PROPOSED LIST OF SUBJECTS AT SENIOR SCHOOL

LESSON DISTRIBUTION AT SENIOR SCHOOL

The number of lessons in each of the compulsory learning areas shall be 4; while the optional areas shall be 6 lessons each. A lesson shall be 40 minutes. The "free" lessons shall be used for development of ICT skills, Pastoral Instruction Programme (PPI), projects, collaborative study and further reading.

ESSENCE STATEMENT

Physics is a body of knowledge exploring the theories, principles and laws that govern natural phenomena observed in the physical environment. The subject builds on the competencies introduced at Junior Secondary School level under the learning area of Integrated Science. In vision 2030 and sessional papers No. 1 of 2005 and No. 1 of 2019, the importance of science, technology and innovation has been prioritized for human capital development through education and training. Therefore, Physics forms an integral part of the STEM subjects in the Basic Education Curriculum Framework. It employs a scientific methodology of study with an emphasis on experimental approach to investigation, enhancing understanding of fundamental scientific concepts and principles. This leads to the acquisition of knowledge, skills, attitudes and values through precise and accurate scientific processes. The subject provides the learner with opportunities to develop competencies by empowering them to be creative and innovative, leading to independent approaches in problem solving and management of their environment. It also prepares learners for further training and the world of work by providing careers in STEM related pathways. The content will be anchored on Kolb Theory of Experiential Learning and Constructivism theory for teaching and learning.

GENERAL LEARNING OUTCOMES

1. Relate Physics to technology and society to enhance the learner's appreciation of the physical environment.
2. Develop science process skills among learners through the use of appropriate instruments as they discover and explain the order of the physical environment.
3. Apply basic research and scientific skills to manipulate the environment and solve human problems.
4. Develop capacity for critical thinking through basic scientific skills and research in addressing pertinent & contemporary issues affecting the society.
5. Apply the principles of Physics for enhancement of innovations and entrepreneurial skills for development.
6. Use relevant skills and values to promote local and global citizenship for harmonious coexistence and appreciation of diversity in people.
7. Acquire adequate knowledge, skills, values and attitudes to enhance exploitation of individual talents for leisure, self -fulfillment, career growth, and for further education and training.
8. Apply acquired knowledge, skills, values, and attitudes for effective communication and utilization of information in technological advancement.

SUMMARY OF STRANDS AND SUB STRANDS

1. MECHANICS AND THERMAL PHYSICS

1.1 Introduction to Physics

1.2 Pressure

1.3 Mechanical Properties of Materials

1.4 Temperature and Thermal Expansion

1.5 Moments and equilibrium 15

1.6 Energy, Work, Power and Machines

2.0 WAVES AND OPTICS

2.1 Properties of Waves

2.2 Radioactivity and Stability of Isotopes

3.0 ELECTRICITY AND MAGNETISM

3.1 Electrostatics

3.2 Current Electricity

3.3 Introduction to electronics

4.0 ENVIRONMENTAL AND SPACE PHYSICS

4.1 Greenhouse Effect and Climate Change

4.2 Introduction to Space Physics

1.0 MECHANICS AND THERMAL PHYSICS:

Sub-Strand 1.1: Introduction to Physics

What is Physics?

- ✓ Physics is the science that studies matter, motion, energy, and forces.
- ✓ It aims to understand the fundamental laws of the universe.

Branches of Physics:

- ✓ **Mechanics:** Motion and forces (e.g., cars, machines).

- ✓ **Electricity & Magnetism:** Charges, currents, and magnets (e.g., generators, electronics).

- ✓ **Thermodynamics:** Heat and energy (e.g., engines, refrigerators).

- ✓ **Geometrical Optics:** Light and its behavior (e.g., lenses, mirrors).

- ✓ **Waves:** Sound and light waves (e.g., music, communication).

- ✓ **Electronics:** Circuits and devices (e.g., computers, phones).

- ✓ **Modern Physics:** Quantum mechanics, relativity (e.g., atoms, space).

- ✓ **Astronomy:** Celestial objects (e.g., stars, planets).

Importance of Physics:

- ✓ Technology: Phones, computers, internet.
- ✓ Transportation: Cars, planes, trains.
- ✓ Medicine: X-rays, MRI scans.
- ✓ Energy: Power generation, solar panels.
- ✓ Everyday life: cooking, building, weather prediction.
- ✓ Designing Transport Machines like cars,robots

Physics and Other Subjects:

- ✓ **Chemistry:** Atomic structure, reactions.
- ✓ **Biology:** Biomechanics, medical devices.
- ✓ **Mathematics:** Tools for calculations and modeling.
- ✓ **Engineering:** Designing and building.
- ✓ **Geography:** Climate and weather.

Physics, as the study of the fundamental principles governing the universe, has deep and intertwined relationships with numerous other academic disciplines. Here's a look at some key connections:

Summary of relationship

1. Mathematics:

- **The Language of Physics:**
  - ✓ Mathematics provides the essential tools for expressing and analyzing physical laws and theories. Calculus, algebra, geometry, and differential equations are indispensable in physics.
  - ✓ Physics relies on mathematical models to describe phenomena, make predictions, and interpret experimental data.

2. Chemistry:

- **Atomic and Molecular Interactions:**
  - ✓ Physics provides the foundation for understanding atomic structure, chemical bonding, and the behavior of molecules.
  - ✓ Quantum mechanics, a branch of physics, is crucial for explaining chemical reactions and properties of materials.
  - ✓ Thermodynamics, a field of physics, is also vital to the understanding of chemical reactions.

3. Biology:

- **Biophysics:**
  - Physics principles are applied to understand biological systems, such as the mechanics of movement, the flow of fluids in the body, and the functioning of the nervous system.
  - Medical imaging technologies like X-rays, MRI, and ultrasound rely on physics principles.
  - Understanding how light interacts with biological material is also an area of biophysics.

4. Engineering:

- **Applied Physics:**
  - Engineering disciplines, such as mechanical, electrical, and civil engineering, heavily rely on physics principles to design and build structures, machines, and devices.
  - Physics provides the basis for understanding materials science, thermodynamics, and electromagnetism, which are essential for engineering applications.

5. Astronomy:

- **Astrophysics:**
  - Physics is essential for understanding the universe, including the motion of celestial bodies, the formation of stars and galaxies, and the nature of black holes.
  - Astrophysicists use physics principles to analyze astronomical observations and develop theories about the cosmos.

6. Geology:

- **Geophysics:**
  - Physics principles are applied to study the Earth's structure, including earthquakes, volcanoes, and the Earth's magnetic field.
  - Geophysicists use techniques like seismic wave analysis and gravity measurements to explore the Earth's interior.

7. Computer Science:

- **Computational Physics:**
  - Physics simulations and modeling rely heavily on computer algorithms and computational power.

- Quantum computing, a rapidly developing field, utilizes principles of quantum mechanics to perform computations.

In essence, physics provides a foundational understanding of the natural world, and its principles are applied across a wide spectrum of scientific and technological fields.

Career Opportunities related to study of physics

- **Engineering:**
  - ✓ Physics provides the fundamental principles for various engineering disciplines:
    - ✓ **Electrical Engineering:** Designing and developing electrical systems, devices, and power generation.
    - ✓ **Civil Engineering:** Designing and constructing infrastructure like bridges, roads, and buildings.
    - ✓ **Mechanical Engineering:** Designing and manufacturing machinery and mechanical systems.
    - ✓ **Telecommunications Engineering:** Working with communication technologies and networks.
- **Technology:**
  - ✓ Physics is essential in the development of cutting-edge technologies:
    - ✓ **Computer Science:** Contributing to areas like computer hardware development and software engineering.
    - ✓ **Renewable Energy:** Working on solar, wind, and other sustainable energy solutions.
- **Medicine:**
  - ✓ Physics plays a crucial role in medical technologies:
    - ✓ **Medical Physics:** Operating and maintaining medical imaging equipment like X-ray and MRI machines.
    - ✓ **Radiology:** Using radiation for medical diagnosis and treatment.
- **Meteorology:**
  - ✓ Physicists work as meteorologists, analyzing weather patterns and forecasting climate.
- **Education:**
  - ✓ Physics graduates can become teachers and lecturers, inspiring future generations of scientists.
- **Research:**
  - ✓ Working in research institutions, conducting experiments, and advancing scientific knowledge.
- **Geophysics:**

- ✓ Working within the field of geophysics, to study the earths physical properties.

Career Opportunities summary:

- ✓ Physicist (research, teaching).
- ✓ Engineer (electrical, mechanical).
- ✓ Astronaut.
- ✓ Medical physicist.
- ✓ Data Scientist.
- ✓ Physics related field Teacher.

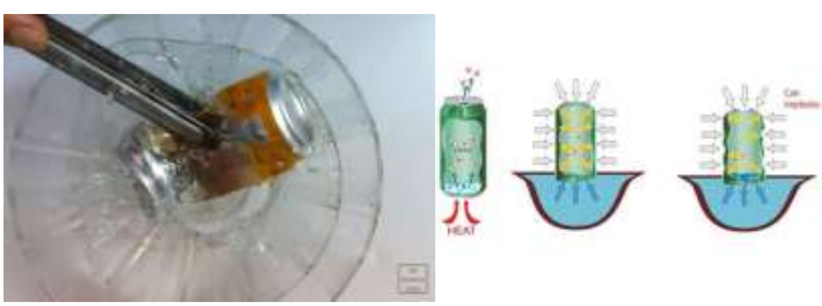
Key Points:

- Physics helps us understand how things work.
- It is essential for technological advancements.
- Many career paths are available for those with physics knowledge.

1.2 Pressure

1. Atmospheric Pressure and Its Effects

- **Definition:**
  - ✓ Atmospheric pressure is the force per unit area exerted by the weight of the air in the atmosphere. It decreases with altitude.
  - ✓ It is caused by the gravitational attraction of the Earth on the air molecules.
- **Demonstrating Atmospheric Pressure:**
  - ✓ **Crushing Can Experiment:**
    - Heat a small amount of water in a metal can until it boils.
    - Quickly seal the can and cool it with cold water.
    - The can crushes due to the higher atmospheric pressure outside.
    - **Explanation:** The boiling water turns to vapor, and displaces the air inside the can. When the can is sealed and cooled, the water vapor condenses, reducing the internal pressure. The external atmospheric pressure then crushes the can.



  - ✓ [Image of Crushing can experiment]

- ✓ **Drinking Straw:**
  - When you suck on a straw, you reduce the air pressure inside the straw.
  - The higher atmospheric pressure on the liquid's surface pushes the liquid up the straw.

- ✓ [Illustration of drinking straw action]

2. Factors Affecting Pressure in Liquids

- **Depth (h):**
  - ✓ Pressure increases with depth. The deeper you go, the more fluid is above you, exerting more weight.
  - ✓ **Density (ρ):**
    - Denser fluids exert more pressure at the same depth. For example, saltwater exerts more pressure than freshwater.
  - ✓ **Acceleration due to Gravity (g):**
    - Pressure is directly proportional to the acceleration due to gravity.
- **Experiment:**
  - ✓ Use a container with holes at different depths.
  - ✓ Observe the distance the water jets travel. The jet from the deepest hole travels the farthest, indicating higher pressure.

- ✓ [Image of Water pressure experiment with holes in a container]

3. Application of the Equation P = ρgh

- **Formula:**
  - ✓ $P=\rho gh$
  - ✓ Where:
    - ❖ P = Pressure (Pascals, Pa)
    - ❖ ρ = Density of the fluid (kg/m^3)
    - ❖ g = Acceleration due to gravity (approximately 9.8 m/s^2)
    - ❖ h = Depth below the free surface (meters, m)
- **Example:**

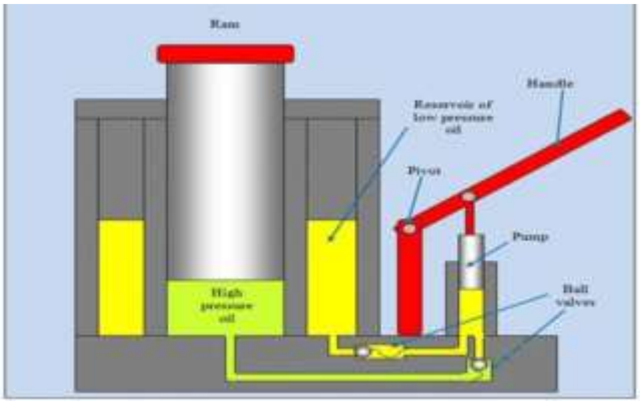
Calculate the pressure at a depth of 10 meters in freshwater (ρ = 1000 kg/m^3).

$P=(1000kg/m^3)\times(9.8m/s^2)\times(10m)=98000Pa$

Explanation: This formula quantifies the relationship between depth, density, and gravitational acceleration, allowing for precise pressure calculations.

4. Transmission of Pressure in Fluids (Pascal's Principle)

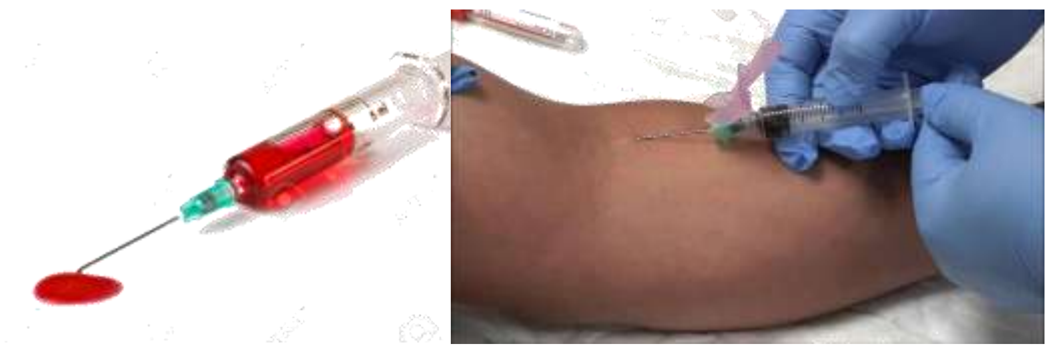
- **Pascal's Principle:**
  - ✓ Pressure applied to an enclosed fluid is transmitted undiminished to every point in the fluid and to the walls of the container.
  - ✓ **Hydraulic Machines:**
    - Hydraulic systems use Pascal's principle to multiply force.
    - Examples: Hydraulic jacks, hydraulic brakes, and hydraulic lifts.



[Illustration of hydraulic jack system]

Syringe:

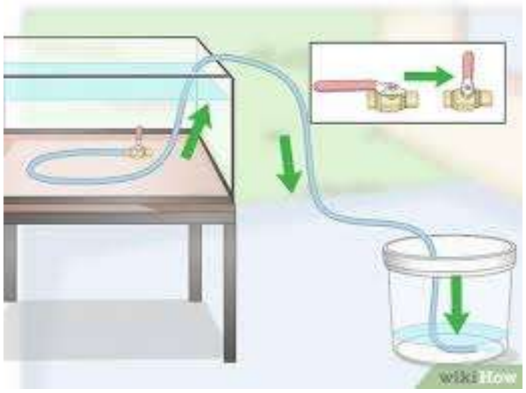
- Applying pressure to the plunger transmits the pressure to the liquid, forcing it out the needle.
- **Photograph:**



- ✓ [Photograph of syringe in use]

5. Applications of Pressure in Fluids

- **Drinking Straw:**
  - ✓ As described earlier, atmospheric pressure pushes the liquid up the straw.
- **Syringe:**
  - ✓ Used for injecting fluids or withdrawing them.
- **Syphon:**
  - ✓ A tube used to transfer liquid from a higher level to a lower level using atmospheric pressure and gravity.
  - ✓ **Illustration:**



- ✓ [Illustration of Syphon operation]
- **Hydraulic Machines:**
  - ✓ Used in various industries for lifting heavy objects and applying force.
- **Bicycle Pump:**
  - ✓ Uses air pressure to inflate tires.

  - ✓ [Photograph of Bicycle pump]
- **Mechanisms of Water Pumping:**
  - ✓ Variety of pumps exist, that use pressure differences to move water.
  - ✓ Pumps that use atmospheric pressure, and pumps that use mechanical pressure.

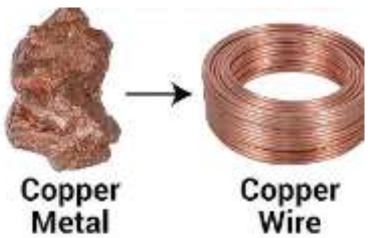
Key Concepts and Connections

- ✓ This sub-strand connects to concepts of force, area, gravity, and density.
- ✓ Understanding pressure is essential for various applications in engineering, medicine, and everyday life.

1.3 Mechanical Properties of Materials

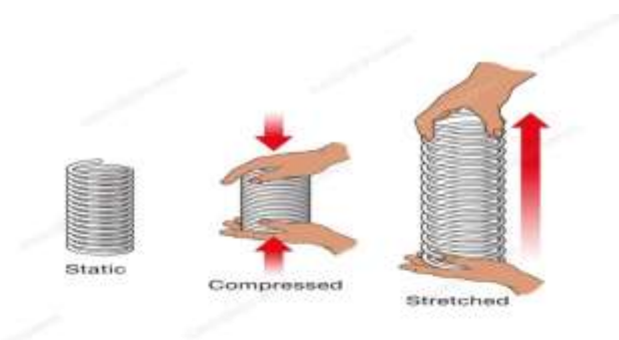
1. Properties of Materials

- **Ductility:**
  - ✓ The ability of a material to be drawn into wires.
  - ✓ Example: Copper is highly ductile, used for electrical wiring.



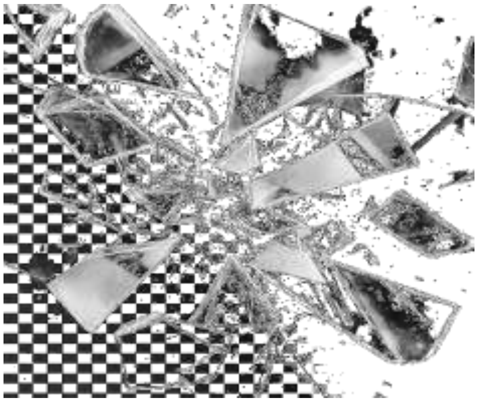
  - ✓ [Image of copper wire being drawn]
- **Malleability:**
  - ✓ The ability of a material to be hammered or rolled into thin sheets.
  - ✓ Example: Gold is highly malleable, used for gold leaf.

  - ✓ [Image of gold leaf creation]
- **Elasticity:**
  - ✓ The ability of a material to return to its original shape after being deformed.
  - ✓ Example: Rubber bands, springs.
  - ✓ **Illustration:**



- **Brittleness:**

- ✓ The tendency of a material to break or shatter without significant deformation.
- ✓ Example: Glass, ceramics.



- ✓ [Image of shattered glass]

- **Strength:**
  - ✓ The ability of a material to withstand stress without breaking.
  - ✓ Example: Steel has high tensile strength.

  - ✓ [Image of steel beams in construction]

- **Hardness:**
  - ✓ The resistance of a material to indentation or scratching.
  - ✓ Example: Diamonds are very hard.

