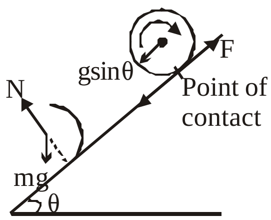
PHYSICS

1. **Choose the correct option. Only ONE option is correct.**

A cylinder rolls up an inclined plane, reaches some height, and then rolls down (without slipping throughout these motions). The directions of the frictional force acting on the cylinder are

(a) up the incline while ascending and down the incline descending
(b) up the incline while ascending as well as descending
(c) down the incline while ascending and up the incline while descending
(d) down the incline while ascending as well as descending.

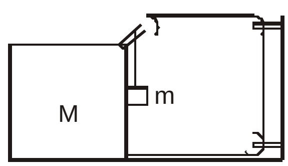
1. (b) Imagine the cylinder to be moving on a frictionless surface. In both the cases the acceleration of the centre of mass of the cylinder is g $\sin\theta$. This is also the acceleration of the point of contact of the cylinder with the inclined surface. Also no torque (about the centre of cylinder) is acting on the cylinder since we assumed the surface to be frictionless and the forces acting on the cylinder are mg and N which pass through the centre of cylinder. Therefore the net movement of the point of contact in both the cases is in the downward direction as shown. Therefore the frictional force will act in the upward direction in both the cases.



[Please note that in general we find the acceleration of the point of contact due to translational and rotational motion and then find the net acceleration of the point of contact. The frictional force acts in the opposite direction to that of net acceleration of point of contact.]

2. **Choose the correct option. Only ONE option is correct.**

Find the acceleration of the block of mass M in the situation of figure. The coefficient of friction between the two blocks is m_1 and between the bigger block and the ground is m_2.



(a) $\frac{[2m-\mu_2(M+m)]g}{M+m[5+2(\mu_1-\mu_2)]}$

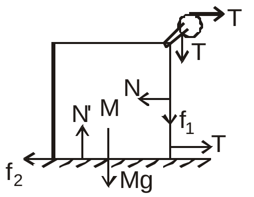
(b) $\frac{[\mu_2(M+m)]g}{M+m[5+2(\mu_1+\mu_2)]}$

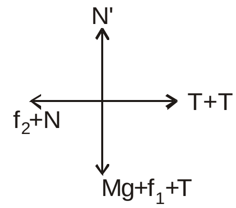
(c) $\frac{[2m-\mu_2(M-m)]g}{m[5+2(\mu_1-\mu_2)]}$

(d) None of these

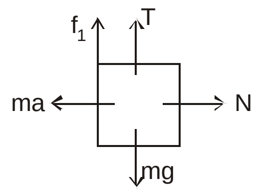
2. (a) We make free body diagram of mass M and m separately,

Let acceleration of M be a, then acceleration of m w.r.t. M will be 2a since m moves twice the distance moved by m





Now see m w.r.t. M



$\therefore N = ma$ ...(1)

$f_1 = \mu_1 N = \mu_1 ma$ ...(2)

$mg - f_1 - T = m(2a) \Rightarrow mg = \mu_1 ma - T + 2ma$

$\Rightarrow mg - T = (2 + \mu_1)ma$ ...(3)

or $T = mg - (2 + \mu_1)ma$ ...(4)

for M, $N' = Mg + f_1 + T = Mg + \mu ma + T$ ...(5)

and $2T - (f_2 + N) = Ma$

$\Rightarrow 2T - \mu_2(N') - N = Ma$ ...(6)

$\Rightarrow 2T - \mu_2(Mg + \mu_1 ma + T) - ma = Ma$ [$\because$ using (6) & (5)]

$\Rightarrow (2 - \mu_2)T = m_2 Mg + \mu_1\mu_2\, ma + (M + m)a$ ...(7)

Solving equation (4) & (7),

$$a = \frac{[2m - \mu_2(M+m)]g}{M + m[5 + 2(\mu_1 - \mu_2)]}$$

3. Water from a tap emerges vertically downwards with an initial speed of 1.0 m s^{-1}. The cross-sectional area of the tap is 10^{-4} m^2. Assume that the pressure is constant throughout the stream of water, and that the flow is steady. The cross-sectional area of the stream 0.15 m below the tap is

