Physics

Q.1:Define:

1- Measurement.

2- Fundamental physical quantities.

3- Derived physical quantities.

4- Standard meter.

5- Standard kilogram.

6- Standard second.

7- Dimensional formula.

8- Absolute error.

9- Relative error.

10- Scalar quantities.

11- Vector quantities.

12- Distance.

13- Displacement.

14- Resultant force.

Q.2:What is meant by?

1- The dot product of two vectors **A** and **B** = 75.2.

2- The vector product of two vectors **A** and **B** = 43.6 $\vec{n}$.

Q.3:By using Dimensional formula prove that:

1- $F \times v = w/t$ (where v is velocity, W is work)

2- F = m . a (a is acceleration)

3- $F = \frac{M \times V^2}{r}$

4 - $t = 2\pi \sqrt{\frac{L}{g}}$ (g is acceleration of gravity)

5 - $v^2 = 2\, g.x$

6 - $x = v_o t + \frac{1}{2} g t^2$ (v_0 is initial velocity)

Q.4: compare between:

1 – Direct and indirect measurements.

2 – Dot and cross product of vectors.

Q.5: Give reasons:

1. Volume is a derivable quantity while length is a fundamental quantity.
2. The measuring process can't be 100% accurate.
3. We don't use glass in the standard meter instead of platinum & iridium
4. The direct measurement is more accurate than the indirect one.
5. The relative error is a better indication for measurement accuracy than absolute error.
6. Speed is a scalar quantity while velocity is a vector one.

Q.6:Derive the Dimensional Formula of:

power = work / time

pressure = force / Area

Impulse = $f \times \Delta t$

Q.7: Complete :

1. Mass is measured in ……..unit in British system, while it is measured in ……unit in S.I.
2. Length is measured in ……unit in Gaussian system, while it is measured in ……unit in British system.
3. Temperature is measured in ……unit in S.I, while the intensity of current is measured in ……unit in S.I.

4. Solid angle is measured in ……..unit ,While plane angle is measured in …….unit.

5. D.F of velocity is …… ,While its measuring unit is …….

6. D.F of force is …….. and its measuring unit is …….

7. $\vec{A} \cdot \vec{B}$ = …….. , while $\vec{A} \wedge \vec{B}$ = …….

8. If a force of 10 N makes an angle 60^o with (x-axis) ,so f_x= …….. , While f_y= …….

9. In a measuring process of length, if L= (5±0.2) ,so the absolute error is …….. and the relative error is ……..

Q.8:Problems :

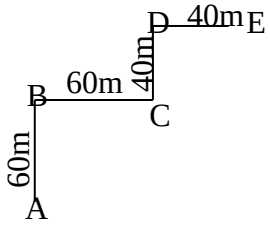
(1) If $X = (5 \pm 0.1)$ cm and $y = (10 \pm 0.2)$cm. calculate each of :

a. $X + Y$ b. $2X + Y$ c. Xy d. Xy^2

(2) Find the relation error in estimating the volume of a cube of side length 5 cm if the relative error in measuring length in 0.01 . Also , find the absolute error in this case .

(3) A ship sails north at velocity 12 km/h. due to tides, it is deviated to west at velocity 15 km/h. Find the magnitude and direction of the resultant velocity of the ship.

(4) In the opposite diagram , a person has moved from point (A) to point (E) passing by the points (B) , (C) & (D) . find his displacement and the distance he moved .



(5) Two perpendicular forces F_x and F_y act on an object where $F_x = F_y = 80N$. Find :

a. The resultant of the two forces F_1 and F_2.

b. The angle between their resultant x-axis .

c. Do object move or remain stationary ?

(6) $\vec{A}$ and $\vec{B}$ are two vectors having an angle 120^0 between them where the magnitude of ($\vec{A}$) = 3 units and the magnitude of ($\vec{B}$) = 4 units. Find : their dot product and their cross product.

Answers

Q.1:Define :

1 – Measurement : The process of comparing an unknown quantity with another one of its kind(called the unit of measurement) to find out how many times the first includes the second .

