SAMPLE QUESTION PAPER – E

1. Its value remains same as $6{\cdot}67 \times 10^{11}\ Nm^2\ kg^{-2}$ as it is universal constant and it does not depend on value of g. **1**

2. Compressibility is the reciprocal of the bulk modules, *i.e.,* compressibility = 1/K **1**

3. (a) PV = constant, since $\Delta T = 0$ **½**

(b) $W = 2{\cdot}303\ nRT \log\left(\frac{V_f}{V_i}\right)$ **½**

4. It gives an evidence for the existence of atoms.

5. Yes, When a ball is dropped from a height on a perfectly elastic plane surface, the motion of a ball is oscillatory but not simple harmonic.

6. The conventional rules are :

(i) If the insignificant digit to be dropped is more than 5 the preceeding digit is increased by 1 but if it is less than five than proceeding digits is not changed, *e.g.* 1·748 is rounded off to 3 significant figures as 1·75 and 1·742 as 1·74. **1**

(ii) If the insignificant digit to be dropped is 5 than this digit is simply dropped if the prceeding digit is even but if odd then the preceeding digit is increased by 1.

e.g., the number 1·845 rounded off to three significant digits is 1·84 but for number 1·875 it is 1·88. **1**

7. In one dimensional motion the intial instant of time or zero time ($t = 0$) is considered at the beginning of the observation of motion. It may not be the instant of beginning of motion. Suppose a ball is thrown from a height of 500 m. It becomes visible say at a height of 100 m. Then origin or inital instant of time or zero time ($t = 0$) is this instant only and not the instant when motion actually began. **1**

Thus, if zero instant is considered as present then times before the instant is past and time after this instant is future. **1**

8. Let θ is the angle between $\vec{A}$ and $\vec{B}$.

$\therefore \quad \vec{A} \cdot \vec{B} = AB\cos\theta$ ....(i) **½**

and $\quad \vec{B} \cdot \vec{A} = BA\cos\theta$ ....(ii) **½**

From eqns. (i) and (ii), we get

$$\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}$$ **1**

Or

In this case force $\vec{F}$ refers to the total external force, on the system (internal forces in the system are not included in $\vec{F}$ and $\vec{a}$ refers to the acceleration of the whole system, *i.e.*, acceleration of the centre of mass of the system. **2**

9. (a) The rotating wheels of a bicycle posses angular momentum. In the absense of an external torque, neither the magnitude nor the direction of angular momentum can change. The direction of angular momentum is along the axis of the wheel. So, the bicycle does not get tilted. **1**

(b) The cycle wheel is constructed in such a way so as to increase the M.I. of the wheel with minimum possible mass, which can be achieved by using spokes and the M.I. is increased to ensure the uniform speed. **1**

10. (i)
$$\sin\omega t - \cos\omega t = \sqrt{2}\left[\sin\omega t\cos\frac{\pi}{4} - \cos\omega t\sin\frac{\pi}{4}\right]$$
$$= \sqrt{2}\sin\left(\omega t - \frac{\pi}{4}\right)$$

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This function represents S.H.M. having period

$$T = 2\pi/\omega \text{ and initial phase} = -\frac{\pi}{4} \text{ rad.} \quad \mathbf{1}$$

(ii) $$\sin^2 \omega t = \frac{1}{2}(1 - \cos^2 \omega t)$$

$$= \frac{1}{2} - \frac{1}{2}\cos^2 \omega t. \quad \mathbf{½}$$

The function is periodic, having a period, **½**

$$T = \frac{2\pi}{2\omega} = \frac{\pi}{\omega}$$

but does not represent S.H.M. **½**

11. It is the indirect method of measuring the distances of the order of 10^{-10} m which is the size of an atom, *i.e.,* small distances, an atom is a tiny sphere. When such atoms lie packed in any substance, empty spaces are left in between. According to Avogadro's hypothesis, volume of all atoms in one gram of substance is 2/3 of the volume occupied by one gram of the substance.

$$V = \frac{2}{3}V \quad \text{....(i)}$$

V = Actual volume of one gram mass.
V = Volume occupied by atoms in 1 gram mass.
ρ = Density of the substance

$$V = \frac{1}{\rho} \quad \text{....(ii)} \ \mathbf{1}$$

Let M = atomic weight of the substance
N = Avogadro's no.