(a) 5.0×10^{-4} m^2 (b) 1.0×10^{-5} m^2 (c) 5.0×10^{-5} m^2 (d) 2.0×10^{-5} m^2

3. **(c)** The equation of continuity is: $v_1A_1 = v_2A_2$

where v and A represent the speed of water stream and its area of cross section, respectively. We are given that

$v_1 = 1.0 \text{m/s}$

$A_1 = 10^{-4} \text{m}^2$

$v_2 = \text{velocity of waterstreamat0.15mbelowthetap}$

$A_2 = ?$

Calculating v_2 from the expression

$v^2 = u^2 + 2gy$

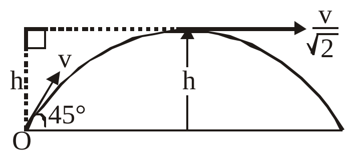
we get, $v_2^2 = (1.0\,m^{-s})^2 + 2(10\,m^{-2})(0.15\,m) = 4.0 m^2 s^{-2}$ or $v_2 = 2.0$ m s^{-1}

Hence, $A_2 = \dfrac{v_1A_1}{v_2} = \dfrac{(1.0 ms^{-1})\,(10^{-4}\,m^2)}{(2.0 m s^{-1})} = 5 \times 10^{-5}\ m^2$

4. **Choose the correct option(s), ONE or more than ONE option may be correct.**
A particle of mass m is projected with a velocity V making an angle of 45° with the horizontal. The magnitude of the angular momentum of the projectile about the point of projection when the particle is at its maximum height h is

(a) zero (b) $\frac{mV^3}{4\sqrt{2}g}$ (c) $\frac{mV^3}{\sqrt{2}g}$ (d) $\frac{mV}{2gh^3}$

4. (b) Angular momentum = (momentum) × (perpendicular distance of the line of action of momentum from the axis of rotation)



Angular momentum about O

$$L = \frac{mv}{\sqrt{2}} \times h \quad \text{....(i)}$$

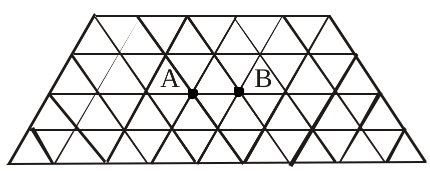
Now, $h = \frac{V^2 \sin^2\theta}{2g} = \frac{V^2}{4g}$ [θ = 45°] ....(ii)

From (i) and (ii)

$$L = \frac{m}{\sqrt{2}}(2\sqrt{gh})h = m\sqrt{2gh^3}$$

Also From (i) and (ii) $L = \frac{mV}{\sqrt{2}} \times \frac{V^2}{4g} = \frac{mV^3}{4\sqrt{2}g}$

5. **Choose the correct option. Only ONE option is correct.**
There is an infinite wire grid with cells in the form of equilateral triangles. The resistance of each wire between neighboring joint connections is R_0. The net resistance of the whole grid between the points A and B as shown is



(a) R_0 (b) $\frac{1}{2}R_0$ (c) $\frac{1}{3}R_0$ (d) $\frac{1}{4}R_0$

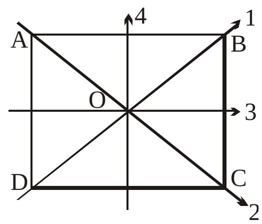
5. (c) Since net resistance is to be found between A and B. So let a current I enter at A and then exit at B. When I enters at A then by symmetry a current $\frac{I}{6}$ must flow in the branch AB from A to B.

For current I to exit from B, a current $\frac{I}{6}$ must flow in the branch AB from A to B. Superimposing the two, we conclude that a current $\left(\frac{I}{6} + \frac{I}{6}\right)$ must flow in the branch AB from A to B.

