ساعد بار Principles of physics (10th eddition)

phy 132

CH_{24} : Electric Potential

Problems: 3, 7, 9, 17, 25, 33, 46, 47

P3: A charged, conducting sphere of radius 5.5 cm set up a potential of 75 V at a radial distance of 2.2 m (with V = 0 set at infinity)
(a) what is the potential on the sphere's surface?
(b) what is the surface charge density?

a) $V = \frac{kq}{r} \Rightarrow q = \frac{Vr}{k} = \frac{75 \times 2.2}{9 \times 10^9} = 1.83 \times 10^{-8} c$

$V_{at\ (r = 5.5 cm)} = \frac{kq}{r}$

$= \frac{9 \times 10^9 \times 1.83 \times 10^{-8}}{5.5 \times 10^{-2}}$

$= 3000$ volt

$= 3 kV$

b) $\sigma = \frac{q}{A} = \frac{q}{4\pi r^2} = \frac{1.83 \times 10^{-8}}{4(3.14)(5.5 \times 10^{-2})^2}$

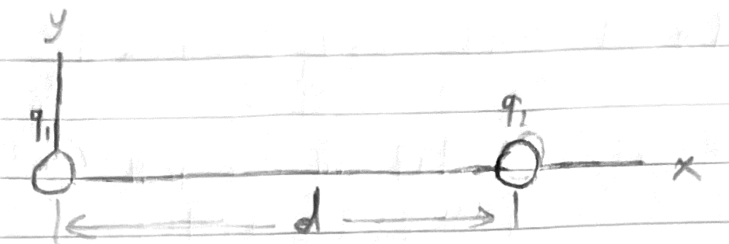
$= 4.8 \times 10^{-7} c/m^2$

$= 0.48 \times 10^{-6} c/m^2$

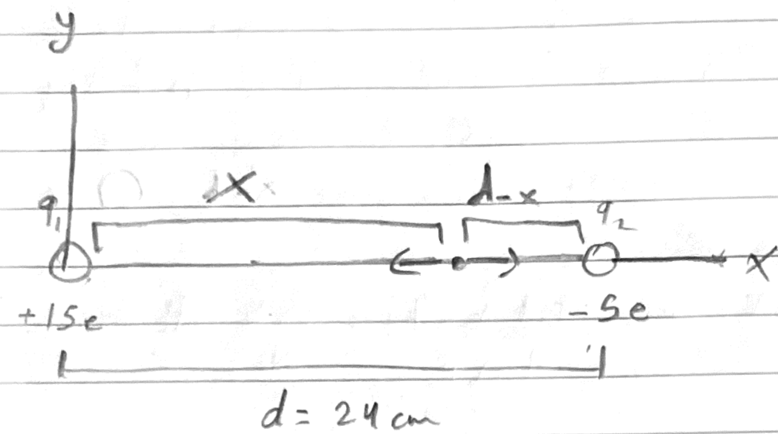
$= 0.48 \mu c/m^2$

P7: In Fig 24-26, particles with the charges $q_1 = +15e$ and $q_2 = -5e$ are fixed in place with a separation of d = 24.0 cm. With electric potential defined to be V = 0 at infinity, What are the finite (a) positive (b) negative values of x at which the net electric potential on the x axis is zero?

سارة بنار



Sol:



المحصله ستكونا صفر بينها واقرب للاصغر
او خارجها والاقرب للاصغر

a) $\Sigma V = 0$

$$\frac{kq_1}{x} + \frac{kq_2}{d-x} = 0$$

$$\frac{k(15e)}{x} + \frac{k(-5e)}{d-x} = 0$$

$$\frac{15ke}{x} = \frac{5ke}{d-x}$$

$$\frac{15}{x} = \frac{5}{d-x}$$

$$\frac{3}{x} = \frac{1}{d-x}$$

سارة نجار

$3(d-x) = x$

$3d - 3x = x$

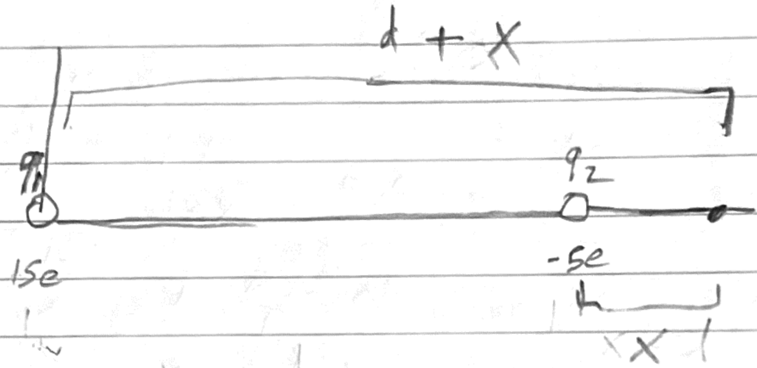
$3d = 4x$

$x = \frac{3}{4} d$

$x = \frac{3(24)}{4}$

$x = 18\ cm$

b)



$\Sigma V = 0 \Rightarrow \frac{kq_1}{d+x} + \frac{kq_2}{x} = 0$

$\frac{k(15e)}{d+x} + \frac{k(-5e)}{x} = 0$

$\frac{15ke}{d+x} - \frac{5ke}{x} = 0$

$\frac{15ke}{d+x} = \frac{5ke}{x}$

$\frac{3}{d+x} = \frac{1}{x}$

$3x = d + x$

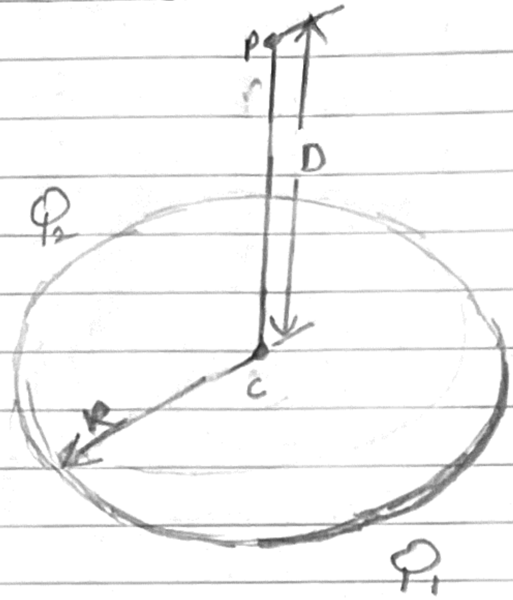
$2x = d$

$x = \frac{d}{2} \Rightarrow x = \frac{24}{2} = 12\ cm$

$\Sigma V = 0$ at $d + x = 24 + 12 = 36$ cm from origine

سارة رعنا

P9: A plastic rod has been bent into a circle of radius $R = 8.20 cm$. It has a charge $Q_1 = +7.07 pC$ uniformly distributed along one-quarter of its circumference and a charge $Q_2 = -6Q_1$ uniformly distributed along the rest of the circumference (Fig 24-27). With $V = 0$ at infinity, what is the electric potential at (a) the center C of the circle and (b) point P, on the central axis of the circle at distance $D = 2.05$ cm from the center?