2 – Fundamental physical Quantities : physical quantities that cannot be defined in terms of other physical quantities .

3 – Derived physical Quantities : physical quantities that can be defined in terms of the fundamental physical quantities .

4 – Standard Meter :The distance between two engraved marks at the ends of a rod made of platinum and iridium alloy kept at $o^o c$.

5 – Standard kilogram : The mass of a cylinder made of platinum and iridium alloy of specific dimensions kept at $0^o c$.

6 – Standard second :

The second = $\frac{1}{86400}$ of the average solar day.

7 – Dimensional formula : The formula that expresses the derived physical quantities in terms of the fundamental physical quantities (mass ,length & time) each has a certain exponent .

8 – Absolute error : The difference between the actual value (x_0) and the measured value (x) $\Delta x = |x_0 - x|$.

9 – Relative error : The ratio between the absolute error (Δx) to the real value (x_0) $\rightarrow r = \frac{\Delta x}{x_0}$.

10 – Scalar quantity : the physical quantity that can be fully defined by its magnitude only .

11 – Vector quantity : The physical quantity that can be fully defined by both magnitude and direction .

12 – Distance : The length of the path moved by an object from a position to another . (Scalar quantity)

13 – Displacement : The change in the position of object , or the length of the straight line segment in a given direction between the starting point and the end point .(vector quantity)

14 – Resultant force : A single force that results in the same effect on the object as that produced by the original acting forces . or , the net force that affects an object as a result of the action of a number of forces .

Q.2 : What's meant by ? :

1 – The dot product of two vectors A and B =75.2.

It's mean that the product of the magnitudes of (A) and (B) and the cosine of the angle between them ($cos\ \theta$)= 75.2 or $AB\ cos\ \theta$ =75.2

2 – The cross product of two vectors $\vec{A}$ and B = 43.6 n .

It's mean that the product of the magnitudes of ($\vec{A}$) and ($\vec{B}$) and the sine of the angle between them and the unit vector directed in a direction perpendicular to the plane of both vectors = 43.6 n ,or

$A\ B\ sine\ \theta\ n$=43.6 n

Q.3 : By using dimensional formula prove that :

1 - $f \times v = w/t$ $\quad (w = f.d)$

Dimensions of $L.H.S. = MLT^{-2} \times LT^{-1}$

$= ML^2T^{-3}$ $\quad (1)$

Dimension of $R.H.S. = MLT^{-2}.L/T$

$= ML^2T^{-2}/T$

$= ML^2T^{-3}$ $\quad (2)$

So $F \times V = w/T$ is dimensionally correct .

2- $\mathbf{F = M \times a}$

Dimensions of $L.H.S. = MLT^{-2}$

Dimension of $R.H.S. = M \times LT^{-2} = MLT^{-2}$

So $F = M \times a$ is dimensionally correct.

3- $\mathbf{F = \frac{m \times v^2}{r}}$

$\mathrm{L.H.S.} = \mathrm{MLT^{-2}}$ (1)

$\mathrm{R.H.S.} = \frac{\mathrm{M \times (LT^{-1})^2}}{\mathrm{L}}$

$= \frac{\mathrm{ML^2T^{-2}}}{\mathrm{L}} = \mathrm{MLT^{-2}}$ (2)

So the relation is dimensionally correct.

4 – $\mathbf{T = 2\pi\sqrt{\frac{L}{g}}}$ (numbers & constants having no dimensions)

$\mathrm{L.H.s.} = \mathrm{T}$ (1)

$\mathrm{R.H.S.} = \sqrt{\frac{\mathrm{L}}{\mathrm{LT^{-2}}}}$

$= \sqrt{\frac{1}{\mathrm{T^{-2}}}} = \sqrt{\mathrm{T^2}} = \mathrm{T}$ (2)

So the relation is dimensionally correct .

