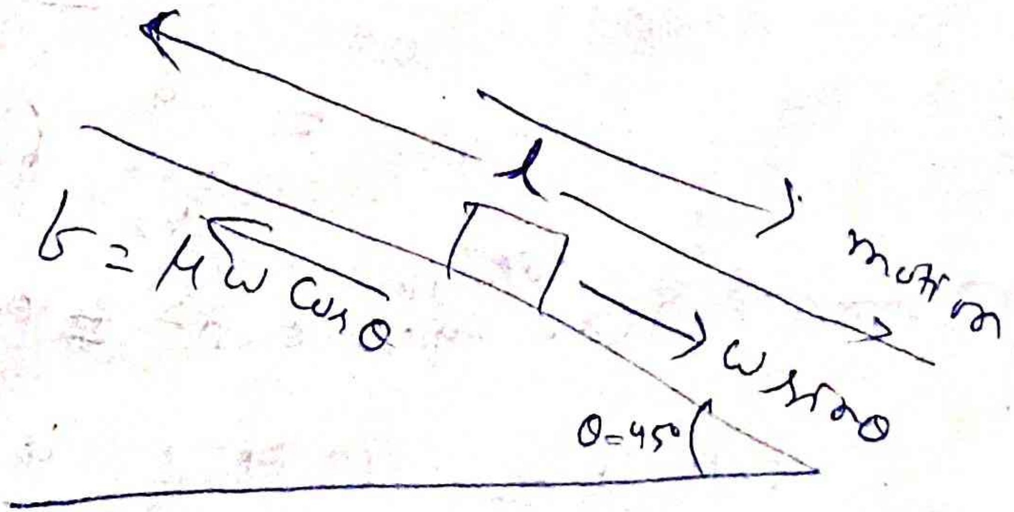
2. A body sliding on a rough inclined plane takes twice the time to cover the same type of frictionless inclined plane. Of the angle of inclination of the inclined plane be 45° in both of the cases, Calculate μ_K



Let us find the time taken by the body to slide down the frictionless 45° inclined plane of length l.

From the formula $S = ut + \frac{1}{2}at^2$ $\left(\because F = W\sin\theta \Rightarrow ma = mg\sin\theta \Rightarrow a = g\sin\theta\right)$

we get $l = 0 + \frac{1}{2} \cdot g\sin\theta \cdot t^2$

$$\Rightarrow \quad = \frac{1}{2} g \frac{1}{\sqrt{2}} \cdot t^2$$

$$\Rightarrow t^2 = \frac{2\sqrt{2}l}{g}$$

$$\Rightarrow t = \sqrt{\frac{2\sqrt{2}l}{g}}$$

Net force on the body on the rough plane

$$W\sin\theta - f = ma$$

$$\therefore a = \frac{W\sin\theta - f}{m}$$

$$= \frac{W\sin\theta - \mu_k W\cos\theta}{m}$$

$$= \cancel{mg\sin\theta \cdot \mu}$$

$$= \frac{W(\sin\theta - \mu_k\cos\theta)}{m}$$

$$= \frac{\cancel{m}g\left(\frac{1}{\sqrt{2}} - \mu_k\frac{1}{\sqrt{2}}\right)}{\cancel{m}}$$

$$= \cancel{\frac{g}{\sqrt{2}}(\frac{1}{\sqrt{2}})}$$

$$= \frac{g}{\sqrt{2}}(1 - \mu_k)$$

~~Now from equation~~ we know $S = ut + \frac{1}{2}at^2$

$$\Rightarrow l = 0 + \frac{1}{2}\frac{g}{\sqrt{2}}(1-\mu_k)t'^2$$

$$\Rightarrow t'^2 = \frac{2\sqrt{2}l}{g(1-\mu_k)}$$

$$\Rightarrow t' = \sqrt{\frac{2\sqrt{2}\,l}{g(1-\mu_k)}}$$

As per question $t' = 2t$

$\therefore t_1^2 = 4t^2$ (squaring both the sides)

$$\Rightarrow \frac{2\sqrt{2}\,l}{g(1-\mu_k)} = 4 \cdot \frac{2\sqrt{2}\,l}{g}$$

$$\Rightarrow \frac{1}{1-\mu_k} = \frac{4}{1}$$

$$\Rightarrow 4 - 4\mu_k = 1$$

$$\Rightarrow 4 - 1 = 4\mu_k$$

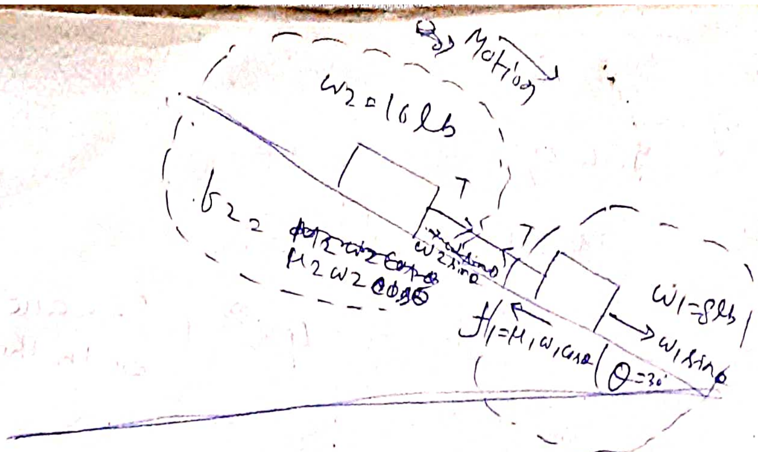
$$\Rightarrow 3 = 4\mu_k$$

$$\Rightarrow \mu_k = \frac{3}{4} = .75 \text{ (ans)}$$

2. An 8 lb block and 16 lb block connected together by a string slide down a 30° inclined plane. The co-efficient of kinetic friction between the 8 lb block and plane is 0.1; between the 16 lb block and the plane it is 0.2

Find (a) the acceleration of the blocks
(b) tension in the string
(c) assuming that the 8 lb block leads
(c) Describe the motion of the blocks are reversed.

Ans: $a = 11.38$ ft/s², $T = 0.464$ lb
$T' = -.464$ lb, $a' = 11.38$ ft/s²



27. A body of mass m accelerates uniformly from rest to a speed V_f in time t_f.

(a) Show that the work done on the body as a function of time t, in terms of V_f and t_f is $\frac{1}{2} \frac{m V_f^2}{t_f^2} \cdot t^2$

(b) As a function of time t, what is the instantaneous power delivered to the body?

(c) what is the instantaneous power at the end of 10 sec delivered to a 3200 lb body which accelerates to 60 miles/hr in 10 sec

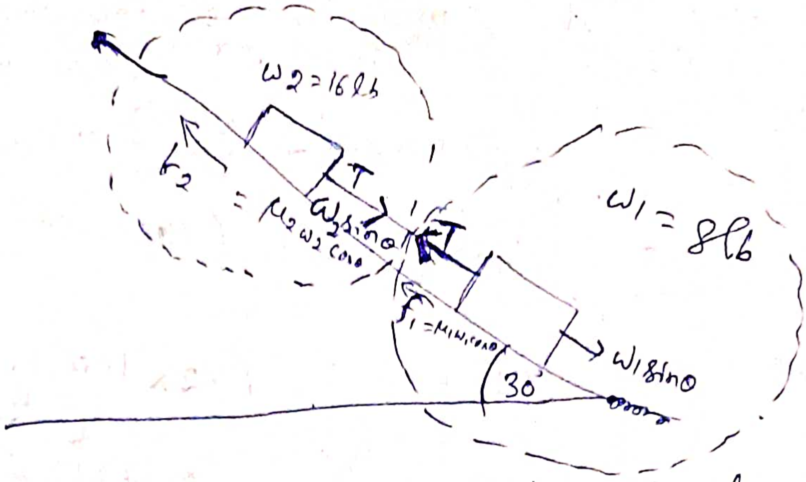
Ans-(a) $W = \frac{1}{2} \frac{m V_f^2}{t_f^2} \cdot t^2$

(b) $\frac{m V_f^2}{t_f^2} \cdot t$

(c) 140.8 h.p

Wed: 7.00 A.M

Ans :(2).



Let the weight of the 8lb block $= w_1$

co-efficient of kinetic friction between 8lb block and plane $= \mu_{1k} = .1$

frictional force $f_1 = \mu_1 w_1 \cos\theta$

$w_1 = 8 lb$. Tension T', $\theta = 30°$

$\Rightarrow m_1 g = 8 lb$

$\Rightarrow m_1 = \frac{8 lb}{32} = \frac{1}{4}$ slug

~~FBA of the~~ Equation of motion for the sliding 8 lb block

$$w_1 \sin\theta - (T + f_1) = m_1 a$$

$$\Rightarrow 8 lb \cdot \frac{1}{2} - (T + \mu_1 w_1 \cos\theta) = \frac{1}{4} a$$

$$\Rightarrow 4 lb - \left\{T + (.1)\cdot(8)\cdot\frac{\sqrt{3}}{2}\right\} = \frac{a}{4}$$

$$\Rightarrow 4 lb - (T' + .4\sqrt{3}) = \frac{a}{4}$$

$$\Rightarrow 4 lb - (T' + (.4)(1.732)) = \frac{a}{4}$$

$$\Rightarrow 4 lb - T' - .6928 = \frac{a}{4}$$

$$\Rightarrow 3.3072 - T' = \frac{a}{4}$$

$$\Rightarrow 13.2288 - 4T = a \quad \text{—(i)}$$

From e^{q^n} (i) and (ii)

$$13.2288 - 4T = 10.4576 + 2T$$

$$\Rightarrow 6T = 2.7712$$

(b) → $\Rightarrow T = \frac{2.7712}{6} = .4618 lb$

(a) $a = 13.2288 - 4.(.4618) = 13.2288 - 1.8472$

$= 11.3814 ft/s^2$

Equation of motion for the sliding 16 lb block

$$(w_2 \sin\theta + T_2) - f_2 = m_2 a$$

$$\Rightarrow \left(16\,lb \cdot \tfrac{1}{2} + T_2\right) - (\mu_2 \times w_2 \cos\theta) = \tfrac{1}{2} a \qquad \left(\because W = 16\,lb,\ mg = 16\,lb,\ m = \tfrac{16}{32} = \tfrac{1}{2}\,slug\right)$$

$$\Rightarrow (8\,lb + T_2) - \left(.2 \times \overset{8}{\cancel{16\,lb}} \cdot \frac{\sqrt{3}}{\cancel{2}}\right) = \frac{a}{2}$$

$$\Rightarrow (8\,lb + T_2) - 2.7712 = \frac{a}{2}$$

$$\Rightarrow 5.2288 + T_2 = \frac{a}{2}$$

$$\Rightarrow 10.4576 + 2T_2 = a \quad \text{— (ii)}$$

Answer of (c) after 29 page

~~Ask $\vec{T}$, $\vec{T_1}$ (Tension) | T_1, a (two unknown)~~

~~F = -6 ...? 123 Nb~~

27. A body of mass m accelerates uniformly from rest to a speed V_f in time t_f

$$V = V_f$$
$$t = t_f$$
$$mass = m$$

Work done $= \vec{F}\cdot\vec{S} = m\vec{a}\cdot\vec{s}$

we know $v = u + at$

$$\Rightarrow V_f = 0 + a\cdot(t_f)$$

$$\Rightarrow a = \frac{V_f}{t_f}$$

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

$$= 0 + \frac{1}{2}\cdot\frac{V_f}{t_f}\cdot t^2$$

$$= \frac{1}{2}\frac{V_f}{t_f}\cdot t^2$$

Work done $= m\vec{a}\cdot\vec{s}$

$$= m\cdot\frac{V_f}{t_f}\cdot\frac{1}{2}\frac{V_f}{t_f}\cdot t^2$$

$$= \frac{1}{2}m\frac{V_f^2}{t_f^2}\cdot t^2$$

(b) The instantaneous power is

$$P_{instant} = \vec{F}\cdot\vec{V}_{instant}$$

$$\cancel{= m\vec{a}\cdot\vec{V_t}}$$

$$\cancel{= m\cdot\frac{V_f}{t_f}\cdot V_f}$$

$$\cancel{= m V_f^2}$$

$$= \frac{dw}{dt}$$

$$= \frac{d}{dt}\left(\frac{1}{2}\cdot m\frac{v^2_f}{t^2_f}\cdot t^2\right)$$

$$= \frac{1}{2}\frac{mv^2_f}{t^2_f}\frac{d}{dt}(t^2)$$

$$= \frac{1}{2}\frac{mv^2_f}{t^2_f}\cdot 2t$$

$$= \frac{mv^2_f}{t^2_f}t$$

$$\cancel{= \frac{m\vec{a}\cdot\vec{S}}{t}}$$

$$\cancel{= \frac{m\cdot\frac{V_f}{t_f}\cdot\frac{1}{2}\frac{V_f}{t_f}\cdot t^2}{t}}$$

$$\cancel{= \frac{1}{2}m\frac{V_f^2}{t_f^2}t}$$

(c) time = 10 sec, weight of body = 3200 lb

$\Rightarrow mg = 3200$ lb

$\Rightarrow m = 100$ slug

$a = 60$ mile/hour

15 mile/hour = 22 feet/sec

1 mile/hour $= \frac{22}{15}$ feet/sec

60 mile/hour $= \frac{22}{15}\times 60 = 88$ ~~feet~~ feet/sec

$a = 88$ feet/sec

~~$S = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}\cdot 88\cdot 100$~~

~~it moves 88 feet in 1 sec.~~

According to question ~~it~~ in 10 sec it cover the distance = 88 feet ~~880 feet~~

$\therefore S = 880$ feet

instantaneous power = $\frac{\text{workdone}}{t} = \frac{\vec{F}\vec{S}}{t}$

$$= \frac{m\vec{a}\vec{S}}{t}$$

$$= \frac{100 \times 88 \times 880}{10}$$

$$= 77440 \text{ feet lb/sec}$$

~~550 feet/sec — 1 h~~

550 feet lb/sec = 1 h.p

1 feet lb/sec = $\frac{1}{550}$ h.p

77440 feet lb/sec = $\frac{77440}{550}$ = 140.8 h.p

— o —

Accuracy, precision of instruments and Errors in measurement.

We make ~~[illegible]~~ measurements with the help of instruments. It is not possible to make measurement with absolute precision because of many factors. The uncertainty is indicated by a ± symbol and a second number indicating the maximum likely error.

Example: Diameter of rod = {28.47 ± 0.04}

⇒ the diameter is likely to lies within 28.43 m.m and 28.51 m.m

Types of errors:

(a) Instrumental errors: There is always a limit to the ability of an instrument

Ex : 1 An ordinary metre scale can measure upto 0.1 c.m or 0.1 m.m accuracy. The error in the use of this metre scale is normaly taken to be one half ($\frac{1}{2}$) of the smallest division. ie $\frac{1}{2}$ mm = 0.5 mm = .05 c.m

Ex-2 : The least count of a screw gauge is 0.001 c.m or 0.01 mm. The error in using a screw gauge is

$$\frac{0.001}{2} \text{ c.m} \quad \text{or} \quad \frac{0.01}{2} \text{ mm.}$$

i.e 0.0005 c.m or 0.005 m.m

(b) Random Errors : This type of error depends on the person who makes the measurement. The occure irregularly and hence random w.r.t magnitude and sign. To minimise random error, a large number of observation are taken for any measurement and the arithmatic mean of all the measurements is taken as the true value of the measured quantity.

(c) Gross Errors : These are due to carelessness of the experimenter. It may be due to improper setting of the instruments.

(d) Systematic errors : This type of errors in instruments are due to imperfect techniques or due to the alterations in the measured quantity.

Absolute error :

Consider n measurements to be made for the length of a body. These readings be denoted by $a_1, a_2, a_3 - - - -, a_n$

$$a_{mean} = \frac{a_1 + a_2 + a_3 - - - - - + a_n}{n}$$

$$= \frac{\sum_{i=1}^{n} a_i}{n}$$

The absolute error of each measurement is given by the difference between the mean value and the individual measurement and these are indicated by Δa_1, Δa_2 etc.

Thus $\Delta a_1 = a_{mean} - a_1$

$$\Delta a_2 = a_{mean} - a_2$$

$$\vdots$$

$$\Delta a_n = a_{mean} - a_n$$

The arithmetic mean of all the absolute errors is taken as the final absolute error of the value of the quantity 'a'. ~~Thus~~ Thus

$$\Delta a_{mean} = \frac{|\Delta a_1| + |\Delta a_2| + |\Delta a_3| - - - - + |\Delta a_n|}{n}$$

$$= \frac{1}{n} \sum_{i=1}^{n} |\Delta a_i|$$

If we do a single measurement, the value we get may be in the range $a_{mean} \pm \Delta a_{mean}$

i.e $[a_{mean} - \Delta a_{mean}] \leq a \leq [a_{mean} + \Delta a_{mean}]$.

Instead of absolute error, we use 'relative error' or 'percentage error' $\boxed{(\delta a)}$

Percentage error is defined as the ratio of the absolute error to the mean value of the quantity being measured, expressed in per cent

$$\therefore \delta a = \frac{(\Delta a)_{mean}}{a_{mean}} \times 100\%$$

<u>Ex-1</u> : The length of <u>a body measured</u> by a metre <u>scale is 2.3 c.m</u> and the absolute error in measurement is <u>0.1 c.m.</u> Calculate the percentage error.

$$\delta a = \frac{\Delta a}{a} \times 100\%$$

$$= \frac{0.1}{2.3} \times 100\%$$

$$= 4.3\%$$

Significant figures

It indicates the extent to which the readings are reliable. It is normally those digits in a quantity that are known reliably plus the first digit that is uncertain.

Ex:- 1 Let the time period of oscillation of a simple pendulum is 2.6 sec. It has two significant figures. 2 is reliable. The second figure 6 is uncertain.