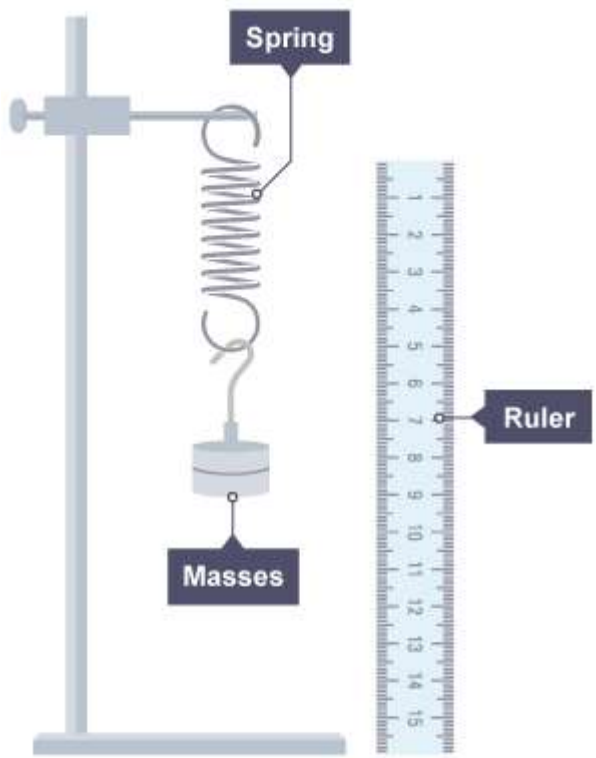
- ✓ [Image of diamond scratching glass]

- **Stiffness:**
  - ✓ The resistance of a material to deformation when a force is applied.
  - ✓ Example: a thick concrete beam is very stiff.
  - ✓ **Image:**

  - ✓ [Image of a concrete beam]

2. Law of Elasticity (Hooke's Law)

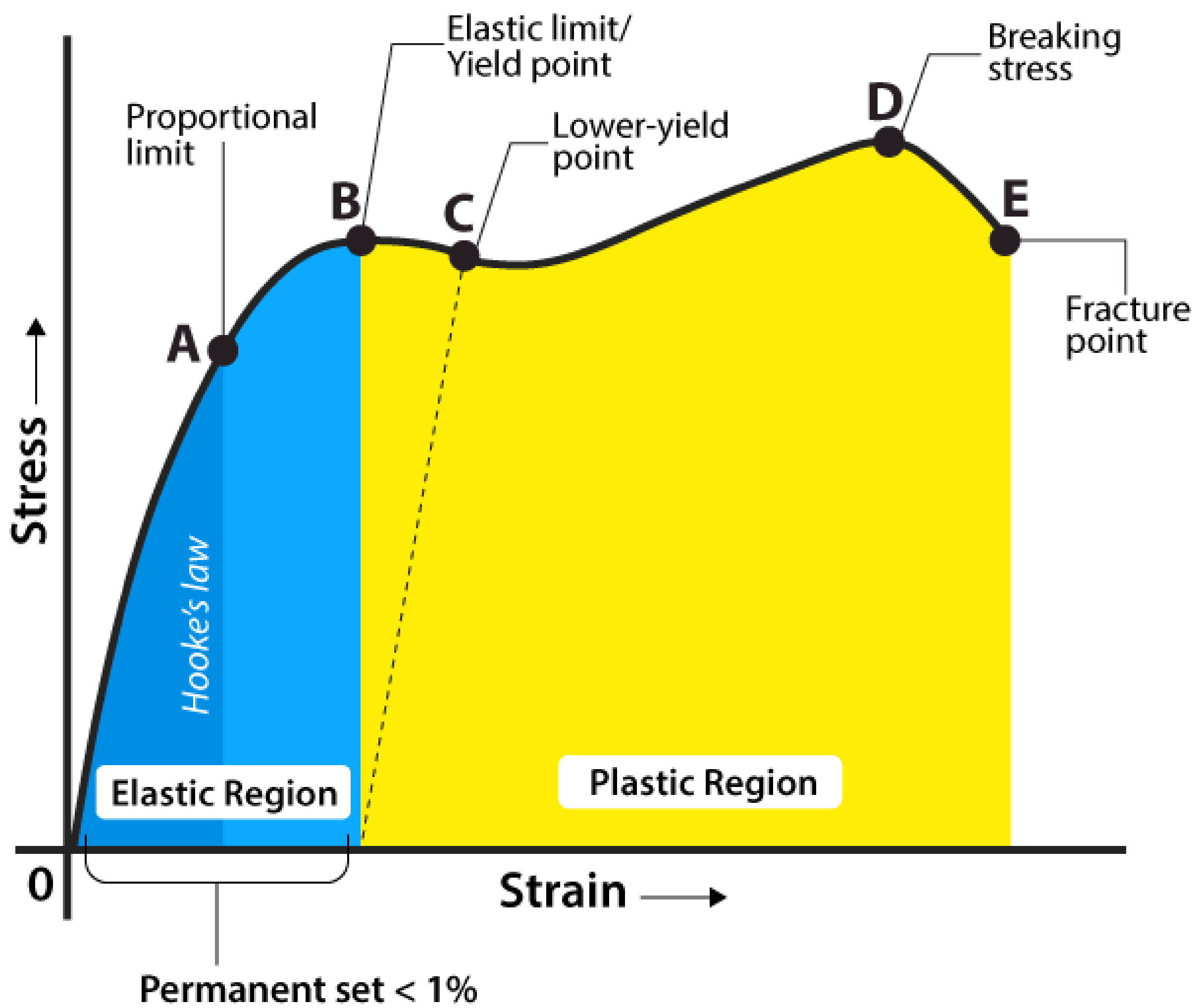
- Hooke's Law states that the force needed to extend or compress a spring by some distance is proportional to that distance.
- F=ke
  - Where:
    - F = Force applied
    - k = Spring constant (stiffness)
    - e = Extension or compression



- [Illustration of a spring extending with applied force]

3. Stress, Strain, and Modulus of Elasticity

- **Stress (σ):**
  - ✓ The force per unit area within a material.
  - ✓ $\sigma = F/A$
    - Where:
      - F = Force applied
      - A = Cross-sectional area
- **Strain (ε):**
  - ✓ The fractional change in length or shape of a material.
  - ✓ $\varepsilon = \Delta L / L0$
    - Where:
      - ΔL = Change in length
      - L_0 = Original length
- **Modulus of Elasticity (Young's Modulus, Y):**
  - ✓ The ratio of stress to strain in the elastic region of a material.
  - ✓ $Y = \sigma / \varepsilon$
  - ✓ Youngs modulus is a measure of stiffness. High Youngs modulus means a material is very stiff.
- **Illustration:**



- [Graph showing stress-strain curve]

4. Industrial Applications of the Properties of Materials

- **Ductility:**
  - ✓ Electrical wiring, cables.
- **Malleability:**
  - ✓ Metal sheets for cars, aircraft, and packaging.
- **Elasticity:**
  - ✓ Springs in vehicles, shock absorbers, elastic bands.
- **Brittleness:**
  - ✓ Ceramic tiles, glass windows.
- **Strength:**

  - ✓ Structural steel in buildings and bridges, reinforced concrete.
- **Hardness:**
  - ✓ Cutting tools, abrasives, protective coatings.
- **Stiffness:**
  - ✓ Concrete and steel in large structures, bridge building.

5. Importance of Knowledge on Mechanical Properties

1. Ensuring safety and reliability in engineering designs.
2. Selecting appropriate materials for specific applications.
3. Understanding material behavior under different conditions.
4. Optimizing material usage, and preventing material failure.

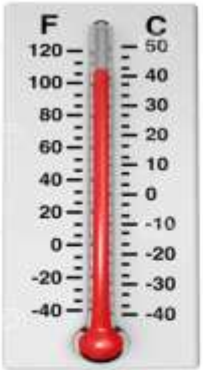
Key Concepts and Connections

- This sub-strand connects to concepts of force, area, deformation, and material science.
- Understanding these properties is crucial for various engineering and industrial applications.

1.4 Temperature and Thermal Expansion

1. Temperature and Its Units

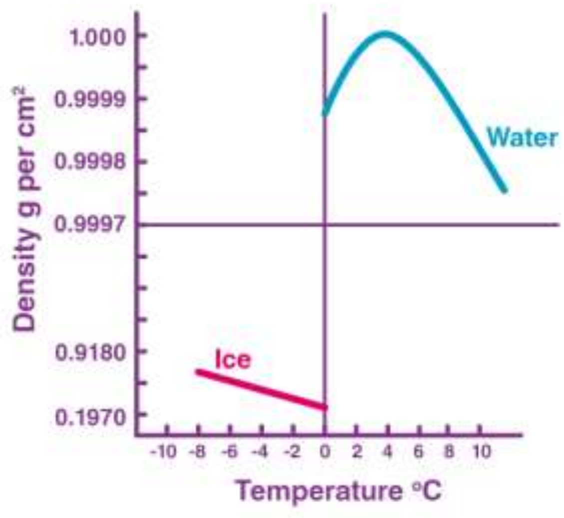
- **Temperature Definition:**
  - ✓ Temperature is a measure of the average kinetic energy of the particles in a substance.
  - ✓ It indicates the degree of hotness or coldness of a body.
- **Units of Temperature:**
  - ✓ Celsius (°C), Fahrenheit (°F), and Kelvin (K).
  - ✓ The SI unit is Kelvin (K).
  - ✓ Conversions:
    - $K = °C + 273.15$
    - $°F = (°C \times 9/5) + 32$



- [Image of a thermometer showing temperature in Celsius and Fahrenheit]

2. Thermal Expansion

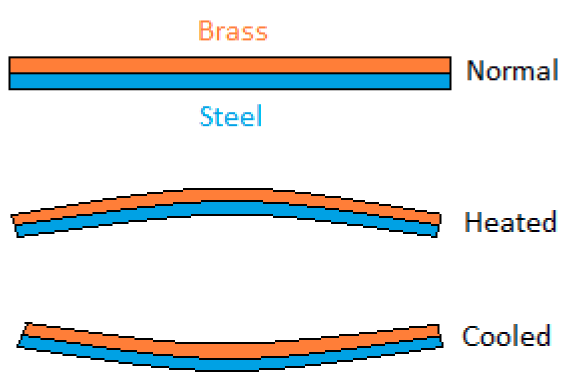
- **Thermal Expansion Definition:**
  - ✓ The tendency of matter to change in volume in response to a change in temperature.
  - ✓ As temperature increases, particles vibrate more, increasing the average distance between them.
- **Linear Expansivity:**
  - ✓ The fractional change in length per degree Celsius.
  - ✓ $\Delta L = \alpha L_0 \Delta T$
    - Where:
      - ΔL = Change in length
      - α = Linear expansivity
      - L_0 = Original length
      - ΔT = Change in temperature
- **Unusual Expansion of Water:**
  - ✓ Water expands when cooled below 4°C.
  - ✓ This is why ice floats (less dense).



- ✓ [Illustration of water density vs. temperature graph]

3. Applications of Thermal Expansion

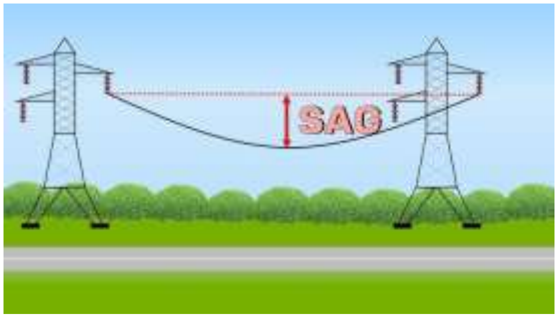
- **Bimetallic Strips:**
  - ✓ Used in thermostats, fire alarms, and circuit breakers.



  - ✓ [Photograph of a bimetallic strip]
- **Expansion Joints in Bridges and Railroads:**
  - ✓ Allow for expansion and contraction due to temperature changes.
  - ✓ **Image:**

- ✓ [Image of expansion joints in a bridge]

- **Power Lines:**
  - ✓ Sag in hot weather and tighten in cold weather.



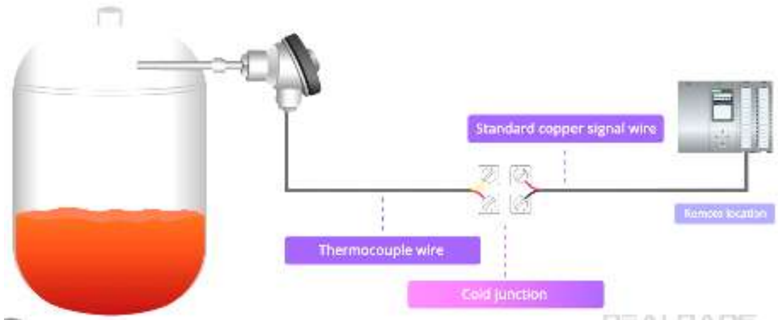
  - ✓ [Image of power lines sagging in heat]
- **Fitting Metal Parts:**
  - ✓ Heating a metal ring to expand it, so that it can fit over another part, then cooling it, so that it contracts and makes a tight fit.
- **Sufuria Lids:**
  - ✓ The lids are made slightly wider to allow for thermal expansion when the *sufuria* is heated.

4. Measurement of Temperature

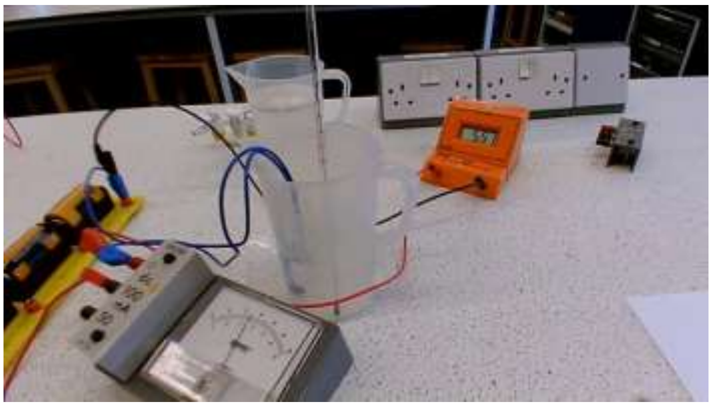
- **Liquid Expansion Devices (Thermometers):**
  - ✓ Use the expansion of liquids like mercury or alcohol.
  - ✓ **Photograph:**

  - ✓ [Photograph of a mercury thermometer]
- **Bimetallic Devices:**

- ✓ Use the differential expansion of two metals.
- **Thermocouples:**
    - ✓ Generate a voltage proportional to temperature differences.
    - ✓ **Illustration:**



- ✓ [Illustration of a thermocouple]
- **Resistive Temperature Devices (RTDs and Thermistors):**
    - ✓ Use the change in electrical resistance with temperature.



- ✓ [Image of a thermistor in use]
- **Infrared Radiators (Infrared Thermometers):**
    - ✓ Measure infrared radiation emitted by objects.

- ✓ [Photograph of an infrared thermometer]
- **Molecular Change-of-State:**

  - ✓ Change of state temperature measurement. Melting point for example.
- **Silicon Diodes:**
  - ✓ The voltage across a silicon diode changes predictably with temperature.
- **Motion Sensors:**
  - ✓ Some motion sensors can also detect heat signatures.

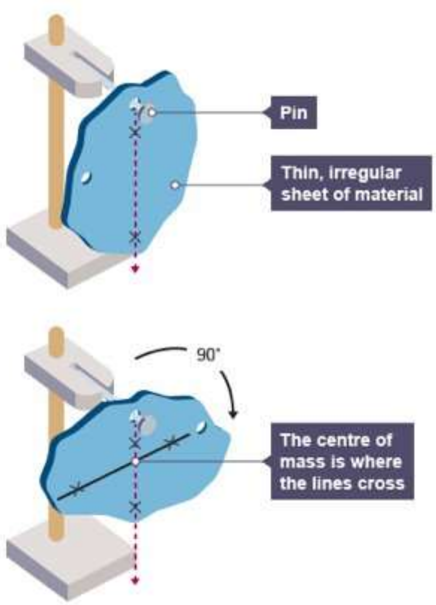
Key Concepts and Connections

- This sub-strand connects to concepts of kinetic energy, heat, and material properties.
- Understanding thermal expansion is crucial in engineering and everyday applications.

1.5 Moments and Equilibrium

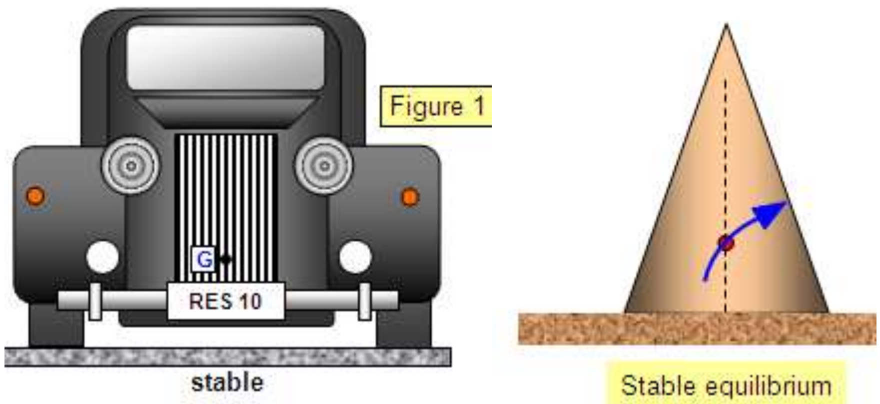
1. Center of Gravity (C.O.G) and Stability

- **Center of Gravity (C.O.G):**
  - ✓ The point where the entire weight of an object appears to act.
  - ✓ For regular objects, it's at the geometric center.
  - ✓ For irregular objects, it can be found experimentally (e.g., by suspending the object).
  - ✓ **Image:**

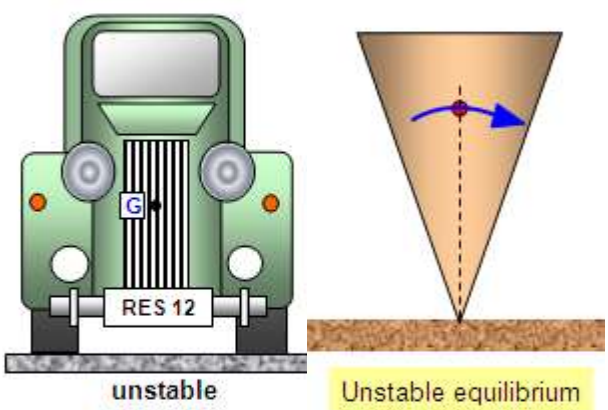


  - ✓ [Image of finding the center of gravity of an irregular object using plumb lines]
- **Stability:**

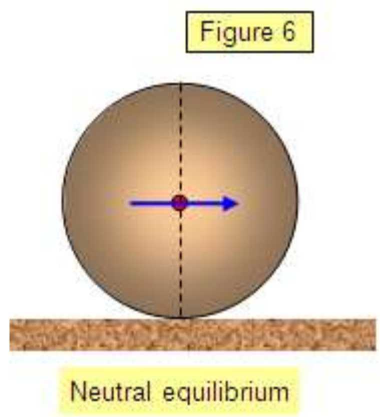
- ✓ The ability of an object to return to its original position after being disturbed.
- ✓ **States of Equilibrium:**
  - **Stable Equilibrium:**
    - Object returns to its original position after a small displacement.
    - C.O.G rises when displaced.
    - **Image:**



    - [Image of a wide-based object in stable equilibrium]
  - **Unstable Equilibrium:**
    - Object moves further away from its original position after a small displacement.
    - C.O.G falls when displaced.
    - **Image:**