According to Thevenin's theorem we have

$$I_{total}R_{eq} = V_{AB} = \frac{IR_0}{3} \Rightarrow IR_{eq} = \frac{IR_0}{3} \Rightarrow R_{eq} = \frac{1}{3}R_0$$

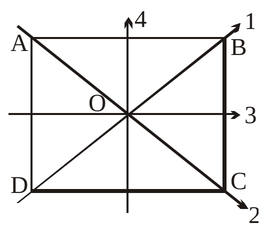
6. **Choose the correct option(s), ONE or more than ONE option may be correct.**
The moment of inertia of a thin square plate ABCD, Fig., of uniform thickness about an axis passing through the centre O and perpendicular to the plane of the plate is



where I_1, I_2, I_3 and I_4 are respectively the moments of inertia about axis 1, 2, 3 and 4 which are in the plane of the plate.

(a) $I_1 + I_2$ (b) $I_3 + I_4$ (c) $I_1 + I_3$ (d) $I_1 + I_2 + I_3 + I_4$

6. (a,b,c) To find the moment of inertia of ABCD about an axis passing through the centre O and perpendicular to the plane of the plate, we use perpendicular axis theorem. If we consider ABCD to be in the X–Y plane then we know that



$\therefore\ I_{zz'} = I_{xx'} + I_{yy'}$

$I_{zz'} = I_1 + I_2$ … (i)

Also, $I_{zz'} = I_3 + I_4$ … (ii)

Adding (i) and (ii), $2I_{zz'} = I_1 + I_2 + I_3 + I_4$

But $I_1 = I_2$ and $I_3 = I_4$ (by symmetry)

$\therefore\ 2I_{zz'} = I_1 + I_1 + I_3 + I_3 = 2I_1 + 2I_3$

$\Rightarrow I_{zz'} = I_1 + I_3$

7. **Choose the correct option(s), ONE or more than ONE option may be correct.**
The torque τ on a body about a given point is found to be equal to $\mathbf{A} \times \mathbf{L}$ where $\mathbf{A}$ is a constant vector, and $\mathbf{L}$ is the angular momentum of the body about that point. From this it follows that

(a) $\frac{d\mathbf{L}}{dt}$ is perpendicular to $\mathbf{L}$ at all instants of time.
(b) the component of $\mathbf{L}$ in the direction of $\mathbf{A}$ does not change with time.
(c) the magnitude of $\mathbf{L}$ does not change with time.
(d) $\mathbf{L}$ does not change with time

7. (a,b,c) $\vec{\tau} = \frac{d\vec{L}}{dt}$

Given that $\vec{\tau} = \vec{A} \times \vec{L} \Rightarrow \frac{d\vec{L}}{dt} = \vec{A} \times \vec{L}$

From cross-product rule, $\frac{d\vec{L}}{dt}$ is always perpendicular to the plane containing $\vec{A}$ and $\vec{L}$

By the dot product definition $\vec{L}.\vec{L} = L^2$

Differentiating with respect to time $\vec{L}.\frac{d\vec{L}}{dt} + \vec{L}.\frac{d\vec{L}}{dt} = 2L\frac{dL}{dt}$

$\Rightarrow 2\vec{L}.\frac{d\vec{L}}{dt} = 2L\frac{dL}{dt}$

Since $\frac{d\vec{L}}{dt}$ is perpendicular to $\vec{L} \Rightarrow \frac{dL}{dt} = 0 \Rightarrow L = \text{constant} \Rightarrow$ a, b, c are correct option.

8. Choose the correct option(s), ONE or more than ONE option may be correct.

A solid cylinder is rolling down a rough inclined plane of inclination θ. Then

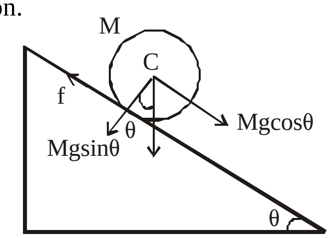
(a) The friction force is dissipative

(b) The friction force is necessarily changing

(c) The friction force will aid rotation but hinder translation

(d) The friction force is reduced if θ is reduced

8. (c,d) As shown in the figure, the component of weight $Mg\sin\theta$ tends to slide the point of contact (of the cylinder with inclined plane) along its direction. The sliding friction f acts in the opposite direction to oppose this relative motion. Because of frictional force the cylinder rolls. Thus frictional force aids rotation but hinders translational motion.



