FORM TWO PHYSICS

A 2019 FELIX LISAUSYO PRODUCTION

FELIX LISAUSYO

YOUR FRIEND WHEN IT COMES TO GATHERING MATERIALS FOR MSCE EXAMINATIONS

TOPICS COVERED

- Scientific investigation
  - Strategies of planning an investigation
  - The structure of a scientific investigation
  - A sample scientific investigation
- Thermal expansion
  - Thermal expansion and contraction
  - Effects of thermal expansion.
  - Application of thermal expansion.
- Density
  - Density
  - Comparison of densities of solids, liquids and gases
  - Effects of temperature on density
  - Unusual expansion of water between 0^oC and 4^oC
  - Floating and sinking
  - Average density
- Specific heat capacity
  - Heat capacity
  - Comparison of specific heat capacity of the three states of matter
  - Application of specific heat capacity
- Heat transfer
  - Heat and temperature
  - Modes of heat transfer
  - Conduction
  - Comparing rates of conduction in metals
  - Convection
  - Radiation
  - Application of heat transfer
- Power and machines
  - Power
  - Machines
- Electronics
  - Electronics
  - Electrostatic charging by rubbing
  - Source of electronic charging
  - The law of charges
  - Electric field and electric field patterns
  - Effects and application of electronics
- Light
  - Rectilinear propagation of light
  - Formation of shadows and eclipses
  - Pinhole camera
  - Reflection on a plane surface

- Rotation of a plan mirror
- Parallel mirrors
- Mirrors inclined at an angle
- Application of reflection at plane surface
- Refraction of light
- Simple experiments to illustrate refraction of light
- Real and apparent depth
- Refraction of light through a prism
- Dispersion of white light

- Introduction to nuclear physics
  - Structure of an atom
  - Isotopes
  - Radioactivity
  - Radioactive decay and half life
  - Types of radiations emitted and their properties
  - Dangers of radioactivity
  - Applications of radioactivity.

UNIT ONE

SCIENTIFIC INVESTIGATION

SKILLS REQUIRED TO DEVELOP FOR SOME ONE TO CARRY OUT SCIENTIFIC INVESTIGATIONS

- Making an observation
    - Involves critically looking at a natural phenomena as they take place.
- Proposing a hypothesis
    - A hypothesis is an idea that is suggested as a possible explanation or answer to the observed problem.
- Designing an experiment to test the hypothesis
    - Identify the variables
        - ✓ Controlled variables
            - Are variables kept constant so that they do not interfere with the results.
        - ✓ Independent variables
            - Are variables you control as you wish within suitable ranges of the investigation.
        - ✓ Dependent variables
            - Are all variables you measure every time you change your independent variables.
        - ✓ Outline the apparatus and procedure or method to be followed.
- Methods of data presentation
    - This includes
        - ✓ drawing tables to show the quantities being measured and their units of measurements
        - ✓ drawing graphs
        - ✓ drawing bar charts etc
- Drawing conclusion from the investigation
    - It involves comparison of the hypothesis and the results of the investigation.
    - This comparison makes you accept or reject the hypothesis.
- Evaluating the strength of the evidence
    - You indicate what could be source of the limitations of hypothesis if accepted.
    - If not accepted, come up with another hypothesis and investigation.

STRATEGIES OF PLANNING AN INVESTIGATION

- Safety measures
    - Required to be followed when carrying out an investigation successfully.
    - It includes the hard factors in case of apparatus and chemicals.
- The apparatus and chemicals to be used
    - Should be appropriate for the measurement of quantities involved.
    - Should have correct scale and range of values.

- In case of chemicals with precautions, follow the precaution measures as stipulated on the container of the chemicals.
- Be conversant on how the apparatus can be operated and used.

- The procedure or method
  - Clearly show the steps to be followed when conducting the investigation.
  - Indicate quantities which will be varied and vary at will.
  - Show how each quantity will be measured.
  - Indicate the value of the quantity that will be kept constant.
- Repeated readings
  - This is done to improve the reliability of the results obtained.
  - Finding the average of the repeated results reduces experimental error.

THE STRUCTURE OF A SCIENTIFIC INVESTIGATION

- Aim of the experiment
  - Is a belief and concise statement of the objective of the experiment.
  - Is derived from the hypothesis initially stated.
- Apparatus/equipment to be used
  - Include all materials to be used.
  - These are identified and listed here.
- Procedure/method
  - Is a section of step-by-step account of what is to be done.
  - You also indicate it will be done.
  - A well labelled diagram of the set-up should be included.
  - Quantities to be varied, measured, kept constant should be indicated clearly with their values.
  - A statement on how the results will be analysed should be included.
- Results
  - Results of measurements are shown here.
  - These include graphs, chart and tables.
- Analysis
  - Is where the result of the investigation are discussed.
  - The usual points of discussion are
    - ✓ Trend of the graph
      - Explain why the graph curve decreases, increases or straight line.
    - ✓ The gradient of the graph
      - Relate the quantities you are investigating with the gradient of the graph where possible.
    - ✓ Area under the graph
      - It may sometimes be related to the quantity of investigation in some way.
- Conclusion
  - You state carefully the results analysed.

- Indicate limitations of the investigation you carried out.
- Sources of errors must be indicated.
- Also give areas that require improvement
- It should finally discuss the extent to which the hypothesis (aim) has been achieved.

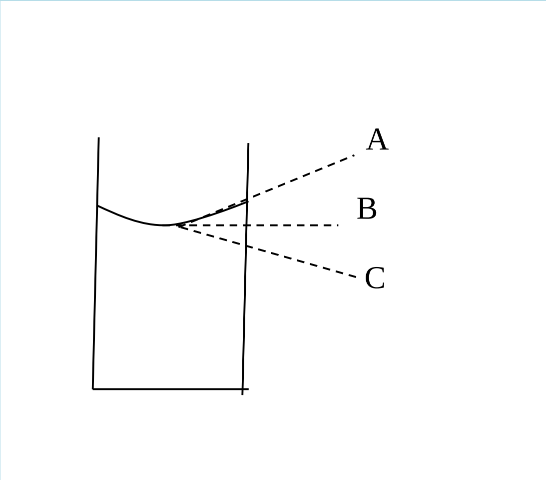
SAMPLE SCIENTIFIC INVESTIGATION

This should base on the observation made in a community.

- Observation
  - If a student observed that a bottle filled with water and closed tightly placed in the fridge breaks as the water freezes
  - From this observation one can come up with the hypothesis.
- Hypothesis
  - Water expands when turns to ice and occupies a greater space than when it is liquid.
- Experimentation
  - Aim
    - ✓ To show that water expands when it freezes and becomes ice.
  - Apparatus
    - ✓ Two identical glass bottles e.g. 25ml bottles
    - ✓ Refrigerator
    - ✓ Water.
  - Procedure
    - ✓ Fill the two glass bottles with 25ml of water at room temperature.
    - ✓ Put the two bottles in the fridge, one in the freezer compartment while the other in the cooling compartment.
    - ✓ Close the fridge and allow the bottles be in the fridge over a night.
    - ✓ Remove the two bottles and observe what happens.
  - Results
    - ✓ The water level in the bottle placed in cooling compartment is lower than before.
    - ✓ The water level in the bottle in the freezing compartment increases and the bottle may break due to expansion of water.
  - Analysis of the results
    - ✓ Since no water was added, and the increase in level of water in one bottle whose water frozen is an indication that water expanded when freezing.
  - Conclusion
    - ✓ The results I found are similar to the hypothesis. Therefore, water expands when freezing.
  - Strength and weaknesses
    - ✓ The strength is that the experiment was conducted only for water which is easy to compare the findings from two bottles.

- ✓ It weakness is that it does not give evidence that other liquid scan behave in the same way since they were not tried.

- Possible sources of error in students
  - ➢ Parallax errors
    - ✓ Occurs when the eye is not well positioned when reading the volume of the water in the measuring cylinders.
    - ✓ To minimize this, one should place the eye in the same horizontal level of the lowest point of the meniscus of the water in the measuring cylinders and read the readings.



- ✓ The correct level of the eye is B.

UNIT TWO

THERMAL EXPANSION

EXPANSION

- Is the increase in size of the substance when heated
- The increase magnitude and direction depends on the type of substance and amount of heat applied to it.

CONTRACTION

- Is the decrease in size of the substance when cooled.
- Every substance has its own rate of expansion except for gases.

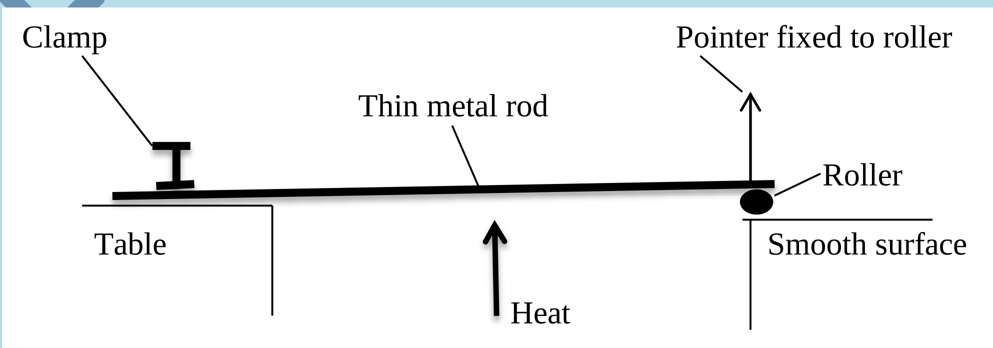
EXPANSION AND CONTRACTION IN SOLIDS

- All solids expand when heated.
- The rate of expansion varies with different solids.

DEMONSTRATING EXPANSION CONTRACTION IN SOLIDS

ACTIVITY ONE

- Aim
  - To demonstrate expansion and contraction using thin metal rod
- Apparatus
  - Thin metal rod
  - Rollers connected to a pointer
  - Source of heat
  - G-clamp
- Procedure
  - Clamp one end of the long thin metal rod tightly with end of the rod resting on a roller fitted with a thin pointer as shown below.



  - Heat the metal rod for some time and observe what happens to the pointer.
  - Remove the burner and allow the rod to cool and observe what happens to rod.

- Repeat the experiment with thin metal rods of different materials and observe what happens.

- Observation
  - The pointer deflects in the clock wise direction when the rod is heated and anticlockwise when the rod is being cooled.
  - The pointer deflects differently with different types of metals.
- Discussion
  - When metals are heated, they increase in length.
  - This increase in length makes the roller to roll hence making pointer deflects.
  - Upon cooling, the metal decreases in size hence makes the roller again to roll and makes the pointer deflect anticlockwise.
- Conclusion
  - Solids expand when heated and contract when cooled.
  - Different solids expand and contract differently.