Ex:- 2 The length of an object is 237.5 c.m. This has four significant figures. Here 5 is uncertain digit. The last digit is normally the uncertain digit.

The number of significant figures does not vary by choosing different units. For instance, if we use metres the above length will be 2.375 metre

It is customary to write the decimal after the first digit. Therefore 237.5 c.m is written as 2.375×10^2 c.m

$m = 0.0345$ k.g $= 3.45 \times 10^{-2}$ k.g

137 000 metre $= 1.37 \times 10^5$ metre

Classification and Combination of errors.

If we do an experiment involving several measurement, we must know how the errors in all the measurement combine.

Example :- Density = $\frac{\text{Mass}}{\text{Volume}}$

If we have errors in the measurement of mass and of the dimension, we must know what the error will be in the density. To make such estimates, the following procedure be adopted.

Case 1 Errors of a sum A+B

Suppose two quantities A and B have measured values $A \pm \Delta A$, $B \pm \Delta B$ respectively. Here ΔA and ΔB are absolute errors of A and B respectively.

Let $Z = A + B$

$$\therefore Z \pm \Delta Z = (A \pm \Delta A) + (B \pm \Delta B)$$

$$= (A+B) \pm (\Delta A + \Delta B)$$

$$\Rightarrow \cancel{Z} \pm \Delta Z = \cancel{Z} \pm (\Delta A + \Delta B)$$

$$\Rightarrow \Delta Z = \Delta A + \Delta B$$

i.e. error sum = sum of the individual errors.

Case - II Errors for the difference A-B

Let $Z = A - B$

$$Z \pm \Delta Z = (A \pm \Delta A) - (B \pm \Delta B)$$
$$= (A - B) \pm (\Delta A + \Delta B)$$

because $|\Delta B|$ is to be used

$\Rightarrow \Delta Z = \Delta A + \Delta B$ = The maximum possible error.

Case - III Errors for the product A×B

Let $Z = A \times B$

Hence $Z \pm \Delta Z = (A \pm \Delta A) \times (B \pm \Delta B)$

$$= (A \times B) \pm (\Delta A \times B) \pm (A \times \Delta B) \pm (\Delta A \times \Delta B)$$

The quantity $\Delta A \times \Delta B$ can be neglected as it is very small.

Dividing the L.H.S by Z and the R.H.S by AB, we get

$$1 \pm \frac{\Delta Z}{Z} = 1 \pm \frac{\Delta A}{A} \pm \frac{\Delta B}{B}$$

$$\Rightarrow \pm \frac{\Delta Z}{Z} = \pm \frac{\Delta A}{A} \pm \frac{\Delta B}{B}$$

The quantities $\frac{\Delta Z}{Z}$, $\frac{\Delta A}{A}$, $\frac{\Delta B}{B}$ are called fractional errors in Z, A, B respectively.

$$\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

Fractional error of the product = Sum of the fractional errors.

Case IV   Errors for the division $\frac{A}{B}$

Let $Z = \frac{A}{B}$

$$\therefore Z \pm \Delta Z = \frac{A \pm \Delta A}{B \pm \Delta B}$$

$$= \frac{A\left(1 \pm \frac{\Delta A}{A}\right)}{B\left(1 \pm \frac{\Delta B}{B}\right)}$$

$$= \frac{A}{B}\left(1 \pm \frac{\Delta A}{A}\right)\left(1 \pm \frac{\Delta B}{B}\right)^{-1}$$

$$= \frac{A}{B}\left(1 \pm \frac{\Delta A}{A}\right)\left(1 \mp \frac{\Delta B}{B}\right)$$

where binomial expansion has been done for the second facter

$$= \frac{A}{B}\left(1 \pm \frac{\Delta A}{A} \mp \frac{\Delta B}{B}\right)$$

where $\frac{\Delta A \, \Delta B}{AB}$ has been neglected.

Dividing L.H.S by Z & R.H.S by $\frac{A}{B}$, we get

$$1 \pm \frac{\Delta Z}{Z} = 1 \pm \frac{\Delta A}{A} \mp \frac{\Delta B}{B}$$

$$\Rightarrow \pm \frac{\Delta Z}{Z} = \pm \frac{\Delta A}{A} \mp \frac{\Delta B}{B}$$

$$\Rightarrow \frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$ = maximum possible error.

Case V Errors due to the power of measured quantity

Let $Z = A^2$.

Then $Z \pm \Delta Z = (A \pm \Delta A)^2$

$= A^2 \pm 2 . A . \Delta A + (\Delta A)^2$

Neglecting $(\Delta A)^2$ as second order in smallness, we have

$$Z \pm \Delta Z = A^2 \pm 2 A . \Delta A$$

Dividing both the sides by Z (Z for L.H.S & A^2 for R.H.S)

$$1 \pm \frac{\Delta Z}{Z} = 1 \pm 2 \frac{\Delta A}{A}$$

$$\Rightarrow \frac{\Delta Z}{Z} = 2 \frac{\Delta A}{A}$$

Ex - 1 A physical quantity S is related to four observations a, b, c, and d as ~~following~~ follows:

$$S = \frac{a^2 b^3 \sqrt{c}}{d^2}$$

Given : The percentage errors of measurement in a, b c and d are 2%, 1%, 4% and 3% respectively. Calculate the net percentage error.

Since $S = \frac{a^2 b^3 c^{\frac{1}{2}}}{d^2}$

Then $\frac{\Delta S}{S} = 2 \cdot \frac{\Delta a}{a} + 3 \frac{\Delta b}{b} + \frac{1}{2} \frac{\Delta c}{c} + 2 \frac{\Delta d}{d}$

$= 2 \times 2\% + 3 \times 1\% + \frac{1}{2} \times 4\% + 2 . 3\%$

$= 4\% + 3\% + 2\% + 6\%$

$= 15\%$

Ex :- 2 :- Time period of oscillation of a simple pendulum are 2.63 s, 2.56 s, 2.42 sec, 2.71 sec, 2.80 sec.

Mean period of oscillation is

$$T_{mean} = \frac{2.63 + 2.56 + 2.42 + 2.71 + 2.80}{5}$$

$$= \frac{13.12}{5} = 2.624 \text{ sec} = 2.62 \text{ sec}$$

The absolute errors in the measurement are

$2.62 - 2.63 = -0.01$ sec

$2.62 - 2.56 = +0.06$ sec

$2.62 - 2.42 = 0.20$ sec

$2.62 - 2.71 = -0.09$

$2.62 - 2.80 = -0.18$

The arithmetic mean of all the absolute errors is the mean of the magnitudes.

$\Delta a_{mean} = \Delta T_{mean} = \frac{0.01 + 0.06 + 0.2 + 0.09 + 0.18}{5}$

$= \frac{.54}{5} = 0.11$ sec

Percentage error

$\delta T = \frac{0.11}{2.62} \times 100 \simeq 4\%$.

—o—

Unit-I , Paper-1

Physical quantities:-

Mass of a body, distance between two places, speed of a vehicle, density of liquid, temperature of body, electrical charge on a body, current flowing in a circuit, time interval between two events etc are called observable or physical quantities:

All such physical quantities are classified into two groups.

(i) Fundamental

(ii) Derived

Length, time and mass are called fundamental quantities. Now-a-days thermodynamic temperature (K), Luminious intensity (Cd), electric current (A), amount of substance (mole), plane angle (Radian) and solid angle (steradian) have been included in the list of fundamental quantities.

Quantities like speed, area, volume, force, momentum etc can be derived from one or more fundamental quantities.

Units :

The unit is is some specific magnitude of a measureable physical quantity in terms of which one may ~~be~~ conveniently express other magnitudes of the same quantity.

All physical quantities are expressed in terms of (a) some number (b) some unit.

Different systems of units

1. C.G.S ~~unit~~ system

centimetre, gram and second are taken as the units of length, mass and time respectively.

2. M.K.S system

Metre, Kilogram, second are taken as the units of length, mass and time respectively.

3. S.I system (system international)

It is system that includes the M.K.S system. Extra units ~~...~~ ~~...~~ are for electric current (Ampere), Luminious intensity (Candela), Absolute temperature (Kelvin) (symbol-K)

Amount of substance (mole), plane angle (radian), Solid angle (steradian)

4. F.P.S System or British system

Foot, pound, Second are regarded as the units for length, mass, time respectively.

Basic standards in S.I system

Any unit to be ~~[illegible]~~ chosen as the standard unit must satisfy the following requirements.

1. It should be of suitable size.
2. It should be easily and accurately reproducable at all places.
3. It shouldn't undergo any change with the passage of time.
4. It should be in a form and shape so that it can be easily compared with other physical quantities.

Metre as the basic standard

It is 1650763.73 times the wave length in vaccum of the radiation corresponding to the ~~[illegible]~~ transition between energy level $2p_{10}$ and $5d_5$ (orange red) of Krypton-86.

Kilogram as the Basic standard

It is the mass of a solid cylinder of diametre equal to its height and made of platinum - Iridium (90% Pt, and 10% Ir) having the mass same as that of 1 litre of water at 4°C under standard atmospheric pressure.

It is preserved at ~~SER~~ SEVRES (near Paris)

Second as the Basic standard

Previously the mean solar second was taken as equal to $\frac{1}{86400}$ of the mean solar day.

Now-a-days atomic standard is used. It is equal to the duration of (9,192,631,770 ± 20 cycles of the radiation corresponding to ~~the fundamental~~ ~~state~~ transition between two hyperfine levels of the fundamental state of C_s^{132} (cesium) atom.

Kelvin as the Basic standard

It is the unit of thermodynamical temprature which is the fraction $\frac{1}{273.16}$ of the triple point of water. (when solid, liquid and vapours co-exist)

Ampere as the Basic ~~fundamental~~ standard

It is that ~~amount~~ amount of current which when maintained in two parallel long conductors, placed on metre apart in vacuum would produce between them a force equal to 2×10^{-7} Newton/metre.

Candela as the Basic standard

One candela is defined as the luminous intensity in the ⊥ lar (perpendicular direction of a surface $\frac{1}{600000}$ square metre of a black body at freezing temp of platinum under a pressure of 101325 Newton/m^2.

Mole as Basic Standard

It is the amount of substance of a system which contains as many elementary particles as there are 'c' atoms in 0.012 k.g of c^{12}.

Radian as the Basic Standard:

It is the angle subtended by an arc of a circle at its center which has the length same as that of radious. 1 radian = 57°

Steridian as the Basic standard :

One Steridian is equal to $\frac{1}{4\pi}$ of the solid angle subtended by a sphere at its center.

Linear Momentum

It is a vector quantity defined as the product of mass of a body and its velocity.

$$\boxed{\vec{p} \rightarrow m . \vec{v}}$$

Dimension of momentum :

$$[p] = [m][v]$$
$$= [M . LT^{-1}]$$

Units of momentum

(a) C.g.s unit = ~~gm cm sec^{-1}~~
= gm cm sec^{-1}

(b) M.K.S Unit = Kg metre sec^{-1}

(c) F.P.S unit (absolute) = poundmass . foot. sec^{-1}

(d) F.P.S unit (Gravitational) = Slug . foot. sec^{-1}

Impulse :

It is a vector quantity defined as the product of a force and the time during which the force acts. Thus impulse $= \vec{F} . \Delta t$

My suggestion $\left(\because F = ma = m . \frac{\Delta v}{\Delta t} = \frac{\Delta mv}{\Delta t} = \frac{\Delta \vec{p}}{\Delta t} \right)$

$= \frac{\Delta \vec{p}}{\Delta t} . \Delta t$

$= \Delta \vec{p}$

= Change in linear momentum.

Units of impulse

(a) C.g.s unit = dyne . sec

(b) M.K.S unit = Newton.sec

(c) F.P.S (absolute) unit = poundal . sec.

(d) F.P.S (gravitional) unit = pound . sec.
= lb .sec

Dimension of impulse :

$[\text{Impulse}] = [F].[\Delta t]$

$= [MLT^{-2}].[T]$

$= [MLT^{-1}]$

= Same as that of linear momentum.

Examples of Impulse

1. A car moving with a high velocity strikes a tree on the road side and comes to rest immediately.

~~Here~~

work = energy
weight = force
momentum = Impulse

dimension same.

Here

$\vec{p_i} = m.\vec{u}$

$\vec{p_f} = m.\vec{v}$

$= m.0$

$= 0$.

$\Delta\vec{p}$ = Change in linear momentum.

$= \vec{p_i} - \vec{p_f}$

$= m\vec{u}$

= Impulse

Example-2 A cricket ball struck by bat so that the direction of the ball is just reversed.

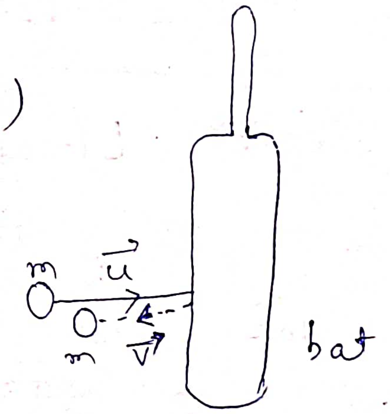
$\vec{p_i} = m\vec{u} = mu\hat{i}$ (say)

$\vec{p_f} = m\vec{v} = mv(-\hat{i})$

$\Delta\vec{p} = mu\hat{i} - (-mv\hat{i})$

$= m(u+v)\hat{i}$

= Impulse.



Principle of Conservation of linear momentum

From Newton's second law of motion, we know that

$$\vec{F} = \frac{d\vec{p}}{dt}$$

If the net external unbalanced force acting on the body vanishes, then $\vec{F} = 0 = \frac{d\vec{p}}{dt}$

Thus $\vec{p}$ = a constant with the passage of time

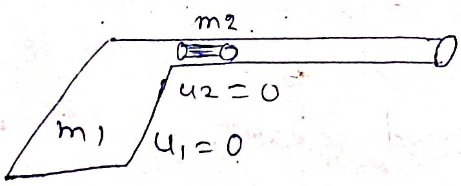
ie $\boxed{\vec{p_i} = \vec{p_f}}$

$\Rightarrow \hat{i}\, p_{ix} + \hat{j}\, p_{iy} + \hat{k}\, p_{iz} = \hat{i}\, p_{fx} + \hat{j}\, p_{fy} + \hat{k}\, p_{fz}$

$$\Rightarrow \boxed{\begin{aligned} p_{ix} &= p_{fx} \\ p_{iy} &= p_{fy} \\ p_{iz} &= p_{fz} \end{aligned}}$$

Statement - Linear momentum of a system is said to be conserved if the net external unbalanced force acting on the system vanishes.

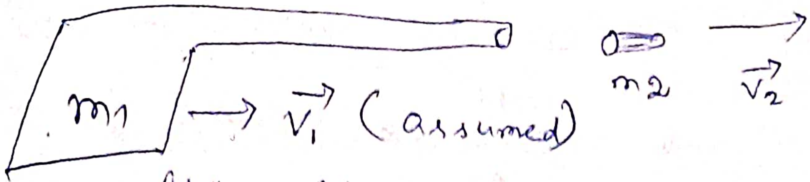
ex-1 Rifle and bullet problem.



Before firing, $\vec{p_i} = m_1\vec{u_1} + m_2\vec{u_2}$

$= 0 + 0$

$= 0$



After firing.

$$\therefore \quad \vec{p_f} = m_1\vec{v_1} + m_2\vec{v_2}$$

From the principle of conservation of linear momentum, we know that

$$\vec{p_i} = \vec{p_f} \quad (\text{in the absence of } \vec{F})$$

$$\Rightarrow 0 = m_1\vec{v_1} + m_2\vec{v_2}$$

$$\Rightarrow m_1\vec{v_1} = -m_2\vec{v_2}$$

$$\Rightarrow \vec{v_1} = -\left(\frac{m_2}{m_1}\right)\vec{v_2} = \text{Recoil velocity of the rifle}$$

$-\left(\frac{m_2}{m_1}\right)\vec{v_2}$

The -ve sign shows that the rifle or gun recoils in ~~to~~ a direction ~~of~~ opposite to that of bullet.

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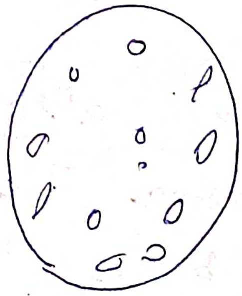
Ex-2 explosion of a bomb

Before explosion

all particle ~~are~~ were at rest.

