, creating a shadow image (shadow gram).

- ❖ **Mechanism:** Tissues with higher atomic numbers (like calcium in bones) block X-rays more effectively, resulting in varying degrees of X-ray absorption that form an image.



**Figure 1.13** Relative arrangement and motion of X-ray source and detectors in CT scan

## Stethoscope & Ultrasound:

### i) Stethoscope

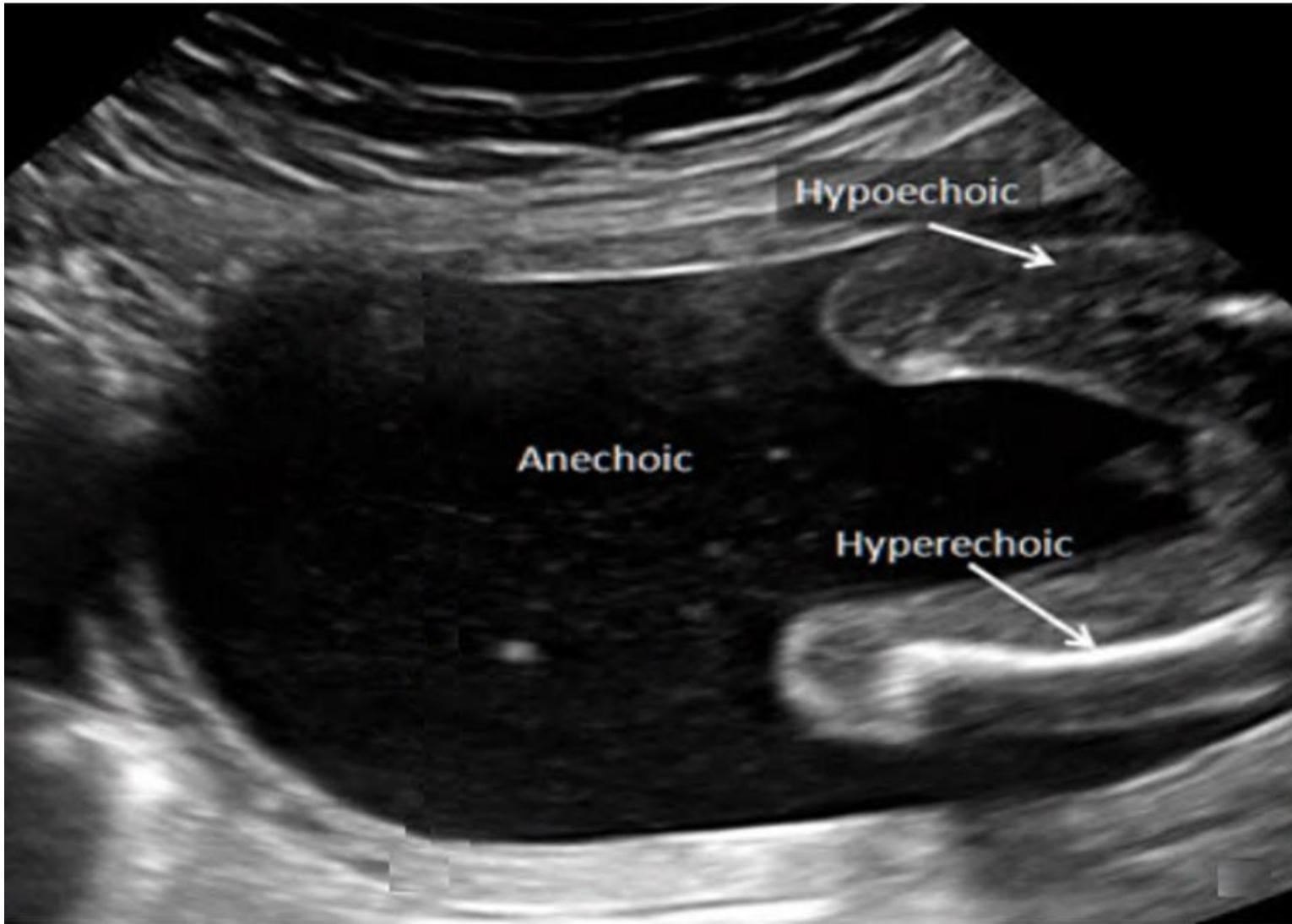
- ✓ Developed by René Laennec in 1816.
- ✓ Consists of a bell-shaped cavity and a hollow flexible tube.
- ✓ Used to listen to heart, lung, intestinal sounds, and blood flow.
- ✓ Detects sound waves ranging from tens to thousands of Hertz.