∴ No. of atoms in 1 gm of the substance

$$= \frac{N}{M}$$

If r be the radius of each atom, then

V = no. of atoms in gm × volume of each atom

$$V = \frac{N}{M} \times \frac{4}{3}\pi r^3 \quad \text{....(iii)} \ \mathbf{1}$$

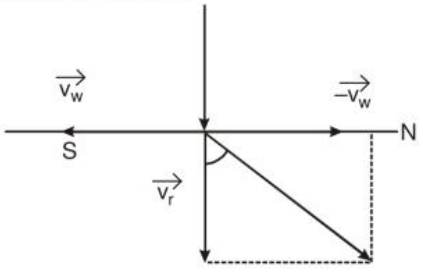
∴ From eqns. (i), (ii) and (iii), we get

$$\frac{N}{M} \times \frac{4}{3}\pi r^3 = \frac{2}{3} \times \frac{1}{\rho}$$

$$r = \left(\frac{M}{2\pi N\rho}\right)^{1/3} \quad \mathbf{1}$$

12. Figure (a) does not represent one dimensional motion of particle because the particle has two different positions at the same instant which is not the case of one dimensional motion. Figure (d) also does not represent one dimensional motion of the particle because here the total path length is shown to decrease with time which is not possible in one dimensional motion. **1**
Graph (ab) does not represent one dimensional motion becuase at the same instant a particle cannot have positive and negative velocity if the motion is one dimensional. **1**
Graph (c) does not represent on dimensional motion because speed cannot be negative as shown in graph. **1**

13. Velocity of rain relative to the woman of cycle is



½

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$$\vec{v}_{rw} = \vec{v}_r - \vec{v}_w$$

$$\tan\theta = \frac{v_w}{v_r} = \frac{10}{30} = \frac{1}{3}$$

$$= 0{\cdot}3333$$

$$\theta = 18°26'$$ ½

with verical towards south.

14. Frequency of revolution of stone is given by

$$f = 40 \text{ rev./min} = \frac{40}{60} \text{ r/s}$$

Mass of stone, $m = 0{\cdot}25$ kg

Radius of circle, $r = 1{\cdot}5$ m

By formula angular speed of the stone,

$$\omega = 2\pi f$$

$$\Rightarrow \quad \omega = 2\pi \times \frac{40}{60}$$

$$= \frac{4\pi}{3} \text{ rad s}^{-1}.$$ **1**

T = tension in the string = ?

T_{max} = maximum tension in the string

= 200 N

i.e., $$T = \frac{mv^2}{r} = mr\omega^2$$

$$\Rightarrow \quad T = 0{\cdot}25 \times 1{\cdot}5 \times \left(\frac{4\pi}{3}\right)^2 \text{ N}$$

$$\Rightarrow \quad T = 0{\cdot}25 \times 1{\cdot}5 \times \frac{16}{9} \times 9{\cdot}87, \qquad (\because \pi^2 = 9{\cdot}87)$$

$$\Rightarrow \quad T = 6{\cdot}58 \text{ N} \approx 6{\cdot}6\text{N}$$ **1**

As the string can withstand a maximum tension of 200 N.

