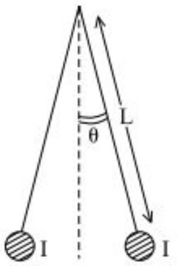
Question



Two long current carrying thin wires, both with current I, are held by insulating threads of length L and are in equilibrium as shown in the figure, with threads making an angle 'θ' with the vertical. If wires have mass λ per unit length then the value of I is :

(g = gravitational acceleration)

(1) $2\sin\theta\sqrt{\dfrac{\pi\lambda gL}{\mu_0\cos\theta}}$

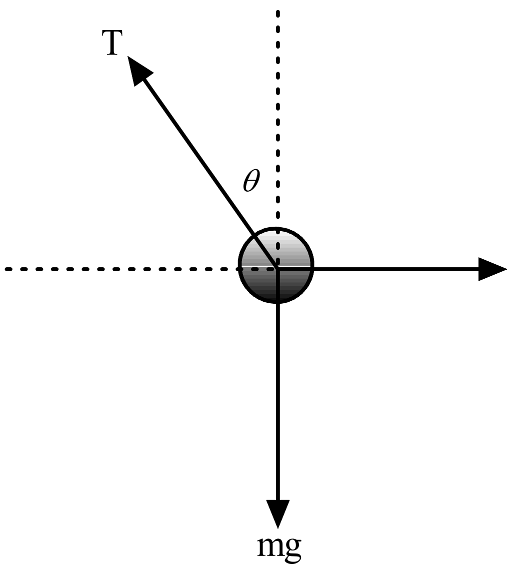
(2) $2\sqrt{\dfrac{\pi gL}{\mu_0}\tan\theta}$

(3) $\sqrt{\dfrac{\pi\lambda gL}{\mu_0}\tan\theta}$

(4) $\sin\theta\sqrt{\dfrac{\pi\lambda gL}{\mu_0\cos\theta}}$

Solution

Let us consider cross-section of the wire on the right side,



$T\cos\theta = mg$

$T\sin\theta = F$ (magnetic repulsion)

$\therefore F = mg\tan\theta$ ....(*)

Let us now consider small part dl of the wire on right,

$$\frac{dF}{dl} = \frac{\mu_0}{4\pi}\frac{2I.I}{r} = \frac{\mu_0}{4\pi}\frac{2I.I}{2L\sin\theta} = \frac{\mu_0}{4\pi}\frac{I^2}{L\sin\theta}$$

$$\therefore \frac{d}{dl}(mg\tan\theta) = \frac{\mu_0}{4\pi}\frac{I^2}{L\sin\theta} \quad \text{[From (*)]}$$

$$\therefore g\tan\theta\frac{dm}{dl} = \frac{\mu_0}{4\pi}\frac{I^2}{L\sin\theta}$$

$$\therefore g\tan\theta\lambda = \frac{\mu_0}{4\pi}\frac{I^2}{L\sin\theta}$$

$$\therefore I = 2\sin\theta\sqrt{\frac{\pi Lg\lambda}{\mu_0\cos\theta}}$$