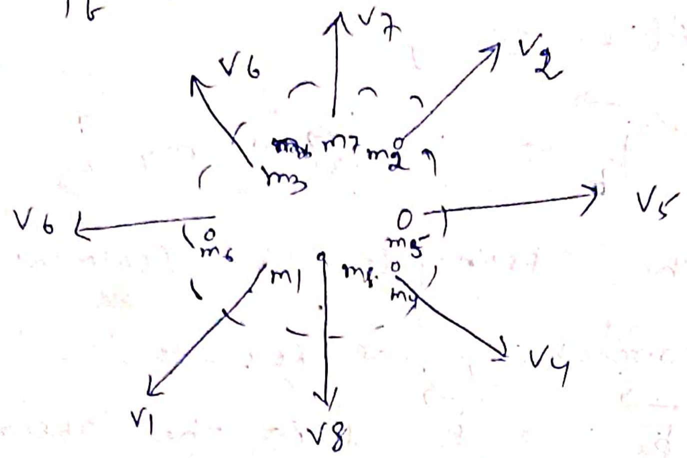


$$\vec{P_i} = m_1\vec{u_1} + m_2\vec{u_2} + \text{------}$$

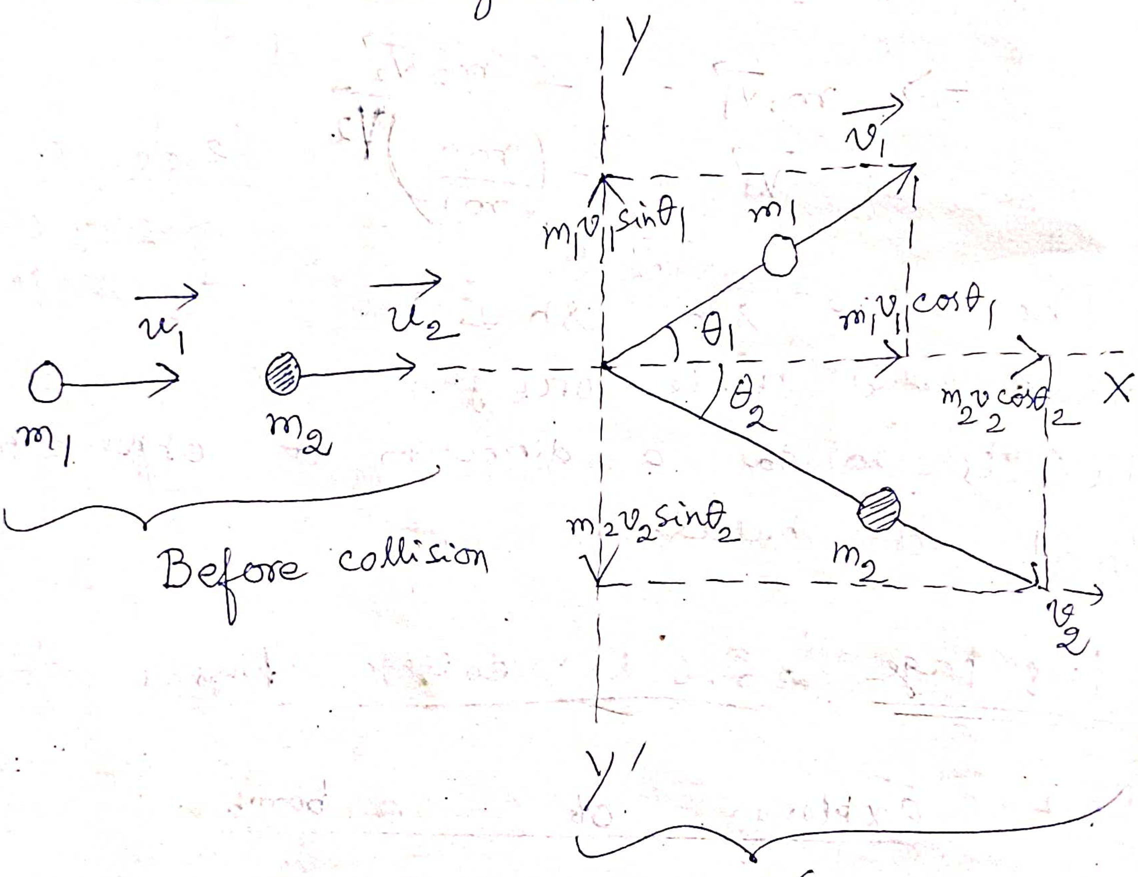
$$= 0 + 0 + \text{---}$$

$$= 0$$

After explosion pairs of particles have to move in opposite direction so that $\vec{p}_f = 0$ will ~~[illegible]~~ be possible



Ex : Billiard ball game



It is also a collision in two dimension. The final momentum of the two bodies have been resolved. From the principle of conservation of linear momentum we know that

~~$p_{ix} = p_{fx}$~~

$p_{ix} = p_{fx}$

$\Rightarrow m_1u_1 + m_2u_2 = m_1v_1\cos\theta_1 + m_2v_2\cos\theta_2$ — (i)

$p_{iy} = p_{fy}$ gives

$0 + 0 = m_1v_1\sin\theta_1 - m_2v_2\sin\theta_2$ — (ii)

Solving these two equations, one can ~~be~~ ~~eased~~ get values of any two ~~for~~ unknown quantities.

Types of collisions

All types of collisions occurring in nature can be classified in to the following 3 types.

1. Elastic collision.
2. Inelastic collision.
3. Perfectly inelastic collision.

Elastic collision :

It is an ideal type of collision where the total kinetic energy of the colliding particles after collision is found to be equal to the total kinetic energy of the same particles before collision that is

$$(E_k)_f = (E_k)_i$$

$$\therefore \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$$

where two bodies have been considered

before and after collision.

Linear momentum is found to be conserved in this type of collision

That is $\vec{P_f} = \vec{P_i}$

$\Rightarrow m_1 \vec{v_1} + m_2 \vec{v_2} = m_1 \vec{u_1} + m_2 \vec{u_2}$.

Co-efficient of restitutiton = e = 1 for elastic collision.

Inelastic Collision :

It is a particular collision where the kinetic energy of the colliding particles after collision is less than the kinetic energy of the same particles before collision. This happens because of the fact that some amount of kinetic energy is utilized to produce heat, sound, light, or to produce mechanical difformation.

$$\therefore (E_K)_f < (E_K)_i$$

Linear momentum is conserved as before.

$$\therefore \vec{P_f} = \vec{P_i}$$

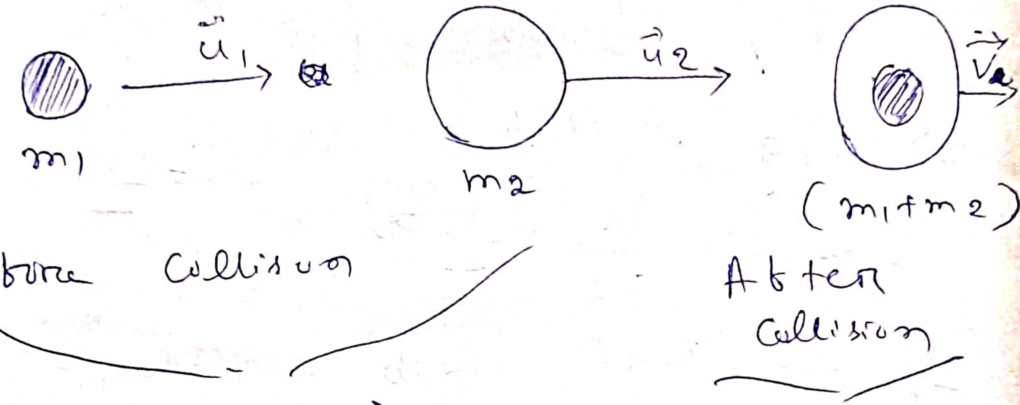
Co-efficient of restitution is < 1

$$\therefore e < 1$$

Perfectly inelastic collision

Here the two or more coliding particles merge (मिलना) into a single body after collision. Here also $(E_K)_f < (E_K)_i$ and $\vec{P_f} = \vec{P_i}$

but co-efficient of restitution $= e = 0$



$\vec{P_i} = \vec{P_f}$ gives

$m_1\vec{u_1} + m_2\vec{u_2} = (m_1+m_2)\vec{V}$

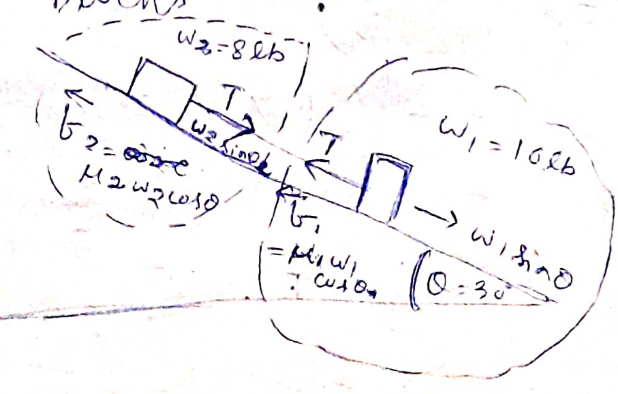
$\Rightarrow V = \dfrac{m_1 u_1 + m_2 u_2}{m_1+m_2}$ (when all the velocities are along the same direction)

Tue : 6 P.M. wed : 7 A.M before 24 page

Ans of 2 No. 8 lb block, 16 lb block.

(a) (b) has done

(c) If the blocks are reversed.



Let weight of 16 lb block $= w_1$

~~coeffi~~ co-efficient of Kinetic friction between 16 lb block and plane $= \mu_1 = .2$

co-efficient of kinetic friction between 8 lb block and plane $= \mu_2 = .1$

frictional force $= f_1$

$$W_1 = 16 \text{ lb}$$
$$\Rightarrow m_1 g = 16 \text{ lb}$$
$$\Rightarrow m_1 = \frac{16}{32} = \frac{1}{2} \text{ slug}$$

$\theta = 30°$, $\sin\theta = \frac{1}{2}$, $\cos\theta = \frac{\sqrt{3}}{2}$

Equation for 16 lb block

$$w_1 \sin\theta - (T + f_1) = m_1 a$$
$$\Rightarrow \left(16 \cdot \frac{1}{2}\right) - (T + \mu_1 w_1 \cos\theta) = \frac{1}{2} \cdot a$$
$$\Rightarrow 8 - T - \left(.2 \times 16 \times \frac{\sqrt{3}}{2}\right) = \frac{a}{2}$$
$$\Rightarrow 8 - T - 2.7712 = \frac{a}{2}$$
$$\Rightarrow 5.2288 - T = \frac{a}{2}$$
$$\Rightarrow 10.4576 - 2T = a \quad \text{—(i)}$$

Equation for 8 lb block

$$w_2 \sin\theta + T - f_2 = m_2 a$$
$$\Rightarrow \left(8 \cdot \frac{1}{2}\right) + T - \mu_2 w_2 \cos\theta = \frac{1}{4} \cdot a$$
$$\Rightarrow 4 + T - \left(.1 \times 8 \times \frac{\sqrt{3}}{2}\right) = \frac{a}{4}$$

$\because W_2 = 8$, $\Rightarrow m_2 g = 8$, $\Rightarrow m_2 = \frac{8}{32} = \frac{1}{4}$ slug

$$\Rightarrow 4 + T - .6928 = \frac{a}{4}$$
$$\Rightarrow 3.3072 + T = \frac{a}{4}$$
$$\Rightarrow 13.2288 + 4T = a \quad \text{—— (ii)}$$

From equation (i) and (ii)

$13.2288 + 4T = 10.4576 - 2T$

$\Rightarrow -6T = 2.7712$

$\Rightarrow T = \frac{2.7712}{-6} = -0.461866$

Putting the value of T in eqn (i) we get

$a = 10.4576 - 2T$

$= 10.4576 - 2\times(-.4618)$

$= 10.4576 + .9236$

$= 11.3812$

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2. When 1.5 N base ball dropped from Washington monument its initial velocity

$u = 0$

$W = 1.5\,N$

$h = s = 170\,m$

$g = 9.8\,m/s^2$

Using the formula $v^2 - u^2 = 2as$ we get

$v^2 - 0 = 2.g.(170)$

$\Rightarrow v^2 = 2\times(9.8)\times170$

$= 3332$

.15306

$\Rightarrow v = \sqrt{3332}$

$= 57.72\,m/s$

$W = 1.5\,N$

$\Rightarrow mg = 1.5\,N$

$\Rightarrow m = \frac{1.5}{9.8} = .15\,kg$

Momentum of the baseball

$= m\vec{v}$

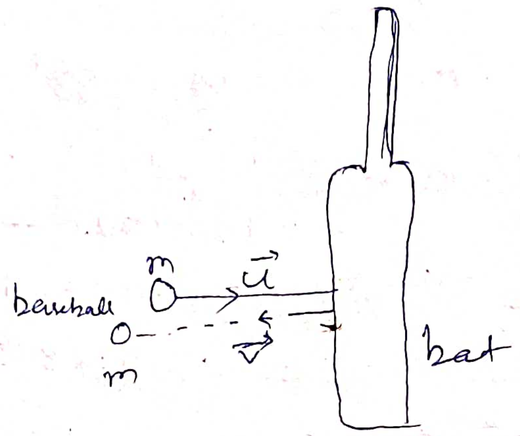
$= .15 \times 57.72$

$= \cancel{8.658}$

$= 8.658$ kg·m/sec

(Ans)

5.



weight of base ball $= 5.0$ oz

$1 \text{ oz} = \frac{1}{16}$ lb

Here $u = 160$ ft/s

$v = 280$ ft/s

$5 \text{ oz} = \frac{5}{16}$ lb

$W = \frac{5}{16}$ lb

$m = \frac{5}{16g} = \frac{5}{16} \times \frac{1}{32} = \frac{5}{512}$ slug

When the baseball struck by bat the direction of ball is reversed.

$\vec{P_i} = m\vec{u} = mu\hat{i}$ (say)

$\vec{P_f} = m\vec{v} = mv(-\hat{i})$

$\Delta \vec{P} = \vec{P_i} - \vec{P_f}$

$= mu\hat{i} - mv(-\hat{i})$

$= mu\hat{i} + mv\hat{i}$

$= m(u+v)\hat{i}$

$= \frac{5}{512}(160+280) \times 1$

$= \frac{5}{512}(440) = \frac{2200}{512} = 4.29$ lb.sec
$= 4.3$ lb. sec.

$\therefore$ Impulse $= 4.3$ lb sec.

(b) ~~Average force = ?~~

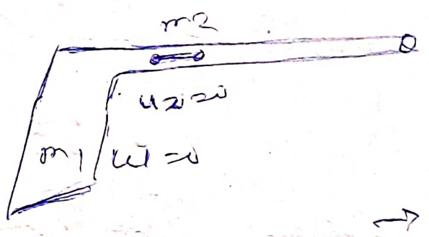
Impulse $= F \cdot \Delta t$

$\Rightarrow 4.3$ lb ~~sec~~ $= F \cdot .020$ ~~sec~~

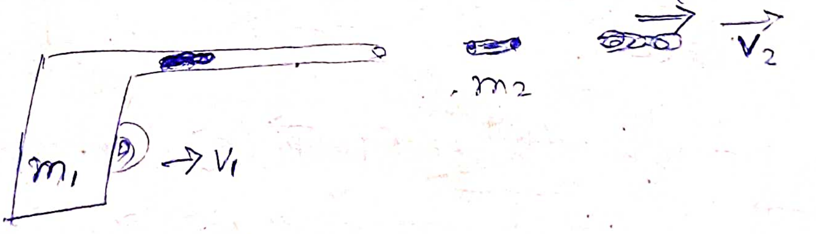
$\Rightarrow F = \frac{4.3}{.020} = \frac{4.3 \times 100}{2}$

$= \frac{430}{2} = 215$ lb

6.



Before firing $\vec{P_i} = m_1u_1 + m_2u_2$
$= 0 + 0 = 0$



After firing.

$\therefore \vec{P_f} = m_1V_1 + m_2V_2$

From the principle of conservation of linear momentum, we know that

$$\vec{P_i} = \vec{P_f}$$

$$\Rightarrow 0 = m_1\vec{v_1} + m_2\vec{v_2}$$

$$\Rightarrow m_2\vec{v_2} = -m_1\vec{v_1}$$

$$\Rightarrow V_1 = -\left(\frac{m_2}{m_1}\right)V_2$$

Weight of gun = 44.5 N

$$\Rightarrow m_1 g = 44.5\text{ N}$$

$$\Rightarrow m_1 = \frac{44.5\text{ N}}{9.8\text{ m/s}^2} = \frac{44.5\text{ kg m/s}^2}{9.8\text{ m/s}^2}$$

$$= 4.7\text{ kg.}$$

$$= 4700\text{ gm}$$

Mass of bullet m_2 1 gm

Recoil velocity of gun $V_1 = -\left(\frac{m_2}{m_1}\right)V_2$

$$= -\left(\frac{1}{4700} \times 2500\right)$$

$$= -.53\text{ m/s}$$

but the (–) sign shows that the gun recoils to the opposite direction of bullet. So recoil velocity = .53 m/s

To prove that (i) $\vec{P}\cdot(\vec{Q}+\vec{R}) = \vec{P}\cdot\vec{Q}+\vec{P}\cdot\vec{R}$

(ii) $\vec{P}\times(\vec{Q}+\vec{R}) = \vec{P}\times\vec{Q}+\vec{P}\times\vec{R}$

(i) L.H.S $\vec{P}\cdot(\vec{Q}+\vec{R})$

$$= (\hat{i}P_x + \hat{j}P_y + \hat{k}P_z)\{(\hat{i}Q_x + \hat{j}Q_y + \hat{k}Q_z) + (\hat{i}R_x + \hat{j}R_y + \hat{k}R_z)\}$$

$$= (\hat{i} P_x + \hat{j} P_y + \hat{k} P_z) \cdot \{ \hat{i} (Q_x + R_x) + \hat{j} (Q_y + R_y) + \hat{k} (Q_z + R_z) \}$$

$$= P_x (Q_x + R_x) + P_y (Q_y + R_y) + P_z (Q_z + R_z)$$

$$= P_x Q_x + P_x R_x + P_y Q_y + P_y R_y + P_z Q_z + P_z R_z$$

$$= (P_x Q_x + P_y Q_y + P_z Q_z) + (P_x R_x + P_y R_y + P_z R_z)$$

$$= \vec{P} \cdot \vec{Q} + \vec{P} \cdot \vec{R}$$ (proved)