$$\therefore \quad T_{max} = \frac{mv^2_{max}}{r}$$

Or $$v_{max} = \sqrt{\frac{rT_{max}}{m}}$$

$$= \sqrt{\frac{1{\cdot}5 \times 200}{0{\cdot}25}}$$

$$= 34{\cdot}64 \text{ ms}^{-1}$$

$$= 35{\cdot}0 \text{ ms}^{-1}$$

$$\therefore \quad T = 6{\cdot}6 \text{ N},$$

$$v_{max} = 35{\cdot}0 \text{ ms}^{-1}.$$ **1**

15. We are given that

T_{max} = maximum tension in the string so that it does not break

= 2 kg wt = 2 × 10 N = 20 N

Let T_1 be the tension in the string when the stone is in its lowest position of its circular path. We know that

$$T_1 = \frac{mv_1^2}{l} + mg.$$ **1**

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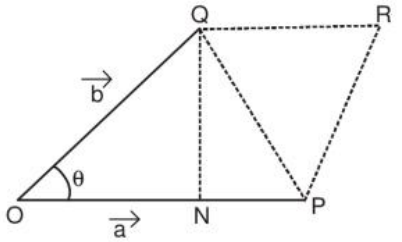
T_1 would have its minimum value when v_1 equal its minimum value = $\sqrt{5gl}$, needed by the stone, to complete its vertical circular path. **1**

Hence, $$(T_1)\ \min = \frac{mv_{\min}^2}{l} + mg = 6mg$$
$$= 6 \times 0{\cdot}4 \times 10$$
$$= 24\ \text{N}$$

We thus see that $(T_1)_{\min}$ is more than the breaking strength of the string. Hence the particle cannot describe the vertical circle. **1**

16. Let $\vec{a}$ be represented by $\overrightarrow{OP}$ and $\vec{b}$ be represented by $\overrightarrow{OQ}$. Let $\angle POQ = \theta$



Complete the parallelogram OPRQ. Join PQ draw QN ⊥ OP.

In ΔQNO, $$\sin\theta = \frac{QN}{OQ} = \frac{QN}{b}$$
$$QN = b \sin\theta$$

Now, by definition,

$$|\vec{a} \times \vec{b}| = ab \sin\theta$$
$$= (OP)(QN)$$
$$= \frac{2(OP)(QN)}{2}$$
$$= 2 \times \text{area of } \Delta OPQ$$

$\therefore$ $$\text{Area of } \Delta OPQ = \frac{1}{2}|\vec{a} \times \vec{b}|$$ **1**

17. (a) The linear speed ($v = \omega R$) changes because the distance, *i.e.,* (R) of the comet from the sun changes due to it elliptical orbit around the sun. **½**

(b) The angular speed of the comet also change because it covers different angle in equal interval of time. **½**

(c) The angular momentum of the comet is same throughout due to the conservation of angular momentum in the absence of any torque. **½**

(d) Kinetic energy changes because linear speed is different at different points. **½**

(e) The potential energy at different points is different because the comet is not at the same distance from the sun (the orbit is not circular).

(f) The total energy of comet remain the same throught the motion. **½**

18. (i) Using , $$v = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$$, we get

$$v = \frac{1}{2\pi}\sqrt{\frac{1200}{3}}$$
$$= 3{\cdot}18\ \text{s}^{-1}$$

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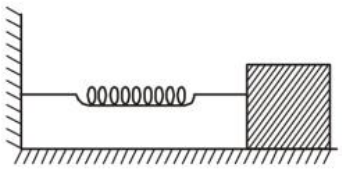

(ii) Maximum acceleration $= r\omega^2$ **1**

$= r\,(2\pi v)^2$

$= 4\pi^2 f^2 r$

$= 4\pi^2\,(3{\cdot}18)^2 \times 0{\cdot}02$

$= 7{\cdot}98\ \text{ms}^{-2}$. **1**

(iii) Maximum speed $= r\omega$

$= r.2\pi f$

$= 2\pi \times 3{\cdot}18 \times 0{\cdot}02$

$= 0{\cdot}04\ \text{ms}^{-1}$ **1**

Or

According to Newton's law, speed of sound,

$$v = \sqrt{\frac{K_{\text{isothermal}}}{p}}$$

where $K_{\text{isotermal}}$ = pressure P for isothermal change

$$v = \sqrt{\frac{P}{p}}$$ **1**

where $P = 76$ cm of Hg

$= 76 \times 13{\cdot}6 \times 980\ \text{dyne cm}^{-2}$

and $\rho = 1{\cdot}293 \times 10^{-3}\ \text{g cm}^{-3}$

$\therefore$ at N.T.P. $= 280\ \text{ms}^{-1}$

Laplace suggested that $K_{\text{isothermal}}$ should be replaced with $K_{\text{adiabitic}}$.