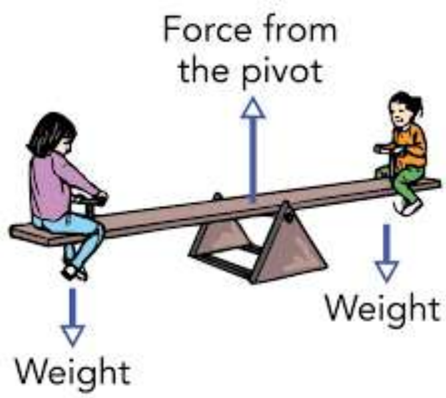
  - **Neutral Equilibrium:**
    - Object stays in its new position after a small displacement.
    - C.O.G remains at the same height.
    - **Image:**



- [Image of a ball on a flat surface in neutral equilibrium]

2. Principle of Moments

- **Moment of a Force:**
  - ✓ The turning effect of a force about a pivot.
  - ✓ Moment = Force × Perpendicular distance from pivot.
  - ✓ **Illustration:**



  - ✓ [Illustration of a force causing a moment about a pivot]
- **Principle of Moments:**
  - ✓ For an object in rotational equilibrium, the sum of clockwise moments equals the sum of counterclockwise moments.
  - ✓ **Mathematical Representation:**
    - ∑Clockwise Moments = ∑Counterclockwise Moments

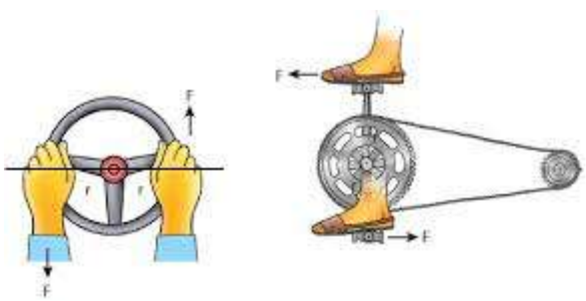
3. Moment, Torque, and Couple

- **Torque:**

- ✓ A rotational force that causes an object to rotate.
- ✓ Similar to moment, but often used when the force is applied to cause rotation.
- ✓ **Image:**

- ✓ [Image of a wrench applying torque to a bolt]

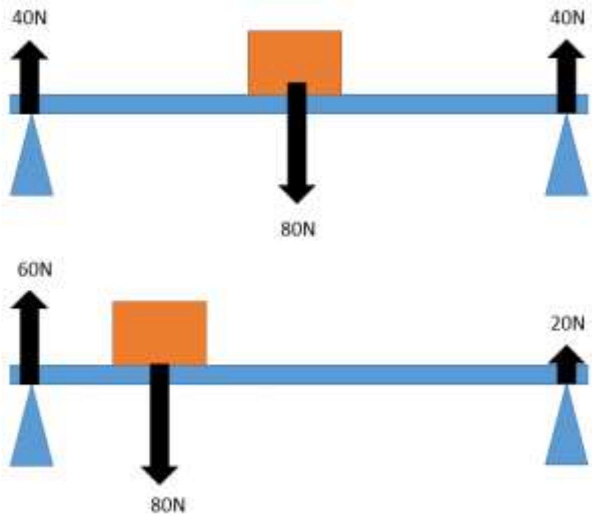
- **Couple:**
  - ✓ A pair of equal and opposite forces acting on an object, causing rotation without translation.
  - ✓ **Illustration:**



  - ✓ [Illustration of a couple causing rotation]

4. Moment About One and Two Points of Support

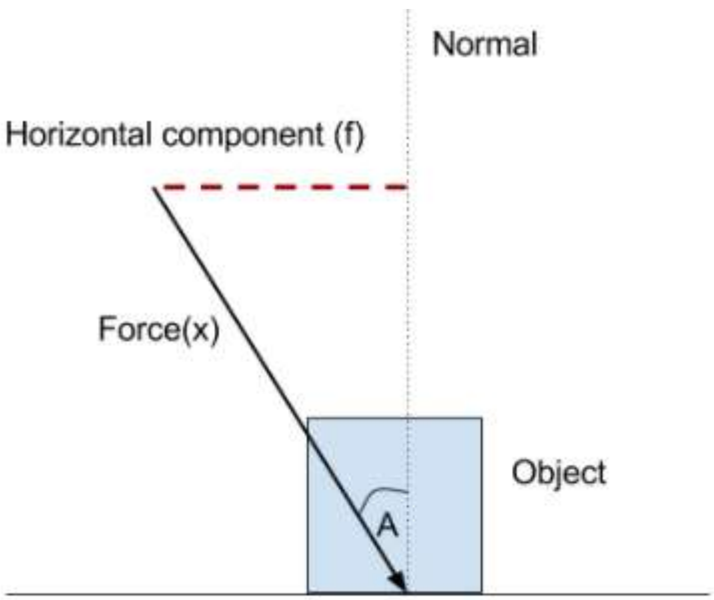
- **Moment About One Point:**
  - ✓ Calculating the turning effect of forces around a single pivot point.
- **Moment About Two Points of Support:**
  - ✓ Analyzing the forces and moments acting on an object supported at two points (e.g., a bridge).
  - ✓ This is important when calculating reaction forces at the supports.



✓ [Image of a beam supported at two points, with forces acting on it]

5. Resolution of Forces

- **Resolution of Forces:**
  - Breaking down a force into its horizontal and vertical components.
  - Used to analyze forces acting at angles.
  - **Illustration:**



  - [Illustration of resolving a force into its components]

6. Applications of Moments and Stability

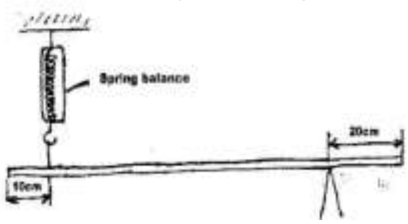
- **Levers:**
  - ✓ Used to multiply force (e.g., crowbars, seesaws).
- **Bridges:**
  - ✓ Designed to withstand moments and maintain stability.
- **Vehicles:**
  - ✓ Stability is crucial for safe handling.
- **Buildings:**
  - ✓ Designed to resist overturning moments from wind and earthquakes.
- **Crane operation:**
  - ✓ Calculations of moments are vital, to prevent the crane from tipping.
- **Balancing objects:**
  - ✓ Calculating moments is vital to balancing objects.

Key Concepts and Connections

- This sub-strand connects to concepts of force, rotation, equilibrium, and structural integrity.
- Understanding moments and stability is essential in engineering, construction, and everyday applications.

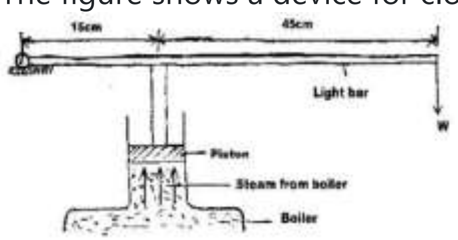
Practice questions

1. The figure below shows a uniform bar of length 1 m pivoted near one end. The bar is kept in equilibrium by a spring balance as shown.



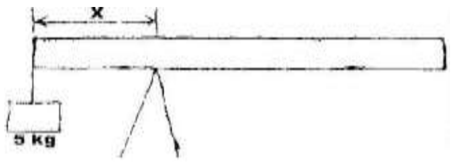
Given that the reading of the spring balance is 0.6N. Determine the weight of the bar.

2. The figure shows a device for closing a steam outlet.



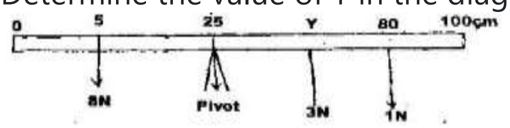
The area of the piston is 4.0×10^{-4} m^2 and the pressure of the steam in the boiler is 2.0×10^5 Nm^{-2}. Determine the weight W that just holds the bar in the horizontal position shown.

3. The diagram below shows a uniform bar of lengths 6m. If the weight of the bar is 15N, determine x.

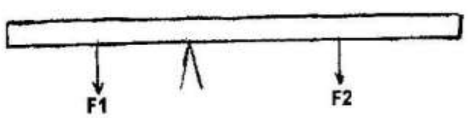


4. State the principle of moments
5. Name four activities which produce a turning effect
6. Why is it very difficult to open a door from a point too close to hinges
7. Why are people who are maimed or have lost one leg provided with crutches?
8. A uniform half- metre rod is balanced by a weight of 38N at one end. If the pivot is placed 10cm from the same end, calculate the weight of the rod.
9. Two forces of 10N and 20N when applied at ends A and B respectively are just able to lift a non-uniform rod of lengths 2m.

   a. What is the weight of the rod?
   b. Determine the position of the centre of gravity of the rod
10. Determine the value of Y in the diagram below



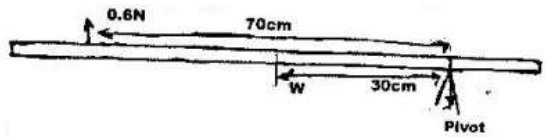
11. The figure below shows force F1 and F2 acting on a metre rule such that it is in equilibrium.



    Mark on the figure a third force F3 acting on the rule such that the equilibrium is maintained.
12.
   a. State the principle of moments.
   b. Two men P and Q carried a uniform ladder 3.6 m long weighing 1200N. P held the ladder from one end while Q supported the ladder at a point 0.4m from the other end.
      i. Sketch a diagram showing the forces acting on the ladder.
      ii. Calculate the load supported by each man.
13. The figure shows a uniform half metre rod that is balanced over a pivot using a block of weight 2N and a spring.
    Given that the tension in the spring is 9N, determine the weight of the rod.

Answers

1.



Taking moment and equating Clockwise moments = anticlockwise moments

0.6 x 70cm = w x 30

$W = \frac{0.6 \times 70}{30}$

W = mg = $^{4.2}/_{3}$

= 1.4N

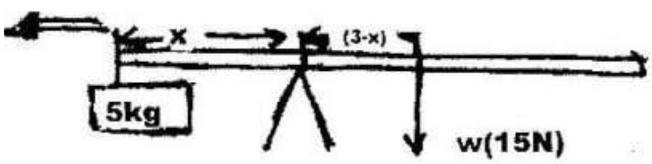
2. Since the system is in equilibrium, then (P x A) 15 = w (15+45)

$2.0 \times 10^5 \times 4 \times 10^{-4} \times 15 = 60w$

$w = \frac{8 \times 15 \times 10}{60}$

Weight, w= 20N

3. **Solution**



5kg = 50N

50x = 15 x (3 − x)

50 x = 45 − 15x

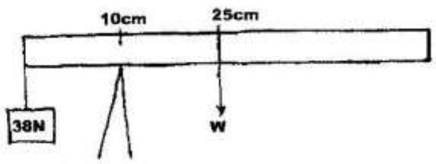
50x=45-15x

65x= 45

x=$^{45}/_{65}$ = 0.692m

4. For a system in equilibrium. The sum of clockwise moments about the same point must be equal to the sum of anticlockwise moments about the same point.
5. • Steering a wheel in a vehicles
   • Tightening a nut using spanner
   • Peddling a bicycle
   • Opening/closing a door
   • Closing /opening a water/gas tap
6. The distance is small hence the moment produced is not enough to open the door. A lot of force will be required.
7. It provides them with the necessary support and also makes them stable as they move about.

8. **Solution**



Clockwise moment = Anticlockwise moment

$38 \times {}^{10}/_{100} = w \times {}^{25}/_{100}$

3.8= 0.25W

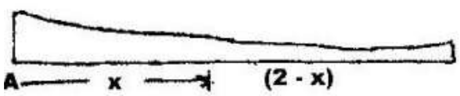
$W = {}^{3.8}/_{0.25}$

= 15.2N

9.

a. Weight = total upward force
   = (10 +20) N
   = 30N

b. Let position of c.o.g be x m away from A i.e



Using point A as pivot thus

30x= 20 × 2

30x=40

$x = {}^{4}/_{3} = 1.33$ m

c.o.g is at 1.33m from A or 0.667 m from B

10. **Solution**

Sum of clockwise moment = sum of anticlockwise moment

8 x 0.2 = (y - 0.25)3 + 0.55

1.6 = 3y- 0.75 + 0.55

1.6= 3y - 0.2

3y= 1.6 + 0.2 = 1.8m

y= 0.6m

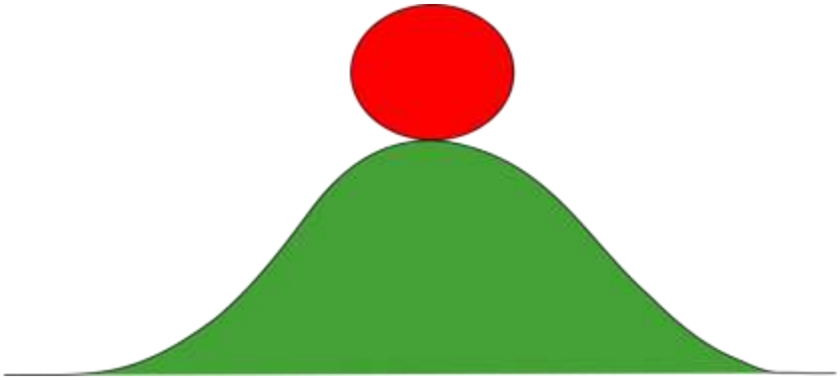
y=60cm

1.6 Energy, Work, Power, and Machines

1. Energy, Work, and Power

- **Energy:**
  - ✓ The capacity to do work.
  - ✓ Units: Joules (J).
  - ✓ Forms: Kinetic, potential (gravitational and elastic), thermal, etc.
  - ✓ **Kinetic Energy (KE):**
    - Energy due to motion.
    - $KE = 1/2\, mv^2$ (where m = mass, v = velocity).

    - [Image of a moving car, demonstrating kinetic energy]
  - ✓ **Potential Energy (PE):**
    - Stored energy.
    - **Gravitational Potential Energy (GPE):**
      - Energy due to height.
      - $GPE = mgh$ (where m = mass, g = acceleration due to gravity, h = height).



[Image of a ball at the top of a hill, demonstrating gravitational potential energy]

    - **Elastic Potential Energy (EPE):**
      - Energy stored in a deformed elastic object.

[Image demonstrating elastic potential energy]

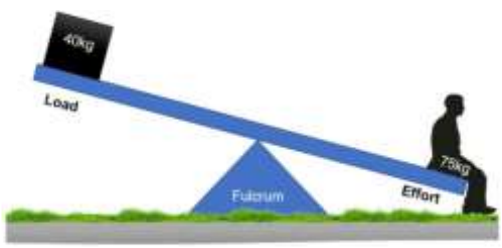
- ✓ **Law of Conservation of Energy:**
  - ▪ Energy cannot be created or destroyed, only transformed from one form to another.
- **Work:**
  - ✓ Done when a force moves an object.
  - ✓ Work = Force × Distance (W = Fd).
  - ✓ Units: Joules (J).
  - ✓ **Illustration:**

  - ✓ [Illustration of a person pushing a box, demonstrating work done]
- **Power:**
  - ✓ The rate at which work is done.
  - ✓ Power = Work / Time (P = W/t).
  - ✓ Units: Watts (W).
  - ✓ **Illustration:**

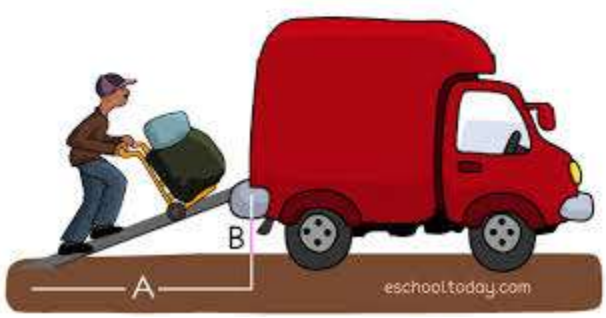
[Illustration of a person running up stairs quickly vs. slowly, demonstrating power]

2. Machines

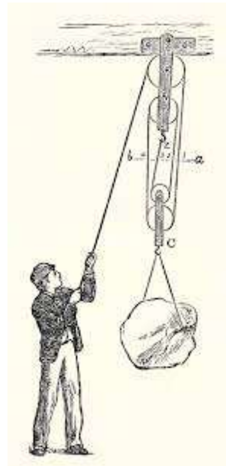
- **Definition:**
  - ✓ Devices that make work easier by changing the magnitude or direction of a force.
- **Simple Machines:**
  - ✓ **Levers:**
    - ▪ Rigid bars that pivot on a fulcrum.



    - ▪ [Image of a seesaw, a type of lever]
  - ✓ **Inclined Planes:**
    - ▪ Sloping surfaces that reduce the force needed to lift an object.

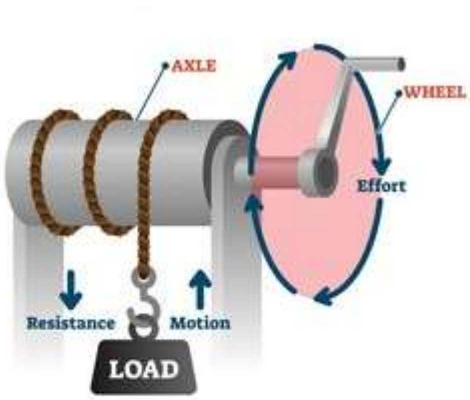


    - ▪ [Image of a ramp, an inclined plane]
  - ✓ **Pulleys:**
    - ▪ Wheels with grooves that hold ropes or cables, used to lift heavy objects.

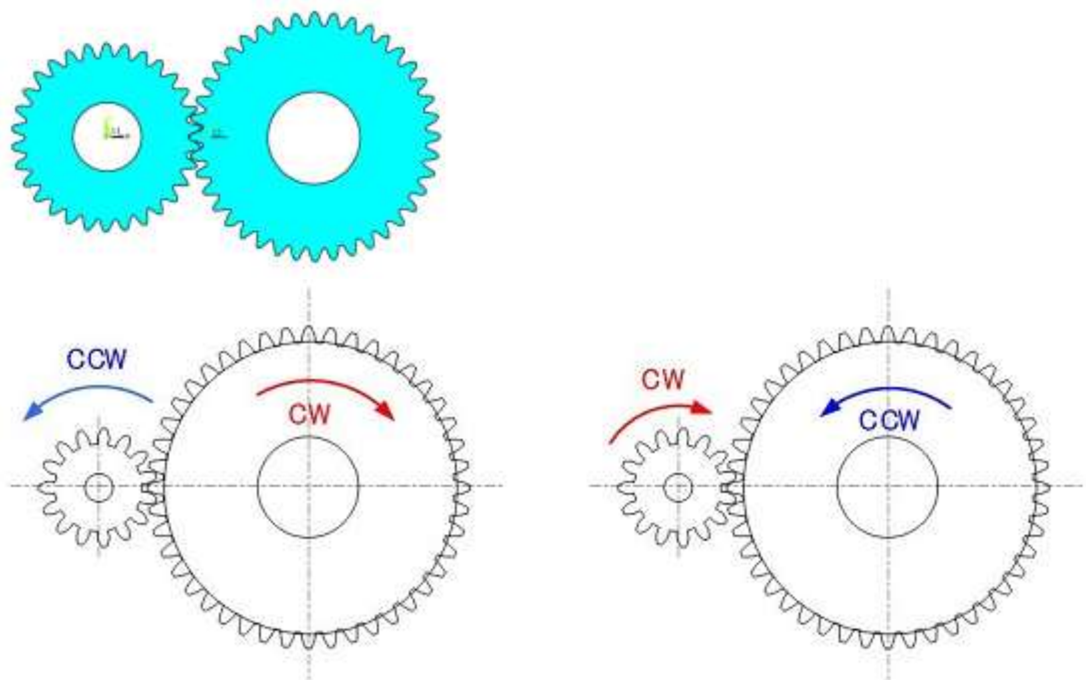


[Image of a pulley system lifting a weight]

- ✓ **Wheel and Axle:**
  - A wheel attached to a smaller axle, used to multiply force.
  - **Image:**

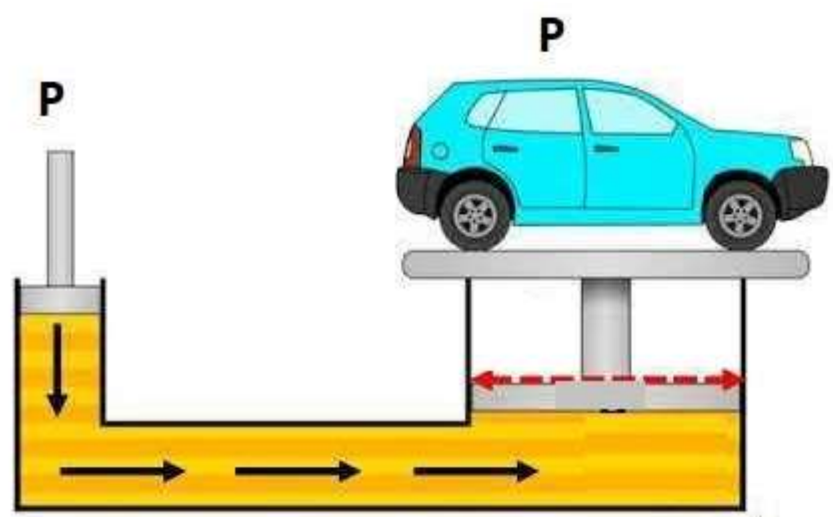


- ✓ **Gears:**
  - Toothed wheels that transmit rotational motion and change speed or torque.
  - **Image:**



- [Image of meshed gears]

✓ **Hydraulic Lift:**
- uses liquid pressure to lift heavy objects.