Applying $F_{net} = ma$ along the direction of inclined plane,

we get $Mg\sin\theta - f = Ma_c$,

where a_c = acceleration of center of mass of cylinder

$\therefore f = Mg\sin\theta - Ma_c$ ....(i)

But $a_c = \frac{g\sin\theta}{1+\frac{I_c}{MR^2}} = \frac{g\sin\theta}{1+\frac{MR^2/2}{MR^2}} = \frac{2}{3}g\sin\theta$ .....(ii)

From (i) & (ii), $f = \frac{Mg\sin\theta}{3}$

If θ is reduced, frictional force is reduced.

9. Match the items given in Column I with the items in Column II. An item of Column I can match with more than one item from Column II. Choose the correct option from the SIX options given below :

	Column I		***Column II***
(A)	Solid sphere	(P)	Rotational Kinetic Energy $\le$ (Translational Kinetic Energy)/2
(B)	Hollow sphere	(Q)	Rotational Kinetic Energy > (Translational Kinetic Energy)/2
(C)	Circular disc	(R)	Moment of Inertia about diameter $< \frac{MR^2}{2}$
(D)	Circular ring	(S)	Moment of Inertia about diameter $\ge \frac{MR^2}{2}$

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

9. **(a) A - P, R ; B - Q, S ; C - P, R ; D - Q, S**

A — P, R; Rotational Kinetic Energy $(E_k)_r$ = 40% of Translation Kinetic Energy $(E_k)_t$

About diameter : $I = \left(\frac{2}{5}\right)MR^2$

B — Q, S; $(E_k)_r$ = 66% of $(E_k)_t$; About diameter : $I = \left(\frac{2}{3}\right)MR^2$

C — P, R; $(E_k)_r$ = 50% of $(E_k)_t$; About diameter : $I = \frac{MR^2}{4}$

D — Q, S; $(E_k)_r = (E_k)_t$; About diameter: $I = \frac{MR^2}{2}$

10. Match the items given in Column I with the items in Column II. An item of Column I can match with more than one item from Column II. Choose the correct option from the SIX options given below :

	Column I		***Column II***
(A)	Orbital velocity of satellite	(P)	radius of orbit of the satellite
(B)	escape velocity	(Q)	radius of earth
(C)	Time period of satellite	(R)	gravitational constant
(D)	Value of gravitational acceleration due to earth	(S)	density of the earth

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

10. (b) A - Q,R,S ; B - Q,R,S ; C - P ; D - Q,R,S

A-Q, R, S ; orbital velocity of satellite

$$V_0 = \sqrt{gR} = \sqrt{\frac{GM}{R}} = \sqrt{\frac{G\times\frac{4}{3}\pi R^3\rho}{R}}$$

So V_0 depends upon G, R & ρ.

B-Q, R, S ; Escape velocity = $\sqrt{2gR} = \sqrt{2\frac{GM}{R}} = \sqrt{\frac{2G\frac{4}{3}\pi R^3\rho}{R}}$

So $V_e \propto G, \rho$ and R

C-P ; (Time period of Satellite)$^2 \propto$ (radius of orbit)^3

D-Q, R, S; Value of g $= \sqrt{\frac{GM}{R}} = \sqrt{\frac{G\times\frac{4}{3}\pi R^3\rho}{R}}$ or g depends upon G, R and ρ

11. Match the items given in Column I with the iterms in Column II. An item of Column I can match with more than one item from Column II. Choose the correct option from the SIX options given below :

Column I	*Column II*
(A) A body is moving with uniform velocity	(P) Newton's first law
(B) There is a recoil in the gun when bullet is fired	(Q) Newton's second law
(C) We fall down in a moving bus when driver applies brake upwards	(R) Newton's third law
(D) When we throw a ball upwards from a moving train, ball falls back into our hands	(S) Law of conservation of momentum

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

11. (c) A - P, S ; B - R, Q, S ; C - P, Q, S ; D - P, Q, S

A -P, S ; As the body continues to move in a state of uniform motion — First law. As the velocity do not change so momentum is conserved.

