XI - PHYSICS - SOLUTIONS

Section I - Multiple Choice Type

1. **b) Increases linearly with time**

   c) Is 2F R t

   From angular impulse = change in angular momentum
   We have $L = \tau t$
   Or $L = F(2R)\, t$
   i.e., L varies linearly with time

2. **a) $I_1 + I_2$**
   b) $I_2 + I_3$
   c) $I_1 + I_3$
   d) $I_3 + I_4$

   By theorem of perpendicular axes:
   $$I = I_3 + I_4 = I_1 + I_2$$
   By symmetry $I_3 = I_4$ and $I_1 = I_2$
   $\therefore$ $I = I_3 + I_4 = 2I_3 + 2I_4$
   Similarly $I = I_1 + I_2 = 2I_1 = 2I_2$
   $\therefore$ $I_1 = I_2 = I_3 \;\; I_4 = \dfrac{I}{2}$
   Or $I = I_1 + I_2 = I_2 + I_3$
   $= I_1 + I_3 = I_3 + I_4$

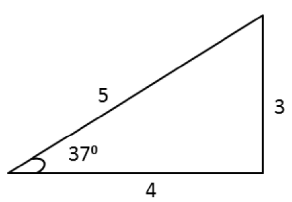
3. **a) $\alpha = \dfrac{1}{2}$**

   d) $\beta = \dfrac{2}{7}$

   In case of pure rolling $\dfrac{K_R}{K_T} = 1$ for a ring and $\dfrac{2}{5}$ for a solid sphere.
   Here, K_R = rotational kinetic energy and
   K_T = translational kinetic energy.
   Therefore, fraction of its total energy associated with rotation is:
   $\alpha = \dfrac{1}{1+1} = \dfrac{1}{2}$ for ring and
   $\beta = \dfrac{2}{2+5} = \dfrac{2}{7}$ for solid sphere.

4. **a) velocity of end A is $\dfrac{4}{3}v_0$ downwards**

   b) Angular velocity of rod is $\dfrac{5}{3}\dfrac{v_0}{l}$



Relative velocity between A and B along AB should be zero. Hence

$v_A \sin\theta = v_B \cos\theta$ or $Zv_A = v_B \cot\theta = \frac{4v_0}{3}$

$\omega = \frac{\text{component of relative velocity perpendicular to AB}}{AB}$

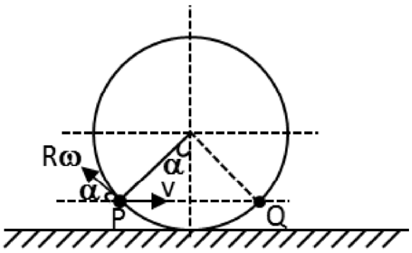
$= \frac{v_A \cos\theta + v_B \sin\theta}{l}$

$= \frac{\left(\frac{4v_0}{3}\right)\left(\frac{4}{5}\right) + v_0\left(\frac{3}{5}\right)}{l}$

$= \frac{5v_0}{3l}$

5. a) **rough inclined plane**
   c) **Rough horizontal surface**
   d) **smooth horizontal surface**
   On a smooth horizontal surface it can roll without slipping if $v = R\omega$ and no external force is acting on it.

6. c) $\pi - \cos^{-1}\left(\frac{v}{R\omega}\right)$
   d) $\pi + \cos^{-1}\left(\frac{v}{R\omega}\right)$



Particle P will have a velocity in vertical direction if
$R\omega \cos\alpha = v$

Or $\alpha = \cos^{-1}\left(\frac{v}{R\omega}\right)$

$\therefore$ Required angle θ is:

$\theta = \pi - \cos^{-1}\left(\frac{v}{R\omega}\right)$

And $\theta = \pi + \cos^{-1}\left(\frac{v}{R\omega}\right)$

Point P corresponds to $\theta = \pi - \cos^{-1}\left(\frac{v}{R\omega}\right)$ and it has velocity in vertically upward direction. While Q corresponds to $\theta = \pi + \cos^{-1}\left(\frac{v}{R\omega}\right)$ and it has velocity in vertically downward direction.

7. a) **The extension produced in copper rod will be more**
   b) **The extension in copper and steel parts will be in the ratio 1:2**
   c) **The stress applied to copper rod will be more**

$(\text{stress})_s = \frac{F}{2A}$, $(\text{stress})_{cu} = \frac{F}{A}$

Given that $\frac{Y_s}{Y_{cu}} = \frac{2}{1}$

$$\frac{(\text{strain})_s}{(\text{strain})_{cu}} = \frac{\frac{(\text{stress})_s}{Y_s}}{\frac{(\text{stress})_{cu}}{Y_{cu}}}$$

$$= \frac{(\text{stress})_s}{(\text{stress})_{cu}} \times \frac{Y_{cu}}{Y_s} = \frac{\frac{F}{2A}}{\frac{F}{A}} \times \frac{1}{2} = \frac{1}{4}$$

Or $\frac{\frac{L_s}{\Delta L_s}}{\frac{L_{cu}}{\Delta L_{cu}}} = \frac{1}{4}$ or $\frac{\frac{L_s}{\Delta L_{cu}}}{\frac{L_{cu}}{\Delta L_s}} = \frac{1}{4}$

Or $\frac{25}{50} \times \frac{\Delta L_{cu}}{\Delta L_s} = \frac{1}{4}$ or $\frac{\Delta L_{cu}}{\Delta L_s} = \frac{1}{2}$

So, option (a), (b) and (c) are correct.