- [Image of a hydraulic lift]

✓ **Pulley Belt:**
- Transfers rotational motion between shafts.

  - [Image of a pulley belt system]
- ✓ **Screw:**
  - An inclined plane wrapped around a cylinder.

  - [Image of a screw]

- **Mechanical Advantage (MA):**
  - ✓ The ratio of output force to input force.
- **Velocity Ratio (VR):**
  - ✓ The ratio of the distance moved by the effort to the distance moved by the load.
- **Efficiency:**
  - ✓ The ratio of useful work output to total work input.

3. Applications of Machines

- **Treadmills, Elevators, Escalators:**
  - ✓ Use various simple machines (pulleys, gears, etc.) to move people and objects.
  - ✓ **Photographs:**

		
treadmill	elevator	escalator

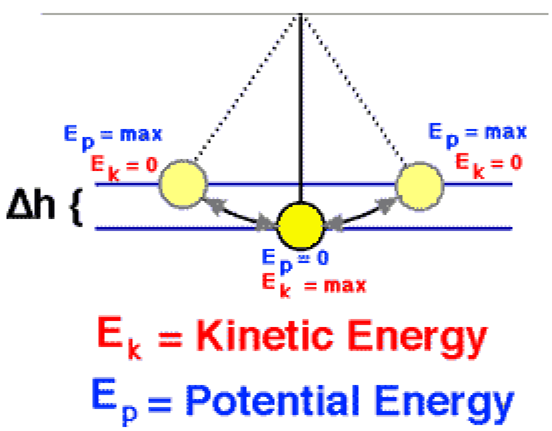
- **Excavators:**
  - ✓ Use hydraulic lifts and levers to dig and move earth.

- ✓ **Photograph:**

- ✓ [Photograph of an excavator]
- **Construction:**
  - ✓ Cranes utilize pulleys and levers.
  - ✓ Inclined planes are used for ramps.

4. Mechanical Energy Transformations

- Demonstrating the conversion of potential energy to kinetic energy (e.g., a swinging pendulum, a ball thrown upwards, a catapult, bow & arrow).
- **Illustration:**



- [Illustration of a pendulum swinging, showing energy transformation]

Key Concepts and Connections

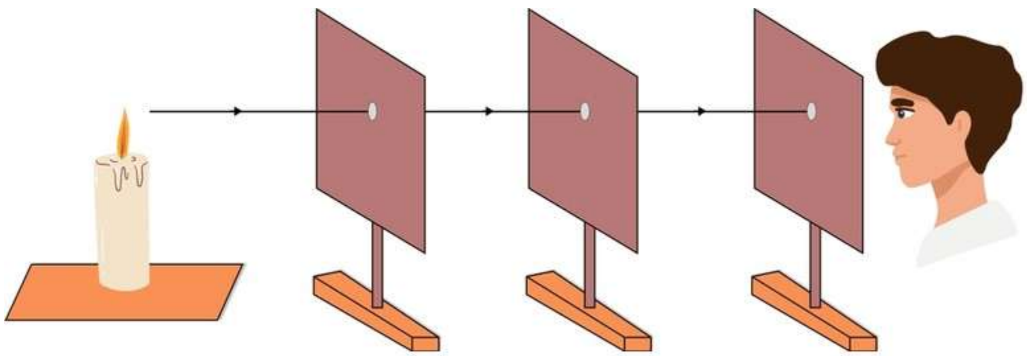
- This sub-strand connects to concepts of force, motion, work, and efficiency.
- Understanding these concepts is crucial for various engineering and everyday applications.

2.0 WAVES AND OPTICS:

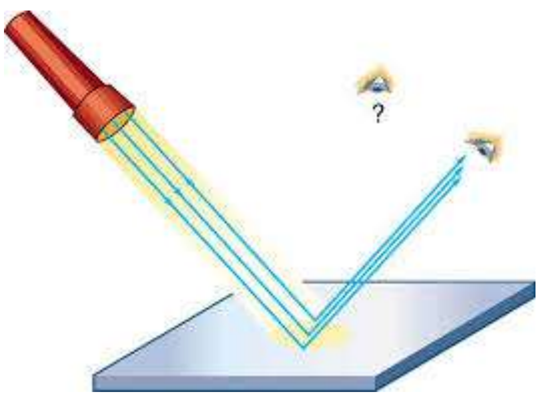
2.1 Properties of Waves

1. Properties of Waves

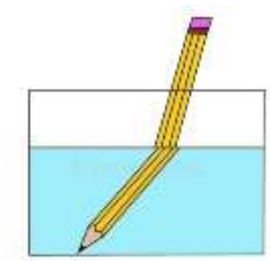
- **Rectilinear Propagation:**
  - ✓ The tendency of waves to travel in straight lines in a uniform medium.
  - ✓ Example: Light rays from the sun, light from candle.
  - ✓ **Illustration:**



  - ✓ [Illustration of light rays travelling in straight lines]
- **Reflection:**
  - ✓ The bouncing back of waves when they encounter a boundary.
  - ✓ Example: Light reflecting off a mirror, sound echoes.

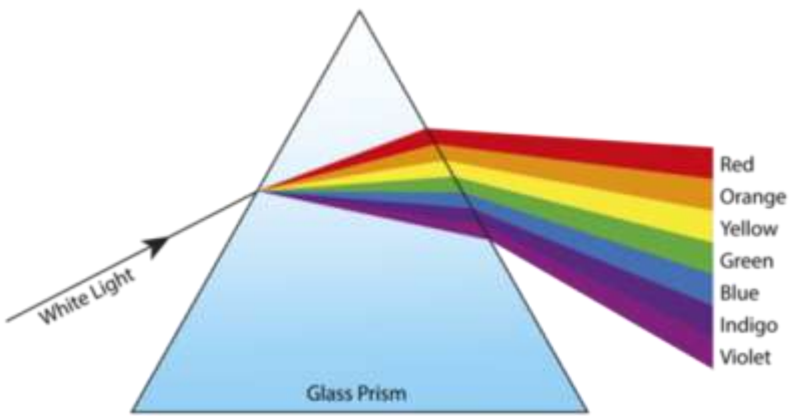


  - ✓ [Image of light reflecting off a mirror]
- **Refraction:**
  - ✓ The bending of waves as they pass from one medium to another.
  - ✓ Example: Light bending as it enters water.



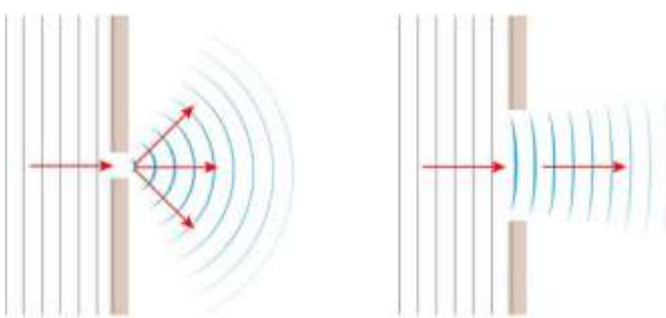
- ✓ **Illustration:**

- **Dispersion of light**



- ✓ [Illustration of light refracting as it passes through a prism]

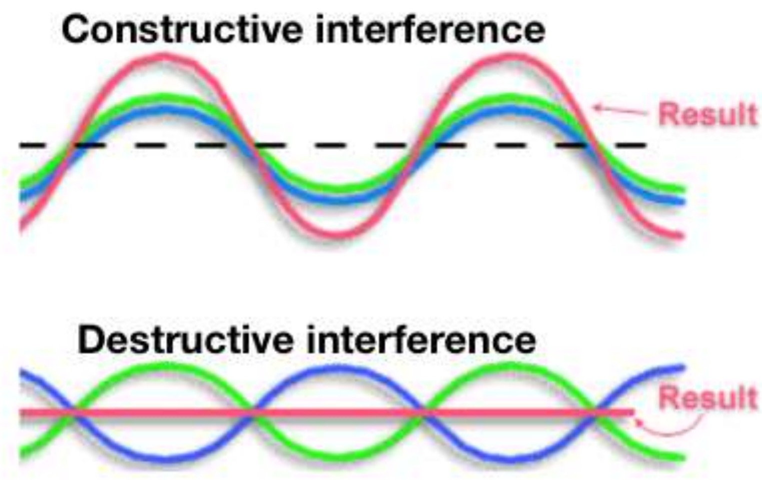
- **Diffraction:**
  - ✓ The spreading of waves as they pass through an opening or around an obstacle.
  - ✓ Example: Sound waves spreading through a doorway.
  - ✓ **Illustration:**



- ✓ [Illustration of waves diffracting through openings]

- **Interference:**
  - ✓ The superposition of two or more waves, resulting in constructive or destructive interference.

- ✓ Example: Interference patterns in light waves (Young's double-slit experiment).
- ✓ **Illustration:**



- ✓ [Illustration of constructive and destructive interference of waves]

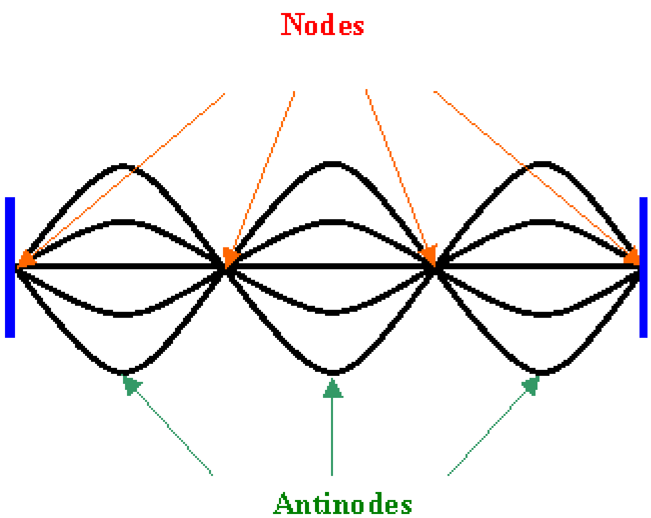
2. Applications of Properties of Waves

- **Need for Modulation:**
  - ✓ Modulation is the process of varying a wave's properties (amplitude, frequency) to carry information.
  - ✓ Essential for radio and television broadcasting.
- **Production and Detection of Frequency-Modulated (FM) Waves:**
  - ✓ FM radio uses frequency modulation to transmit audio signals.
  - ✓ FM receivers detect these variations.

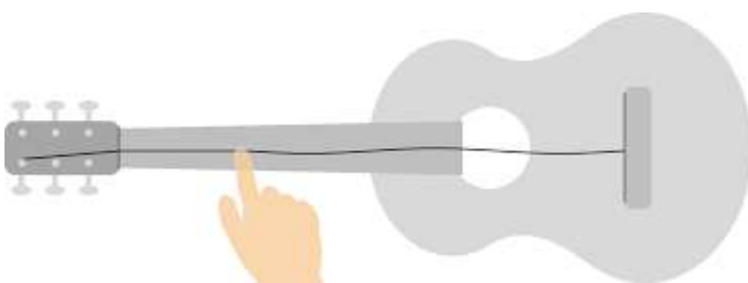
- ✓ [Image of a radio tower transmitting FM waves]

3. Stationary Waves and Its Applications

- **Stationary Waves (Standing Waves):**
  - ✓ Formed when two waves of the same frequency and amplitude travel in opposite directions and interfere.
  - ✓ Nodes (points of zero displacement) and antinodes (points of maximum displacement) are formed.
  - ✓ **Illustration:**



  - ✓ [Illustration of a stationary wave on a string, showing nodes and antinodes]
- **Applications:**
  - ✓ **Resonance:**
    - ✓ Occurs when a system is driven at its natural frequency, leading to large-amplitude oscillations.
    - ✓ Used in musical instruments (e.g., vibrating strings, air columns).
    - ✓ **Image:**

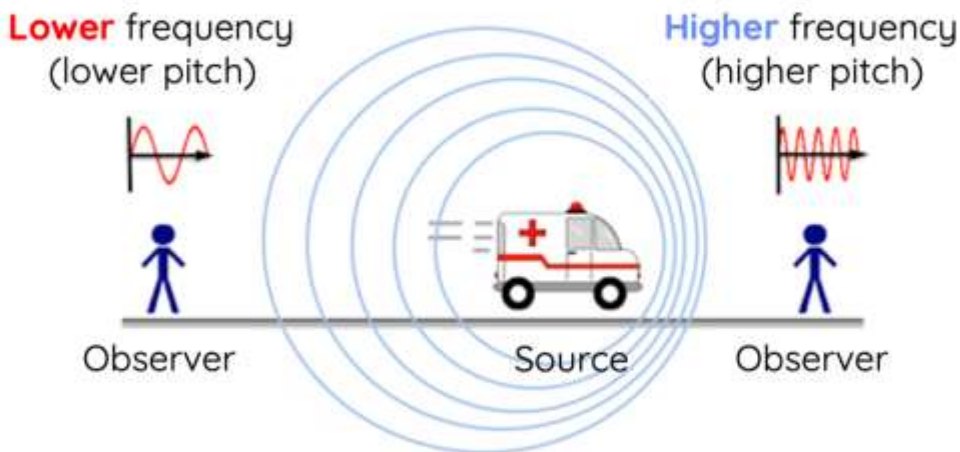


    - ✓ [Image of a guitar string vibrating, creating a stationary wave]
  - ✓ **Vibrating Strings and Air Columns:**

- ✓ Used in musical instruments like guitars, violins, and wind instruments.
- ✓ The length of the string or air column determines the resonant frequencies.

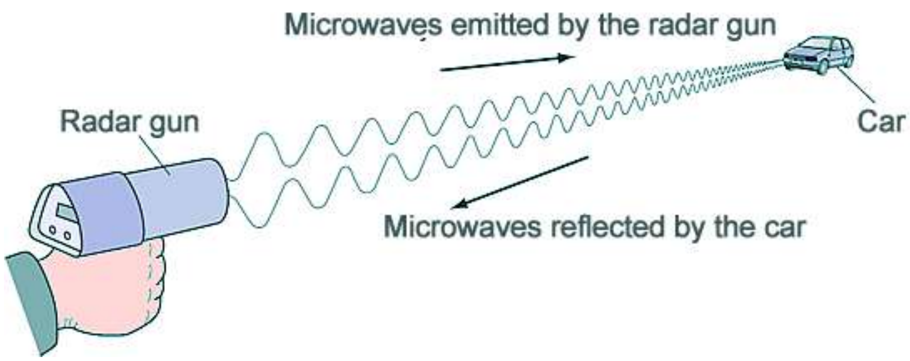
4. Doppler Effect and Applications

- **Doppler Effect:**
  - ✓ The apparent change in frequency of a wave due to the relative motion between the source and the observer.
  - ✓ Example: The change in pitch of a siren as an ambulance passes.
  - ✓ **Illustration:**



[Illustration of the Doppler effect, showing compressed and stretched wavelengths]

- **Applications:**
  - ✓ **Radar:**
    - ✓ Used to measure the speed of vehicles and weather patterns.
  - ✓ **Medical Imaging (Ultrasound):**
    - ✓ Used to measure blood flow and visualize internal organs.
  - ✓ **Astronomy:**
    - ✓ Used to determine the motion of stars and galaxies (redshift and blueshift).
  - ✓ **Image:**



- ✓ [Image of a radar gun measuring the speed of a car]

Key Concepts and Connections

- This sub-strand connects to concepts of wave motion, frequency, wavelength, and superposition.
- Understanding wave properties is essential in various fields, including communication, medicine, and music.

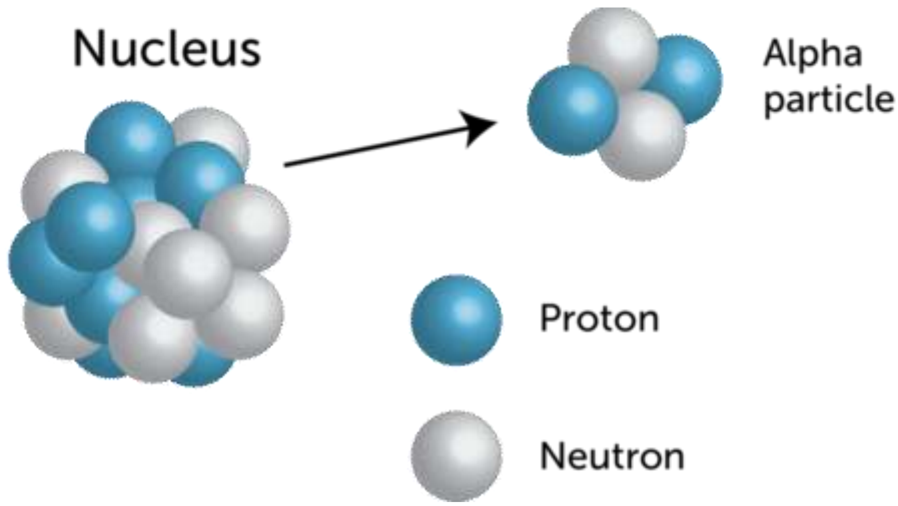
2.2 Radioactivity and Stability of Isotopes

1. Stability of Isotopes and Radioactive Decay

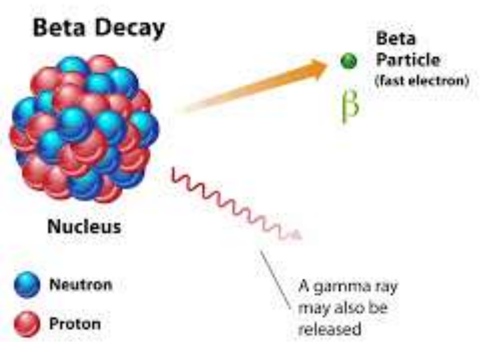
- ❖ **Isotopes:**
  - ✓ Atoms of the same element with the same number of protons but different numbers of neutrons.
- ❖ **Nuclear Stability:**
  - ✓ The balance between protons and neutrons in a nucleus.
  - ✓ Unstable isotopes undergo radioactive decay to achieve stability.
- ❖ **Radioactive Decay:**
  - ✓ The spontaneous breakdown of an unstable nucleus, emitting radiation.
- ❖ **Key Terminologies:**
  - ✓ **Nuclide:** A specific nucleus with a particular number of protons and neutrons.
  - ✓ **Radioisotope:** An unstable isotope that undergoes radioactive decay.
  - ✓ **Background Radiation:** Radiation from natural sources (cosmic rays, rocks, etc.).
  - ✓ **Half-life:** The time taken for half of the radioactive nuclei in a sample to decay.