a) All the charge is at the same distance R from C

$$V = \frac{kQ_1}{r_1} + \frac{kQ_2}{r_2}$$

$$= \frac{kQ_1}{R} - \frac{k6Q_1}{R}$$

$$= k\left(\frac{Q_1 - 6Q_1}{R}\right)$$

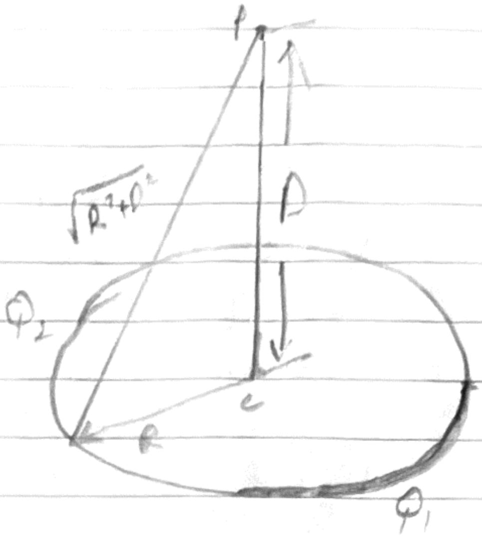
$$= \frac{-k5Q_1}{R}$$

$$= -\frac{9\times10^9 \times 5 \times 7.07\times10^{-12}}{8.20\times10^{-2}} \Rightarrow V = -3.88 \text{ Volt}$$

⑤

سارة بلال

b)



All the charge is the same distance from P and equale $\sqrt{R^2+D^2}$

$$V = \frac{kQ_1}{r_1} + \frac{kQ_2}{r_2}$$

$$= \frac{kQ_1}{\sqrt{R^2+D^2}} - \frac{k6Q_1}{\sqrt{R^2+D^2}}$$

$$= \frac{-5kQ_1}{\sqrt{R^2+D^2}}$$

$$= \frac{-5 \times 9 \times 10^9 \times 7.07 \times 10^{-12}}{\sqrt{(8.2 \times 10^{-2})^2 + (2.05 \times 10^{-2})^2}}$$

$$= \frac{-0.3185}{0.0845}$$

$= -3.76$ volt

سارو بنا

P17: What is the magnitude of the electric field at the point $(-1.00\hat{i} - 2.00\hat{j} + 4.00\hat{k})$ m, if the electric potential in the region is given by $V = 2.00xyz^2$, where V is in volt and coordinates x, y, and z are in meters?

Sol:

$E_x = -\frac{\partial V}{\partial x} = -2yz^2$

$E_y = -\frac{\partial V}{\partial y} = -2xz^2$

$E_z = -\frac{\partial V}{\partial z} = -4xyz$

the point (x, y, z) is $(-1, -2, 4)$ m

$E_x = -2yz^2 = -2(-2)(4)^2 = +64$ V/m
$E_y = -2xz^2 = -2(-1)(4)^2 = 32$ V/m

$E_z = -4xyz = -4(-1)(-2)(4) = -32$ V/m

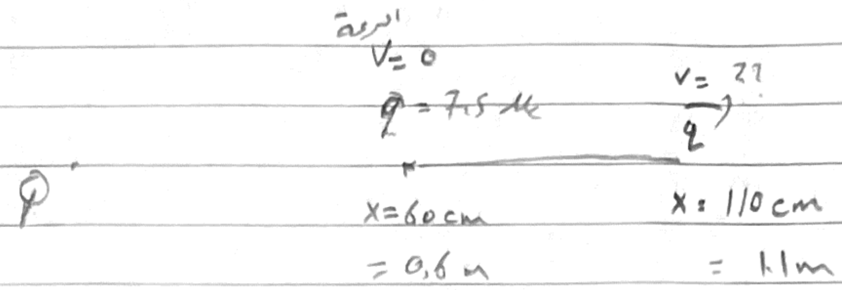
$|\vec{E}| = \sqrt{E_x^2 + E_y^2 + E_z^2}$

$= \sqrt{(64)^2 + (32)^2 + (-32)^2}$

$= 78.38$
$= 78.4$ N/C

P25: A particle of charge $+7.5\ \mu c$ is released from rest at the point $x = 60$ cm on an X-axis. The particle begins to move due to the presence of a charge Q that remains fixed at the origin. What is the kinetic energy of the particle at the instant it has moved 50 cm if (a) $Q = +20\ \mu c$ and (b) $Q = -20\ \mu c$?