8. d) **0.1 J**

$U = \frac{1}{2} F \times \Delta l$

$\Delta l = \frac{1}{2} \times 200 \times 1 \times 10^{-3}$

= 0.1 J

9. a) **A will break before B if $r_A = r_B$**
   b) **A will break before B if $r_A < 2r_B$**
   c) **Either A or B may break if $r_A = 2r_B$**

Tension in B = $T_B = \frac{mg}{3}$

Tension in $A = T_A = T_B + mg = \frac{4mg}{3}$

$\therefore$ $T_A = 4T_B$

Stress $\frac{T}{\pi r^2} = S$

Wire breaks when S is equal to breaking stress

For $r_A = r_B$, $S_A = 4S_B$

Therefore, A breaks before B

For $r_A = 2r_B$

$$S_B = \frac{T_B}{\pi r_A^2} - \frac{T_B}{\pi r_A^2} = \frac{4T_B}{\pi (2r_B)^2} = \frac{T_B}{\pi r_B^2} = S_B$$

As the stresses are equal, either of the wires may break

10. a) **Material A has a higher Young's modulus**
    d) **Material A can withstand greater stress**

The slope of the linear portion of the curve gives the Young's modulus of the material. The slope of the linear portion OP for material A is greater than that of the linear portion OR for material B. Hence, statement (a) is correct. The plastic region for material A (from P to Q) is greater than that (from R to S) for material B, which indicates that material A is more ductile. Hence, statement (b) is incorrect. The breaking g stress for material B (i.e., stress corresponding to point S) is less than that material A. thus, material B is more brittle. Hence, choice (c) is also incorrect. Material A is stronger than material B because it can withstand a greater stress before it breaks. The breaking stress is the stress corresponding to point Q for material A and to point S for material B. Hence, the correct choices are (a) and (d)

Section II – Matrix Match Type

1. **A-Q, B-P, C-S, D-R**

In general as $v_P = 2v \sin\left(\frac{\theta}{2}\right)$

2. **A-P,R ; B-P,S ; C-Q, S ; D-Q,R**

For a and B, the rod is in equilibrium and hence internal restoring force developed per unit area across any cross-section is same and stress developed in the rod is uniform, while in C and D, the case is reverse.

Section III – Integer Type

1. **5**

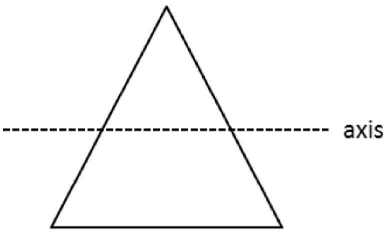
$I' = I - \frac{I}{6}$

$= 5\frac{I}{6}$

$= \frac{5}{6} \times 6 \times 10^{-1}$

$= 5 \times 10^{-1}$

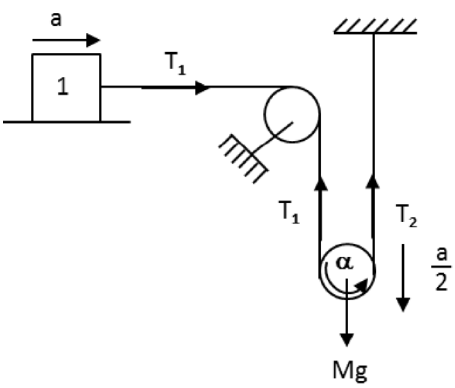
2. **5**



$I = \frac{M(2l)^2}{12}\ .\ \sin^2 60 + \frac{M(2l)^2}{12}\ .\ \sin^2 60 + M(l \sin 60)^2$

$= \frac{5}{4} Ml^2$

3. **1**



$T_1 = 1a$

$Mg - T - T_2 = M\frac{a}{2}$

$(T_2 - T_1)R = I\alpha$

$\frac{a}{2} = \alpha R$

$I = MR^2$

Using these equations get the value of a.

4. **2**

$JR = RMV_{CM} + MR^2 \frac{V_{CM}}{R}$

$V_{CM} = \frac{J}{2M}$

K = 2

5. **2**

$x = \frac{K^2}{d}$

$= \frac{l^2}{3 \cdot \frac{l}{2}}$

$= 2\frac{l}{3}$

K = 2

6. **1**

$\Delta l = \frac{(120+80)}{2(0.5)(2\times10^{11})}$

$= \frac{200}{2\times10^{11}} = 100\times10^{-11}$

$= 10^{-9}$

7. **2**

$T = \lambda\omega^2R^2$

$T = \rho \,.\, A\omega^2R^2$

$\sigma = \rho\omega^2R^2$

$\omega^2 = \frac{\sigma}{\rho R^2} = 4$

$\omega = 2$

8. **5**

T = mg

$\sigma = \frac{T}{A}$

$= \frac{mg}{A}$

$$10 = \frac{\rho \,.\, A l g}{A}$$

$$10 = 2 \times 10^{3} \,.\, l \times 10$$

$$l = \frac{10^{5}}{2 \times 10^{4}} = 5\text{m}$$