$$v = \sqrt{\frac{K_{\text{adiabitic}}}{p}}$$

Here $PV^{\gamma} = \text{constant}$ **1**

Differentiating, we have

$P^{\gamma}V^{\gamma-1}\,dV + V^{\gamma}\,dP = 0$

i.e., $\gamma P\,dV = -V\,dP$

Or $dV/V = -\,dP/\gamma P$

But $K_{\text{adiabitic}} = \dfrac{d\,P}{d\,V/v} = \gamma P$

$\therefore$ $v = \sqrt{\dfrac{\gamma P}{p}}$

$$V_{\text{N.T.P.}} = \sqrt{\frac{(1{\cdot}41)(76 \times 13{\cdot}6 \times 980)}{1{\cdot}293 \times 10^{-3}}}$$

$= 333\ \text{ms}^{-1}$. **1**

19. Given, $Y = 12{\cdot}5 \times 10^{11}\ \text{dyne cm}^{-2}$

$= 12{\cdot}5 \times 10^{10}\ \text{Nm}^{-2}$

Diameter, $D = 2{\cdot}5\ \text{mm} = 2{\cdot}5 \times 10^{-3}$ m

$\therefore$ Radius, $r = \dfrac{D}{2} = 1{\cdot}25 \times 10^{-3}$ m.

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$$F = 100 \text{ kgf}$$
$$= 100 \times 9{\cdot}8 \text{ N} = 980 \text{ N}$$

$$\frac{\Delta L}{L} \times 100 = ?$$

$$A = \pi r^2 = \pi (1{\cdot}25 \times 10^{-3})^2 \text{ m}^2 .$$

$$Y = \frac{F/A}{AL/L} \qquad \mathbf{1}$$

$$\% \text{ increase in length} = \frac{\Delta L}{L} \times 100$$

$$= \frac{F}{AY} \times 100 = \frac{F}{\pi r^2 Y} \times 100$$

$$= \frac{980}{3{\cdot}142 \times (1{\cdot}25 \times 10^{-3})^2 \times 12{\cdot}5 \times 10^{10}} \times 100$$

$$= 15{\cdot}96 \times 10^{-2} = 0{\cdot}16\% \qquad \mathbf{1}$$

20. Let a be the area of cross-section of the rod, v be the volume of mass attached, when rod is floating on water, then

$$\text{wt. of float} = \text{weight of water displaced}$$
$$= (a \times 3 \times v) \times 1 \times g \qquad \ldots.(1) \ \mathbf{½}$$

When rod is floating in a liquid.

$$\text{Weight of liquid displaced} = (a \times 3{\cdot}5 + V)\, 0{\cdot}9 \times g \qquad \ldots.(2)$$

Or $$3a + v = 3{\cdot}15a + 0{\cdot}9V$$

Or $$v = 1{\cdot}5a \qquad \mathbf{½}$$

Let x be the depth of the rod immersed in a sp. gravity 1·2, then weight of liquid displaced

$$= (xa + V)1{\cdot}2 \times g \qquad \mathbf{1}$$

$\therefore$ $$(xa + v)\, 1{\cdot}2 \times g = (a \times 3 + v)\, g$$

$$(xa + 1{\cdot}5a) \times 1{\cdot}2 = 3a + 1{\cdot}5\, a = 4{\cdot}5\, a$$

Or $$1{\cdot}2x + 1{\cdot}8 = 4{\cdot}5$$

$$x = 2{\cdot}25 \text{ cm.} \qquad \mathbf{1}$$

21. From Newton's law of cooling, the rate of cooling $\propto$ difference in temperatures

Given, average of 80°C and 50°C = 65°C

Temperature of surroundings = 20°C

$\therefore$ Difference = 65 – 20 = 45°C $\qquad \mathbf{½}$

Under these conditions, the body cools 30°C in time 5 minutes.