2. Types and Properties of Radiations

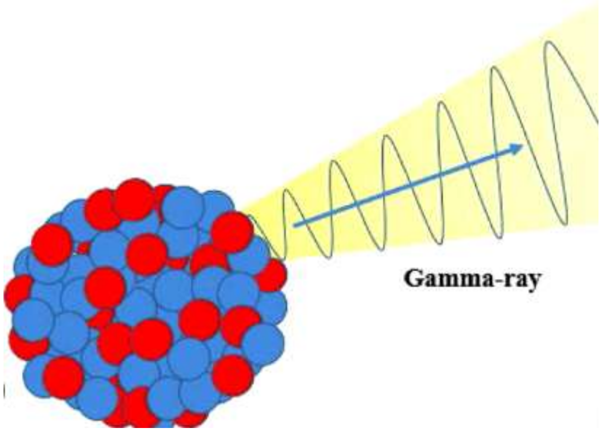
- **Alpha (α) Particles:**
  - ✓ Helium nuclei (2 protons, 2 neutrons).
  - ✓ Positive charge, relatively heavy, low penetrating power.



  - ✓ [Image of Alpha particle emission]
- **Beta (β) Particles:**
  - ✓ High-speed electrons or positrons.
  - ✓ Negative or positive charge, light, moderate penetrating power.



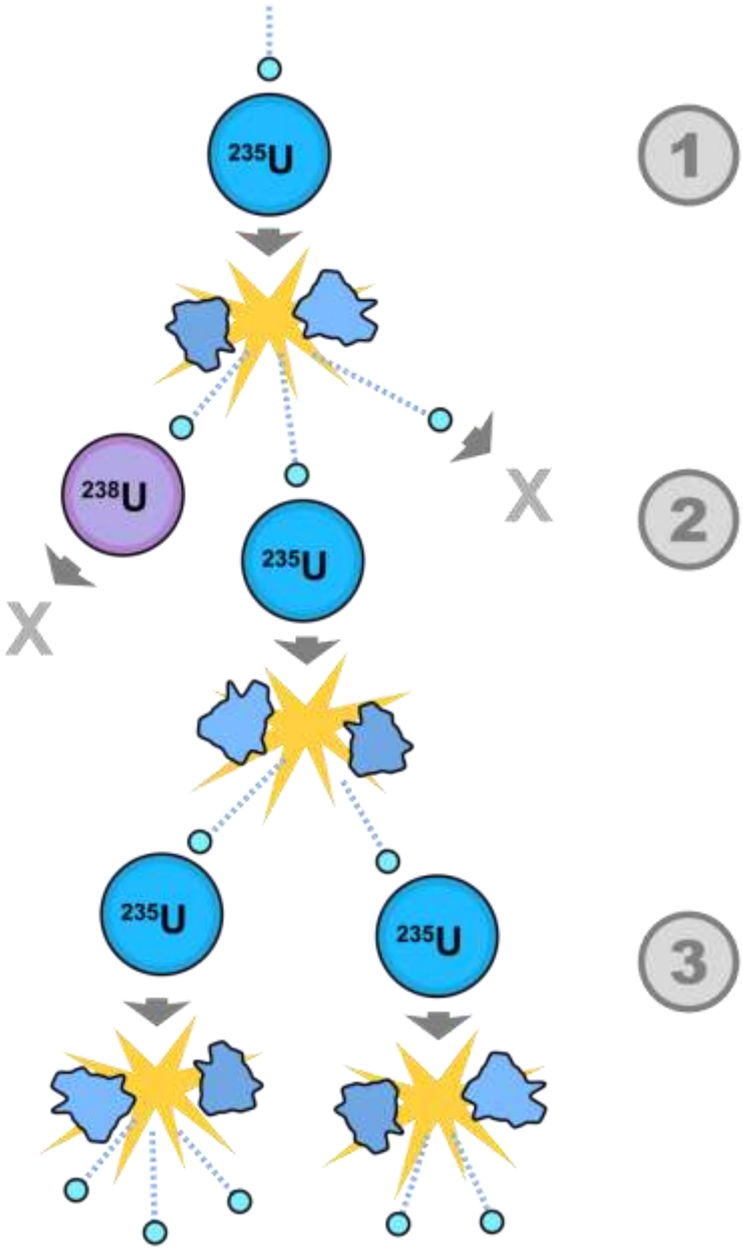
  - ✓ [Image of Beta particle emission]
- **Gamma (γ) Rays:**
  - ✓ High-energy electromagnetic radiation.
  - ✓ No charge, no mass, high penetrating power.



- [Image of Gamma ray emission]
- **Properties Chart:**
  - Charts showing the nature, charge, mass, absorption, velocity, ionizing power, and behavior in electric and magnetic fields of each type of radiation.

3. Nuclear Equations and Stability

- **Nuclear Equations:**
  - Represent radioactive decay processes.
  - Balance atomic numbers and mass numbers.
  - **Example:**
    - Alpha decay: 92238U→90234Th+24He
    - Beta decay: 614C→714N+−10e
- **Chain Reactions:**
  - A series of nuclear fissions in which the neutrons released by one fission can initiate another.



✓ [Image of Nuclear chain reaction]

4. Detection of Radiations

- **Photographic Emulsion/Plate:**
  - ✓ Radiation darkens photographic film.
- **Cloud Chamber:**
  - ✓ Radiation ionizes air, creating visible tracks.

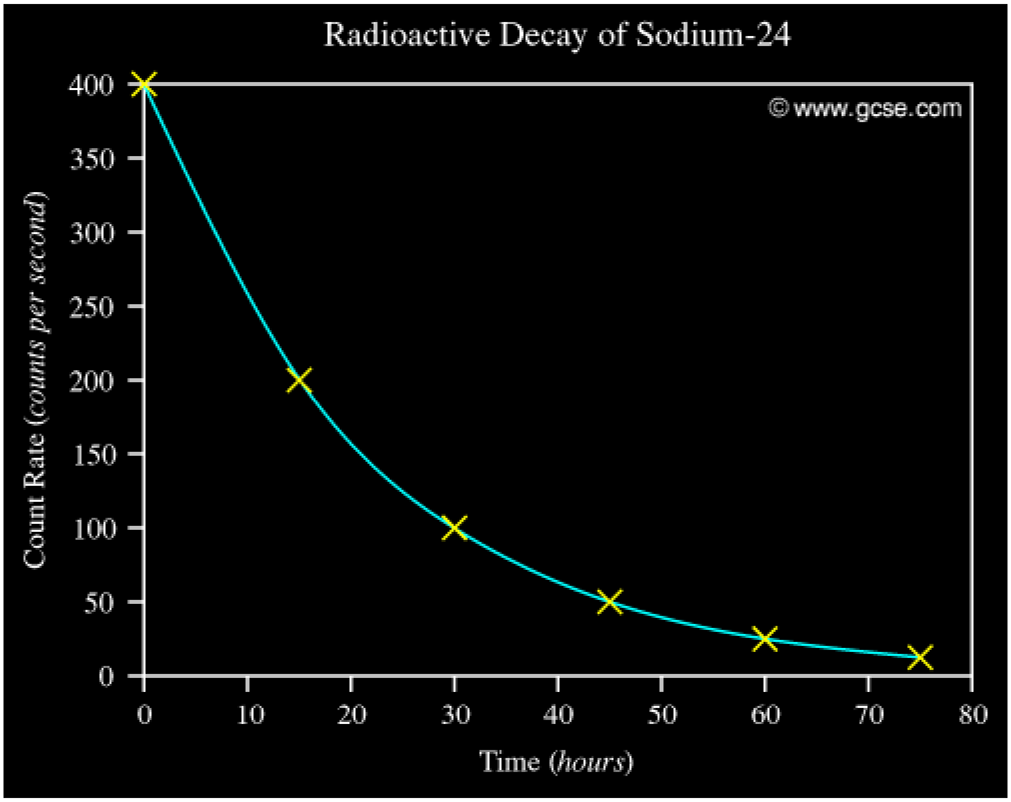
[Image of a cloud chamber]

- **Leaf Electroscope:**
  - ✓ Radiation ionizes air, discharging the electroscope.
- **Geiger-Müller (GM) Counter:**
  - ✓ Detects radiation by ionizing gas, producing electrical pulses.

- ✓ [Image of a Geiger counter]

5. Half-Life (t1/2)

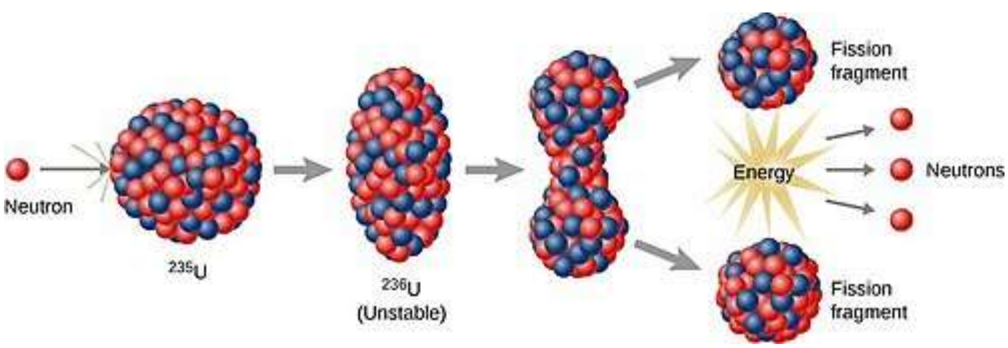
- **Determination:**
  - ✓ Using data from print or non-print media.
  - ✓ Using the formula: $N(t)=N0(1/2)t/t1/2$
  - ✓ Graphical method (decay curve).
  - ✓ **Image:**



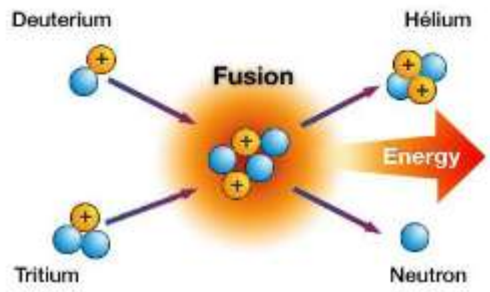
- ✓ [Image of a radioactive decay curve showing half-life]
- **Significance:**
  - ✓ Used in carbon dating, medical diagnosis, and industrial applications.

6. Nuclear Fission and Fusion

- **Nuclear Fission:**
  - ✓ The splitting of a heavy nucleus into lighter nuclei, releasing energy.



- ✓ [Image of Nuclear fission]
- **Nuclear Fusion:**
  - ✓ The combining of light nuclei to form a heavier nucleus, releasing energy.



- ✓ [Image of Nuclear fusion]
- **Energy Source:**
  - ✓ Nuclear reactions are a significant source of energy.

7. Applications and Safety Precautions

- **Medical Applications:**
  - ✓ Radiation therapy, medical imaging.
- **Industrial Applications:**
  - ✓ Thickness gauging, sterilization.
- **Carbon Dating:**
  - ✓ Determining the age of ancient artifacts.
- **Agricultural Applications:**
  - ✓ Used in pest control, and food irradiation.
- **Safety Precautions:**
  - ✓ Minimize exposure time, use shielding, maintain distance.
  - ✓ **Dangers:**
    - Radiation sickness, cancer, genetic mutations.
    - Nuclear disasters (e.g., Chernobyl).

Key Concepts and Connections

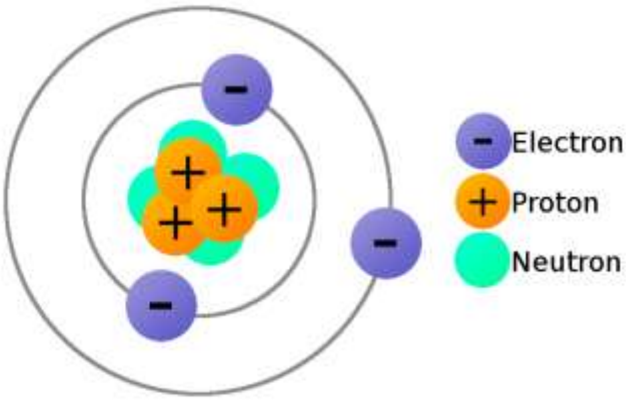
- This sub-strand connects to concepts of atomic structure, nuclear physics, and radiation.
- Understanding radioactivity is crucial for medical, industrial, and scientific applications, as well as for ensuring safety.

3.0 ELECTRICITY AND MAGNETISM:

3.1 Electrostatics

1. Origin of Charges in a Material

- **Atomic Structure:**
  - ✓ Atoms consist of a nucleus (protons and neutrons) surrounded by electrons.
  - ✓ Protons have a positive charge, electrons have a negative charge, and neutrons have no charge.
  - ✓ Normally, atoms are neutral (equal number of protons and electrons).



  - ✓ [Illustration of an atom showing protons, neutrons, and electrons]
- **Charging by Rubbing:**
  - ✓ When materials are rubbed together, electrons can be transferred from one material to another.
  - ✓ One material becomes positively charged (loses electrons), and the other becomes negatively charged (gains electrons).
  - ✓ **SI Unit of Charge:**
    - Coulomb (C).
- **Law of Electrostatics:**
  - ✓ Like charges repel, and unlike charges attract.
  - ✓ **Illustration:**

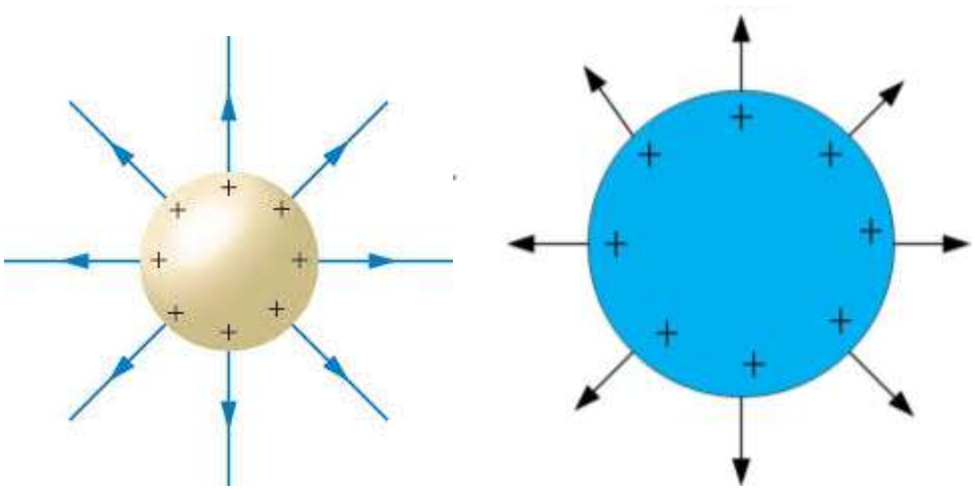
- ✓ [Illustration of like charges repelling and unlike charges attracting]

2. Methods of Charging a Conductor

- **Charging by Contact (Conduction):**
  - ✓ Transferring charge by direct contact between a charged object and a neutral conductor.
  - ✓ The conductor acquires the same type of charge as the charged object.
  - ✓ **Illustration:**
  - ✓ [Illustration of charging by contact]
- **Charging by Induction:**
  - ✓ Charging a conductor without direct contact by bringing a charged object near it.
  - ✓ The conductor acquires the opposite type of charge on the side nearest the charged object.
  - ✓ **Illustration:**
  - ✓ [Illustration of charging by induction]
- **Charging by Separation:**
  - ✓ This usually refers to separating previously contacted charges, by moving a charged item, while another conductor is also in contact with the neutral object.

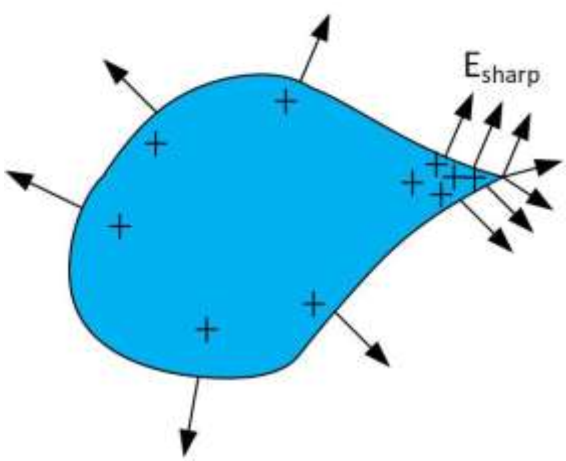
3. Charge Distribution on Conductors

- **Spherical Conductors:**
  - ✓ Charge is evenly distributed on the surface.



- ✓ [Illustration of charge distribution on a spherical conductor]

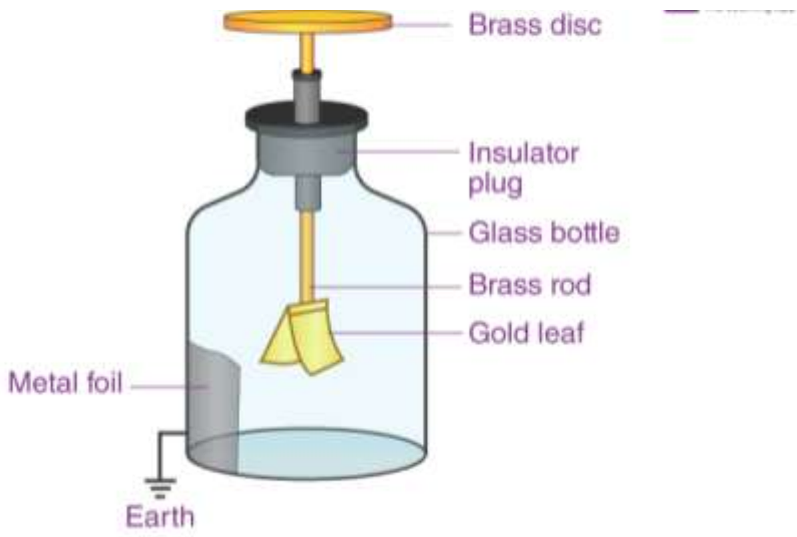
- **Wedge-Shaped, Pear-Shaped, and Sharp Conductors:**
  - ✓ Charge tends to concentrate at sharp points or areas of high curvature.



