SUBJECT:

PHYSICS

CLASS:

SENIOR SECONDARY SCHOOL 1

TERM:

FIRST

SCHEME OF WORK

WEEK	TOPIC
1.	Introduction to Physics
2.	Measurement of Mass, Weight, Length and Time.
3.	Motion in Nature, Force, Circular Motion, Centripetal and Centrifugal Forces
4.	Friction

5. Vector and Scalar Quantity, Distance/Displacement, Speed/Velocity, Acceleration, Distance/Displacement-Time Graph, Speed/Velocity-Time Graph
6. Density and Relative Density

MID-TERM PROJECT

7. Upthrust, Archimedes Principle, Law of floatation, Pressure
8. Work, Energy and power
9. Work Done in a Force Field, Types of Energy and Energy Conversion
10. Viscosity
11. Revision
12. Examination

WEEK ONE

INTRODUCTION TO PHYSICS

CONTENT

- Meaning of Physics
- Aspects of Physics

- Importance of physics
- Scholars Achievement in the Field of Physics

MEANING OF PHYSICS

Physics is the scientific study of matter and energy and how they interact with each other. The interests and concerns of physicists have always formed the basis of future technology.

Physics has the capability of playing a major role in finding solutions to many of the problems facing the human race. In a broader sense, physics can be seen as the most fundamental of the natural sciences.

ASPECTS OF PHYSICS

1. Mechanics
2. Electricity
3. Electromagnetism
4. Nuclear and quantum physics
5. Optics and Light
6. Heat and thermodynamics

IMPORTANCE OF PHYSICS

Physics being the bedrock of technology has in no way been the foundation of global technological advancement. Physics contributes to the technological infrastructure and provides trained personnel needed to take advantage of scientific advances and discoveries.

Physics is important to man's life because it is used in

- Cooking food
- Cleaning clothes
- Watching TV
- Heating your house
- Playing sports

Everything else in your life

· Physics plays an important role in health

· Economic development

· Education

· Energy and

· The environment

SCHOLARS ACHIEVEMENT IN THE FIELD OF PHYSICS

1. *William Gilbert* (1544-1603) - An English physicist who hypothesized that the Earth is a giant magnet.
2. *Galileo Galilei* (1564-1642) - An Italian physicist. He performed fundamental observations, experiments, and mathematical analyses in astronomy and physics
3. *Willebrod Snell* (1580-1626) - A Dutch physicist who discovered law of refraction (Snell's law)
4. *Blaise Pascal* (1623-1662) - A French physicist who discovered that pressure applied to an enclosed fluid is transmitted undiminished to every part of the fluid and to the walls of its container (Pascal's principle)
5. *Christiaan Huygens* (1629-1695) - A Dutch physicist. He proposed a simple geometrical wave theory of light, now known as ``Huygen's principle"
6. *Robert Hooke* (1635-1703) - An English who discovered Hooke's law of elasticity
7. *Sir Isaac Newton (*1643-1727) - An English physicist who developed theories of gravitation and mechanics, and invented differential calculus
8. *Daniel Bernoulli* (1700-1782) - A Swiss physicist. He developed the fundamental relationship of fluid flow now known as Bernoulli's principle
9. *Benjamin Franklin* (1706-1790) - An American. He was the first American physicist; characterized two kinds of electric charge, which he named ``positive" and ``negative"

10. *Charles Augustin de Coulomb* (1736-1806) - A French physicist who performed experiments on elasticity, electricity, and magnetism; established experimentally nature of the force between two charges
11. *André Marie Ampère* (1775-1836) - A French physicist and father of electrodynamics
12. *Georg Ohm* (1789-1854) - A physicist from Germany. He discovered that current flow is proportional to potential difference and inversely proportional to resistance (Ohm's law)
13. *Michael Faraday* 1791-1867) - An English physicist who discovered electromagnetic induction and devised first electrical transformer
14. *Lord Kelvin* (1824-1907) - A British physicist who proposed absolute temperature scale, of essence to development of thermodynamics

CLASSWORK

1. What is physics?
2. State five aspects of physics

ASSIGNMENT

SECTION A

1. Which of the following statements is/are not true of physics (i) it is the building block of technology (ii) it is the basis for all technological invention (iii) it is irrelevant in electricity (a) i (b) ii (c) iii (d) i and ii
2. Which of these is not a physicist (a) Albert Einstein (b) Sir Isaac Newton (c) Charles G. Finney (d) Neil Armstrong
3. The following are invention related to physics except (a) electricity (b) raincoats (c) matches (d) driving skills
4. Physics relies upon mathematics to provide the logical framework in which physical laws may be precisely formulated and predictions quantified (a) true (b) false (c) cannot say (d) all of the above
5. Which of this physicist is known for the law of elasticity (a) Robert Hooke (b) Georg Ohm (c) Lord Kelvin

SECTION B

1. Briefly describe how physics has helped in technological advancement
2. Mention three scientists and their contributions to physics

WEEK TWO

MEASUREMENT OF MASS, WEIGHT, LENGTH & TIME

CONTENT

- Meaning of Measurement
- Measurement of Mass
- Measurement of Weight

- Measurement of Length
- Measurement of Time

MEANING OF MEASUREMENT

Measurement is the process of observing and recording the observations that are collected as part of a research effort. To get the exact measurement of an object we make use of tools used in the field of science, especially in physics called measuring instrument. Examples of such instrument are chemical balance, spring balance, meter rule, caliper, micrometer screw guage, clock, thermometer etc.

MEASUREMENT OF MASS

Mass is the quantity of matter contained in a body. The instrument used in measuring mass is chemical/beam balance. It is a scalar quantity & measured in kilogram (kg). Mass is a fundamental quantity & is constant from place to place.

MEASUREMENT OF WEIGHT

Weight is the earth pull on a body or the downward force produced when a mass is in a gravitational field. The instrument used in measuring weight is spring balance. It is a vector quantity & measured in newton (N). Weight is a derived quantity & varies from place to place.

Relationship Between mass & weight

$W=mg$

Where: W=weight (N); m=mass (kg) & g=acceleration due to gravity (m/s^2)

MEASUREMENT OF LENGTH

Length is simply distance extended. It is a fundamental quantity & measured in meters (m).

Length can be measured using tape rule, meter rule, caliper, vernier caliper and micrometer screw guage

MEASUREMENT OF TIME

Time can be defined as the interval between events. It is a fundamental quantity & measured in seconds(s).Time can be measured using stop watch/clock

FUNDAMENTAL & DERIVED QUANTITY

Fundamental quantities are the basic quantities that are independent of others. They are length (m), mass (kg) and Time (s), electric current (A), temperature (k), amount of substance (moles) and luminous intensity (candela).