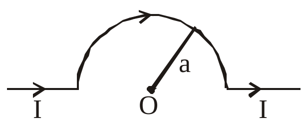
B - Q, R, S ; On fring, the bullet moves forward and the gun moves backward (recoil) – Third law. Law of conservation of momentum is valid. IInd law is applicable as force is required to provide the motion.

C -P, Q, S ; As we tend to be in a state of motion when the brakes are applied — First law. As the driver applies brakes, i.e. external force — hence IInd law. Again the momentum is conserved.

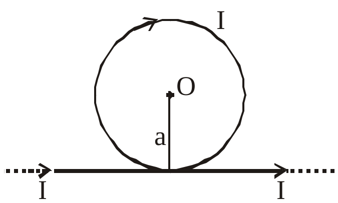
D-P, Q, S ; As the ball is in inertia so Ist law is applicable. The body requires gravitational force to come back, so second law. Again the momentum is conserved.

12. Match the items given in Column I with the items in Column II. An item of Column I can match with more than one item from Column II. Choose the correct option from the SIX options given below :

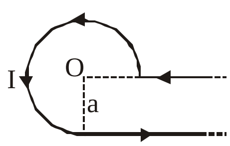
Column I *Column II*

(A) 

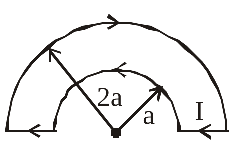
(P) $B \leq \frac{\mu_0}{4\pi}\frac{\pi I}{a}$

(B) 

(Q) $B > \frac{\mu_0}{4\pi}\frac{\pi I}{a}$

(C) 

(R) Normal to the plane of paper down ward

(D) 

(S) Normal to the plane of paper upward

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

12. **(a) A - P, S ; B - Q, R ; C - Q, R ; D - P, S**

A-P, S ; There is no Field at O due to the horizontal wires as they pass through O.

For the semi-circle, $B = \frac{\mu_0}{4\pi}\frac{\pi I}{a}$; acting normal to the plane paper downwards

B-Q, R ; For the circle, $B = \frac{\mu_0}{4\pi}\frac{2\pi I}{a}$; acting downwards

For the horizontal line at a distance of a from O, $B = \frac{\mu}{4\pi}\frac{2I}{a}$ acting upwards

Total magnetic field = $B = \frac{\mu}{4\pi}\frac{I}{a}[2\pi - 2] = 4.28\frac{\mu}{4\pi}\frac{I}{a}$ **;** Normal to the plane paper downwards.

C-Q, R ; Magnetic induction at the point O due to circular portion of the wire

$B_1 = \frac{\mu_0 I}{4\pi a}\times\frac{3}{2}\pi$; directed upwards

Magnetic induction at O due to upper straight wire will be zero since it passes through O.
Magnetic induction at O due to the lower infinite long straight wire is

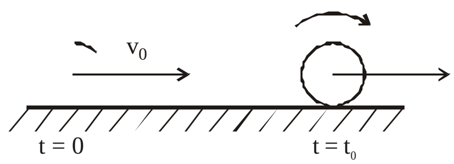
$B_2 = \frac{\mu_0 i}{4\pi a}[\sin\phi_1 + \sin\phi_2] = \frac{\mu_0 i}{4\pi a}[\sin 0 + \sin\frac{\pi}{2}] = \frac{\mu_0 i}{4\pi a}$; directed upwards

Net Magnetic field at O = B = $B_1 = \frac{\mu_0 I}{4\pi a}\times\left(\frac{3}{2}\pi + 1\right) = 5.71\frac{\mu_0 I}{4\pi a}$ upwards

D-P, S; Magnetic field due to the straight portions is 0. Magnetic field due to the semi-circular portions will be in opposite directions because current passes in opposite directions in them.