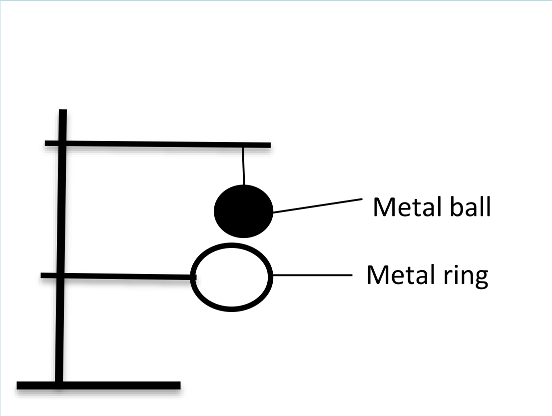
ACTIVITY TWO

- Aim
  - To demonstrate expansion and contraction using the bar and gauge apparatus.
- Apparatus
  - A bar and gauge apparatus. (This is a bar with a suitable wooden handle and gauge of which a bar fits into the gauge at room temperature)
  - Bunsen burner
- Procedure
  - Move the metal bar into and out of the gauge at room temperature and observe what happens.
  - Keep the metal bar a way from gauge and heat the bar for some time.
  - Try to fit the bar into the gauge and observe what happens.
  - Allow the bar to cool and try to fit it into the gauge and observe.
- Observation
  - At room temperature, the bar fit exactly into the gauge.
  - After the bar is heated, the metal bar does not fit into the gauge. It is larger.
  - The metal bar again fits exactly when cooled.
- Discussion
  - When the bar is heated, there is an increase in length than before hence it does not fit in.
  - When cooled, the bar goes to its original size hence fits well.
- Conclusion
  - Solids expand when heated and contract when cooled.

ACTIVITY THREE

- Aim
  - To demonstrate expansion and contraction of solids using the ball and ring apparatus.

- Apparatus
  - A ball and a ring
  - Bunsen burner
  - A bowl of cold water
- Procedure
  - Arrange the setting as shown below.



  - Move the ball in and out of the metal ring at room temperature
  - Keep the metal ball away from the ring and heat it for some time.
  - Try to pass the ball through the metal ring and record your observation.
  - Cool the metal ball again in a bowl of cold water and try to pass the ball through the ring and record your observation.
- Observation
  - At room temperature, the metal ball passes through the ring.
  - When the ball is heated, it does not pass through the metal ring.
  - When it is cooled, it passes through it easily.
- Discussion
  - When metal ball is heated it expended. There was an increase in volume and the ball could not pass through the metal ring.
  - When the metal ball was cooled, it contracted and gained the original volume which makes it to pass through the metal ring easily.
- Conclusion
  - Solids expand when heated and contract when cooled.

WHY DO SOLIDS EXPAND WHEN HEATED?

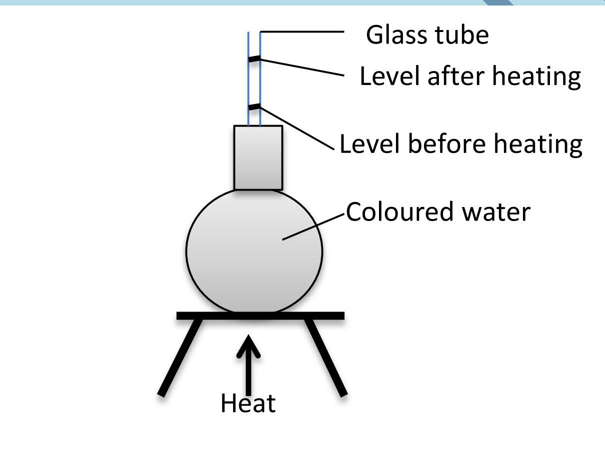
- When solids are being heated, the molecules start to vibrate with large amplitude on a fixed position.
- This makes them to collide with each other hence move far apart.
- As the distance between the molecules increase, the volume also increase.

EXPANSION OF LIQUIDS

- All liquids expand when heated.
- Expansion do differ at the same temperature.

INVESTIGATION TO DEMONSTRATE EXPANSION OF LIQUIDS

- Aim
  - To demonstrate expansion of liquids
- Apparatus
  - A glass flask
  - Long narrow glass tubing
  - Coloured water
  - Tripod stand
  - A rubber stopper
  - Bunsen burner
  - Wire gauze
- Procedure
  - Fill a glass flask with coloured water.
  - Fit the flask with rubber stopper carrying long narrow glass tubing.
  - Mark the initial level of water in the glass tube before heating.
  - Heat the water in the flask and observe the level of water in the glass tube.



- Observation
  - The level of water after heating was higher than the level of water before heating.
- Discussion
  - When heating, the glass flask expands and the level of water drops first.
  - When heating continued, the level of water started to increase.
  - When the water was allowed to cool down, the level of water went down to its initial level
- Conclusion
  - Liquids expand when heated and contract when cooled.

WHY LIQUIDS EXPAND ON HEATING

- Molecules in liquids are closely compacted but can slide on one another.
- When heated, the gain extra kinetic energy which makes them to move far apart.
- This makes the volume to increase.

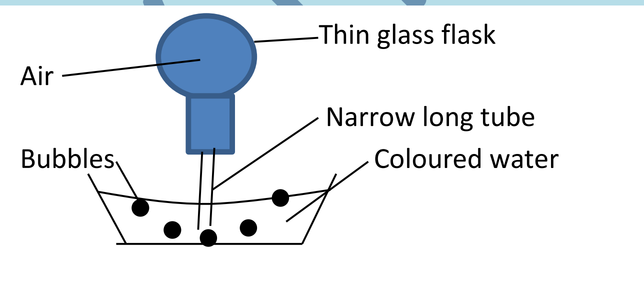
EXPANSION OF GASES

- Gas also expand when heated.
- Gases have equal expansion rate.

INVESTIGATION TO DEMONSTRATE EXPANSION OF GASES.

ACTIVITY ONE

- Aim
  - To demonstrate the expansion of air.
- Materials
  - A thin glass flask
  - A long narrow glass tube
  - A rubber stopper
- Procedure
  - Take a thin glass flask opened on top.
  - Close the flask with the rubber stopper carrying a long narrow tube.
  - Invert the flask so that the glass tube dips into the water in a container and record your observation.



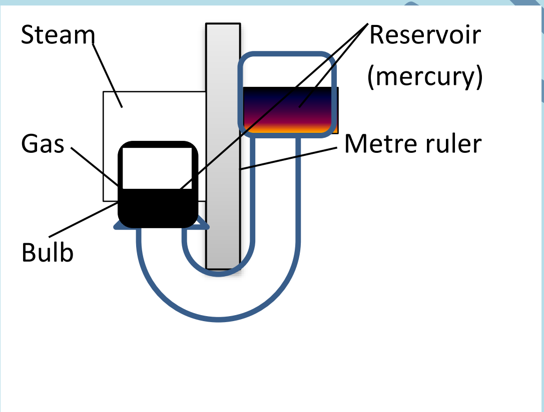
  - Place your hands over the flask to warm it for some time and observe what happens .
  - Remove your hands from the flask and wait for some time and observe what happens.
- Observation
  - The water level rises from the glass flask to the narrow glass tube dipped in water.
  - When the flask is warmed, the level of water in the tube drops and some bubbles are seen escaping from the flask through the tube.
  - On removing the hands from the flask, water level rises the glass tube again.
- Discussion

- Water level in the glass tube drops because of the expansion of the air in the glass flask when warmed.
- When cooled, the water level rises up the glass tube.

- Conclusion
  - Gases expand when heated and contract when cooled.

ACTIVITY TWO

- Aim
  - To demonstrate the expansion of gases.
- Materials
  - Glass bulb with air inside.
  - A metre rule in vertical position
  - A reservoir with mercury
  - Steam
  - Glass jacket
- Procedure
  - Set up the apparatus as shown below.



  - Calculate water at 0°C through the jacket and adjust reservoir so that the level of mercury is the same both sides.
  - Measure the volume of air (gas) in the bulb.
  - Pass the steam through the jacket until the temperature is constant.
  - Adjust the level of mercury in both sides until they are the same and measure the volume of air in the bulb.
- Observation
  - When passing the cold water at 0°C, the volume of the air in the bulb reduces.
  - The volume of air increases on passing the steam through the glass jacket.
- Discussion
  - The volume of air reduces when cold water is passed through due to contraction.
  - The volume of air increased when the steam is passed though due to expansion.
- Conclusion
  - Gases expand when heated and contract when cooled.

EFFECTS OF THERMAL EXPANSION

- Force produced due to expansion and contraction can
  - make metals to bend
  - make building to crack
  - make glass bottle full of water when frozen breaks
  - make railway lines to bend
  - make the egg shell to break

APPLICATION OF THERMAL EXPANSION

- Led to the development of thermostats used as automatic switches in electrical appliances.
- Industries use hot rivets when joining the steel plates together, when cooling, the force of contraction pulls the plates firmly together.
- Metal pipes carrying steam are joined using expansion joints (loops) which allow the pipes to expand or contract easily when steam or hot water passes through them or when pipes cool down.
- Telephone and electric cables are loosely connected to give room for contraction.
- Surveyors measuring tapes are made up of alloys (iron and nickel called invar) so that there should be a very small change in length due to changes in temperature.
- Expansion channels are made in concrete roads or when making cemented floors of buildings to give room for expansion during hot days.
- Construction at the end of concrete bridges has steel metals resting on rollers so that it should not be affected when contracting and expanding.

UNIT THREE
DENSITY

DENSITY

- Is define as the quotient of mass and its volume.
  i.e. density = $\frac{mass}{volume}$
- When the volume is increased, the density is reduced and when the mass of the substance increases, the density increases
- So, it can be defined as mass per unit volume.
- Density is the derived quantity.
- SI unit for density is $\frac{kg}{m^3}$.

DETERMINING DENSTIES OF SOLIDS

DENSITY OF REGULAR OBJECTS

- Find the mass using a balance.
- Measure its dimensions and multiply them to find volume.
- Divide the volume into the mass.

DENSITY OF IRREGULAR OBJECTS

- Find the mass using a balance.
- Use liquid to find its volume using the principal that the displaced amount of water is equal to the volume of the solid.
  - Pour the water in the measuring cylinder and record its volume.
  - Immerse in the irregular solid and record the new volume.
  - Subtract the first volume before the solid was immersed from the second volume after immersing the solid. This will give you the volume of the solid.
  - Divide the mass by the volume.

DETERMINING THE DENSITY OF LIQUIDS

- Measure the mass of the clean container.
- Pour in the known volume of liquid and measure its mass.
- Subtract the mass of the empty container from the mass of container plus liquid. This gives the mass of the liquid.
- To find the volume, use the measuring cylinder.
- Divide the mass by the volume.

