PHYSICS ⇒ As-Level

Physical Quatities

⇒ Def:- Anything that can be measured and is represented in terms of magnitude along with a unit is called physical quantity.

- Italics represent symbol for physical Qty.
- physical Qty has a measuring device

⇒ Exp:

physical Qty	Symbol (Italic)	measuring device	S.I unit
1-) Mass	m, M	Top pan balance	kilogram (kg)
~~2) Time~~		~~sp stopwatch~~	
2-) Time	t, T	stopwatch	second (s)
3-) Force	F	Newton meter / spring balance	Newton (N)
4-) Emf	E	Voltmeter	Volt (V)
5-) Power	P	Watt meter	Watt ($W = Js^{-1}$)

→ Types of physical Qty

1-) Base Qty:-

Physical qualities which are not derived from other quantities and are considered as basic building blocks of physics. ~~They are 7 in numbers.~~
→ They are 7 in numbers

Base Qty	Symbol (Italics)	measuring device	Base unit (units for base Qty)
1-) Length	x, l, s, d	metre ~~meter~~ rule	metre (m)
2-) Mass	m, M	Top pan balance	kilogram (kg)
3-) Time	t, T (T → represents time period)	stopwatch	second (s)
4-) Temperature	θ, T	thermometer	Kelvin (K)
5-) Current	I	Ammeter	Ampere (A)
6-) Amount of a substance	N	—	mole (mol)
7-) ✗ luminous intensity (Not in syllabus)	I	—	Candella (cd)

2) **Derived Qty**:- Physical Qty which are the product, quotient or union of product and quotient of base Qty are called derived Qty.

⇒ **Product** → **example**:-

(i) Area = length × width
(ii) charge = current × time ($Q = It$)

⇒ **Quotient** → **example**:-

i) Speed = $\frac{\text{distance}}{\text{time}}$ ($v = \frac{s}{t}$)

⇒ **union of product and quotient** → **e.g.**:-

i) momentum $= p = mv = \frac{ms}{t}$

ii) Acceleration $= a = \frac{\Delta v}{\Delta t} = \frac{\frac{\Delta s}{\Delta t}}{\Delta t} = \frac{\Delta s}{\Delta t^2}$

iii) Force $= F = ma = \frac{m \Delta s}{\Delta t^2}$

★ when 2 vectors multiplied and angle b/w them = 0° or 180° then → Scalar

★ When angle is 90° or 270° → vector

⇒ Classification of physical Qty

i) Scalar :-

→ Magnitude + unit

→ eg :- length, mass, time, volume, density, speed, work, energy, power, pressure, p.d (voltage), ~~etc electrical~~ electrical resistance, etc

ii) Vector :-

→ (Magnitude + unit) + direction

→ e.g. :- displacement, velocity, acceleration, momentum, Impulse, Force, Electric/Gravitational/magnetic field strength, current, upthrust, etc

⇒ Significance of SI units

i) To identify a physical Qty :-

V – voltage } 220V 8A → e.g.
A – current }
kg – mass } 80 kg → e.g.

ii) To check the homogenity of an equation

★ term → identified by equality, sign, + ~~or~~ or − sign

★ homogenous equations: All ~~quantities~~ terms have same units e.g.:

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

(m) = (ms^{-1})(s) + (ms^{-2})(s^2)

Notes:
An equation is said to be homogenous if all the terms used in it have the same unit.

Q) Velocity of water wave is represented in terms of ~~wavelenth~~ wavelength and acceleration due to gravity. Which option is correct???

i) $V = \sqrt{\frac{g}{\lambda}} \Rightarrow \sqrt{\frac{ms^{-2}}{m}} = s^{-1}$ ✗

ii) $V = \lambda^2 g \Rightarrow m^2(ms^{-1}) = m^3 s^{-1}$ ✗

iii) $V = \sqrt{g\lambda} \Rightarrow \sqrt{(ms^{-2})(m} = \sqrt{(ms^{-1})^2} = ms^{-1}$ ✓

iv) $V = \frac{g^2}{\lambda}$

★ check units given in these options → the option in which units are equal to V i.e. ms^{-1} is the Ans.

★ left hand side must be equal to right hand side → units.

★ units must be equal of both left and right hand side

Q) The relative force ~~velocity~~ ~~of a cricket ball~~ acting on a cricket ball due to air is

$$F = 6\pi\eta r V$$

when,

η – Viscosity of air
r – radius of ball
v – Terminal velocity

Show ~~that~~ η in terms of base unit of above ~~eq~~ eq is homogeneous

$$\eta = \frac{ma}{6\pi r V}$$ ⇒ make η subject

$$= \frac{(kg)(ms^{-2})}{(m)(ms^{-1})}$$

$$= kg\, m^{-1} s^{-1}$$

⇒ multiple and sub-multiples of 10 (Prefix)

Prefix	Notation	Value
Deci	d	10^{-1}
Centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}
Kilo	k	10^{3}
Mega	M	10^{6}
Giga	G	10^{9}
Tera		

(Jun 2001)

Q) Show that
Pressure = (density)(speed)^2 is a homogeneous equation

~~$\frac{N}{m^2} = \frac{kg}{m^3} \times \frac{m^2}{s^2}$~~

P → L.H.S:- $P = \frac{F}{A} = \frac{ma}{A} = \frac{(kg)(ms^{-2})}{m^2} = kg\,m^{-1}s^{-2}$

→ R.H.S:- $\rho v^2 = \left(\frac{m}{V}\right)\left(\frac{s}{t}\right)^2 = \left(\frac{kg}{m^3}\right)\left(\frac{m^2}{s^2}\right) = kg\,m^{-1}s^{-2}$

Q) Intensity = $\dfrac{\frac{\text{Energy}}{\text{time}}}{\text{Area}}$, Express intensity in terms of base ~~unit~~ units.

* energy is ability to do work → (F)(d) → or s
* every form of energy has formula ⇒ (F)(d)

$I = \frac{E}{tA} = \frac{(F)(s)}{tA} = \frac{(ma)(s)}{tA}$

$= \frac{(kg\,m\,s^{-2})(m)}{(s)(m^2)}$

$= kg\,s^{-3}$

(Jun/Nov 2008)

Q) define frequency ???

Ans) Number of complete oscillations generated by a source per unit time

⇒ formula:- $f = \frac{n}{t}$

For 1 oscillation, $n = 1$, $t = T$ → time period

Q) $\frac{1\ \mu m}{1\ Gm} = \frac{1(10^{-6})}{1(10^{9})} = 10^{-6-9} = 10^{-15}$ → no units, since ratio

Q) Which option is ~~one~~ correct ???

× m = gradient
i) Gradient of displacement-time graph defines acceleration
× ii) Gradient of extension against force graph defines 'K'
× iii) 'm' of energy ~~agent~~ against time graph defines Watt → watt is a unit, so wrong
✓ iv) 'm' of displacement against time graph defines velocity.

Ans = d / iv

* graph is always → y-axis against x-axis or y - x axis

i) m of displacement time graph doesn't define a
ii) m of ~~extens~~ extension against force graph defines $\frac{1}{K}$ and not K
iii) It should have been power instead of the word Watt, since watt is a unit, whereas energy and time are physical Qty and not their units, so wrong

Imp!!! ★ eV (electron volt) is a unit for energy
↳ $W = VQ$
$1.60 \times 10^{-19}\ J = (1V)(1e)$

Q) Define volt in terms of base units???

Ans) $V = \frac{W}{Q}$

$= \frac{(F)(s)}{(I)(t)} = \frac{(ma)(s)}{(I)(t)} = \frac{(kg)(m s^{-2})(m)}{(A)(s)}$

$= kg\ m^2\ A^{-1}\ s^{-3}$

Measurements & Errors

→ taken directly from measuring device

⇒ **Reading:-**
Single determination taken directly from a measuring device is called reading i.e. time for 'n' oscillations, volume of a liquid in a cylinder, speedometer value, voltmeter / Ammeter / pressure guage, etc

⇒ ~~Me~~

⇒ **Measurement:-**
It is the final answer ~~obtan~~ obtained by applying the arithmatic operations on a no. of readings e.g. time period $\left(T = \frac{t}{n}\right)$, volume of a solid ~~stone~~ by displacement method, determination of Resistance $\left(R = \frac{V}{I}\right)$, etc

★ arithmetic operations → $+, -, \times, \div$

⇒ **Errors:-**
Source which deviate the measured ~~resutt~~ result from its true value.

⇒ **Sources:-**

a) Systematic error
b) Random error
c) Absolute error
d) Mathematical error
   ↳ i) Fractional error → %age error
   ↳ ii) Arithmatic error → $+, -, \times, \div$
   ↳ iii)

a) Systematic Errors:-

⇒ Error with constant sign and magnitude in repeated readings is called systematic error.
↳ def / characteristic • error remains constant e.g. zero error for a vernier caliper will be same/constant and same value will be added/subtracted from the reading.

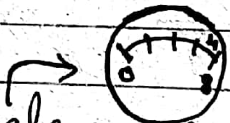
⇒ Sources:-

i) Instrument:-

1.) Zero error (V.C, M.S.G, Analogue device such as stopwatch)
2.) change in the physical condition of the apparatus
↳ change is before the exp and not during it → not reffering to change during exp
3.) A watch which runs fast / slow

ii) Observer:-

1.) Reading wrong meniscus / scale



voltmeter → reading wrong scale

2.) Colour blindness (Titration exp, dispersion of white light)
3.) Reaction time (0.2s to 0.4s) → varies from person to person, but remains same/constant for a particular person e.g. reaction time of person A will be same
4.) Weak persistance of vision / hearing
→ time period / interval is constant
→ same/constant for a particular person

iii) apply assumptions:

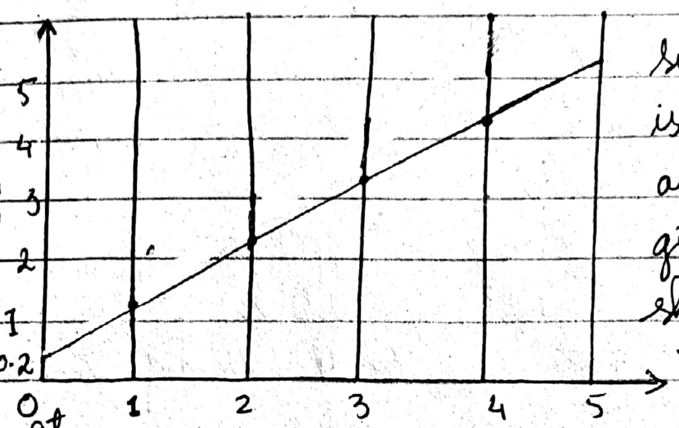
e.g. a person can't detect pink colour, so this colour ~~blidr~~ blindness will remain same for the rest of his life

1.) $g = 10\ ms^{-2}$ ✗
$g = 9.81\ ms^{-2}$ ✓

⇒ Methods to remove / or eliminate systematic error

1-) Apply zero correction technique to remove zero error.

→ when reading is not according to the graduation, then zero error

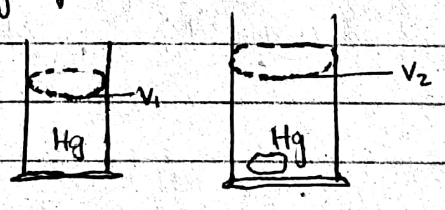


At 0 graduation, it's giving reading of 0.2

★ when instrument such as digital M.S. is not measuring anything, but still giving a reading, as shown in graph → zero error

→ Intercept of reading ~~apart~~ against graduation defines zero error i.e systematic error

2-) Subtract two values with systematic errors to get gradient of graph



$V = V_2 - V_1$ (no systematic error) ← no error

systematic error, since lower meniscus recorded in both, but no error when the two are subtracted

3) Avoid assumptions

~~★ whenever instrument with error~~

★ systematic error can be completely eliminated, except for reaction time error, colour ~~blind~~ blindness, etc.

★ background radiations → random error

b) **Random Error:-**

⇒ Def / Characteristic :-

Error with varying sign and magnitude in repeated readings is called random error.

⇒ **Sources:-**

i) Parallax error

- error in parallel axis
- when plane of observer and plane of measuring device is not parallel
- line of sight is not ⊥ to measuring device

ii) Use of micrometer to measure diameter without using a ratchet → prevents undue pressure to be exerted on object → if not used, error

★ e.g. to be asked from sir

iii) Fluctuation in the least significant digit of digital measuring devices. e.g. [ ] → fluctuations in the unit digit

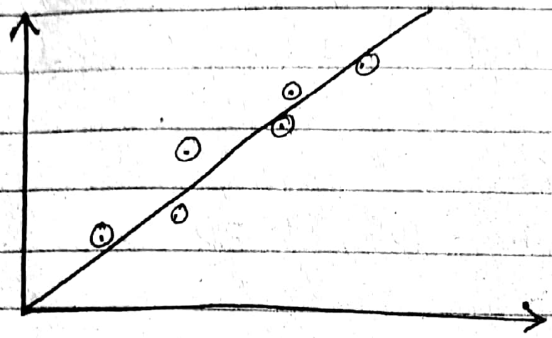
iv) Change in physical conditions (environmental conditions) during exp

v) Background radiations in the nuclear physics experiments

⇒ Methods to reduce random error → word removed can't be used, since can't be removed completely.

→ can't be eliminated completely except for parallax error, but can be reduced

1.) Take greater no. of readings and get their average
2.) Plot the line of best fit

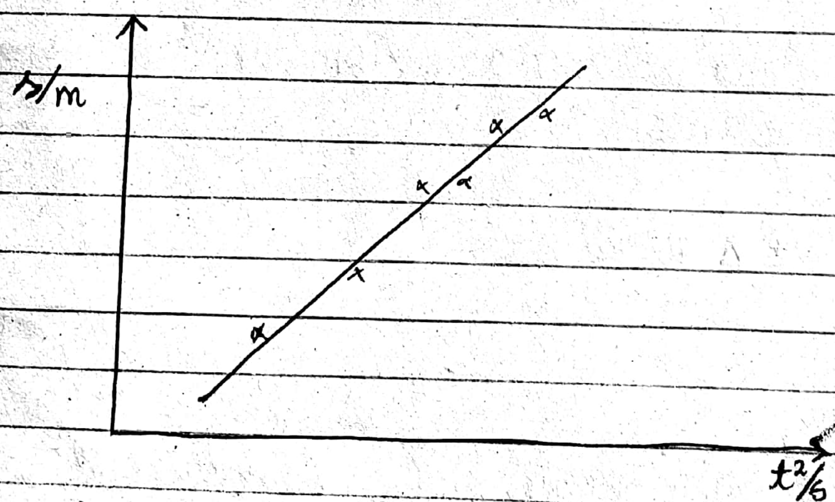


→ scattering of points about the lines shows random error

3.) Avoid parallax

→ keep line of sight ⊥ to measuring device

Q)



i) use above figure to specify
a) Random error.
b) systematic error
ii) which quantity can be calculated ~~by~~ if you get the gradient of graph

1a) → Scattering of points about the line of best fit

b) → Graph does not pass through origin (x-intercept) → when x or y-intercept then systematic (zero) error. → no intercept when graph passing through origin

★

ii) → $S = ut + \frac{1}{2}at^2$

If object starts from rest, $u = 0$

$S = 0 + \frac{1}{2}at^2$

$a = 2\left(\frac{S}{t^2}\right)$

a = 2(gradient of graph)

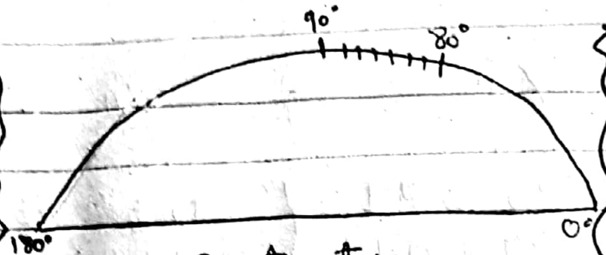
c) **Absolute error :-** ⇒ def:-

It is the smallest graduation on a measuring device

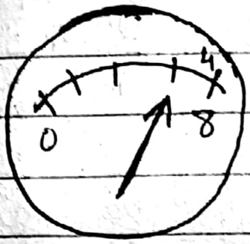
⇒ Notation :- ± Δ error

⇒ Example :-

S.No	Measuring device	Absolute error
1-)	micrometer screw guage	0.01 mm
2-)	Vernier callipers	0.01 cm, 0.1mm
3-)	meter rule	1 mm, 0.1 cm, 0.001 m

4) 

Protractor — 1°

5) 

2 V

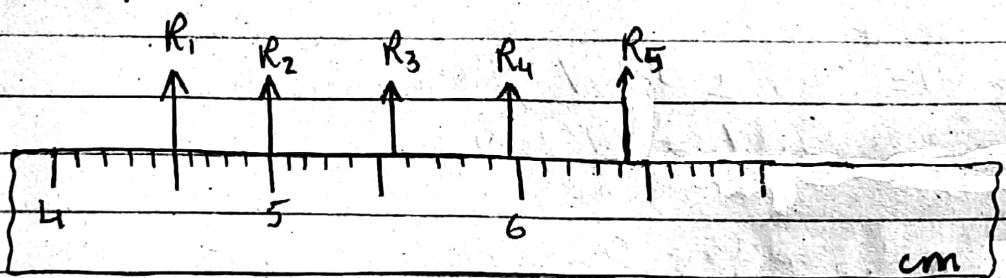
6-) Stopwatch — Human reaction time error 0.2s to 0.4s

Note:-
Absolute error must be true in 1 s.f
→ must be in 1 s.f

⇒ **Representation of a value along with absolute error**

→ Notation:- Physical Qty = value ± absolute error

→ Example



	l/mm	l/cm	l/m
R_1	45 ± 1	4.5 ± 0.1	0.045 ± 0.001
R_2	50 ± 1	5.0 ± 0.1	0.050 ± 0.001
R_3	56 ± 1	5.6 ± 0.1	0.056 ± 0.001
R_4	60 ± 1	6.0 ± 0.1	0.060 ± 0.001
R_5	64 ± 1	6.4 ± 0.1	0.064 ± 0.001

★ this error can't be reduced nor eliminated, since it is the smallest graduation which an instrument can measure.

d) Mathematical errors

1) Fractional error

⇒ Formula :- Fractional error = $\frac{\text{Absolute error}}{\text{Value}}$

Example :- If $L = 5.6 \pm 0.1$
then fractional error in $L = \frac{\Delta L}{L} = \frac{0.1}{5.6}$

$= 0.018$

2) Percentage error

⇒ formula :- %age error = $\frac{\text{Absolute error}}{\text{Value}} \times 100$

e.g :-
If $V = 2.46 \pm 0.2\ V$ then
%age error in $V = \frac{\Delta V}{V} \times 100$

$= \frac{0.2}{24.6} \times 100$

$= 0.81\ \%$

3) Arithmatic errors

i) Addition

⇒ formula :- Addition = (sum of values) ± (sum of absolute errors)

e.g :-
If $L_1 = 24.6 \pm 0.2$ cm, $L_2 = 10.8 \pm 0.1$ cm } not measured from same measuring device, since smallest graduations are different

$L = L_1 + L_2$
$= (24.6 + 10.8) \pm (0.2 + 0.1)$
$= 35.4 \pm 0.3$ cm

ii) ~~Subt~~ Subtraction :-

⇒ formula :- (difference of values) ± (sum of absolute errors)

e.g:- same as above

$L = L_1 - L_2$
$= (24.6 - 10.8) \pm (0.2 + 0.1)$
$= 13.8 \pm 0.3$ cm

iii) Product

⇒ formula :- Product = (product of values) ± (sum of fractional errors)(product of values)

e.g:- If $V = 10.2 \pm 0.1\ V$
$I = 3.2 \pm 0.2\ A$

$P = VI$

$$P = (V)(I) \pm \left[\frac{\Delta V}{V} + \frac{\Delta I}{I}\right]\left[VI\right]$$

$$= (10.2)(3.2) \pm \left[\frac{0.1}{10.2} + \frac{0.2}{3.2}\right]\left[(10.2)(3.2)\right]$$

$= 32.6 \pm 2.36$ ★ 1st convert absolute error in 1 s.f if since absolute error must be in 1 s.f not in 1 s.f

$P = 32.6 \pm 2$ ★ then compare (decimal places) of error and value, since there is no d.p in absolute error and round off value so the value should have no d.p accordingly

$P = 32 \pm 2W$

★ 1st check s.f figures of absolute error (must be in 1 s.f). If Then compare it with the value: If no d.p in error, then no d.p in value (like in above e.g.) and if 1 d.p in error then 1 d.p in value and so on.

iv) Quotient

⇒ Formula:

$$\text{Division} = \left(\text{Ratio of values}\right) \pm \left(\text{sum of fractional errors}\right)\left(\text{Ratio of values}\right)$$

eg: Same as above

$R = V/I$

$$R = \frac{V}{I} \pm \left[\frac{\Delta V}{V} + \frac{\Delta I}{I}\right]\left[\frac{V}{I}\right]$$

$$= \frac{10.2}{3.2} \pm \left[\frac{0.1}{10.2} + \frac{0.2}{3.2}\right]\left[\frac{10.2}{3.2}\right]$$

$= 3.19 \pm 0.23$

~~Sin~~ since absolute error must be in 1 s.f

$R = 3.2 \pm 0.2\ \Omega$

★ n... d.p

4-) Power rule errors

i) If $V = L^3$

fractional error in $V = \frac{\Delta V}{V} = 3\left(\frac{\Delta L}{L}\right)$

e.g:-

Length of cube $= L = 2.4 \pm 0.1$ cm

Calculate :

(I) Fractional error in volume

$$V = L^3$$

$$\frac{\Delta V}{V} = 3\left(\frac{\Delta L}{L}\right)$$

$$= 3\left(\frac{0.1}{2.4}\right)$$

$$= 0.125$$

(II) Volume along with its uncertainity

$$V = L^3 \pm 3\left(\frac{\Delta L}{L}\right) L^3$$

$$= (2.4)^3 \pm 3\left(\frac{0.1}{2.4}\right)(2.4)^3$$

$$= 13.8 \pm 1.7$$

$= 13.8 \pm 2$ → since absolute error in 1 s.f

$= 14 \pm 2$ → since no d.p in error

ii) If $y = a^m b^n$ then

fractional error in $y = \frac{\Delta y}{y} = m\left(\frac{\Delta a}{a}\right) + n\left(\frac{\Delta b}{b}\right)$

e.g: If $I = 1.4 \pm 0.2\,A$
$R = 0.6 \pm 0.1\,\Omega$
the power along with its uncertainity be
$P = I^2 R$

$$P = I^2R \pm \left[2\frac{\Delta I}{I} + \frac{\Delta R}{R}\right]\left[I^2R\right]$$

$$= (1.4)^2(0.6) \pm \left[2\left(\frac{0.2}{1.4}\right) + \left(\frac{0.1}{0.6}\right)\right]\left[(1.4)^2(0.6)\right]$$

$= 1.176 \pm 0.532$

$= 1.176 \pm 0.5$

$= 1.2 \pm 0.5$

Estimation & Approximation

i) Density of air at r.t.p = 0.5 to 1.5 $kg\,m^{-3}$

ii) Mass of an athlete = 60 to 80 kg

iii) Mass of an adult person = 70 to 90 kg

iv) Speed of sound at 0°C (in air) = 330 to 340 ms^{-1} (340 → at 15°C)

v) frequency and wavelength of e.m ~~waves~~ radiations

	G	X	U	V	I	M	R
f/Hz	10^{20}	10^{18}	10^{16}	10^{14}	10^{12}	10^{10}	10^{8}
λ/m	10^{-12}	10^{-10}	10^{-8}	10^{-6}	10^{-4}	10^{-2}	$10^{0} = 1$

f/Hz ⇒ dec by power 2
λ/m ⇒ inc by power 2

vi) time taken by an athlete to travel a 100m race ≈ 10 s

vii) Diameter of a nucleus = 10^{-14} or 10^{-15} m

viii) diameter of an atom = 10^{-10} m

ix) mass of an ~~atom~~ alpha particle
= $4(1.66 \times 10^{-27})$ = ______ kg
↓
mass of ...

x) wavelength of visible light

	V	I	B	G	Y	O	R
λ/nm	400	450	500	550	600	650	700

⇒ difference is of 50

★ all above points are to be remembered

Precision

⇒ **Def:-**
It is the degree of refinement ~~ore~~ or exactness of a measurement.

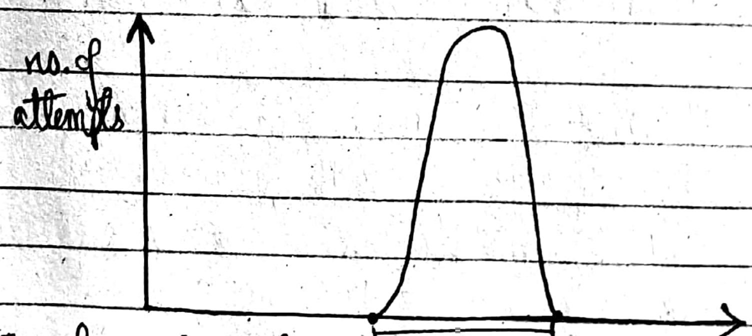
⇒ **Note:-**

(i) Precision is determined by the absolute error of instrument i.e. higher is precision if uncertainity of instrument is small.

