$$\underbrace{mgh}_{\text{Disc}} + \underbrace{mgh}_{\text{Point Mass}} + \underbrace{\frac{1}{2}I\omega^2}_{\text{System}} = \underbrace{mgh}_{\text{Disc}} + \underbrace{mgh}_{\text{Point Mass}} + \underbrace{\frac{1}{2}I\omega^2}_{\text{System}}$$

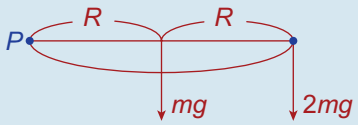
$$mg(2R) + (2m)g(2R) + \frac{1}{2}I(0)^2 = mg(R) + (2m)g(0) + \frac{1}{2}\left(\frac{19}{2}mR^2\right)\omega^2$$

$$5mgR = \frac{19}{4}mR^2\omega^2$$

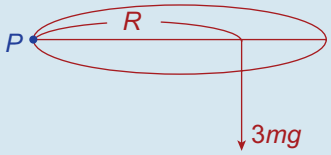
$$\Rightarrow \omega = \frac{\sqrt{20g}}{19R}$$

(ii) **To find *h*:**

**Forces:**




**Resultant:**




$$mg(R) + 2mg(2R) = 3mg(h)$$

$$\Rightarrow h = \frac{5}{3}R$$

The mass of the system is $3m$.

$$T = 2\pi\sqrt{\frac{I}{mgh}} = 2\pi\sqrt{\frac{\frac{19mR^2}{2}}{(3m)g\frac{5R}{3}}} = 2\pi\sqrt{\frac{19R}{10g}}$$

If this equals $2\pi\sqrt{\frac{l}{g}}$, then $l = \frac{19R}{10}$

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**Q. 10.** (i) **The rod:**

$$I_a = \frac{4}{3}(3m)p^2$$

$$= 4mp^2$$

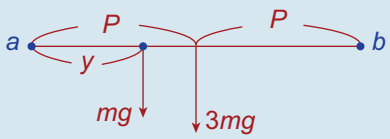
**The point mass:**

$$I_a = my^2$$

The system $= 4mp^2 + my^2$

(ii) **To find *h*:**

**Forces**




**Resultant**


**Taking moments about *a*:**

$$mgy + 3mgp = 4mgh$$

$$\Rightarrow h = \frac{y + 3p}{4}$$

The mass of the system is $4m$.

$$T = 2\pi\sqrt{\frac{I}{mgh}}$$

$$= 2\pi\sqrt{\frac{4mp^2 + my^2}{4mg\left(\frac{y + 3p}{4}\right)}}$$

$$= 2\pi\sqrt{\frac{4p^2 + y^2}{g(y + 3p)}}$$

But this equals $2\pi\sqrt{\frac{40p}{33g}}$

$$\therefore \frac{4p^2 + y^2}{y + 3p} = \frac{40p}{33}$$

$$\Rightarrow 33y^2 - 40py + 12p^2 = 0$$

$$\Rightarrow (3y - 2p)(11y - 6p) = 0$$

$$\Rightarrow y = \frac{2p}{3} \quad \textbf{OR} \quad \frac{6p}{11}$$