Derived quantities are those obtained by simple combination of basic quantities e.g. Area, Volume, Density, Velocity, Acceleration, Force, energy, work, power, momentum, pressure, electric charge, electric potential etc.

S/N	QUANTITY	DERIVATION	DIMENSION	UNIT
1.	Area	length x breadth	L^2	m^2
2.	Volume	length x breadth x heights	L^3	m^3
3.	Density	mass ÷ volume	ML^{-3}	Kg/m^3
4.	Speed or velocity	distance ÷ time	LT^{-1}	m/s
5.	Acceleration	change in velocity ÷ time	LT^{-2}	m/s^2
6.	Force	Mass x acceleration	$M\ LT^{-2}$	N
7.	Weight	Mass x acceleration due to gravity	MLT^{-2}	N
8.	Momentum	mass x velocity	$M\ LT^{-1}$	kgm/s

9.	Impulse	force x time	$M\,LT^{-1}$	NS
10.	Pressure	Force ÷ Area	$M\,L^{-1}T^{-2}$	Pa or NM^2
11.	Energy or work	force x distance	$M\,L^2T^{-2}$	J or Nm
12.	Power	Work ÷ time	$M\,L^2T^{-1}$	W or Nm/s

CLASSWORK

1. Define these: (i) mass (ii) weight (iii) length

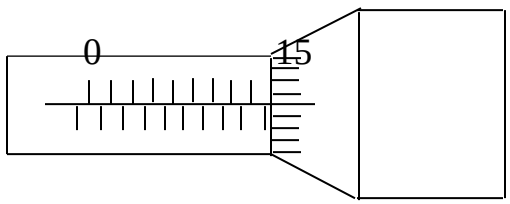
2. Calculate the weight of an object of mass 5000g if g = $10m/s^2$

3. List five instrument for measuring length

ASSIGNMENT

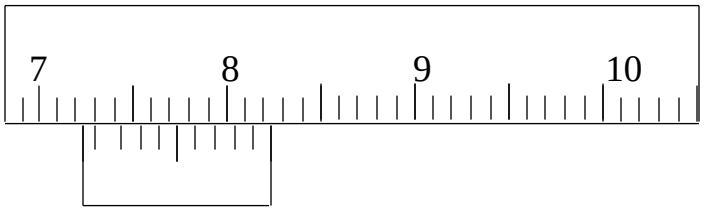
SECTION A

1. The following are the fundamental quantities except (a) Length (b) weight (c) mass (d) time
2. The reading accuracy of meter rule is (a) 0.01cm (b)0.1cm (c) 10.005cm (d) 0.004cm
3. The best instrument for measuring the diameter of a thin wire is (a) vernier caliper (b) steel rule (c) micrometer screw gauge (d) meter rule
4. The SI unit of weight is (a) N (b) m (c) mls^2 (d) kg
5. What is the reading on the micrometer screw gauge below:



(a) 8.511 (b) 8.011 (c) 8.519 (d) 8.151

6. What is the reading the vernier caliper is showing?



(a) 7.13 (b) 7.21 (c) 7.12 (d) 7.31

SECTION B

1. Derive the dimension for (a) work (b) volume (c) acceleration (d) force
2. Distinguished between fundamental and derived quantity
3. Distinguished between mass and weight

WEEK THREE

MOTION IN NATURE

CONTENT

- Definition of Motion
- Causes of Motion

- Circular Motion
- Centripetal Acceleration and Force

DEFINITION OF MOTION

Motion is the change of position of a body with time. The study of motion without involving the force causing the motion is called ***kinematics***. The study of motion of objects and the forces acting on them is called ***dynamics***.

Types of Motion

1. *Translational motion*: This type of motion occurs when a body moves in a fixed direction without rotating e.g. A car moving in one direction from one town to another, movement of a man etc. It is also called ***rectilinear motion***
2. *Rotational or Circular motion*: This is the movement of a body in a circular manner about its axis e.g. the movement of car wheels, electric fan blade, earth about its axis etc.
3. *Random Motion*: This is a type of motion in which a body moves in a zigzag or disorderly manner with no specific direction e.g. motion to molecules of gasses, butterflies etc.
4. *Vibratory or Oscillatory Motion*: This is a to and fro or up and down movement of a body about a fixed point e.g. the simple pendulum, vibration of plucked guitar string, etc.

Relative Motion

If two bodies, A and B are moving on a straight line, the velocity of A relative to B is found by adding the Velocity of B revered to the velocity of A. For instance, if a car traveling on a straight road at 100km/hr passes a bus going in the same direction at 60km/hr., the velocity of the car relative to the bus is (-60+100) = 40km/hr. If the car and the bus are traveling in opposite direction with the same velocities of 100km/r and 60km/hr respectively, the velocity of the car relative to the bus is (-(-60) + 100) = (60 +100) = 160 km/hr.

NB: When the velocities are not in the same straight line, the parallelograms law should be used to add this since velocities are vectors, and their magnitudes and direction must be taken into consideration.

CAUSES OF MOTION

All objects will continue in their state of rest unless acted upon by force. Only the application of a force can cause visible motion. Hence, force causes motion. There are two types of force (a) Contact force (b) Field force

(a) *Contact Force*: They are forces that are in contact with the body they affect e.g. tension, reaction frictional forces, forces of pull & push, viscous force etc.

(b) *Field Force*: They are forces whose sources do not require contact but the effect of such forces is felt in a field of the force e.g. electrical force, magnetic, gravitational pull etc.

CIRCULAR MOTION

In physics, circular motion is movement along a circular path or orbit. It can be uniform (i.e. with constant angular rate of rotation) or non-uniform (i.e. with a changing rate of rotation)

Formulae for uniform circular motion

Consider a body of mass (kg), moving in a circle of radius *r (m)*, with an angular velocity of ω (rads^{-1})

- The angular velocity is w = Θ/t where Θ-angle subtended (rad) & t-time (s)
- The linear speed is v = s/t where s-distance covered (m)

- The linear speed is $v = r \times \omega$ (m/s)
- The centripetal (inward) acceleration is $a = r \times \omega^2 = v^2/r$ (m/s^2)
- The centripetal force is $F = m \times a = r \times m \times \omega^2 = mv^2/r$ (N)
- The momentum of the body is $p = m \times v = r \times m \times \omega$(kgm/s)
- The moment of inertia is $I = r^2 \times m$ (kgm^2)
- The angular momentum is $L = r \times m \times v = r^2 \times m \times \omega = I\omega$(kg·m^2·s^{-1}).

