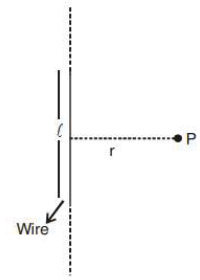
ELECTRIC FIELD DUE TO WIRE AND CIRCULAR RING

Electric field due to infinite wire: (l >> r)

Here we have to find the electric field at point p due to the given infinite wire. Using the formula learnt in above section which



$$E_{||} = \frac{k\lambda}{r}(\cos\theta_2 - \cos\theta_1)$$

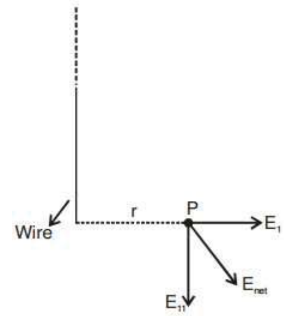
$$E_{\perp} = \frac{k\lambda}{r}(\sin\theta_2 + \sin\theta_1)$$

For above case, $\theta_1 = \theta_2 = \frac{\pi}{2}$

$$E_{net} \text{ at P} = \frac{k\lambda}{r}(1+1) = \frac{2k\lambda}{r}$$

Electric field due to semi-infinite wire:

For this case

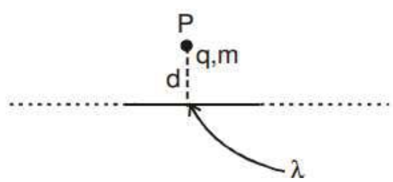


$$\theta_1 = \frac{\pi}{2}, \theta_2 = 0°$$

$$E_r = \frac{k\lambda}{r}; E_{1|} = \frac{k\lambda}{r}$$

$$E_{net} \text{ at P} = \frac{\sqrt{2}k\lambda}{r}s$$

Ex. Consider the system shown below if the charge is slightly displaced perpendicular to the wire from its equilibrium position then find out the time period of SHM.



Sol. At equilibrium position weight of the particle is balanced by the electric force

$$mg = qE$$

$$mg = q\frac{2k\lambda}{d} \quad \text{... (1)}$$

Now if the particle is slightly displaced by a distance xλ (where x << d) net force on the body,

$$F_{net} = \frac{2k\lambda q}{d+x} - mg$$

From (1) $$F_{net} = \frac{2k\lambda q}{d+x} - \frac{2k\lambda q}{d} = \frac{-2k\lambda qx}{d(d+x)}$$

As x << d $$F_{net} \approx \frac{-2k\lambda qx}{d^2} \Rightarrow a = -\frac{-2k\lambda qx}{md^2}$$

For SHM $$a = -\omega^2 x$$

$$\omega^2 = \frac{2k\lambda q}{md^2} \Rightarrow \omega = \sqrt{\frac{2k\lambda q}{md^2}}$$

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{md^2}{2k\lambda q}}$$