DETERMINING DENSITY OF GASES

- Find the mass of deflated balloon or plastic paper.
- Inflate it and find the new mass.
- Subtract the mass of deflated container from the inflated container.

- To find the volume use the measuring cylinder,
  - Fill it with water and put it upside down.
  - Connected the inflated balloon to it and record the volume of water displaced. This is the volume of the gas inflated in.
- Divide the mass by the volume.

DETERMINING DENSITY OF AN ALLOY

- An alloy is the metallic substance made by melting two or more types of metals together in a controlled proportion.
- In this case, you add the masses of the combined metals and add the volumes of the combined metals.
- Divide the total mass by total volume.

COMPARISON OF DENSITIES OF SOLIDS, LIQUIDS AND GASES

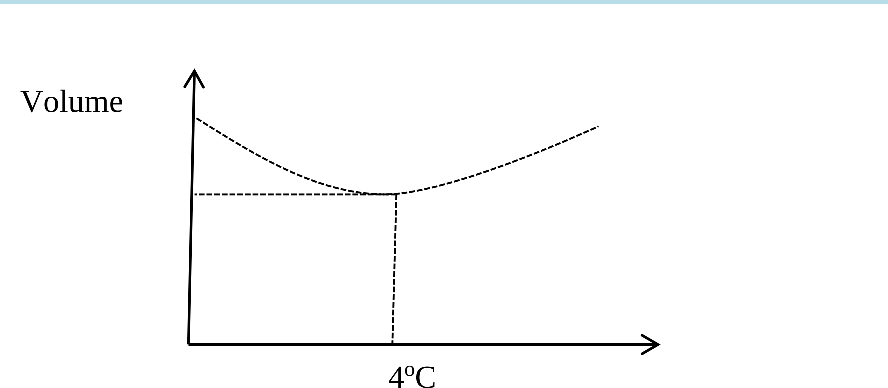
- Solids have highest densities because their particles are closely compacted hence have greatest masses.
- They are followed by liquids since particles are also closely packed but with loose connection.
- Gases have the least densities because particles are always in motion.

EFFECT OF TEMPERATURE ON DENSITY OD A SUBSTANCE

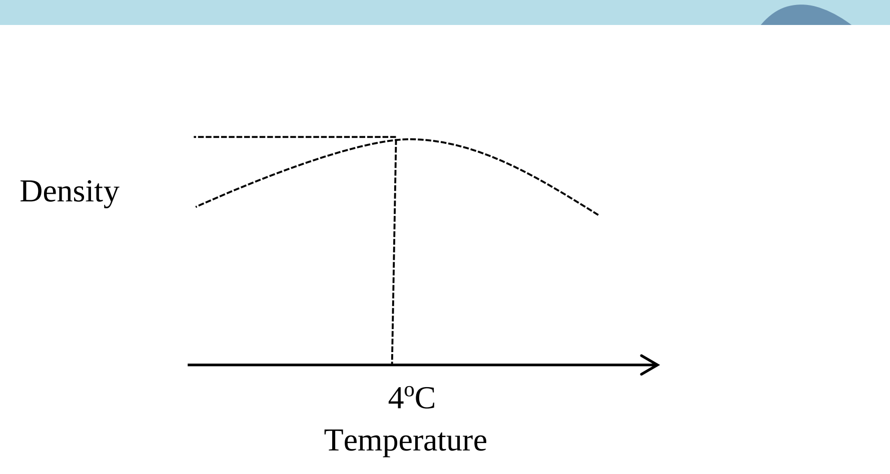
- Density is defined as mass per unit volume.
- When the substance is heated, the volume increases with no change in mass.
- When this mass is divided by the new larger volume, the quotient is lowered.
- Hence increase in temperature decreases the density.
- However, cooling the substance reduces the volume due to contraction.
- This increases the density of the substance.
- Most liquids expand steadily on heating.
- Water behaves in an unusual (abnormal) manner.
- When water is heated above 0^oC, temperature rises up to 4^oC without changing its volume.

EFFECTS OF ANOMALOUS EXPANSION OF WATER

- Above 4^oC, volume starts to increase like other liquids.
- Between 0^oC to 4^oC. Water shows abnormal behaviour (unusual) called unusual expansion of water.
- Thus a fixed mass of water has a minimum volume at 4^oC.



- From the graph it is seen that a fixed mass of water is minimum at 4°C.
- That's where the water has the minimum density.



1. Survival of aquatic organisms in freezer of lakes and ponds.

   - The maximum density of water is at 4oC.
   - Anything above or below 4oC becomes less dense.
   - The frozen water becomes less dense hence floats on top.
   - This makes the bottom water still at liquid state.

2. Bursting of water pipes.

   - When water is below 4oC, it starts to freeze and expands.
   - This expansion increases the volume and cannot fit into the pipes hence pipes break.

3. Weathering of rocks.

   - When water freezes in the rock cracks, it expands hence increasing the crack of the rock.
   - This results into breaking of the rock (weathering).

4. Floating and sinking.

   - When bodies have higher densities than that of water, they sink in water.
   - When they have equal or lower densities than that of water, they float on water.

APPLICATION OF FLOATING AND SINKING IN RELATION TO DENSITY

- Development of large machines which float of water. They are made in such a way that the average density should be lower than that of water.
- Submarine is made with a reserve of air bag to be used when they want it to float to reduce its density to that of water.

UNIT FOUR

SPECIFIC HEAT CAPACITY

HEAT

- Is the form of energy which passes from the body of high temperature to the body of low temperature.r
- The SI unit of heat is joule (J).

HEAT CAPACITY

- Is the quantity of heat energy required to change the temperature of the substance by 1 kelvin.
- Heat capacity varies direct proportional to the change in temperature.

  Heat capacity = $\frac{amount\ of\ heat\ energy\ (Q)}{Temperature\ change\ (\Delta\theta)}$
- The SI unit of heat capacity is joule per kelvin $\left(\frac{J}{K}\right)$

Examples

200j of heat energy is needed to change the temperature of a given mass of water from 25^{o}C to 34^{o}C. How much heat energy is needed to change temperature of this mass of water from 20^{o}C to 48^{o}C?

Solution

Initial temperature change was (34 – 20)^{o}C = 14^{o}C

Final temperature change was (48 -20) ^{o}C = 28^{o}C

If 14^{o}C used the heat energy (Q) of 200j

∴ 28^{o}C can used more energy

Q = $\frac{Final\ temperature\ change\ x\ initial\ energy\ used}{Initial\ temperature\ change}$

= $\frac{28^oC\ x\ 200j}{14^oC}$

= 400j.

Exercise

- Calculate the quantity of heat required to raise the temperature of a metal block of capacity of 520j/k from 9^{o}C to 39^{o}C.
- The quantity of heat required to raise the temperature of water from10^{o}C to 65^{o}C is 6200j. Calculate the heat capacity of water.

SPECIFIC HEAT CAPACITY

- Is the heart energy required to change the temperature of a substance of mass 1 kg by 1 kelvin.

  Specific heat capacity (C) = $\frac{Haet\ capacity\ (Q)}{Mass\ of\ the\ substance\ x\ change\ in\ temperature}$

$C = \frac{Q}{m\Delta\theta}$

$\therefore Q = mC\Delta\theta$

- The SI unit of specific heat capacity is joule per kilogram per kelvin (J/kgK).

Exercise

- Calculate the heat energy required to raise the temperature of 2.5kg of aluminium from 20°C to 40°C if the specific heat capacity of aluminium is 900J/knK.
- 18000J of heat is supplied to raise the temperature of a solid of mass 5kg from 10°C to 50°C. Calculate the specific heat capacity of the solid.
- Find the final temperature of water if 12000J of heat is supplied by heater to heat 100g of water at 10oC if specific heat capacity of water is 4200J/kgK.

NB

- Solids have highest specific heat capacities because they require a lot of energy to melt them.
- This is followed by liquids then gases.

SPECIFIC HEAT CAPACITIES OF SOME SUBSTANCES

SOLIDS		LIQUIDS	
SUBSTANCE	SPECIFIC HEAT CAPACITY (J/kgK)	SUBSTANCE	SPECIFIC HEAT CAPACITY (J/kgK)
Aluminium	900	Castor oil	2130
Brass	370	Coconut oil	2400
Copper	390	Glycerol	2400
Cork	2000	Mercury	140
Glass	670	Olive oil	2000
Ice	2100	Paraffin oil	2130
Iron	460	Sulphuric acid	1380
Lead	130	Water	4200
Silver and tin	230	Sea water	3900

APPLICATION OF SPECIFIC HEAT CAPACITY

- Materials with high specific heat capacity absorbs a lot of heat energy with small raise in temperature. This makes water to be used in car radiators and hydrogen gas enclosed in electric generator.
- Materials with low specific heat capacity are quickly heated up and experience big change in temperature. They are uses in making cooking utensils.
- Sensitive thermometers are made from materials with low specific heat capacity in order to detect even small amount of heat energy supplied with its change in temperature.
- Materials with high specific heat capacity are used in making handles of heating devices such as pans.

- Water taken by human being is used to regulate the temperature of the body since it has high specific heat capacity.
- Sea water has little change in temperature during the day and night because it has high specific capacity. Cold during the day and warm during the night.

UNITY FIVE

HEAT TRANSFER

HEAT

- Is the form of energy which passes from the body of high temperature to the body of low temperature.
- The SI unit of heat is joule (J).

TEMPERATURE

- Is the degree of coldness or hotness of the body.
- Kinetic Theory of Matter states that particles of matter are always in motion.
- Temperature can be defined as a measure of the average kinetic energy of the molecules of a substance.
- The SI unit for temperature is Kelvin(K).
- But the common measure of temperature is in degrees Celsius (^oC).

DIFFERENCES BETWEEN HEAT AND TEMPERATURE

- Heat is a form of energy while temperature is the degree of hotness and coldness.
- Heat is measured in joules (J) while temperature is measured in degrees Celsius (^oC).

MODES OF HEAT TRANSFER

- Conduction
- Convection
- Radiation

CONDUCTION

- Is the transfer of heat through solids.
- Conduction occurs from region of high temperature to the region of low temperature.
- There is no visible movement of the heated particles.

FACTORS AFFECTING HEAT TRANSFER THROUGH CONDUCTION

- Temperature differences.
  - Heat energy in solids flow due to differences in temperature. The higher the temperature difference, the higher the energy flow.
- Material differences.
  - Different materials conduct heat at different rates.
- Thickness/ cross section
  - Thick materials conduct heat faster than thin materials.
- Length/size differences.
  - Short materials conduct heat faster than long materials.