- The kinetic energy is $E = ½(m \times v^2) = ½(r^2 \times m \times \omega^2) = \cdot p^2\ (2 \cdot m)^{-1} = ½(I \cdot \omega^2) = ½(L^2)$ (J).
- The circumference of the orbit is $2\pi r$ *(m)*.
- The period of the motion is $T = 2\pi\omega^{-1}$ (s)
- The frequency is $f = T^{-1}$ (Hz)

(To convert radian from degree $360^0 = 2\prod$)

CENTRIFUGAL FORCE

Centrifugal force is a force that acts in opposite direction to the centripetal force. Centrifugal force is an outward force associated with rotation.

CLASSWORK

1. What is kinematics?
2. Define motion
3. List two types of motion and explain briefly each of them giving in each case one example

ASSIGNMENT

SECTION A

1. An airplane from Kano to Lagos is an example of which if these types of motion? (a) Linear (b) rotational (c) random (d) oscillatory.
2. Which of the following correctly gives the relationship between linear speed v & angular velocity w of a body moving uniformly (a) v=w r (b) $v=w^2r$ (c) $v=wr^2$(d) v=w/r
3. Which of the following is odd? (a) Random motion (b) rotational motion (c) nuclear motion (d) oscillatory motion.
4. The motion of the prongs of a sounding turning fork is (a) random (b) translational(c) rotational (d) vibratory

5. A body moving in a circle at constant speed has (i) a velocity tangential to the circle (ii) a constant kinetic energy (iii) an acceleration directed towards the circumference of the circle. Which of the statement above are correct (a) I & ii only (b) ii & iii only (c) i & iii only (d) i, ii& iii

SECTION B

1. Explain the causes of motion
2. Define centripetal and centrifugal force
3. A body of mass 5kg moving in a circular path with a velocity of 5m/s for 10 complete revolution within 4s. If the radius of the circular path is 30m, find: (a) the centripetal force (b) the centripetal acceleration (c) angle subtended in radian (d) angular velocity

WEEK FOUR

FRICTION

CONTENT

- Definition of Friction
- Laws Governing Solid Friction
- Advantages & Disadvantages of Friction
- Reducing Friction

DEFINITION OF FRICTION

Friction (F_r) is defined as an opposing force which acts at the surface of two objects or bodies in contact. It is simply force of opposition. We have two types of friction:

(a) Static friction, F_s

(b) Dynamic friction, F_d.

NOTE: F_s is greater than F_d for object at rest while F_d is greater than F_s for object in motion.

LAWS GOVERNING SOLID FRICTION

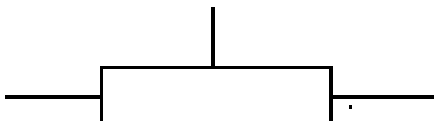
1. Friction opposes the relative motion of two surfaces in contact
2. It is independent of the area of the surface of contact
3. It depends on the nature of the surface
4. It is proportional to normal reaction (R)
5. It is independent of relative velocity between the surfaces

$F_r \alpha R$

$F_r = \mu R$ 1

Where: F_r=frictional force: μ=coefficient of friction and R=normal reaction

R

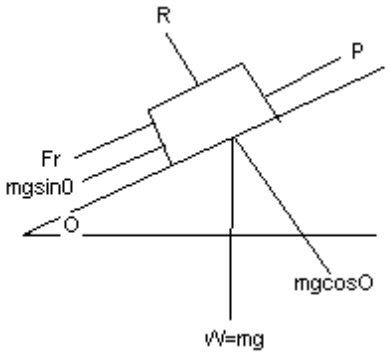


Fr F P

W=mg

At equilibrium, R = mg, this implies that

$Fr = \mu mg$ 2



$\mu = \tan\Theta$ 3

$Fr = R\tan\Theta$ 4

If $\mu > 0$, $P < Fr + mg\sin\Theta$

ADVANTAGES OF FRICTION

1. It makes walking and running possible

2. It enables gripping of belt in machines possible
3. It enables nails to stay in the wall when driven
4. It stops tyre from slipping
5. Enable cars to stop when breaks are applied
6. Enables human to use mouse in surfing web

DISADVANTAGES OF FRICTION

1. It causes wear and tear
2. It reduces the efficiency of the machines
3. It causes a lot of energy to be consumed by the machine
4. It causes loss of resources

METHODS OF REDUCING FRICTION

1. Lubricating surfaces with grease, oil etc.
2. Using ball or roller on wheels
3. Smoothing or polishing the surface
4. Streamlining bodies

CLASSWORK

1. Define friction
2. Mention four effect of friction
3. State 2 ways of reducing friction

ASSIGNMENT

SECTION A

1. Which of the following statements about the concept of solid friction is NOT true? (a) it always acts in the direction of motion (b) it causes wear and tear in car tyres (c) it depends on the nature of the surfaces in contact (d) it reduces the efficiency of machines
2. A metal block of mass 8kg lies on a rough horizontal platform. If the horizontal resistive force is 10N, find the coefficient of static friction ($g=10m/s^2$) (a) 0.25 (b) 0.125 (c) 0.8 (d) 0.124

3. Which of the statement is correct (a) static friction is less than dynamic friction (b) static friction equals dynamic friction (c) static friction is greater than dynamic friction (d) none of the arrange
4. A metal block of mass 5kg lies on a rough horizontal platform. If a horizontal force of 8N applied to the block on the platform, then the coefficient of limiting friction between the block and the platform is: (a) 0.16 (b) 0.63 (c) 0.80 (d) 1.06
5. If the angle between the incline length and the horizontal platform of an incline plane is 60^0 calculate the coefficient of friction (a) 0.86 (b) 1.73 (c) 0.50 (d) 0.73

SECTION B

1. State two (a) laws governing solid friction (ii) advantages of friction (iii) disadvantage of friction (iv) methods of reducing friction
2. A body of weight 6N rest on a plane inclined at an angle of $30^0$to the horizontal (a) what force keeps it sliding down the plane? (b) what is the coefficient of friction
3. A body of mass 25kg, moving at 3m/s on a rough horizontal floor is brought to rest after sliding through a distance of 2.5m on the floor. Calculate the coefficient of sliding friction ($g=10m/s^2$)

WEEK 5

VECTOR & SCALAR QUANTITY, DISTANCE/DISPLACEMENT, SPEED/VELOCITY, ACCELERATION, DISTANCE/DISPLACEMENT-TIME GRAPH, SPEED/VELOCITY-TIME GRAPH

CONTENT

- Distance & Displacement
- Speed & Velocity
- Acceleration & Retardation
- Distance/Displacement - Time Graph
- Speed/Velocity - Time Graph

LINEAR MOTION

Terminologies used in linear motion:

1. Distance: This defined as the total length of path traversed. It is also the separation between two points. It is denoted as "s" or "x". It is a scalar quantity. The SI unit of distance is meters (m)
2. Displacement: this is distance moved in a specified direction. It is denoted as "s" or "x". It is a vector quantity. The SI unit of displacement is meters (m)
3. Speed: This is the rate of change of distance with time. It is a scalar quantity. Its SI unit is meter per seconds (m/s or ms^{-1})

$$speed = \frac{distance\ travelled}{time\ taken}$$

$$v = \frac{s}{t}$$

4. Uniform speed: This is when the rate of change of distance with time is constant.
5. Velocity: This is the rate of change of displacement with time. It is a vector quantity. Its SI unit is meter per seconds (m/s or ms^{-1}).

$$velocity = \frac{distplacement}{time\ taken}$$

$$v = \frac{s}{t}$$

6. Uniform velocity: This is when the rate of change of displacement with time is constant.

NOTE: Velocity is often used interchangeably with speed during calculations

7. Acceleration: This is the increasing rate of change of velocity with time. It is a vector quantity. Its SI unit is meter per seconds-square (m/s^2 or ms^{-2})

$$acceleration \frac{change\ in\ velocity}{change\ in\ time}$$

$$a = \frac{\Delta v}{\Delta t}$$

$$a = \frac{v - u}{t_2 - t_1}$$

$$v = final\ velocity$$

$$u = initial\ velocity$$

8. Uniform acceleration: This is when the increasing rate of change of velocity with time is constant
9. Deceleration: This is the decreasing rate of change of velocity with time. It is a vector quantity. It is commonly referred to as negative acceleration or retardation.
10. Uniform deceleration: This is when the decreasing rate of change of velocity with time is constant

Equation of Uniformly Accelerated motion

$S = \frac{(v+u)}{2} t$ 7

$v = u + at$ 8

$v^2 = u^2 + 2aS$ 9

$S = ut + \frac{1}{2} at^2$ 10

Equations (7) to (10) are called equations of uniformly accelerated motion and could be used to solve problems associated with uniformly accelerated motion

where u- initial velocity, v – final velocity, a – acceleration, S – distance covered and t – time

Example - A car moves from rest with an acceleration of $0.2mls^2$. Find its velocity when it has moved a distance of 50m.

Solution

Given:

$a = 0.2mls^2$, S = 50m, u = 0m/s, v =?

$v^2 = u^2 + 2as$

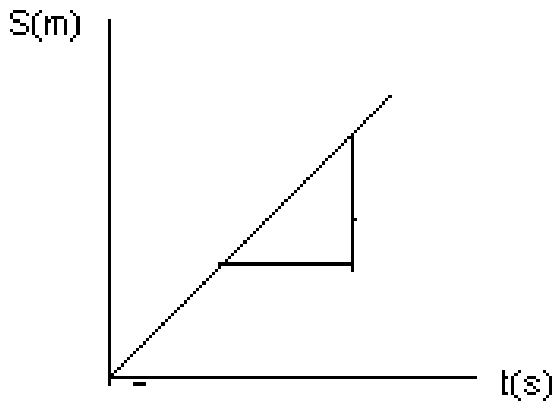
$v^2 = 0^2 + (2x0.2x50) = 20$

$v = \sqrt{20}$ m/s

Distance/Displacement- Time Graph

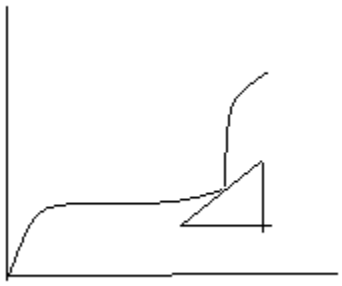
The slope of this time graph gives speed/velocity.

For a uniform speed/velocity, the time graph is given below:



If the velocity is non – uniform, the velocity at a point is the gradient or slope of the tangent at that point.

S (m)



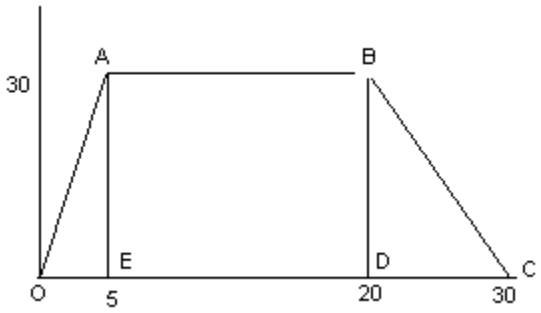
t (s)

Speed/Velocity - Time Graph

The slope of the speed/velocity-time graph gives acceleration.

Example - A car starts from rest and accelerates uniformly until it reaches a velocity of 30mls after 5 seconds. It travels with uniform velocity for 15 seconds and is then brought to rest in 10s with a uniform retardation. Determine (a) the acceleration of the car(b) The retardation (c) The distance covered after 5s(d) The total distance covered (use both graphical and analytical method)

The velocity – time diagram for the journey is shown above, from this diagram



a. the acceleration = slope of OA

= AE / EO

= (30-0) /(5-0)=30/5

= 6mls^2

b. the retardation = slope of BC = CB / CD

= (0-30) / (30-20) = -30/10

= -3mls^2 (the negative sign indicate that the body is retarding)

c. Distance traveled after 5s = area of A E O

= ½ x b x h

= ½ x 5 x 30

= 75m

d. total distance covered = area of the trapezium OABC

= ½ (AB + OC) AE

= ½ (15 + 30) 30

= 675m.

Using equations of motion:

a) U = O, V = 3, t = 5

V = u + t

a = v-u/t = 30 – 0 / 5

a = 30/5 = $6ms^{-2}$

b) a = (v – u) / t

a = (0-30) / 10

a = -3 mls^2

c) $S = \frac{(u + v)}{2} 5$

S= (30 x 5)/2

S= 75m

d) To determine the total distance traveled we need to find the various distance for the three stages of the journey and then add them.

For the 1st part S= 75m from (c) above

For the 2nd stage: where it moves with uniform velocity.

S = vt

= 30 x 15

= 450m

For the last stage S = ½ (u + v) t

= ½ (30 + 0) 10

= 150m.

Total distance = 75 + 450 + 100 = 675m.

