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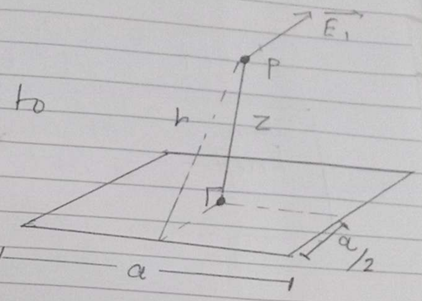
Batch 2a

* Find the electric field a distance z above the centre of a square loop side a, carrying uniform line charge λ.

Soln :-

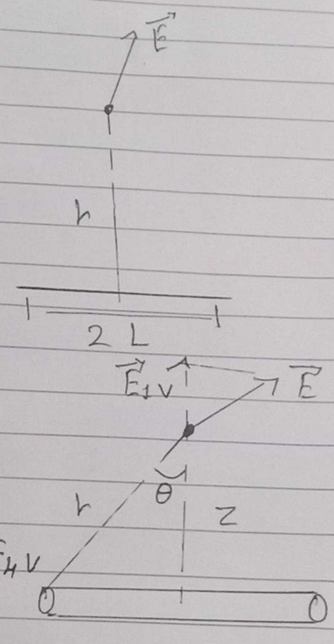


Electric field due to line charge.

$$\therefore \vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{2\lambda L}{h\sqrt{h^2+L^2}}$$

$$\therefore h = \sqrt{z^2 + \left(\frac{a}{2}\right)^2} = \sqrt{z^2 + \frac{a^2}{4}}$$

$$\therefore L^2 = \left(\frac{a}{2}\right)^2 = \frac{a^2}{4}$$



For segment 1.

$$E_1 = \frac{1}{4\pi\varepsilon_0} \frac{\lambda a}{\sqrt{z^2+\frac{a^2}{4}}\sqrt{z^2+\frac{a^2}{4}+\frac{a^2}{4}}}$$

$$E_{1V} = E_1 \cos\theta = E_{2V} = E_{3V} = E_{4V}$$

$$\cos\theta = \frac{z}{\sqrt{z^2+\frac{a^2}{4}}}$$

net electric field will be sum of vertical components of electric

field due to other each segment.

$$E_{net} = 4 E_{V_1} = 4 E_1 \cos\theta$$

So, Total net electric field

$$E_{net} = \frac{4}{4\pi\varepsilon_0} \times \frac{\lambda a}{\sqrt{z^2 + \frac{a^2}{4}}} \sqrt{z^2 + \frac{a^2}{2}} \times \frac{z}{\sqrt{z^2 + \frac{a^2}{4}}}$$

$$\therefore \boxed{\vec{E_{net}} = \frac{1}{\pi\varepsilon_0} \times \frac{\lambda a z}{\left(z^2 + \frac{a^2}{4}\right)\sqrt{z^2 + \frac{a^2}{2}}} \hat{z}}$$