- Duration of heating.
    - Time taken to heat the material will determine how much heat is conducted though the material.

TYPES OF CONDUCTORS

- Good conductors
- Poor conductors

GOOD CONDUCTORS

- All materials which allow heat to pass through them easily. Most of these are metals.
- These conduct heat with different rates.

POOR CONDUCTORS

- All materials which have poor ability to transfer heat through them. Examples of these include water, air, wood, plastics, papers etc.

RELATIVE CONDUCTIVITIES

- Different substances at room temperature conduct heat differently.
- The conductivity of heat in air at room temperature is said to be 1.
- The heat conduction of different substances related to heat conduction in air at room temperature is called relative conductivity.
- Some of the relative conductivities are as follows;

SUBSTANCE	CONDUCTIVITY	SUBSTANCE	CONDUCTIVITY
Air	1	Mercury	270
Wood	6	Iron	3000
Cardboard	8	Brass	4500
Brick	23	Aluminium	8000
Water	25	Copper	16000
Glass (window)	35	Silver	18000

CONVECTION

- Is a mode of heat transfer through fluids by actual physical movement of molecules of the fluids due to temperature differences within the fluid.
- Convection occurs from bottom going up the container of the fluid.
  Example; When water is boiling, it starts from down going up.

APPLICATION OF CONVECTION

- Fixing of windows in buildings uses air convection.
- Natural convection currents over the earth's surface.
    - Sea breeze
        - ✓ During the day, the temperature of the land rises faster than the temperature of the sea water.

    - ✓ The air over the land becomes warmer than the air over the sea water.
    - ✓ The warm air of less dense rises from the land allowing the cold air over the sea to blow to the land.
    - ✓ This movement of cold air from the sea to the land is called sea breeze.
  - ➢ Land breeze
    - ✓ During the night, the land cools faster than the sea water.
    - ✓ Warm air from the sea rises up.
    - ✓ The denser air from the land moves to the sea makes the land become warm.
    - ✓ This movement of cool air from the land to the sea is called land breeze.
- Electrical devices
  - ➢ They have their heating coil at the bottom.
  - ➢ The refrigerators have their freezing unit at the top.

RADIATION

- Movement of heat in energy through the vacuum.
- Is the heat transfer that does not affect the intermediate medium
- Heat transfer from the sun uses radiation.
- The heat that is being transferred is called radiant.
- Amount of heat energy radiated depends up temperature of the body.

FACTORS AFFECTING RADIATION

- Temperature of the body.
  - ➢ Increase in temperature increase amount of energy radiated.
- Colour of the body.
  - ➢ Dull colours such as black absorb more heat energy than bright colours such as white.
- Type of conductor.
  - ➢ Bad conductors are good absorbers and good emitters while good conductors are poor absorbers and poor emitters.

APPLICATION OF HEAT TRANSFER

- Construction of vacuum flasks.
- Construction domestic hot water system.
- Extraction of solar energy.
- Construction of solar heater.
- Construction of solar concentrations.
- Construction of glass thatched houses.

UNIT SIX

POWER AND MACHINES

POWER

- Is the rate of doing work in a unit time.
- The SI unit is joules per second (J/s) also called watt (W).
- IJ/s = 1 watt
- Watt is the rate of transfer of energy of 1 joule in one second.

RELATIONSHIP BETWEEN POWER AND VELOCITY

- Work done = force x distance covered.
- Power = $\frac{work\ done}{time\ take\ in\ seconds}$

  Power = $\frac{force\ x\ distance\ move\ in\ the\ direction\ of\ force}{time\ taken\ in\ seconds}$

  But $\frac{distance\ moved\ in\ the\ direction\ of\ force}{time\ take}$ = velocity.

  Therefore, power = force x velocity
  P = Fv

Exercise

- A force of 100N drags a box at a constant velocity of 5m/s. What is the power of the source of the force?
- A student of mass 45kg runs up a flight of 40 steps in a stair case each 15cm in 12 seconds. Find the power of the student.
- A car engine developed a 24kw while travelling along a level road. If there was a resistance of 800N due to friction, calculate the maximum speed attained.

MACHINES

- A machine is any device that makes work to be done easily.
- Is any device that facilitates a force applied at one point to overcome another force at a different point in the system.

TERMS USED IN MACHINES

- Mechanical advantage
  - is the ratio of the load and applied force

    Mechanical advantage = $\frac{load}{effert}$

    M.A. = $\frac{L}{E}$

- Velocity ratio
  - Is the ratio of velocity of effort and velocity of the load

    Velocity ratio = $\frac{velocity\ of\ effort}{velocity\ of\ load}$

    Velocity of effort =$\frac{displacement\ made\ by\ effort\ (effort\ distance)}{time\ taken}$

    Velocity of the load = $\frac{displacement\ made\ by\ the\ load\ (load\ distance}{time\ take}$

    Velocity ratio = $\frac{effort\ distance}{tload\ distance}$
- Efficiency of machine
  - Is how best is it to use a machine.
  - Is measured in percentages.
  - Is the ratio useful energy output multiply by 100 and energy input.
  -

    Efficiency = $\frac{useful\ energy\ output\ x\ 100}{energy\ input}$

    But useful energy output = load x distance move by the load and
    energy input = effort x distance moved by the effort

    efficiency = $\frac{Load}{Effort}$ x $\frac{Distance\ load\ is\ moved}{Distance\ moved\ by\ effort}$

    But $\frac{Load}{Effort}$ = M.A. and $\frac{Distance\ load\ is\ moved}{Distance\ moved\ by\ effort}$ = $\frac{1}{V.R.}$

    Therefore, efficiency = $\frac{M.A.x\ 100}{V.R.}$

NB

- No machine is 100% efficiency.
- Some energy is lost when the machine overcomes frictional force in movable part of the machine and surface.

THE EEFECT OF FRICTION ON MECHANICAL ADVANTAGE, VELOCITY RATIO AND EFFICIENCY OF A MACHINE.

- Mechanical advantage (M.A.)
  - When the frictional force is high, the effort applied is also high.
  - This reduces the mechanical advantage of a machine.
- Velocity ratio
  - Is not affected by the friction.
  - The angle at which the machine is does affect the velocity ratio.
- Efficiency of a machine

- ➢ Is affected by the friction.
- ➢ Decrease in M.A. also reduces the efficiency of the machine.
- ➢ ∴ increased friction lowers the efficiency of the machine.

Exercise

- A machine whose velocity ratio is 8 is used to lift a load of 300N. The effort required is 60N.
  a. What is the mechanical advantage of the machine?
  b. Calculate the efficiency of the machine.
- An effort of 250N raises a load of 900N through a 5m in a machine. If the effort moves through 25m, find
  a. The total useful work done in raising the load.
  b. The work done by the effort.
  c. The efficiency of the machine.
- Calculate the efficiency of a machine if 8000J of work is needed to lift a mass of 120kg through a vertical height of 5m.

TYPES OF MACHINES

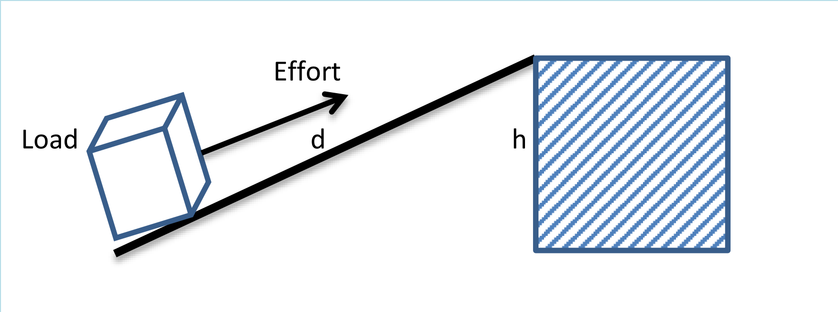
- Force multipliers
  - ➢ Are those that allow a small effort to move a large load
  - ➢ Levers are good example such as
    - ✓ Screw jack of a car
    - ✓ Hydraulic press
    - ✓ Hydraulic jack
    - ✓ Hydraulic breaks
- Distance or speed multipliers
  - ➢ Are those which multiply the distance or speed.
  - ➢ Inclined planes and pulleys are good examples such as
    - ✓ Bicycle gears
    - ✓ Car gears
    - ✓ Incline planes
    - ✓ Pulley systems

EXAMPLES OF MACHINES

- Inclined planes
- Pulleys
- Levers

INCLINED PLANES

- Is a slope or ramp that enables us to raise a heavy load to a certain vertical height.



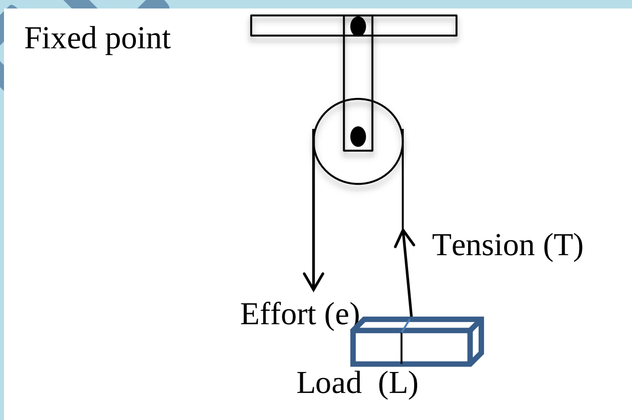
- Suppose the load of mass 200kg is pulled along an inclined plane above by the force (e) of 1500N, distance (d) of 5m and height (h) of 3m, calculating
  a. Mechanical advantage of the machine
     M.A. $= \frac{L}{E} = \frac{200\ x\ 10N}{1500N} = 1.33$
  b. Velocity ratio of the machine
     V.R. $= \frac{Distance\ moved\ by\ the\ effort}{Distance\ move\ by\ the\ load} = \frac{m5}{3m} = 1.67$
  c. Efficiency of the machine
     Efficiency $= \frac{M.A.x\ 100}{V.R.} = \frac{1.33\ x\ 100}{1.67}$ 80%.

PULLEY

- Is usually a grooved wheel or rim.
- Pulleys are used to change the direction of force.