$\therefore$ $$\frac{\text{Change in temperature}}{\text{Time}} = k\, \Delta T$$

$\Rightarrow$ $$\frac{30}{5} = k \times 45^\circ \qquad \ldots.(1) \ \mathbf{1}$$

The average of 60° C and 30°C is 45° C which is 25°C (45 – 20) above the room temperature and the body cools by 30°C (60 – 30) in a time t (say)

$$\frac{30}{5} = k \times 25 \qquad \ldots.(2) \ \mathbf{½}$$

where k is same for this situation as for the original.

Equation (1)/(2) gives,

$$\frac{30/5}{30/t} = \frac{k \times 45}{k \times 25}$$

$\Rightarrow$ $$\frac{t}{5} = \frac{9}{5}$$

$\Rightarrow$ $$t = 9 \text{ min.} \qquad \mathbf{1}$$

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22. For using the internal energy of sea water to operate the engine of a ship. The internal energy of the sea water has to be converted into mechanical energy. Since whole of the internal energy cannot be converted into mechanical energy, a part has to be rejected to a colder body (sink). Since, no such body is available, the internal energy of the sea water cannot be used to operate the engine of the ship. **3**

23. (a) Adarsh is hardworking, thinks logically, having scientific temper, able to find solutions with patience. **2**

(b) Since, I is proportional to g, the length of the pendulum on the surface of the moon will be 1/6 m. **2**

24. Proof. When we can show that Newton's first and third laws are contained in the second law, then we can say that it is the real law of motion.

(i) First law is contained in second law : According to Newton's second law of motion,

$$\vec{F} = \vec{ma} \qquad ....(1)$$

where m = mass of the body on which an external force $\vec{F}$ is applied and acceleration produced in it.

When no external force is applied on the body, *i.e.,*

When $\vec{F} = 0$, then from equation (1), we get

$$\vec{ma} = 0, \text{ but as } m \neq 0$$

$$\therefore \quad \vec{a} = 0 \qquad \text{½}$$

It means that there will be no acceleration in the body if no external force is applied. This represents that a body at rest will remain at rest and a body in uniform motion will continue to move along the same straight line in the absence of an external force. This corresponds to Newton's first law of motion. So, first law of motion is contained in Second law of motion. **½**

(ii) Third law is contained in second law : Consider an isolated system of two bodies A and B. Let they act and react internally.

Suppose,

F_{AB} = force applied on body A by body B.

and F_{BA} = force applied on body B by body A.

When $\frac{d\vec{p}_A}{dt}$ = rate of change of momentum of body A.

and $\frac{d\vec{p}_B}{dt}$ = rate of chage of momentum of body B.

Then, from Newton's second law of motion,

$$F_{AB} = \frac{d\vec{p}_A}{dt} \qquad ....(2)$$

$$F_{BA} = \frac{d\vec{p}_B}{dt} \qquad ....(3) \quad \textbf{1}$$

Equations (2) and (3) give,

$$\vec{F}_{AB} + \vec{F}_{BA} = \frac{d}{dt}(\vec{p}_A) + \frac{d}{dt}(\vec{p}_B) = \frac{d}{dt}(\vec{p}_A + \vec{p}_B) \qquad \textbf{1}$$

Since no external force acts on the system ($\because$ it is isolated), therefore according to Newton's second law of motion,

$$\frac{d}{dt}(\vec{p}_1 + \vec{p}_2) = 0$$

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Or $\vec{F}_{AB} + \vec{F}_{BA} = 0$

Or $\vec{F}_{AB} = -\vec{F}_{BA}$

Action = – Reaction. **1**

It means that action and reaction are equal and opposite. It is the statement of Newton's third law of motion. Thus, 3rd law is contained in the second law of motion.