CLASSWORK

1. Define the following terms as used in linear motion: i. Acceleration ii. Speed iii. Displacement
2. A car moves with a velocity of 72kmhr^{-1}. It is brought to rest in 10s. Find (i) the velocity in ms^{-1} (ii) the retardation
3. State the differences & similarity between speed & velocity

ASSIGNMENT

SECTION A

1. The area under the curve of a velocity-time graph represents (a) distance covered (b) acceleration (c) instantaneous speed (d) work done
2. Which of the following statements is correct about speed and velocity (a) speed and velocity are both scalar quantities (b) speed and velocity have the same unit (c) velocity relates to translational motion while speed relates to circular motion (d) velocity and speed cannot be represented graphically
3. A car moving with speed 90kmhr^{-1} was brought uniformly to rest by the application of brakes in 10s. How far did the car travel after brakes were applied (a)120m (b) 150m (c) 125m(d)15km
4. The slope of distant-time graph f0r a uniform rectilinear motion of a body represents (a) its acceleration (b) its total distance travelled (c) its speed (d) the force causing the motion
5. The distance traveled by a particle starting from rest is plotted against the square of the time elapsed from the commencement of motion. The resulting graph is linear. The slope of this graph is a measure of (a) initial displacement (b) initial velocity (c) acceleration (d) half of acceleration

SECION B

1. (a) Explain the terms uniform acceleration and average speed (b) a body at rest is given an initial uniform acceleration of 8.0ms^{-2} for 30 seconds after which the acceleration is reduced to 5.0ms^{-2} for the next 20 seconds. The body maintains the speed for 60seconds after which it is brought to rest in 20 seconds. Draw the velocity-time graph of the motion using the information

given above (c) using the graph, calculate the: (i) maximum speed attained during the motion; (ii) average retardation as the body is being brought to rest (iii) total distance travelled during the first 50s; (iv) average speed during the same interval as in (iii)

2. A car starts from rest and accelerates uniformly for 10s, until it attains a velocity of $25ms^{-1}$; it then travels with uniform velocity for 20s before decelerating uniformly to rest in 5s. (i) calculate the acceleration during the first 10s (ii) calculate the deceleration during the last 5s (iii) sketch a graph of the motion and calculate the total distance covered throughout the motion

WEEK SIX

DENSITY& RELATIVE DENSITY

CONTENT

- Definition of Density
- Determination of Density
- Relative Density
- Determination of Relative Density of Solids & Liquid

DEFINITION OF DENSITY

The density of a substance is the mass per unit volume of the substance.

$$\text{Density} = \frac{\text{mass of a given substance}}{\text{Volume of the substance}}$$

Density is scalar quantity& measured in kgm^{-3} (kilogram per cubic meter)

DETERMINATION OF DENSITY

The determination of density involves the determination of a mass and a volume. The mass can be found by weighing. The density of a substance can be determined using a graduated density bottle.

Relative Density

Relative density is also known as specific gravity. Relative density of a substance is defined as the density of the substance per density of water.

$$\text{R.D} = \frac{\text{Density of the substance}}{\text{Density of water}}$$

R.D is also equal to the ratio weight of a substance to weight of an equal volume of water. As weight is proportional to mass

$$\text{R.D} = \frac{\text{mass of substance}}{\text{Mass of equal volume of water}}$$

DETERMINATION OF R.D OF SOLID (E.G. SAND)

Mass of empty bottle = m_1

Mass of bottle + sand = m_2

Mass of bottle + sand + water = m_3

Mass of bottle + water only= m_4

Mass of sand = $m_2 - m_1$

Mass of water added to sand = $m_3 - m_2$

Mass of water filling the bottle = $m_4 - m_1$

Mass of water having the same volume as sand = $(M_4-M_1) - (M_3-M_2)$

Relative density = $\frac{\text{Mass of sand}}{\text{Mass of equal volume of water}}$

R.D = $\frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$

DETERMINATION OF R.D OF LIQUID

Mass of empty density bottle = m_1

Mass of bottle filled with water = m_2

Mass of bottle filled with liquid = m_3

R.D of liquid = $\frac{m_3 - m_1}{m_2 - m_1}$

Example - A glass block of length 10cm width 8cm and thickness 2cm has a mass of 400g. Calculate the density of the glass.

Solution

l = 10cm = 0.1m, b = 8cm = 0.08cm, h = 2cm = 0.02m, m = 400g = 0.4kg

V = l x b x h = 0.1 x 0.08 x 0.02 = $0.00016m^3$

Density = $\frac{\text{Mass (m)}}{\text{Volume (V)}} = \frac{0.4}{0.00016} = 2500kgm^3$

Example 1

Calculate the volume in m^3 of a piece of wood of mass 500g and density $0.76gcm^{-3}$

Mass of the wood = 500g

Density = $0.76gcm^{-3}$

Volume =?

Volume = mass / density

$= \frac{500}{0.76}$

Volume = $658cm^3 = 6.58 \text{ x } 10\text{-}4\ m^3$

Example 2

An empty relative density bottle has a mass of 15.0g. When completely filled with water, its mass is 39.0g. What will be its mass if completely filled with acid of relative density 1.20?

Solution

m_1, mass of empty bottle = 15.0g

m_2, mass of bottle + water = 39.0g

Mass of acid = n – 15.0g

Mass of water = 39.0 – 15.0g

= 24.0g

R.D = 1.20

$$R.D = \frac{n - 15.0g}{39.0 - 15.0g}$$

$$1.20 = \frac{n - 15.0}{24.0}$$

n- 15.0= 1.20x24.0

n- 15= 28.8

n =28.8+15

n=43.8g

NOTE: The hydrometer is an instrument used to measure the relative density of liquids

CLASSWORK

1. Define density
2. What does it mean by the statement that the density of gold is $19.3gcm^{-3}$
3. Differentiate between density & relative density
4. A glass block of length 100cm width 60cm and thickness 20cm has a mass of 4000g. Calculate the density of the glass

ASSIGNMENT

SECTION A

1. The relative densities of zinc, brass, copper, gold and silver are respectively 7.1, 8.5, 8.9, 19.3 and 10.5. A metal ornament which weighs 0.425kg and can displace $50x10^{-6}m^3$ of water is made of (a) zinc (b) brass (c) copper (d) gold (e) silver
2. Find the density of a substance, if the mass of the substance is 150,000g and the dimension is 20m by 10m by 500cm (a) $0.5kg/m^3$ (b) 0.24 kg/m^3 (c) 1.50 kg/m^3 (d) 2.40 kg/m^3.
3. What is the height of a cylindrical iron if the density is 7900kg1m? The mass is 700kg and the radius is 0.1m (a) 2.918m (b) 2.819m (c) 3.418m
4. Which is the correct unit of density? (a) m^3/kg (b) kg/m (c) kg/m^3 (d) m/v
5. What volume of alcohol with density of $8.4x10^2kgm^{-3}$ will have the same mass as $4.2m^3$ of alcohol whose density is $7.2x10^2kgm^{-3}$? (a) $1.4m^3$ (b) $6.3m^3$ (c) $4.9m^3$ (d) $3.6m^3$

SECTION B

1. 40 m^3 of liquid P is mixed with $60m^3$ of another liquid Q. if the density of P and Q are $1.00kgm^{-3}$ and $1.6kgm^{-3}$ respectively. What is the density of the mixture?
2. The density of $400cm^3$ of palm oil was $0.9gcm^{-3}$ before frying. If the density of the oil was $0.6cm^{-3}$ after frying, assuming no loss of oil due to spilling, its new volume was?