**Figure 1.14** Stethoscopes

## Ultrasound:

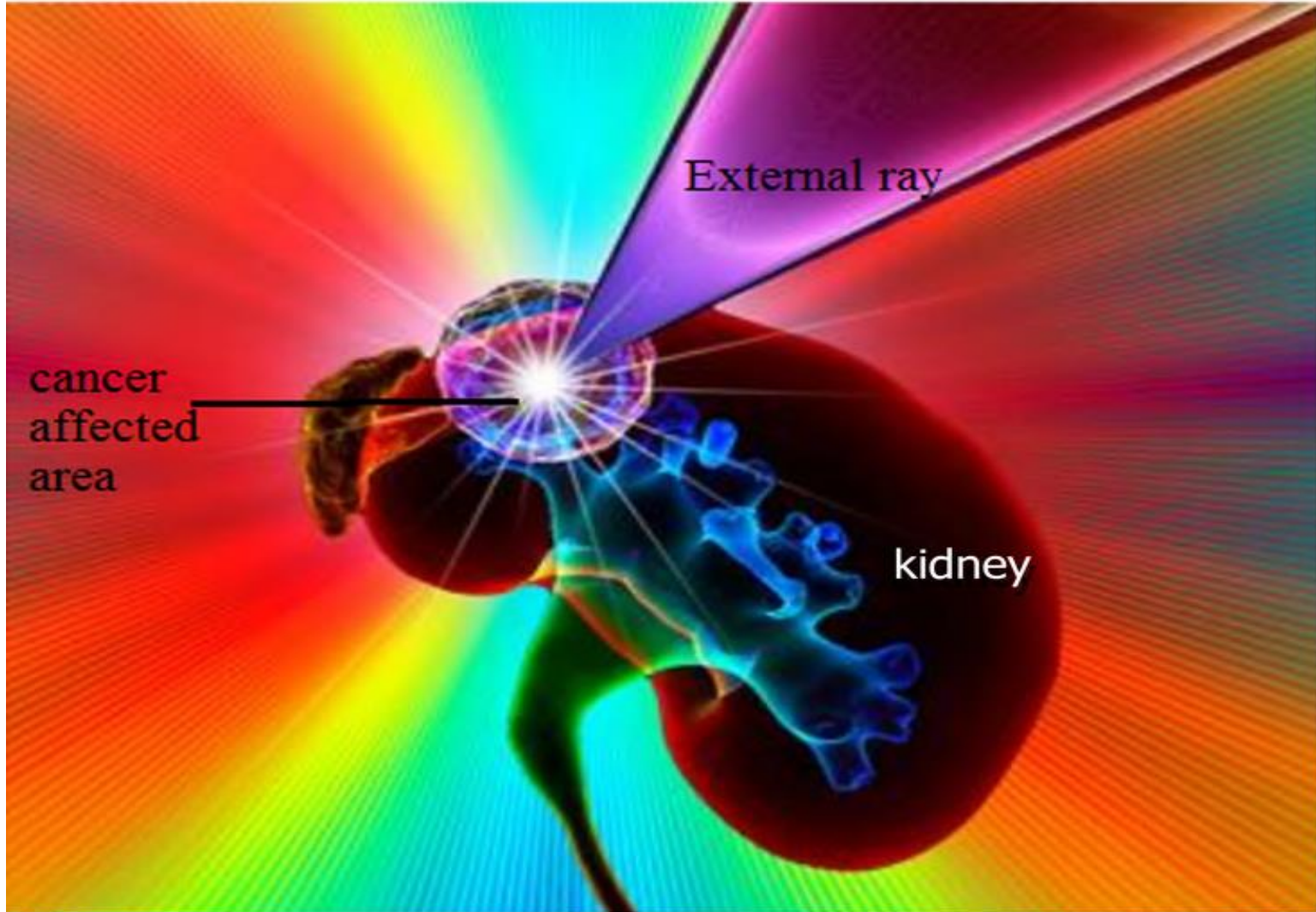
- ❖ **Principle:** Ultrasound involves high-frequency sound waves (3.5-10 MHz) that penetrate tissues and reflect back, providing information about tissue structure.
- ❖ **Mechanism:** The reflected sound waves are used to generate images described as follows (depending on the density of the tissue).
  - ✓ *anechoic- area that do not produce any echoes ( dark or black area)*
  - ✓ *hypo echoic- area that produce fewer echoes ( gray area) &*
  - ✓ *hyper echoic- area that produce more echoes (bright or white area)*