As both First and Third las are contained in Second law, so Second law is the real law of motion. **1**

Or

Impulse-momentum theorem states that the impulse of force on a body is equal to the change in momentum of the body.

i.e., $\vec{J} = \vec{F}\,t = \vec{p_2} - \vec{p_1}$ **1**

Proof. According to Newton's Second law of motion, we know that

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

Or $\vec{F}\,dt = d\vec{p}$ ....(i) **½**

When $\vec{F}$ = constant force acting on the body.

Suppose $\vec{p_1}$ and $\vec{p_2}$ be the linear moment of the body at time $t = 0$ and t respectively.

$\therefore$ Integrating equation (i) within these limits, we get

$$\int_0^t \vec{F}\,dt = \int_{\vec{p_1}}^{\vec{p_2}} d\vec{p}$$ **½**

$\Rightarrow$ $$F\int_0^t dt = \int_{\vec{p_1}}^{\vec{p_2}} d\vec{p}$$

$$\vec{F}\left[t\right]_0^t = [p]_{p_1}^{p_2}$$

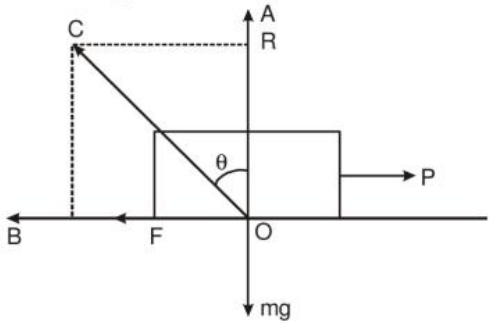
$$\vec{F}\,t = \vec{p_2} - \vec{p_1}$$

$$\vec{J} = \vec{p_2} - \vec{p_1}\,.$$ **1**

(b) The coefficient of friction between any two surfaces in contact is defined as the ratio of the force of limiting friction and normal reaction between them.

$$\mu = \frac{F}{R}$$ **½**

Angle which the resultant of force of limting friction F and normal reaction R makes with the direction of normal reaction R is angle of reaction. **½**



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$\Rightarrow$ $m(g + a) = 2\,Ma$

So, $m = \dfrac{2Ma}{a+g}$. **1**

25. Suppose two balls A and B of masses m_1 and m_2 are moving initially along the same striaght line with velocities u_1 and u_2 respectively.

When $u_1 > u_2$, relative velocity of approach before collision,

$= u_1 - u_2$ ½

Hence the two balls collide, (b) Let the collision be perfectly elastic. After collision, suppose v_1 is velocity of A and v_2 is velocity of B along the same straight line, (a) when $v_2 > v_1$, the bodies separate after collision

$= v_2 - v_1$ ½

Linear momentum of the two balls before collision,

$= m_1u_1 + m_2u_2$ ½

Linear momentum of the two balls after collision,

$= m_1v_1 + m_2v_2$ ½

As linear momentum is conserved in an elastic collision, therefore ½

$m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2$ ....(i)

Or $m_2\,(v_2 - u_2) = m_1\,(u_1 - v_1)$ ....(ii)

Total K.E. of the two balls before collision

$= \dfrac{1}{2}m_1u_1^2 + \dfrac{1}{2}m_2u_2^2$ ....(iii)

Total K.E. of the two balls after collision

$= \dfrac{1}{2}m_1v_1^2 + \dfrac{1}{2}m_1v_2^2$ ...(vi) ½

As K.E. is also conserved in an elastic collision, therefore from (iii) and (iv),

$\dfrac{1}{2}m_1v_1^2 + \dfrac{1}{2}m_1v_2^2 = \dfrac{1}{2}m_1u_1^2 + \dfrac{1}{2}m_1u_2^2$ ½

Or $\dfrac{1}{2}m_2(v_2^2 - u_2^2) = \dfrac{1}{2}m_1(u_1^2 - v_1^2)$

Or $m_2\,(v_2{}^2 - u_2{}^2) = m_1(u_1{}^2 - v_1{}^2)$ ....(v) ½

Dividing (v) by (ii), we get

$$\frac{m_2(v_2^2 - u_2^2)}{m_2(v_2 - u_2)} = \frac{m_1(u_1^2 - v_1^2)}{m_1(u_1 - v_1)}$$

$$\frac{(v_2 + u_2)(v_2 - u_2)}{(v_2 - u_2)} = \frac{(u_1 + v_1)(u_1 - v_1)}{(u_1 - v_1)}$$

Or $v_2 + u_2 = u_1 + v_1$

Or $v_2 - v_1 = u_1 - u_2$ ....(vi) ½

Hence in one dimensional elastic collision relative velocity of separation after collision is equal to relative velocity of approach before collision.