TYPES OF PULLEYS

- Single fixed pulleys
  - ➢ Has fixed support which does not move.
  - ➢ Either the load or effort does move.
  - ➢ The tension in the rope is the same throughout.
  - ➢ The load is equal to the effort if these is no loss of energy (friction)
  - ➢ The M.A. is therefore 1



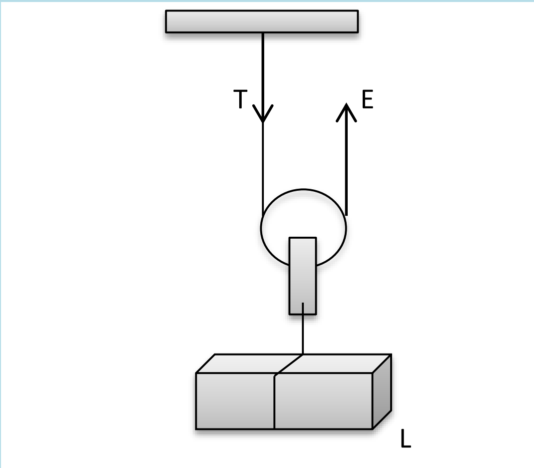
- ➢ Application of fixed pulley
  - ✓ Raising of flag
  - ✓ Raising bricks up by builders

- ✓ Raising water from the well

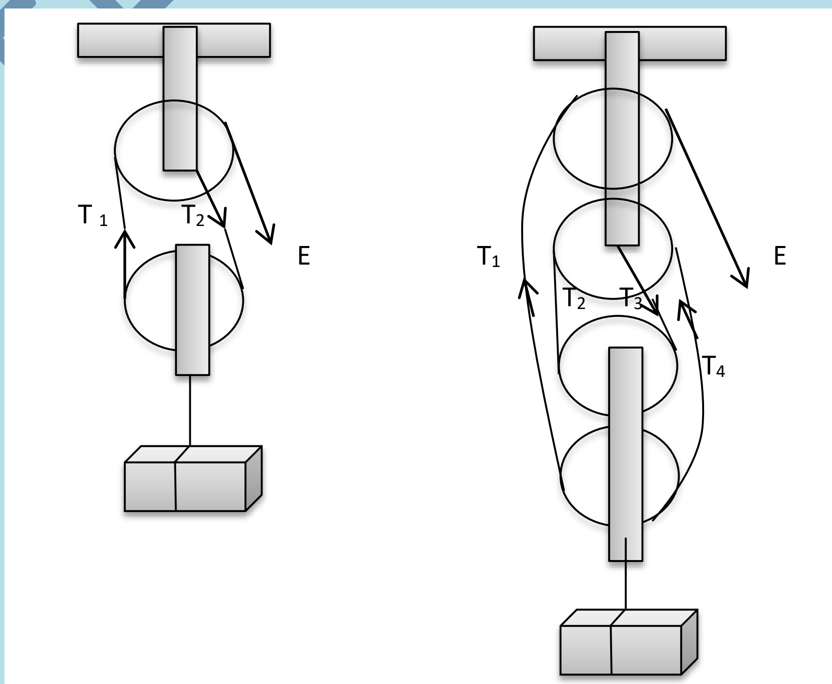
- Single moving pulleys
  - The total force supporting the load if given by the tension (T) plus the effort (E).
  - Tension (T) force is equal to twice the effort (2E).
  - The load (L) is equal to twice the effort (2E).

    M.A. $= \frac{L}{E} = \frac{2E}{E} = 2$
  - The effort moves twice the distance moved by the load.

    V.R. $= \frac{Distance\ moved\ by\ effort}{Distance\ move\ by\ the\ load} = \frac{2}{1} = 2$
  - Since M.A = V.R, the pulley system has 100% efficiency if there is no frictional force.



- Block and tackle pulleys
  - Consists of two pulley sets.
  - One set is fixed while the other set is allowed to move.
  - Pulleys are usually assembled side by side in a block or frame on the same axle.
  - The pulleys and ropes are called the tackle.



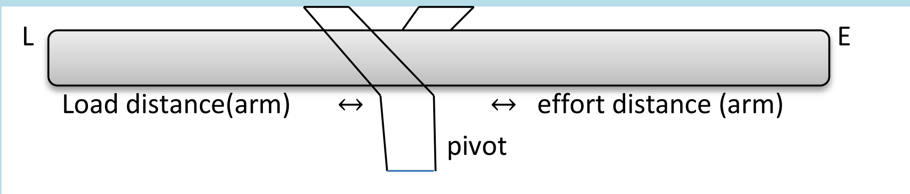
- For each of the pulleys above,
  - ✓ For a single fixed pulley, L = T = E
    ∴ E = L
  - ✓ For a single movable pulley,2T = L, and T = E
    ∴ 2E = L
  - ✓ For the block and tackle, 4T = L, T = E
    ∴ 4E = L

NOTE:

- In a perfect pulley system, the mechanical advantage is equal to the velocity ratio and both are equal to the number of sections of the string supporting the load.
- The weight of the block in the lower section of the system and fraction in the pulley reduces the mechanical advantage of the system.
- Velocity ratio of a pulley system is numerically equal to the number of string sections supporting the load.

LEVER

- Is a rigid bar capable of rotation about a fixed point called pivot of fulcrum.
- Are three types of levers depending on the position of the pivot with respect to the load to be overcome and effort applied.
  - Pivot
    - ✓ Is between the load and the effort.
      - Crowbar
      - A pair of scissors
      - Claw hammer
      - Pliers
      - See-saw
      - spanner
  - Load
    - ✓ Is between the pivot and effort.
      - Wheel barrow
      - Bottle opener
  - Effort
    - ✓ Is between the pivot and the load.
      - Fishing rod
      - Tweezers
      - Forceps



PRINCIPLES OF MOMENTS

- A moment of force about a point is the product of the force and perpendicular distance from the point to the line of action of the force.

PRINCIPLES OF LEVERS

- States that sum clockwise moment at a point is equal to the sum of anti-clockwise moment at the same point of equilibrium.

MECHANICAL ADVANTAGE OF A LEVER

- Taking moment about the pivot as
  Load x load arm = effort x effort arm

  $$\frac{Load}{Effort} = \frac{Effort\ arm}{Load\ arm}$$

  But $\frac{Load}{Effort}$ = mechanical advantage

  M.A $= \frac{Load}{Effort} = \frac{Effort\ arm}{Load\ arm}$

  V.R. $= \frac{Effort\ arm}{Load\ arm}$
- Since effort arm is usually greater than load arms, levers have mechanical advantage greater than 1.
- Examples of levers and their uses
  - Bottle openers, lid openers used to open bottle tops and lids respectively.
  - See saw and beam balance used for playing games and comparing weights of different objects.
  - Hinges are used in closing and opening of the doors, windows etc.
  - Spanners are used in tightening and loosening bolts and nuts.
  - A pair of scissors or garden shears used in cutting etc.
  - Crowbar used in moving heavy loads.

UNIT SEVEN

ELECTROSTATICS

ELECTROSTATICS

- Is the study of branch of physics that deals with phenomena due to attraction or repulsion of electric charges.

ELECTROSTATIC CHARGING BY RUBBING

- When polythene stripe is rubbed against silk, it acquires attractive property.
- This is because it has been charged by friction.
- It can attract thin stream of water, small pieces of paper, and tiny pieces of cloth.
- This implies that bodies can be charged by rubbing each other.
- These charges cannot be move from one point to another.
- These are static charges.

TYPES OF STATIC CHARGES

- Positive charges
  - Are charges which the body gains when it loses electron(s).
  - Silk loses electron(s) when rubbed against the polythene.
- Negative charges
  - Are charges which the body gains when it gains electron(s).
  - Polythene gains electron(s) when rubbed against silk.

SOURCES OF ELECTROSTATIC CHARGING

- Charges can be gained when materials
  - Gain electrons
    - ✓ Polythene gains electron(s).
  - Lose electrons
    - ✓ Cloth loose electron(s).

TAKE NOTE

- The excess negative charges on one body is equal to the excess positive charges on the other body. i.e. no charge have been created.
- During the rubbing process, materials may acquire either negative or positive charges.
- The quantity of charge produced in some cases may be small and in some cases the charges may escape before they are defected. A dry atmosphere and a clean dry state of the body are essential for holding the electrical charges.

THE LAW OF CHARGES

- Like charges repel and unlike charges attract.

CONFIRM THAT A BODY IS CHARGED

- Bring charged bodies close together.
- If they attract, they have different types of charges.
- If they repel, they have the same type of charge.
- No attraction, they are neutral.
- SI unit for charge is coulomb (C), named after a famous scientist called Charles Augustin de Coulomb (1736 – 1806)

EARTHING

- This means to neutralise a charged body.
- Low charges can be earthed by touching the charged body with our hands.
- High charges should be connected to the thick metal rod.
- The metal plate is connected to the earth.
- This conducts excess electrons flow from the plate to the earth.
- If a positively charged plate is connected to the earth, the electrons from the earth move to the plate and neutralise the deficiency of electrons.

ELECTRIC FIELD AND ELECTRIC FIELD PATTERNS

ELECTRIC FIELD

- Is indicated using arrow lines.
- The arrow indicates direction of electric field and the tail is where the electric field comes from.
- These line which show direction of movement of charges are called electric field lines or electric line of force.
- Number of field lines indicates the strength of charge. The more the lines, the high the charge.
- These electric field lines are also called field patterns or flux patterns.

PROPERTIES OF ELECTRIC LINES OF FORCE

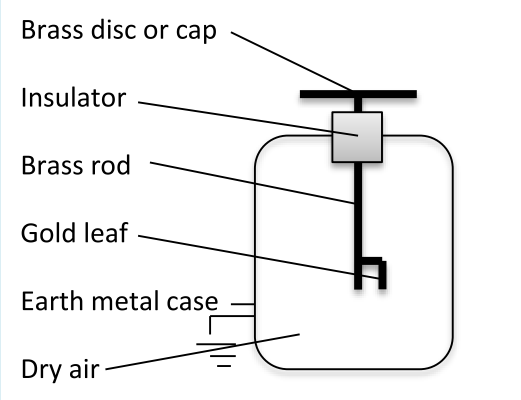
- Lines of forces start at 90^o from the positive charge and end on the negative charge at 90^o.
- No two lines of forces can ever cross each other.
- The field lines can contract or expand so that they never intersect each other.

FACTORS AFFECTING THE MAGNITUDE OF THE FORCE BETWEEN TWO CHARGED BODIES

- Quantity of charge
    - The greater the quantity of charge, the greater the force between the body.
- Distance of separation
    - The greater the distance, the smaller the force.

LEAF ELECTROSCOPE

- Is an instrument used for detecting and testing small electric charges.
- Was invented by Abraham at the end of 18th century.



- The electroscope should be charged before being used.
- If uncharged, it can detect the presence of charge but not indicating the type of charge present.
- If the electroscope is charged positively, the leaf electroscope leaflets can attract each other if negative charges are present and repel if positive charges are detected.
- If charged negatively, positive charges can make leaflets attract and negative charges can make leaflet repel.

METHODS OF CHARGING

- Contact
  - Is done when the charged body is contact with the body to be charged.
  - The alignment of domains point to one direction.
  - The body becomes charged.
- Induction
  - The charged body is brought close to the body to be charged.
  - The alignment of domains point to one direction.
  - The body becomes charged.