	Vernier Caliper	Micrometer S. G
1-) Absolute error	0.01 cm	0.01 mm
2-) Precision order	smaller	larger

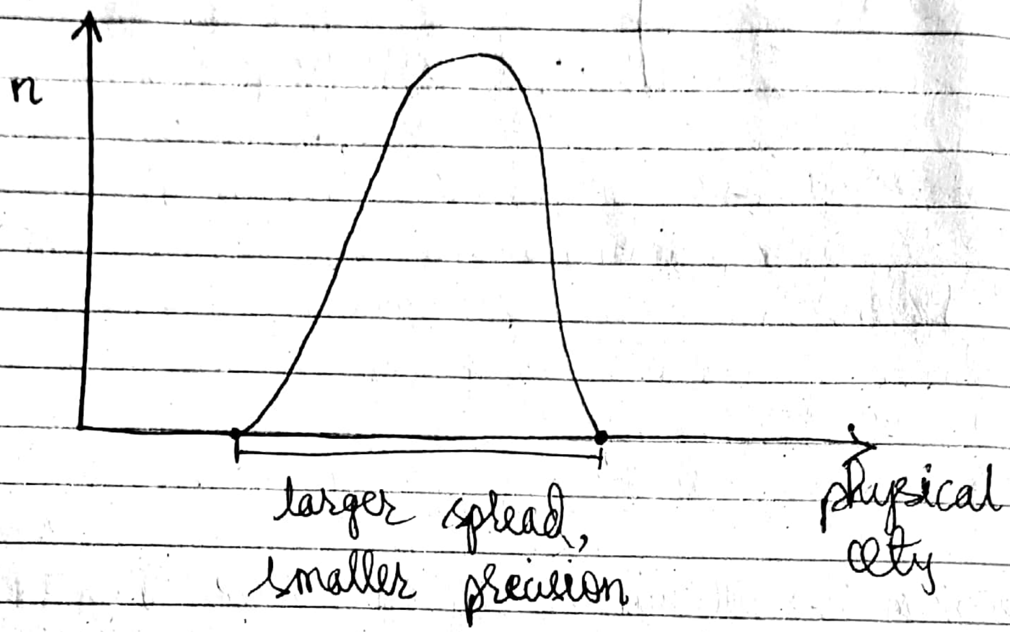
ii) A small spread in the measurement increases the precision

* spread is the range of values i.e. max value − min value



spread represents random error, and hence when spread ...

smaller spread, ← larger precision



iii) The readings are said to be precise if their mean deviation is small.
* we don't consider any sign in deviation

Student A

(value should be +ive)

g/ms^2	deviation
9.81	10.19 − 9.81 = 0.38
9.84	10.19 − 9.84 = 0.35
10.6	10.6 − 10.19 = 0.41
11.4	11.4 − 10.19 = 0.21
9.30	10.19 − 9.30 = 0.89

$$mean = \langle g \rangle \Rightarrow \frac{9.81 + 9.84 + 10.6 + 11.4 + 9.30}{5}$$

$= 10.19\ ms^{-2}$

mean deviation ⇒ take mean of results of deviation

$= 0.648\ ms^{-2}$

Student B

g/ms^2	deviation
9.81	10.65 − 9.81 = 0.84
11.8	11.8 − 10.65 = 1.15
14.6	14.6 − 10.65 = 3.95
7.82	10.65 − 7.82 = 2.83
9.21	10.65 − 9.21 = 1.44

$$mean = \langle g \rangle \Rightarrow \frac{9.81 + 11.8 + 14.6 + 7.82 + 9.21}{5}$$

$= 10.65\ ms^{-2}$

mean deviation ⇒ take mean of results of deviation

$= 2.04\ ms^{-2}$

→ Increase in the no. of significant figures also increases the precision.

⇒ Result :- (↓) mean deviation means ~~average value is close to~~ spread of readings (↓), hence (↓) random errors.

(Mean deviation of student A) < (mean deviation of student B)

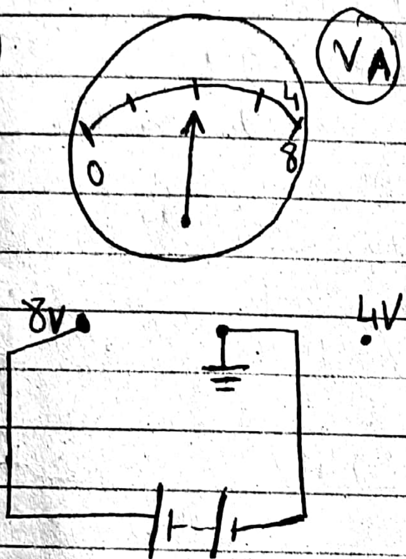
Mean deviation: deviation of readings from the actual value (i.e. scattering of points around the line of best fit)

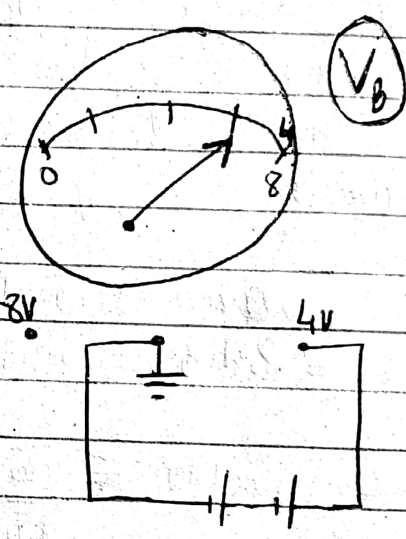
So, student A readings are more precise than student B.

iv) Use of magnifying glass ~~in~~ improves [(↑)] the precision of a reading

(v) (vi) Random error loses [(↓)] the precision

Q)





Absolute error = ± 2V

Absolute error = ±1V

So, V_B is more precise than V_A

Q) $h_1 = 0.214 \pm 0.001\,m$

$h_2 = 0.046 \pm 0.002\,m$

Which length is more precise???

Ans) h_1, since absolute error is less (↓) in h_1 than in h_2, hence h_1 is more precise.

⇒ Accuracy

⇒ Def:-
The readings are said to be accurate ~~if it is close to an actual value~~ their mean value is close to the actual value.

Note:-
The accuracy of a measurement is determined by its ~~% or abs~~ %age error i.e. smaller the %age error, higher is the accuracy.

→ If h_1 is replaced with 0.46, then h_2 is more precise, since it has more s.f

e.g. $h_1 = 2.46 \pm 0.01$ cm
$h_2 = 8.43 \pm 0.01$ cm

$$\frac{\Delta h_1}{h_1} \times 100 = \frac{0.01}{2.46} \times 100 = 0.41\%$$

$$\frac{\Delta h_2}{h_2} \times 100 = \frac{0.01}{8.43} \times 100 = 0.12\%$$

h_2 is more accurate ~~to~~ than h_1 and both have same precision

ii) Systematic error loses (↓) the accuracy of the measurement.

⇒ Significant figures

1 s.f	2 s.f	3 s.f
2	2.0	20.0
0.2	0.20	2.00
0.02	0.020	0.200
0.002	0.0020	0.0200
20	20	0.00200
	22	200
	2.2	

Note:- (1.36) (2.2) = Final answer is either in 2 s.f or 1 better s.f ~~(either~~ (i.e. 2 or 3)

(1.36) → 3 s.f. ; (2.2) → 2 s.f

147.3 → 4 s.f

0.0 203

★ either give answer in least s.f, present in question or ~~one~~ 1 ~~bette~~ better. e.g. in above question least s.f is 2, so ~~ans~~ final answer must be in 2 s.f or 1 better i.e. in 3 s.f.

★ 1st test to check precision is the absolute error and the 2nd is to check the s.f.

⇒ Measurements using C.R.O

Note :-

1-) Y-plates are parallel horizontal plates and deflect the electron beam vertically.

2-) X-plates are parallel vertical plates and deflect the electron beam horizontally by means of saw-tooth wave generated by the internal circuit of C.R.O

3-) The waveform to be studied must be connected across Y-plates.

4-) Measurement of time period :-

$$T = \left(\text{no. of units to represent a wave}\right)\left(\text{X-plate sensitivity}\right)$$

5-) Calculation of frequency :-

$$f = \frac{1}{T}$$

6-) Measurement of voltage / Peak value :-

$$V = \left(\text{No. of units to represent an amplitude}\right)\left(\text{Y-plate sensitivity}\right)$$

★ the waveform or circuit to ~~to b~~ be studied is connected across y-plates

★ X-plates have their own internal circuit

7-) The scale associated with X-plates is called time base control or X-plate sensitivity and represent time in terms of no. of divisions i.e. 4ms/cm (supposed value (e.g.))

8-) The scale associated with Y-plates is called voltage gain or ~~y~~ Y-plate sensitivity and represent voltage in terms of no. of divisions i.e. 5V/cm (supposed value (e.g.))

9-)

• Time base = 2ms/cm • gain control = 4V/cm

$T = 2 \times 2$ (2 → no. of units to represent a wave; 2 → time base)

$= 4ms$

$= 4 \times 10^{-3}$ s

$f = \frac{1}{T}$

$= \frac{1}{4 \times 10^{-3}}$

$= 250$ Hz or s^{-1}

Peak voltage $= (1.5)(4)$ (1.5 → no. of units/boxes to represent a wave; 4 → gain control)

$= 6.0V$

10) The waveform is squeezed horizontally if the time base setting is increased and vertically if the gain control setting is increased

Vectors

⇒ **Def:-**
Physical Qty : (Magnitude + unit) + (direction)

⇒ **Example:-** displacement, velocity, acceleration, force, momentum, Impulse, Gravitational field strength, Electric field strength, magnetic field strength, current, moment of a force

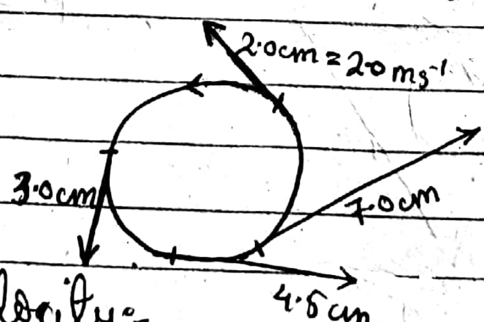
⇒ **Graphical representation of a vector**

★ vector is never represent by a curve
★ vector always represented by straight line

• **Magnitude :-**
Straight line as per scale

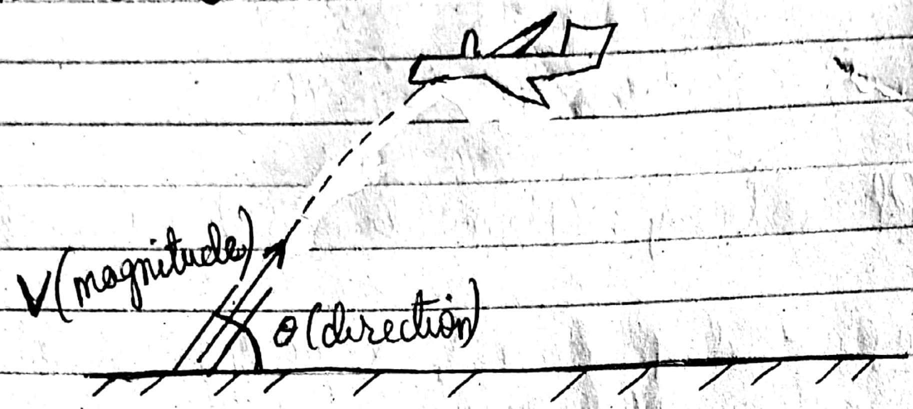
• **direction :-**
Arrow head on straight line
↓
(for accurate direction) ← angle with any refrence axis

Variable velocity:-



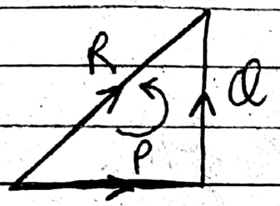
★ length of straight line represents magnitude.

* In case of vectors → magnitude and direction both are critical



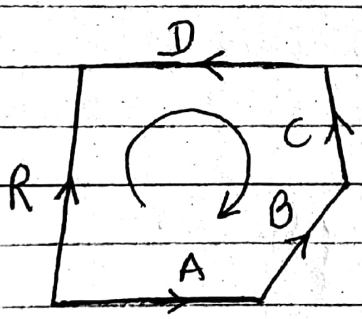
→Mathematical representation of a vector diagram

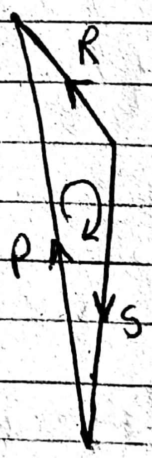
* all the vectors which are along the loop are written with a +ive sign and those against the loop are written with -ive sign



$P + Q - R = 0$

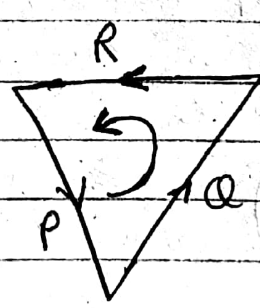
$R = P + Q$





$R - D - C - B - A = 0$

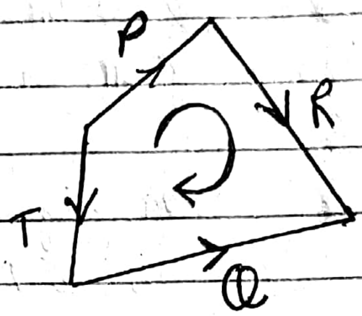
$R = D + C + B + A$



$P - R + S = 0$

$R = P + S$

Hint :-
Assume a loop in clockwise or anit-clockwise in a closed vector diagram. Put positive signs with vectors which are along the loop and negative sign which are ~~go~~ against the loop. (with vectors)



$$P + R - Q - T = 0$$
$$P + R = Q + T$$

⇒ **Angle b/w 2 vectors in a diagram**

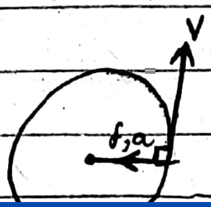
★ force and acceleration are always in the same direction, whatsoever is the type of motion

★ **In a straight line path :-**

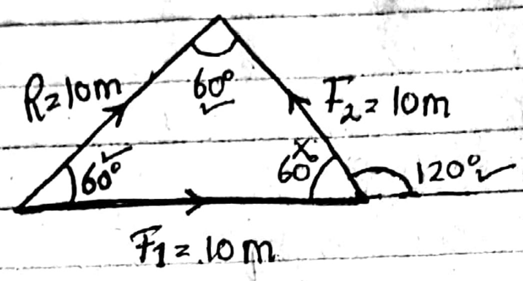
f, a, v, d →

force, acceleration, ~~velod~~ velocity and displacement are in one direction

★ **In circular path :-**



force and acceleration only



Notes:-

1.) In vectors we always take an angle where both vectors diverge from a point or converge to a point.

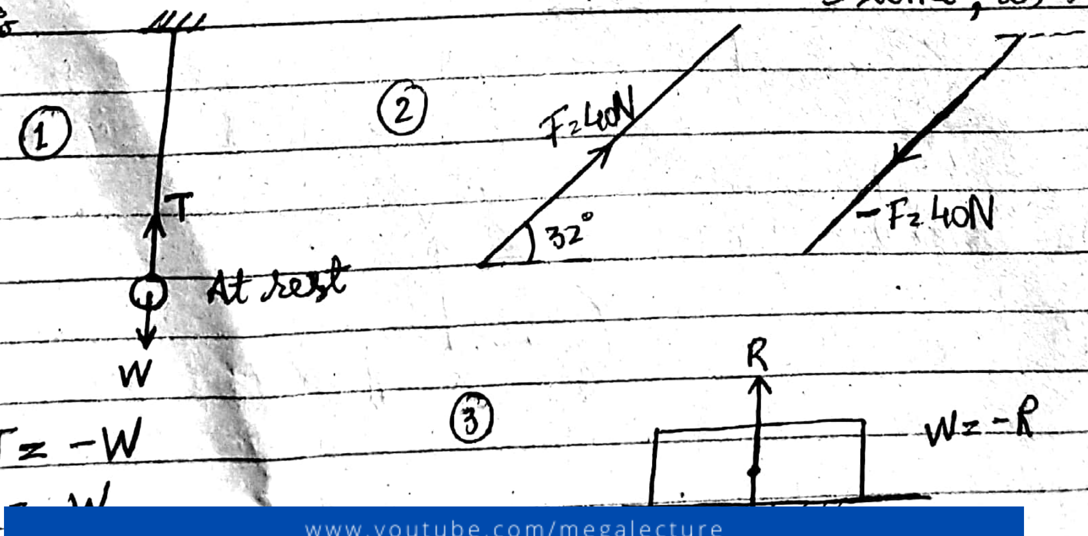
2.) An exterior angle is taken if one vector is converging and the other is diverging away.

⇒ **Negative of a vector:**

→ **Def:** The negative of a vector is another vector which has the same magnitude as that of original vector, but its direction is opposite to it.

★ length of st. lines must be same, as they define magnitude

→ e.g.:



$T = -W$

$W = -R$

$-T = W$

⇒ Addition of Vectors

a) Graphical Addition :-

i) Head-to-tail Rule
ii) Parallelogram of forces

b) Mathematical addition :-

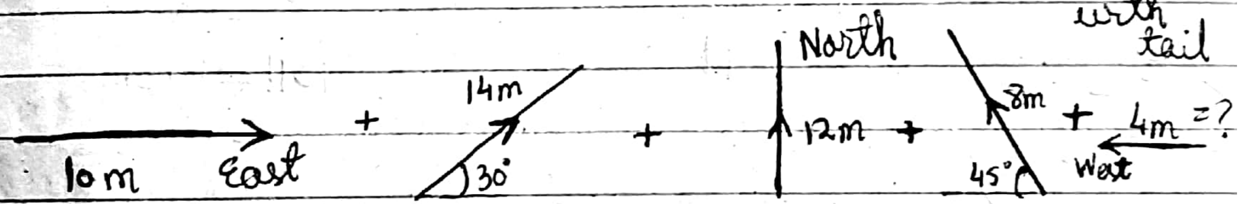
i) By resolution of vectors method

a)i) Head to tail Rule :-

- head of 1 vector will be joined with tail of 2nd.
- for resultant only → head of resultant will be joined with head of the other vector and tail will be joined with tail

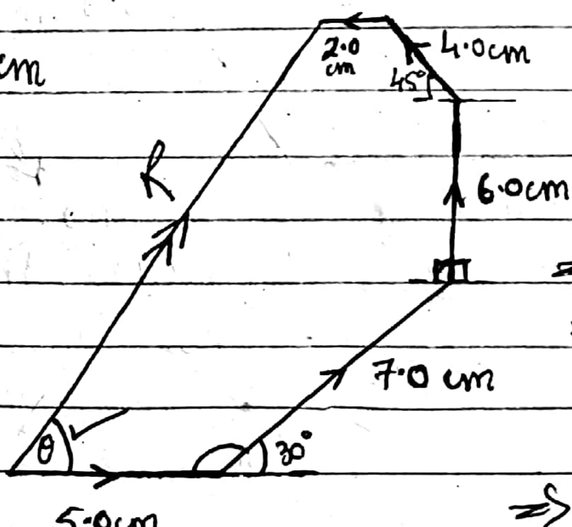
★ take larger scale → scale must cover more than 75% of the provided space

Q)



Scale

2m = 1.0 cm



⇒ Magnitude of Resultant = (measured length) x (scale) = ______ m

⇒ direction of Resultant = Measure angle with any refrence

a) ii) Parallelogram of forces (Addition of 2 vectors only)

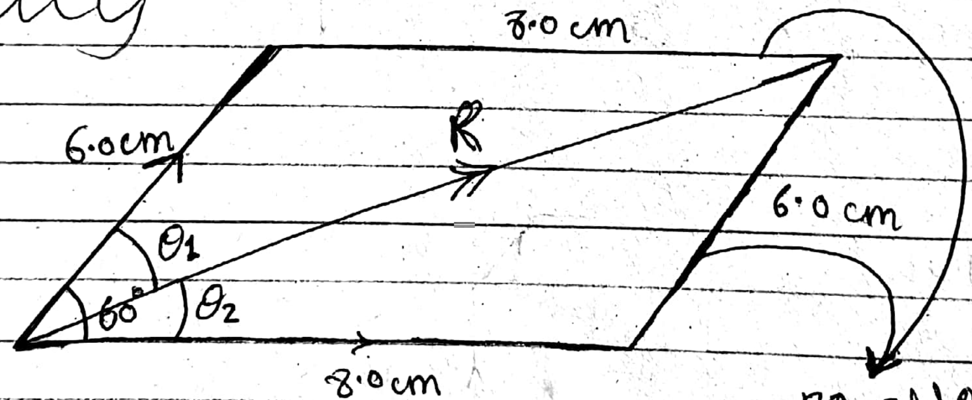
If 2 outward drawn forces are acting at a point then their resultant is obtained initially by completing a parallelogram and then draw a line as resultant from the point where both these forces are acting to its opposite vertex. The direction of resultant is always away from the point of application of forces.

★ Vector can never be represented by dotted line, it should be a regular st. line

(Jun 2004 → P2/Q1)

Q) $F_1 = 60N$ Scale
$F_2 = 80N$ $10N = 1.0 cm$

1st July



no arrow-heads on these lines since these are not vectors, but simply reference lines drawn in order to complete //gram.

⇒ Magnitude of Resultant = (measured length) × (scale) =

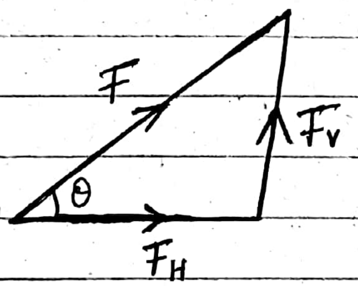
⇒ Direction of resultant = Measure angle with any reference vector
i.e. θ_1 with F_1 or θ_2 with F_2

b) Resolution of a vector

⇒ def:
Splitting up of a vector into its mutually perpendicular components is called resolution of a vector.

⇒ Analysis

⇒ Case 1:- If angle 'θ' is with the horizontal



★ usually we are given with 2 or more vectors and we have to find resultant, but here we are given with resultant, and we have to find the other vectors or forces

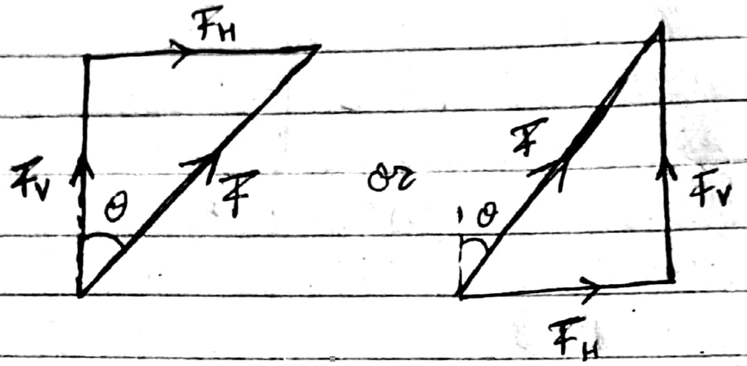
Horizontal component :-

$\cos\theta = \frac{F_H \rightarrow \text{Base}}{F \rightarrow \text{Hyp}} \Rightarrow F_H = F\cos\theta$

Vertical component :-

$\sin\theta = \frac{\text{perp}}{\text{Hyp}} \Rightarrow \sin\theta = \frac{F_v}{F} \Rightarrow F_v = F(\sin\theta)$

→ Case 2: If angle 'θ' is with the vertical



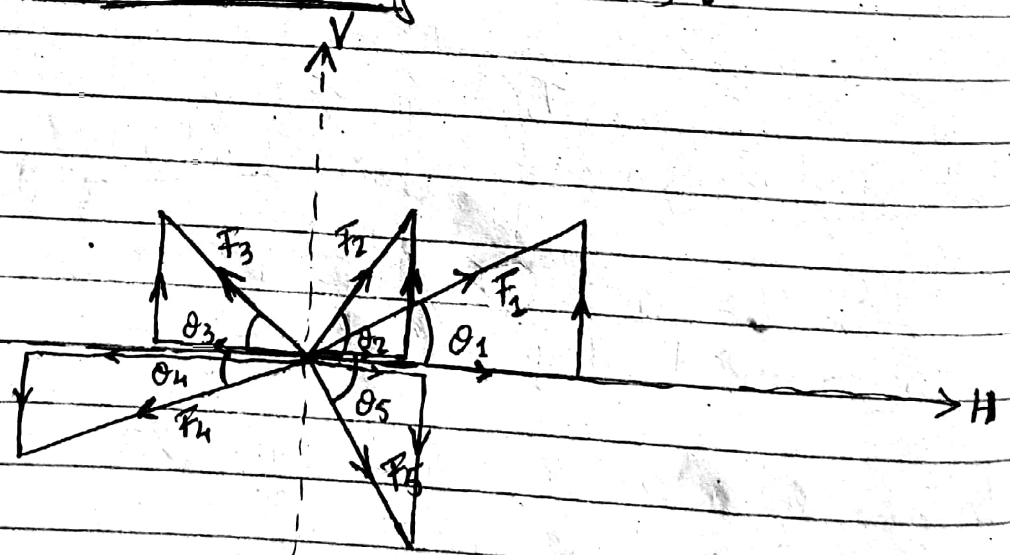
Horizontal component:

$\sin\theta = \frac{F_H}{F}$ (perp / Hyp) ⇒ $F_H = F\sin\theta$

Vertical component:

$\cos\theta = \frac{F_V}{F}$ (Base / Hyp) ⇒ $F_V = F\cos\theta$

⇒ Mathematical addition of n-vectors:



→ **Step 1:-**

Resolve each inclined force into its horizontal and vertical components (split up ↑)

→ **Step 2:-**

Find the resultant horizontal force along horizontal direction by making use of negative of a vector concept

$$F_H = F_1\cos\theta_1 + F_2\cos\theta_2 - F_3\cos\theta_3 - F_4\cos\theta_4 + F_5\cos\theta_5$$

= +ive → or −ive ← (If answer +ive then direction → (right side), if −ive ← (left side))

→ **Step 3:-**

Find the resultant vertical force by making use of negative of a vector concept

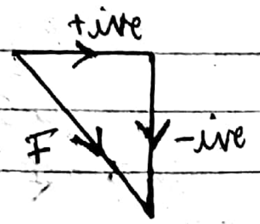
$$F_V = F_1\sin\theta_1 + F_2\sin\theta_2 + F_3\sin\theta_3 - F_4\sin\theta_4 - F_5\sin\theta_5$$

= +ive ↑ or −ive ↓ (In answer +ive then direction is ↑ (i.e. upward) and if −ive then direction is ↓ (i.e. downward).