5- $\boldsymbol{V^2 = 2gx}$

$L.H.S. = (LT^{-1})^2$

$= L^2T^{-2}$ (1)

$R.H.S. = LT^{-2} \times L$

$= L^2T^{-2}$ (2)

So the relation is dimensionally correct .

6- $X = v_0 T + \frac{1}{2} g t^2$

$L.H.S. = L \quad (1)$

$R.H.S. = LT^{-1} \times T + LT^{-2} \times T^2$

$= 2\,L = L \quad (2)$

So the relation is dimensionally correct .

Q.4 : Compare between :

1 – Direct & indirect measurements.

Points of comparison	Direct measurement	Indirect measurement
No. of processes	One measurement process.	More than one measurement process.
calculations	No mathematical relation is applied.	A mathematical relation is applied to find the quantity.
Measurement error	One measurement error.	More one measurement error
Examples	Measuring volume using the graduated cylinder.	Measuring volume by length , width and height.

2 – Dot and cross product of vectors.

Point of comparison	Dot product	Cross product
1.Result quantity.	Scalar quantity.	Vector quantity.
2.Mathematical relation.	$\vec{A}.\vec{B} = A\,B\,cos\theta$	$\vec{A} \wedge \vec{B} = AB\,sin\theta\,\vec{n}$

Q. 5 :Give reason :

1. Volume is a derivable quantity , while length is a fundamental quantity.
   Because volume can be defined in terms of length ($V = L \times w \times h$) ,while the length can't be defined in terms of any other physical quantity.
2. The measuring process can't be 100% accurate .
   Because there are several reasons for measurement error
   As: - choosing improper tools. - A defect in the measuring tool.
   - wrong procedure. - Environmental conditions.
3. We don't use glass in the standard meter instead of platinum and iridium allay .
   Because platinum & iridium alloy is rigid , chemically inactive and not affected by the surrounding temperature contrary to other materials like glass.
4. The direct measurement is more accurate than the indirect one.
   Because in direct measurement there is only one measurement error, while in indirect one there are more than one error “Cumulative error”.

5. The relative error is better indication for measurement accuracy than absolute error.

   Because it is found by the ratio between the absolute error (Δx) to the real value (X_o).

6. Speed is a scalar quantity ,while velocity is a vector one.

   Because speed can fully defined by its magnitude only, while velocity must be defined by both magnitude and direction.

Q. 6: Derive the dimensional formula of :

1- power =work/time ($\mathbf{work = F.d}$)

$$\text{Work} = MLT^{-2}.L$$
$$= ML^2T^{-2}$$
$$\text{Time} = T$$
$$\text{Power} = \frac{ML^2T^{-2}}{T} = ML^2T^{-3}$$

2- pressure= Force / Area

$$\text{Force} = M\,L\,T^{-2}$$
$$\text{Area} = L^2$$
$$\text{Pressure} = \frac{MLT^{-2}}{L^2} = M\,L^{-1}T^{-2}$$

3- Impulse $= \mathbf{F} \times \Delta\mathbf{t}$

$$F = M\,L\,T^{-2}$$
$$\Delta t = T$$
$$\text{Impulse} = M\,L\,T^{-2} \times T$$
$$= M\,L\,T^{-1}$$

Q . 7: complete

1. pound - kilogram.
2. cm – foot.
3. Kelvin – Ampere.
4. Steradian - Radian.
5. $L\,T^{-1} - \ m/s$
6. $M\,LT^{-2} - \ Newton$
7. $AB\ cos\theta - AB\ sin\theta\ \vec{n}$
8. $F_x = F\ cos\theta$

$= 10 \cos 60$

$= 5\ N$

$F_y = F\ sin\theta$

$= 10\ sin60$

$= 5\sqrt{3}$

Q.8: Problems :

(1) If $X = (\ 5 \pm 0.1\ )\ cm$ and $y = (\ 10 \pm 0.2\ )cm$. calculate

Each of :