- ✓ [Illustration of charge distribution on a sharp conductor]

4. Electroscope

- **Parts and Functions:**
  - ✓ Metal cap: Where charge is applied.
  - ✓ Metal rod: Conducts charge to the leaves.
  - ✓ Thin metal leaves: Diverge when charged, indicating the presence of charge.
  - ✓ Insulator: Prevents charge leakage.
  - ✓ **Photograph:**

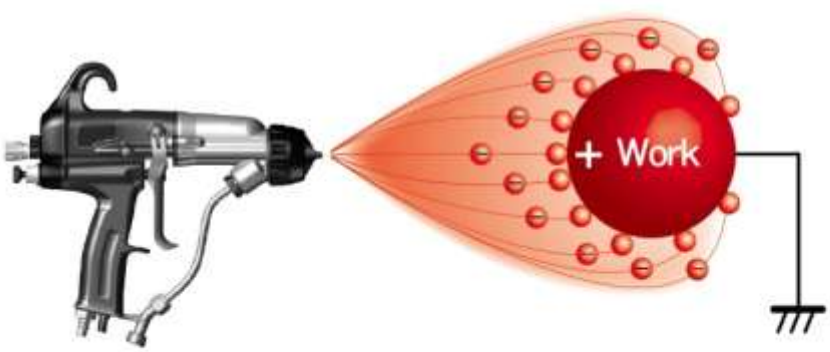


- [Photograph of a leaf electroscope]

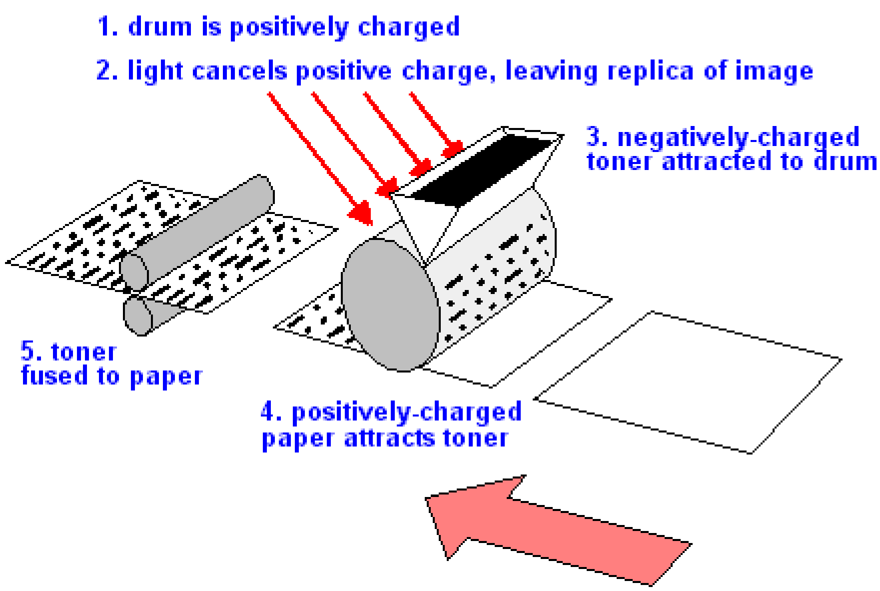
- **Charging an Electroscope:**
  - By contact: Touching a charged object to the metal cap.
  - By induction: Bringing a charged object near the cap.
- **Uses of an Electroscope:**
  - Detecting the presence of charge.
  - Determining the type of charge (positive or negative).
  - Comparing the quantity of charge.
  - Testing conduction and insulation properties.

5. Applications of Electrostatics

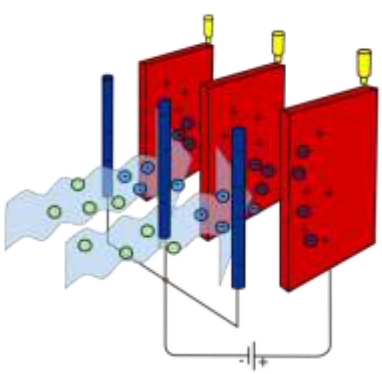
- **Spray Gun:**
  - Electrostatically charges paint droplets, which are then attracted to the object being painted.
  - **Photograph:**



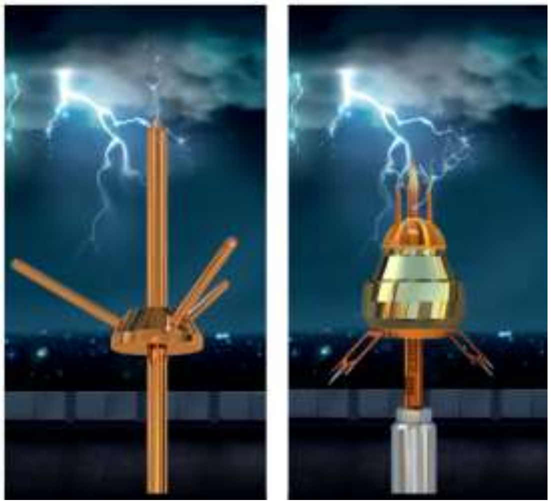
- ✓ [Photograph of an electrostatic spray gun]
- **Photocopiers:**
  - ✓ Use static electricity to transfer toner to paper.
  - ✓ **Illustration:**



  - ✓ [Illustration of a photocopier process]
- **Finger Printing:**
  - ✓ Electrostatic dust application to detect latent finger prints.
- **Electrostatic Precipitators:**
  - ✓ Remove dust and pollutants from industrial exhaust gases.



  - ✓ [Image of an electrostatic precipitator]
- **Lightning and Lightning Arrestors:**
  - ✓ Lightning is a discharge of static electricity.
  - ✓ Lightning arrestors provide a safe path for lightning to ground.



- ✓ [Image of a lightning arrestor]

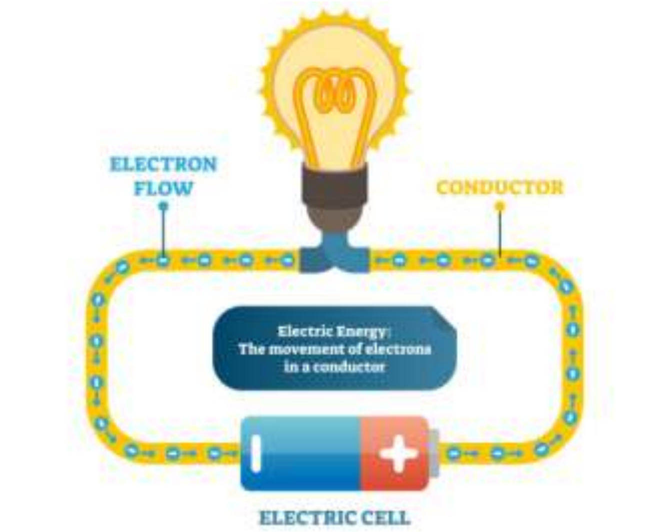
Key Concepts and Connections

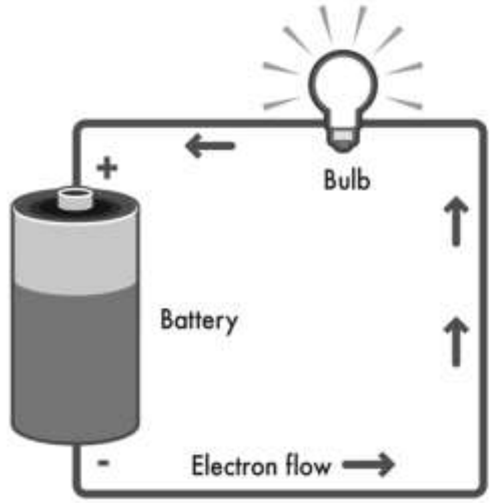
- This sub-strand connects to concepts of atomic structure, charge, and electric fields.
- Understanding electrostatics is essential for various technological applications and safety measures.

3.2 Current Electricity

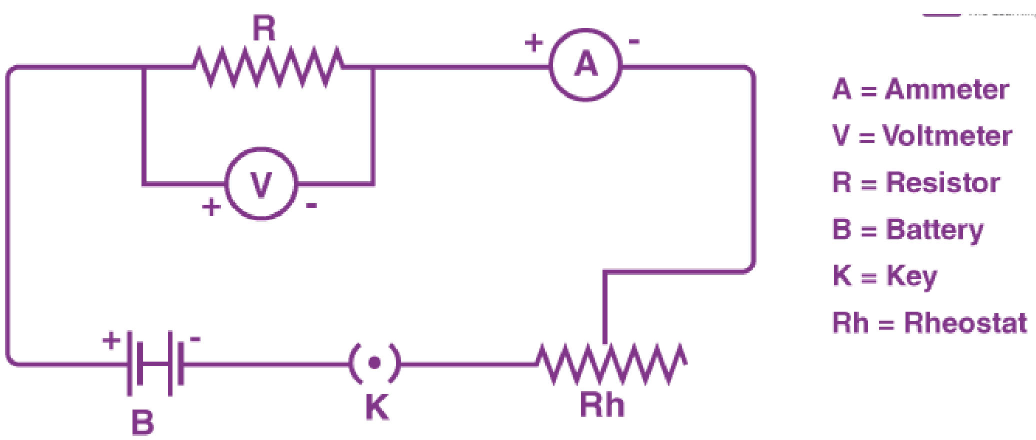
1. Basic Terminologies

- **Current (I):**
  - ✓ The rate of flow of electric charge.
  - ✓ Unit: Ampere (A).

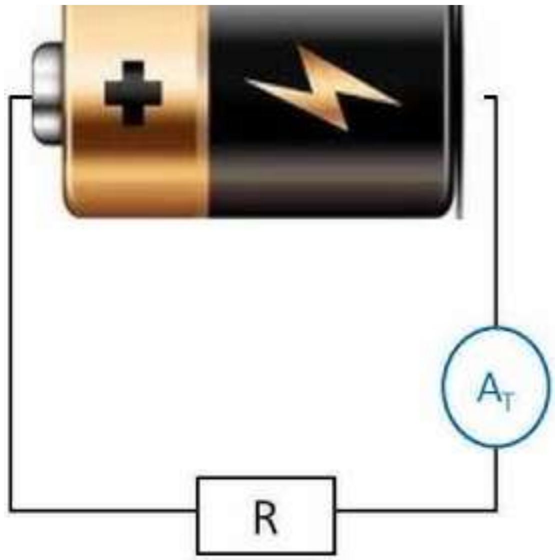




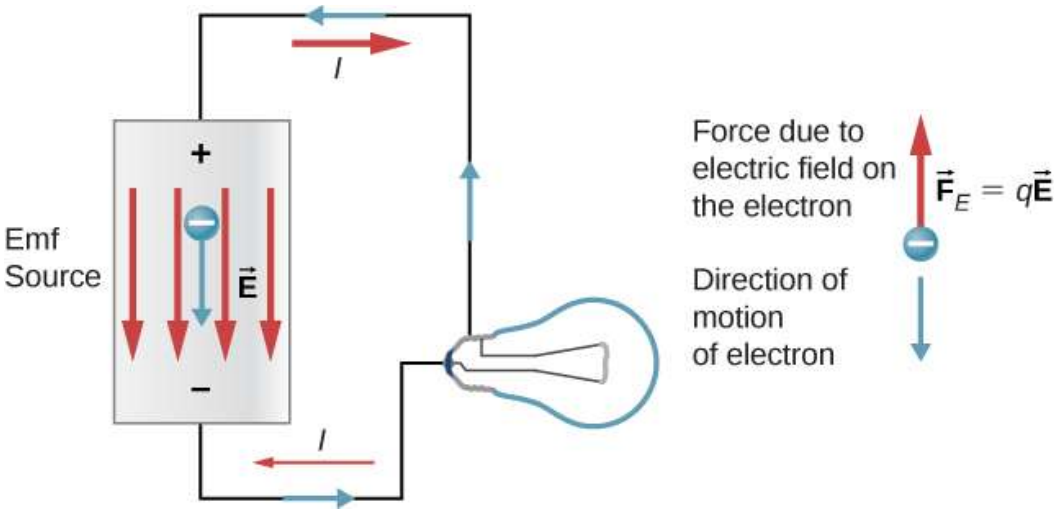
- ✓ [Illustration of electrons flowing through a wire]
- **Potential Difference (V):**
  - ✓ The work done per unit charge to move a charge between two points.
  - ✓ Unit: Volt (V).
  - ✓ **Illustration:**



- ✓ [Illustration of potential difference across a resistor]
- **Electromotive Force (EMF, E):**
  - ✓ The total work done per unit charge by a source (e.g., battery).
  - ✓ Unit: Volt (V).



- ✓ **Illustration:**



- ✓ [Illustration of a battery providing EMF]

- **Resistance (R):**
  - ✓ The opposition to the flow of electric current.
  - ✓ Unit: Ohm (Ω).

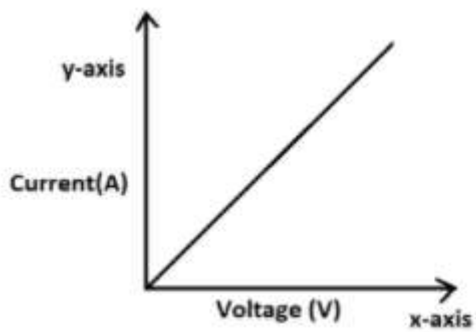
  - ✓ [Image of a resistor]

- **Internal Resistance (r):**

- ✓ The resistance within a source (e.g., battery).

2. Verifying Relationships

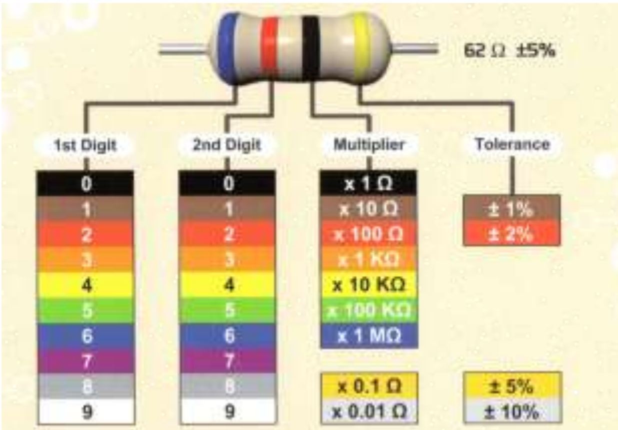
- **Ohm's Law (V = IR):**
  - ✓ The potential difference across a conductor is directly proportional to the current flowing through it, provided the temperature remains constant.
  - ✓ **Experiment:**
    - Vary the voltage across a resistor and measure the current.
    - Plot a graph of V against I.
    - A straight-line graph verifies Ohm's law.
  - ✓ **Illustration:**



  - ✓ [Graph of Voltage vs Current showing a linear relationship]
- **EMF and Internal Resistance (E = I(R + r)):**
  - ✓ The EMF of a source is equal to the potential difference across the external resistance plus the potential drop across the internal resistance.
  - ✓ **Experiment:**
    - Vary the external resistance and measure the current and potential difference.
    - Plot a graph to determine the EMF and internal resistance.

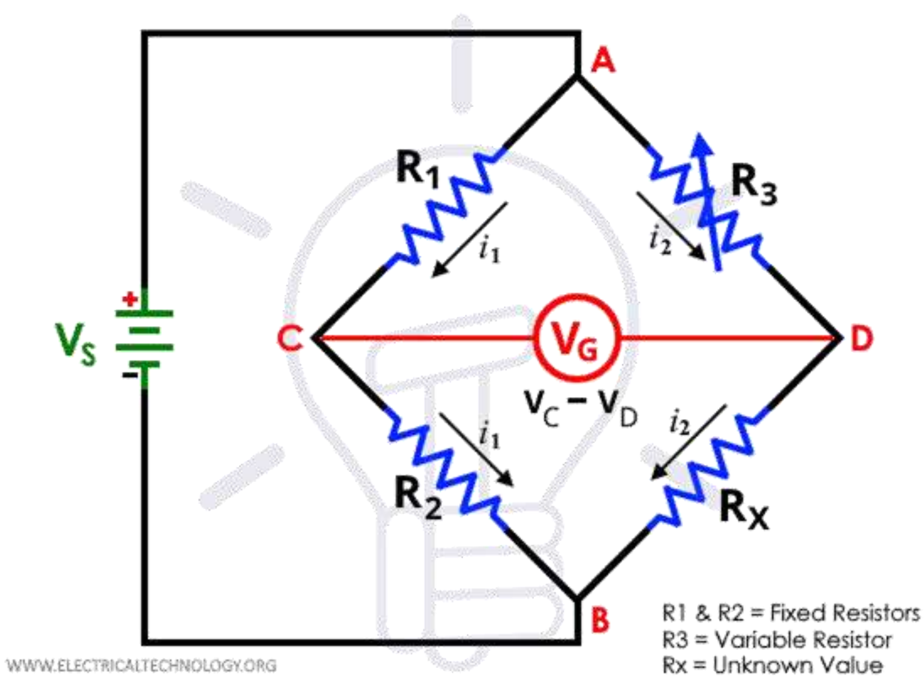
3. Determining Resistance and Resistivity

- **Resistor Colour Codes:**
  - ✓ Resistors have colour bands that indicate their resistance value.



- ✓ [Image of a resistor with colour bands]

- **Ammeter-Voltmeter Method:**
  - ✓ Using an ammeter to measure current and a voltmeter to measure potential difference.
  - ✓ Calculate resistance using Ohm's law (R = V/I).
- **Wheatstone Bridge:**
  - ✓ A circuit used to measure an unknown resistance by comparing it with known resistances.
  - ✓ **Illustration:**

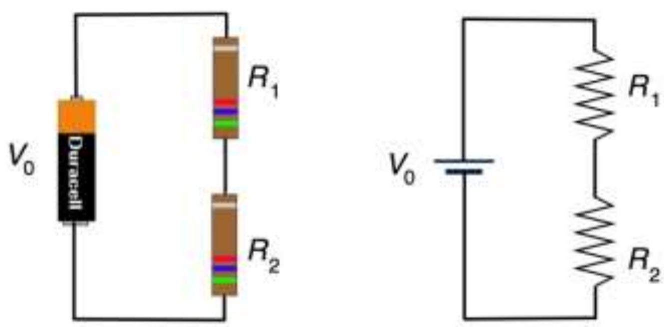


  - ✓ [Illustration of a Wheatstone bridge circuit]
- **Metre Bridge:**
  - ✓ A practical application of the Wheatstone bridge.

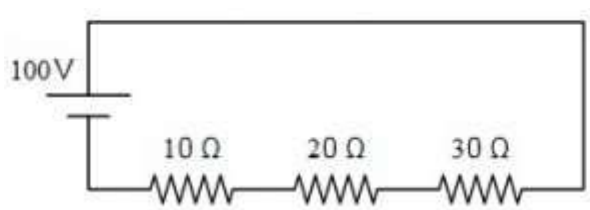
- **Resistivity (ρ):**
  - ✓ A measure of a material's resistance to the flow of electric current.
  - ✓ $R = \rho L/A$ (where L = length, A = cross-sectional area).