→ **Step 4:-** ~~The~~

The magnitude of resultant is obtained by pythagorus theorum

$$F = \sqrt{F_H^2 + F_V^2}$$

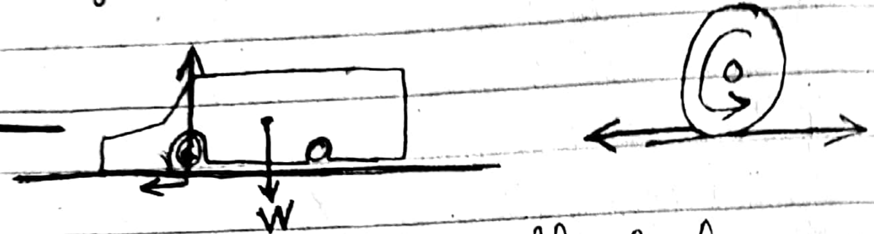


→ **Step 5:-**

The direction of resultant is obtained by using trignometric ratios i.e.

$$\theta = \tan^{-1}\left(\frac{F_V}{F_H}\right)$$

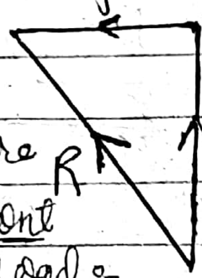
Q) A car ~~moves towards~~ of mass 'm' move towards left side as shown.



What is the direction of resultant force exerted by road on front wheel

A) ←
B) →
C) ↑
(D) ↖

f → frictional force

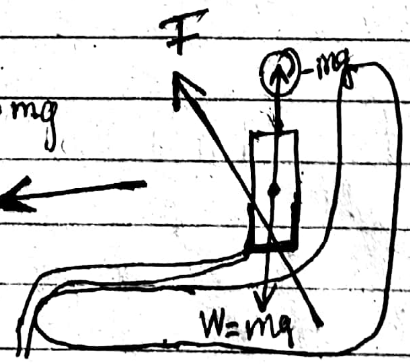


★ 2 forces are exerted on front wheel by road :-
1 is the frictional force
2nd is the upward force which is the reactional force to weight

Q) A child of mass 'm' siting in a car which moves with an acceleration of ~~of~~ ~~0.10g~~ 0.50g, where g is the acceleration due to gravity

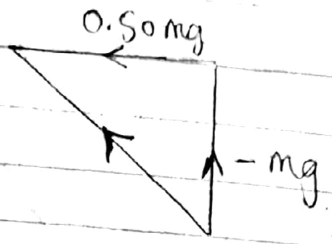
F = ma
= 0.50 mg

a = ~~0.10g~~ 0.50

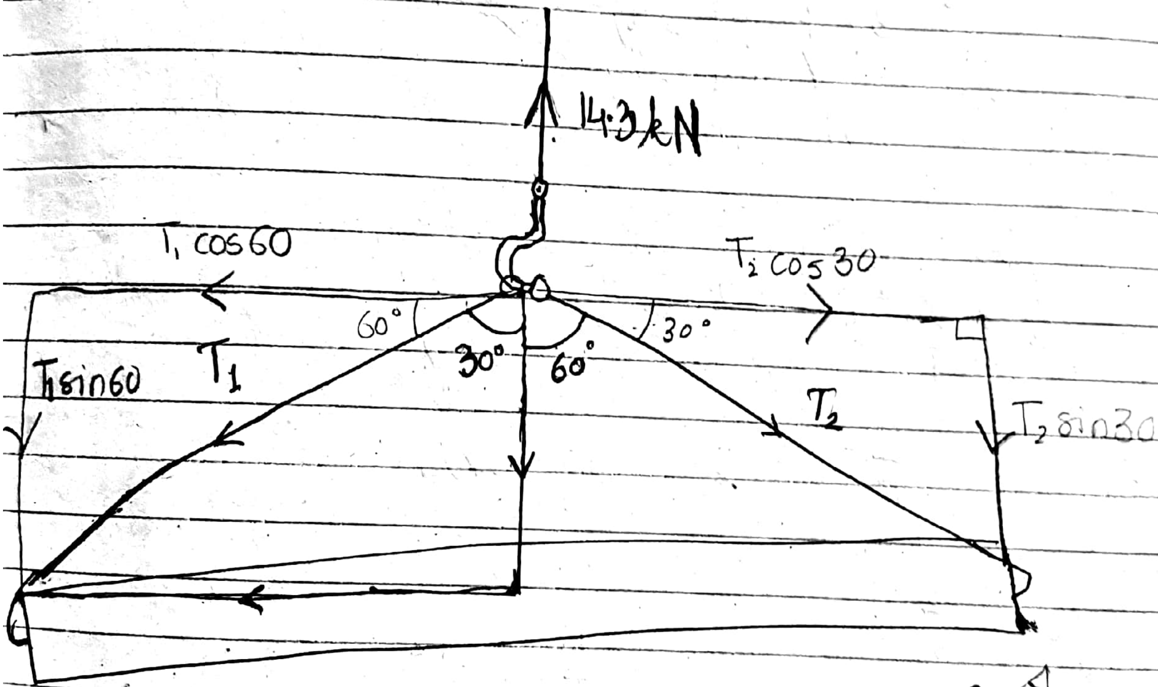


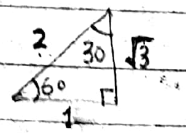
Calculate the magnitude of resultant force F 'F' exerted by seat on child

$F = \sqrt{(-mg)^2 + (0.5mg)^2}$
$= 1.1\ mg$



d) A plank is suspended by a crane which has a tension force of 14.3 kN as shown. At rest !!!





Calculate the value of T_1 and T_2

horizontal $T_1 \cos 60 = T_2 \cos 30$ — (1)

vertical $T_1 \sin 60 + T_2 \sin 30 = 14300$ — (2)

$T_1 = \dfrac{T_2 \cos 30}{\cos 60}$ — (1)

$\frac{T_2 \cos 30 \times \sin 60}{\cos 60} + T_2 \sin 30 = 14300$

$1.5T_2 + 0.5T_2 = 14300$

$T_2 = 7150N$

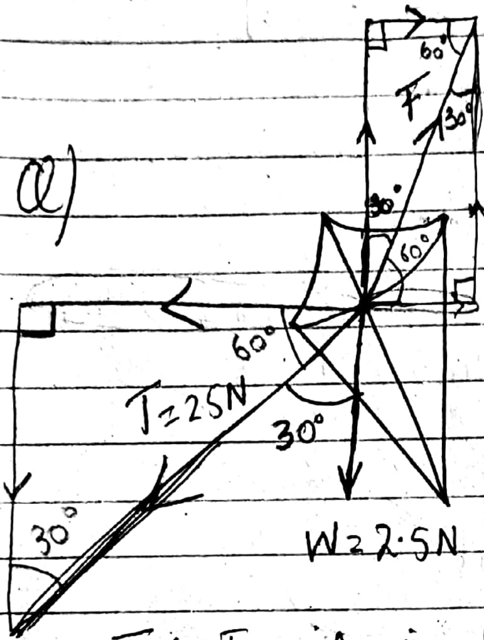
$T_1 = \frac{7150 \times \cos 30}{\cos 60}$

$T_1 = 12384.16$

$= 12384N$

Q)

stationary kite



$T_H = F_H$

T => Tension in the string = 25N
W => weight = 2.5N
F => Force due to air (lift)

a) Resolve F with its components

b) Calculate
i) Horizontal component of T
ii) Vertical component of T

c) What is the magnitude of
i) Horizontal component of 'F'
ii) Vertical component of 'F'
iii) magnitude of 'F'
iv) direction of 'F'

b)

i) $T_H = T\sin\theta$
$= 25\sin 30 = 12.5\text{ N}$

ii) $T_V = T\cos\theta$
$= 25\cos(30)$
$= 21.7\text{ N}$

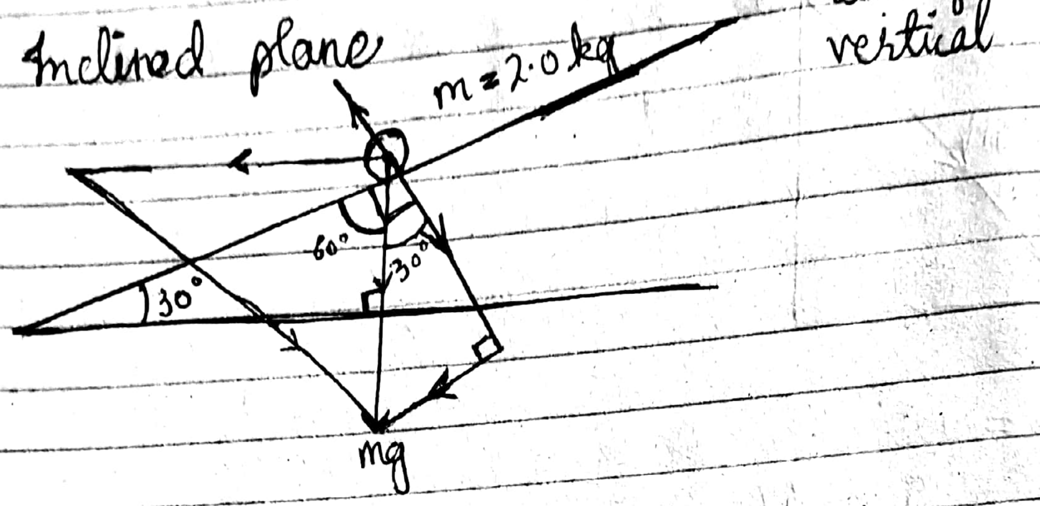
c) i) $F_H = T_H = 12.5\text{ N}$

ii) $F_V = T_V + W = 21.7 + 2.5 = 24.2\text{ N}$

iii) $F = \sqrt{F_H^2 + F_V^2}$
$= \sqrt{(12.5)^2 + (24.2^2)}$
$= 27.2\text{ N}$

iv) $\theta = \tan^{-1}\left(\frac{F_V}{F_H}\right)$
$= \tan^{-1}\left(\frac{24.2}{12.5}\right) = 62.7^\circ$ with horizontal

Q) Inclined plane



a) Resolve mg into its components

b) Calculate the magnitude of
i) Force acting along the plane in downwards
ii) the component of weight which is perpendicular to the plane.
iii) acceleration of object along the plane.

i) $F_1 = mg \sin 30°$
$= (2.0)(9.81) \sin 30$
$= 9.81 \text{ N}$

ii) $F_2 = mg \cos 30$
$= (2.0)(9.81) \cos 30$
$= 17.0 \text{ N}$

iii) $F = ma$
$9.81 = (2.0)a$
$a = 4.91$

Q) A rectangular picture of weight ~~25 N~~ 5.0 N is suspended by a string whose breaking strength is 25 N.

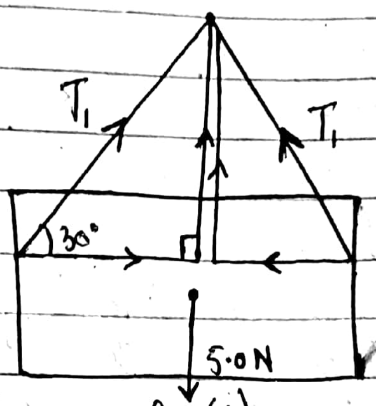


fig (i)

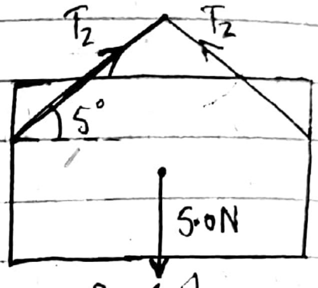


fig (ii)

In order to increase height of picture, the string is shortened and decreases the angle to 5° as shown in figure (ii)

a) Calculate
i) Tension T_1 in the string
ii) Tension T_2 in the string

b) Why the string breaks in figure (ii)

a) i) Resolve tension force and consider vertical component

$$T_1 \sin 30 + T_1 \sin 30 = mg$$
$$2T_1 \sin 30 = 5.0$$
$$T_1 = \underline{5.0\,N}$$

ii) $T_2 \sin 5 + T_2 \sin 5 = W$

$$T_2 = \frac{5.0}{2(\sin 5)}$$

$$T_2 = 28.7\,N$$

b) Because tension force is greater then the breaking strength of string.

⇒ Triangle of forces

→ **Statement 1:-**

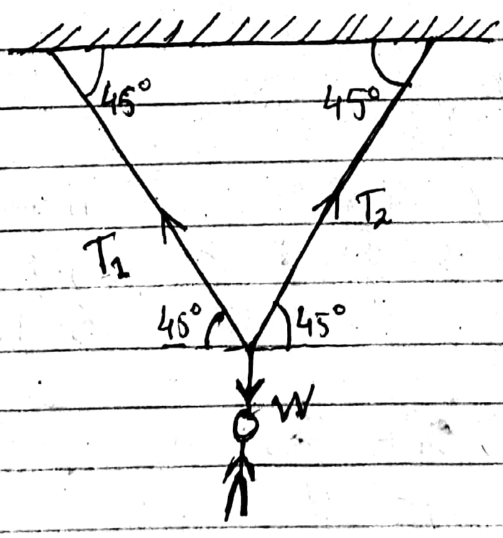
If 3 forces are acting at a point and are represented in terms of magnitude and direction by 3 sides of a triangle then the object is in equilibrium ★ equilibrium means ~~forces~~ $a = 0$ i.e. forces are balanced

Or

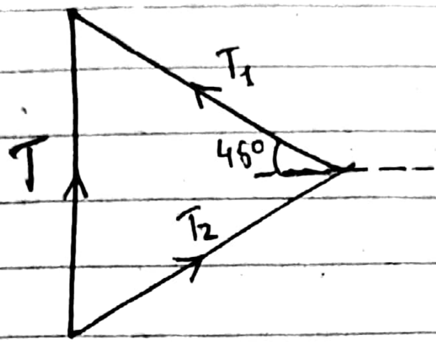
→ **Statement 2:-**

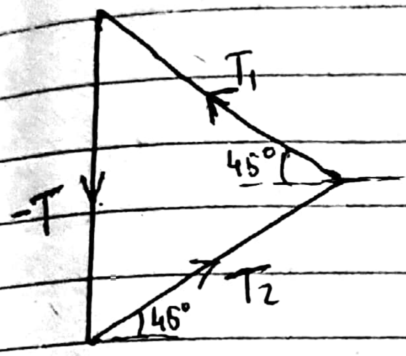
If the object is in equilibrium due to 3 forces then these 3 forces can represent 3 sides of a triangle in one order

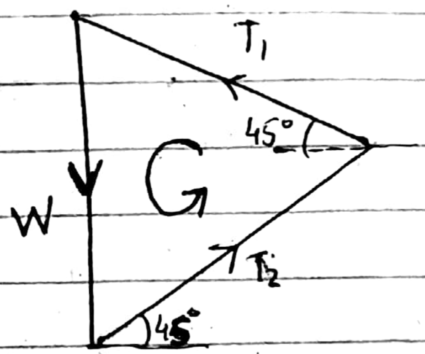
→ **Example:-**



Resultant vector of T_1 and T_2







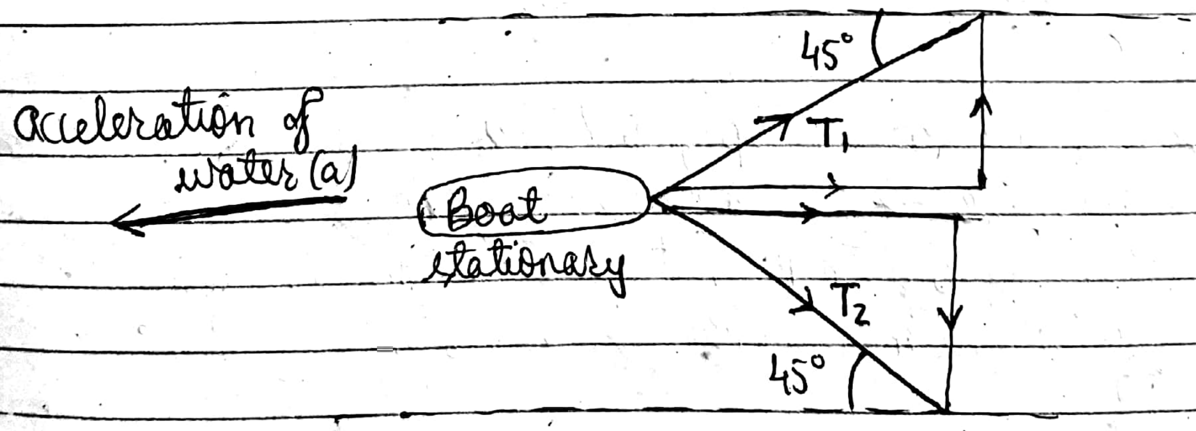
$T_2 + T_1 + W = 0$

$\Sigma f = 0$

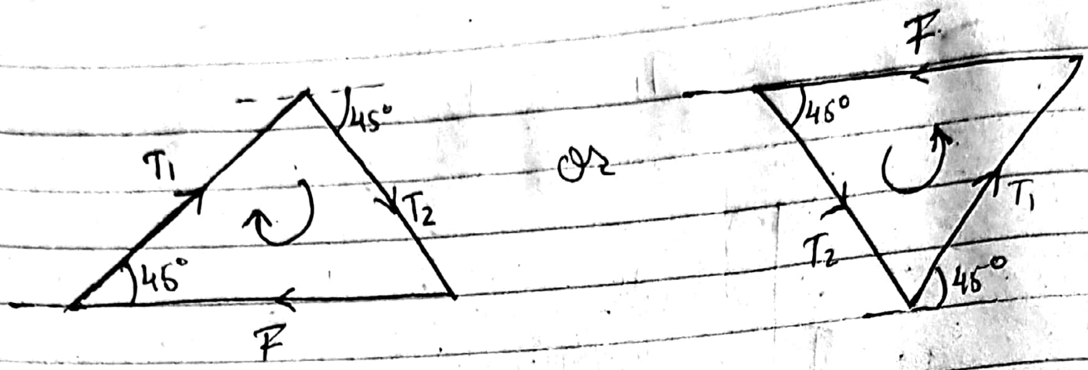
$ma = 0$

$a = 0$, so object is in equilibrium

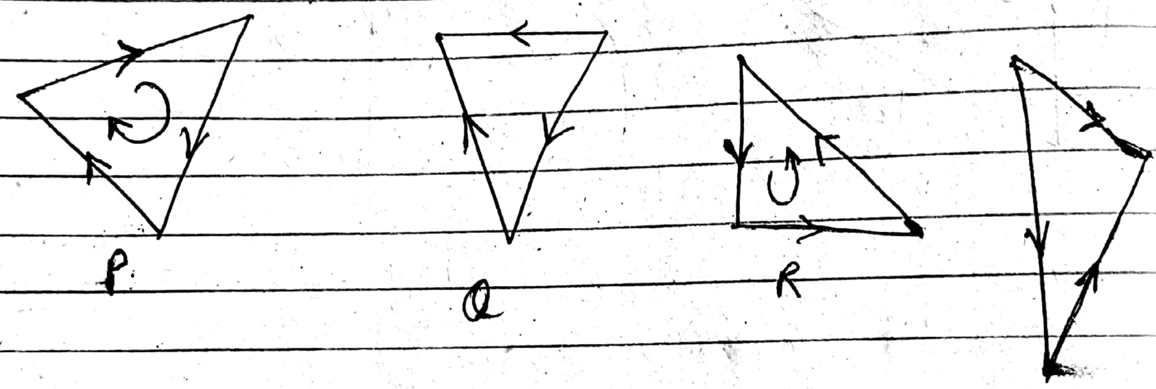
Q)



Show by vector diagram that the boat is at rest



Q) Which vector diagram represent ~~equilib~~ equilibrium



(A) R and S
(B) P and Q
(C) P and R
(D) Q and S

★ assume a loop, whether clockwise or anti-clockwise → if all forces/vectors are along the loop, then vector diagram is in equilibrium, otherwise not.

Kinematics

Study of motion without any reference of force and mass

⇒ Displacement

→ def :-
straight directed distance from the starting point to the ending point is called displacement.

→ Symbol :- s

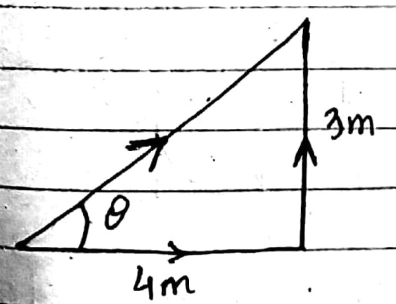
→ P.S :- Vector

→ Direction :- Towards ending point

→ Conceptual Question

a) Linear motion :-

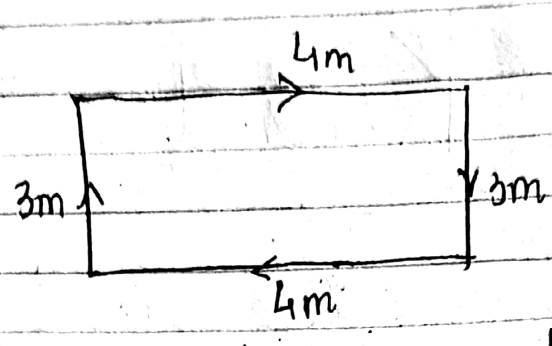
Q1)



→ Distance moved = 4+3
= 7 m

→ displacement = $\sqrt{4^2 + 3^2}$
= 5 m @ $\tan^{-1}\left(\frac{3}{4}\right) = 37°$

Q2)

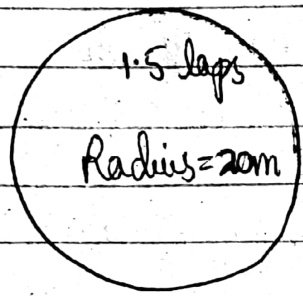


→ distance travelled = 4 + 3 + 4 + 3 = 14m

→ displacement = 0

b) Circular motion :

Q3)



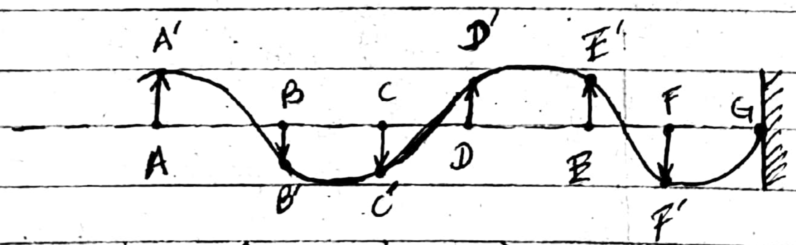
→ distance travelled = $(2\pi r)\,1{\cdot}5$

$= 2 \times 3{\cdot}14 \times 20 \times 1{\cdot}5$

$=$ ~~189~~ 189m

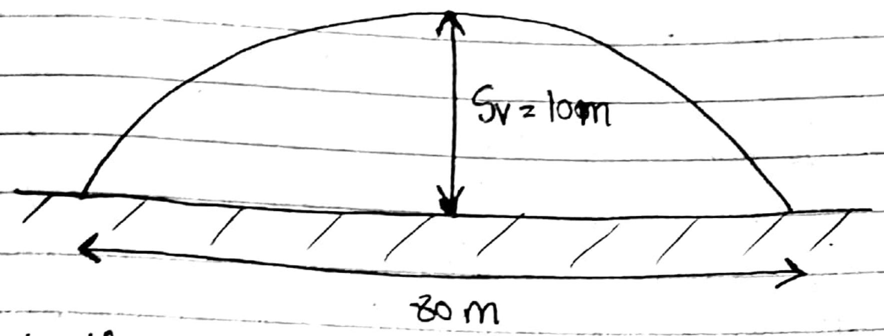
→ displacement = 20 + 20 = 40 m towards ending pt (20 + 20: diameter)

c) Wave motion :



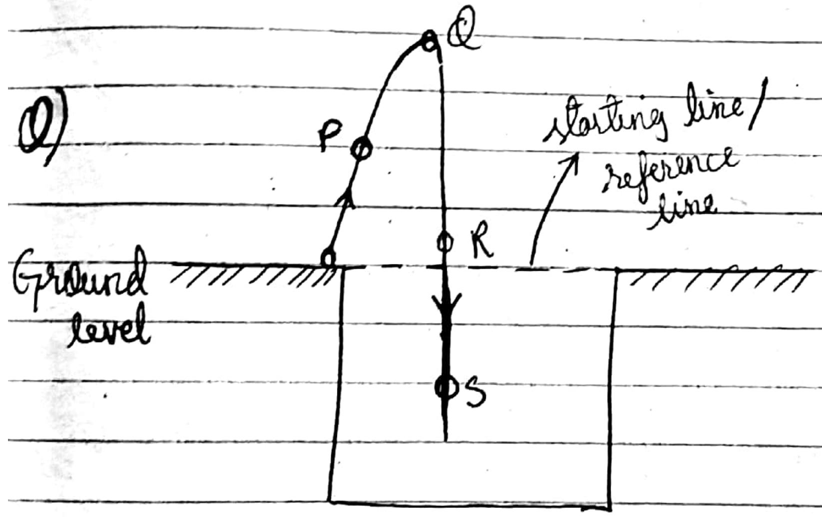
	A	B	C	D	E	F	G
displacement	✓	✓	✓	✓	✓	✓	X (= 0)
direction	upward	downward	downward	upward	upward	downward	—

Q4) A ball is thrown and it follows a parabollic path as shown



x) What is the
i) vertical displacement = 0 m
ii) Horizontal // = 80 m

Q)



★ always take a reference point / line / starting point or line in case of displacement

What is the direction of ~~resultant at~~ displacements at different position

	P	Q	R	S
(A)	↑	↑	↑	↓
B	↑	↑	↓	↓
C	↓	↓	↑	↑
D	↓	↓	↓	↑

⇒ Speed = $\frac{\text{distance moved / travelled}}{\text{time}}$

or

distance travelled per unit time

⇒ uniform speed = $\frac{\text{equal distance travelled}}{\text{equal time interval}}$

or

equal distance travelled in equal time interval

⇒ Variable speed = $\frac{\text{unequal distance moved}}{\text{equal time interval}}$

or

unequal distance travelled in equal time interval

⇒ Average speed = $\frac{\text{total distance travelled}}{\text{total time interval}}$

or

total distance travelled in total time interval

⇒ Instantaneous speed = Gradient of distance against time graph

- speed at a particular instant / time
e.g. speed at 4th second

or

Rate of change of distance

- speed after 4 seconds will be simple / average speed and not instantaneous speed

or

Time derivative of distance moved

derivative and thing ... time

* In A-levels, base definations are to be given

Notes
To define ~~velocity~~ velocity and its respective terms simply replace distance by displacement in above definations of speed.