MIDTERM PROJECT

Using a white cardboard draw these instruments, write short note and explain how to take readings from them:

- **Vernier caliper**
- **Micrometer screwguage**
- **Metre rule**
- **Spring balance**
- **Beam balance**

WEEK SEVEN

PRESSURE, ARCHIMEDES' PRINCIPLES, UPTHRUST&LAWS OF FLOATATION

CONTENT

- Pressure
- Archimedes' Principles & Upthrust
- Laws of Floatation

PRESSURE

Pressure is defined as force per unit surface area. It is a scalar quantity & measured in N/m^2 or Pascal (pa).

$P = \frac{F}{A}$ 1

Where P-pressure, F- force & A-area

NOTE: 1 bar = 10^5 N/m^2 = 10^5 pa

Example – A force of 40N acts on an area of $5m^2$. What is the pressure exerted on the surface?

Solution

F = 40N, A = $5m^2$, P =?

P = F/A = 40/5 = 8pa

Pressure in Liquid

Pressure in liquid has the following properties

1. Pressure increases with depth
2. Pressure depend on density
3. Pressure at any point in the liquid acts equally in all direction
4. Pressure at all points at the same level within a liquid is the same
5. It is independent of cross-sectional area

$P = \rho gh$ 2

Where: p-pressure, ρ-density, h-height & g-acceleration due to gravity**.**

ARCHIMEDES' PRINCIPLES AND UPTHRUST

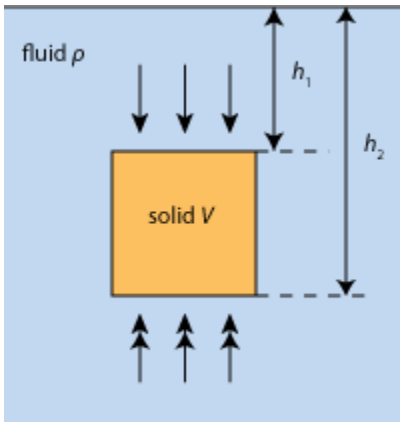
Archimedes' principle is a law that explains buoyancy or upthrust. It states that when a body is completely or partially immersed in a fluid it experiences an upthrust, or an apparent loss in weight, which is equal to the weight of fluid displaced.

From pressure, p is given by $p = h\rho g$, where:

h is the height of the fluid column

ρ is the density of the fluid

g is the acceleration due to gravity



Let us confirm this principle theoretically. On the figure on the left, a solid block is immersed completely in a fluid with density ρ. The difference in the force exerted, d on the top and bottom surfaces with area a is due to the difference in pressure, given by

$d = h_2a\rho g - h_1a\rho g = (h_2 - h_1)a\rho g$

But $(h_2 - h_1)$ is the height of the wooden block. So, $(h_2 - h_1)a$ is the volume of the solid block, V.

$d = V\rho g$

Upthrust = $V\rho g$

Weight in air – upthrust = weight in fluid

Upthrust = weight in air – weight in fluid

Upthrust = Apparent loss in weight

NB: When an object is wholly immersed, it displaces its volume of fluid.

So;

Upthrust = weight of fluid displaces

Upthrust = Volume of fluid displaced x its density x g

Upthrust= volume of object x density of fluid x g

Determination of Relative Density by Archimedes' Principle

1. *Relative density of solid*

The body is weighed in air w_1, and then when completely immersed in water w_2

Relative density of solid = $\frac{\text{Weight of solid in air}}{\text{Weight of equal volume in water}}$

$= \frac{w_1}{W_1 - W_2}$

2. *Relative density of liquid*

A solid is weighed in air (w_1), then in water (w_2) and finally in the given liquid (w_3)

Relative density of liquid = $\frac{\text{apparent loss of weight of solid in liquid}}{\text{apparent loss of weight of solid in water.}}$

$= \frac{W_1 - W_3}{W_1 - W_2}$

Example - The mass of a stone is 15g when completely immersed in water and 10g when completely immersed in liquid of relative density 2.0. What is the mass of the stone in air?

Solution:

Relative density = $\frac{\text{upthrust in liquid}}{\text{upthrust in water}}$

Let W represents the mass of the stone in air

$2 = \frac{w - 10}{w - 15}$

$2(w - 15) = w - 10$

$2w - 30 = w - 10$

2 w – w = -10 + 30

w = 20g

LAW OF FLOATATION

A floating object displaces its own weight of the fluid in which it floats or an object floats when the upthrust exerted upon it by the fluid is equal to the weight of the body. When an object is floating freely (i.e. neither sinking nor moving vertically upwards), then the upthrust must be fully supporting the object's weight. We can say Upthrust on body = Weight of floating body. By Archimedes' principle, Upthrust on body = Weight of fluid displaced.

Therefore, Weight of floating body = Weight of fluid displaced. This result sometimes called the "principle of floatation", is a special case of Archimedes' principle

CLASSWORK

1. Define pressure
2. State three characteristics of pressure in liquids
3. State Archimedes' principle.

ASSIGNMENT

SECTION A

1. A force of 40N acts on an area of $10m^2$. What is the pressure exerted on the surface? (a) 8pa (b) 4pa (c) 400pa (d) 10pa
2. For which of the following sets are the units fundamental? (a) density, length and pressure (b) impulse, mass and time (c) volume, mass and density (d) length, time and mass
3. What is the height of a cylindrical iron if the density is $7900kglm^3$ the mass is 700kg and the radius is 0.1m (a) 2.918cm (b) 2.819m (c) 3.418m (d) 4.328m

4. A piece of cork density $0.25x10^{3}kgm^{-3}$ floats in a liquid of density $1.25x10^{5}kgm^{-3}$, what fraction of volume of the cork will be immersed? (a) 5 (b) 1/5 (c) 2/5 (d) 1/3
5. The SI unit for pressure, density and upthrust is respectively (a) Nm^{-2}; gm^{-3}; F (b) Nm^{-2}; Kgm^{-3}; N (c) F; Kgm^{-3}; Nm^{-2} (d) Nm^{-3}; Kgm^{-2}, N

SECTION B

1. Explain the following terms: (i) viscosity (ii) terminal velocity
2. State two (i) effect of viscosity (ii) applications of viscosity
3. What is the pressure due to water at the bottom of a tank which is 20cm deep and is half of water? (Density of water = $10^{3}kg/m^{3}$& g = $10m/s^{2}$)

WEEK EIGHT

WORK, ENERGY AND POWER

CONTENT

- Work
- Energy
- Power

WORK

Work is defined as the product of force and distance in the direction of the force. It is a scalar quantity & measured in Joules.

Mathematically:

$W = F \times d$ 1.

$W = mgh$ 2.