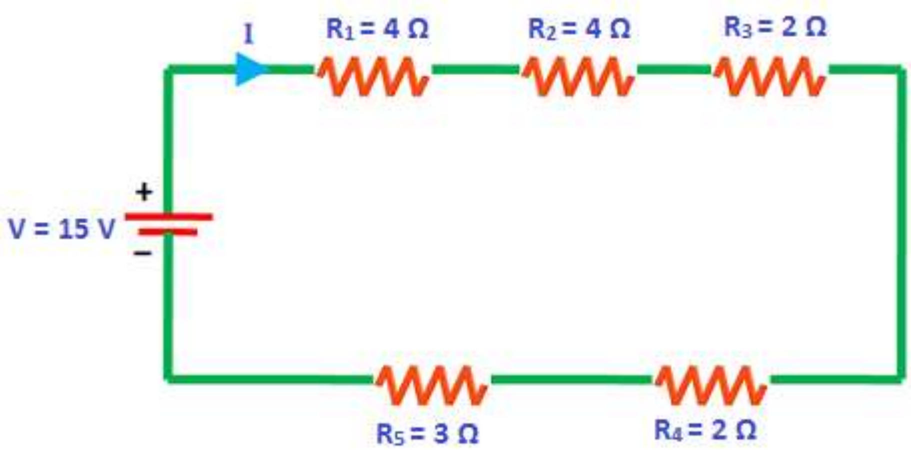
4. Resistor Networks

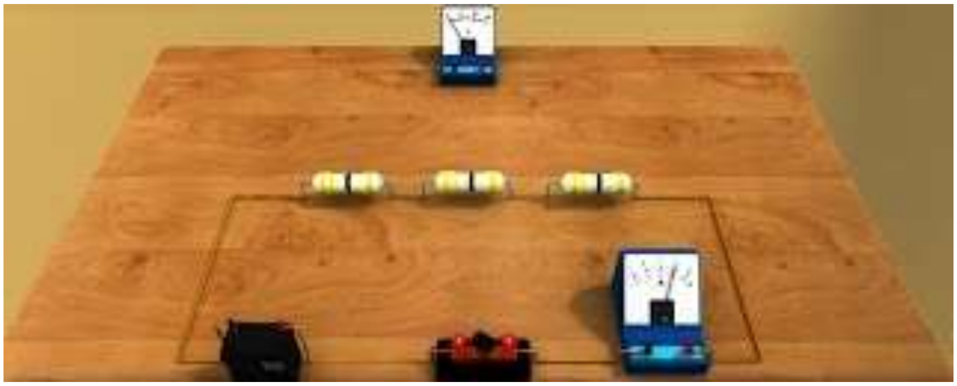
- **Series Resistors:**
  - The total resistance is the sum of individual resistances (R_total = R1 + R2 + R3 + ...).



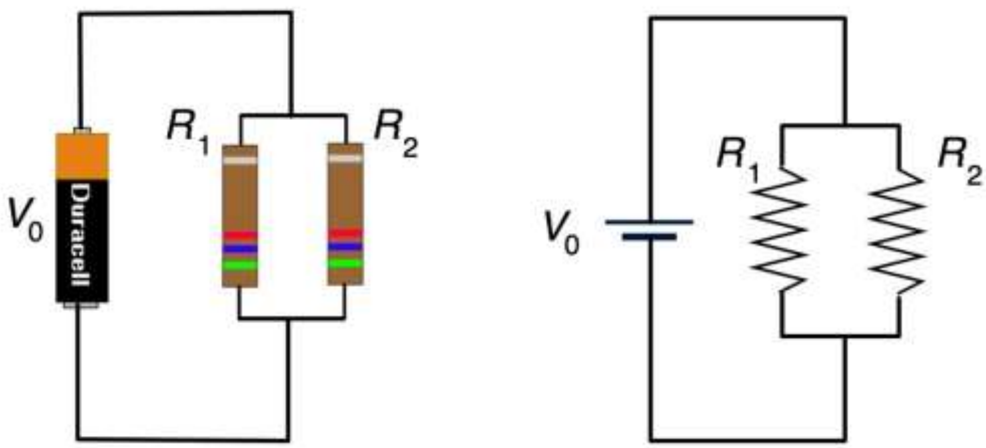
  - **Illustration:**



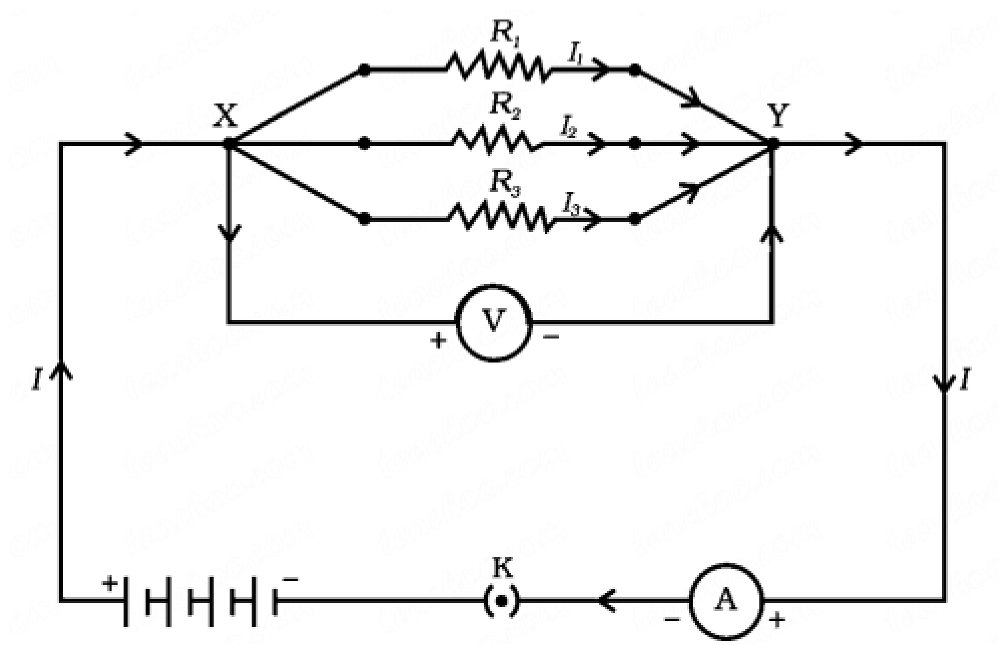


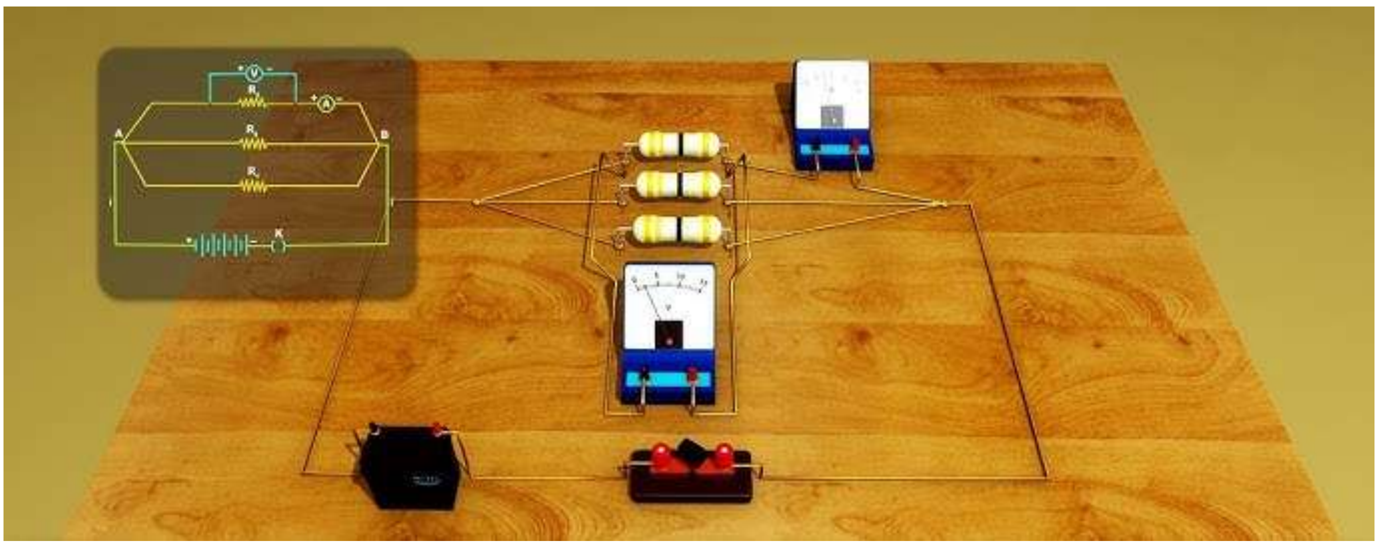
- 
- [Illustrations of resistors connected in series]

- **Parallel Resistors:**
  - The reciprocal of the total resistance is the sum of the reciprocals of individual resistances (1/R_total = 1/R1 + 1/R2 + 1/R3 + ...).



  - **Illustration:**





- [Illustration of resistors connected in parallel]

5. Power and Heating Effect

- **Power (P):**
  - ✓ The rate at which electrical energy is converted into other forms of energy.
  - ✓ $P = VI = I^2R = V^2/R$.
  - ✓ **Experiment:**
    - Vary the voltage and current and measure the power.
    - Plot a graph to show the relationship.
- **Heating Effect:**

  - ✓ When current flows through a resistor, electrical energy is converted into heat.
  - ✓ Applications: Electric heaters, toasters, light bulbs.

6. Applications of Resistors

- **Current Limiting:**
  - ✓ Resistors are used to limit the current in circuits.
- **Voltage Division:**
  - ✓ Resistors are used to divide voltage in circuits.
- **Sensors:**
  - ✓ Thermistors and light-dependent resistors (LDRs) are used as sensors.

7. Applications of Current Electricity

- **Lighting:**
  - ✓ Electric bulbs.
- **Heating:**
  - ✓ Electric heaters, ovens.
- **Electronics:**
  - ✓ Computers, smartphones.
- **Transportation:**
  - ✓ Electric vehicles, trains.

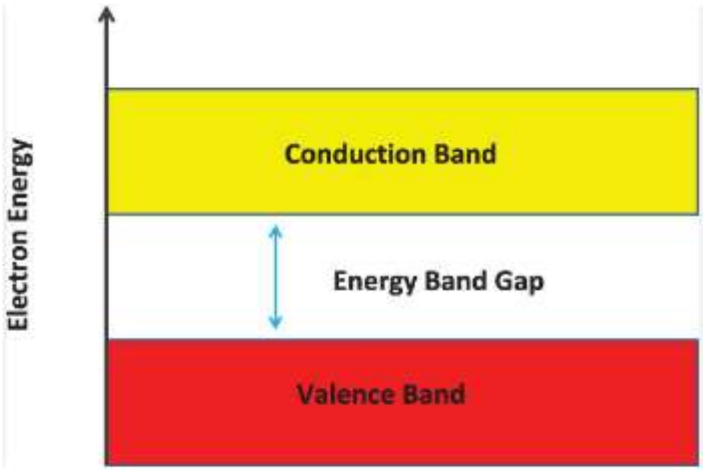
Key Concepts and Connections

- This sub-strand connects to concepts of charge, energy, and power.
- Understanding current electricity is essential for various technological applications and everyday life.

3.3 Introduction to Electronics (6 Lessons)

1. Energy Band Theory

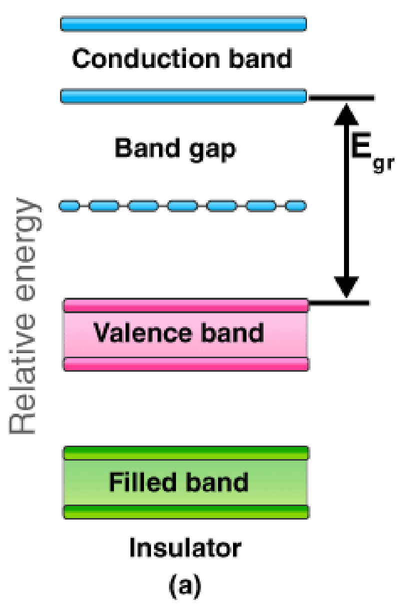
- **Energy Bands:**
  - ✓ In solids, electron energies are grouped into bands.
  - ✓ **Valence Band:** The outermost band containing electrons involved in bonding.
  - ✓ **Conduction Band:** The band where electrons can move freely, allowing electrical conductivity.
  - ✓ **Band Gap:** The energy gap between the valence and conduction bands.
  - ✓ **Illustration:**



- ✓ [Illustration of energy band diagram showing valence band, conduction band, and band gap]

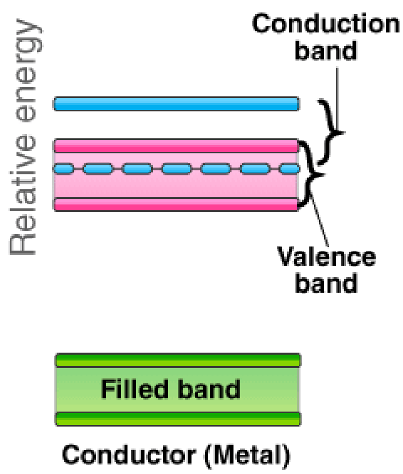
2. Insulators, Conductors, Semiconductors, and Superconductors

- **Insulators:**
  - ✓ Materials with a large band gap.
  - ✓ Electrons cannot easily move to the conduction band.
  - ✓ Examples: Rubber, glass, plastic.
  - ✓ **Illustration:**



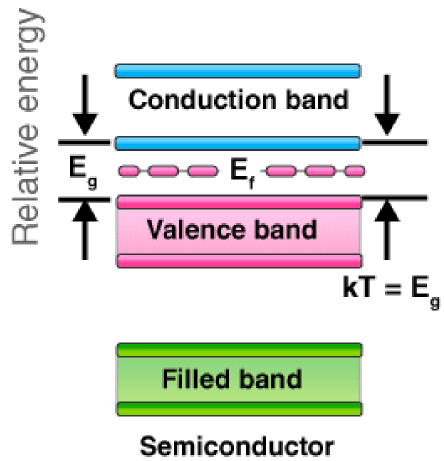
  - ✓ [Energy band diagram showing a large band gap for insulators]
- **Conductors:**

- ✓ Materials with overlapping valence and conduction bands or a very small band gap.
- ✓ Electrons can move freely, allowing high conductivity.
- ✓ Examples: Metals (copper, aluminum).
- ✓ **Illustration:**

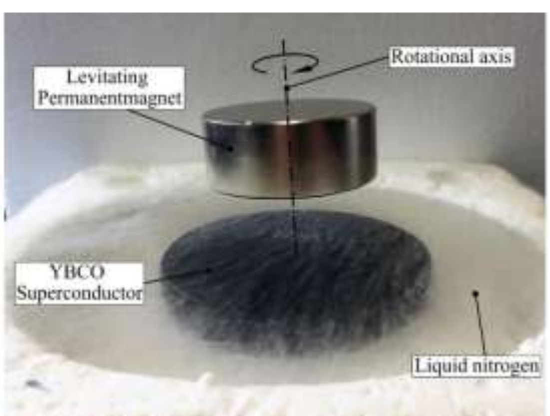


- ✓ [Energy band diagram showing overlapping bands for conductors]

- **Semiconductors:**
  - ✓ Materials with a moderate band gap.
  - ✓ Conductivity is between that of conductors and insulators.
  - ✓ Conductivity increases with temperature.
  - ✓ Examples: Silicon, germanium.
  - ✓ **Illustration:**



- ✓ [Energy band diagram showing a moderate band gap for semiconductors]
- **Superconductors:**
  - ✓ Materials that exhibit zero resistance below a critical temperature.
  - ✓ Allow current to flow without energy loss.
  - ✓ Examples: Certain metals and alloys at very low temperatures.

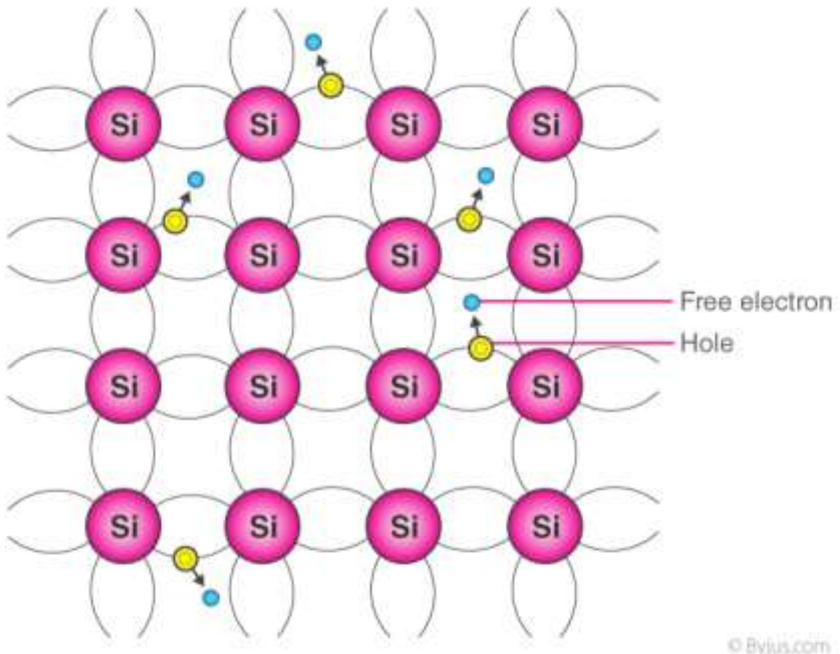


3. Electrical Behavior with Varying Temperatures

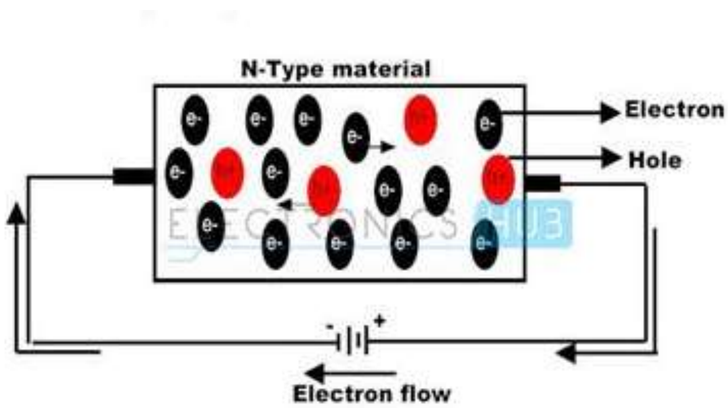
- **Conductors:**
  - ✓ Resistance increases with temperature.
- **Semiconductors:**
  - ✓ Resistance decreases with temperature.
- **Insulators:**
  - ✓ Resistance generally remains high with temperature.