⇒ Acceleration = $\frac{\text{change of velocity}}{\text{time}}$

or

change of velocity per unit time

⇒ Uniform Acceleration = $\frac{\text{equal change of velocity}}{\text{equal time interval}}$

or

equal change of velocity over equal time interval

⇒ Variable acceleration = $\frac{\text{unequal change of velocity}}{\text{equal time interval}}$

or

unequal change of velocity over equal time interval

⇒ Average acceleration = $\frac{\text{total change of velocity}}{\text{total time interval}}$

or

total change of velocity over total time interval

⇒ Instantaneous acceleration = Gradient of velocity against time graph

↓ acceleration at a particular time/instant

or

time derivative of velocity

or

Rate of change of velocity

eq is only valid for uniform acceleration

⇒ Proof of equations of uniform accelerated motion

(J-2002, Nov-2003 → Q1, 2011)

Suppose an object move with an initial velocity 'u'. After time 't', its velocity becomes 'v' and travel a displacement 's' with uniform acceleration 'a'.

eq 1:- $v = u + at$

→ change of velocity $= v - u$

→ Rate of change of velocity $= \frac{v-u}{t}$

→ By defination of acceleration:-

$$a = \frac{v-u}{t}$$

$$at = v - u$$

or $v = u + at$

eq 2:- $s = ut + \frac{1}{2}at^2$

→ Average velocity $= \frac{\text{Total displacement}}{\text{total time}}$

$$\frac{u+v}{} = s$$

$s = \left(\frac{u+v}{2}\right)t$

→ But $v = u + at$

→ So, $s = \left(\frac{u + u + at}{2}\right)t$

$s = \frac{2ut}{2} + \frac{at^2}{2}$

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

eq 3:- $2as = v^2 - u^2$

→ $s = \left(\frac{u+v}{2}\right)t$

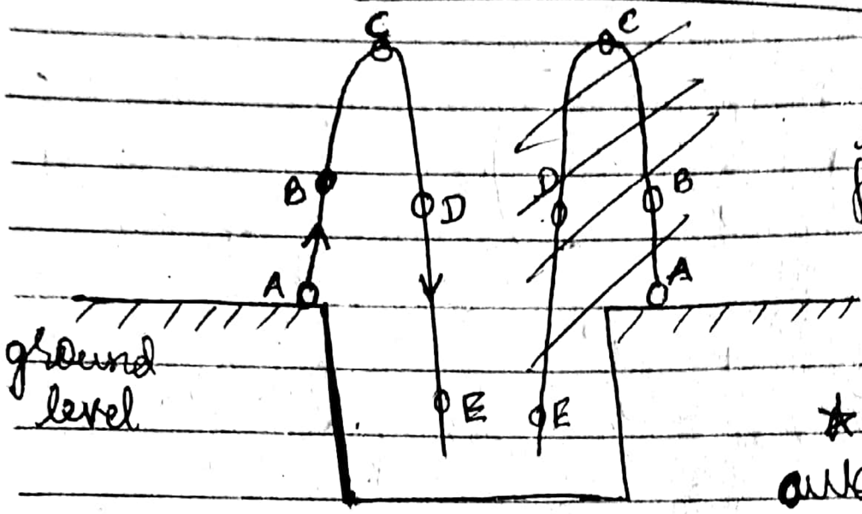
→ But $\frac{v-u}{a} = t$

→ So, $s = \left(\frac{v+u}{2}\right)\left(\frac{v-u}{a}\right)$

$s = \frac{v^2 - u^2}{2a}$

$2as = v^2 - u^2$

⇒ General example of vector quantities in kinematics graphs



★ displacement is always taken from a reference point/axis

★ when moving away from reference point, then displacement ↑

Assumption: upward motion is +ive

Physical qty	A	B	C	D	E

Physical Qty	A	B	C	D	E	Result
Displacement/m	O	Increases	Max	decreases	Increases	Displacement is independant of assumption and is taken from a reference ~~pt~~ point/axis
direction	—	upward	upward	upward	downward	
Velocity/ms^{-1}	Max	decreases	zero	Increases	maximum ($V_E > V_A$)	Velocity under ~~along~~ assumption = +ive; velocity against assumption =
direction	+ive	+ive	—	–ive	–ive	
Acceleration/ms^{-2}	9.81	9.81	9.81	9.81	9.81	Both magnitude and direction as per assumption are considered
direction	–ive	–ive	–ive	–ive	–ive	

• If direction of assumption ~~motion~~ is reversed then:-

(i) no change in displacement, since it is independent of assumptions (i.e. direction remains same) a is taken from the same reference point (magnitude remains same)

(ii) for velocity, only the directions are reversed, but no change in magnitude

(iii) for acceleration → same as that of velocity, i.e. only direction reversed starting position

Note :-

1-) Displacement time graph is either in 1st or 4th quadrant provided the object does not cross its equilibrium position.

2-) Velocity-time graph is in 1st and 4th quadrant due to change of direction as per assumption

3-) Acceleration time graph is either in first or forth quadrant due to change of its magnitude and direction as per assumption.

4-) When an object is projected upwards, its initial velocity is max which becomes 0 at the highest point.

5-) The acceleration of the ~~obn~~ object remain constant i.e. $9.81\ ms^{-2}$ whatsoever is the position of object if the air resistance is negligible.

6-) Displacement is independant of assumptions and is taken from a reference point ~~&~~ always.

⇒ **Displacement-time graph**

↓ dependant Qty (y-axis)

→ Independant Qty (x-axis)

→ **Results :-**

(i) Instantaneous displacement → y-axis

(ii) Instantaneous velocity → gradient of graph

iii

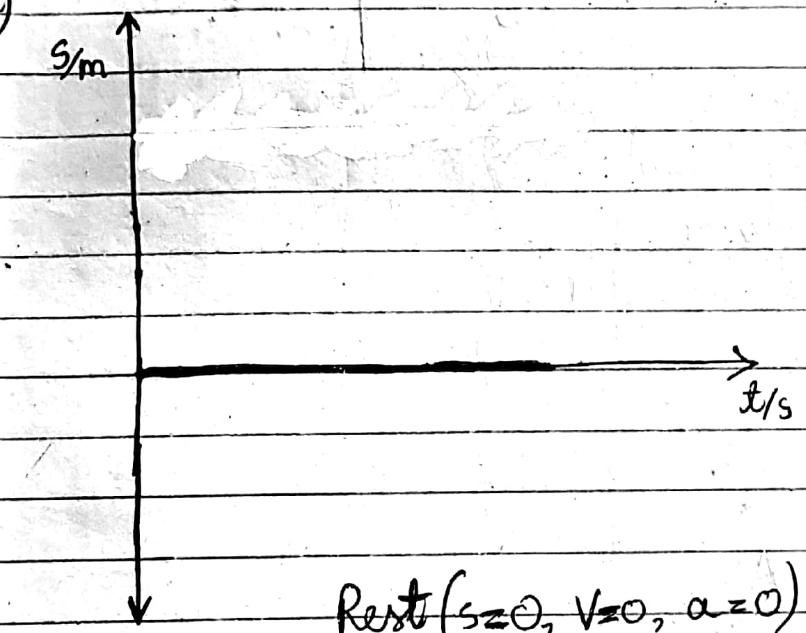
towards reference point/axis

away from reference point/axis.

(iii) Analysis of graph → Rest
→ Motion → direction of motion

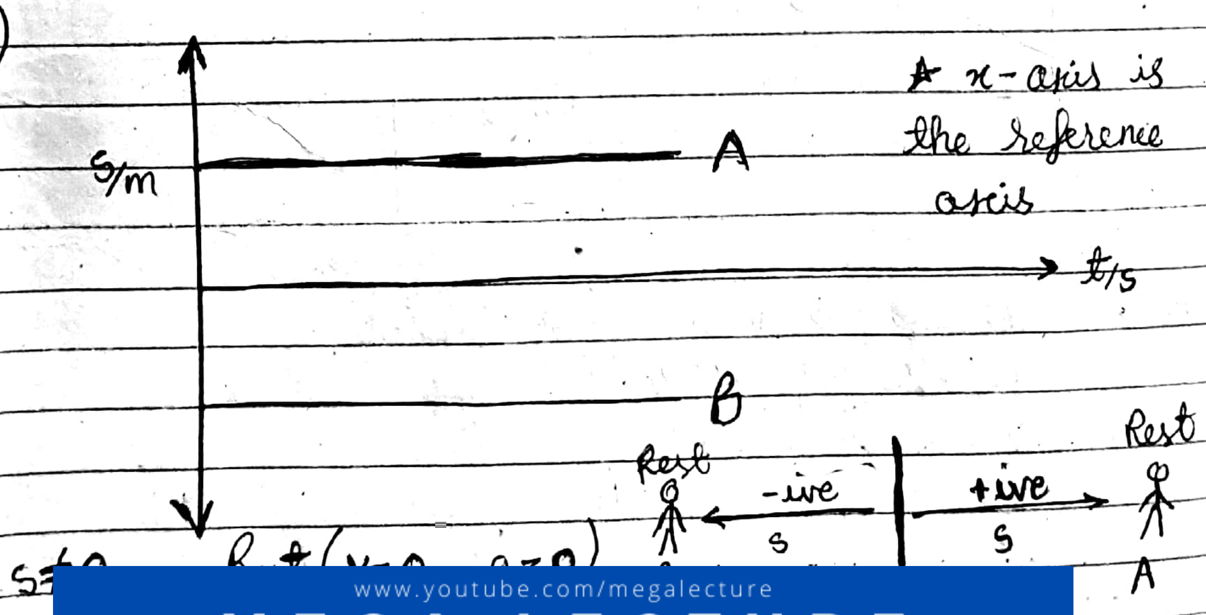
- uniform velocity ($a=0$)
- Increasing velocity (accelerate)
- Decreasing velocity (Retard)

a)



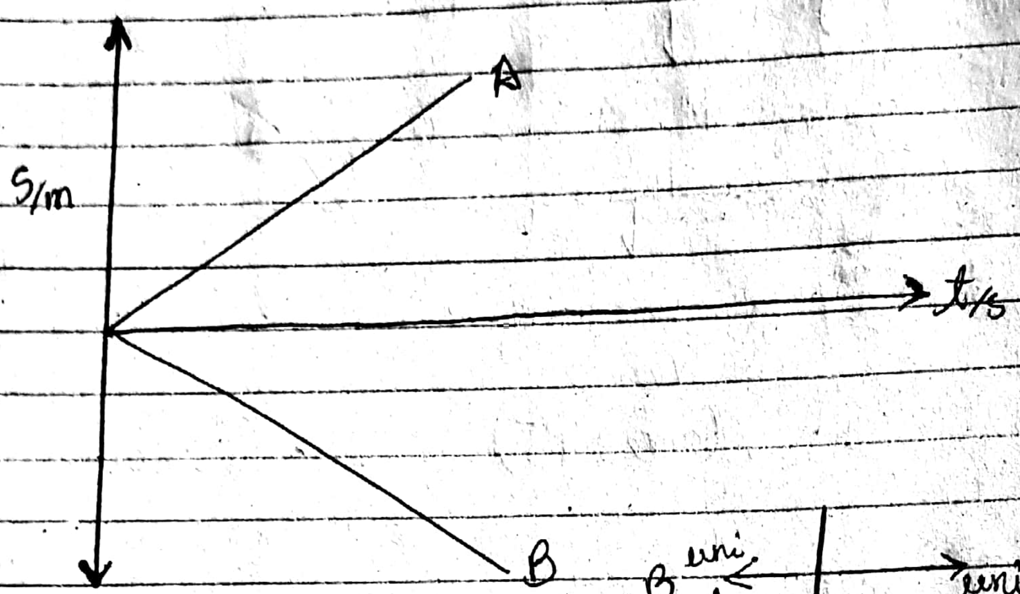
Rest ($s=0$, $V=0$, $a=0$) → absolute rest

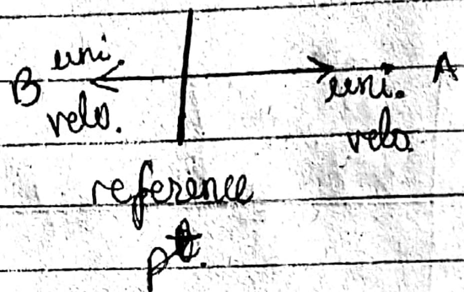
b)



* x-axis is the reference axis

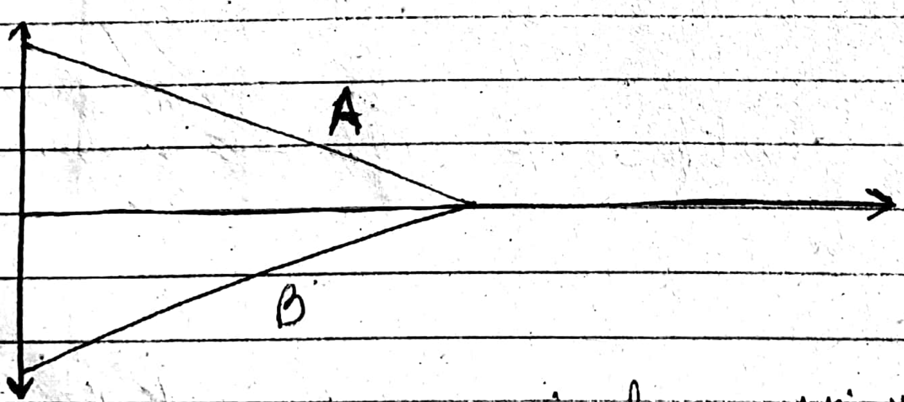
c)

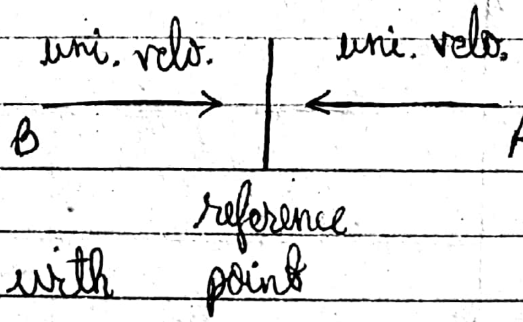




★ Both move with uniform velocity (a=0)
★ in opposite direction
★ away from reference point

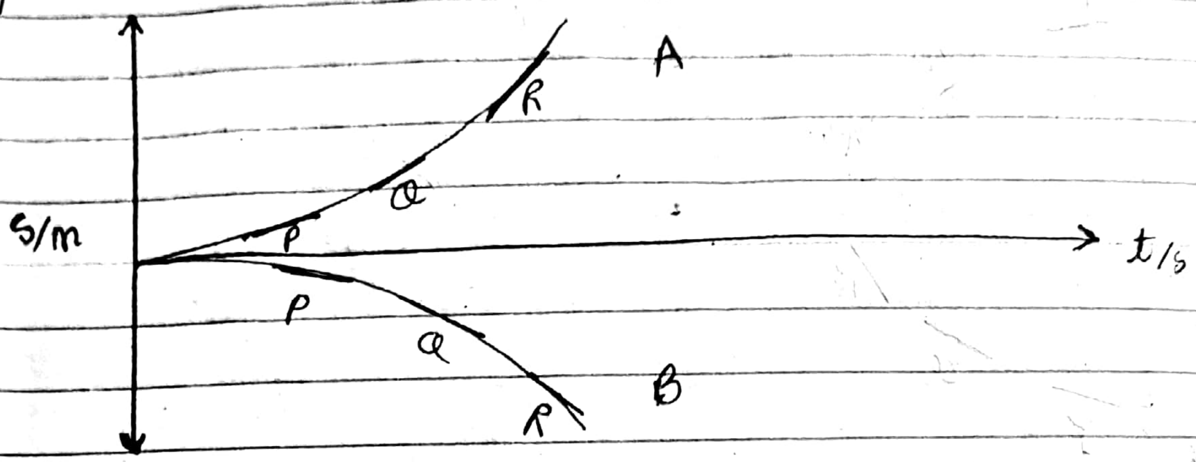
d)





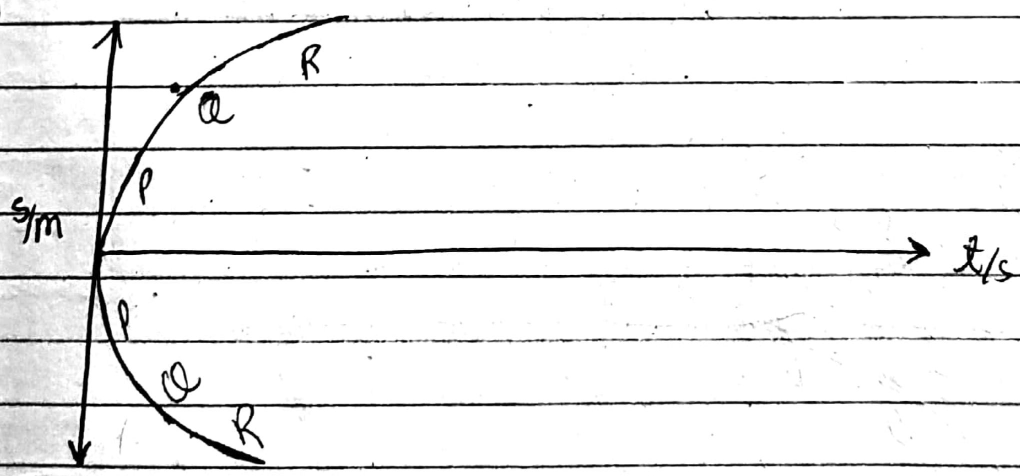
★ Both A and B move with uniform velocity (a=0)
★ in opposite directions

e)



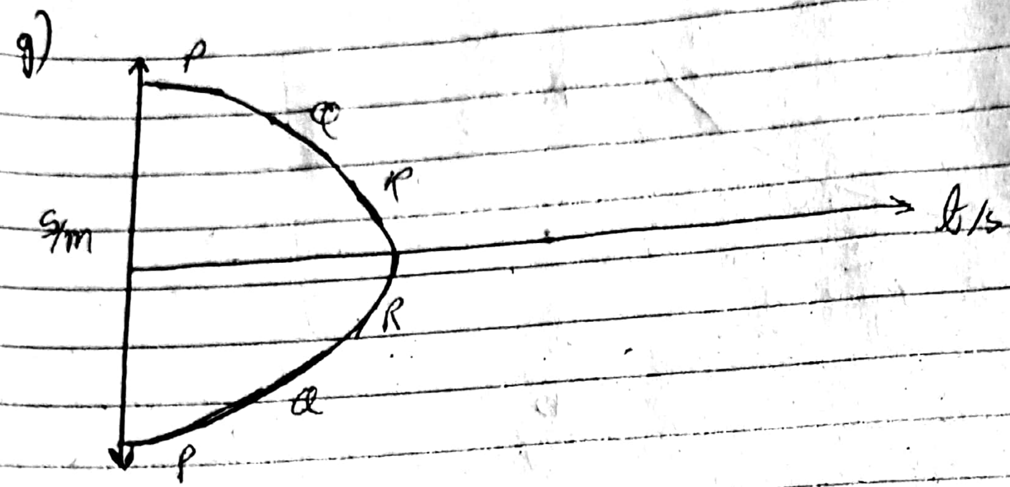
* both move with increasing velocity ($V_P < V_Q < V_R$) → uniform acceleration
* ~~both~~ in opposite directions
* away from reference point

f)



* Both move with decreasing velocity ($V_P > V_Q > V_R$) → uniform retardation
* away from reference point
* in opposite directions

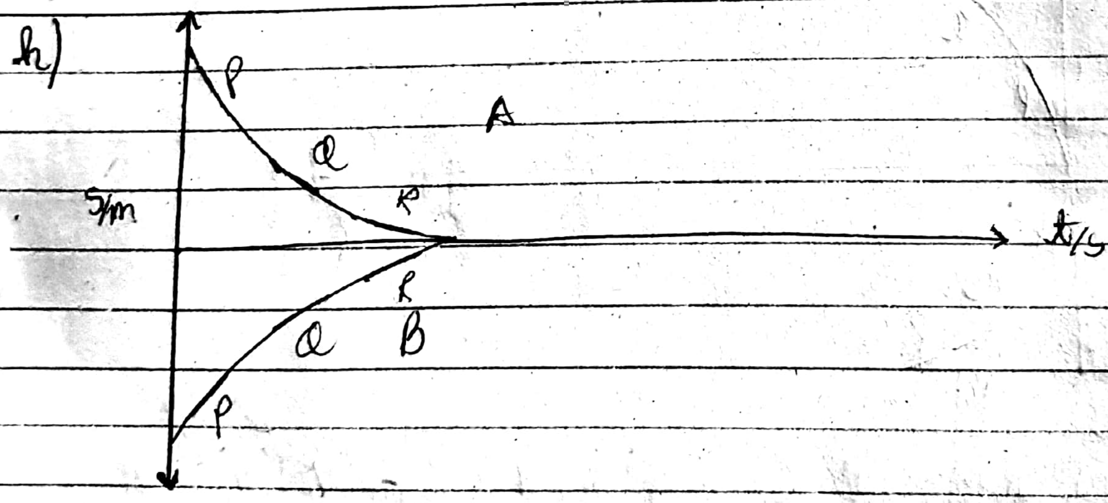
g)



Both move :-

* with increasing velocity (gradient increasing)
  → uniform acceleration
* in opposite directions
* towards reference point

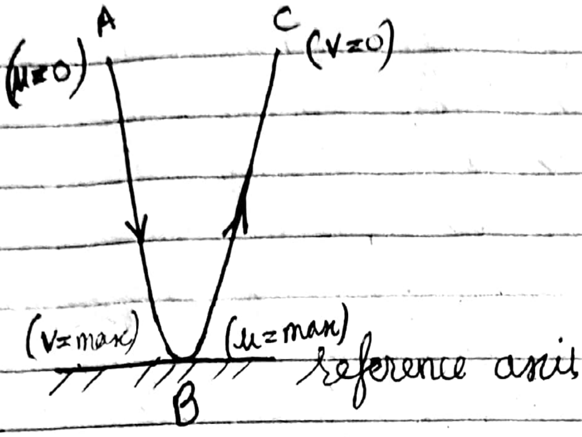
h)

