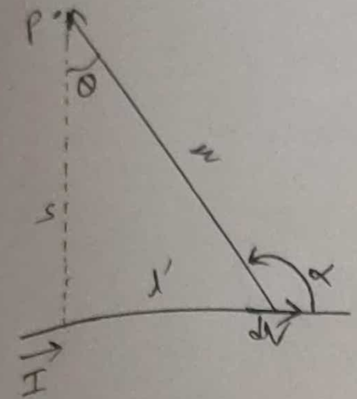
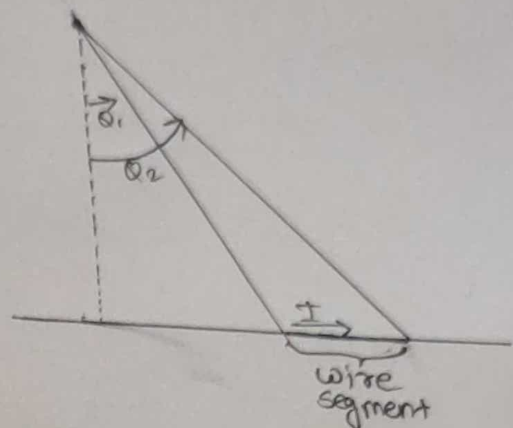
Q. Find the magnetic field a distance s from a long straight wire carrying a steady current I.





$$dl' \sin\alpha = dl' \cos\theta \quad \text{— (1)}$$

by fig. we also know that

$$l' = s\tan\theta \quad \text{— (2)}$$

$$dl' = \frac{s\, d\theta}{\cos^2\theta}$$

We also know that,

$$s = r\cos\theta$$

squaring both sides

$$s^2 = r^2\cos^2\theta$$

$$\frac{1}{r^2} = \frac{1}{s^2}\cos^2\theta \quad \text{— (3)}$$

So according to given condition magnetic field will be,

$$= \frac{\mu_0 I}{4\pi} \int_{\theta_1}^{\theta_2} \left(\frac{\cos^2\theta}{s^2} \right) \left(\frac{s}{\cos^2\theta} \right) \cos\theta \, d\theta$$

$$= \frac{\mu_0 I}{4\pi} \int_{\theta_1}^{\theta_2} \frac{\cancel{\cos^2\theta}}{s^{\cancel{2}}} \frac{\cancel{s}}{\cancel{\cos^2\theta}} \cos\theta \, d\theta$$

$$= \frac{\mu_0 I}{4\pi} \int_{\theta_1}^{\theta_2} \frac{\cos\theta \, d\theta}{s}$$

$$= \frac{\mu_0 I}{4\pi s} \int_{\theta_1}^{\theta_2} \cos\theta \, d\theta \quad \text{—— (4)}$$

We know that,

$$\int \cos\theta \, d\theta = \sin\theta$$

$$\int_{\theta_1}^{\theta_2} \cos\theta \, d\theta = [\sin\theta]_{\theta_1}^{\theta_2}$$

$$\boxed{= \sin\theta_2 - \sin\theta_1}$$

put in eqn (4)

so we get

$$\text{magnetic field} = \frac{\mu_0 I}{4\pi s} [\sin\theta_2 - \sin\theta_1]$$

This will be magnetic field due to current carrying wire.