From, $\dfrac{v_2 - v_1}{u_1 - u_2} = 1$

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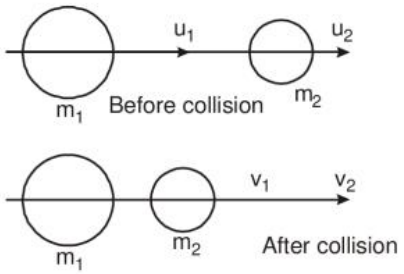
By definition, $\frac{v_2 - v_1}{u_1 - u_2} = e = 1.$ ½

Or

Figure shows two bodies of masses m_1 and m_2 moving with velocities u_1 and u_2 respectively, along a single axis. They collide involving some loss of kinetic energy. Therefore, the collision is inelastic. Let v_1 and v_2 be the velocities of the two bodies after collision.



As the two bodies from one system, which is closed and isolated, we can write the law of conservation of linear momentum for the two body system as :

Total momentum before the collision (P_i)

= Total momentum after the collision (P_f)

$$m_1u_1 + m_2 u_2 = m_1v_1 + m_2 v_2$$ ½

Perfectly inelastic collision between two bodies of masses m_1 and m_2. The body of mass m_2 happen to be initially at rest ($u_2 = 0$) we refers to this body as the target. The incoming body of mass m_1, moving with intial velocity u_1 is referred to as the projectile. After the collision, the two bodies move together with a common velocity v. The collision is perfectly inelastic. As the total linear momentum of the system cannot change, therefore $P_i = P_f$.

i.e., $m_1u_1 + m_2u_2 = (m_1 + m_2)v$

Or $m_1 u_1 = (m_1 + m_2)v,$ $(\because u_2 = 0)$

Or $$v = \frac{m_1u_1}{m_1 + m_2}$$ ....(i) **1**

Knowing m_1, m_2 and u_1, we can calculate the final velocity v. As the mass ratio $\frac{m_1}{m_1 + m_2} < 1$, therefore $v < u_1$. **1**

We can calculate loss of K.E. in this collision.

$$\text{Total K.E. before collision} = E_1 = \frac{1}{2}m_1u_1^2$$

$$\text{Total K.E. after collision} = E_2 = \frac{1}{2}(m_1 + m_2)v^2$$

$$= \frac{1}{2}(m_1 + u_2)\left(\frac{m_1u_1}{m_1 + m_2}\right)^2 \quad \text{Using (i)}$$

$$= \frac{m_1^2u_1^2}{2(m_1 + m_2)}$$ ½

$$\text{Loss of K.E.} = E_1 - E_2$$

$$= \frac{1}{2}m_1v_1^2 - \frac{m_1^2u_1^2}{2(m_1 + m_2)}$$

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$$= \frac{m_1^2u_1^2 + m_1m_2u_1^2 - m_1^2u_1^2}{2(m_1 + m_2)}$$

$$= \frac{m_1m_2u_1^2}{2(m_1 + m_2)}.$$

which is positive. **1**

26. Consider an incompressible non-viscous liquid entering the cross-section A_1 at A with a velocity v_1 and coming out at a height h_2 at B with velocity v_2.

The P.E. and K.E. increase since h_2 and v_2 are more than h_1 and v_1 respectively. These done by the pressure doing work on the liquid. If P_1 and P_2 are the pressures at A and B and a small displacement at A and B.