(ii) L.H.S $\vec{P} \times (\vec{Q} + \vec{R})$

$$= (\hat{i} P_x + \hat{j} P_y + \hat{k} P_z) \times \{ (\hat{i} Q_x + \hat{j} Q_y + \hat{k} Q_z) + (\hat{i} R_x + \hat{j} R_y + \hat{k} R_z) \}$$

$$= (\hat{i} P_x + \hat{j} P_y + \hat{k} P_z) \times \{ \hat{i} (Q_x + R_x) + \hat{j} (Q_y + R_y) + \hat{k} (Q_z + R_z) \}$$

$$= (\hat{i} \times \hat{j}) P_x (Q_y + R_y) + (\hat{i} \times \hat{k}) P_x (Q_z + R_z) + (\hat{j} \times \hat{i}) P_y (Q_x + R_x) + (\hat{j} \times \hat{k}) P_y (Q_z + R_z) + (\hat{k} \times \hat{i}) P_z (Q_x + R_x) + (\hat{k} \times \hat{j}) P_z (Q_y + R_y)$$

$$= \hat{k} P_x (Q_y + R_y) - \hat{j} P_x (Q_z + R_z) - \hat{k} P_y (Q_x + R_x) + \hat{i} P_y (Q_z + R_z) + \hat{j} P_z (Q_x + R_x) - \hat{i} P_z (Q_y + R_y)$$

$$= \hat{k} P_x Q_y + \hat{k} P_x R_y - \hat{j} P_x Q_z - \hat{j} P_x R_z - \hat{k} P_y Q_x - \hat{k} P_y R_x + \hat{i} P_y Q_z + \hat{i} P_y R_z + \hat{j} P_z Q_x + \hat{j} P_z R_x - \hat{i} P_z Q_y - \hat{i} P_z R_y$$

$$= [\hat{i} (P_y Q_z - P_z Q_y) + \hat{j} (P_z Q_x - P_x Q_z) + \hat{k} (P_x Q_y - P_y Q_x)] + [\hat{i} (P_y R_z - P_z R_y) + \hat{j} (P_z R_x - P_x R_z) + \hat{k} (P_x R_y - P_y R_x)]$$

$$= \vec{P}\times\vec{Q} + \vec{P}\times\vec{R} = \text{R.H.S (Proved)}$$

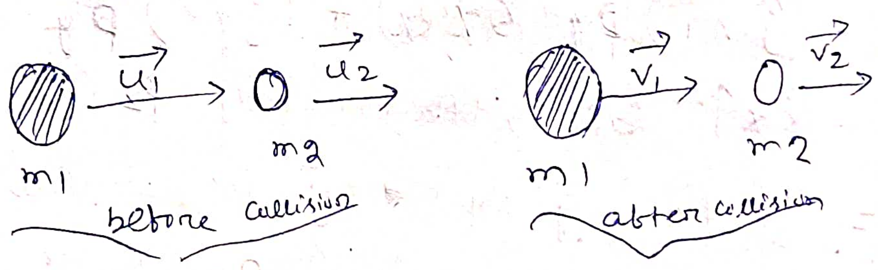
Co-efficient of restitution (e)

To understand the meaning of this term, let us consider all types of collisions in general for which the following inequality holds

$$(E_K)_f \leq (E_K)_i$$

But $\vec{P_f} = \vec{P_i}$ holds

~~docs~~ For simplicity we can consider a collision between two bodies whose velocity directions before and after collision are the same.



$$(E_K)_f = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$$

$$(E_K)_i = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2$$

Thus $(E_K)_f \leq (E_K)_i$ gives

$$\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 \leq \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 \quad \text{---(1)}$$

$$p_f = p_i \text{ gives}$$

$$m_1 v_1 + m_2 v_2 = m_1 u_1 + m_2 u_2 \quad \text{---(2)}$$

or $\left\{ \begin{array}{l} m_1 v_1^2 - m_1 u_1^2 \leqslant m_2 u_2^2 - m_2 v_2^2 \\ m_1 (v_1 - u_1) = m_2 (u_2 - v_2) \end{array} \right.$

Dividing one by the other

or
$$\frac{m_1 (v_1 + u_1)(v_1 - u_1)}{m_1 (v_1 - u_1)} \leqslant \frac{m_2 (u_2 + v_2)(u_2 - v_2)}{m_2 (u_2 - v_2)}$$

or $v_1 + u_1 \leqslant u_2 + v_2$

or $v_1 - v_2 \leqslant u_2 - u_1$

or $\frac{v_1 - v_2}{u_2 - u_1} \leqslant 1$

$\therefore -\left(\frac{v_1 - v_2}{u_1 - u_2}\right) \leqslant 1$

or $e \leqslant 1$

Thus co-efficient of restitution can be defined as the negative ratio of the of the ~~vel~~ relative velocity after the collision to the relative velocity before collision.

$$\boxed{\therefore e = -\left(\frac{v_1 - v_2}{u_1 - u_2}\right)} = \frac{\text{Relative } v. \text{ separation}}{\text{" " approach}}$$

Special cases

also perfectly elastic 1. Elastic collision: Here the starting equations are $(E_K)_f = (E_K)_i$

$$p_f = p_i$$

Proceeding as before, one can get

$e = 1$

2. <u>In elastic collision</u> : Starting equations are $(E_K)_f < (E_K)_i$

$$p_f = p_i$$

Proceeding as before, one can get

$$e < 1$$

3. <u>Perfectly in-elastic collision</u>

Here the two bodies merge into a single body. Hence $V_1 = V_2$

$$\therefore \quad e = 0$$

<u>Problem</u>

1. A body is dropped ~~from~~ upon a floor from a height of 10 m. Find the height to which it will rise

Given $e = \frac{1}{2}$ for the ball & the floor

<u>Ans</u> : 2.5 m. $\boxed{e^2 = \frac{h_2}{h_1}}$ $\frac{1}{4} = \frac{x}{10}$. $\therefore x = 2.5$

<u>Ans</u> : Let us find the velocity with which the body will strike the floor.

$$v^2 - u^2 = 2as$$
$$\Rightarrow v^2 - 0 = 2.(9.8)\,10$$
$$\Rightarrow v^2 = 196$$
$$\Rightarrow v = 14\ m/s.$$

$u = 0$

$a = 9.8\ m/s^2$

$s = 10m$

Now collision with the floor be considered. $u_1 = 14m/s$, $v_1 = ?$

$u_2 = 0 = v_2$ (because floor is at rest.)

(Here the floor is considered to be the second body.

$$e = \frac{1}{2} \quad \Rightarrow -\left(\frac{v_1 - v_2}{u_1 - u_2}\right) = \frac{1}{2}$$
$$\Rightarrow -\left(\frac{v_1 - 0}{14 - 0}\right) = \frac{1}{2}$$
$$\Rightarrow -\frac{v_1}{14} = \frac{1}{2}$$
$$\Rightarrow v_1 = -\frac{14}{2} = -7\ m/sec$$

The -ve sign indicates the body rises up.

$$v^2 - u^2 = 2as$$
$$\Rightarrow 0 - (7)^2 = 2.(-9.8).s$$
$$\Rightarrow -49 = -19.6\,s$$
$$\Rightarrow s = \frac{49}{19.6} = 2.5\ metre$$

$v = 0$

$a = -9.8$

$u = 7m/s$

2. Prove that a body dropped from a height 'h' upon a floor will rise to a height "e^2h" where e = Co-efficient of restitution between the body & floor

Ans :- Let us find the velocity with the ~~velocity~~ body strike the floor.

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

$$\Rightarrow v^2 - 0 = 2 \cdot \cancel{(9.8)}g\, h$$

$$\Rightarrow v^2 = \cancel{19.6h}\ 2gh$$

$$\Rightarrow v = \cancel{\ }\ \sqrt{2gh}$$

$u = 0$
$a = \cancel{9.8}\ g$
$s = h$

Now collision with the floor be considered. $u_1 = \sqrt{2gh}$, $v_1 = ?$

$$u_2 = 0 = v_2$$

(Here floor is considered the second body)

$$e = -\left(\frac{v_1 - v_2}{u_1 - u_2}\right)$$

$$= -\left(\frac{v_1 - 0}{\sqrt{2gh} - 0}\right)$$

$$= -\left(\frac{v_1}{\sqrt{2gh}}\right) \Rightarrow v_1 = -e\sqrt{2gh}$$

The (-ve) sign indicates the body rise up.

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

$$\cancel{\Rightarrow 0 - \left(\frac{v_1^2}{2gh}\right) = 2 \cdot g \cdot h}$$

$$\Rightarrow \cancel{\ } + \frac{v^2}{2gh} = \cancel{2gh}$$

$$\cancel{\Rightarrow v^2 = 2gh}$$

$\Rightarrow$

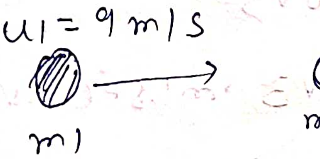
$v = 0$
$u = \cancel{\frac{(v_1)}{\sqrt{2gh}}}\ e\sqrt{2gh}$
~~g~~

$\Rightarrow 0 - (e\sqrt{2gh})^2 = 2(g)S$

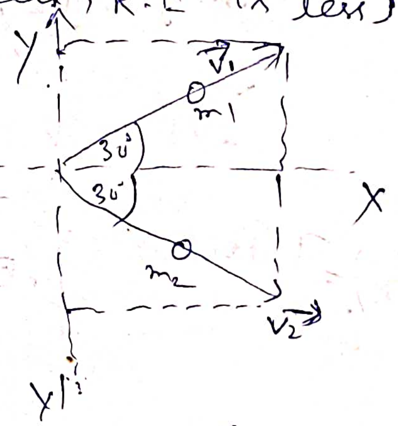
$\Rightarrow \cancel{-}e^2 \cancel{2g}h = \cancel{-2g}S$

$\Rightarrow S = e^2h$ (proved).

4. A ball moving with a speed of 9 m/s strikes an identical ball such that after the collision the direction of each ball makes an angle of 30° with ~~th~~ the original line of motion. Is the K.E conserved in the process? (Ans $3\sqrt{3}$ m/sec for each ball, K.E is less]



before collision



After collision

From the principle of conservation of linear momentum we have $p_{ix} = p_{fx}$

$p_{iy} = p_{fy}$

$p_{ix} = p_{fx}$ gives

$m_1u_1 + m_2u_2 = m_1v_1\cos\theta_1 + m_2v_2\cos\theta_2$

$\Rightarrow (m_1 \times 9) + (m_2 \times 0) = (m_1 \times v_1 \cos 30°) + (m_2 v_2 \cos 30°)$

$\Rightarrow$ But $m_1 = m_2$

$$9 = v_1 \frac{\sqrt{3}}{2} + v_2 \frac{\sqrt{3}}{2}$$

on $(v_1 + v_2)\frac{\sqrt{3}}{2} = 9$

$$\Rightarrow v_1 + v_2 = \frac{9 \times 2}{\sqrt{3}} = 3\sqrt{3} \times 2$$
$$= 6\sqrt{3} \quad \text{---(1)}$$

$P_{iy} = P_{fy}$ gives

~~$(m_1 + u_2) + (m$~~

$$m_1 \times 0 + m_2 \times 0 = m_1 v_1 \sin 30^\circ - m v_2 \sin 30^\circ$$

$$\Rightarrow 0 = m\, v_1 \frac{1}{2} - m\, v_2 \frac{1}{2}$$

$$\Rightarrow v_1 - v_2 = 0$$

$$\Rightarrow v_1 = v_2 \quad \text{---(2)}$$

using (2) in eqn (1) we get

$$2v_1 = 6\sqrt{3}$$

$$\Rightarrow v_1 = 3\sqrt{3} \text{ m/sec} = v_2$$

$(E_K)_i$ = Total K.E before collision $= \frac{1}{2} \cdot m_1 \cdot (9)^2$

$$= \frac{81}{2} \text{ m joule}$$
$$= 40.5 \text{ m joule}$$

$(E_K)_f$ = Total K.E After collision

$$= \frac{1}{2} \cdot m \cdot (3\sqrt{3})^2 + \frac{1}{2} \cdot m (3\sqrt{3})^2$$
$$= 27 \text{ m joule}$$

ΔE = Initial energy - final energy

$$= 40.5 \text{ m Joule} - 27 \text{ m joule}$$
$$= 13.5 \text{ m joule}$$

Thus $(E_K)_f < (E_K)_i$ and the

Collision is in elastic.

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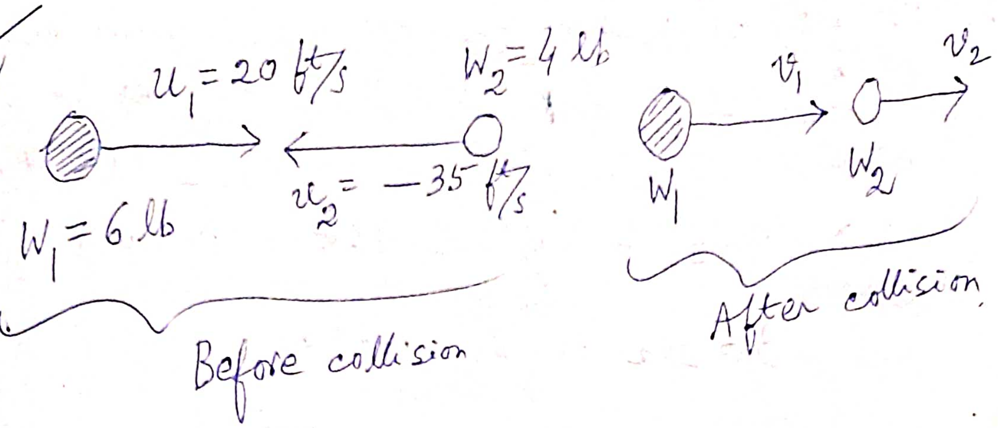


From the princle of conservation of linear momentum we know that

$$p_i = p_f$$

$$\Rightarrow m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

$$\Rightarrow \frac{6}{32} \cdot 20 + \frac{4}{32}(-35) = \frac{6}{32} \cdot v_1 + \frac{4}{32} v_2$$

$$\Rightarrow 120 - 140 = 6v_1 + 4v_2$$

$$\Rightarrow -20 = 2(3v_1 + 2v_2)$$

$$\Rightarrow 3v_1 + 2v_2 = -10 \quad \text{——— (i)}$$

From the defn of co-efficient of restution we know that

$$e = -\left(\frac{v_1 - v_2}{u_1 - u_2}\right)$$

$$\Rightarrow 1 = -\left\{\frac{v_1 - v_2}{20 - (-35)}\right\}$$

$$\Rightarrow 1 = \frac{v_2 - v_1}{55}$$

$$\Rightarrow v_2 - v_1 = 55 \quad \text{——— (ii)}$$

$3v_1 + 2v_2 = -10$ ———— (i)

Multiplying by 3 to both the sides of equation (ii) and adding it with eq^n (i)

$3(v_2 - v_1 = 55)$

$\Rightarrow 3v_2 - 3\cancel{v_1} = 165$

$2v_2 + 3\cancel{v_1} = -10$

$5v_2 = 155$

$\Rightarrow v_2 = \frac{155}{5} = 31$ ft/sec.

Putting this value v_2 in eq^n (ii)

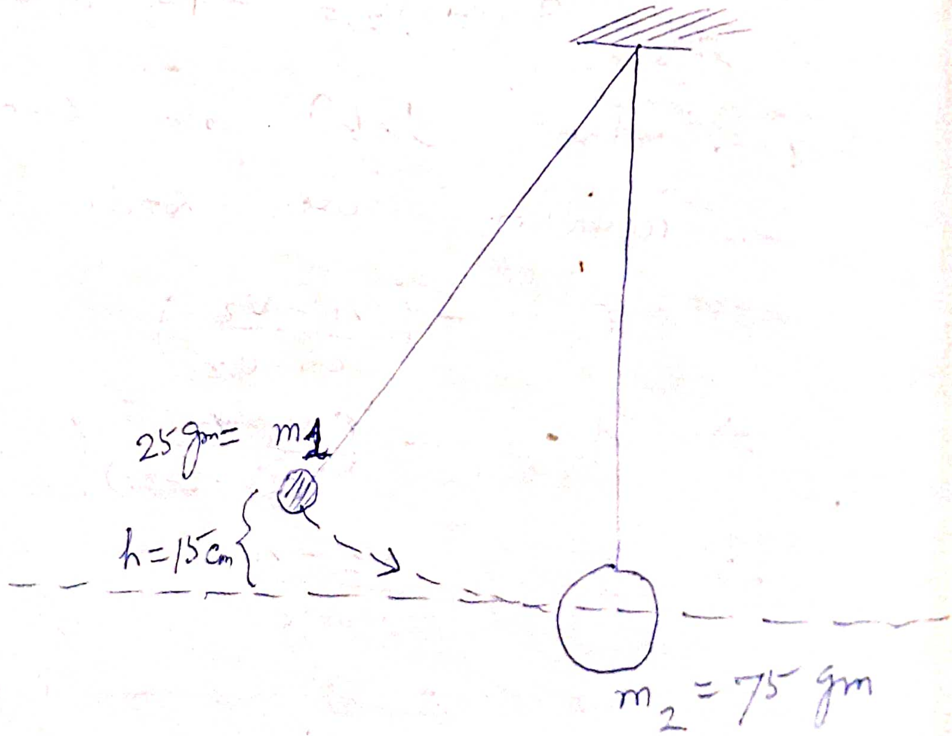
$v_2 - v_1 = 55$

$\Rightarrow 31 - v_1 = 55$

$\Rightarrow v_1 = 31 - 55 = -24$ ft/sec

The (−ve) sign show that the first body moves backward.