**Figure 1.15** Ultrasound image showing hyper echoic, hypo echoic and anechoic regions

### *Radiation Therapy:*

- ❖ **Principle:** Radiation therapy uses high-energy photons (X-rays, gamma rays) to treat cancer by damaging the DNA of cancer cells.
- ❖ **Mechanism:** It can be applied externally or through implanted radioactive materials, targeting cancerous tissues while minimizing damage to healthy tissues.



**Figure 1.16** Radiotherapy of kidney cancer.

## Physics and Defense Technology:

Defense Technologies Involving Physics:

- ❑ **Laser Guidance Systems:** Used for precision targeting in weapons and navigation systems.
- ❑ **Satellite Technology:** Essential for communication, surveillance, and GPS.
- ❑ **Modern Electronics:** Critical in developing advanced communication and control systems.
- ❑ **Optics and Sensing Systems:** Used in night vision, surveillance, and targeting.
- ❑ **High-Energy-Density Physics:** Involved in the development of weapons like explosives and nuclear devices.

- ❑ **Atomic and Nuclear Physics:** Fundamental for nuclear energy, weapons, and radiological detection systems.
- ❑ **Advanced Materials Physics:** Develops stronger, lighter, and more resilient materials for military use.

### Branch-Specific Physics Applications:

#### Navy:

- **Oceanographic Physics:** Understanding ocean currents, tides, and sonar.
- **Underwater Acoustics:** Sound propagation in water for submarine detection.
- **Meteorology:** Weather prediction crucial for naval operations.

**ii) Air Force:**

- **Turbulent Fluid Flows:** Essential for aircraft design and performance.
- **Navigation:** Uses principles of physics for accurate positioning and flight paths.
- **Long-Range Observation:** Advanced optics for reconnaissance and intelligence gathering.
- **Pattern Recognition:** Critical for identifying and tracking objects.

**iii) Army:**

- **Night Vision:** Uses infrared technology to see in low-light conditions.
- **All-Weather Vision:** Ensures visibility in various environmental conditions.

- **Stealth Technology:** Reducing detectability of military assets.

#### iv) Space Force:

- **Satellite Surveillance:** Monitoring space and ground activities.
- **Advanced Optics:** High-resolution imaging for reconnaissance.

#### v) Radar Technology:

RADAR (Radio Detection And Ranging) detects and tracks objects by sending out electromagnetic signals and analyzing the returned echoes.

