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Subject:- Physics solved numericals of chapter 25 (Electric Potential)
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Example 25.1:-
The electric Field between two parallel plates of oppsite changes
Solution:-

$$E = \frac{|V_B - V_A|}{d}$$

$$E = \frac{12V}{0.30\times10^{-2}m}$$

$$\boxed{E = 4.0\times10^{3}V/m}$$ Ans

Example 25.2:-
Motion of a Protorn in a uniform Electric Field.
Solution:-

$$\Delta V = -Ed$$
$$\Delta V = -(8.0\times10^{4}V/m)(0.50m)$$
$$\Delta V = -4.0\times10^{4}V$$

Now,

$$\Delta K + \Delta U = 0$$
$$(\tfrac{1}{2}mv^2 - 0) + e\Delta V = 0$$

$$V = \sqrt{\frac{-2e\Delta V}{m}}$$

(P.T.O)

Putting values,

$$v = \sqrt{\frac{-2(1.6\times10^{-19}\,C)(-4.0\times10^{4}\,V)}{1.67\times10^{-27}\,kg}}$$

$$\boxed{v = 2.8\times10^{6}\,m/s} \quad \text{Ans}$$

Example 25.3:-

The electric potential due to two point charges.

<u>Solution:-</u>

ⓐ Find the ...... (4.00, 0) m.

<u>Ans:-</u>

$$V_p = k_e\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right)$$

$$V_p = (8.99\times10^{9}\,N\cdot m^2/C^2)\left(\frac{2.00\times10^{-6}\,C}{4.00\,m} + \frac{-6.00\times10^{-6}}{5.00\,m}\right)$$

$$\boxed{V_p = -6.29\times10^{3}\,V}$$

Ⓑ Find the change ..... infinity to point P.

<u>Ans:-</u>

$$U_f = q_3 V_p$$

$$\Delta U = U_f - U_i = q_3 V_p - 0$$

$$\Delta U = (3.00\times10^{-6}\,C)(-6.29\times10^{3}\,V)$$

$$\boxed{\Delta U = -18.9\times10^{-2}\,J} \quad \text{Ans}$$

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Example 25.4 :- The electric potential due to a dipole.

Solutions:-

(a) calculate the electric potential at point P on the y-axis

Ans:

$$V_P = k_e \sum_i \frac{q_i}{r_i}$$

$$= k_e \left(\frac{q}{\sqrt{a^2+y^2}} + \frac{-q}{\sqrt{a^2+y^2}} \right)$$

$$\boxed{V_P = 0}$$

(b) calculate the electric Potential at Point R on the x-axis

$$V_R = k_e \sum_i \frac{q_i}{r_i}$$

$$= k_e \left(\frac{-q}{x-a} + \frac{q}{x+a} \right)$$

$$\boxed{V_R = \frac{-2k_e qa}{x^2-a^2}}$$

(c) calculate V and E_x at a point on the x-axis far from dipole.

$$V_R = \lim_{x \gg a} \left(\frac{-2k_e qa}{x^2-a^2} \right)$$

$$= \frac{-2k_e qa}{x^2} \quad (x \gg a)$$

In a vector notation, $\vec{E}$ is often written in cartesian coordinate System as,

$$E = -\nabla V = -\left(\hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z} \right) V$$

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where ∇ is gradient operator.

So, $E_x = \frac{-dv}{dx} = -\frac{d}{dx}\left(\frac{-2k_e q_a}{x^2}\right)$

$= 2k_e q a \frac{d}{dx}\left(\frac{1}{x^2}\right)$

$\boxed{= \frac{-4k_e q a}{x^3}}$ $(x > a)$

Example 25.5:-

Electric Potential Due to a uniformly charge Ring.

Solution:-

(A) Find an expression ------ total charge Q.

Ans:

$V = k_e \int \frac{dq}{r}$

$= k_e \int \frac{dq}{\sqrt{a^2 + x^2}}$

$V = \frac{k_e}{\sqrt{a^2+x^2}} \int dq$

$\boxed{= \frac{k_e Q}{\sqrt{a^2+x^2}}}$

(B) Find an expression ...... at point P.

Soution:-

$E_x = \frac{-dv}{dx} = -k_e Q \frac{d}{dx}(a^2+x^2)^{-1/2}$

$= -k_e Q(-\tfrac{1}{2})(a^2+x^2)^{-3/2}(2x)$

$\boxed{E_x = \frac{k_e x}{(a^2+x^2)^{3/2}} Q}$

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Example 25.6

Electric potential due to a uniformly charged disk

Solution:-

(A) Find the expression ..... axis of the disk.

$$dq = \sigma dA = \sigma (2\pi r dr) = 2\pi\sigma r dr$$

$$dV = \frac{k_e dq}{\sqrt{r^2+x^2}} = \frac{k_e 2\pi\sigma r dr}{\sqrt{r^2+x^2}}$$

$$V = \pi k_e \sigma \int_0^R \frac{2r dr}{\sqrt{r^2+x^2}}$$

$$= \pi k_e \sigma \int_0^R (r^2+x^2)^{-1/2} 2r dr$$

$$\boxed{V = 2\pi k_e \sigma [(R^2+x^2)^{1/2} - x]}$$

(B) Find the x ...... axis of the disk.

Ans:-

$$E_x = \frac{-dV}{dx} = -2\pi k_e \sigma \left[1 - \frac{x}{(R^2+x^2)^{1/2}}\right]$$

Example 25-7:-

Electric field due to a finite line of charge.

Solution:-

$$dV = k_e \frac{dq}{r} = k_e \frac{\lambda dx}{\sqrt{a^2+x^2}}$$

$$V = \int_0^l k_e \frac{\lambda dx}{\sqrt{a^2+x^2}}$$

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$$V = k_e \lambda \int_0^l \frac{dx}{\sqrt{a^2+x^2}} = k_e \frac{Q}{l} \ln\left(x+\sqrt{a^2+x^2}\right)\Big|_0^l$$

$$V = k_e \frac{Q}{l}\left[\ln\left(l+\sqrt{a^2+l^2}\right) - \ln a\right]$$

$$= k_e \frac{Q}{l} \ln\left(\frac{l+\sqrt{a^2+l^2}}{a}\right)$$

E example 25.8:-

Two connected charged spheres

Solution:-

$$V = k_e \frac{q_1}{r_1} = k_e \frac{q_2}{r_2}$$

$$(1)\quad \frac{q_1}{q_2} = \frac{r_1}{r_2}$$

$$E_1 = k_e \frac{q_1}{r_1^2} \text{ and } E_2 = k_e \frac{q_2}{r_2^2}$$

$$\frac{E_1}{E_2} = \frac{q_1}{q_2} \frac{r_2^2}{r_1^2}$$

$$(2)\quad \frac{E_1}{E_2} = \frac{r_1}{r_2} \frac{r_2^2}{r_1^2}$$

$$\boxed{= \frac{r_2}{r_1}}$$

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