$a. X + Y$ $b. 2X + Y$ $c. Xy$ $d. Xy^2$

a. $X_o + \ Y_o = 5 + 10 = 15$ cm

$\Delta x + \ \Delta y = 0.1 + 0.2 = 0.3$ cm

$X + Y = (\ 15\ \pm 0.3\ )$ cm

b. $2X_o + Y_o = 10 + 10 = 20$ cm

$2\Delta X + \Delta Y = 0.2 + 0.2 = 0.4$ cm

$2X + Y = (20 \pm 0.4)$ cm

c. $r_1 = \frac{\Delta X}{X_o} = \frac{0.1}{5} = 0.02$

$r_2 = \frac{\Delta y}{y_o} = \frac{0.2}{10} = 0.02$

$r = r_1 + r_2 = 0.02 + 0.02 = 0.04$

$r = \frac{\Delta(xy)}{x_o y_o} \rightarrow \Delta(xy) = r\, x_o y_o = 0.04 \times 5 \times 10 = 2$

$x_o y_o = 5 \times 10 = 50$

$xy = (50 \pm 2)\text{cm}^2$

d. $r_1 = \frac{\Delta x}{x_o} = \frac{0.1}{5} = 0.02$

$r_2 = \frac{\Delta y^2}{y_o^2} = \frac{(0.2)^2}{10^2} = \frac{0.4}{100} = 4 \times 10^{-4}$

$r = r_1 + r_2 = 0.02 + 4 \times 10^{-4} = 0.0204$

$r = \frac{\Delta(xy^2)}{x_o y^2}$

$\Delta(xy^2) = r\, X_0\, y_{o^2} = 0.0204 \text{ x } 5 \text{ x } 10^2 = 10.2$

$x_o y_{o^2} = 5 \times 10^2 = 500$

$xY^2 = (500 \pm 10.2)\text{cm}^3$

(2) Find the relative error in estimating the volume of a cube of side length 5 cm if the relative error in measuring length in 0.01 . Also , find the absolute error in this case .

$r_1 = r_2 = r_3 = 0.01$

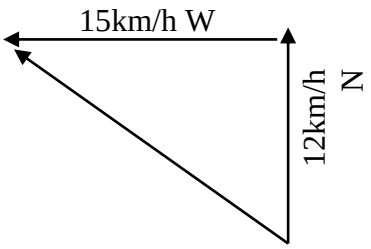
$r = r_1 + r_2 + r_3 = 0.01 + 0.01 + 0.01 = 0.03$

$V_o = X_o Y_o Z_o = 5 \times 5 \times 5 = 125\ cm^3$

$r = \frac{\Delta V}{V_o},\ \Delta V = \text{r}\ v_0$

$\Delta V = 0.03 \times 125 = 3.75\ cm^3$

(3) A ship sails north at velocity 12 km/h. due to tides, it is deviated to west at velocity 15 km/h. Find the magnitude and direction of the resultant velocity of the ship.



$v^2 = v_1^2 + v_2^2$

$V^2 = 12^2 + 15^2$

$V^2 = 144 + 225 = 369$

V = 19.2 km/h (north-west direction)

(4) In the opposite diagram, a person has moved from point (A) to point (E) passing by the points (B) , (C) & (n). find his displacement and the distance he moved.

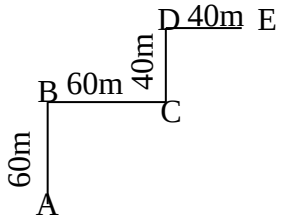
$\text{d} = \overrightarrow{\text{AE}} = \overrightarrow{\text{AC}} + \overrightarrow{\text{CE}}$

$\overrightarrow{\text{AC}} = \sqrt{(60)^2 + (60)^2} = 84.9\ \text{m}$

$\overrightarrow{\text{CE}} = \sqrt{(40)^2 + (40)^2} = 56.6\ \text{m}$

$\text{d} = 84.9 + 56.6 = 141.5\ \text{m}$

$\text{s} = 60 + 60 + 40 + 40 = 200\ \text{m}$



(5) Two perpendicular forces F_x and F_y act on an object where $F_x = F_y = 80N$. Find :

a. the resultant of the two forces F_1 and F_2.

b. the angle between their resultant x-axis .

c. Do object move or remain stationary ?

a . $F = F_x^2 + F_y^2 = \sqrt{80^2 + 80^2} = 113.13N$

b . $Tan\theta = \frac{F_Y}{F_X} = \frac{80}{80} = 1 = 45^o$

c . the object moves .