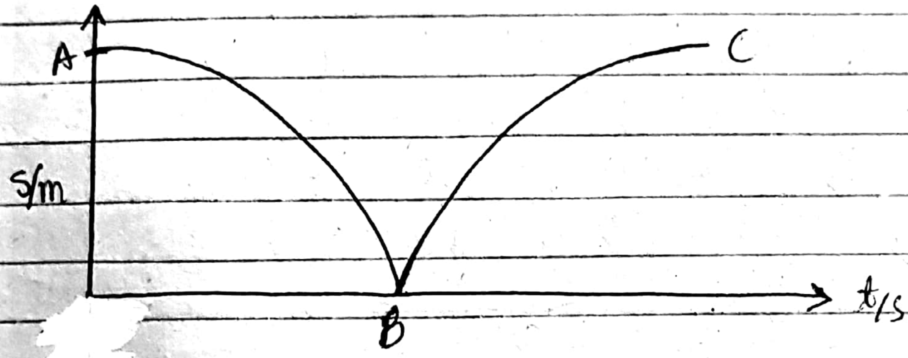


Both move :-

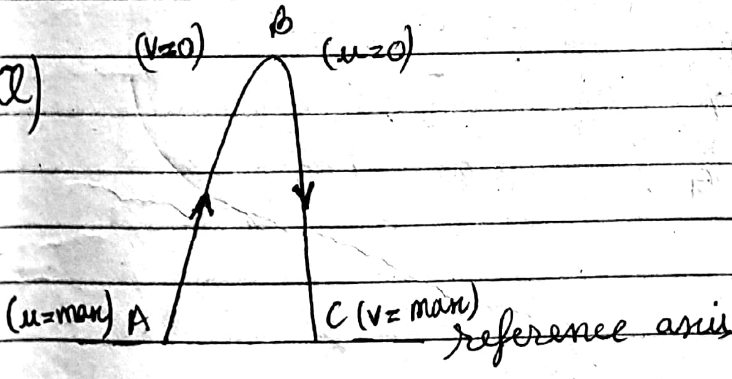
* with ~~inc~~ decreasing velocity (gradient decreasing)
  → uniform retardation
* in opposite directions
* towards reference point

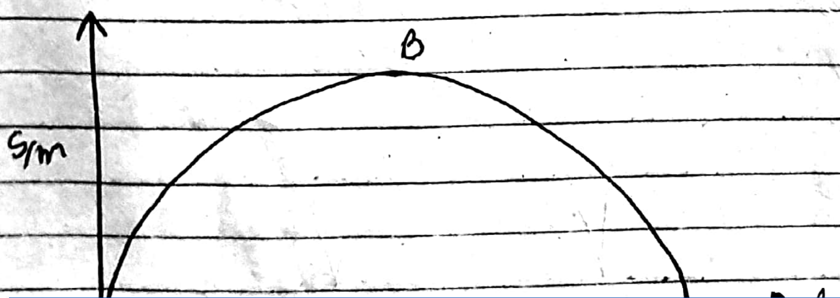
Q)


A
(u=0)
C
(v=0)
(v=max)
(u=max)
reference axis
B

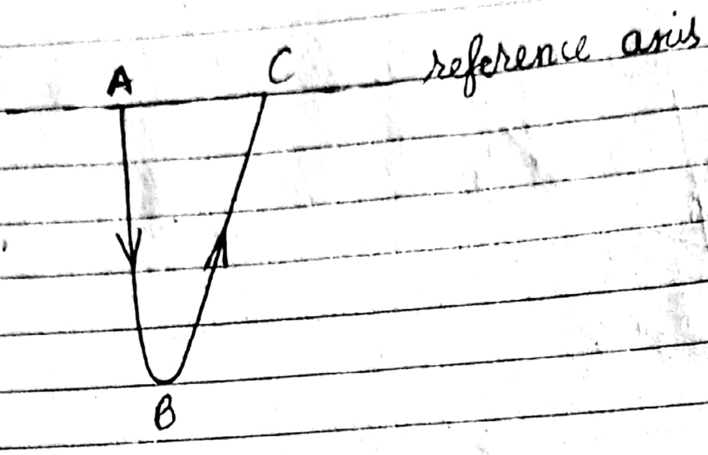

A
C
S/m
B
t/s

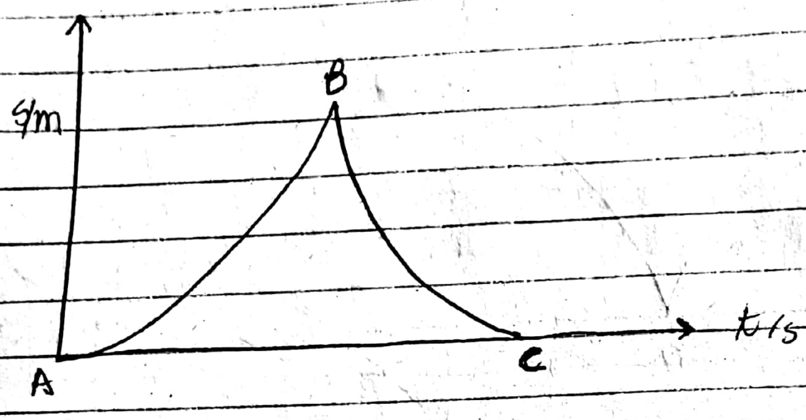
Q)


(v=0)
B
(u=0)
(u=max) A
C (v=max)
reference axis

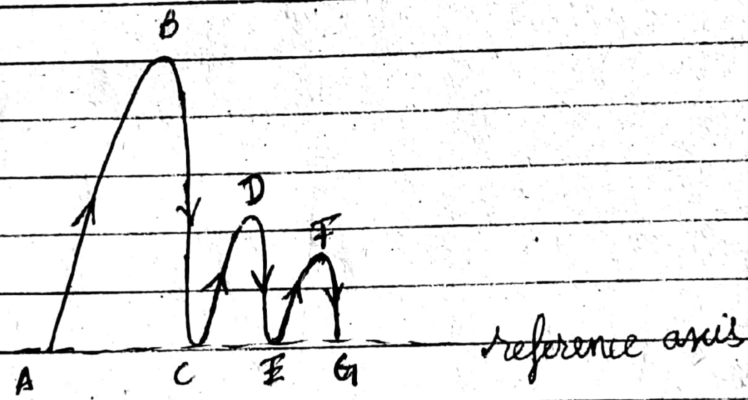

B
S/m

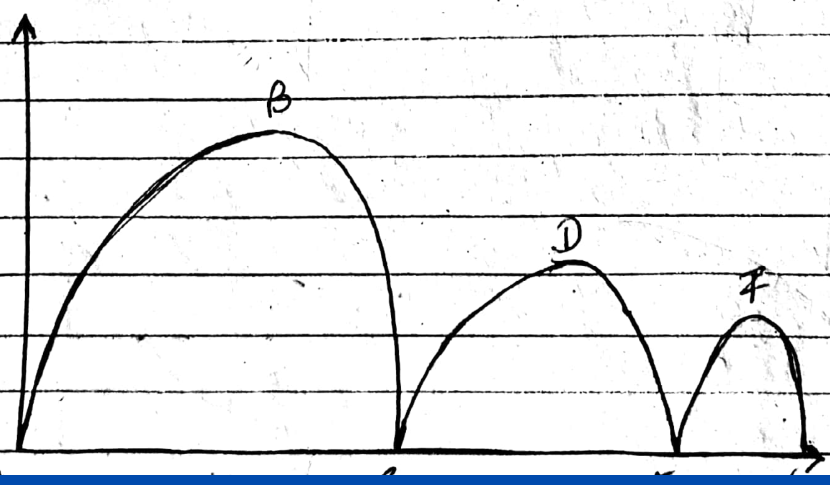
a)



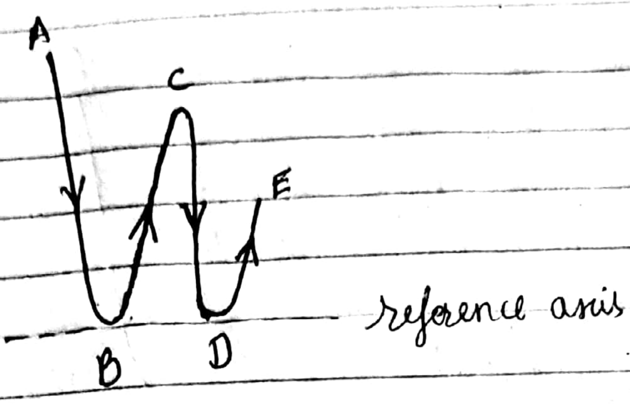


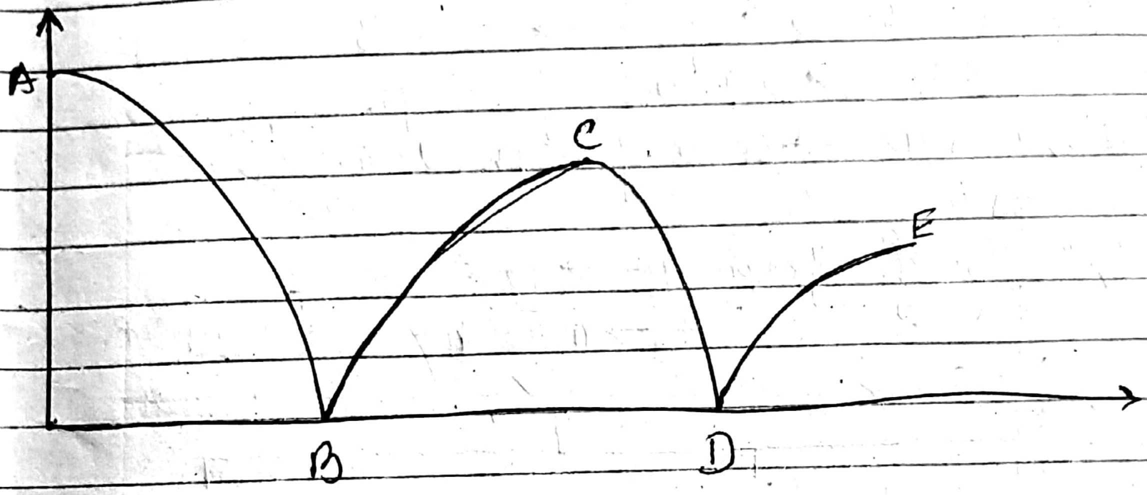
a)



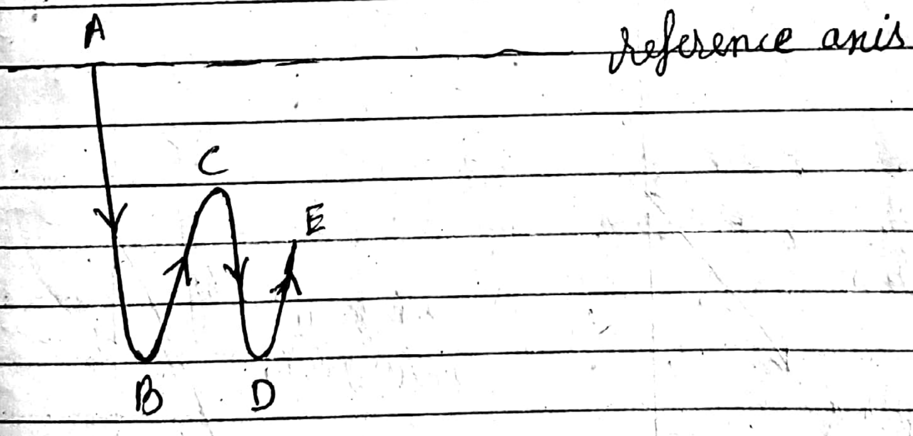


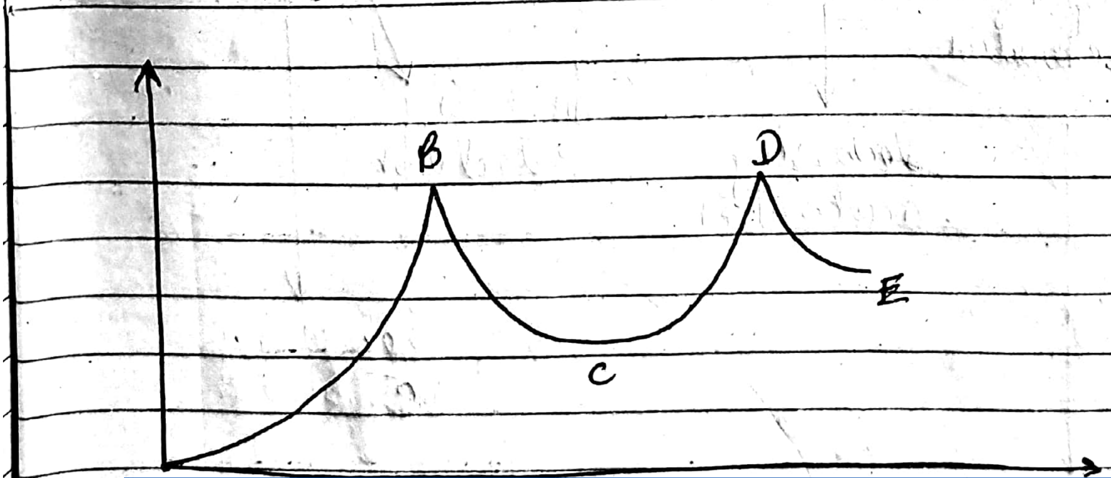
a)





a)





Velocity - time graph

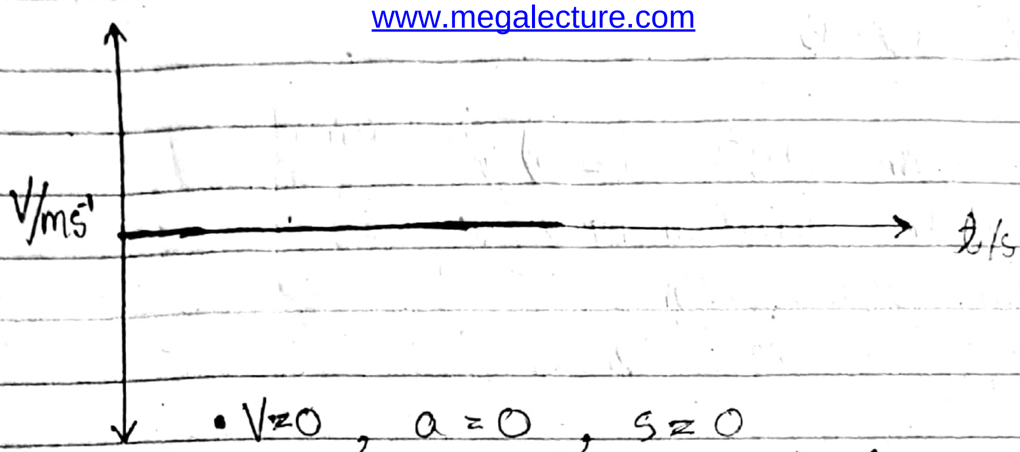
- Velocity → y-axis
- time → x-axis

- Results:

(i) Instantaneous velocity → y-axis
(ii) Acceleration → gradient of graph
(iii) Displacement → Area of graph along with time axis
(iv) Analysis of graph → Rest
→ motion → direction of motion

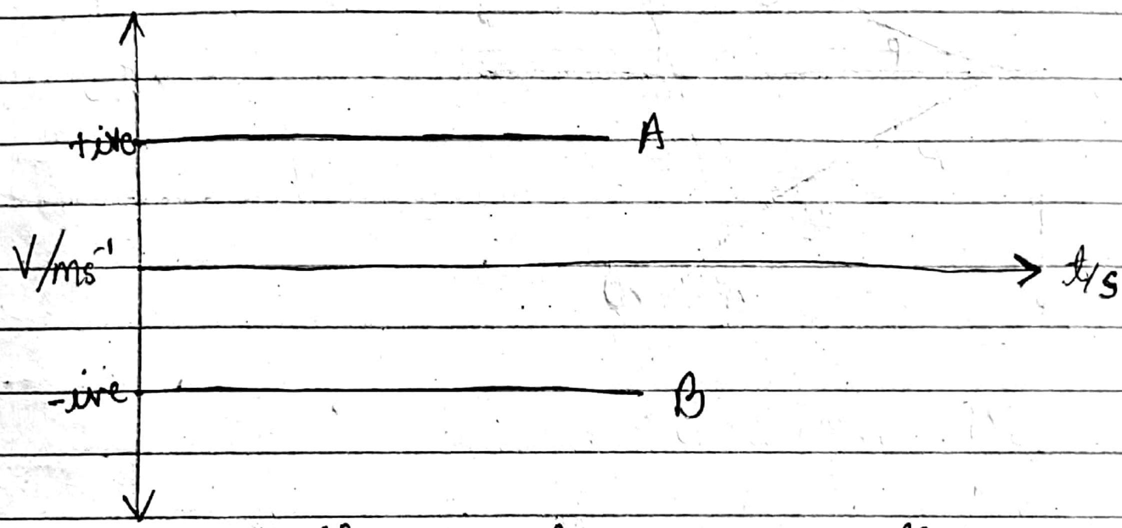
- uniform velocity (a=0)
- increasing velocity
  - uniform acceleration
  - increasing acceleration
  - decreasing acceleration
- decreasing velocity
  - uniform retardation
  - increasing retardation
  - decreasing retardation

a)



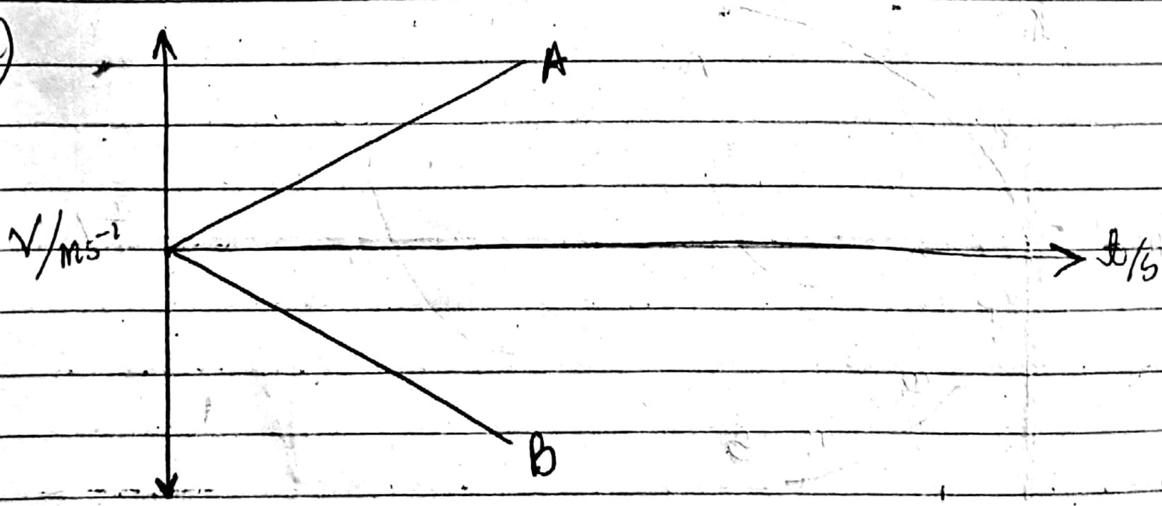
- $V = 0$, $a = 0$, $s = 0$
- Rest position → object is in absolute rest

b)



- Both A and B move with uniform velocity in opposite direction
- $a = 0$

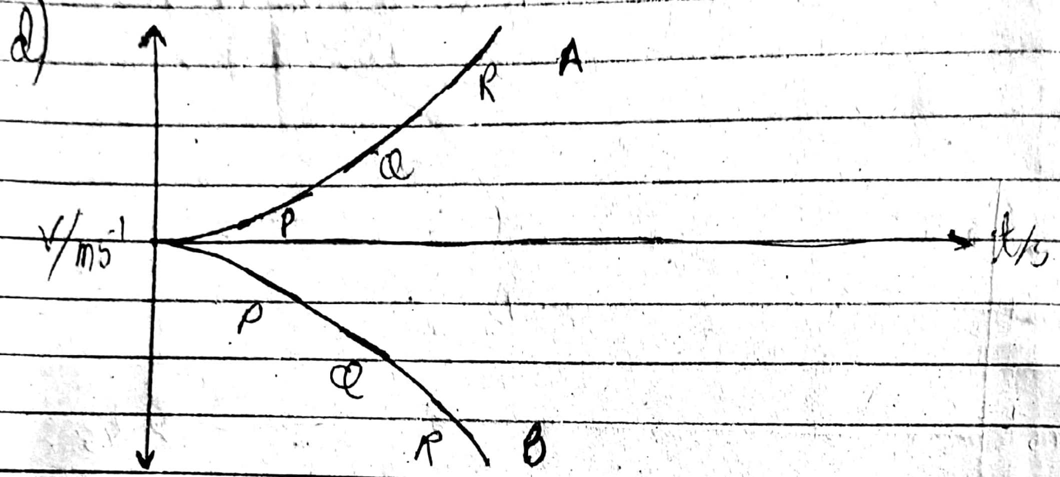
c)



Both A and B:-

- Start from rest ($u = 0$)
- move with uniform increasing velocity
- uniform acceleration
- in opposite directions

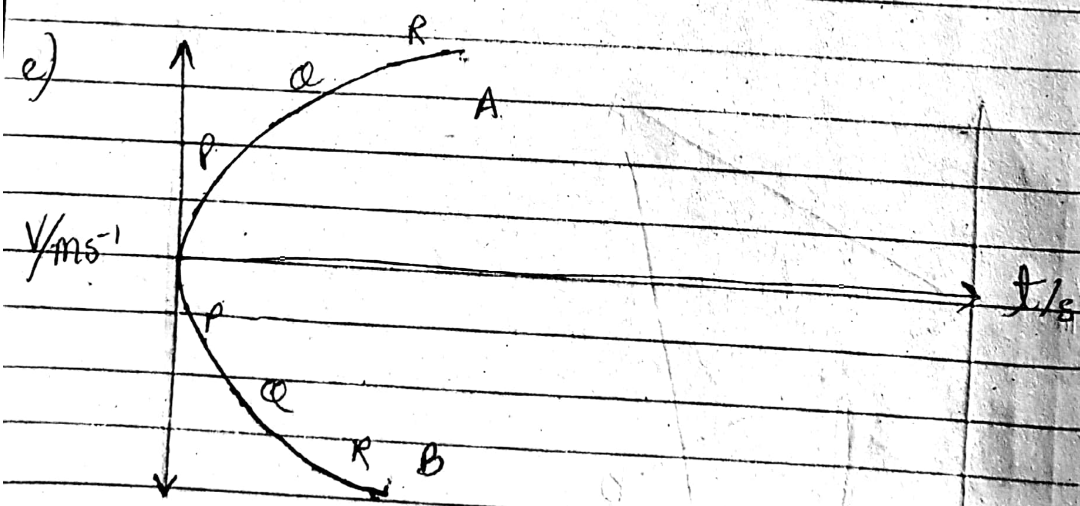
d)



Both A and B:-

- Start from Rest ($u = 0$)
  move with non-uniform increasing velocity
- move with increasing acceleration ($a_P < a_Q < a_R$)
- in opposite directions

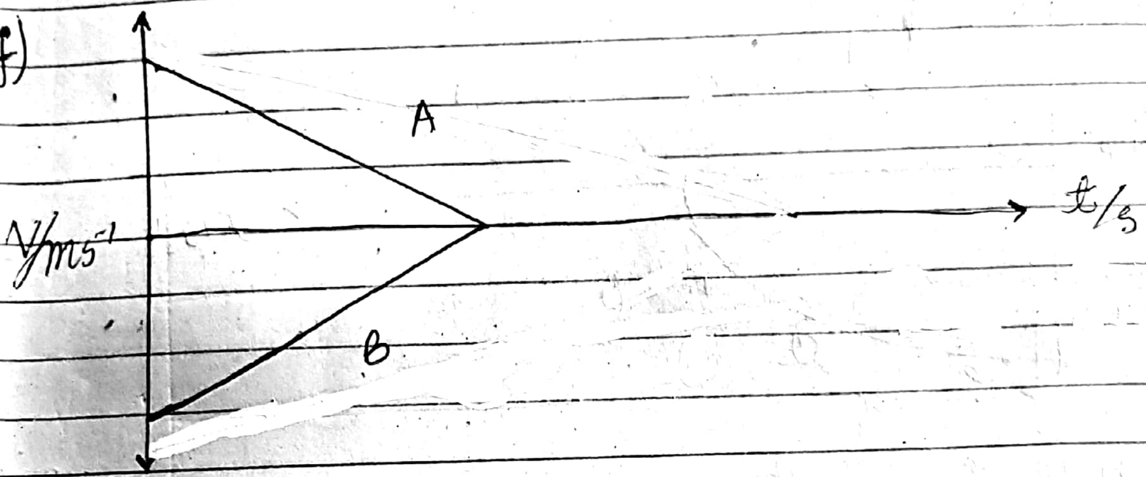
e)



Both A and B :-

- start from rest ($u = 0$)
- non-uniform increasing velocity
- decreasing acceleration ($a_P > a_Q > a_R$)
- opposite directions (different quadrants)

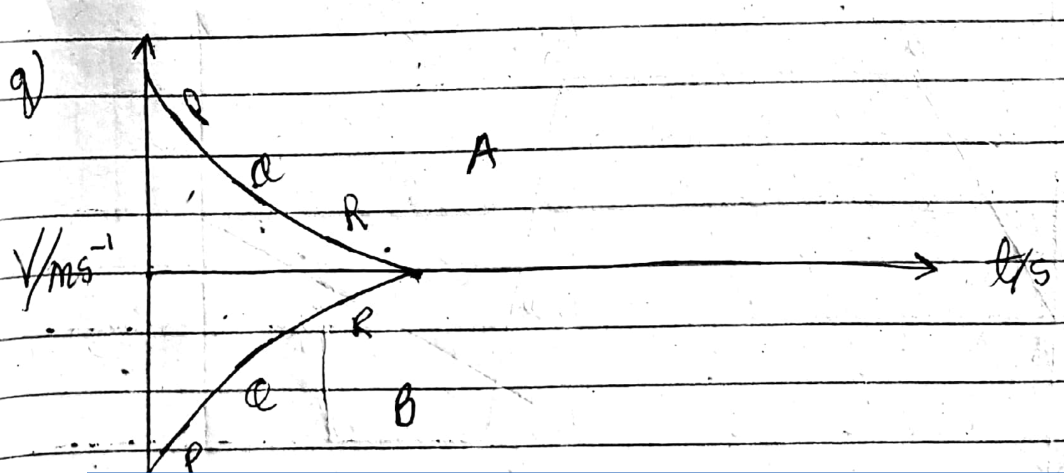
f)