USES OF LEAF ELECTROSCOPE

- Detecting presence of charges.
- Identifying type of charges.
- Distinguishing between conductors and non-conductors.

EFFECTS AND APPLICATION OF ELECTROSTATICS

- One gets a shock.
  - The car that has been left so long on the sunlight becomes charged and upon touching the knob one gets shock.
  - When one is shocked, the car's charges become neutralised.

  - The discharging of the charges is mostly done by the chain connected to the vehicles.
  - The charges pass through the chain to the earth.
- Cleaning the mirror with a dry cloth makes both the mirror and cloth become charged. This makes dust particles to be attracted on the surface of the mirror.
- Painting of cars using spray gun, the paint receives a positive charge which makes it to be attracted to the car body.
- Removal of dust and smoke particles from the chimney uses electrostatic attraction. This reduces the air pollution which is a health hazard.
- Electrostatic induction is used in photocopying machines.
- The rubbers insulator called conductive rubber is used to make aeroplane tyres. This reduces the risk of an explosion during refuelling the aircraft.

LIGHTNING ARRESTOR

- Is used to prevent tall buildings and towers against the destructive effect of lightning.
- Is made up of the metal rod attached to the metal plate and buried deep in the ground one end while the other end point up above the building to conductelectrons down the earth.

UNIT EIGHT

LIGHT

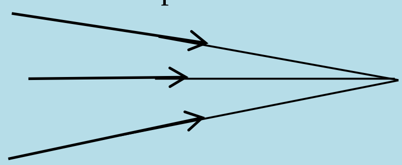
LIGHT

- Is a form of energy that enables us to see the surrounding objects.
- Is not visible but its effect is felt by eyes.
- It travels in a straight line.

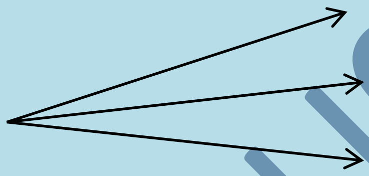
TERMS USED IN STUDY OF LIGHT

- Luminous bodies
  - Are bodies which emit light on their own.
  - Are also known as self-luminous bodies.
  - Examples include
    - ✓ Sun
    - ✓ Torch
    - ✓ Fire
    - ✓ star
- Non-luminous bodies
  - Are bodies which have no light of their own.
  - Are visible in the presence of some luminous bodies.
  - Examples include
    - ✓ Moon
    - ✓ Polished bodies
- Optical medium
  - Are substances through which light can pass.
  - Are three types of them
    - ✓ Transparent bodies
      - The ones through which light pass with no problem e.g. window glass.
    - ✓ Translucent bodies
      - The one through which light passes partially e.g. some plastic containers.
    - ✓ Opaque bodies
      - The ones through which light cannot pass e.g. clay pot.
- A ray of light
  - Is the path through which light travels in a medium.
  - Is shown using a single arrow line.
- A beam of light
  - Is a collection of rays of light.
  - These can be
    - ✓ Parallel beam of light
      - Rays which point to one direction but do not meet.

- ✓ Convergent beam of light
  - rays which originate from different points and meet on one focal point.



- ✓ Divergent beam of light
  - Rays originate from one point to different directions.



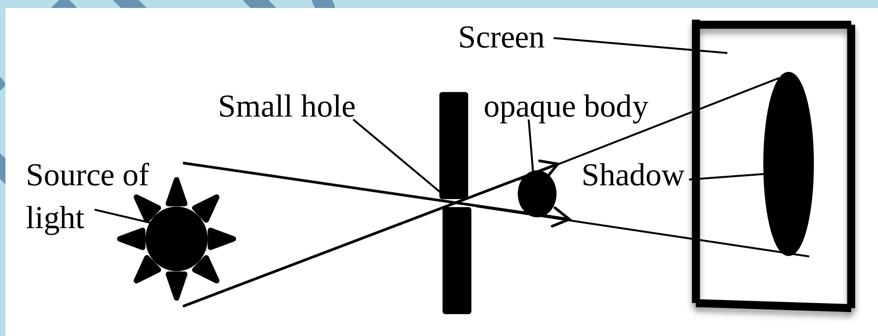
FORMATION OF SHADOWS AND ESCLIPSES

SHADOWS

Is a shade cast by an object blocking the direct ray of light.

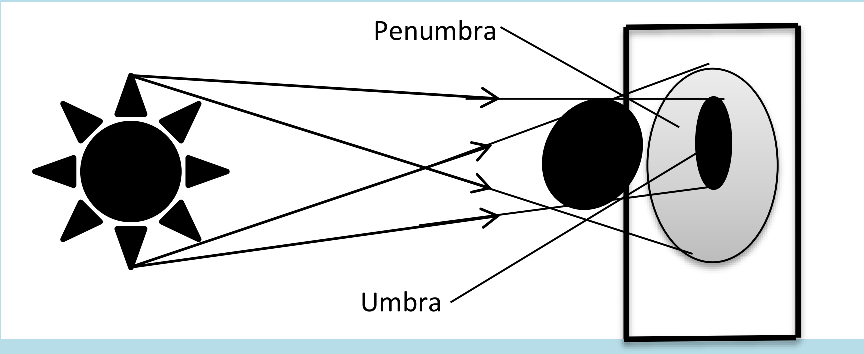
FORMATION OF SHADOW WITH A POINT SOURCE

- When light is allowed to pass through a small opening blocked by opaque object, the path of light is also blocked.
- Forms a total darkness on the screen.
- This region of a complete darkness is called umbra.



FORMATION OF SHADOW WITH AN EXTENDED SOURCE OF LIGHT

- When light is passed through a large opening blocked by opaque object, forms an extended source of light.
- This forms two types of shadows on the screen.
- A total darkness is formed at the middle of the screen called umbra.
- Surrounding the umbra, there is partial darkness called penumbra.

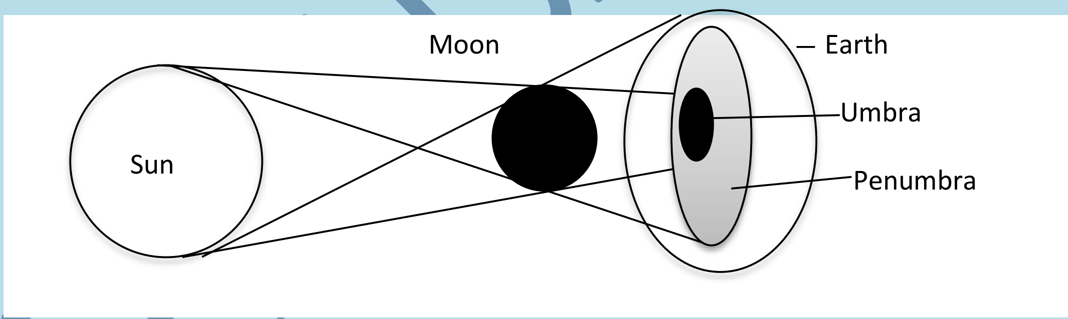


ECLIPSE

- Is when light is blocked or cut off from region of observation.
- Are two types of eclipses
  - Solar eclipse
  - Lunar eclipse

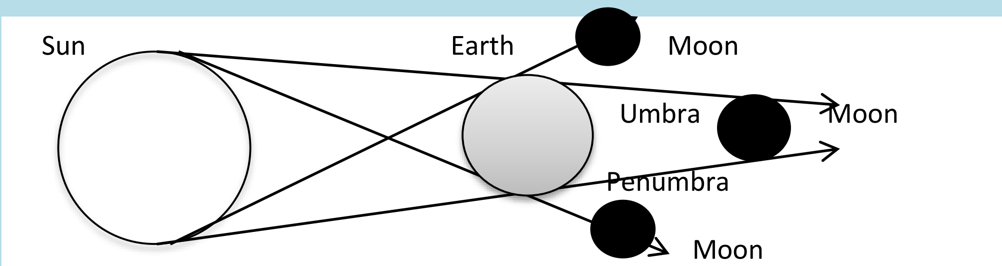
SOLAR ECLIPSE

- Happens when the moon is between the sun and earth.
- The shadow of the moon is formed on the earth. The shadow is called eclipse or eclipse of the sun.
- Depending on the position of the sun, some parts lie in the region of umbra while the other parts lie on the region of penumbra.
- Total eclipse lies in the region of umbra while partial eclipse lies in the region of penumbra.



LUNAR ESCLIPSE

- The moon is non-luminous object.
- Can be seen only when light from the sun falls on it.
- What is seen is only the shape of the lighted portion.
- The earth is between the sun and moon.
- This is called lunar eclipse or eclipse of the moon.



PINHOLE CAMERA

- Is an instrument an instrument that can be used to show that light travels in a straight line.
- Form an image smaller than the object.
- The image is upside-down .
- Forms a real image.

MAGNIFICATION

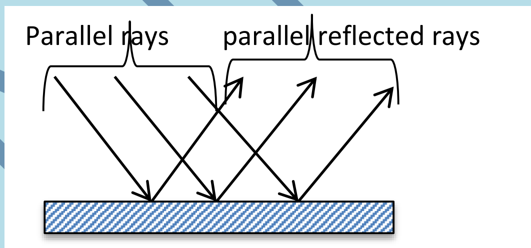
- Is how big or small the image is as compared to the object.
- Is the ration of the height of image and the height of the object.

$$\text{Magnification} = \frac{height\ of\ image\ (IM)}{height\ of\ object\ (OB)} = \frac{image\ distance\ (V)}{object\ distance\ (U)}$$

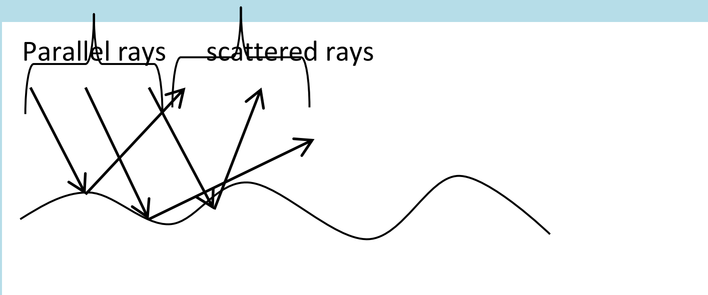
$$M = \frac{IM}{OB} = \frac{V}{U}$$

REFLECTION

- Is the bouncing off of light.
- Are two types of reflections namely
  - Regular reflection
    - ✓ When the light strikes a smooth surface.
    - ✓ The parallel rays of light form parallel reflected rays of light.

