Mon Tue Wed Thu Fri Sat

Date: __/__/20__

-:(Applied Physics):-

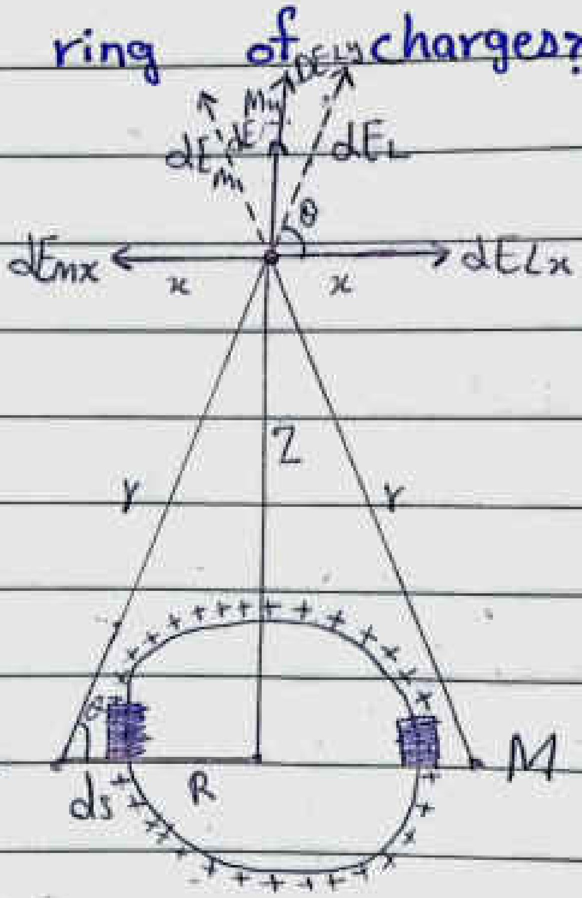
Assignment 01:-

Qno1:-

Explain the electric field due to ring of charges?

Ans:-

Diagram:-



Explanation:-

Consider a positively charged ring having radius 'R' on which positive charge 'q' is distributed uniformly. This is called Linear charge distribution. Take a small length element ds of ring having charge dq.

The linear charge density is defined as:

$$\lambda = \frac{dq}{ds}$$

$$dq = \lambda ds \quad \text{—— (i)}$$

It is given:

$$dE_L = \frac{Kdq}{r^2} \quad \text{—— (a)}$$

$$dE_M = \frac{Kdq}{r^2} \quad \text{—— (b)}$$

Compairing (a) and (b)

$$dE_L = dE_M$$

To find magnitude of electric field

$$dE = \sqrt{dE_x^2 + dE_y^3} \quad \text{—— (ii)}$$

Component of dE_L:-

$$dE_{Lx} = dE_L \cos\theta$$

$$dE_{Ly} = dE_L \sin\theta$$

Components of dE_M:-

$dE_{Mx} = dE_M \cos\theta$

$dE_{My} = dE_M \sin\theta$

Resultant x-component:-

$dE_x = dE_L \cos\theta + (-dE_M \cos\theta)$

$dE_x = \cancel{dE_L \cos\theta} - \cancel{dE_M \cos\theta}$

$\boxed{dE_x = 0}$

Resultant Y-component:-

$dE_y = dE_L \sin\theta + dE_M \sin\theta$

$\boxed{dE_y = 2dE \sin\theta}$

Now eq. (ii) becomes

$dE = \sqrt{(0)^2 + (2dE_L \sin\theta)^2}$

$dE = 2dE_L \sin\theta$

$dE = \frac{2Kdq}{r^2} \sin\theta$

$\left\{ \because \sin\theta = \frac{P}{H} = \frac{z}{r} \right\}$

$dE = \frac{2Kdqz}{r^3}$

from eq (i)

$$dE = \frac{2K\lambda ds\, z}{r^3} \quad \text{—— (iii)}$$

The value of r is:

$$c^2 = a^2 + b^2$$

$$r^2 = z^2 + R^2$$

$$r = \sqrt{z^2 + R^2}$$

$$r = (z^2 + R^2)^{\frac{1}{2}}$$

Put r in (iii)

$$dE = \frac{2K\lambda ds\, z}{(z^2 + R^2)^{3/2}}$$

Integrating

$$\int dE = \int \frac{2K\lambda ds\, z}{(z^2 + R^2)^{3/2}}$$

$$E = \frac{2zK}{(z^2 + R^2)^{3/2}} \int \lambda ds$$

$$\boxed{E = \frac{2z\lambda K}{(z^2 + R^2)^{3/2}}\, \pi R} \quad \text{—— (iv)}$$

we Know that

$$\lambda = \frac{dq}{ds} \Rightarrow dq = \lambda ds \Rightarrow q = \lambda \int ds$$

$q = \lambda(2\pi R)$

The equation (iv) is

$$E = \frac{zK\lambda(2\pi R)}{(z^2+R^2)^{3/2}}$$

$$\boxed{E = \frac{zKq}{(z^2+R^2)^{3/2}}}$$

This is called electric field at point P due to ring of charges. When the point P lies at large distance $z >> R$. The Term R^2 can be neglected as compare to z^2.