(6) $\vec{A}$ and $\vec{B}$ are two vectors having an angle 120^0 between them where the magnitude of ($\vec{A}$) = 3 units and the magnitude of ($\vec{B}$) = 4 units. Find: their dot product and their cross product.

$\vec{A} . \vec{B}$ = AB cosθ

= 3 x 4 x cos 120

= - 6

$\vec{A} \wedge \vec{B}$ = AB sinθ $\vec{n}$

= 3 x 4 x sin120

= $6\sqrt{3}$

Motion in a straight line

A. What is meant by each of the following:

1. Motion

   The change of the position of an object with respect to a fixed point as time passes.

2. Acceleration

   The change of the object velocity by unit time.

3. Uniform velocity

   The object velocity when it is displaced through equal displacements in equal times.

4. Non-uniform velocity

   The object velocity when it is displaced through unequal displacements in equal times.

Compare between:

Transitional motion and periodic motion.

Point of comparison	Transitional motion	Periodic motion
Definition	The motion which is characterized by having starting and ending point.	The motion that repeats itself over equal intervals of time.
Example	Motion in straight line	Vibrational motion

Speed and velocity.

Point of comparison	Speed	Velocity
Definition	The distance moved by the object per unit time.	The displacement of the object per unit time.
Type	Scalar	Vector
Sign	+ ve	+ve in one direction & -ve in the opposite direction.

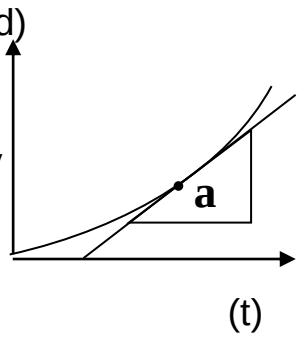
Instantaneous velocity , average velocity and average speed.

Point of comparison	Instantaneous velocity	Average velocity
Definition	The velocity of the object at a given instant.	The total displacement divided by the total time of motion.
Determination graphically.	By the slope of the tangent drawn to the velocity curve at that instant.	By the slope of the straight line joining the starting and the ending point.

Define the type of motion in each graph and the quantity that the slope represents:

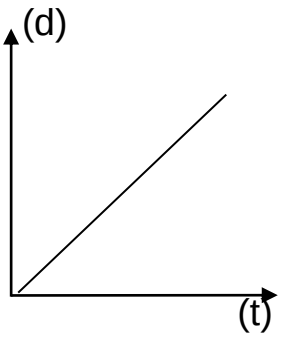
Non-uniform velocity

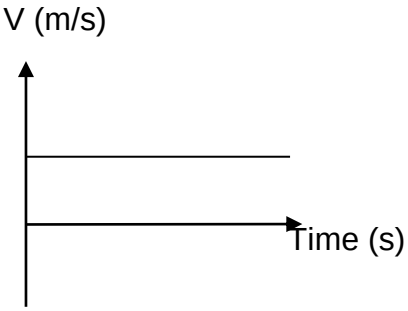
Slope = instant. V



uniform velocity

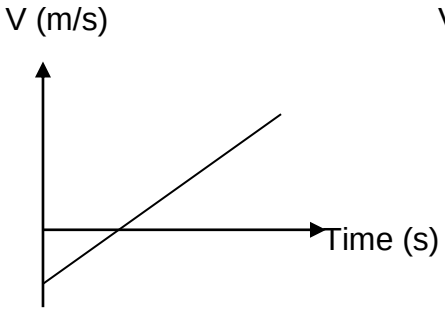
slope = $\frac{\Delta d}{\Delta t}$ = v





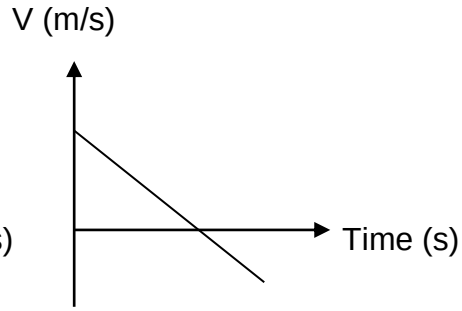
uniform velocity (zero acc.)