11.



vec x,
force
work
forc
momentu
projectaile

By using the princle of conservation of energy it can be shown that the smaller sphere will strike the bigger sphere with a velocity $=\sqrt{2gh}$

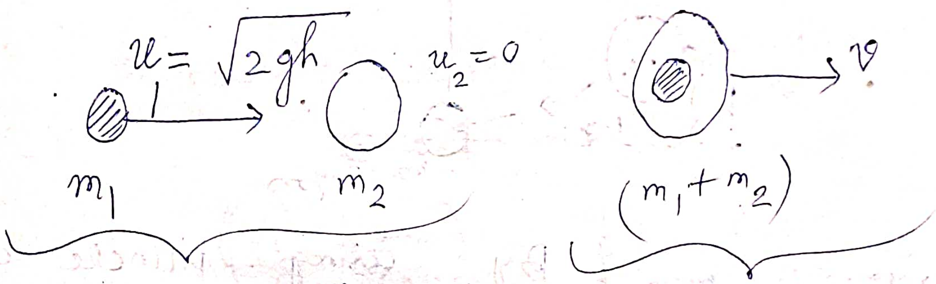
$= \sqrt{2 \times 980 \times 15}$

$= 2 \times 7 \times 5 \sqrt{6}$

$= 70\sqrt{6}$ cm/sec

$= 70 \times 2.449$

$= 171.43$ cm/sec (Ans)



Before collision   After collision

we know that in perfectly inelastic collision the two body merge in to a single body after collision.

$$m_1 u_1 + m_2 \cdot 0 = (m_1 + m_2) \cdot v$$

$$\Rightarrow v = \frac{m_1 u_1}{m_1 + m_2}$$

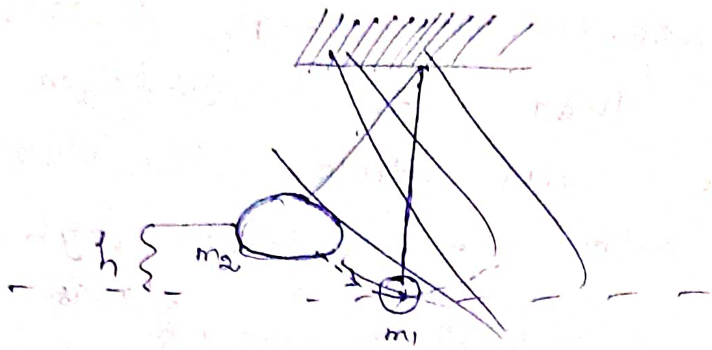
$$= \frac{25 \cdot (171.43)}{25 + 75}$$

$$= \frac{1}{4} \cdot (171.43)$$

$$= 42.8575 \text{ cm/s} \quad \text{(Ans)}$$

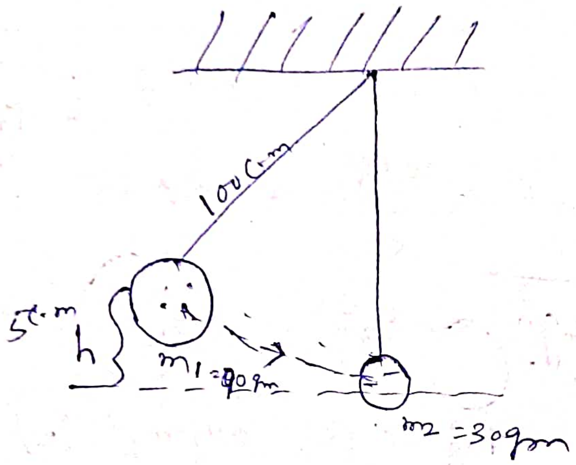
Friday :- 6 P.M.

12.



$$\begin{array}{r} 148.48 \\ 98.99 \\ \hline 49.49 \end{array}$$

12.



By using princle of conservation of energy it can be shown that the bigger sphere will strike the small sphere with a velocity $= \sqrt{2gh}$.

$= \sqrt{2.980 \times 5}$

$= \sqrt{9800} = 70\sqrt{2}$ cm/s

$u_1 = 98.99$ cm/s.

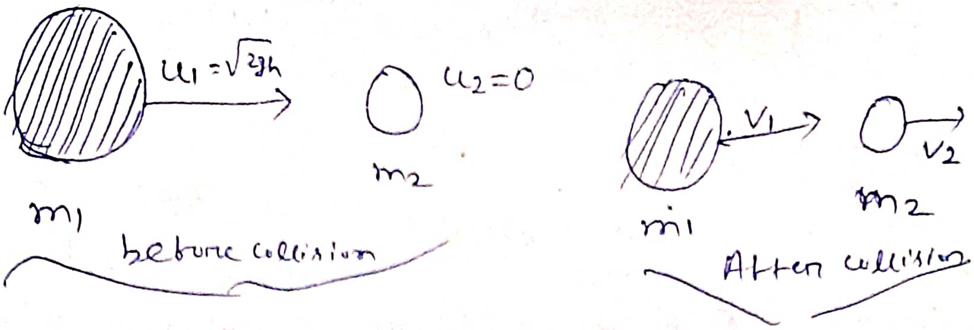
Since mometum is conserved

$P_f = P_i$

$\Rightarrow m_1 v_1 + m_2 v_2 = m_1 u_1 + m_2 u_2$

~~$\Rightarrow 90.(98.99) + (30).0 = 90.$~~

$\Rightarrow 90 . v_1 + 30 v_2 = m_1 (98.99) + m_2 (0)$



$\Rightarrow \quad 90v_1 + 30v_2 = 98.99(90) + 0.30$

$\Rightarrow \quad 3v_1 + v_2 = 98.99 \times 3$

$= 296.97$

$\Rightarrow \quad 3v_1 + v_2 = 296.97$ ——— (i)

In perfectly elastic collision

$$e = 1$$

$$-\left(\frac{v_1 - v_2}{u_1 - u_2}\right) = 1$$

$\Rightarrow \quad v_2 - v_1 = u_1 - u_2$

$\Rightarrow \quad v_2 - v_1 = \sqrt{2gh} - 0 = \sqrt{2gh}$

$= 98.99$ cm/s

$\Rightarrow \quad v_2 - v_1 = 98.99$ ——— (ii)

Multipling (3) in equation (ii)

we get $3v_2 - 3v_1 = 296.97$ — (iii)

Adding eqn (i) and (iii) we get

$$3v_1 + v_2 = 296.97$$
$$3v_2 - 3v_1 = 296.97$$
$$\overline{4v_2 = 593.94}$$

$\Rightarrow \quad v_2 = \frac{593.94}{4}$

Putting the value (v_2) in eqn (ii) $= 148.48$ cm/s.

we get $\quad v_1 = v_2 - 98.99 = 148.48 - 98.99 = 49.49$ cm/s

Head-on collision (Collision in one dimension)

It is an elastic collision between two bodies such that after the collision the two bodies will be found in the same direction as they were moving before collision.

Case-I $u_2 = 0$ that is the second body was in rest and the first body moving with a speed u_1 strikes the second body. The final velocity be denoted by v_1 and v_2.

Our aim is to derive expressions for v_1 and v_2 in terms of m_1, m_2 and u_1.

Since the collision is elastic, the co-efficient of restitution $= e = 1$.

$$\therefore \quad -\left(\frac{v_1 - v_2}{u_1 - u_2}\right) = 1$$

$$\Rightarrow \quad v_2 - v_1 = u_1 \text{ ——— (i)}$$

(because $u_2 = 0$)

Since momentum is conserved in all types of collisions, we have

$$\vec{P_f} = \vec{P_i}$$

$$\Rightarrow m_1\vec{v_1} + m_2\vec{v_2} = m_1\vec{u_1} + m_2\vec{u_2}$$

Since all the directions are the same and $u_2 = 0$,

we have

$$m_1 v_1 + m_2 v_2 = m_1 u_1 \quad \text{—— (ii)}$$

Multipling by m_1 to both the sides of eqn (i), we get

$$m_1 v_2 - m_1 v_1 = m_1 u_1 \quad \text{—— (iii)}$$

Adding eqn's (ii) and (iii) we get

$$m_2 v_2 + \cancel{m_1 v_1} = m_1 u_1$$
$$m_1 v_2 - \cancel{m_1 v_1} = m_1 u_1$$

$$m_1 v_2 + m_2 v_2 = 2 m_1 u_1$$

$$\Rightarrow v_2 (m_1 + m_2) = 2 m_1 u_1$$

$$\Rightarrow v_2 = \frac{2 m_1 u_1}{m_1 + m_2} \quad \text{— (iv)}$$

Putting the value v_2 in eqn (i)

$$v_2 - v_1 = u_1$$

$$\Rightarrow \frac{2 m_1 u_1}{m_1 + m_2} - v_1 = u_1$$

$$\Rightarrow v_1 = \frac{2 m_1 u_1}{m_1 + m_2} - u_1$$

$$= \frac{2 m_1 u_1 - m_1 u_1 - m_2 u_1}{m_1 + m_2}$$

$$= \frac{m_1 u_1 - m_2 u_1}{m_1 + m_2}$$

$$= \frac{u_1 (m_1 - m_2)}{(m_1 + m_2)} \quad \text{— (v)}$$

Special Cases

(a) $m_1 >> m_2$ &

i.e a very much heavier body like a loaded truck strikes a lighter body like a bicycle at rest.

Let's devide the numarator and the denominator of equations (iv) and (v) by m_1

$$V_2 = \frac{2u_1}{1 + \frac{m_2}{m_1}}$$

$$V_1 = \frac{\left(1 - \frac{m_2}{m_1}\right)u_1}{\left(1 + \frac{m_2}{m_1}\right)}$$

Since $\frac{m_2}{m_1} \to 0$, we have $V_2 \to 2u_1$
$V_1 \to u_1$

i.e the speed of heavier body remains unchanged after collision where as the speed of the lighter body gets doubled of the initial speed of the heavier body.

(b) $m_1 << m_2$

i.e a very much lighter body like a ping pung ball strikes a floor which is at rest.

Let's divide the numarator and denominator of equation (iv) and (v) by m_2

$$V_2 = \frac{2\left(\frac{m_1}{m_2}\right)u_1}{\frac{m_1}{m_2}+1}$$

$$V_1 = \frac{\left(\frac{m_1}{m_2}-1\right)u_1}{\left(\frac{m_1}{m_2}+1\right)}$$

Since $\frac{m_1}{m_2} \to 0$ we have $V_2 = 0$

$V_1 = -u_1$

i.e the speed of hevier body remains at rest after collision where as the speed of lighter body remains same in the opposite direction.

(c) $m_1 = m_2$

i.e the masses of two bodies are equal as in the case of collision between two carroom dots.

~~Let's divide the numarator and~~ ~~denomi~~ Putting $m_1 = m_2$ in eqns (iv) and (v) we get

$$V_2 = \frac{2m_1u_1}{m_1+m_2}$$

~~$V_2 = u_1$~~

~~$V_1 = 0$~~

$$\Rightarrow V_2 = \frac{2m_1u_1}{m_1+m_1} = \frac{2m_1u_1}{2m_1} = u_1$$

$$V_1 = \frac{u_1(m_1-m_2)}{(m_1+m_2)} = \frac{u_1(m_1-m_1)}{2m_1}$$

$$= \frac{u_1 \cdot 0}{2m_1}$$

$$= 0$$

Thus the first body comes to rest after collision and the second body moves with the speed of the first body.

Case-II

The Second body moves with a velocity $\vec{u_2}$ along the same direction as that of the first body.

The final velocity be denoted by V_1 and V_2

Our aim is to derive expressions for V_1 and V_2 in terms of m_1 and m_2 and u_1 and u_2.

Since the collision is elastic the co-efficient of restitution $e = 1$

$$-\left(\frac{V_1 - V_2}{u_1 - u_2}\right) = 1$$

$$\Rightarrow V_2 - V_1 = u_1 - u_2 \text{ —(i)}$$

Since momentum is conserved in

all types of collisions, we have

$$\vec{p}_f = \vec{p}_i$$

$$\Rightarrow m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{u}_1 + m_2\vec{u}_2$$

Since all the direction are the same we have

$$m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2 \quad \text{—(ii)}$$

Multibling m_1 to the both the sides of eqn (i) we get

$$m_1v_2 - m_1v_1 = m_1u_1 - m_1u_2 \quad \text{—(iii)}$$

Adding eqn (ii) and (iii) we get

$$\cancel{m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2}$$
$$\cancel{m_1v_1 - m_1v_1 = m_1u_1 - m_1u_2}$$
$$\cancel{m_1v_1 + m_1v_2 = m_1u_1 + m_2u_2}$$
$$\cancel{\Rightarrow m_1(v_1+v_2) = 2m_1u_1}$$
$$\cancel{\Rightarrow v_1+v_2 = \frac{2m_1u_1}{m_1}}$$
$$\cancel{\Rightarrow v_2 = 2u_1 - v_1}$$

$$m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2$$
$$m_1v_2 - m_1v_1 = m_1u_1 - m_1u_2$$

$$m_1v_2 + m_2v_2 = 2m_1u_1 + m_2u_2 - m_1u_2$$

$$\Rightarrow v_2(m_1+m_2) = 2m_1u_1 - u_2(m_1-m_2)$$

$$\Rightarrow v_2 = \frac{2m_1u_1 - u_2(m_1-m_2)}{(m_1+m_2)}$$

$$= \frac{2m_1u_1}{m_1+m_2} - \frac{u_2(m_1-m_2)}{m_1+m_2} \quad \text{—(iv)}$$

Putting the value of (V_2) in eqn (1) we get

$$V_2 - V_1 = u_1 - u_2$$

$$\Rightarrow \frac{2m_1u_1}{m_1+m_2} - \frac{u_2(m_1-m_2)}{m_1+m_2} - V_1 = u_1 - u_2$$

$$\Rightarrow V_1 = \frac{2m_1u_1}{m_1+m_2} - \frac{u_2(m_1-m_2)}{m_1+m_2} - u_1 + u_2$$

$$= \frac{\cancel{2m_1u_1 - m_1u_2 + m_2u_2 - m_1u_1 -}}{\cancel{m_1+m_2}}$$

$$= \frac{2m_1u_1 - m_1\cancel{u_2} + m_2u_2 - m_1u_1 - m_2u_1 + m_1\cancel{u_2} + m_2u_2}{m_1+m_2}$$

$$= \frac{m_1u_1 + 2m_2u_2 - m_2u_1}{m_1+m_2}$$

$$= \frac{u_1(m_1-m_2)}{m_1+m_2} + \frac{2m_2u_2}{m_1+m_2} \quad \text{—— (v)}$$

As a check, one can put $u_2 = 0$ in eqn's (iv) and (v) which should give the corresponding expressions derive in Case I

Problem

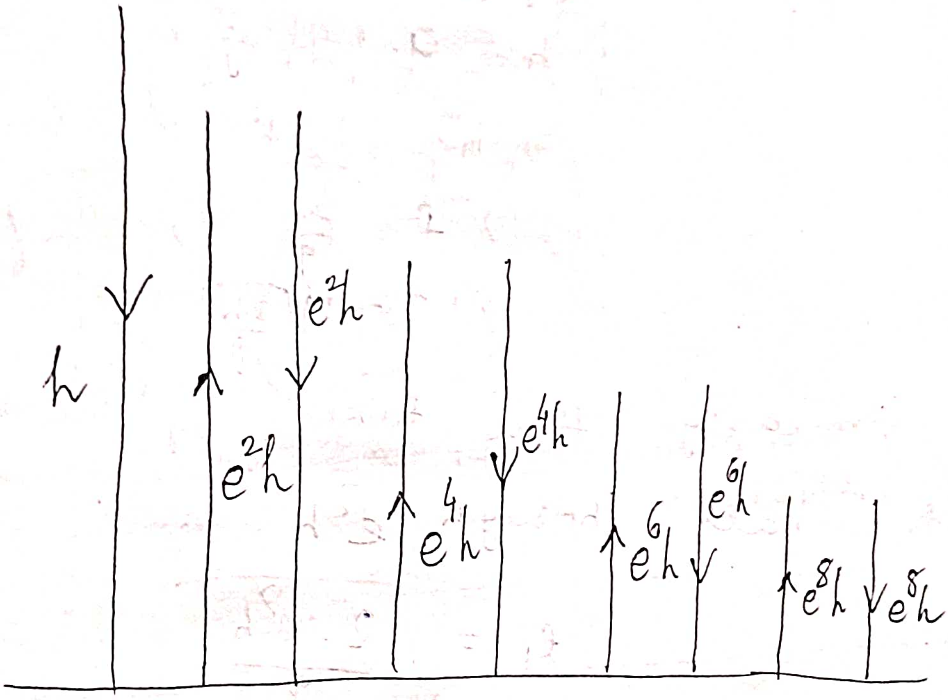
A ball is dropped from a height (h) upon a floor on which the co-efficient of restitution is e

(a) Prove that the total distance

Covered by the ball before it comes to rest is $\left(\frac{1+e^2}{1-e^2}\right) \cdot h$

(b) Prove that the total time taken by the ball before it comes to rest is $\left(\frac{1+e}{1-e}\right) \cdot \sqrt{\frac{2h}{g}}$

Soln



Total distance covered by the ball

$$= h + 2e^2h + 2e^4h + 2e^6h + \cdots\cdots$$

$$= (2h + 2e^2h + 2e^4h + \cdots\cdots) - h$$

$$= 2h(1 + e^2 + e^4 + \cdots\cdots) - h$$

$$= 2h\left(\frac{1}{1-e^2}\right) - h$$

$$= h\left[\frac{2}{1-e^2} - 1\right] = h\left[\frac{2-(1-e^2)}{1-e^2}\right]$$

$$= h\left[2 - 1 + e^2 / (1-e^2)\right] = h\left(\frac{1+e^2}{1-e^2}\right) \text{ (Proved)}$$

(b) Let's find the time ~~to~~ taken by the ball to fall from distance h.

Here $u = 0$
$s = h$
$t = ?$
$a = g$

Using the formula $s = ut + \frac{1}{2}at^2$, we get

$$h = 0 \cdot t + \frac{1}{2} g \cdot t^2$$
$$\Rightarrow h = \frac{1}{2} g t^2$$
$$\Rightarrow t^2 = \frac{2h}{g}$$
$$\Rightarrow t = \sqrt{\frac{2h}{g}}$$

Similarly time taken by the ball to fall through $e^2 h$

$$t_1 = \sqrt{\frac{2 \cdot e^2 h}{g}}$$
$$= e\sqrt{\frac{2h}{g}}$$

t_2 = time taken by the ball to fall $e^4 h$

$$t_2 = \sqrt{\frac{2 \cdot e^4 h}{g}}$$
$$= e^2\sqrt{\frac{2h}{g}}$$ and so on.