Both A and B :-

- move in opposite directions (different quadrants)
- with uniformly decreasing velocity
- uniform retardation ($-a_P = -a_Q = -a_R$)
- finally comes to rest ($V = 0$)

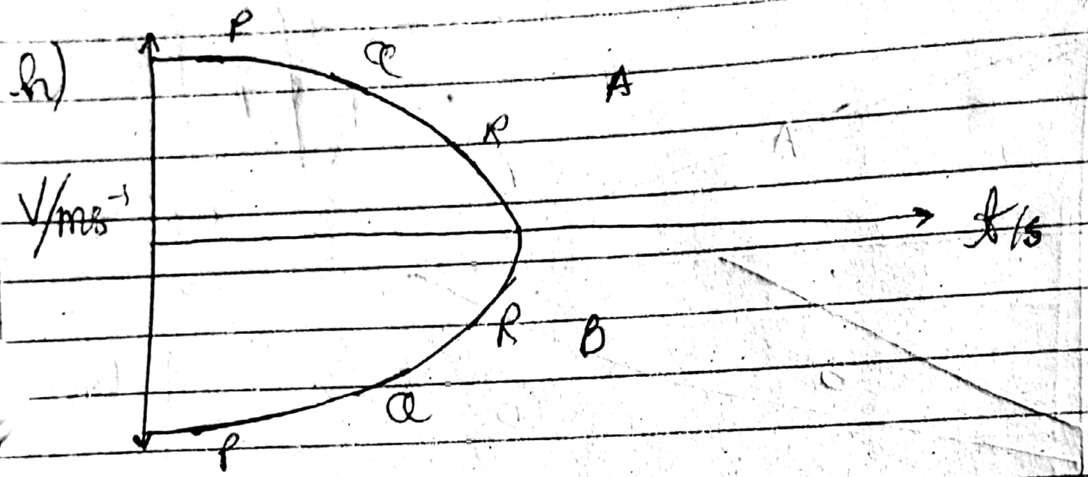
g)



Both A and B :-

- move with non-uniform decreasing velocity
- decreasing retardation ($-a_P > -a_Q > -a_R$)
- in opposite directions (different quadrants)
- finally comes to rest ($v = 0$)

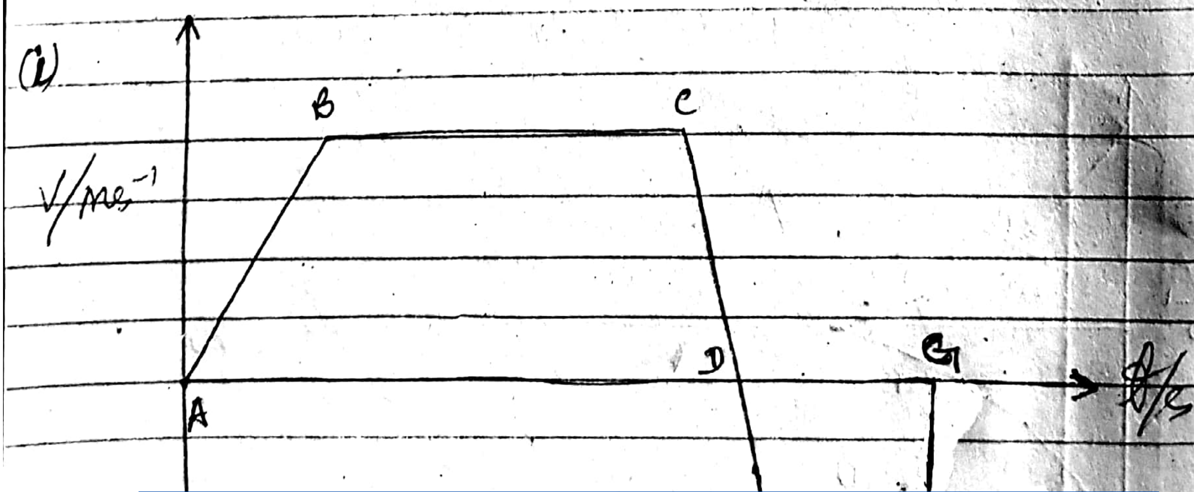
h)



Both A and B :-

- move with non-uniform decreasing velocity
- increasing retardation ($-a_P < -a_Q < -a_R$)
- in opposite directions (different quadrants)
- finally comes to rest ($v = 0$)

(i)

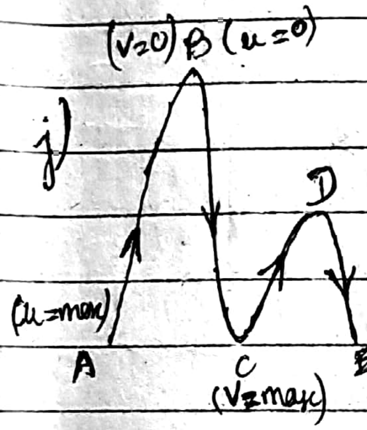


Position	speed	acceleration	direction of motion
At A	0	0*	— (Rest)
AB	uniform (↑)	uniform	Right side
BC	constant	0	" "
CD	uniform (↓)	uniform but in-ive	" "
At D	0	0*	—
DE	uniform (↑)	uniform	left side
EF	constant	0	" "
FG	0	∝ but in-ive	left side

FG speed 0 → comes to rest instantaneously (momentary rest)

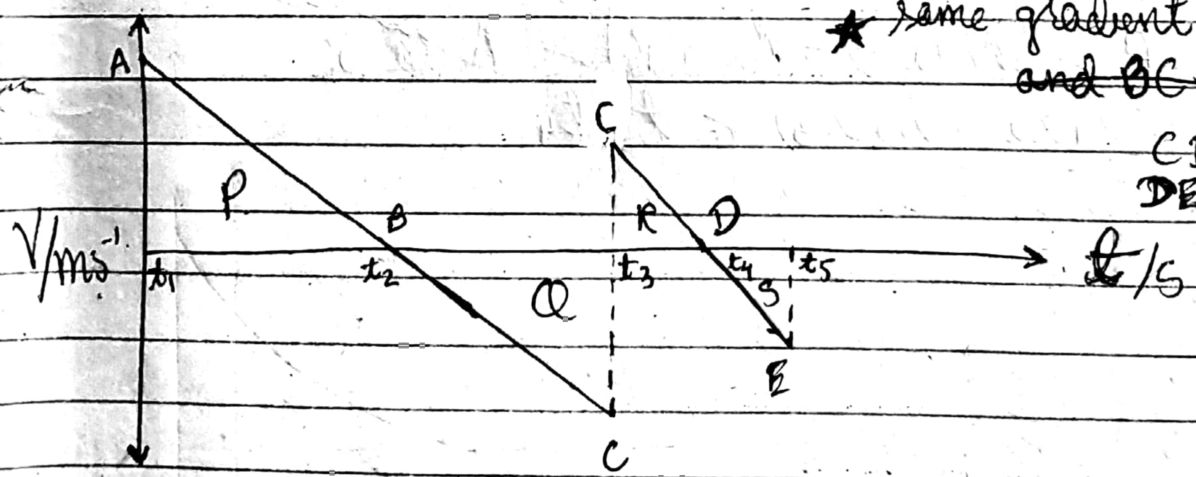
∝ → infinity

j)



Assumptions:

- ↑ upward motion is +ive
- time of contact is negligible
- time to change direction of motion is negligible



★ same gradient of AB, ~~and BC~~ BC, CD and DE = 9.81ms⁻²

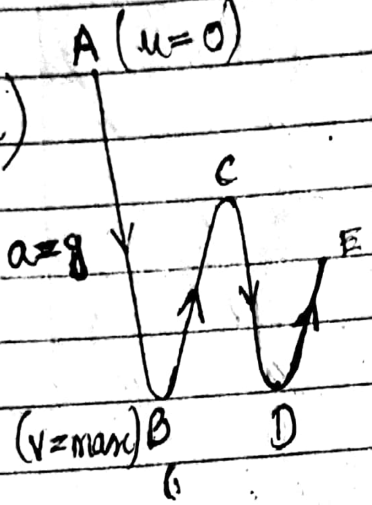
★ $(V_A = V_C) > (V_C = V_E)$

★ $(t_1 t_2 = t_2 t_3) > (t_3 t_4 = t_4 t_5)$

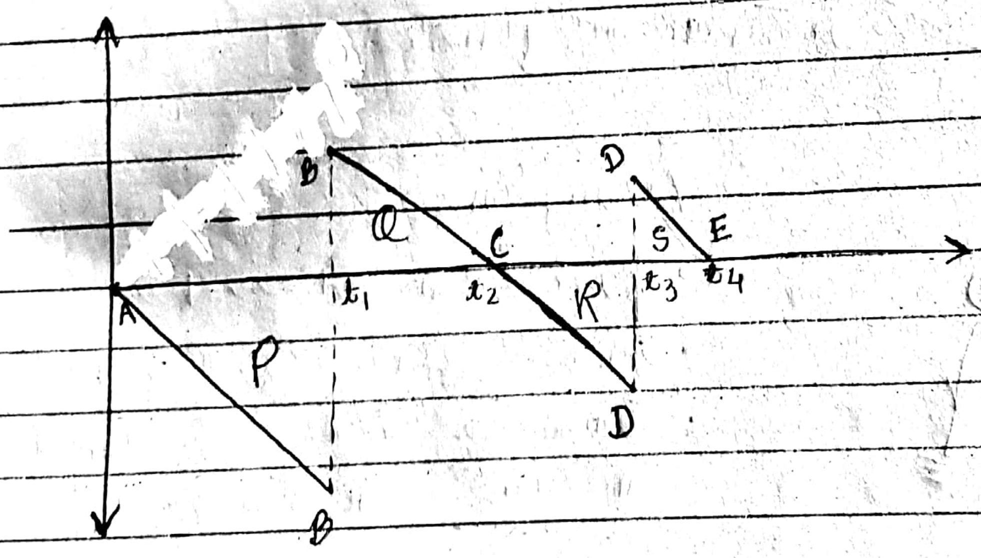
★ (Area P = Area Q) > (Area R = Area S)

★ gradient of AB = BC = CD = DE = 9.81 ms^{-2}

k)



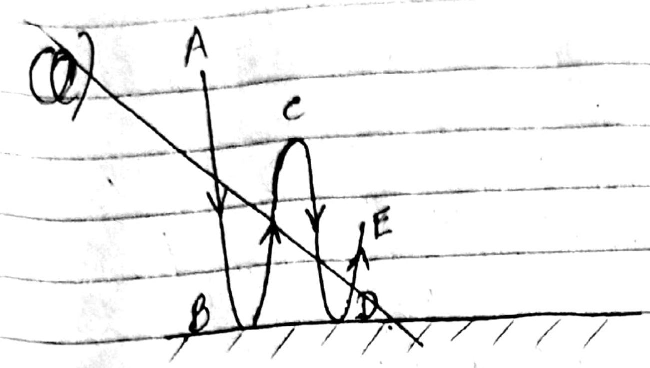
★ same assumptions as in (j)



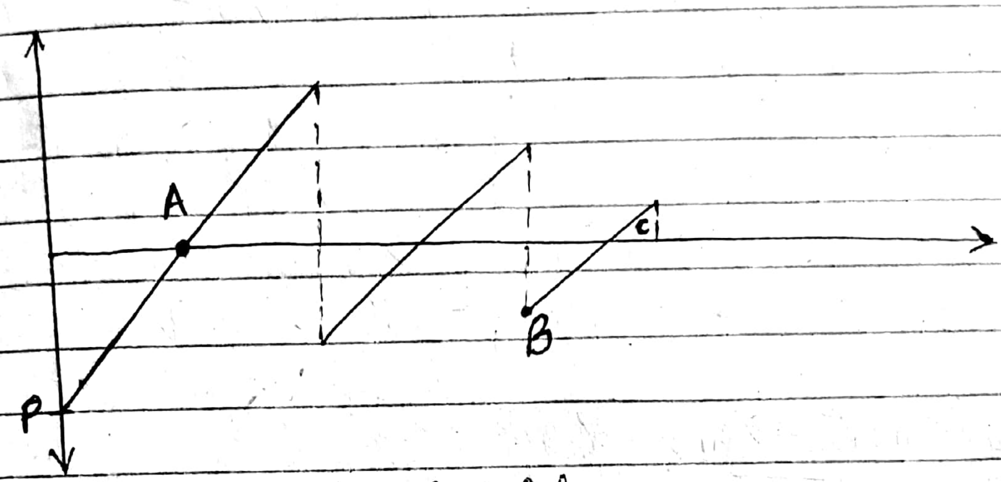
★ Area P > (Area Q = Area R) > Area S

★ t_1 > (t_1t_2 = t_2t_3) > t_3t_4

Q)

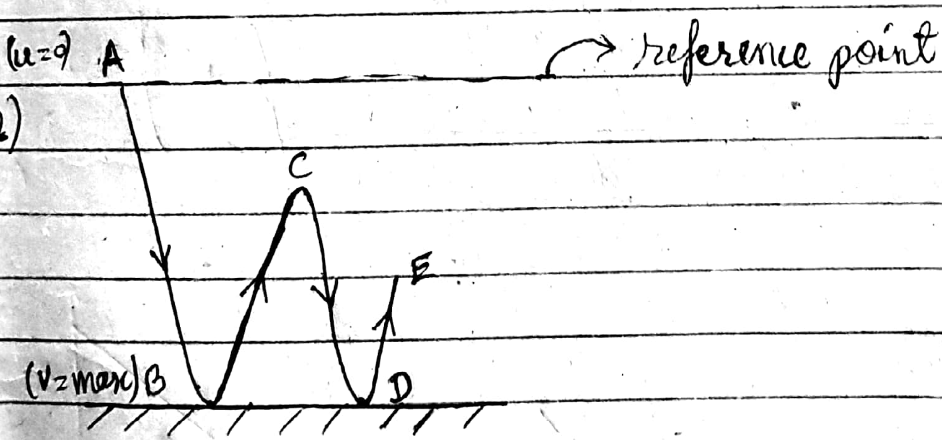


Q)



A → max height
B → Rebounding position 2nd Time
C → Region which may

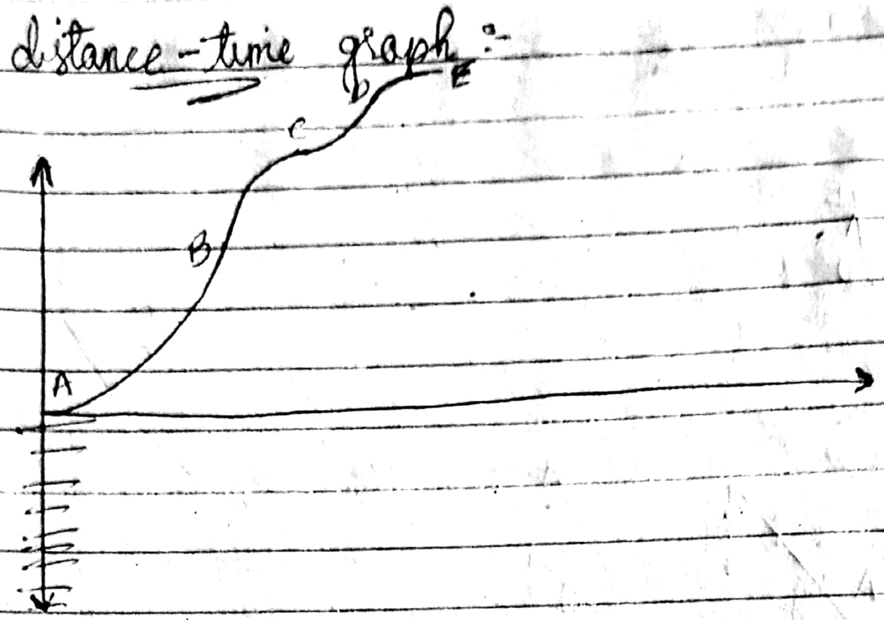
Q)



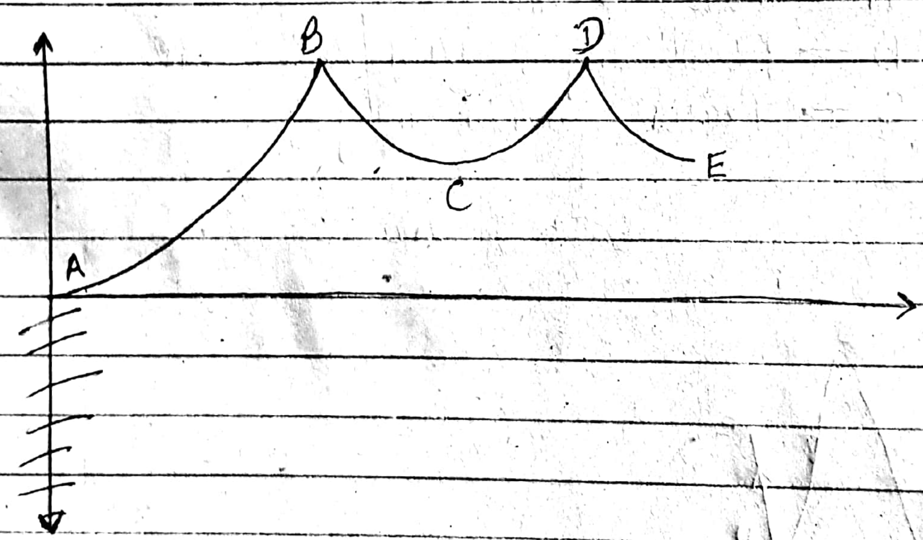
Assumptions:

- Reference position is 'A'
- upward motion is +ive

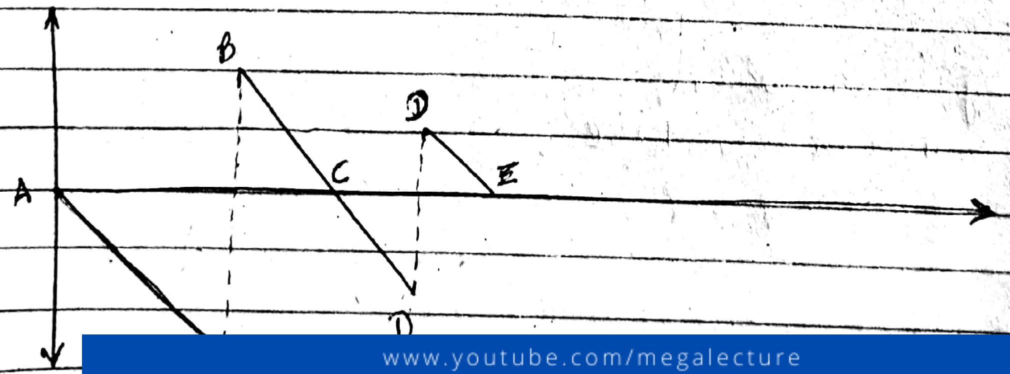
i) distance-time graph:-



ii) displacement-time graph



iii) velocity-time graph

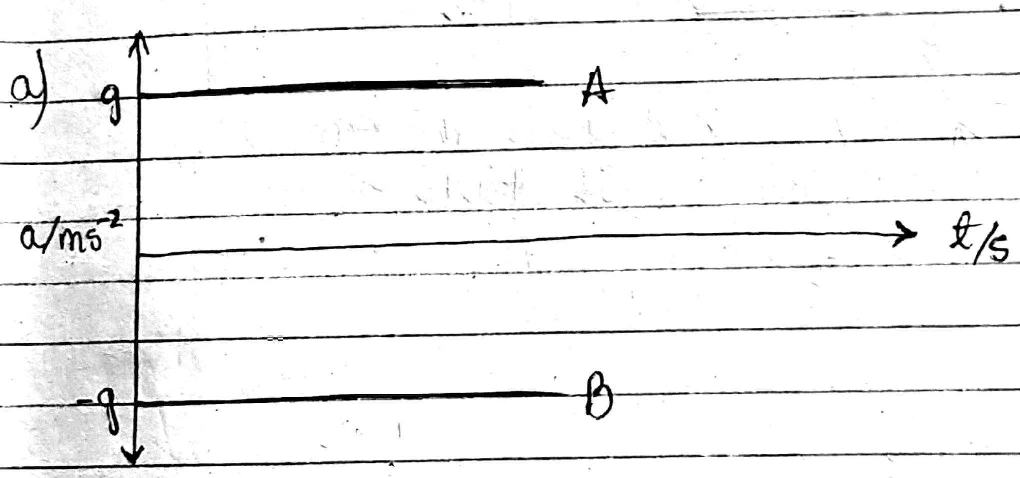


⇒ Acceleration - time graph

- Acceleration → y - axis
- time → x - axis

- **Results:-**

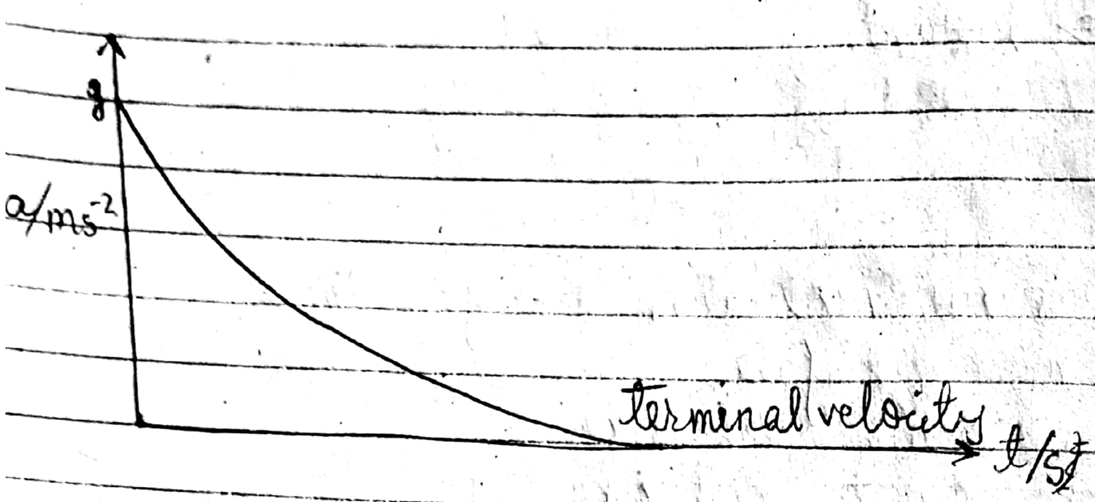
*(i) Instantaneous Acceleration → y - axis
(ii) motion of free fall
(iii) motion in air resistance
(iv) motion due to collision.

a) 

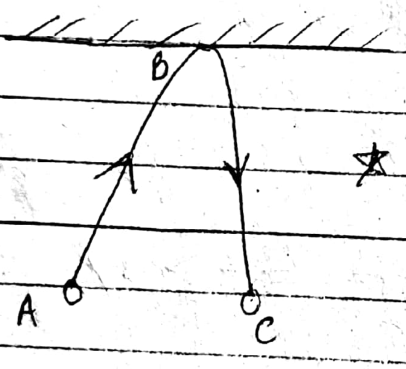
A ⇒ uniform acceleration when upward motion is -ive either the object moves upward or downward

B ⇒ uniform acceleration when " " " is +ive either the object moves upward or downward.