13. Read the following passage and answer the THREE questions that follows (only ONE option correct) :

A uniform disc of mass m and radius R is projected horizontally with velocity v_0 on a rough horizontal floor so that it starts off with a purely sliding motion at t= 0. After t_0 seconds, it acquires a purely rolling motion as shown in figure



Assuming the coefficient of friction to be μ

(i) Calculate the velocity of the center of mass of the disc at t_0.

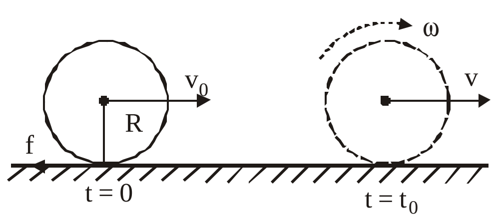
(a) $\mu g t_0$ (b) $2\mu g t_0$ (c) $4\mu g t_0$ (d) $\frac{\mu g t_0}{4}$

(i) (b) Initially the motion is purely sliding motion.The sliding friction acts on the body in the opposite side of motion to stop the relative motion of the point of contact.

$f = \mu N = \mu mg$

Due to this a torque will act on the disc and the disc starts to rotate

$$\tau = I\alpha = f \times R \Rightarrow \alpha = \frac{fR}{I} = \frac{\mu mgR}{\frac{1}{2}mR^2} = \frac{2\mu g}{R}$$



Let after time t_0 , the velocity of centre of mass be v. At this instant if the disc attains rolling motion then

$v = R\omega \Rightarrow \omega = \frac{v}{R}$ Also $\omega_0 = 0$ at $\omega = \frac{v}{R}$, $t = t_0, \alpha = \frac{2\mu g}{R}$

Using, $\omega = \omega_0 + \alpha t = \frac{v}{R} = 0 + \frac{2\mu g}{R}\times t_0 \Rightarrow v = 2\mu g t_0$

(ii) Calculate the value of the time t_0.

(a) $\frac{v_0}{2\mu g}$ (b) $\frac{v_0}{\mu g}$ (c) $\frac{v_0}{3\mu g}$ (d) None of these

(ii) (c) For translation motion

$$u = v_0,\ v = v,\ a = \frac{-f}{m} = -\mu g,\ t = t_0$$

$\therefore$ Using $v = u + at \Rightarrow v = v_0 - \mu g t_0$ … (i)

Using the value of v in (i),

$$v = v_0 - \mu g \times \frac{v}{2\mu g} \Rightarrow \frac{3v}{2} = v_0 \Rightarrow v = \frac{2v_0}{3}$$

Putting the value of v_0 in t_0, calculated in Q. 1, $t_0 = \frac{v}{2\mu g} = \frac{v_0}{3\mu g}$

(iii) Calculate the work done by the frictional force.

(a) $-\frac{mv_0^2}{6}$ (b) $-\frac{mv_0^2}{2}$ (c) $-\frac{mv_0^2}{3}$ (d) None of these

(iii) (a) Work done by frictional force = Kinetic energy at time t_0 – Kinetic energy at t = 0

$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 - \frac{1}{2}mv_0^2$$

But $V = v_0 - \mu g t_0,\ I = \frac{1}{2}mR^2,\ \omega = \alpha t_0 = \frac{2\mu g t_0}{R}$

$$\therefore\ W = \frac{1}{2}m[v_0 - \mu g t_0]^2 + \frac{1}{2}\left(\frac{1}{2}mR^2\right)\left(\frac{2\mu g t_0}{R}\right)^2 - \frac{1}{2}mv_0^2 = \frac{m\mu g t_0}{2}[3\mu g t_0 - 2v_0]$$

Or, $W = \frac{m\mu g}{2}\left(\frac{v_0}{3\mu g}\right)\left[3\mu g \times \left(\frac{v_0}{3\mu g}\right) - 2v_0\right] = -\frac{mv_0^2}{6}$

When the body has attained rolling motion, the sliding friction will cease to exist. There will only be rolling friction which is very small.