Total time taken by the ball

$= t + 2t_1 + 2t_2 + 2t_3 + \cdots$

$$= \sqrt{\frac{2h}{g}} + 2e\sqrt{\frac{2h}{g}} + 2e^2\sqrt{\frac{2h}{g}} + \cdots$$

$$= \left(2\sqrt{\frac{2h}{g}} + 2e\sqrt{\frac{2h}{g}} + 2e^2\sqrt{\frac{2h}{g}} + \cdots\right) - \sqrt{\frac{2h}{g}}$$

$$= 2\sqrt{\frac{2h}{g}}\left(1 + e + e^2 + \cdots\right) - \sqrt{\frac{2h}{g}}$$

$$= 2\sqrt{\frac{2h}{g}}\left(\frac{1}{1-e}\right) - \sqrt{\frac{2h}{g}}$$

$$= \sqrt{\frac{2h}{g}}\left\{2\left(\frac{1}{1-e}\right) - 1\right\}$$

$$= \sqrt{\frac{2h}{g}}\left(\frac{2-1+e}{1-e}\right)$$

$$= \sqrt{\frac{2h}{g}}\left(\frac{1+e}{1-e}\right) \quad \text{(proved)}$$

Problem on Calorimetry

The amount of heat required to raise the temperature of 1 gm of pure water through 1°C is called 1 ~~Calory~~. Calorie.

Specific heat of water = 1

No. 1 formula $\because \left(\begin{array}{l} 1\ \text{Cal} = 1\ \text{gm}\cdot S_w \cdot 1^\circ C \\ S_w = 1\ \text{Cal}\ \text{gm}^{-1}\ {}^\circ C^{-1} \end{array}\right)$

$$\Delta Q = m s \cdot \Delta\theta$$

where ΔQ = amount of heat supplied to a body of mass m gm and specific heat s units.

$\Delta\theta$ = rise of temperature in ~~°~~ degree Centigrade (°C)

Formula:- 2

Heat lost = Heat gained.

(by higher temperature body) = (by lower temp body)

Flow of ~~heat~~ heat is continued till the temperature of the two body become equal.

3. When m gm of solid is converted into liquid at the melting temperature, the amount of heat necessary is given by $Q = m.L_f$

where L_f latent heat of fusion.

= amount of heat necessary to convert 1 gm of solid ~~s~~ into liquid at the melting temperature with no rise of temperature.

Ex: L_f = 80 Calorie / ~~gm~~ gm form ice at 0° C

4. When m gm of liquid at the boiling point is to be converted into gas or vapour then $Q = m.L_v$ Where L_v = latent

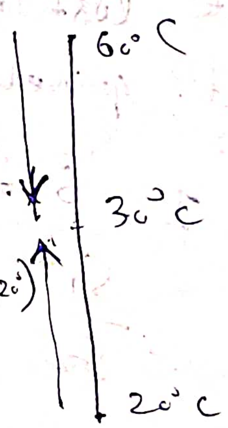
heat of vapourisation.

Ex: L_v for water = 536 Calorie/gm or 540 cal/gm

Problem

1. ~~The~~ A liquid of specific heat 0.5 at 60° C is mixed with another liquid of specific heat 0.3 at 20° C. After mixing, the temperature of mixture becomes 30° C. In what proportion by weight are the liquids mixed. (Ans: 1:5)

Solution:



Heat lost by the first liquid = Heat gained by the second liquid.

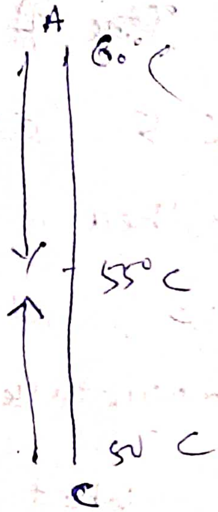
$\Rightarrow m_1 \times 0.5 \times (60^\circ - 30^\circ) = m_2 \times (0.3)(30^\circ - 20^\circ)$

$\Rightarrow \frac{m_1}{m_2} = \frac{0.3 \times 10}{0.5 \times 30} = \frac{3}{15} = \frac{1}{5}$

1 : 5

2. 3 liquids A, B, C are given. 4 gms of A at 60° C and 1 gm. of C at 50° C, have after mixing, a temperature of 55° C. A mixture of 1 gm of A at 60° and 1 gm of B at 50° C shows a temperature of 55° C. What would be the temp in the mixture of 1 gm of B at 60° C and 1 gm of C at 50° C? (Ans: 52° C)

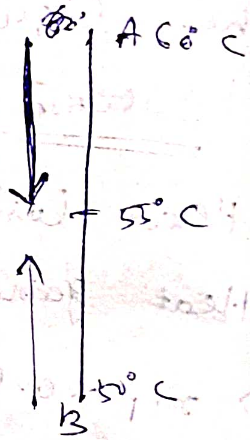
Ans : Let the specific heat of 3 liquids A, B, C be S_1, S_2, S_3 respectively :



~~Sodsot~~
Heat lost by the A liquid
= Heat gained by the C liquid :

$$\Rightarrow \cancel{m_1}\,4 \cdot S_1 \cdot (60^\circ - 55^\circ) = \cancel{m_3}\,1 \cdot S_3 \cdot (55^\circ - 50)$$

$$\Rightarrow \frac{S_1}{S_3} = \frac{1 \times 5}{5 \times 4} = \frac{1}{4}$$

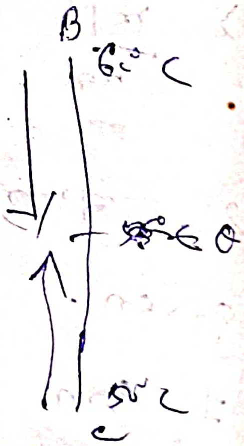


Heat lost by the A liquid
= Heat gained by B liquid

$$\Rightarrow 1 \cdot S_1 = (60^\circ - 55^\circ) = 1 \cdot S_2 \, (60^\circ - 55)$$

$$\Rightarrow \frac{S_1}{S_2} = \frac{1}{1}$$

~~Heat lost by B liquid~~
= ~~Heat gained by C liquid~~



Let temperature mixture be $\theta^\circ C$

There Heat lost by B = Heat gained by C

$$= 1 \cdot S_2 \cdot (60^\circ - \theta) = 1 \cdot S_3 \, (\theta - 50)$$

$$\Rightarrow \frac{S_2}{S_3} = \frac{\theta - 50}{60^\circ - \theta}$$

$$\Rightarrow \frac{1}{4} = \frac{\theta - 50}{60^\circ - \theta}$$

$\Rightarrow 60^\circ - \theta = \cancel{200-40}\ 40\theta - 200$

$\Rightarrow \cancel{5\theta = 260^\circ}$

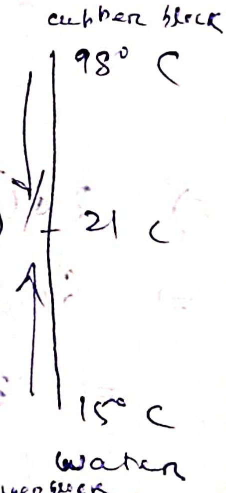
$\Rightarrow \cancel{\theta = \frac{260}{5} = 52^\circ C}$

$\Rightarrow 5\theta = 260^\circ$

$\Rightarrow \theta = \frac{260^\circ}{5} = 52^\circ C$

3. A mass of 700 gm of Cu at 98° C is put into 800 gm of water at 15° C contained in a Cu vessel weighing 200 gm which and the final temperature notice to be 21° C. Find the specific heat of Cu. (Ans: 0.09)

Ans: Heat lost by the copper block = Heat gained by the water + Heat gained by copper vessel.



$m_1 S_1 \Delta\theta = m_2 S_2 \Delta\theta + M_3 S_1 \Delta\theta$

$\cancel{= 800 \cdot (1) \cdot (}$

$= (700) \cdot (S_1) \cdot (98^\circ - 21) = 800 \cdot (1) \cdot (21^\circ - 15) + 200\,(S_1)\,(21^\circ - 15)$

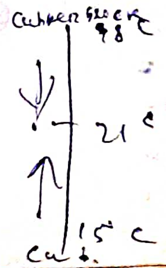
$= 700\, S_1\, 77 = 800 \times 6 + 200 \cdot 6 \times S_1$

$= 4800 + 1200\, S_1$

$\Rightarrow 53900\, S_1 - 1200\, S_1 = 4800$

$\Rightarrow 52700\, S_1 = 4800$

$\Rightarrow S_1 = \frac{4800}{52700} = .09$ cal/gm °C

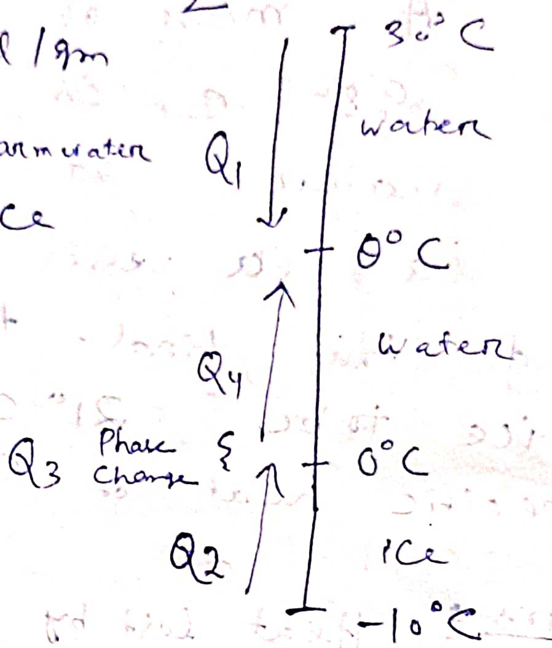


4. What will be the final temp of the mixture when 5 gm of ice at $-10^\circ C$ is mixed with 20 gm of H_2O at $30^\circ C$ Ans: $7^\circ C$

Ans:

S of ice $= \frac{1}{2}$ units.

$L_f = 80$ cal/gm



Heat lost by warm water

= Heat gained by ice

$\Rightarrow Q_1 = Q_2 + Q_3 + Q_4$

$\Rightarrow 20 \times 1 \, (30 - \theta)$

$= 5 \times \frac{1}{2} \{0 - (-10^\circ)\}$

$+ 5 \times 80$

$+ 5 \times 1 \times (\theta - 0^\circ)$

$\Rightarrow 20(30 - \theta) = 5 \times \frac{1}{2} \times \cancel{10}^{5} + 400 + 5\theta$

$= 25 + 400 + 5\theta$

$\Rightarrow 600 - 20\theta$

$\Rightarrow 25\theta = 600 - 425 = 175$

$\Rightarrow \theta = \frac{175}{25} = 7^\circ C$

Task: 10, 11,

Ans: 0.2397

S of Al = ~~0.21~~ or 212 C.g.S unit

$95° = \frac{37°}{95} \times 180$ ... $\times 9 + 32$

~~35~~ C

100 − 32 = 65

15, Ans: 0.505

$180 \times \frac{5}{9} - 32$

16,

17, Ans: 23.562° C

18.

20.

$\boxed{\text{307 page}}$ → C-Physics

2. Heat lost by warm water = Heat gained by ice

Q_4 ↑ 0° C

Phase change Q_3 0° C

Q_2 −20° C

$\Rightarrow Q_1 = Q_2 + Q_3 + Q_4$

$\Rightarrow 25\theta = 25 \times \frac{1}{2} \times \{0 - (-20°)\} + 25 \times 80 + 25 \times 1 \times (\theta - 0°)$

$\Rightarrow 25\theta = 25 \times \frac{1}{2} \times 20^{10} + 2000 + 25\theta$

$\Rightarrow 25\theta = 250 + 2000 + 250$

$\Rightarrow 250 = 2500 - 2250 = 250$

$\Rightarrow \theta = \frac{250}{25} = 10°C$

6. ~~180° F~~

$= \frac{\cancel{180}^{20} \times 5}{9} - 32$

$= 100 - 32$

$= 68° C$

70 F

$= 70 \times \frac{5}{9} - 32$

$= 38.8 - 32$

$= 6.8 C$

68° C

6.8° C

Heat lost by Coffee Cup

= Heat gain by

$m_1 s_1 \Delta\theta = m_2 s_2 \Delta\theta$. 1000 / 500 (60)

~~⇒ Loose of H~~

~~Heat gain by the cup~~

~~$= m s \Delta\theta$~~

~~$= 200 \times .20 \times (68^\circ - 6.8)$~~

~~$= \cancel{4000}^{40} \times 61.2$~~

~~$= \cancel{2244}$~~

∴ Heat gain by the coffee = 2448 Cal

Friday 7 P.m

$$\boxed{\begin{aligned} C^\circ \text{ to } F &= C \times \tfrac{9}{5} + 32 = F \\ F \text{ to } C &= F - 32 \times \tfrac{5}{9} = C^\circ \end{aligned}}$$

6. $180^\circ F = 180 - 32 = 148 \times \frac{5}{9}$

$= 82.22^\circ C$

$70^\circ F = 70 - 32 = 38 \times \frac{5}{9} = 21.11^\circ C$

Heat lost by coffee = Heat gained by cup.

Heat gain by ~~coffecut~~

$= m s \Delta\theta$

$= 200 \times .20 \times (82.22 - 21.11)$

$= 4000 \times 61.11$

$= 2444$ Calorie.

So Heat lost by coffee 2444 Calorie.

~~9~~. 10.

Heat required = Heat gained by water + Heat gained by bran

⇒ $m_1 S_1 \Delta\theta_1 = m_2 S_2 \Delta\theta_2 + m_3 S_3 \Delta\theta_3$

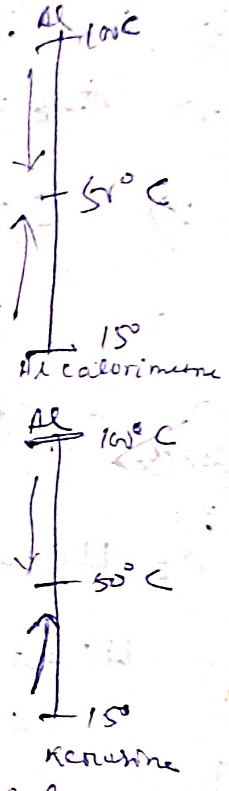
$\Rightarrow 590 = 100\,gm.(1).(5^\circ C) + (200).S_3.(5)$

$= 500 + 1000\,S_3$

$\Rightarrow 1000\,S_3 = 590 - 500 = 90$

$\Rightarrow S_3 = \frac{90}{1000} = .09$ Cal/gm.°C

11. Heat lost by Aluminium = Heat gained by aluminium Calorimeter + Heat gained by kerosene.



$\Rightarrow m_1 S_1 \Delta\theta_1 = m_2 S_2 \Delta\theta_2 + m_3 S_3 \Delta\theta_3$

$\Rightarrow (200).(.217)(100-50)$

$= (120).(.217).(50-15^\circ) + (150).(S_3)(50-15^\circ)$

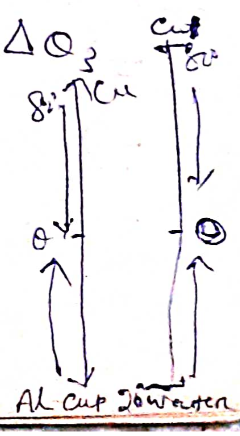
$\Rightarrow 2170 = 911.4 + 5250\,S_3$

$\Rightarrow 5250\,S_3 = 2170 - 911.4$

$= 1258.6$

$\Rightarrow S_3 = \frac{1258.6}{5250} = .2397$ Cal/gm°C

16. Heat lost by Copper = Heat gained by Water + Heat gained by aluminium Cup



$\Rightarrow m_1 S_1 \Delta\theta_1 = m_2 S_2 \Delta\theta_2 + m_3 S_3 \Delta\theta_3$

$\Rightarrow (200).(.1).(80^\circ-\theta) = (200)(1).(\theta-20^\circ) + (50).(.22).(\theta-20^\circ)$

$\Rightarrow 1600 - 20\theta = 200\theta - 4000 + 11\theta - 220$

$\Rightarrow 200\theta + 11\theta + 20\theta = 1600 + 4000 + 220$

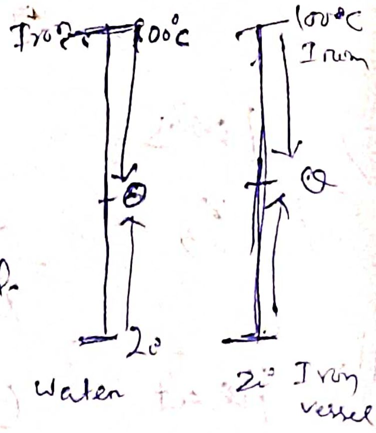
$\Rightarrow 231\theta = 5820$

$\Rightarrow \theta = \frac{5820}{231} = 25.194 \approx 25.2^\circ C$

17. Heat lost by ~~[illegible]~~ iron

= Heat gained by water

+ Heat gained by iron vessel.