Sol



a) $Q = 20\ \mu c$

$$u_i + k_i = u_f + k_f$$

$$\frac{kQq}{r_i} + 0 = \frac{kQq}{r_f} + k_f$$

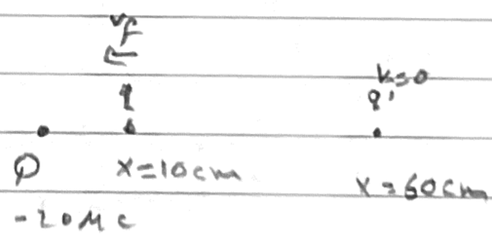
$$\frac{kQq}{r_i} - \frac{kQq}{r_f} = k_f$$

$$kQq\left(\frac{1}{r_i} - \frac{1}{r_f}\right) = k_f$$

$$9\times10^{9} \times 20\times10^{-6} \times 7.5\times10^{-6}\left(\frac{1}{0.6} - \frac{1}{1.1}\right) = k_f$$

$$1.02\ J = k_f$$

b) $Q = -20\ \mu c$



$$u_i + k_i = u_f + k_f$$

$$\frac{kQq}{r_i} + 0 = \frac{kQq}{r_f} + k_f$$

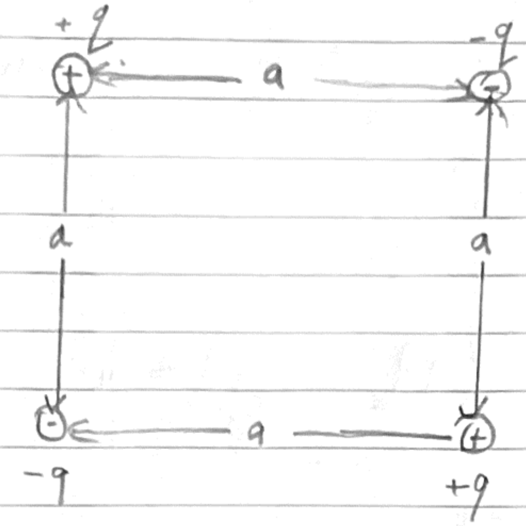
$$kQq\left(\frac{1}{r_i} - \frac{1}{r_f}\right) = k_f$$

ساره بكار

$9\times10^{9} \times -20\times10^{-6} \times 7.5\times10^{-6} \left(\frac{1}{0.6} - \frac{1}{0.1}\right) = k_f$

$11.25\ J = k_f$

P_{33}: The particles shown in fig 24-38 each have charge magnitude $q = 5.00$ pc and were intially infinitely far a part. To form the squre with edge length $a = 64$ cm (a) how much work must be done by an external agent (b) how work must be done by the electric forces and (c) What is the potential energy of the system?



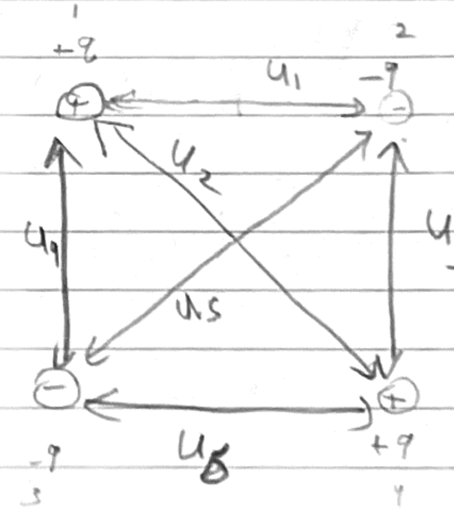
sol

$W = U_f - U_i$

the particles intially infinitely far apart $\Rightarrow U_i = 0\ J$

$W = U_f$

$U = \frac{k q_1 q_2}{r}$



[illegible]

$U_1 = \frac{-kq^2}{a}$, $U_2 = \frac{k(+q)(+q)}{\sqrt{a^2+a^2}}$ $\Rightarrow$ $U_2 = \frac{+kq^2}{a\sqrt{2}}$