If a force is applied on a body at an angle Ø to the horizontal

Work done = $F\cos Ø \times d$ 3.

Work done to raise the body to an appreciable height

$= F\sin Ø \times d$ 4.

Example - A boy of mass 50kg runs up a set of steps of total height 3.0m. Find the work done against gravity

Solution

$m = 50kg$, $h = 3m$, $g = 10m/s^2$

Work done = $m \times g \times h$

$= 50 \times 10 \times 3$

$= 1500$ Joules

ENERGY

Energy is defined as the ability to do work. It is a scalar quantity &measured in Joules. There are many forms of energy. These include:

i. Mechanical energy
ii. Thermal energy
iii. Chemical energy
iv. Electrical energy

v. Nuclear/Atomic Energy

vi. Solar/Light energy

vii. Sound Energy

Types of Mechanical Energy

Mechanical energy is classified as

1) Potential energy
2) Kinetic energy

Potential Energy - is simply "stored energy" i.e. energy possessed by a body by virtue of its states:

$P.E = mgh$ 5.

Kinetic Energy: is the energy possessed by a body by virtue of its motion. Examples area student running a race, wind or air motion, electrical charges in motion, a moving bullet

$K.E = \frac{1}{2} mv^2$ 6.

Example I - An object of mass 5kg is moving at a constant velocity of 15m/s. Calculate its kinetic energy.

Solution

$K.E = \frac{1}{2} mv^2 = \frac{1}{2} \times 5 \times 15 \times 15 = 562.5$ J

Example II- Find the potential energy of a boy of mass 10kg standing on a building floor 10m above the ground level. $g = 10m/s^2$

Solution:

$P.E = m \times g \times h = 10 \times 10 \times 10 = 1000$ J

POWER

Power is defined as the rate of doing work or the rate of transfer of energy. It is a scalar quantity & measured in watt

$$\text{Power} = \frac{\text{work done}}{\text{Time}} \quad 7$$

$$P = (F \times d)/t = F \times d/t = FV \quad 8$$

Example -A boy of mass 10kg climbs up 10 steps each of height 0.2m in 20 seconds. Calculate the power of the boy.

Solution

Height climbed = 10 x 0.2 = 2m

Work done = m x g x h = 10 x 10 x 2= 200 Joules

Power = work

Time

= 10 x 10 x 2 = 10watts

20

CLASSWORK

1. Define these terms (i) power (ii) work done (iii) energy
2. A boy of mass 960g climbs up to 12 steps each of height 20cm in 20 seconds. Calculate the power of the boy

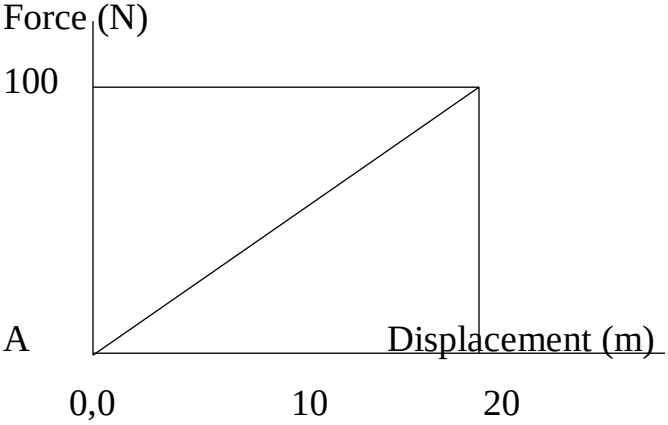
ASSIGNMENT

SECTION A

1. Under which of the following conditions is work done (a) a man supports heavy load above his head with his hands (b) a woman holds pot of water (c) a boy climb unto a table (d) a man pushes against stationary petrol tanker
2. An object of mass 0.5kg has kinetic energy of 25J. Calculate the speed of the object (a) $50ms^{1}$ (b) $25ms^{-1}$ (c) $2.ms^{-1}$ (d)$10ml^{-1}$
3. A man of mass 50kg ascends a flight of stairs 5m high in 5seconds. If acceleration due to gravity is $10m/s^2$, the power expended is (a) 100W (b) 250W (c) 500W (d) 400W
4. The kinetic energy of a bullet fired from a gun is 40J. If the mass of the bullet is 0.1kg, calculate the initial speed of the bullet (a) $4.0ms^{-1}$ (b) $40.0ms^{-1}$ (c) 28.28 ms^{-1} (d) 20.0 ms^{-1}
5. A diver is 5.2m below the surface of water of density 10^3 $kg/m^{3.}$ If the atmospheric pressure is 1.02 x 10^5 pa. Calculate the pressure on the diver.

($g=10m/s^2$) (a) 6.02 x 10^4 pa (b) 1.02 x 10^5 pa (c) 1.54 x 10^5 pa (d) 5.20 x 10^5 pa

6. Force (N)



Using the force-displacement diagram shown above, calculate the work done.

(a) 2000J (b) 1000J (c) 20J (d) 5J

SECTION B

1. Explain work done.
2. (a) State the law of conservation of energy. (b) A body is displaced through a certain distance x by a force of 30N. If the work done is 100J and the displacement is in the direction of force, what is the value of x?
3. A motor can converts chemical energy of petrol to mechanical energy at 30% efficiency. Calculate the mechanical energy obtained from 10litres of petrol. (1 litre of petrol contains 2.8kJ of chemical energy)
4. A student eats a dinner container $8.0x10^6$J of energy. He wishes to do an equivalent amount of work in a nearby gym by lifting a 60kg object. How many times must he raise the object to expand this much energy? Assume that he raises it a distance of 2.0m each time

WEEK 9

WORK DONE IN A FORCE FIELD& ENERGY CONVERSION

- Work done in Lifting a Body & Falling Bodies
- Conservation & Transformation of Energy
- World Energy Resources

WORK DONE IN LIFTING A BODY & FALLING BODIES

The magnitude of work done in lifting a body is given by

Work = force x distance = m x g x h = mgh

Also, the work done on falling bodies is given by

Work = force x distance = m x g x h = mgh

CONSERVATION & TRANSFORMATION OF ENERGY

Energy can be converted from one form to another in a closed system. The law of conservation of energy states that *energy can neither be created nor destroyed but can be converted from one form to the other*.