$$E = \frac{zKq}{(z^2+0)^{3/2}}$$

$$E = \frac{zKq}{(z^2)^{3/2}} \rightarrow E = \frac{\cancel{z}Kq}{z^3}$$

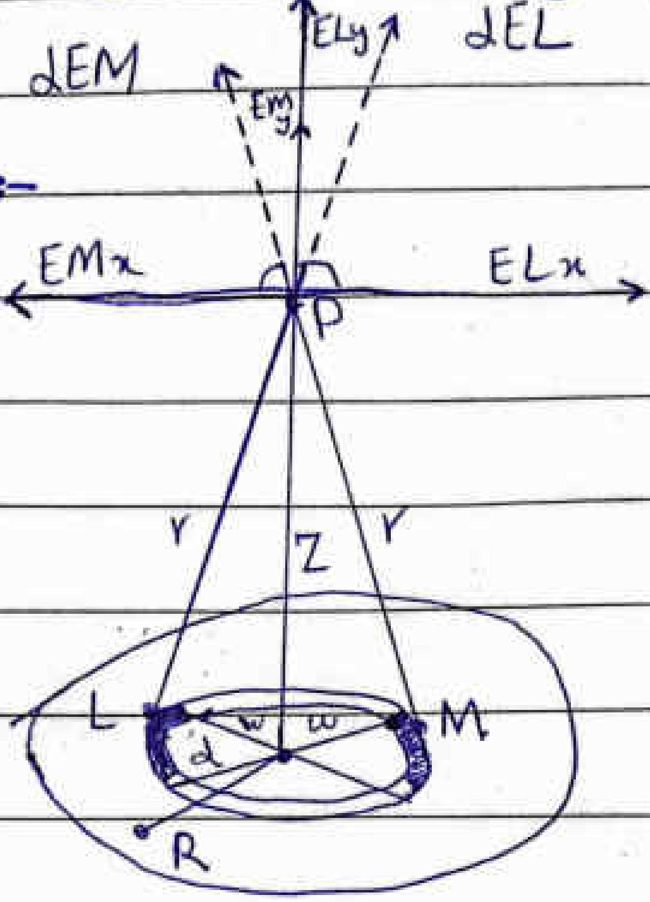
$$\boxed{E = \frac{Kq}{z^2}}$$

Q No 2:-

Explain the electric field due to disk of charges?

Answer:-

Diagram:-



Explanation:-

Consider a positivily charged disk of radius R having surface charge density σ. & Divide the disk into small rings. Now consider such a small ring having radius 'w' and 'dw'.

The surface charge density is:

$$\sigma = \frac{dq}{da}$$

$$\boxed{dq = \sigma da}$$

integrate:

$$q = \sigma \int da$$

$$q = \sigma (dadw) \text{ ——— (i)}$$

we have to calculate electric field at point P having distance z from the plane of disk.

$$dE_L = \frac{Kdq}{r^2}$$

$$dE_M = \frac{Kdq}{r^2}$$

Compairing:-

$$dE_L = dE_M$$

To calculate electric field dE at P resolve the electric field into components.

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along x-axis:-

$dE_x = dE_{Lx} + (-E_{Mx})$

$dE_x = \cancel{E_{Lx}} - \cancel{E_{Mx}}$

$\boxed{dE_x = 0}$

along y-axis

$dE_y = E_{Ly} + E_{My}$

$dE_y = 2E_{Ly}$ $\{\because E_{Ly} = E_{Lm}\}$

$dE_y = 2E_{Ly} \sin\theta$

The magnitude of electric field is:

$dE = \sqrt{dE_x^2 + dE_y^2}$

$dE = \sqrt{(0)^2 + (2E_{Ly}\sin\theta)^2}$

$dE = 2E_{Ly}\sin\theta$

$dE = \frac{2Kdq}{r^2}\sin\theta$ $\left\{\sin\theta = \frac{P}{H} = \frac{Z}{r}\right\}$

from eq (i)

$dE = \frac{2K\sigma da}{r^2}\left(\frac{Z}{r}\right)$

$dE = \frac{2ZK\sigma da}{r^3}$

For 'r' By phytogoron Theorem:-

$c^2 = a^2 + b^2$

$r^2 = Z^2 + R^2$

$r = (z^2 + R^2)^{\frac{1}{2}}$

Put in :

$$dE = \frac{2zK\sigma da}{r^3}$$

$$dE = \frac{2zK\sigma da}{(z^2+R^2)^{3/2}}$$

Integrate

$$\int dE = \int_0^R \frac{2zK\sigma(d\alpha dw)}{(z^2+R^2)^{3/2}}$$

$$\int dE = K\sigma z \int_0^R \frac{2wdw}{(z^2+R^2)^{3/2}} \int_0^\pi d\alpha$$

$$\int dE = K\sigma z \int_0^R (z^2+R^2)^{-3/2} 2wdw \, (\pi)$$

$$\int dE = K\sigma z \left| \frac{(z^2+R^2)^{-\frac{1}{2}}}{-\frac{1}{2}} \right|_0^R$$

$$\int dE = \frac{\pi\sigma z}{4\pi\varepsilon_0} \left| -2(z^2+R^2)^{-\frac{1}{2}} \right|_0^R$$

$$\int dE = \frac{-2\pi\sigma z}{4\pi\varepsilon_0} \left(\frac{1}{(z^2+R^2)^{\frac{1}{2}}} - \frac{1}{(z^2+0^2)^{\frac{1}{2}}} \right)$$

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$$\int dE = \frac{-\sigma z (-1)}{2\varepsilon_0}\left(\frac{1}{z} - \frac{1}{(z^2+R^2)^{\frac{1}{2}}}\right)$$

$$\int dE = \frac{\sigma}{2\varepsilon_0}\left(\frac{z}{z} - \frac{z}{(z^2+R^2)^{\frac{1}{2}}}\right)$$

$$\int dE = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{z}{(z^2+R^2)^{\frac{1}{2}}}\right)$$

if $R \to \infty$

$$E = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{z}{\infty}\right)$$

$$E = \frac{\sigma}{2\varepsilon_0}(1)$$

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

if $z << R$

then $z \to 0$

$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$