$\Rightarrow m_1 S_1 \Delta\theta_1 = m_2 S_2 \Delta\theta_2 + m_3 S_3 \Delta\theta_2$

$\Rightarrow 80 \times (.12) \times (100^\circ - \theta) = 200.(1).(\theta - 20^\circ) + (50).(.12).(\theta - 20^\circ)$

$\Rightarrow 960 - 9.6\theta = 200\theta - 4000 + 6\theta - 120$

$\Rightarrow 200\theta + 6\theta + 9.6\theta = 960 + 4000 + 120$

$\Rightarrow 215.6\theta = 5080$

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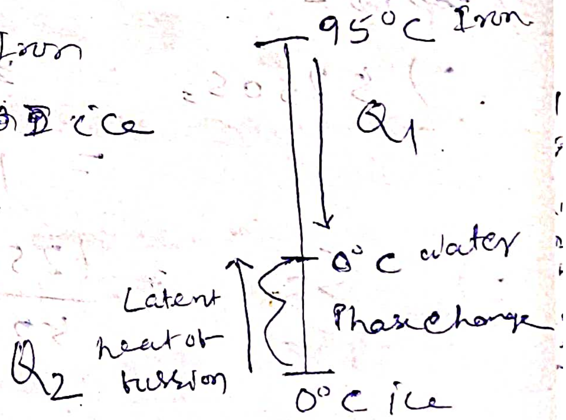
$\Rightarrow \theta = \frac{5080}{215.6} = 23.56^\circ c$ (Ans).

18. Heat lost by Iron

= Heat gained by ~~[illegible]~~ ice



$\Rightarrow m_1 s_1 \Delta\theta_1 =$ ~~[illegible]~~ $m_2 . L_f$

$\Rightarrow (150).(.115).(95 - 0^\circ) = 21 gm\ L_f$

$\Rightarrow 1638.75 = 21 gm\ L_f$

$\Rightarrow L_f = \frac{1638.75}{21} = 78.03$ Calory/gm

20. A Substance has.

boiling point = $120°C$

freezing point = $-20°C$

Specific heat as gas = 0.4 cal/gm°C

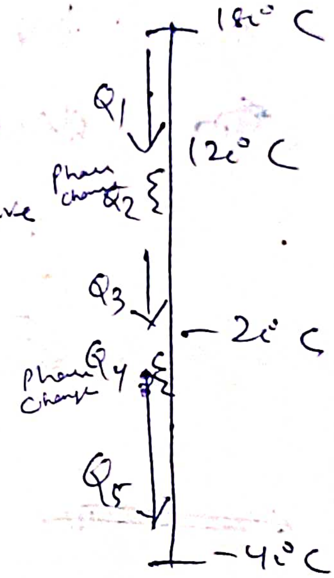
liquid = 1.5 cal/gm°C

solid = 1 cal/gm°C

heat of fusion $L_f = 200$ cal/g.

heat of ~~...~~ vaporization 600 cal/g.

Mass = 15 gm.



Q_1 = Amount of heat gave by the vapour by decreasing $180°$ to $120°$

$= m \cdot S_v \cdot \Delta\theta$

$= 15 \times .4 \times (180 - 120°)$

$= \cancel{600}\ 6 \times 60$

$= 360$ Calary.

Q_2 = Amount of heat given out, when the vapour become condens to the liquid. at the boiling point.

$= m \cdot L_v$

$= 15 \times 600$

$= 9000$ calory.

Q_3 = Amount of heat given out liquid when the temp decreases $120°$ ~~to~~ to $-20°C$

$= m \cdot S_L \cdot \Delta\theta$

$= 15 \times (1.5) \times \{120° - (-20°)\}$

$= 22.5 \times 140$

$= 3150$ Calory.

Q_4 = Amount of heat given out by the liquid condes to ~~liquid~~ solid

$= m_1 \cdot L_f$

$= 15 \times 20$ cal/g

$= 300$ calory.

Q_5 = Amount of heat given out by the solid when it ~~is~~ decreases from -20 to $-40°C$.

$= m_1 \cdot S_{solid} \cdot \Delta\theta$

$= 15 \times 1 \times \{-20° - (-40°)\}$

$= 15 \times 1 \times (-20° + 40°)$

$= 15 \times 20$

$= 300$ Calory.

Total amount of heat given out

$= Q_1 + Q_2 + Q_3 + Q_4 + Q_5$

$= 360 + 9000 + 3150 + 3000 + 300$

$=$ 15810 Calory.

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~~Principle~~ Principle of Rocket propulsion

A rocket is an internal combustion engine that carries its own supply of Oxygen. Therefore it can operate in empty space (vaccum). When the burning gases are ~~expand~~ expelled with some velocity v relative to the rocket, dis-charging mass at a constant rate

$\frac{\Delta m}{\Delta t}$, then the force on the rocket will contain two terms.

$$F = \frac{\Delta p}{\Delta t} \quad \text{(From Newton's 2nd law)}$$

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

$$= m \cdot \frac{\Delta v}{\Delta t} + v \cdot \frac{\Delta m}{\Delta t} \quad \text{———— (i)}$$

The (দূরত্ব/ লক্ষ্যভেদ) range and accuracy of the rocket depends on the velocity V_b attained by the time the fuel has burned out or is cut off.

Suppose a rocket is launched vertically from the earth and continues upward in a straight line (সামান্য) encountering negligible atmospheric resistance.

Eqn (i) can be rewritten as

$$F = m\frac{\Delta v}{\Delta t} + \bar{V}_e \cdot \frac{\Delta m}{\Delta t} \quad \text{------------ (ii)}$$

where $\bar{V}_e$ = Avarage exhaust velocity ~~of the gases~~. of the gases ejected from the rocket motor in the direction opposite to the velocity V of the rocket.

equation (ii) can be solved for the burned out velocity (V_b).

$$V_b = \bar{V}_e \log_e \frac{m_0}{m_b} - \bar{g}\, t_b \quad \text{(iii)}$$

where m_0 = mass of the the rocket at the starting point.

m_b = mass of the rocket after a time t_b from start when all the fuel has been burnt or supply of fuel is cut off.

$\bar{g}$ = Average value of acceleration due to gravity.

In a <u>single stage rocket</u>, the propulsion energy must be used to accelerate the entire empty mass of the rocket even after most of that mass is no longer useful. This severely limits the speed attainable. Infact a single stage rocket can not achieve the speeds of the order of 25,000 ft/sec and greater required to place a satelite in orbit or to escape the earth's gravitional field.

A multiple-stage rocket is made up of a number of independent sections each equipped with a propulsion system. Initially 1 section is ~~exi~~ excited and after reaching the burnout velocity, the entire section is to be dropped from the rocket. Then the second section is excited and ultimately that has to be thrown out. In this way very high speeds can be attained.

Page 181 Coll. Phy

10. Here initial velocity of rocket

$u = 0$

$V = 966 \text{ km/hour}$

$= 966000 \text{ metre}/3600$

$S = 305 \text{ m}$

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

$\Rightarrow \frac{v^2}{2S} = a$ (because $u=0$)

$\Rightarrow a = \frac{\left(\frac{9660}{36}\right)^2}{2 \times 305} = \frac{93315600 \times 1}{1296 \times 2 \times 305}$

$= \frac{93315600}{790560}$

$= 118.037 \text{ m/s}^2$

Number of times of g

$= \frac{a}{g} = \frac{118.037 \text{ m/s}^2}{9.8 \text{ m/s}^2} = 12.04$

$\therefore$ it is 12 times of g.

15. $W = JH$

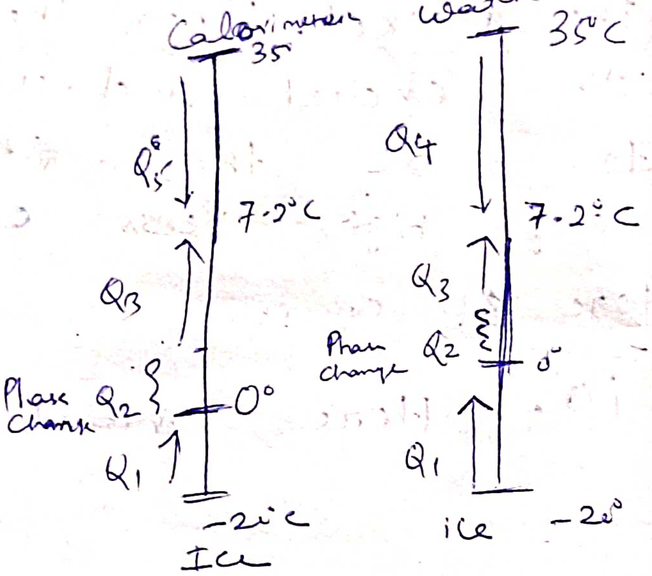
$H = \frac{W \rightarrow \text{work in joule}}{J \rightarrow 4.2 \text{ Joule/cal}}$

Heat produced in calorie

$\Rightarrow s = \frac{840 \text{ J/kg/}^\circ\text{C}}{4.2 \text{ J/cal}}$

$\Rightarrow s = \frac{200}{1000} \text{ cal/gm/}^\circ\text{C}$

$\Rightarrow \therefore S = 0.2 \text{ cal. gm}^{-1}\ {}^\circ\text{C}^{-1}$



Heat lost by water + Heat lost by calorimeter = Heat gained by ice.

$\Rightarrow Q_4 + Q_5 = Q_1 + Q_2 + Q_3$

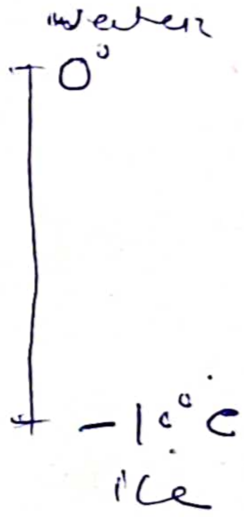
$\Rightarrow m_4 s_4 \Delta\theta_4 + m_5 s_5 \Delta\theta_5 = m_1 s_1 \Delta\theta_1 + m_2 L_f + m_3 s_3 \Delta\theta_3$

$\Rightarrow (100) \times (1) \times (35 - 7.2) + 25 \times (.2) \times (35 - 7.2)$
$= 30.(s_1).\{0 - (-20)\} + 30 \times 80 + 30 \times 1 \times (7.2 - 0)$

$\Rightarrow 2780 + 139 = 600 s_1 + 2400 + 216$

$\Rightarrow 600 s_1 = 2919 - 2616$
$= 303$

$\Rightarrow s_1 = \frac{303}{600} = .505$ (Ans) a-> A lump of ice at $-10^\circ C$ weighing 80 gm, is dropped into water at $0^\circ C$. If 5 gm water freeze, Calculate the Specific heat of ice. (Ans. 0.5)



Ans: Heat lose by water = Heat gain by ice

$\Rightarrow m_1 \, L_f = m_2 \, S_2 \, \Delta\theta_2$

$\Rightarrow 5\,gm \times 80 \, \frac{calory}{gm} = 80 . S_2 \{0 - (-10^\circ)\}$

$= 800$ Calorie

$\Rightarrow$ 400 calory $= S_2 . 800$ Calorie

$\Rightarrow S_2 = \frac{400}{800} = .5$

S. heat of ice $= .5$

.616
503
+9

Dimension of a few physical quantities.

Most of the physical quantities can be expressed by the symbols {M (for mass), L (for length), and T (for time). For other physical quantities one has to use the symbols A (for current), K (for temprature), Cd (for luminous intensity), Mol (for mass expressed in mole)

1. <u>Charge</u> :- The rate of flow of charge is known as current.

$$I = \frac{Q}{t}$$

$$\Rightarrow Q = It$$

$$\Rightarrow [Q] = [I].[t]$$

$$= [A][T]$$

$$= [AT]$$

2. <u>Electric potential</u> :-

The amount of work done to displace a charge q units between two points having a potential difference ΔV units is given by

$$\Delta W = q \cdot \Delta V$$

where ΔV = potential difference between two points.

q = Charge shifted.

ΔW = work done.

$$\therefore \Delta V = \frac{\Delta W}{q}$$

$$\Rightarrow [\Delta V] = \frac{[\Delta W]}{[q]}$$

$$= \frac{[ML^2T^{-2}]}{[AT]}$$

$$= [ML^2T^{-3}A^{-1}]$$

3. Electrical capacity :

It is given by the formula

$$C = \frac{Q}{V}$$

where C = Capacity of the capaciter.

Q = Amount of charge present in the capaciter.

V = electric potential developed in the capaciter.

$$[C] = \frac{[Q]}{[V]} = \frac{[AT]}{[ML^2T^{-3}A^{-1}]}$$

$$[C] = \left[\frac{A^2 T^4}{M L^2}\right]$$

$$= [M^{-1} L^{-2} T^4 A^2]$$

4. Resistance

From Ohm's law, we know that

$$V = RI$$

where V = potential difference between the two ends of a ~~Ro~~ conductor of resistance R ohm.

I = Current flowing through the resistance wire

$$R = \frac{V}{I}$$

$$[R] = \frac{[V]}{[I]}$$

$$= \frac{[ML^2 T^{-3} A^{-1}]}{[A]}$$

$$= [ML^2 T^{-3} A^{-2}]$$

5: Permittivity

From Coulomb's law in electrostatics the force between two point charges is given by

$$F = \frac{1}{4\pi \epsilon_0} \frac{q_1 q_2}{r^2}$$

where q_1 and q_2 are the charges separated through a distance of r units. ϵ_0 = Permittivity of air or vacuum

$$\epsilon_0 = \frac{q_1 q_2}{F\, 4\pi r^2}$$

$$[\epsilon_0] = \frac{[q_1][q_2]}{[F][r^2]}$$

$$= \frac{[AT][AT]}{[MLT^{-2}][L^2]}$$

$$= \frac{[A^2 T^2]}{[ML^3 T^{-2}]}$$

$$= [A^2 T^4 M^{-1} L^{-3}]$$

6. Magnetic flux : (ϕ_m)

From Faraday's second law of electro magnetic induction, we know that,

$$e = -N \cdot \frac{d\phi_m}{dt}$$

where e = induced e.m.f developed in a coil having N number of ~~turns~~ turns.

$\frac{d\phi_m}{dt}$ = Rate of change of magnetic flux with time

Thus $d\phi_m = \frac{e \cdot dt}{N}$ {(−) sign is of no importance when dimension is considered}

$\Rightarrow [d\phi_m] = [e].[dt]$ (since N has no dimension)

$= [ML^2T^{-3}A^{-1}].[T]$

$= [ML^2T^{-2}A^{-1}]$

7. Magnetic induction (B)

Magnetic flux over a plane surface kept at right angles to a uniform magnetic field is given by

$$\phi_m = BA$$

where A = area of the plane surface or coil having the dimension L^2

$$B = \frac{\phi_m}{A}$$

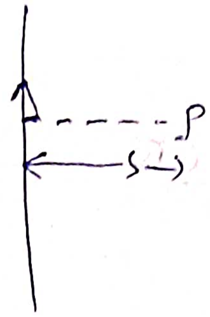
$$[B] = \frac{[ML^2T^{-2}A^{-1}]}{[L^2]}$$

$$= [MT^{-2}A^{-1}]$$

8. <u>Magnetic permeability (μ_0).</u>

The magnetic induction developed near a long, straight conductor carrying current is given by the expression :

$$B = \frac{\mu_0 I}{2\pi S}$$



where S = distance of the point from the conductor.

$$\mu_0 = \frac{B\, 2\pi S}{I}$$

$$[\mu_0] = \frac{[B].[S]}{[I]}$$

$$= \frac{[M T^{-2} A^{-1}][L]}{A}$$

$$= [MLT^{-2} A^{-2}]$$

9. <u>Self inductants (L)</u>

From Faraday's second law it can be shown that

$$e = -L\frac{dI}{dt}$$

or $\phi_m = LI$ can be used to find the dimension of L

$$L = \frac{\phi_m}{I}$$

$$= \left[\frac{ML^2T^{-2}A^{-1}}{A}\right]$$

$$= [ML^2T^{-2}A^{-2}]$$

OR

$$L = -\frac{e\,dt}{dI}$$

$$= \frac{e\,dt}{dI}$$ (−ve sign is of no importance in dimension)

$$= \frac{[ML^2T^{-3}A^{-1}].[T]}{[A]}$$

$$= [ML^2T^{-2}.A^{-2}]$$

10. <u>Electric field intensity</u> (E)

The force experience by a charged particle moving in an electric field is given by

$$F = q.E$$

$$\Rightarrow E = \frac{F}{q}$$

$$\Rightarrow [E] = \frac{[MLT^{-2}]}{[AT]}$$

$$= [MLT^{-3}A^{-1}]$$

11. Electric flux (ϕ_e)

Electric flux over a plane surface kept at right angles to a uniform electric field is given by $\phi_e = E.A$

where A = Area of the plane surface or coil having dimension L^2.

$$[\phi_e] = [E].[A]$$

$$= [MLT^{-3}A^{-1}].[L^2]$$

$$= [ML^3T^{-3}A^{-1}]$$

12. Stefan-Boltzmann constant (σ)

Energy radiated by a black body per second to the surrounding medium is given by

$$P = \sigma . A . T^4$$

where A = surface area of the black body.

T = ~~~~ Absolute temp of the black body.

$$P = \frac{\text{Energy}}{\text{time}}$$ ~~by time~~

$$\sigma = \frac{P}{AT^4}$$

$$[\sigma] = \frac{\frac{[ML^2T^{-2}]}{[T]}}{[L^2 . K^4]}$$

$$= \frac{ML^2T^{-2}}{[T]} \times \frac{1}{L^2K^4}$$

$$= \cancel{MPE^3} = [M\ T^{-3}\ K^{-4}]$$

13. Co-efficient of thermal conductivity(K)

The amount of heat flowing through bar or rod during t second is given by

$$Q = \frac{K A (\theta_1 - \theta_2) . t}{l}$$

where Q = Amount of heat (energy) flowing through the bar of length l. and area of cross section A

$(\theta_1 - Q_2)$ = difference of temperature ~~betw~~ between the two ends of the bar.

t = time for which the flow is consider.