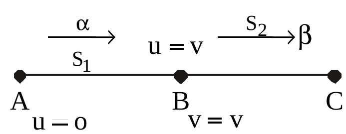
14. Read the following passage and answer the THREE questions that follows (only ONE option correct) :

A car accelerates from rest at a constant rate α for sometime, after which it decelerates at a constant rate β to come to rest. If the total time elapsed is t,

(i) The maximum velocity acquired by the car is

(a) $\frac{\alpha\beta t}{\alpha + \beta}$ (b) $\frac{(\alpha + \beta)}{\alpha\beta}t$ (c) $\frac{\alpha^2 + \beta^2}{\alpha\beta}$ (d) $\frac{\alpha^2 - \beta^2}{\alpha\beta}t$

(i) (a)



For A to B, $V = \alpha t_1$ or $t_1 = \frac{v}{\alpha}$

$V^2 = u^2 + 2\alpha s_1 \Rightarrow S_1 = V^2/2\alpha$

For B to C, $0 = v - \beta t_2$ or $t_2 = V/\beta$

$0 = V^2 - 2\beta S_2$ or $S_2 = V^2/2\beta$

$$t = t_1 + t_2 = V/\alpha + V/\beta = V\frac{(\alpha + \beta)}{\alpha\beta} \text{ or } V = \frac{\alpha\beta}{(\alpha + \beta)}t$$

(ii) The distance travelled by the car is

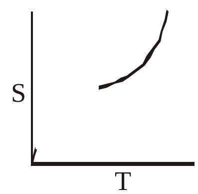
(a) $\frac{1}{2}\left(\frac{\alpha\beta}{\alpha+\beta}\right)t^2$ (b) $\frac{1}{2}\left(\frac{\alpha+\beta}{\alpha\beta}\right)t^2$

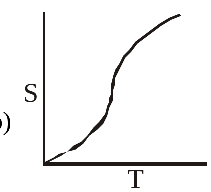
(c) $\frac{1}{2}\left(\frac{\alpha^2+\beta^2}{\alpha\beta}\right)t^2$ (d) $\frac{1}{2}\left(\frac{\alpha^2-\beta^2}{\alpha\beta}\right)t^2$

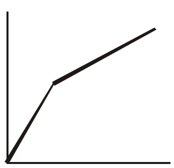
(ii) (a) $S_1 + S_2 = \frac{V^2}{2}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right) = V^2\frac{(\alpha+\beta)}{2\alpha\beta} = \frac{(\alpha\beta)^2}{(\alpha+\beta)^2}t^2\frac{(\alpha+\beta)}{2\alpha\beta}$

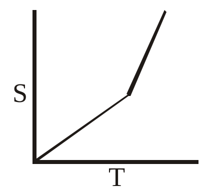
$$= \frac{1}{2}\frac{\alpha\beta}{(\alpha+\beta)}t^2 = \frac{\alpha\beta}{2(\alpha+\beta)}t^2$$

(iii) Which of the following graphs would exactly describe the motion of the car.

(a) 

(b) 

(c) 

(d) 

(iii) (b) During the first part of motion the car accelerates at a constant rate α.

$S_1 = \frac{V^2}{2\alpha} = \frac{t_1^2\alpha^2}{2\alpha} = \frac{t_1^2\alpha}{2}$ or $S \propto t_1^2$ (a parabola opening upwards)

For the second part of motion, the car decelerates at a constant rate β.

$S_2 = \frac{V^2}{2\beta} = \frac{(t_2\beta)^2}{2\beta} = \frac{t_2^2\beta}{2}$ or $S_2 \propto t_2^2$

$\because \beta$ is negative so a parabola opening downwards.

15. Read the following passage and answer the THREE questions that follows (only ONE option correct) :

There are some important points regarding power dissipation in electrical circuits.

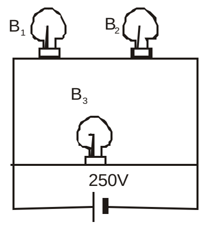
(a) When a number of resistances are connected in series, then the current through each resistance is the same. In this case power dissipation through a resistance is proportional to the resistance. Also potential drop across a resistance is proportional to the resistance. Therefore the power dissipation will be more for higher resistance.