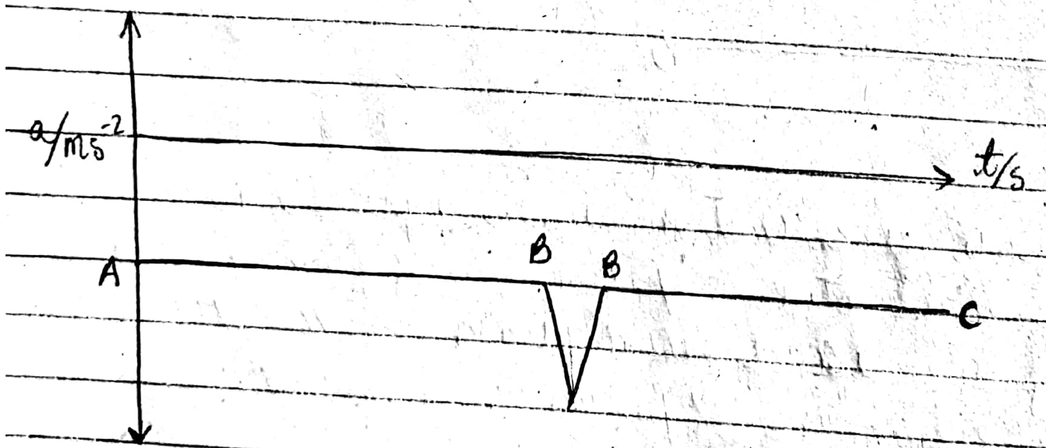
b) Motion in air resistance of an object falling downward when upward motion is -ive



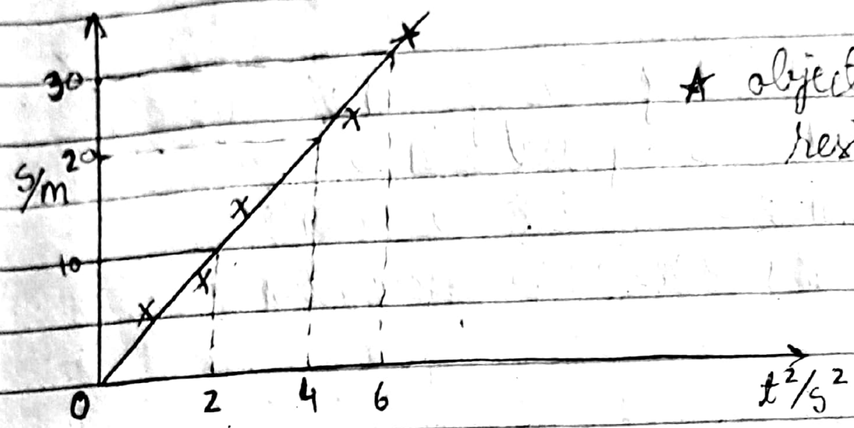
c)



★ upward motion is +ive



⇒ Displacement – (time)^2 graph



★ object starts from rest

Calculate:-

i) Gradient of graph

$$\text{Gradient} = \frac{30-0}{6-0}$$

$$= 5\,ms^{-2}$$

ii) Acceleration of object

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

$$s = 0 + \frac{1}{2}at^2$$

$$a = 2\left(\frac{s}{t^2}\right)$$

a = 2(gradient of graph)

$$a = 2(5.0)$$

$$a = 10\,ms^{-2}$$

⇒ Acceleration due to gravity

→ def:-
All bodies irrespective of their masses fall freely due to gravitational pull of Earth and move with a constant acceleration known as acceleration due to gravity.

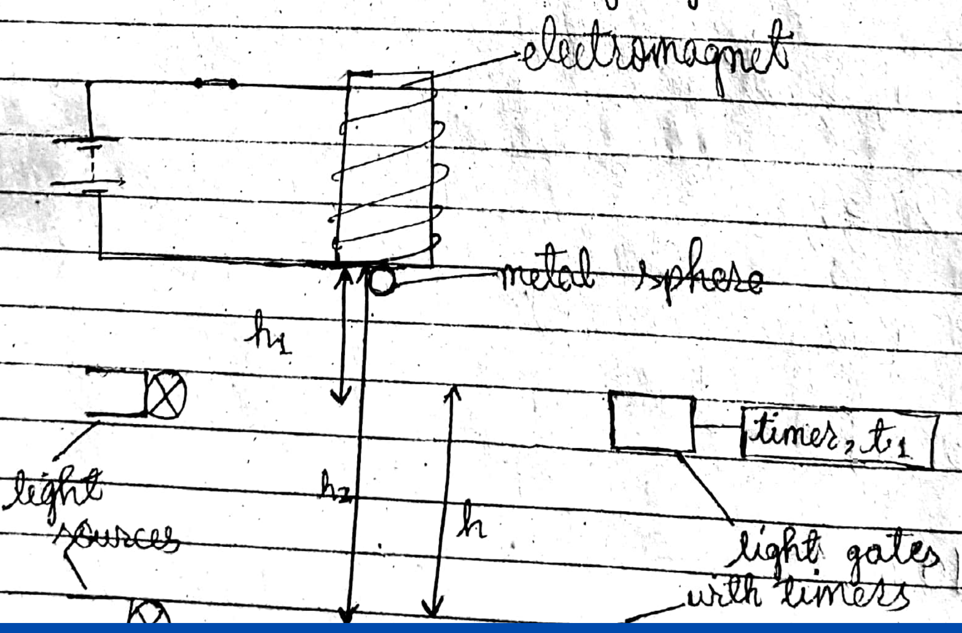
→ Symbol:- g

→ Value:- For Earth = $9.81\ ms^{-2}$

→ Sign Convention:- ~~(i) upward~~

(i) upward motion↑, g = −ive
(ii) downward motion, g = +ive

→ Experimental determination of g



For h_1

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

$h_1 = (0)(t_1) + \frac{1}{2} g t_1^2$

$h_1 = \frac{g t_1^2}{2}$ ---- (i)

For h_2

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

$h_2 = (0)(t_2) + \frac{1}{2} g t_2^2$

$h_2 = \frac{g t_2^2}{2}$ ---- (ii)

~~For h~~ Subtracting (i) from (ii)

$h_2 - h_1 = \frac{g}{2}(t_2^2 - t_1^2)$

$h = \frac{g}{2}(t_2^2 - t_1^2)$

$g = \frac{2h}{t_2^2 - t_1^2}$

Q) A vehicle moving at $30\ ms^{-1}$ is brought to rest after travelling 20m. What distance should it travel before ~~it~~ coming to rest, if the speed is $90\ ms^{-1}$ using same braking force.

★ same braking force means, acceleration is same in both

$$\frac{2aS_2}{2aS_1} = \frac{V_2^2 - u_2^2}{V_1^2 - u_1^2}$$

$$\frac{S_2}{20} = \frac{0^2 - 90^2}{0^2 - 30^2}$$

$$S_2 = \left(\frac{+8100}{+900}\right)(20)$$

$$S_2 = 180\ m$$

Work done against motion = loss of E_K

$$FS = \frac{1}{2}mv^2$$

$$\frac{(F)(S_2)}{(F)(S_1)} = \frac{\frac{1}{2}mv_2^2}{\frac{1}{2}mv_1^2}$$

$$\frac{S_2}{20} = \frac{90^2}{30^2}$$

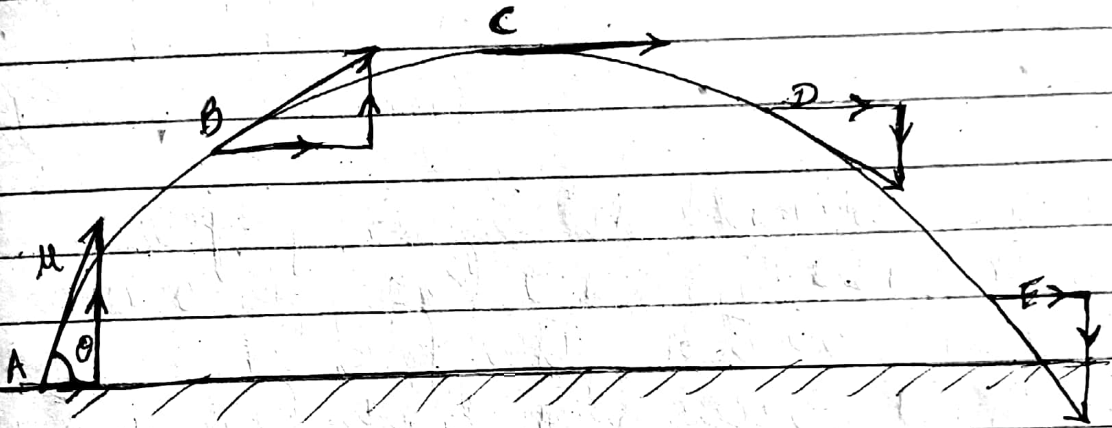
$$S_2 = 180m$$

Worksheet (Kinematics)

- when accelerating, then displacement-time graph is always a curve ⇒ Q1
- time of contact is only neglected when a situation is given i.e. a ball is thrown... and not in case of a graph ⇒ Q9

⇒ Motion in two dimensions (Projectile)

def: When a body is thrown in such a way that it makes an angle 'θ' with the horizontal, then it moves along a curved path due to gravitational pull of earth. Such a motion in 2 dimension is called projectile and the path traced by the projectile is called trajectory.



Analysis

At any position:-

(i) Vertical component of velocity = $V \sin \theta$
(ii) Horizontal " " " = $V \cos \theta$

★ θ°	0	30	45	60	90
sinθ	0	0.5	0.707	0.86	1
cosθ	1	0.866	0.707	0.5	0

⇒ value of 'sinθ' ↑ when value of 'θ' ↑ and vice versa

★ $\sin\theta \propto \theta$

★ $\cos\theta \propto \frac{1}{\theta}$

⇒ value of 'cosθ' ↑ when value of 'θ' ↓ and vice versa

Motion	A	B	C	D	E	Result
Vertical	$u \sin\theta$	$V_B \sin\theta_B$	$V_C \sin\theta_C$	$V_D \sin\theta_D$	$V_E \sin\theta_E$	Vertical component of velocity vary
	Max	Decreases	0	Increases	Max	
Horizontal	$u \cos\theta$	$V_B \cos\theta_B$	$V_C \cos\theta_C$	$V_D \cos\theta_D$	$V_E \cos\theta_E$	Horizontal component of velocity remains constant
	= constant	(↓)(↑) = constant	Constant	constant	constant	

Note:-

(i) The horizontal velocity in projectile remain constant as no force is acting along this direction. Therefore, the horizontal acceleration throughout motion is 0 → if we neglect air resistance, then $\Sigma f_H = 0$ i.e. horizontal velocity = constant, otherwise not.

(ii) The ~~vertt~~ vertical velocity decreases and becomes 0 at the highest point and ~~incer~~ increases during decending due to gravitational pull of earth.

(iii) The vertical acceleration at any position remain $9.81\ ms^{-2}$

(iv) The E_K at any position, even at the highest point is not ≠ 0.

• the direction in which projectile is moving, we only have to refer to that component (i.e. either horizontal or vertical)

⇒ **Hight gained by projectile**

Consider vertical motion

$2a_v S_v = V_v^2 - u_v^2$

$2(-g)S_v = 0^2 - (u \sin \theta)^2$

$$S_v = \frac{(u \sin \theta)^2}{2g}$$

★ horizontal distance travelled due to horizontal component

★ vertical distance travelled due to vertical component

⇒ **Time to reach the highest point**

Consider vertical motion

$V_v = u_v + a_v t$

$0 = u \sin \theta + (-g) t$

$$t = \frac{u \sin \theta}{g}$$

⇒ **Time of flight:**

This is the time to go up and come down.

$T = 2t$

$$T = \frac{2u \sin \theta}{g}$$

⇒ **Range:-**

It is the horizontal distance travelled by the projectile

consider horizontal motion

$$S_H = V_H T$$

$$S_H = (u\cos\theta)\left(\frac{2u\sin\theta}{g}\right)$$

$$= \frac{u^2}{g}\left[2\sin\theta\cos\theta\right]$$

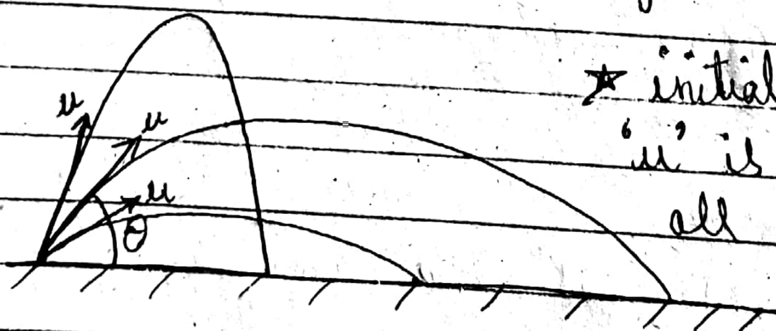
Formula:-

$$\sin(2\theta) = 2\sin\theta\cos\theta$$

$$\sin(20) = 2\sin 10 \cos 10$$

$$\boxed{S_H = \frac{u^2}{g}\sin 2\theta}$$

⇒ **Angle for maximum range**



★ initial velocity i.e. 'u' is same in all the 3. The variation in the horizontal distance travelled is due to different angles

Range is Max if

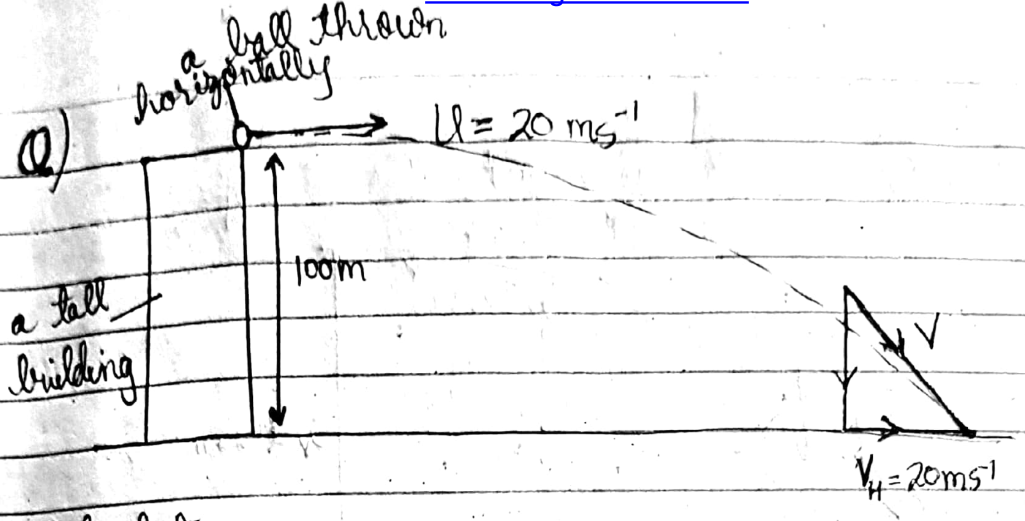
$$\sin 2\theta = \max$$

$$\sin 2\theta = 1$$

$$2\theta = \sin^{-1}(1)$$

$$2\theta = 90 \ldots$$

Q)



Calculate

i) the velocity with which it hits the ground [4]
ii) the time of flight [1]

i) $2as_v = v_v^2 - u_v^2$

$2(9.81)(100) = V_v^2 - (0)^2$

$V_v = 44.3\ ms^{-1}$

$V = \sqrt{V_v^2 + V_H^2}$

$= \sqrt{(44.3)^2 + (20)^2} = 48.6\ ms^{-1}$

@ $\theta = \tan^{-1}\left(\frac{V_v}{V_H}\right) = \tan^{-1}\left(\frac{44.2}{20}\right) = 65.7°$

ii) $V_v = u_v + a_v t$

$44.3 = 0 + 9.81t$

$t = 4.5s$

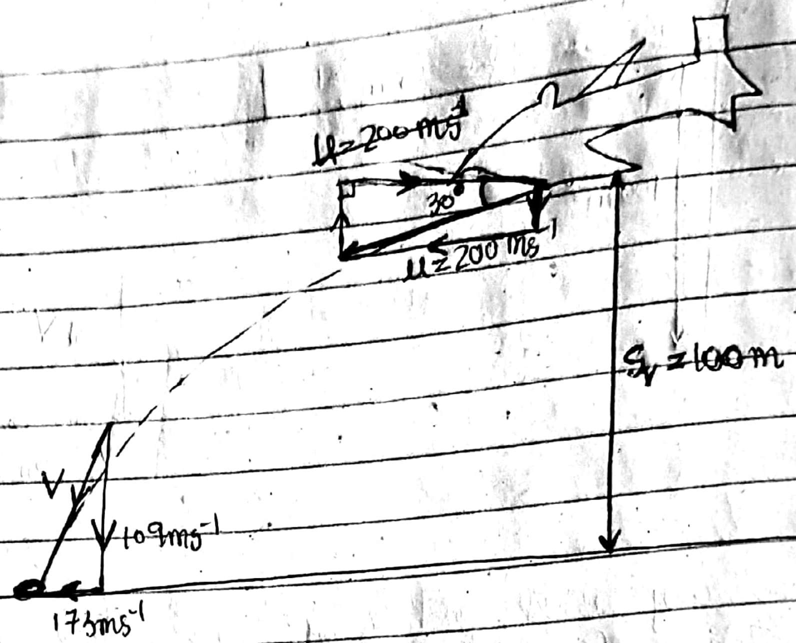
iii) Range of projectile

$S_H = V_H t$

$S_H = (20)(4.5)$

$S_H = 90m$

Q)



a) Calculate

i) Initial vertical velocity
ii) initial horizontal velocity
iii) final vertical velocity
iv) final velocity
v) time taken to hit the ground
vi) range of projectile

(i) ~~$2as = V_v^2 - u_v^2$~~ $\quad U_V = U\sin\theta = 200\sin 30^\circ$
~~$2(9.81)(100) =$~~ $\quad = 100\ ms^{-1}$

ii) $U_H = U\cos\theta = 200\cos 30 = 173\ ms^{-1}$

iii) $2a_v S_v = V_v^2 - U_v^2$
$2(9.81)(100) = V_v^2 - (100)^2$
$V_v = 109\ ms^{-1}$

iv) $V = \sqrt{(109)^2 + (173)^2}$
$= 204\ ms^{-1}$

@ $\theta = \tan^{-1}\left(\frac{109}{\;}\right) = 32.2^\circ$

v) $V_v = u_v + a_v t$

$109 = 100 + (9.81)t$

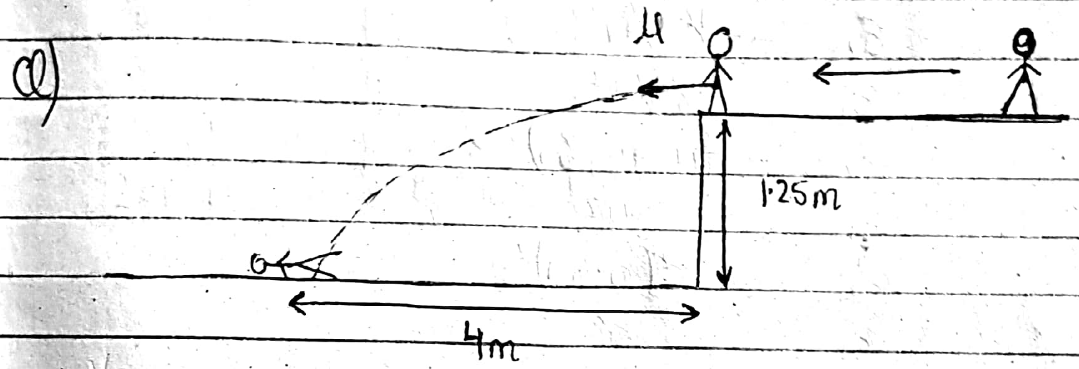
$t = 0.917 s$

vi) $S_H = V_H t$

$= (173)(0.917)$

$= 159 m$

d)



Calculate the initial horizontal velocity ???

First calculate time by considering the vertical motion

$$S_v = u_v t + \frac{1}{2} a_v t^2$$

$$1.25 = 0 + \frac{1}{2}(9.81) t^2$$

$$t = \sqrt{\frac{2.50}{9.81}}$$

$$t = 0.505 s$$

Consider horizontal motion

$S_H = V_H t$

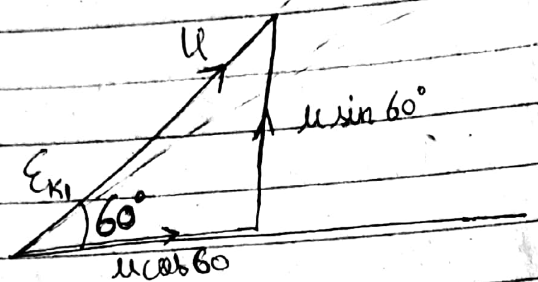
$4 = V_H (0.505)$

$V_H = 7.92 ms^{-1}$

Q) A ball of mass 0.2 is projected with initial velocity u and E_{K_1} at 60° with the horizontal. What is its E_K in terms of E_{K_1} at the highest point

$E_2 = ?$

$V_H = u\cos 60°$



$$\frac{E_2}{E_1} = \frac{\frac{1}{2} m v^2}{\frac{1}{2} m v^2}$$

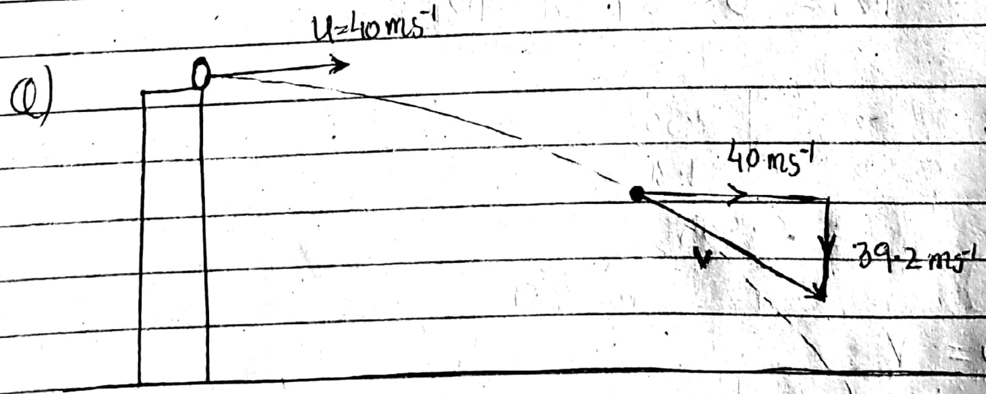
$$\frac{E_2}{E_1} = \frac{(u\cos 60)^2}{u^2}$$

$$\frac{E_2}{E_1} = \frac{u^2 (0.50)^2}{u^2}$$

$$E_2 = \frac{E_1}{4}$$

☆ when question says 'calculate in terms of...', always solve it by ratio method.

Q)



Calculate

i) vertical velocity after ~~0.4 s~~ 4.0 s
ii) horizontal distance travelled in 4.0 s
iii) vertical distance travelled in 4.0 s
iv) velocity after 4.0 s

i) ~~2as~~ $V_v = u_v + a_v t$

$V_v = 0 + (9.81)(4.0)$

$V_v = 39.2 \text{ ms}^{-1}$

ii) $S_H = V_H t$

$S_H = (40)(4.0)$

$S_H = \underline{160 \text{ m}}$

iii) $S_v = u_v t + \frac{1}{2} a_v t^2$ → $2as = v^2 - u^2$ can also be used

$S_v = 0 + \frac{1}{2}(9.81)(4.0)^2$

$S_v = \underline{78.5 \text{ m}}$

iv) $V = \sqrt{(39.2)^2 + (40)^2}$

$= 56 \text{ ms}^{-1}$

(a) $\tan^{-1} = \left(\frac{39.2}{40}\right) = 44.4°$

Dynamics

Def:- Study of motion with reference to force and mass is called dynamics.

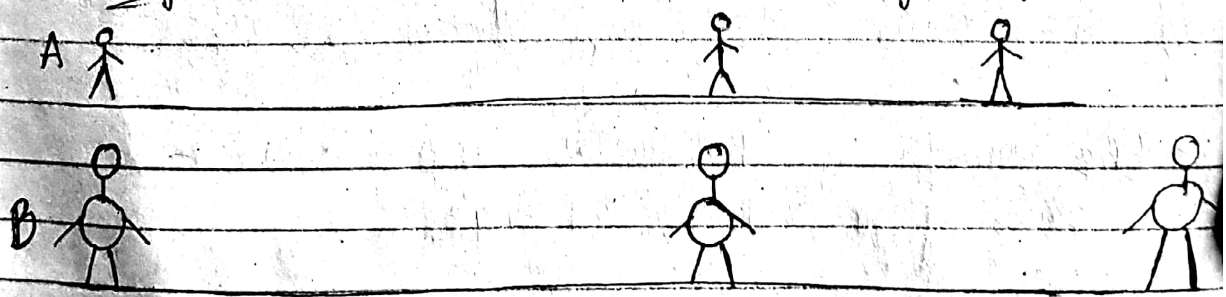
⇒ Inertia ⟶ physical property

⇒ def:-
The inability of a body to change its state of rest or of ~~unifo~~ motion with uniform velocity.
↳ straight line motion

- uniform velocity is always in st. line

⇒ dependance:-
★ Mass of object
★ Greater the mass, larger is the inertia

⇒ Example:- Race b/w slim and fat person



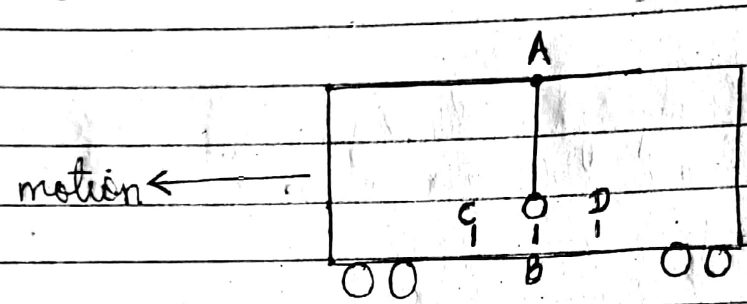
→ Observation:-

* From motion to rest & $t_A < t_B$

→ Reason:- $(mass)_A < (mass)_B$

→ Result:- $(Inertia)_A < (Inertia)_B$

⇒ Ex. 2:- Simple pendulum in a train



What is the position of bob if:-

a) train is at rest ⇒ B

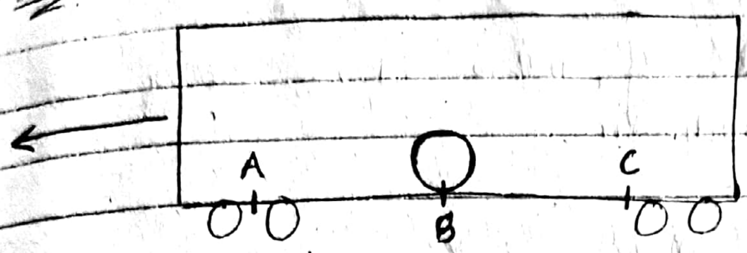
b) train starts motion towards left

c) train moves with uniform velocity towards left

d) the train decelerates towards left

* the concept of inertia is applied when the state of motion is changed.