slope = $\frac{\Delta v}{\Delta t}$ = zero



Uniform +ve acc

slope = $\frac{\Delta v}{\Delta t}$ = +acc.



uniform –ve acc.

slope = $\frac{\Delta v}{\Delta t}$ = - acc

solved problems:

1. **A car covered 600 m in a 60 sec , find its average velocity.**

   Solution

   $\overline{V} = \frac{d}{t} = \frac{600}{60}$ = 10 m/sec

2. **When the velocity of a body changes by 10 m/sec during interval of time equals 5 sec, calculate the acceleration of the moving body.**

   Solution:

   A = $\frac{\Delta v}{\Delta t} = \frac{10}{5}$ = 2 m /sec^2

Motion at uniform acceleration

A. Derive the second equation of motion in straight line at uniform acceleration (displacement – $d = v_i + \frac{1}{2} a t^2$

Acceleration is given by $a = \frac{v_f - v_i}{t} \Longrightarrow v_f = v_i + at \longrightarrow (1)$

The average velocity of a moving object $\overline{V} = \frac{d}{t}$

The object move with a uniform acceleration so $\overline{V} = \frac{v_f - v_i}{2}$

$\frac{d}{t} = \frac{v_f - v_i}{2} \Longrightarrow$ **substituting** v_f **from equation 1,**

$\frac{d}{t} = \frac{2v_i + at}{2} = v_i + \frac{1}{2} a t \Longrightarrow \boxed{d = v_i + \frac{1}{2} a}$

B. Derive the second equation of motion in straight line at uniform acceleration (displacement velocity) 2ad = $v_f^2 - v_i^2$

The average velocity of a moving object $\overline{V} = \frac{d}{t} \Longrightarrow d = \overline{v}\ t$

The object move with a uniform acceleration so $\overline{V} = \frac{v_f - v_i}{2}$

From equation 1 , $t = \frac{v_f - v_i}{a}$

So, $d = \frac{v_f - v_i}{2} \times \frac{v_f - v_i}{a} = \frac{v_f^2 - v_i^2}{2a} \Longrightarrow$ $\boxed{2ad = v_f^2 - v_i^2}$

C. Derive the second equation of motion at in straight line at uniform acceleration graphically.

d = v x t so, it is equal to the numeral value of the area under the curve in velocity-time graph.

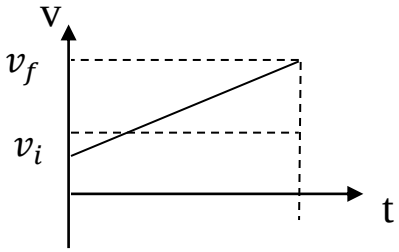
for motion with initial and final velocities the graph will be as follows:

the area of the rectangle = $v_i\ t$

the area of the triangle = $\frac{1}{2}$ **(** v_f **-** v_i **) t**

where $a = \frac{v_f - v_i}{t} \Longrightarrow$ $v_f - v_i = at$

so, the area of the triangle = $\frac{1}{2}$ **a** t^2



d = sum. of the triangle and rectangle area = $v_i + \frac{1}{2}$ a t^2

Solved problems:

1- A race car starting from rest accelerates uniformly at a rate of 4.9 m/ sec^2, what is the car velocity after it has traveled 200 meters.