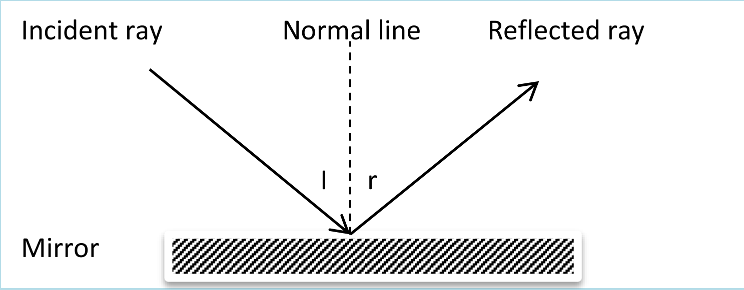


  - Diffuse reflection
    - ✓ When the light strikes a rough surface.
    - ✓ Parallel rays of light make scattered reflected rays of light.



PLANE MIRROR

- Is a thin glass plate coated with silver on one side and a protective layer on the other side.
- Can reflect light rays.

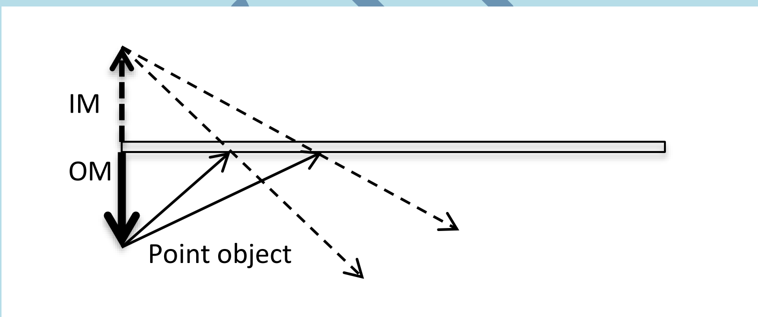


LAWS OF REFLECTION

- Incident ray, reflected ray and normal ray lie in the same plane
- The angle of incident (i) and angle of reflection (r) are equal.

IMAGE FORMATION FOR A POINT OBJECT

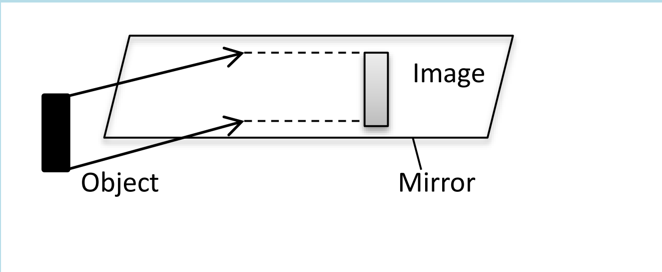
- Two rays can be used to locate the position of the image using plane mirror.
- The reflected ray and incident rays meet at a point.
- This point of contact is the position of the image.
- The image is called virtual image and cannot be projected on a screen.

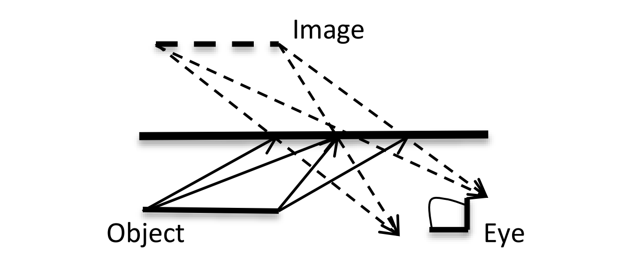


- Image distance from the mirror is equal to the object distance from the mirror.
- OM = IM

IMAGE FORMTION FOR AN EXTENDED OBJECT.

- If an object is extended in front of a vertical plane mirror, the image formed is erect.
- The size of the image is the same as the size of the object.
- The image is upright.





- The image formed is lateral inversion image.
- This is the image whose left hand side is seen to be the right hand side.

CHARCTERISTICS OF IMAGES FORMED BY PLANE MIRRORS

- The size of the image is equal to the size of the object.
- The image is erect.
- The image is virtual.
- The image is lateral inverted.
- The image distance is equal to the object distance and is behind the mirror.

ROTATION OF THE PLANE MIRROR

- For the same incident ray, the angle of rotation of the reflected ray is twice the angle of rotation of the mirror.

PARALLEL MIRRORS

- When the object is placed between two parallel mirrors, the image formed on one mirror is reflected to form another image on the other mirror.
- That image can also form another image on the other mirror.

WORKING OUT NUMBER OF IMAGES FORMED TWO MIRRORS AT AN ANGLE

- Number of images formed (n) $= \frac{complete\ turn}{angle\ \theta} - 1$

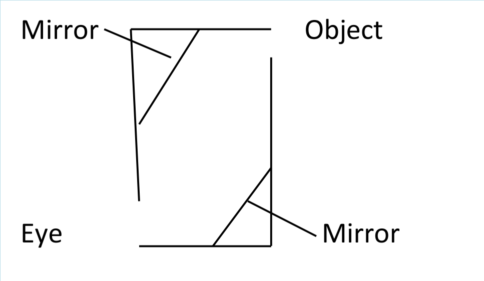
If the angle is 60o, n $= \frac{360}{60} - 1$

$= 6 - 1$

$= 5$

APPLICATION OF REFLECTION OF LIGHT

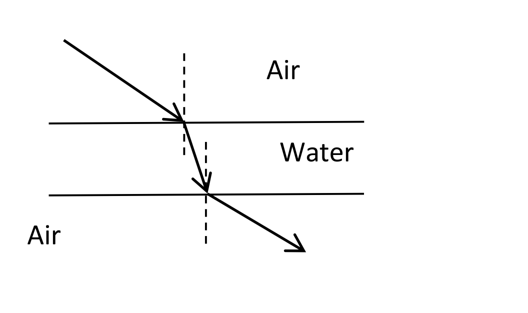
- In periscope
  - Is an instrument for seeing distant objects.
  - Two mirrors are placed parallel to each other.
  - This makes the image formed on one mirror forms an image on another mirror.



- In kaleidoscope
  - For production of series of beautiful images.

REFRACTION OF LIGHT

- Is the bending of light after crossing substances of two different densities.
  - Thin rod dipped into water appears to be bent at the water surface.
  - Pool waters appears to be shallow than its real depth.
- When light is passed from denser substance to the less dense substance, it bends away from the normal line.
- When it is passed from less dense to denser, it bends towards the normal line.
- So, reflection can be defined as the change of direction or bending of light when it travels from one medium to another.



MONOCHROMATIC LIGHT

- Is the one that has a single frequency of single wavelength.
- White light is not monochromatic light because it is made up different colours.

DISPERSION OF WHITE LIGHT

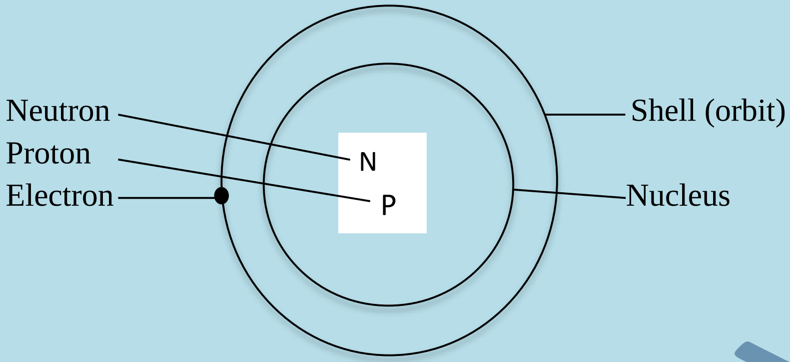
- White light can be dispersed into a light spectrum.
- Dispersion is the splitting of white colour into its constituent colours.
- The colours starting from top are
  - Red
  - Orange
  - Yellow
  - Green
  - Blue

- Indigo
- Violet

UNIT NINE

INTRODUCTION OF NUCLEAR PHYSICS

NUCLEAR STRUCTURE OF AN ATOM



NUCLEUS

- Is the most inner part of an atom.
- Makes the mass of the whole atom.
- Is comprised of protons and neutrons.

NEUTRONS

- Are uncharged particles in the nucleus of an atom.

PROTONS

- Are positively charged particles in the nucleus of an atom.

PROTONS AND NEUTRONS

- Number of protons and number of neutrons together make up atomic mass.
- Protons alone gives the atomic number.

NUCLEAR NOTATIONS

- Atomic number is denoted by a symbol A.
- Atomic mass is denoted by a symbol Z.

ISOTOPES

- These are atoms of the same element with different atomic mass but same atomic number.

- This is because they have different number of neutrons in their nuclei.
    - Hydrogen has the following isotopes

$^{1}_{1}H$

$^{2}_{1}H$

$^{3}_{1}H$

RADIOISOTOPES

- Are isotopes as a result of spontaneous disintegration of an atom to attain stability.

RADIOACTIVITY

- Is the spontaneous disintegration of an atom to attain stability.
- Is the emission of particles or electromagnetic radiations by nuclei.
- Is also known as radioactive decay.

TYPES OF RADIOACTIVE DECAY

- Radioactivity results into three forms of subatomic particles.
- These include
    - Alpha particles (α)
    - Beta particle (β)
    - Gamma ray (γ)

ALPHA PARTICLES (α)

- A nucleus eject two protons.
- These reduce the mass of an atom.
- It results into transformation of the element into a different element.
- The particle is helium nucleus ($^{4}_{2}H$) in nature.
- The atomic mass of a parent nucleus decreases by 4 while the atomic number decreases by 2.

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He^{2+}$$

- As you can see above, the particles is positively charged.
- This charge makes it to deflect magnetic field.
- They deflect less because they have large masses.
- These have less penetrating power.
- They cannot penetrate the skin.

- These are very dangerous when they are injected or inhaled.
- Their penetrating power is one.

BETA PARTICLE (β)

- A negatively charged particle identical with electron is produced i.e ${}^{0}_{-1}e$.
- You recall that nuclear structure of an atom shows no electron in the nucleus.
- These electrons are produced in the nucleus when a neutron. Changes into a proton.

$$ {}^{1}_{0}n \longrightarrow {}^{1}_{1}P + {}^{0}_{-1}e $$

$$ {}^{27}_{15}P \longrightarrow {}^{32}_{16}S + {}^{0}_{-1}e $$

- During beta decay, the mass number of a radioactive element remains unchanged, while the atomic number increases by one unit.
- The particle moves at nearly the speed of light i.e. $3x10^{8}$m/s.
- It has greater penetrating power than alpha.
- It has the penetrating power of 100.
- The particle is negatively charged.
- It has almost no mass (negligible mass).
- It is deflected towards the positive pole of a strong magnetic field.
- The deflection is much greater than that of alpha.