World Energy Resources

World energy resources can be classified as

1. Renewable Energy Resources: They are energy that can be replaced as they are used e.g. solar energy, wind energy, water energy & biomass

2. Non-renewable Energy Resources: Energy that cannot be replaced after use e.g. nuclear energy, petroleum & natural gas

CLASSWORK

1. State the law of conservation of energy
2. A loaded sack of total mass 100kg falls down from the floor of a lorry 2m high. Calculate the work done by gravity on the load
3. Differentiate between renewable & non-renewable energy

ASSIGNMENT

SECTION A

1. Which of the following correctly explain energy conversion in a food eaten by a student to the energy he gets to play around? (a) potential energy – kinetic energy (b) chemical energy – kinetic energy (c) heat energy – potential energy (d) mechanical energy – chemical energy
2. Electric cell convert …… to electrical energy (a) nuclear (b) chemical (c) mechanical (d) heat
3. A body rolls down a slope from a height of 100m. Its velocity at the foot of the slope is $20ms^{-1}$. What percentage of its initial potential energy is converted into kinetic energy? ($g=10ms^{-2}$)
4. The following are examples of renewable energy except (a) biomass (b) solar (c) wind (d) nuclear
5. A boy of mass 50kg runs up a set of steps of total height 3.0m. Find the work done against gravity (a) 1200J (b) 1500J (c) 1000J (d) 1300J

SECTION B

1. A loaded sack of total mass 100kg falls down from the floor of a lorry 2m high. Calculate the work done by gravity on the load
2. A body of mass 0.6kg is thrown vertically upward from the ground with a speed of $20ms^{-1}$. Calculate its: (a) potential energy at the maximum height reached; (b) kinetic energy just before it hits the ground

WEEK 10

VISCOSITY

CONTENT:

- Meaning of Viscosity
- Experiment to Determine the Terminal Velocity of a Steel Ball Falling in a Fluid
- Factors Affecting Viscosity
- Effect of Viscosity
- Application of Viscosity

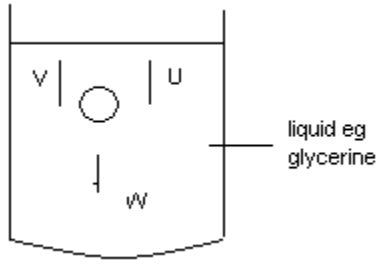
MEANING OF VISCOSITY

Viscosity is the internal friction which exists between layers of the molecules of fluid (liquid or gas) in motion. The viscosity of a fluid can also be defined as the measure of how resistive the fluid is to flow. It is a vector quantity & measured in Pascal-seconds (Pa.s).

It can be defined mathematically as the ratio of the shearing stress to the velocity gradient in a fluid

$$\text{Viscosity } (\eta) = \frac{\text{Force}}{\text{Area x Velocity gradient}} \quad 1.$$

$$\text{Velocity gradient} = \frac{\text{velocity}}{\text{Length}} \quad 2.$$



$W = U + V$

W – U- V = 0 ……3.

V = W – U (apparent or effective weight)

Where: V-viscous force, W- weight, U- upthrust

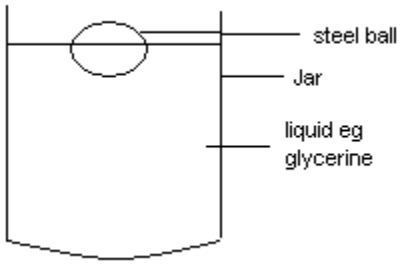
NOTE: Substances with low viscosity include water, kerosene, petrol, ethanol etc. Those with high viscosity are glue, syrup, grease, glycerin etc.

Experiment to Determine the Terminal Velocity of a Steel Ball Falling Through a Fluid

Aim: To determine the terminal velocity of a steel ball falling in through a jar of glycerin

Apparatus: steel ball, cylindrical calibrated jar, glycerine

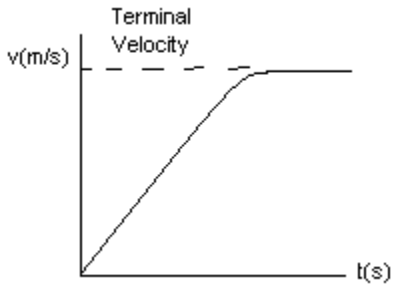
Diagram:



Procedure: Set-up the apparatus as shown above &gently drop the steel ball in the jar of glycerin

Observation: It will be observed that the ball is accelerating in the liquid. Also the time taken for the ball to move from A-B will be different from B-C and so on. A time will be reached when the ball will be moving at a constant speed or velocity. It is that point that terminal velocity is experience.

Graph:



Conclusion: Terminal velocity is attained when W = V + U. At a point when the ball is moving at a constant speed through the glycerine.

Precaution:

1. The steel ball should be dropped gently on the liquid
2. Experiment should be done under constant temperature
3. Avoid error of measurement when taken the reading.

NB: **Terminal velocity** is the maximum velocity of an object when the viscous force due to motion of the object equals the apparent (effective) weight of the object in the fluid where there is no longer net force on the object.

Drag force is the force that keeps the object continuously moving after the terminal velocity has been attained.

Stokes' Law state that at the terminal velocity, the upward frictional force

$(F) = 6\Pi\eta rV$

Where F- Frictional/Drag force, ŋ- viscosity, r- radius of sphere, V_t- Terminal velocity

Factors Affecting Viscosity

1. Viscosity varies with material
2. The viscosity of simple liquids (a) decreases with increasing temperature (b) increases under very high pressure
3. The viscosity of gases (a) increases with increasing temperature (b) is independent of pressure & density

Effect of Viscosity

1. Viscosity is responsible for different rate of fluid flow
2. Viscosity affect motion of body in fluid

Application of Viscosity

1. It is use as a lubricant
2. The knowledge of viscous drag/drag force is applied in the design of ship & aircraft
3. Use to estimate the enlarge size of particles

NB: A liquid is said to be VISCOSTATIC if its viscosity does not change (appreciably) with change in temperature.

CLASSWORK

1. What is viscosity?
2. State two application of viscosity
3. Mention three viscous liquid that you know

ASSIGNMENT

SECTION A

1. Viscosity of a liquid does not depend on the (a) nature of liquid (b) normal reaction between the liquid layers (c) area of the surface in contact (d) temperature of the liquid
2. Viscosity opposes motion of an object in (a) solid (b) liquid only(c) gas only (d) liquid & gas
3. Which of the following statements about viscosity are correct? When a ball falls through a viscous liquid (i) viscosity opposes the gravitational force on the ball (ii) viscosity opposes the upthrust on the body (iii) viscosity is in the same direction as the upthrust on the ball (iv) the ball falls faster in a more viscous liquid (a) I and II (b) I and III (c) II and IV (d) III and IV
4. The SI unit of velocity gradient is (a) m/s (b) s^{-1} (c) m/s^2 (d) ms
5. Terminal velocity is attained when (a) w + v = u (b) w = v – u (c) w + u = v (d) w = v + u

SECTION B

1. Derive the dimension of viscosity
2. State two effect of viscosity
3. Describe an experiment to determine the terminal velocity of a steel ball falling in a fluid

WEEK 11

Revision

WEEK 12

Examination