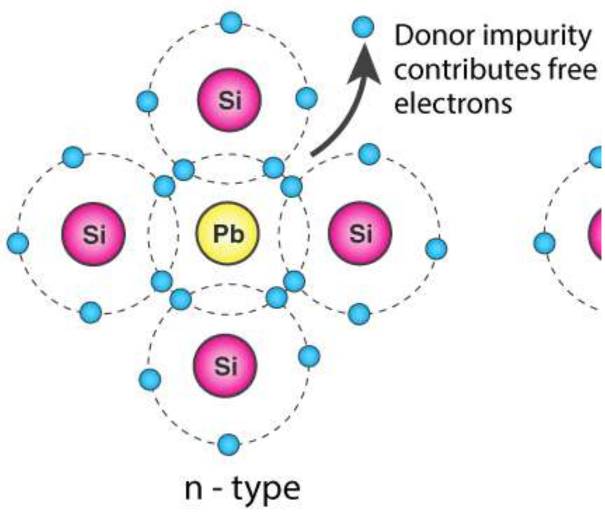
4. Intrinsic and Extrinsic Semiconductors

- **Intrinsic Semiconductors:**
  - ✓ Pure semiconductors with equal numbers of electrons and holes (electron vacancies).
  - ✓ **Illustration:**



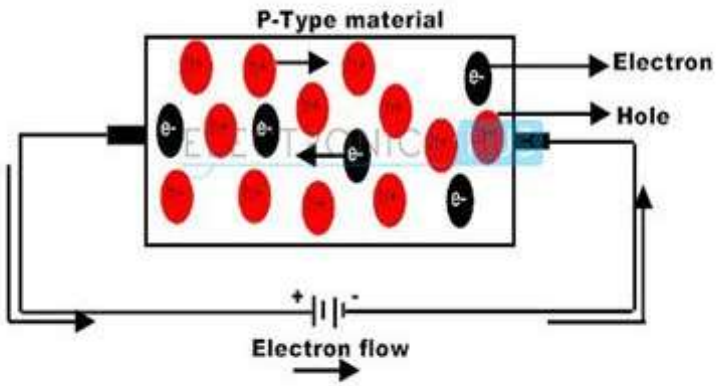
  - ✓ [Illustration of intrinsic semiconductor structure]
- **Extrinsic Semiconductors:**
  - ✓ Intrinsic semiconductors doped with impurities to increase conductivity.
  - ✓ **N-type Semiconductors:**
    - Doped with pentavalent impurities (e.g., phosphorus).
    - Have excess electrons.
    - **Illustration:**

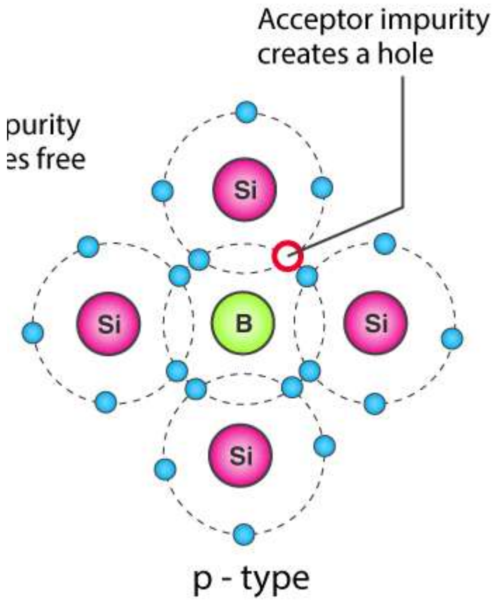




- [Illustration of n-type semiconductor structure]

✓ **P-type Semiconductors:**
- Doped with trivalent impurities (e.g., boron).
- Have excess holes.
- **Illustration:**

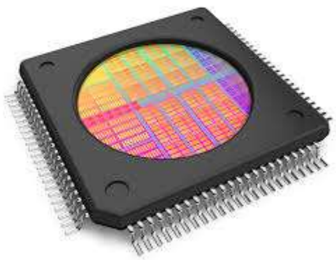




- [Illustration of p-type semiconductor structure]

5. Applications

- **Conductors:**
  - ✓ Electrical wiring, power transmission.
- **Semiconductors:**
  - ✓ Diodes, transistors, integrated circuits (ICs).
  - ✓ Essential in modern electronics (computers, smartphones).



  - ✓ [Image of a silicon wafer with integrated circuits]
- **Insulators:**
  - ✓ Electrical insulation, thermal insulation.
- **Superconductors:**
  - ✓ MRI machines, high-speed trains (maglev).

Key Concepts and Connections

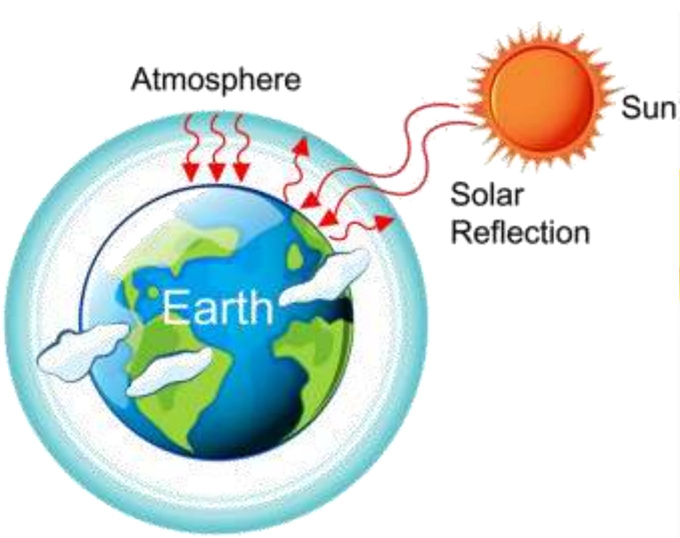
- This sub-strand connects to concepts of atomic structure, energy levels, and electrical conductivity.
- Understanding these materials is crucial for various technological applications in electronics and beyond.

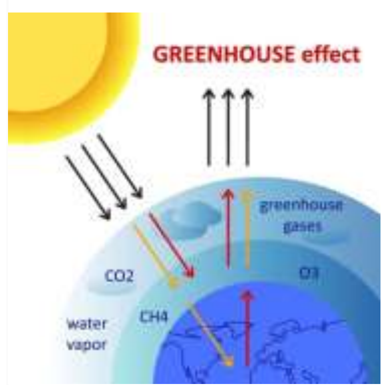
4.0 ENVIRONMENTAL AND SPACE PHYSICS:

4.1 Greenhouse Effect and Climate Change

1. Greenhouse Effect

- **Definition:**
  - ✓ The process by which certain gases in the Earth's atmosphere trap heat from the sun, warming the planet.
  - ✓ **Greenhouse Gases:**
    - Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and water vapor (H_2O).
  - ✓ **Process:**
    - Solar radiation enters the atmosphere.
    - Earth's surface absorbs some radiation and re-emits it as infrared radiation.
    - Greenhouse gases absorb and re-emit this infrared radiation, trapping heat.
  - ✓ **Illustration:**





[Illustration of the Greenhouse effect, where heat enters the earth but can't escape out]

- **Examples:**
  - ✓ Temperatures within a greenhouse.

- ✓ Cars parked with closed windows in the sun.

- ✓ A house with no ventilation

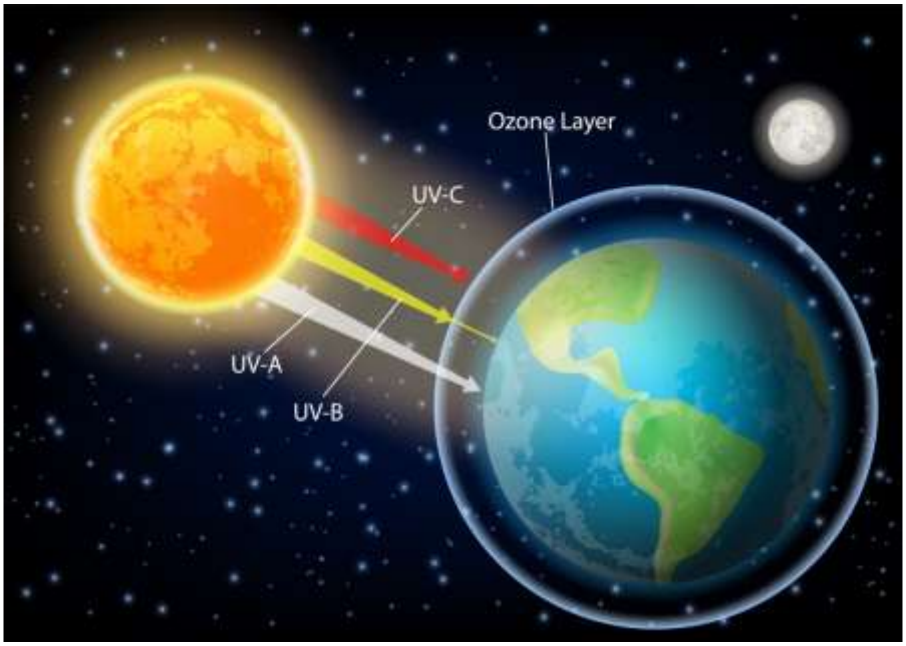
2. Factors Leading to Greenhouse Effect

- **Burning of Fossil Fuels:**
  - ✓ Releases CO_2 into the atmosphere.
- **Deforestation:**
  - ✓ Reduces the Earth's ability to absorb CO_2.
- **Industrial Processes:**
  - ✓ Release various greenhouse gases.
- **Agriculture:**
  - ✓ Releases methane and nitrous oxide.
- **Waste Disposal:**
  - ✓ Releases methane.

3. Ozone Layer and Climate Change

- **Ozone Layer:**

- ✓ A layer in the Earth's stratosphere that absorbs most of the sun's harmful ultraviolet (UV) radiation.



- ✓ [Illustration of the Ozone Layer]

- **Ozone Depletion:**
  - ✓ Caused by human-made chemicals (e.g., chlorofluorocarbons or CFCs).
  - ✓ Leads to increased UV radiation reaching the Earth's surface.
- **Effect on Climate Change:**
  - ✓ Ozone depletion can indirectly affect climate change by altering atmospheric circulation and temperature patterns.
  - ✓ Increased UV radiation has negative impacts on ecosystems and human health.

4. Global Warming and Climate Change

- **Global Warming:**
  - ✓ The long-term heating of Earth's climate system observed since the pre-industrial period (between 1850 and 1900) due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth’s atmosphere.
  - ✓ **Image:**
  - ✓ [Graph showing global temperature rise]
- **Climate Change:**
  - ✓ Long-term shifts in temperatures and weather patterns.
  - ✓ Includes changes in precipitation, sea level, and extreme weather events.
- **Effects of Climate Change:**

- ✓ Rising sea levels.
- ✓ More frequent and intense heatwaves.
- ✓ Changes in precipitation patterns.
- ✓ Increased frequency of extreme weather events (e.g., hurricanes, droughts).
- ✓ Changes in ecosystems.

5. Mitigating Factors Against Climate Change

- **Reduce Greenhouse Gas Emissions:**
  - ✓ Transition to renewable energy sources.
  - ✓ Improve energy efficiency.
  - ✓ Reduce deforestation.
- **Carbon Sequestration:**
  - ✓ Planting trees.
  - ✓ Carbon capture and storage technologies.
- **Adaptation Measures:**
  - ✓ Building seawalls.
  - ✓ Developing drought-resistant crops.
  - ✓ Improving water management.
- **International Cooperation:**
  - ✓ Agreements like the Paris Agreement.
- **Public Awareness and Education:**
  - ✓ Promoting sustainable practices.

6. Demonstrating Effects of Climate Change

- **Observations:**
  - ✓ Changes in water levels in lakes and rivers.
  - ✓ Changes in vegetation.
  - ✓ Changes in weather patterns.
  - ✓ Changes in land use.
- **Discussions:**
  - ✓ Role of human activities in environmental degradation.

Key Concepts and Connections

- This sub-strand connects to concepts of atmospheric science, heat transfer, and environmental science.
- Understanding climate change is crucial for addressing its impacts and promoting sustainable practices.

4.2 Introduction to Space Physics

1. Theory of the Origin of the Universe (Big Bang Theory)

- **Big Bang Theory:**
  - ✓ The prevailing cosmological model explaining the universe's origin and evolution.
  - ✓ States that the universe originated from an extremely hot, dense state about 13.8 billion years ago.
  - ✓ The universe has been expanding and cooling ever since.
  - ✓ **Illustration:**

  - ✓ [Illustration of the Big Bang Theory]
- **Evidence:**
  - ✓ Redshift of galaxies (indicating expansion).
  - ✓ Cosmic microwave background radiation (leftover heat from the Big Bang).
  - ✓ Abundance of light elements (hydrogen, helium).

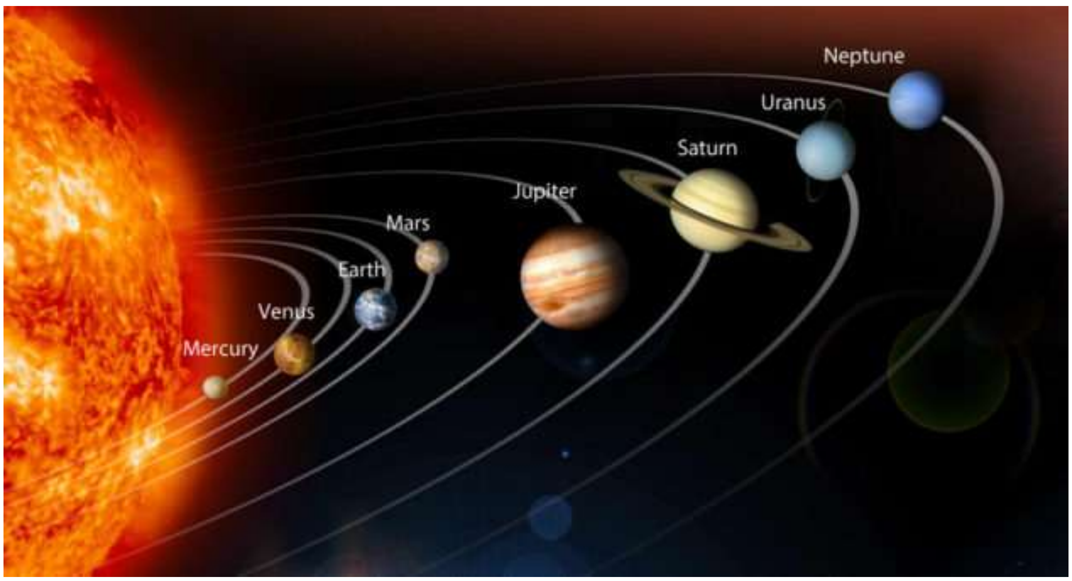
2. Classification of Bodies in the Universe

- **Stars:**
  - ✓ Massive, luminous balls of plasma held together by gravity.
  - ✓ Produce light and heat through nuclear fusion.

- ✓ Examples: The Sun, Sirius.

- ✓ [Image of a star]

- **Planets:**
  - ✓ Celestial bodies orbiting a star.
  - ✓ Do not produce their own light.
  - ✓ Examples: Earth, Mars, Jupiter.

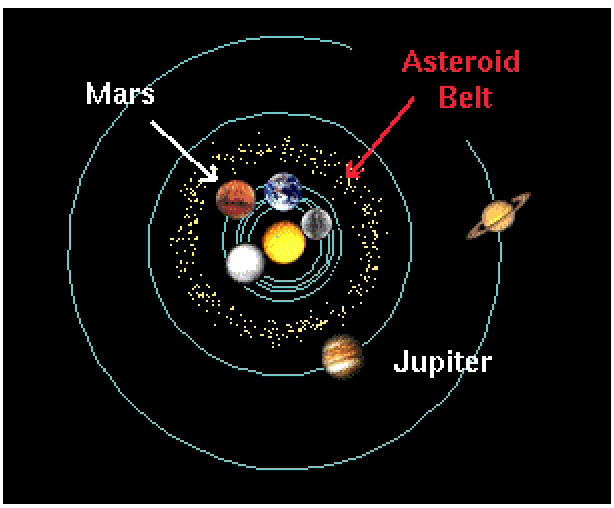


- ✓ [Image of a planet]

- **Moons (Natural Satellites):**
  - ✓ Celestial bodies orbiting a planet.
  - ✓ Examples: Earth's Moon, Jupiter's moons.

- ✓ [Image of a moon orbiting a planet]

- **Asteroids:**
  - ✓ Rocky bodies orbiting the sun, mainly found in the asteroid belt.



  - ✓ [Image of an asteroid belt]

- **Comets:**
  - ✓ Icy bodies with long, bright tails that orbit the sun.

  - ✓ [Image of a comet]

- **Galaxies:**
  - ✓ Vast systems of stars, gas, dust, and dark matter held together by gravity.
  - ✓ Examples: Milky Way, Andromeda.

  - ✓ [Image of a galaxy]
- **Nebulae:**
  - ✓ Clouds of gas and dust in space.

  - ✓ [Image of a nebula]

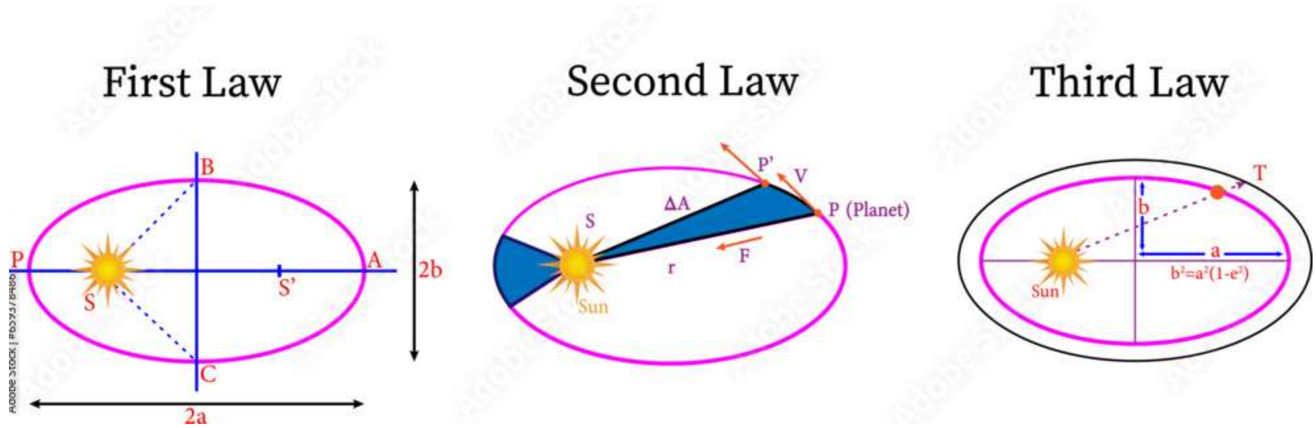
3. Evolution of Astrophysics and Space Exploration

- **Early Astronomy:**
  - ✓ Ancient civilizations observed and tracked celestial bodies.

- ✓ Development of early telescopes.
- **Galileo Galilei:**
  - ✓ Used a telescope to make groundbreaking observations.
  - ✓ Supported the heliocentric model.
- **Isaac Newton:**
  - ✓ Developed the laws of motion and universal gravitation.
- **Modern Astrophysics:**
  - ✓ Use of advanced telescopes, space probes, and satellites.
  - ✓ Study of stars, galaxies, and the universe.
- **Space Exploration:**
  - ✓ Sputnik 1 (first artificial satellite).
  - ✓ Apollo missions (human moon landings).
  - ✓ International Space Station (ISS).
  - ✓ Space telescopes (Hubble, James Webb).
  - ✓ **Image:**
  - ✓ [Image of a space telescope]

4. Planetary Motion

- **Kepler's Laws of Planetary Motion:**
  - ✓ **First Law:** Planets move in elliptical orbits with the sun at one focus.
  - ✓ **Second Law:** A line joining a planet to the sun sweeps out equal areas in equal intervals of time.
  - ✓ **Third Law:** The square of the orbital period is proportional to the cube of the semi-major axis.
  - ✓ **Illustration:**



  - ✓ [Illustration of Kepler's laws of planetary motion]
- **Modeling Planetary Motion:**
  - ✓ Using simulations or physical models to demonstrate planetary orbits.

5. Telescopy

- **Telescopes:**
  - ✓ Instruments used to observe distant objects in space.
  - ✓ **Types:**
    - Optical telescopes (refracting and reflecting).

    - Radio telescopes.

    - Space telescopes.

- **Methods of Exploring the Universe:**
  - ✓ Space probes.
  - ✓ Satellites.
  - ✓ Spectroscopy.

6. Careers in Space Exploration

- **Astrophysicists:**
  - ✓ Study the physics of celestial bodies.
- **Astronomers:**
  - ✓ Observe and study celestial phenomena.
- **Aerospace Engineers:**
  - ✓ Design and build spacecraft and satellites.
- **Astronauts:**
  - ✓ Travel to space and conduct experiments.
- **Space Scientists:**
  - ✓ Study various aspects of space, including planetary science and cosmology.
- **Mission Control Personnel:**
  - ✓ Monitor and control space missions.
- **Data Analysts:**
  - ✓ Process and analyze data from space missions.

Key Concepts and Connections

- This sub-strand connects to concepts of physics, astronomy, and cosmology.
- Understanding space physics is crucial for exploring the universe and developing space technologies.

Teachers are advised to also use the course books