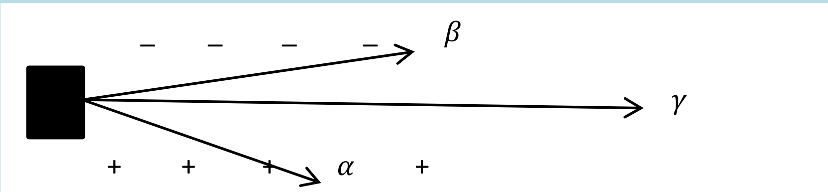
GAMMA RAY (γ)

- Sometimes the nucleus can remain unstable even after emitting the alpha or beta particles.
- It possesses a lot of energy after the decay.
- It emits a ray of light to get rid of the excess energy.

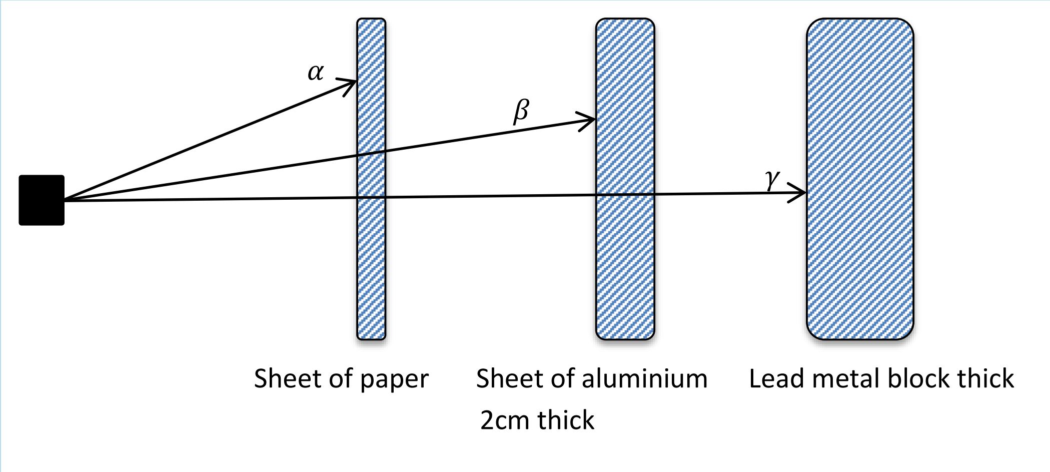
$$ {}^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e \longrightarrow {}^{14}_{7}N + \gamma $$

- ${}^{14}_{6}N$ is unstable. It gains stability by the loss of gamma rays.
- This does not make any change of both atomic number and atomic mass.
- Gamma rays are not particles.
- They do not possess any charge.
- These do not deflect in the presence of the electric and magnetic field.
- They have the penetrating power of 10,000.

DEFLECTION SUMMARY



PENETRATING POWER SUMMARY



NUCLEAR STABILITY

- The nucleus of an atom contains many protons and neutrons.
- Since protons carry similar changes, they repel each other.
- This repulsion is due to short distances between the protons.
- The protons are bound by a powerful localised force with the help of the neutrons which balance the opposing forces of the protons.
- This force is called nuclear binding force.
- This force is limited to number of protons coexist with the neutrons in a nucleus.
- If the number is greater, the nuclei break on their own to achieve stability.
- This leads to the radioactivity.

HALF-LIFE AND RATES OF DECAY

- Half-life is time it takes for half the original amount of isotope in a given sample to decay.
- It is time taken for a substance to decay half of its mass.
- It is formed by N = $N_0{}^{-\lambda t}$ where N is radioactive nuclei present, No is number of nuclei present at time t, λ is decay constant and t is time taken.
- Half-life is indicated as $T_{½}$.
- the relationship between half-life and decay constant is $T_{½} = \frac{0.693}{\lambda}$.

USES OF RADIOISOTOPES

- generation of atomic energy
  - nuclear fission
    - ✓ is the splitting of heavy nucleus into two lighter nuclei of approximately the same size.
    - ✓ Slow moving neutrons are used to strike nuclei of less stable heavy elements.

$$^{235}_{92}U + ^{1}_{0}N \longrightarrow ^{144}_{56}Ba + ^{90}_{30}Kr + \text{Energy}$$

- ✓ As shown above the process involves the release of energy.

- nuclear fusion
  - ✓ it is the combining of two small nuclei to form heavy nucleus which is unstable.
  - ✓ Some mass is converted into large amount of energy.

$$^{2}_{1}H + ^{3}_{1}H \longrightarrow ^{4}_{2}H + ^{1}_{0}N + \text{Energy}$$

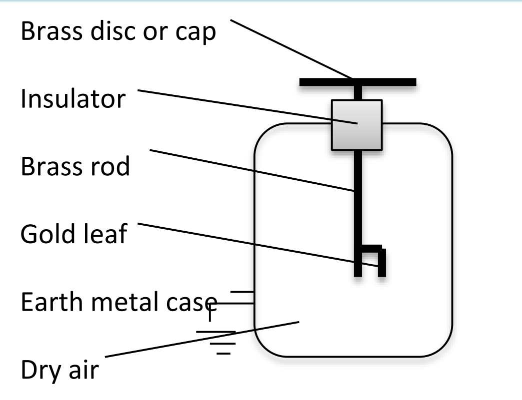
- Carbon dating
  - Carbon 14 is used to estimate when a certain fossil could have been existing.
- Medical use
  - Cobalt 60 is used to curb cancer.
  - Gamma radiations penetrate the body and kill the cancerous cells.
  - Gamma radiation is used to sterilise surgical instruments.
  - Used for treating goitre
  - For diagnosing of circulatory problem
  - Treating tumours
- Industrial use
  - Radioactivity is used in packaging industries
    - ✓ Tea factory uses such isotopes to detect whether the tea leaves are packed correctly or not.
  - Detecting of oil leaks in pipe lines. Short-lived radioisotopes are introduced in the pipe to be detected from where the pipe is broken.
- Agricultural use
  - Tracing fertilizer action.
  - Sterilising male insects so as to reduce population.
  - Obtaining information about animal and plant nutrition.

DANGERS OF RADIOISOTOPES

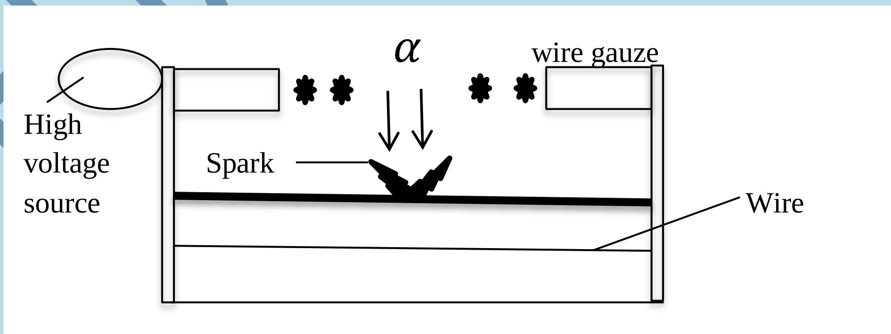
- Can cause skin burn.
- Can cause cell ionisation in the body.
- Can cause uncontrolled growth of tissue and cancer.
- Can affect genetic make-up that can result into deformed babies born.
- Can result into emission of enormous amount of energy in the form of heat.
- Causes redness of the skin.
- Blistering and sores.

DETECTION OF RADIATIONS

- Photographic plate
  - When exposed to radiations, radiations penetrate the plate.
  - Penetration exposes the surface.
- Electroscope
  - Can be made using money clips and the paper inside the cigerate packet.
  - Air molecules become charged by alpha ions.
  - This discharges the electroscope.
  - The gold leaf repels

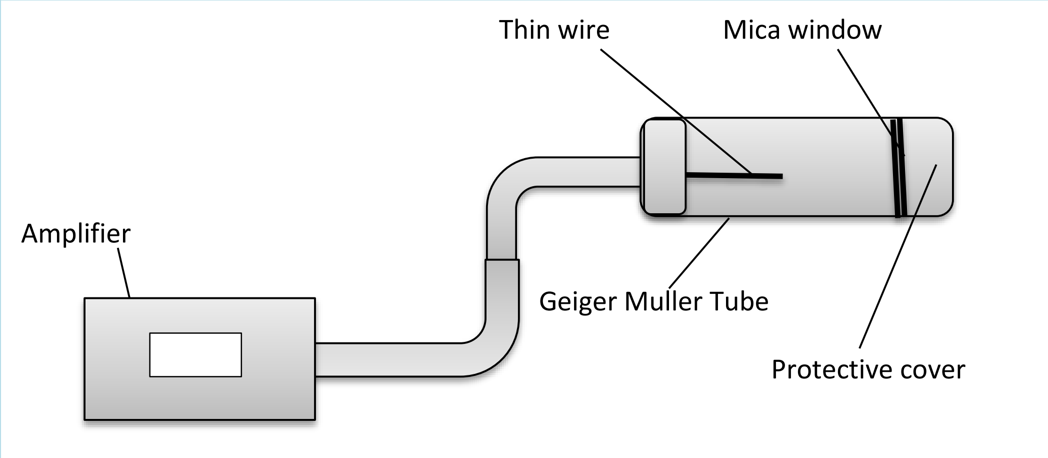


- Spark Counter
  - Device for detecting radiations.
  - Consists of a fine wire stretched below a piece of wire gauze.
  - A high voltage between the gauze and wire is adjusted until it is almost but not quite sparkling.
  - The ionising power of the radiations would then make the air ionized becoming conductive.
  - Sparks are then produced under high voltage.



- Geiger-Muller Tube
  - Consists of a long tube containing inert gas at low temperature.
  - It has a protective cover for the mica window.
  - The tube has anode as well as cathode.
  - The tube is connected to an amplify.
  - When a radioactive source is brought from the source penetrate it and ionises the gas inside.

- This induces a current.
- Whenever current flows in the amplify, a click is heard.



- Cloud Chamber
  - Device used to detect ionizating radiations.
  - Consists of closed container filled with supersaturated vapour.
  - When the ionizing radiation passes through the vapour, the vapour leaves a trail of charged particles (ions).
  - Ions saves as condensation centre for vapour.
- Scintillation Counter
  - Is also a device for detecting and measuring radiations by means of tiny visible flashes produced by the radiations when it strikes a sensitive substance called phosphor.
  - The individual flashes are caused by absorption and re-emission of radiation by the phosphor.
  - This detects only gamma rays because it is very thick.

PRECAUTIONS MEASURES

- Handle radioactive substances with forceps never with bare hands.
- Cover any cut on the skin before handling radioactive substances.
- Do not point radioactive substances towards a human body.
- Return radioactive substances to their container soon after use and store them in lead container.
- Always check for radiations after experiment.
- Do not stay long in a region of radioactive substances.
- If possible, use lead shielding when in a region of radioactive substances.