(b) When a number of resistance are connected in parallel, then the potential difference across each resistance is the same. In this case power dissipation through a resistance is inversely proportional to the resistance and current flowing through a resistance is also inversely proportional to the resistance. Therefore the power dissipation will be more in smaller resistance.

(c) When a number of bulbs of different wattages (designed for same voltage are connected in parallel across a given source of voltage. the bulb with greater wattage will grow with maximum intensity and will allow more current through it.

(d) When bulbs of same wattages (designed for same voltage) are connected in series and if more than twice the rated voltage is applied then the bulb with least wattage will fuse off

(i) A 100 W bulb B_1, and two bulbs of 60 W B_2 and B_3 are connected to a 250 V source, as shown in figure. Now W_1, W_2 and W_3 are the output powers of the bulbs B_1, B_2 and B_3, respectively. Then



(a) $W_1 > W_2 = W_3$ (b) $W_1 > W_2 > W_3$ (c) $W_1 < W_2 = W_3$ (d) $W_1 < W_2 < W_3$

(i) **(d)** We know that $R = \frac{V^2}{P}$

$$\therefore\ R_1 = \frac{V^2}{100}, R_2 = \frac{V^2}{60} R_3;$$

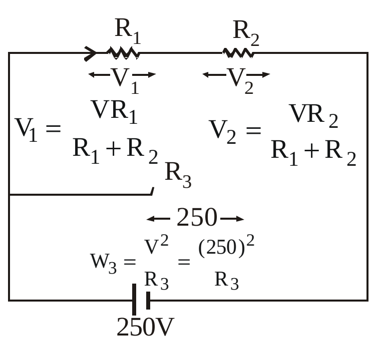
$$W_1 = \frac{V_1^2}{R_1} = \frac{V^2 R_1}{(R_1 + R_2)^2},\ W_2 = \frac{V_2^2}{R_2}$$

$$w_3 : w_2 : w_1 :: \frac{(250)^2}{R_3} : \frac{(250)^2}{(R_1 + R_2)^2} R_2 : \frac{(250)^2}{(R_1 + R_2)^2} R_1$$

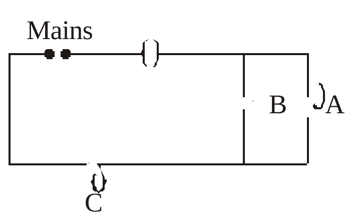
$$\frac{(250)^2}{V^2} \times 60 \frac{(250)^2}{\left[\frac{1}{100} + \frac{1}{60}\right]^2 V^4} \times \frac{V^2}{60} : \frac{(250)^2 V^2}{\left[\frac{1}{100} + \frac{1}{60}\right]^2 V^4 \times 100}$$

$$60 : \frac{100 \times 100 \times 60 \times 60}{160 \times 160 \times 60} : \frac{100 \times 100 \times 60 \times 60}{160 \times 160 \times 100}$$

64 : 25 : 15



(ii) Three 60 W, 240 V bulbs are connected across a 240 V mains as shown.



The total power dissipated in three bulbs

(a) 60 W (b) 30 W (c) 40 W (d) 120 W

(ii) **(c)** Resistance of each bulb $R = \frac{V^2}{p} = \frac{(240)^2}{60} = 960\,\Omega$

Total resistance in the circuit $= 960 + \frac{960 \times 960}{960 + 960} = 1440\,\Omega$

current in the circuit = $\frac{240}{1440} = \frac{1}{6}$ A

$\therefore$ Total power consumed = $I^2 \times 1440 = \frac{1}{3} \times 1440 = 40\,W$

(iii) A heating coil is labelled 100 W, 220 V. The coil is cut in half and the two pieces are joined in parallel to the same source. The energy now liberated per second is

(a) 25 J (b) 50 J (c) 200 J (d) 400 J

(iii) **(d)** The heating coil is cut into two parts and joined in parallel. Therefore the resistance of the coil is reduced to one-fourth of the previous value. Therefore the energy liberated per second becomes 4 times (V^2/R).