The work done on the liquid $A = (P_1 A_1)$

$$\Delta x_1 = P_1 A_1 v_1 \Delta t$$

The work done by the liquid at B $= -(P_2A_2)$

$$\Delta x_2 = -P_1A_2 v_2\Delta t$$ **1**

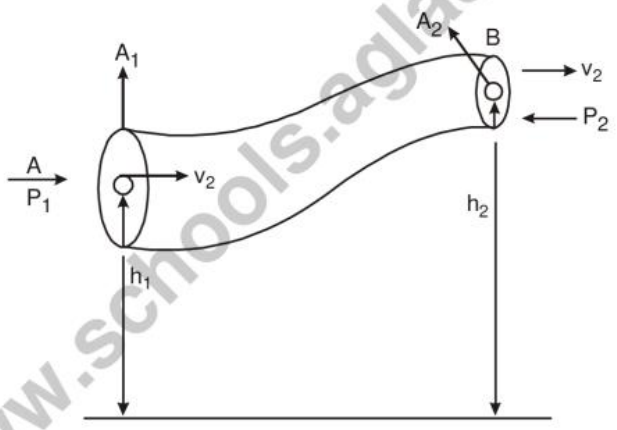
(Considering a small time Δt so that area may be same.)

Net work done by pressure $= (P_1 - P_2) Av\Delta t$, since $A_1v_1 = A_2v_2$

From the conservation of energy,

$(P_1 - P_2) Av\Delta t$ = change in (K.E. + P.E.) **1**

$$(P_1 - P_2)Av\Delta t = Av\rho\Delta tg(h_2 - h_1) + \frac{1}{2}Av\rho\Delta tg(v_2^2 - v_1^2)$$ **½**



$$(P_1 - P_2) = \rho g(h_2 - h_1) + \frac{\rho}{2}(v_2^2 - v_1^2)$$ **½**

i.e., $$P_1 + \rho gh_1 + \frac{\rho}{2}v_1^2 = P_2 + \rho hg_2 + \frac{\rho}{2}v_2^2$$

i.e., $$\frac{P}{\rho g} + h + \frac{v^2}{2g} = \text{constant.}$$ **1**

Or

Pascal's law : If gravity effect is neglected the pressure at every point of liquid in equilibrium of rest is same. **1**

Hydraulic lift : It is used to lift the heavy loads. Its working is based on Pascal's law. A simple hydraulic lift is shown if Figure. Here C and D are two cylinders of different areas of cross-section. They are connected to each other with a pipe E. Each cylinder of cylinder is provided with airtight firctionless piston. Let a, A be the areas of cross-sections of the pistons in C and D respectively, where $a << A$. The cylinders are filled with an incompressible liquid. **1**

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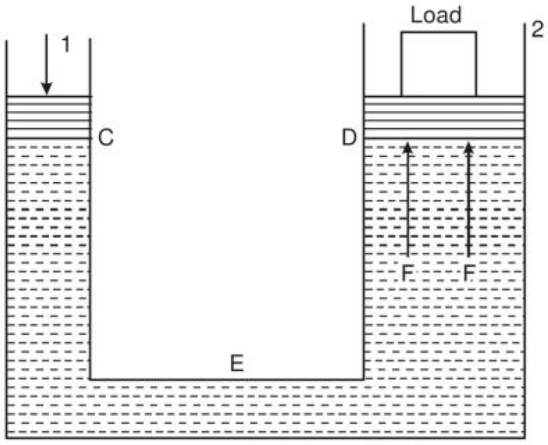

1

Let a downward force f be applied on the piston of C. Then the pressure exerted on the liquid. $P = f/a$.

According to Pascal's law, this pressure is transmitted equally to piston of cylinder D.

$\therefore$ Upward force acting on the piston of cylinder D will be

$$F = PA = \frac{f}{a}A = f\frac{A}{a}$$ **1**

As $A >> a$, therefore $F >> f$.

This shows that the small force applied on the smaller piston will be appearing as a very large force on the large piston. As a result of which a heavy load placed on the larger piston is easily lifted upwards. **1**

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