#### Components:

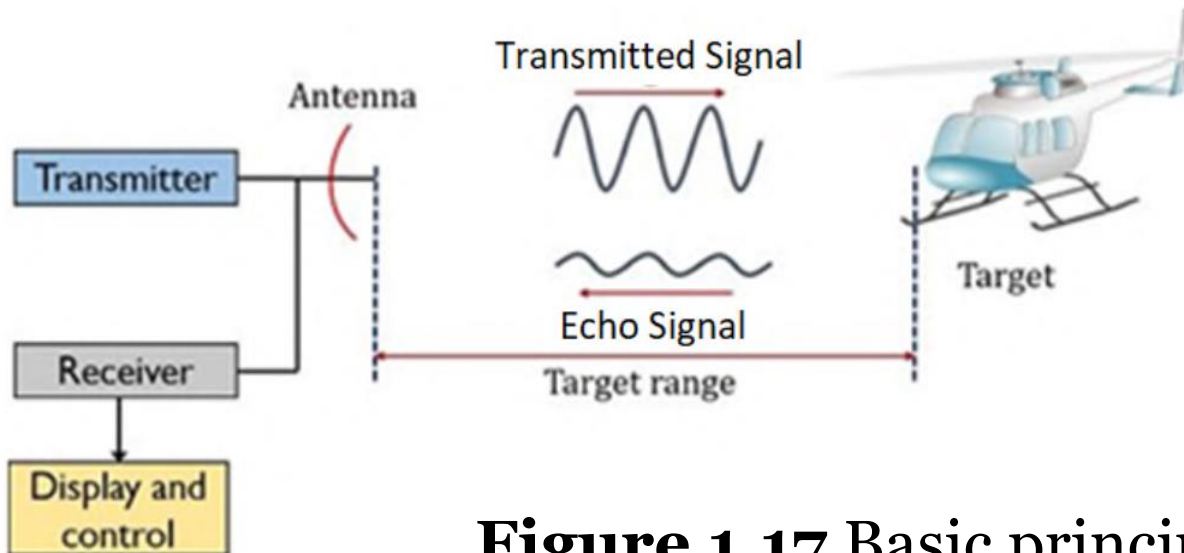
- **Transmitter:** Sends out radar signals.
- **Antenna:** Used for both transmitting and receiving signals.

- **Receiver:** Captures reflected signals and processes them.

Detection Process:

- ✓ Signal is sent towards the target.
- ✓ Target reflects the signal back.
- ✓ The time taken (t) for the signal to return is used to calculate the range (R) using the formula;

$$R = \frac{ct}{2}$$



**Figure 1.17** Basic principles of radar



**Figure 1.18** Radar system

## Military Applications of Radar:

- **Air Defense:** Detects and tracks enemy aircraft, missiles, and other threats.
- **Weapon Guidance:** Helps guide missiles and other weapons to their targets.
- **Civilian Applications:** Air traffic control, weather monitoring, ship navigation, environmental monitoring, and space observation.

### i) Infrared Light in Defense:

- **Infrared Detection:** Used for night vision to see in darkness by detecting heat emitted by objects.
- **Targeting and Tracking:** Infrared sensors help in locating and following targets, especially in low visibility conditions.



**Figure 1.19** A helicopter with Night Vision Goggles

## ii) Missile Propulsion and Tracking:

### Propulsion Types:

- **Jet-Propelled Missiles:** Use oxygen from the atmosphere to burn fuel.
- **Rocket-Propelled Missiles:** Carry their own oxygen, allowing them to operate in space.

### Types of Missiles:

- i. **Cruise Missiles:** Jet-propelled throughout their flight, capable of flying at low altitudes.
- ii. **Ballistic Missiles:** Rocket-powered during the initial phase, then follow a high-arching ballistic trajectory.

### Tracking Technology:

- ✓ Missiles use radar, GPS, and infrared systems to track and hit enemy targets with high precision.

## Role of Physicists in the Military:

- **Research and Development:** Physicists contribute to the development of advanced technologies such as laser systems, satellite technology, and nuclear weapons.
- **Optimization:** They work on improving the efficiency and effectiveness of military equipment.
- **Innovation:** Physicists are involved in creating new materials, enhancing stealth capabilities, and advancing computational methods for simulation and design.
- **Applications Across Forces:** Their work supports the Navy, Air Force, Army, and Space Force in specialized fields such as sonar, aerodynamics, and space surveillance.

## 1.7 Physics in Communication

### i) Communication Technologies:

- ✓ Communication involves transferring information from one point to another.
- ✓ Technologies like telephones, cell phones, and computers facilitate communication.