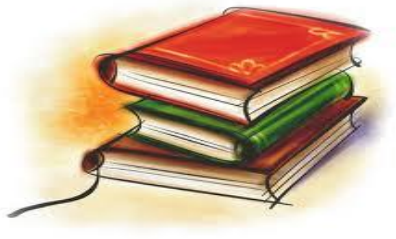
Solution:

We will use the third equation **2ad =** $v_f^2 - v_i^2$

2x4.9x200 = v_f^2 - 0

$v_f = \sqrt{1960}$ = 44.27 m/sec

v_i	0
a	4.9 m/sec^2
d	200 m
v_f	?
t	x



2- A car travelling on a straight road at 15 m/sec accelerates uniformly to a velocity of 21 m/sec in 12 seconds find the displacement traveled by the car in this time interval.

v_i	15 m/sec
a	
d	?
v_f	21 m/sec
t	12 sec

Solution:

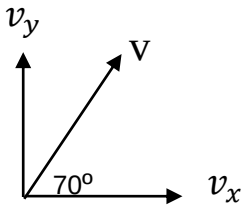
$$v_f = v_i + at$$

21 = 15 + a (12) $\Longrightarrow$ a = 0.5 m/sec^2

$$d = v_i + \frac{1}{2} a t^2$$

$$d = 15 + \frac{0.5(12)^2}{2} = 51 \text{ m}$$

3- Suppose a rock is thrown upward at a speed of 20 m/s, at an angle of 70 degrees above the horizontal, find the time of the rock's flight and the maximum height it reaches.



$v_{iy} = v \sin 70 = 20 \times 0.93 = 18.8$ m/sec

$v_{ix} = v \cos 70 = 20 \times 0.34 = 6.84$ m/sec

$$t = \frac{-v_{iy}}{g} = \frac{-18.8}{-9.8} = 1.9 \text{ sec}$$

Flight time T = 2t = 3.83 sec

Maximum height $h = \frac{-v_{iy}^2}{2g} = \frac{-(18.8)^2}{2(-9.8)} = 18$ m

4- What is the acceleration of an object thrown straight up in the air, near the surface of the earth, at the very top of its fight?

Answer : The acceleration is downwards at 9. 8 m/s2 . The only force acting on the object at the top of its fight is the gravitational force^ so the object is in free fall. The object is changing velocity as it passes through zero velocity.

Force and motion:

A. What is meant by:

1. **Force**

The external influence that affects the object to change its state or direction of motion.

2. **Inertia**

The tendency of an object to keep either its state of rest or its state of motion at its original velocity uniformly in a straight line.

3. **Weight**

The force of gravity acting on the body.

B. State Newton's first law of motion and mention its mathematical formula

Static object keeps its state of rest, and a moving object keeps its state of motion at uniform velocity in a straight line unless acted upon by a resultant force. $\sum F = 0$

Indicate whether each of the following statements is true or false. Briefly justify your answers.

A) If an object is moving there must be anon-zero net force acting on the object.

False. If the object has constant velocity the net force could be zero.

B) An object has the same mass when on earth and when on the moon.

True. Mass is an intrinsic property.

C) An object has the same weight when on earth and when on the moon.

False. The weight is the measure of the gravitational pull on the object. This pull is less on the moon than on the earth.

C. Give reasons for each of the following:

1. **Weight differs according to the planet where the object exists**
   Because weight is the force of gravity acting on the body.
2. **A motorcycle rider flies off the motorcycle when it suddenly stops.**
   Due to inertia his body tends to keep his state of motion with a uniform velocity in a straight line.
3. **Your body moves backward when the car starts to move suddenly.**
   Due to inertia our body tries to keep its stat of rest.

problems

1. **A tennis ball, 0.314 kg, is accelerated at a rate of 164 m/s2 when hit by a professional tennis player. What force does the player's tennis racket exert on the ball?**

Solution:

F = ma

F = 0.314 x 164 = 51.5 N

2. **A crate is dragged across an ice covered lake. The box accelerates at 0.08 m/s2 and is pulled by a 47 N force. What is the mass of the box?**

Solution:

F = ma

$m = \frac{F}{a} = \frac{47}{0.08} = 587.5$ kg