$U_3 = -\frac{kq^2}{a}$, $U_4 = \frac{-kq^2}{a}$, $U_5 = \frac{kq^2}{\sqrt{2}a}$, $U_6 = \frac{-kq^2}{a}$

a) $W = U_f = U_1 + U_2 + U_3 + U_4 + U_5 + U_6$

$= \frac{-kq^2}{a} + \frac{kq^2}{a\sqrt{2}} - \frac{kq^2}{a} - \frac{kq^2}{a} + \frac{kq^2}{a\sqrt{2}} - \frac{kq^2}{a}$

$= \frac{kq^2}{a}\left[-1 + \frac{1}{\sqrt{2}} - 1 - 1 + \frac{1}{\sqrt{2}} - 1\right]$

$= \frac{kq^2}{a}\left[-4 + \frac{2}{\sqrt{2}}\right]$

$= \frac{kq^2}{a}\left[-4 + \sqrt{2}\right]$

$W = \frac{9\times10^9 (5\times10^{-12})^2}{64\times10^{-2}}\left[-4+\sqrt{2}\right]$

$W_{app} = -9.09\times10^{-13}$ J the amount of work required to set up the system

b) the work done by the electric force $= -W_{app}$
$= 9.09\times10^{-13}$ J
$= 0.909\times10^{-12}$ J
$= 0.909$ pJ

c) the potential energy of the system is the work required to set up the arrangment

$U = W_{app} = -9.09\times10^{-13}$ J $= 0.909$ pJ

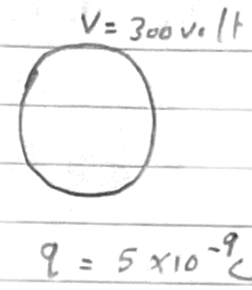
اجوف

مساويا

P46: A hollow metal sphere has a potential of +300 V with respect to ground (defined to be at $V=0$) and a charge of 5.0×10^{-9} C. Find the electric potential at the center of the sphere.

sol: * potential of ground = 0

* Electric field inside a conductor = 0



$$E = -\frac{dV}{dx} = 0$$

$$-dV = 0$$

$$dV = 0$$

$$\int dV = \int 0$$

$$V = \text{constant}$$

$\Rightarrow$ potential at center = +300 V

P47: An electron is projected with an initial speed of 1.6×10^{5} m/s directly toward a proton that is fixed in place. If the electron is initially a great distance from the proton, at what distance from the proton is the speed of the electron instantaneously equal to twice the initial value?

sol: $e = -1.6 \times 10^{-19}$ C

$p = +1.6 \times 10^{-19}$ C $\Rightarrow p = -e$

$$K_i + U_i = K_f + U_f$$

سلدبار

$$K_i + 0 = K_f + U_f$$

$$\frac{1}{2} m_e v_i^2 = \frac{1}{2} m_e v_f^2 + \frac{k e p}{r_f}$$

$$\frac{1}{2} m_e v_i^2 = \frac{1}{2} m_e v_f^2 - \frac{k e^2}{r_f}$$

$$\frac{k e^2}{r_f} = \frac{1}{2} m_e v_f^2 - \frac{1}{2} m_e v_i^2$$

$$\frac{k e^2}{r_f} = \frac{1}{2} m_e (v_f^2 - v_i^2)$$

$$r_f = \frac{2 k e^2}{m_e (v_f^2 - v_i^2)} \qquad \text{but } v_f = 2v_i$$

$$= \frac{2 k e^2}{m_e ((2v_i)^2 - v_i^2)}$$

$$= \frac{2 k e^2}{m_e (4v_i^2 - v_i^2)}$$

$$r_f = \frac{2 k e^2}{3 m_e v_i^2}$$

$$r_f = \frac{2 \times 9\times 10^9 (1.6\times 10^{-19})^2}{3 \times 9.11 \times 10^{-31} \times (1.6\times 10^5)^2}$$

$$r_f = 6.6 \times 10^{-9}\ m$$