### ii) Types of Communication Systems:

- Wired Communication:** Utilizes wires and optical fibers to transmit data.
- Wireless Communication:** Relies on radio waves, microwaves, and infrared waves. Examples include satellite and ground wave communication.

### iii) Role of Physics in Communication:

- ✓ **Physics principles** are essential for understanding communication technologies.
- ✓ **Electromagnetic theory** is crucial for wireless and fiber optic communication.
- ✓ **Concepts like electricity, magnetism, electronics, and wave phenomena** (e.g., reflection, diffraction, refraction) are fundamental in the functioning of communication systems.

The end!  
Thank you!



## The Relationship Between Physics and Chemistry

1. Which physics concept is commonly applied in the separation of dissolved salt from water by evaporation?
  - A) Newton's laws
  - B) **Thermodynamics**
  - C) Electromagnetic waves
  - D) Fluid dynamics
2. Spectroscopy is a fundamental technique in both physics and chemistry. What does it primarily study?
  - A) Interaction between light and sound
  - B) **Interaction between matter and electromagnetic radiation**
  - C) Behavior of gases under pressure
  - D) The chemical composition of water



## Relation of Physics and Biology

3. Which of the following physics concepts is involved in the fluid dynamics of blood flow?
  - A) Thermodynamics
  - B) Acoustics
  - C) Fluid mechanics**
  - D) Electromagnetism
  
4. What explains the stability of animals and athletes, such as a cheetah or a standing human?
  - A) Newton's first law
  - B) Electromagnetic theory
  - C) Center of mass and base support**
  - D) Gravitational potential energy



## Relation of Physics and Astronomy

5. Newton's law of gravitation primarily explains which of the following?
- A) The chemical reactions in stars
  - B) The motion of celestial bodies**
  - C) The color of stars
  - D) The atomic structure of elements
6. What is the primary method used by astronomers to measure distances of astronomical objects?
- A) Sound waves
  - B) Light year**
  - C) X-ray diffraction
  - D) Radioactive decay



## Relation of Physics with Geology

7. Which branch of Earth science is focused on the study of Earth's solid and liquid matter?
  - A) Meteorology
  - B) Astronomy
  - C) Geology
  - D) Oceanography
8. Which physics concept is used to study the electrical properties, density, and magnetization of rocks and minerals?
  - A) Fluid dynamics
  - B) Optics
  - C) Electromagnetism
  - D) Quantum mechanics



## Physics and Engineering

9. Which branch of engineering applies physics concepts like mechanics, thermodynamics, and aerodynamics?
- A) Civil engineering
  - B) Mechanical engineering**
  - C) Chemical engineering
  - D) Electrical engineering
10. The design and construction of infrastructure, such as bridges and roads, is most related to which branch of engineering?
- A) Mechanical engineering
  - B) Electrical engineering
  - C) Civil engineering**
  - D) Chemical engineering



## Medical Physics

11. Which medical imaging technique relies on the principle of magnetic resonance?
- A) X-ray
  - B) MRI**
  - C) Ultrasound
  - D) CT scan
12. Radiation therapy primarily uses which type of radiation to treat cancer?
- A) Microwave
  - B) Infrared
  - C) Gamma rays**
  - D) Visible light



## Physics and Defense Technology

13. What is the primary purpose of radar technology in defense?
- A) Communication
  - B) Weather prediction
  - C) Detecting and tracking objects
  - D) Generating electricity
14. What type of light is used for night vision technology in defense systems?
- A) Ultraviolet
  - B) Visible light
  - C) Infrared
  - D) X-ray



## Physics in Communication

15. Which type of communication system relies on radio waves, microwaves, and infrared waves?
- A) Wired communication
  - B) Wireless communication**
  - C) Optical communication
  - D) Satellite communication
16. The fundamental theory behind fiber optic communication systems is based on which of the following?
- A) Quantum mechanics
  - B) Electromagnetic theory**
  - C) Fluid dynamics
  - D) Thermodynamics