⇒ Ex.3:-



* at every situation ball is considered to be at B

Ball is at rest on a mark on floor at B. What is the situation of Ball if

a) train moves towards left with an acceleration
⇒ C

b) " " " " " zero acceleration
⇒ B

c) " " " " " a retardation
⇒ A

⇒ Mass

⇒ def: Measure of inertia in a body is called mass

⇒ Symbol: m

⇒ Conservation: Remain conserve everywhere in the universe

⇒ P.S: Scalar

⇒ Measuring device: Top pan balance

⇒ Momentum

⇒ def: The product of mass and velocity is called momentum.

⇒ Symbol:- p (small letters)

⇒ Formula:- $p = mv$, where m = mass, v = velocity

⇒ Unit:- (1-) $kg\,\frac{m}{s}$

(2-) $\left(kg\,\frac{m}{s}\right)\left(\frac{s}{s}\right)$

$= \left(kg\,\frac{m}{s^2}\right)(s) = Ns$

m → mass

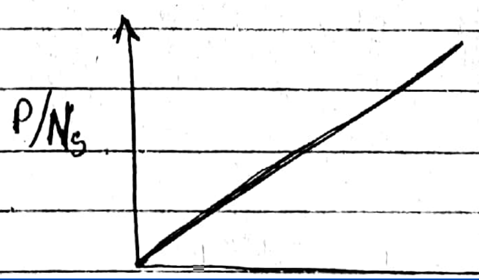
a → acceleration

F → force i.e. $F = ma$

⇒ Dependance:-

i) mass of object:-

$p \propto m$ for constant velocity

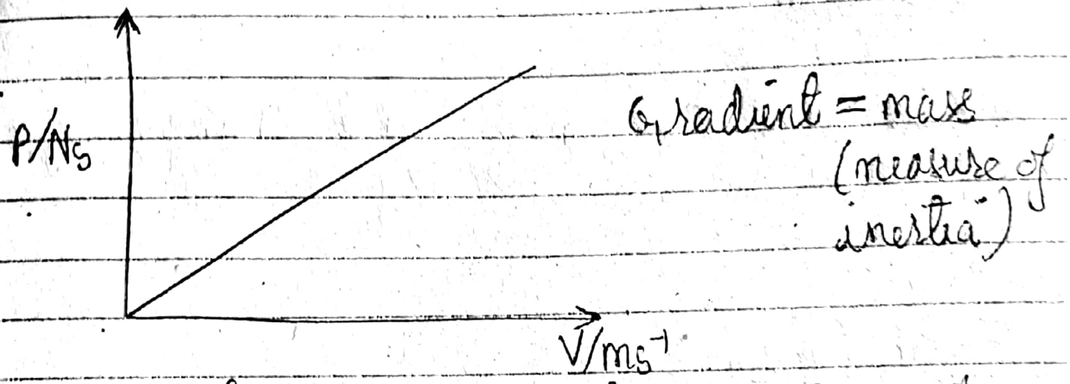


Gradient = velocity

e.g:-
Difficult to stop a truck in comparison to a bike bicycle, moving with same velocity due to greater mass and hence inertia / momentum.

(ii) Velocity of object :-

$p \propto v$ for constant mass



e.g:-
Difficult to stop a cycle ~~to~~, moving at higher velocity in comparison to identical cycle at lower velocity, because of momentum

⇒ Force

⇒ def :-
Change of momentum per unit time is called force.

★ base definations are to be written and not the derived ones.

⇒ Symbol :- F

⇒ Formula :-

(i) $F = \frac{\Delta P}{\Delta t}$ ⇒ basic formula

$\left(F = \frac{dp}{dt}\right)$

$F = \frac{\Delta (mv)}{\Delta t}$

⇒ Dependance :-

Case 1 :- Constant mass and change of velocity

$F = m\left(\frac{\Delta v}{\Delta t}\right)$

$F = ma$

So, $F \neq 0$, if m = constant and $\left(\frac{\Delta v}{\Delta t}\right) \neq 0$

e.g :-

i.e (1) an accelerated battery driven (cell) toy vehicle/car

(2) A stone moving in a vertical circle circle

(3) Motion of a paratroper when terminal velocity is not achieved

Case 2 :- Constant velocity, but change of mass

$F \neq 0$, if velocity = constant, but $\left(\frac{\Delta m}{\Delta t}\right) \neq 0$

i.e., e.g.:

1-) A ~~perl~~ petrol driven vehicle move with uniform velocity

2-) Conveyor belt used to transport luggage

3-) Maximum thrust on rocket due to combustion of petrol.

4-) Fluid coming out from a vehicle moving with uniform velocity (e.g. a truck unloading cement ~~onto~~ onto the road)

Case 3:- Both mass and velocity changes

$F \neq 0$, if $\frac{\Delta m}{\Delta t}$ and $\frac{\Delta v}{\Delta t}$ ~~vary~~ vary

i.e., e.g.:

1-) an accelerated vehicle on a motor way

⇒ **Notes:**

$$F = \frac{\Delta p}{\Delta t}$$

$$\Delta p = F \Delta t$$

(i) If force = constant, then

ii) $F = \frac{\Delta p}{\Delta t} \Rightarrow F$ ↓ if Δt ↑ for Δp = constant
↓ momentum is being changed, but change of momentum is constant

i.e., e.g.:-

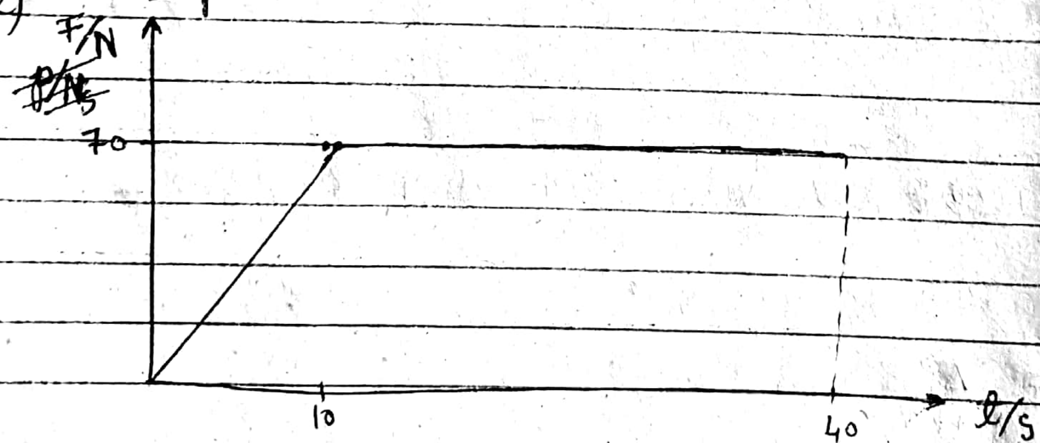
1-) A fielder moves his hands in backward direction while catching a ball

2-) Bumpers of modern vehicles are made of plastic & fibres

3-) ~~When~~ An athlete jump on a soft matress / grassy ground, rather than cemented floor.

(iii) Area under force against time graph defines the change of momentum or ~~imp~~ impulse

(c) ~~impulse~~



Calculate the change in momentum

$\frac{1}{2} \times (40 + 30)(70)$

$= (70)(35)$

$= 2450 \text{ kg ms}^{-1}$

(iv) Impulse

since $F = \frac{\Delta p}{\Delta t}$

$F \Delta t = \Delta p$

Impulse = change of momentum

⇒ def:-
The product of force and time of contact is called impulse

⇒ P.S :- vector

⇒ Newton's 1st law of motion (law of inertia)

⇒ Statement:-
Every body continue its state of rest or of uniform motion in a straight line until no resultant force acts on it.

★ not applied on circular motion

⇒ Newton's 2nd law of motion

⇒ Statement :-
Rate of change of momentum is directly proportional to an applied force.

⇒ Mathematical form

→ $F \propto \frac{\Delta p}{\Delta t}$

$F = K \frac{\Delta p}{\Delta t}$

where K is the constant of propotionality and its value in S.I ~~unit~~ is 1

$F = \frac{\Delta p}{\Delta t}$

→ If mass of object is kept constant and velocity changes than,

$F = m\left(\frac{\Delta v}{\Delta t}\right)$

$F = ma$

i.e. Resultant force can cause acceleration to a constant mass

⇒ Newton's 3rd law of motion

⇒ Statement :-
Forces b/w 2 interacting bodies are of same type and have same magnitude, but act ~~in~~ in opposite directions.

⇒ Principle of conservation of momentum

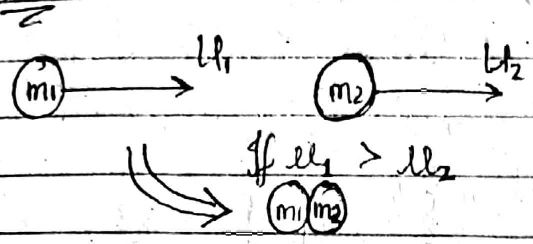
⇒ Statement :-
(Isolated system means no external ~~extending~~ force is acting on ~~it~~ the object) → closed system

In an isolated system, the total momentum of the bodies before and after collision remain conserved.

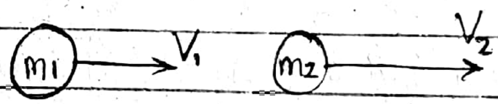
• momentum of an isolated system before and after collision remain conserved

⇒ **Mathematical form**

a) **Collision:-**

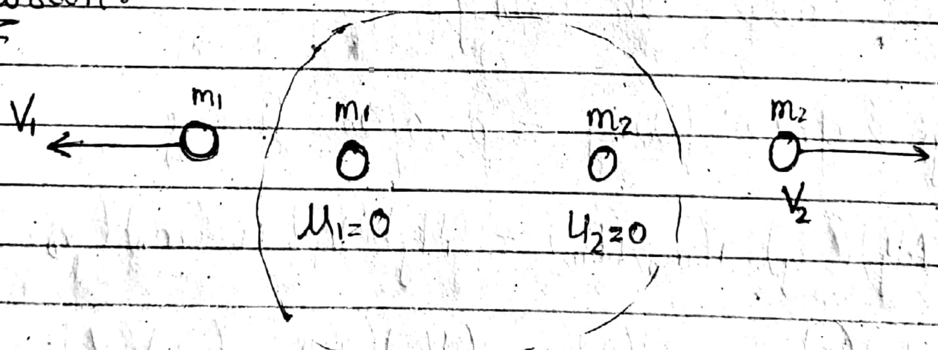


Total momentum before collision = Total momentum after collision



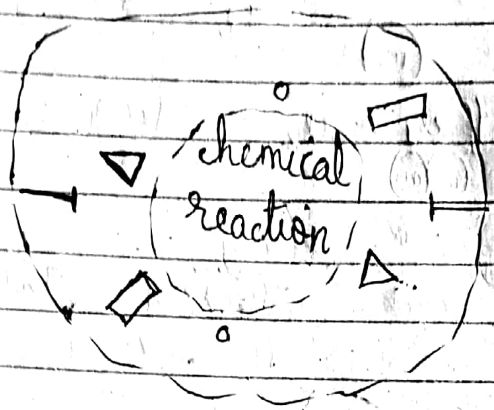
$m_1u_1 + m_2u_2 = m_1V_1 + m_2V_2$

b) **Explosion:-**



Total momentum before explosion = Total momentum after explosion

→ ~~metallic~~ metallic beads / material always move in opposite direction after explosion to keep their resultant momentum 0.



Q) Why the recoiling speed of gun is lesser than ~~bull~~ bullet on firing.

$$p \text{ before firing} = p \text{ after firing}$$

$$(M_g)(u_g) + (m_b)(u_b) = (M_g)(V_g) + (m_b)(V_b)$$

$$(M_g)(0) + (m_b)(0) = (M_g)(-V_g) + (m_b)(V_b)$$

$$M_g \uparrow \; V_g \downarrow = m_b \downarrow \; V_b \uparrow$$

⇒ Collision:-

Interaction b/w 2 bodies due to their contact which exert equal and opposite force on each other by Newton's 3rd law of motion.

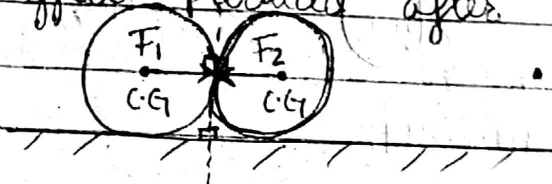
→ Classification (nature) of collision:-

→ (i) Head-on- collision:-

- forces lie on ~~c.g~~ centre of gravity
- forces are concentrated on centre of gravity

★ forces are concentrated at the centre of gravity of object and the tangent at the point of application of force is perpendicular to the plane where both objects move (((dictated by Sir)))

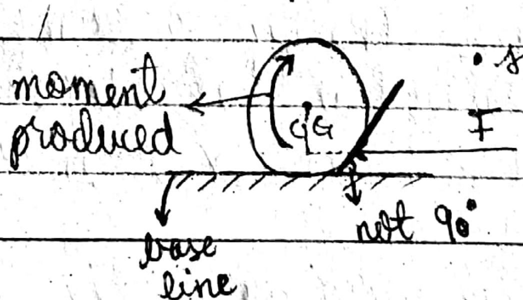
- no spinning effect produced after collision



- tangent plotted at the point of collision is ⊥ to the plain on which the objects move

→ (ii) Inclined ~~plane~~ collision:-

★ collision in which forces are not concentrated at the centre of gravity of objects and the tangent at the point of application of force is not 90° to the ~~plance~~ plane where both ~~these forces act~~ objects move.



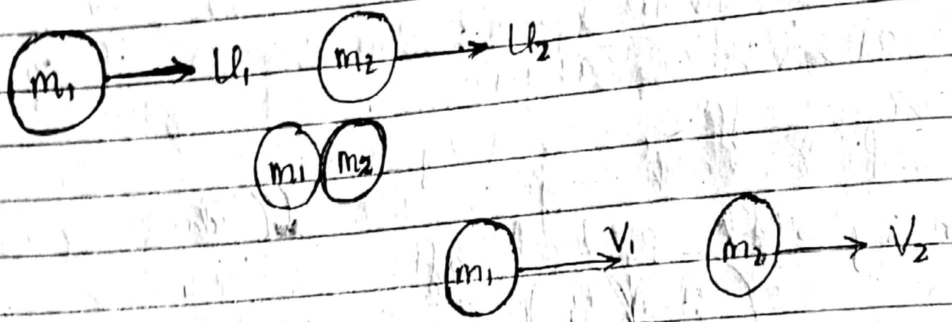
- spinning ~~effect~~ produced ~~occurs in object~~ after collision
- tangent at the position of collision is not 90° to the base line

⇒ Types of collisions

a) Elastic
b) Inelastic

a) → def: collision in which momentum and E_K of objects before and after interaction remain conserve.

→ Mathematical form:-



Conservation of momentum:

$$m_1 U_1 + m_2 U_2 = m_1 V_1 + m_2 V_2$$

Conservation of E_K:

$$\frac{1}{2} m_1 U_1^2 + \frac{1}{2} m_2 U_2^2 = \frac{1}{2} m_1 V_1^2 + \frac{1}{2} m_2 V_2^2$$

→ Note:-

i) As per kinetic theory assumptions, collision of gas particles is always elastic.

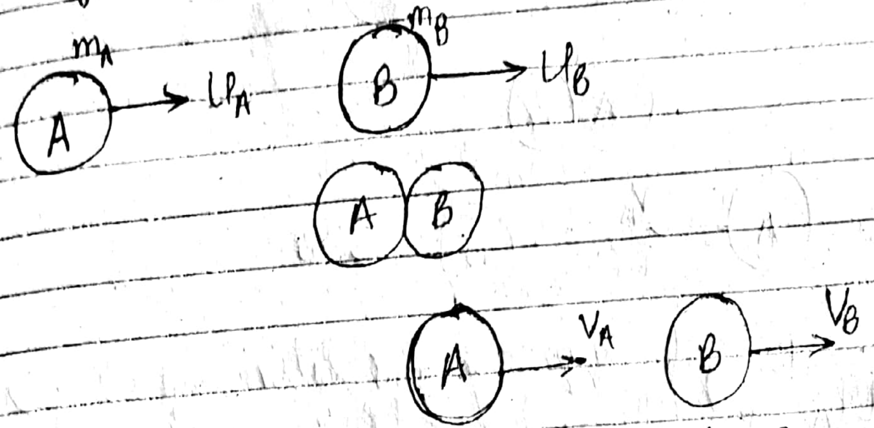
ii) Total energy is always conserved in every type of collision.

[illegible]or a perfect elastic collision, the relative [illegible] of approach must be equal to the speed of separation. (((most imp!!!)))

→ [illegible] not stick to each other after an [illegible] collision, as this will make their relative [illegible] of separation = 0, and hence th[illegible] [illegible]tic.

e.g. of point (iii):-

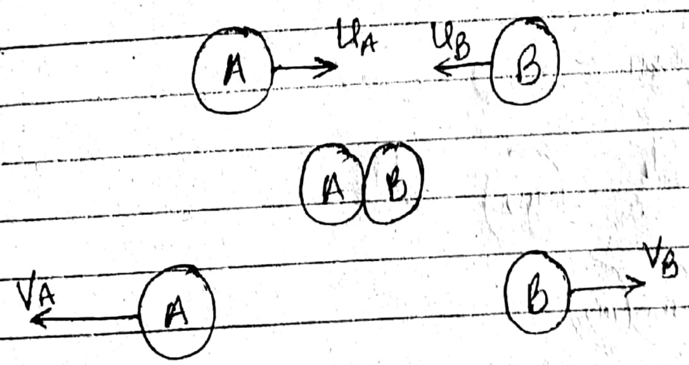
Ex. 1:- If both objects move in same direction



Relative speed of approach = Relative speed of separation

$u_A - u_B = v_B - v_A$

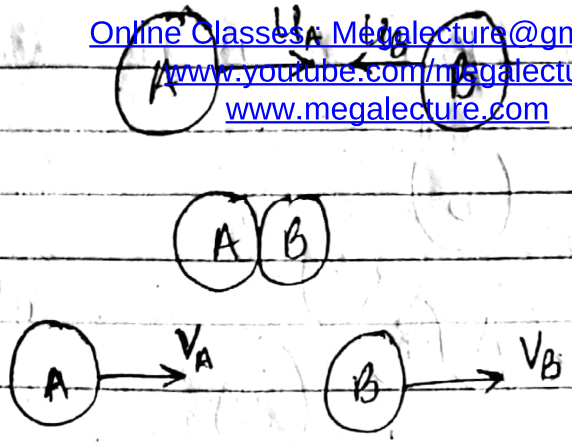
→ Ex. 2:- If both objects move in opposite directions



Relative speed of approach = Relative speed of separation

$u_A + u_B = v_A + v_B$

Ex. 3:- If both objects move in same direction after collision



Relative speed of approach = relative speed of separation

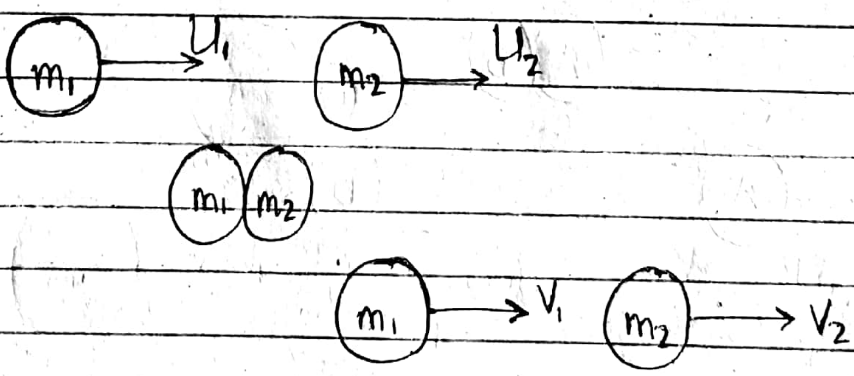
$$u_A + u_B = V_B - V_A$$

b) → def:-

collision in which momentum is conserved, but E_K before and after collision is not conserved.

e.g:- (i) explosion

→ mathematical form:



Conservation of momentum:-

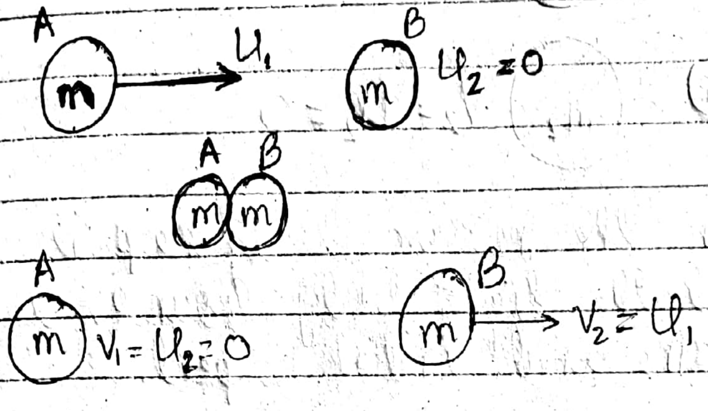
$$m_1 u_1 + m_2 u_2 = m_1 V_1 + m_2 V_2$$

Conservation of E_K:-

$$\frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 \neq \frac{1}{2} m_1 V_1^2 + \frac{1}{2} m_2 V_2^2$$

⇒ Special cases of elastic collision in one dimension

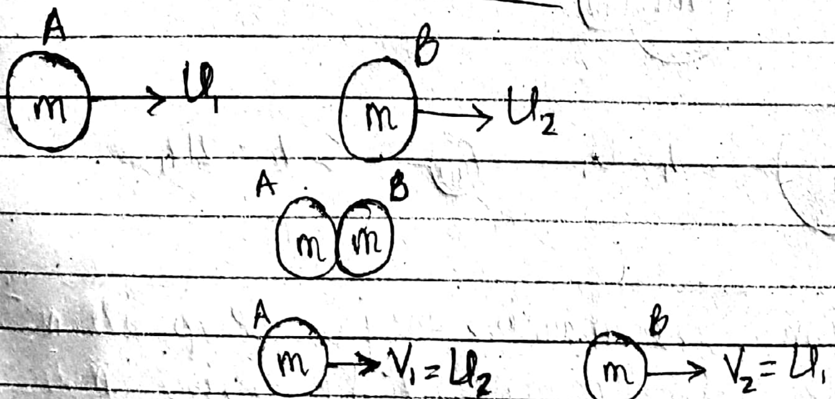
a) If a body collide with an identical body at rest :-



(e.g. snooker balls

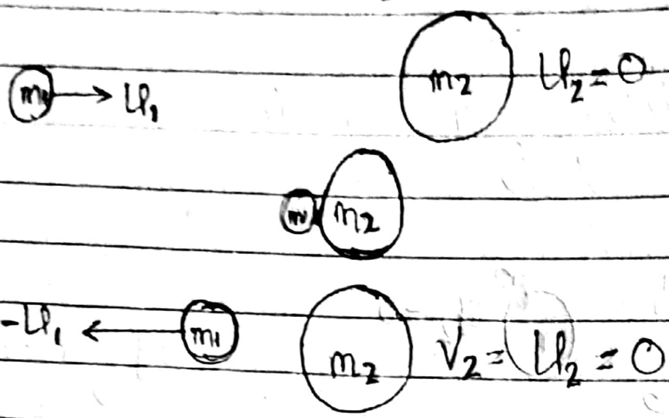
After collision, the first body will come to rest and second body move with an ~~end~~ initial velocity of first body.

b) If a body collides with an identical body in motion



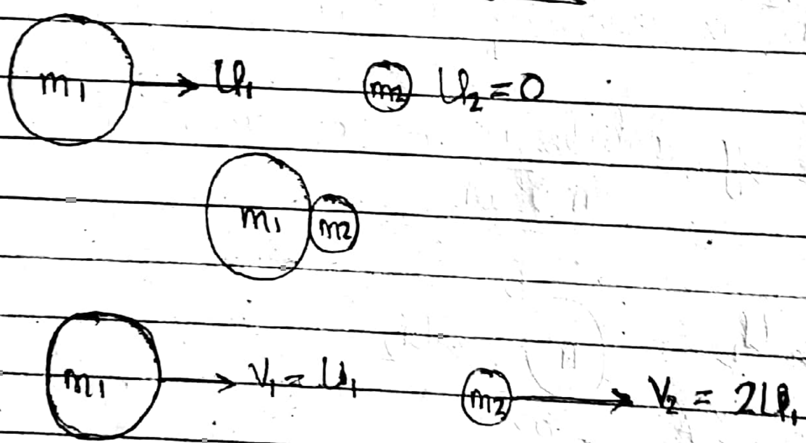
Velocities of both objects are interchanged after collision

c) If a light object collides with a massive object at rest:



After collision the massive body keep its state of rest and the light body bounces back with its same initial speed.

d) If a massive body collide with a light body at rest:



After collision the massive object keep its motion with same velocity and light object move with double the initial velocity of massive object.

e.g. collision of a truck and a cycle

- the smaller object's mass is neglected when compared with mass of massive object

Note for Inelastic collision:-
If 2 bodies stick together on collision and then move with a same velocity, so the relative speed of separation is 0 and the collision is inelastic.