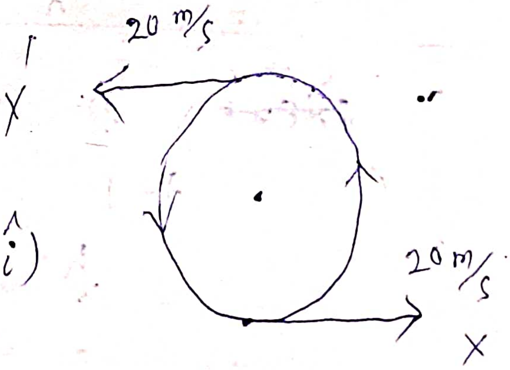
$$K_1 = \frac{Ql}{A(\theta_1-\theta_2)t}$$

$$[K_1] = \frac{[ML^2T^{-2}].[L]}{[L^2].[K].[T]}$$

$$= [MT^{-3}.K^{-1}L]$$

$$= [MLT^{-3}K^{-1}]$$

Wed: 7 P.M.



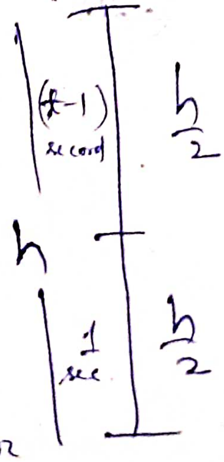
Relative vel^g

$= 20\hat{i} - 20(-\hat{i})$

$= 40\,\hat{i}$

Relative speed $= 40$ m/s

14. A body dropped from some height covers half of ~~its~~ the distance in the last second of its fall.



Let the height be h.

In the last second it cover $\frac{1}{2}$ of its distance

$= \frac{h}{2}$.

Let total time taken $= t$.

In the last second it cover $\frac{h}{2}$ distance.

then next $\frac{h}{2}$ distance covers in $(t-1)$ second

In ~~the~~ ~~first~~ second it covered

the ~~distance~~

$$\frac{h}{2} = ut + \frac{1}{2}at^2$$
$$= 0.t + \frac{1}{2}.g.t^2$$
$$= \frac{1}{2}gt^2$$

next $\frac{h}{2}$ distance it ~~takes~~

~~time~~ = h

∴ upper ~~next~~ $\frac{h}{2}$ distance it covered

in t-1 second.

$$\frac{h}{2} = u.t + \frac{1}{2}at^2$$
$$= 0 + \frac{1}{2}g(t-1)^2$$
$$\frac{h}{2} = \frac{1}{2}g(t-1)^2 \quad \text{——(i)}$$

Total height (h) covered in t second.

$$h = ut + \frac{1}{2}at^2$$
$$h = 0 + \frac{1}{2}gt^2 \quad \text{——(ii)}$$

Putting the value of h in eqn (i), we get

$$\frac{\cancel{\frac{1}{2}}\cancel{g}t^2}{2} = \cancel{\frac{1}{2}}\cancel{g}(t^2+1-2t)$$
$$\Rightarrow 1t^2 = 2t^2 + 2 - 4t$$
$$\Rightarrow t^2 - 4t + 2 = 0$$
$$t = \frac{-(-4) \pm \sqrt{(-4)^2 - 4.(1).(2)}}{2.(1)}$$

$$= \frac{4 \pm \sqrt{8}}{2}$$

$$= \frac{4 \pm 2\sqrt{2}}{2}$$

$$t = \frac{4 + 2\sqrt{2}}{2} \text{ or } \frac{4 - 2\sqrt{2}}{2}$$

$$= \frac{4 + 2.828}{2} \text{ or } \frac{4 - 2.828}{2}$$

$$= \frac{6.828}{2} \text{ or } \frac{1.172}{2}$$

$$= 3.414 \text{ or } .586 \text{ (which is impossible)}$$

So $t = 3.414$.

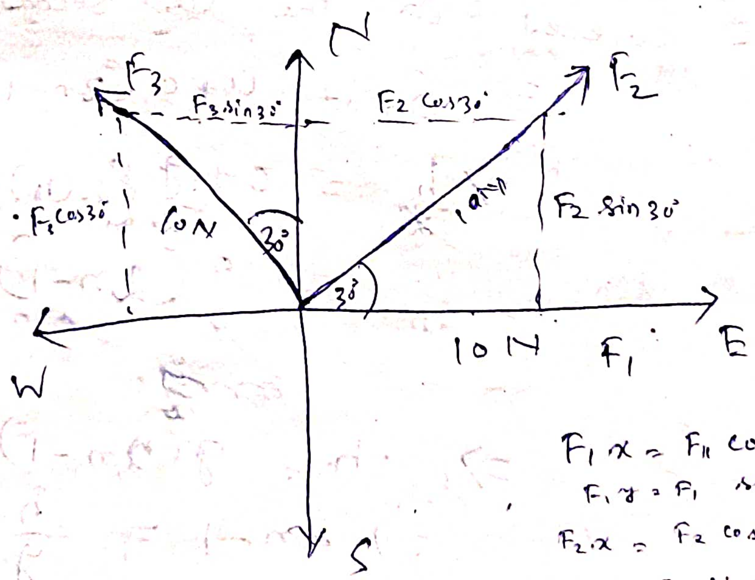
$$h = \frac{1}{2} g t^2$$

$$= \frac{1}{2} \cdot \overset{16}{\cancel{32}} \cdot (3.414)^2$$

$$= 16 \times 11.655396$$

$$= 186.5 \text{ feet (Ans)}$$

15.



$F_{1x} = F_1 \cos 0 = F_1$

$F_{1y} = F_1 \sin 0 = 0.$

$F_{2x} = F_2 \cos 30° = F_2 \cdot \frac{\sqrt{3}}{2}$

$F_{2y} = F_2 \sin 30° = F_2 \frac{1}{2}$

$F_{3x} = F_3 \cos 30° = F_3 \frac{\sqrt{3}}{2}$

$F_{3y} = F_3 \sin 30° = F_3 \frac{1}{2}$

$$R_x = F_{1x} + F_{2x} + F_{3x}$$

$$= F_1 + F_2 \frac{\sqrt{3}}{2} + F_3 \frac{\sqrt{3}}{2}$$

$$= 10 + 5\sqrt{3} + 5\sqrt{3}$$

$$= 10 + 10\sqrt{3}$$

$$= 10 + 10(1.732) = 10 + 17.32 = 27.32$$

$R_y = F_1y + F_2y + F_3y$

$= 0 + F_2\frac{1}{2} + F_3 \cdot \frac{1}{2}$

$= 5 + 5$

$= 10\ N$

$R = \sqrt{R_x^2 + R_y^2}$

$= \sqrt{(27.37)^2 + 10^2}$

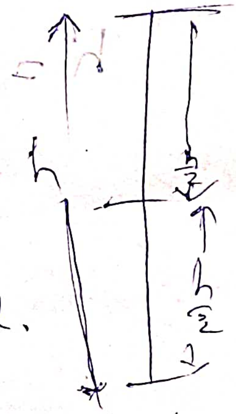
$= \sqrt{746.3824 + 100}$

$= \sqrt{846.3824}$

$= 29.09\ N$

~~14, 15 time Out 2 Ans~~

33. A body dropped from some height covers half of the distance in the last second of its fall.



Distance covered in the last second

$= S_n = u + \frac{g}{2}(2n-1)$

$\Rightarrow \frac{h}{2} = 0 + \frac{g}{2}\{2(n)-1\}$

$= \frac{g}{2}(2n-1)$

$\Rightarrow h = g(2n-1)$

$\Rightarrow 2n-1 = \frac{h}{g}$

$\Rightarrow 2n = 1 + \frac{h}{g}$

$\Rightarrow n = \frac{1}{2} + \frac{h}{2g}$

$= \frac{1}{2} + \frac{h}{64} = \frac{32+h}{64}$ —(1') ~~$\frac{g+h}{2g}$ —(1)~~

Total height covered in n second using the formula $S = ut + \frac{1}{2}at^2$ we get

$\Rightarrow h = 0.t + \frac{1}{2}gn^2$

$= \frac{1}{2}gn^2 = \frac{1}{2}.32.n^2$

$= 16n^2$ —(ii)

equation (i) $n = \frac{32+h}{64}$

$\Rightarrow 64n = 32+h$

$\Rightarrow h = 64n - 32$

From equation (i) and (ii)

$16n^2 = 64n - 32$

$\Rightarrow n^2 = 4n - 2$

$\Rightarrow n^2 - 4n + 2$

$\Rightarrow n = \frac{-(-4) \pm \sqrt{(-4)^2 - 4.(1).(+2)}}{2.(1)}$

$= \frac{4 \pm \sqrt{8}}{2}$

$= \frac{4+2\sqrt{2}}{2}, \frac{4-2\sqrt{2}}{2}$

$= \frac{4+2.828}{2}$ or $\frac{4-2.818}{2}$

$= 3.414$ sec or $.586$ sec

.586 sec is impossible because in 1 sec it covers half distance.

So it must not cover the total distance in .586 sec.

Total height $= 16n^2$

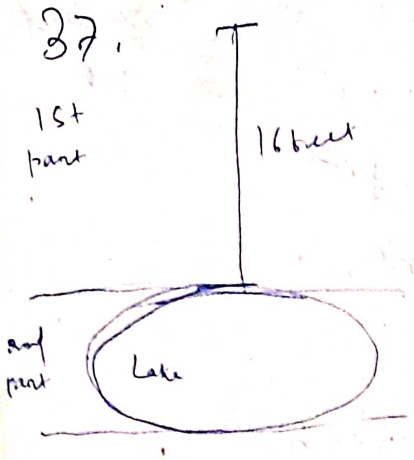
$= 16.(3.414)^2$

$= 16 \times 11.655396$

$= 186.5$ feet

(Ans)

37.



When the ball is dropped $u = 0$.

$S = 16$ feet.

$g = 32$ feet.

using the formula $v^2 - u^2 = 2as$ we get

$\Rightarrow v^2 - 0 = 2.(32)(16)$

$\Rightarrow v^2 = 1024$

$\Rightarrow v_1 = 32$ feet/sec

When the ball moves in the lake

$u_2 = v_1 = 32$ feet/sec.

$S = ?$

~~$v = 0$~~

~~$a = g = 32$ feet/sec.~~

~~using the formula $v^2 - u^2 = 2as$, we get~~

~~$0 - 1024 = 2.(32).S$~~

~~$\Rightarrow$~~

using the formula $v_1 = u + at$ we get

$\Rightarrow 32 = 0 + 32.t$

$\Rightarrow t = 1$ sec

So it takes 1 sec to cover the distance from the dropped place to touching place the lake.

But total time taken to reach the bottom 5 sec..

So total time taken to reach the bottom from the touching point = 4 sec

(a) So ~~total distance~~ deep of the lake

$$S = ut + \frac{1}{2}at^2$$
$$= 32.(4) + \frac{1}{2}.0.t^2$$
$$= 128 \text{ feet.}$$

(b) Average velocity = $\dfrac{\text{Total distance covered}}{\text{Total time taken}}$

$$= \frac{128 + 16}{5}$$
$$= \frac{144}{5}$$
$$= 28.8 \text{ feet/sec.}$$

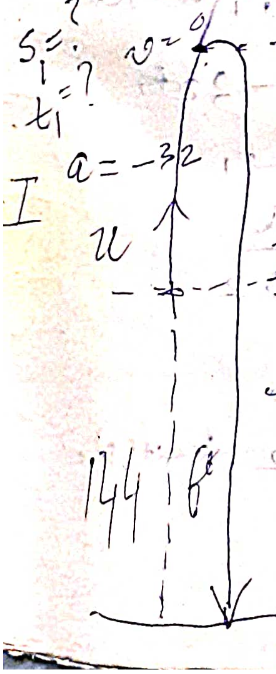
(c) ~~The toto~~ Of the water of lake is drained.

then $S = 144$ feet.

$u = ?$

$t = 5$ sec.

(c)



$S_2 = S_1 + 144$

$t_2 = ?$

$t_1 + t_2 = 5$ sec

using the formula, $S = ut + \frac{1}{2}at^2$ we get

$$144 = u.5 + \frac{1}{2} 32.25$$
$$144 = 5u + 400$$
$$\Rightarrow 5u = 144 - 400$$
$$= -256$$
$$\Rightarrow u = -\frac{256}{5} \text{ feet/sec.}$$

For first part

initial velocity $= u_1$

$a = -32$ feet/sec^2

$t_1 = ?$

$S_1 = ?$

$V_1 = 0$

Using the formula $V^2 - u^2 = 2as$, we get

$\Rightarrow 0 - u^2 = 2.(-32).S_1$

$\Rightarrow \cancel{-}u^2 = \cancel{-}64\ S_1$

$\Rightarrow S_1 = \dfrac{u^2}{64}$

~~using the formula~~ $\cancel{S = ut + \frac{1}{2}at^2}$ ~~, we get~~

$\cancel{\Rightarrow \dfrac{u^2}{64} = ut + \frac{1}{2}.(-32)t^2}$

$\cancel{\Rightarrow \dfrac{u^2}{64} = ut - 16t^2}$

Using the formula, $V_1 = u_1 + a_1t_1$, we get

$\Rightarrow 0 = u_1 - 32t_1$

$\Rightarrow u_1 = 32t_1$

$\Rightarrow t_1 = \dfrac{u_1}{32}$

For the second part $u_2 = 0$

$a_2 = 32$ feet/sec^2

$S_2 = ?$

$t_2 = ?$

$S_2 = u_2 t_2 + \frac{1}{2} a_2 t_2^2$

$= 0 + \frac{1}{2} \cdot (32) \cdot t_2^2$

$= 16 t^2$

$\Rightarrow S_1 + 144$

$\Rightarrow \frac{u^2}{64} + 144 = 16 t_2^2$

$\Rightarrow \frac{u^2}{64 \cdot 16} + \cancel{144}\, 9 = t_2^2$

$\Rightarrow t_2 = \sqrt{\frac{u^2}{64 \cdot 16} + 9}$

As per the question

$t_1 + t_2 = 5$ second

$\Rightarrow \frac{u_1}{32} + \sqrt{\frac{u^2}{1024} + 9} = 5$

$\Rightarrow \left(5 - \frac{u_1}{32}\right)^2 = \frac{u^2}{1024} + 9$

$\cancel{\Rightarrow \left(\frac{160 - u_1}{32}\right)^2 = \frac{u^2 + 11216}{1024}}$ 32

$\Rightarrow \frac{(160 - u_1)^2}{1024} = \frac{u^2 + 9216}{\cancel{1024}}$

25600
11216
14384

$\Rightarrow 25600 + \cancel{u^2} - 3204 = \cancel{u^2} + 9216$

$\Rightarrow 3204 = 25600 - 9216$

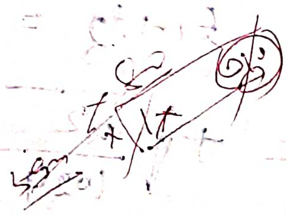
$= 16384$

$\Rightarrow u = \frac{16384}{\cancel{320}} = \frac{256}{5} = 51.2$ ft/sec

$$F = \frac{dp}{dt} = \frac{d(mv)}{dt} = m\frac{d(v)}{dt}$$
$$= ma$$

If the mass does not remain constant with time then $F = \frac{d(mv)}{dt} = m\frac{dv}{dt} + v\frac{dm}{dt}$

$$= 5 \times L_f$$
$$80 \times S_{ice} \times [0 - (-10)] = 400 \text{ cal}$$
$$80 \times S_{ice} \times 10 = 400$$
$$\Rightarrow S_{ice} = \frac{400}{800} = \frac{1}{2}$$

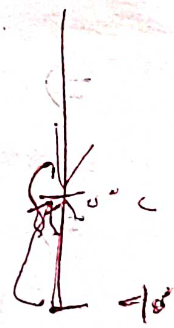


$\boxed{ms\Delta\theta}$

$80 gm \times S \times (0-(-10)) =$

$\Rightarrow S = \frac{5}{80}$

Heat gained by ice



$-10°c$

$\boxed{\text{Heat lost by water}}$

$81 \times S \times 10$

$5gm \times 1 \times 8 =$

$\Rightarrow 5 \times 1 \times 8$

$40 = S$

$$P_{instant} = \frac{dW}{dt}$$

$$= \frac{d}{dt}\left(\frac{1}{2} m \frac{v_f^2}{t_f^2} t^2\right)$$

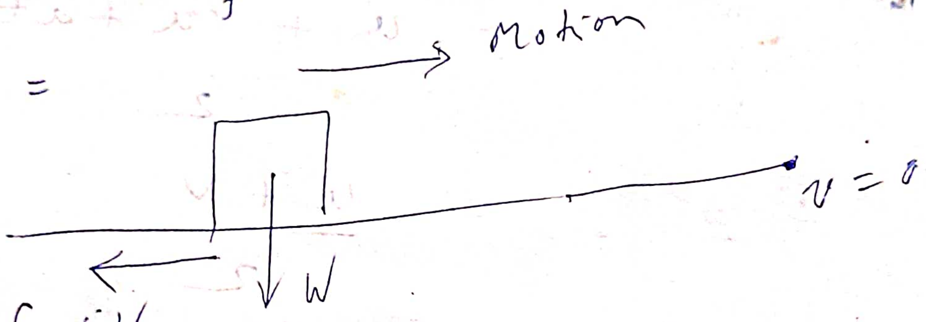
$$= \frac{1}{2} m \frac{v_f^2}{t_f^2} \cdot \frac{d}{dt}(t^2)$$

$$= \frac{1}{2} m \cdot \frac{v_f^2}{t_f^2} \cdot 2t$$

$$=$$

1. Dimension
2. Error
3. Problem

vb HL



$f = \mu W$

Net force $= -\mu \cancel{m} g = \cancel{m} a$

$\Rightarrow a = -\mu g$

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7. A lump of ice at -10°C weighing 80 g, is dropped into water at 0°C. If 5 gm of water freeze, calculate the specific heat of ice. (.5 Ans)

11. It takes 15 minutes for an electric kettle to heat a certain quantity of water 0°C to 100°C. It requires 80 min to turn all the water at 100°C into steam. Determine the latent heat of steam. (533.33 Cal g^{-1})