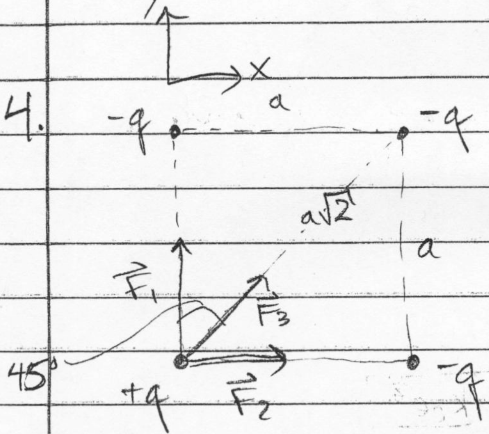
PHY 1B(b) HW# 1 (Chap. 15) Solutions

4.



In general, $F = \frac{k_e |q_1||q_2|}{r^2}\hat{r}$

$$F_1 = F_2 = \frac{k_e q^2}{a^2} \quad \text{(magnitude)}$$

$$F_3 = \frac{k_e q^2}{(a\sqrt{2})^2} = \frac{k_e q^2}{2a^2} \quad \text{(magnitude)}$$

$$\sum F_x = \left[F_2 + F_3 \cos(45°)\right]\hat{x}$$

$$= \frac{k_e q^2}{a^2} + \frac{k_e q^2}{2a^2}\cos(45°) \approx 1.35\left(\frac{k_e q^2}{a^2}\right)\hat{x}$$

$$\sum F_y = \left[F_1 + F_3 \sin(45°)\right]\hat{y}$$

$$= \frac{k_e q^2}{a^2} + \frac{k_e q^2}{2a^2}\sin(45°) \approx 1.35\left(\frac{k_e q^2}{a^2}\right)\hat{y}$$

$$\left(\vec{F}_T\right)^2 = \left[1.35\left(\frac{k_e q^2}{a^2}\right)\hat{x}\right]^2 + \left[1.35\left(\frac{k_e q^2}{a^2}\right)\hat{y}\right]^2$$

$\Rightarrow$ $\boxed{\vec{F}_T \approx 1.91\left(\frac{k_e q^2}{a^2}\right) \text{ along the diagonal toward the negative charge.}}$

8. The two charges are in static equilibrium.

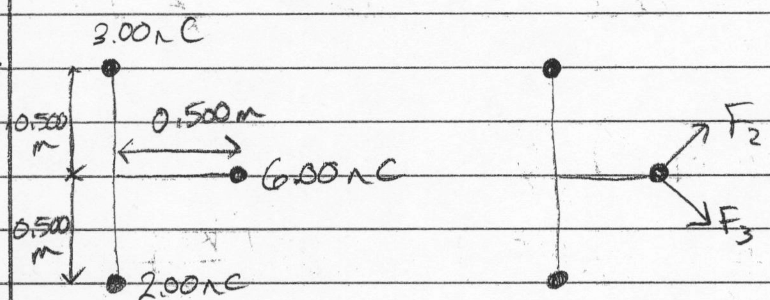
$$\Rightarrow \sum F = 0$$

$$\Rightarrow F_{grav} = F_{elect.}$$

$$m_e g = \frac{k_e e^2}{r^2} \Rightarrow r = \sqrt{\frac{k_e e^2}{m_e g}}$$

$$\Rightarrow r = \sqrt{\frac{(8.99\times10^{9}\,N\cdot m^2/C^2)(1.60\times10^{-19}\,C)^2}{(9.11\times10^{-31}\,kg)(9.80\,m/s^2)}} = \boxed{5.08\,m}$$

12.



$k_e \approx 8.99\times10^{9}\ \frac{N\cdot m^2}{C^2}$

Magnitudes: $F_2 = \frac{k_e|6.00\,nC||2.00\,nC|}{\left(\sqrt{(.5\,m)^2+(.5\,m)^2}\right)^2} \approx 2.16\times10^{-7}\,N$

$$F_3 = \frac{k_e|6.00\,nC||3.00\,nC|}{\left(\sqrt{(.5\,m)^2+(.5\,m)^2}\right)^2} \approx 3.24\times10^{-7}\,N$$

$$\sum F_x = F_2\cos(45^\circ) + F_3\cos(45^\circ) = 3.81\times10^{-7}\,N$$

$$\sum F_y = (F_2 - F_3)\sin(45^\circ) = -7.63\times10^{-8}\,N$$

12. $F_R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} = 3.89 \times 10^{-7}\ N$

$$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right) = -11.3°$$

$$\boxed{\vec{F}_R = 3.89 \times 10^{-7}\ N \text{ at } 11.3° \text{ below x-axis}}$$

19. Contribution due to positive charge at 3000 m:

$$E_+ = \frac{k_e|q|}{r^2} = \left(8.99 \times 10^{-9}\ \frac{N \cdot m^2}{C^2}\right)\frac{(40.0\ C)}{(1000\ m)^2}$$

$$= 3.60 \times 10^5\ N/C \text{ (downward)}$$

The direction is downward because the electric field points in same direction as the force on a positive test charge would point.

For negative charge,

$$E_- = \frac{k_e|q|}{r^2} = \left(8.99 \times 10^{-9}\ \frac{N \cdot m^2}{C^2}\right)\left(\frac{40.0\ C}{(1000\ m)^2}\right)$$

$$= 3.60 \times 10^5\ N/C \text{ (downward)}$$

$$\boxed{\vec{E} = \vec{E}_+ + \vec{E}_- = 7.20 \times 10^5\ N/C \text{ (downward)}}$$

22 Electric field must act opposite to the direction the proton moves. Therefore, the electric field does <u>negative</u> work.

By work-energy theorem,

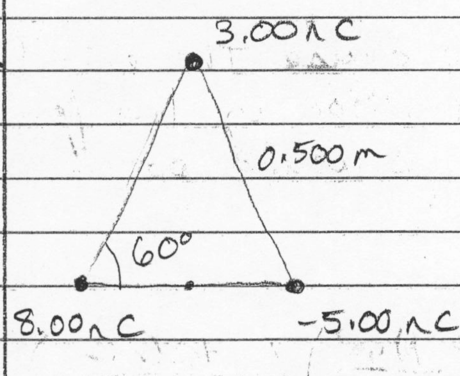
$$W_{net} = KE_f - KE_i$$

$$\Rightarrow -(qE)\Delta x = 0 - KE_i$$

$$\Rightarrow E = \frac{KE_i}{q\Delta x} = \frac{3.25\times 10^{-5}\ J}{(1.60\times 10^{-19} C)(1.25 m)}$$

$$= \boxed{1.63\times 10^{4}\ N/C}$$ in direction opposite to proton's velocity.

24.



$$h = (.500 m)\sin(60)^{\circ}$$
$$\approx .433\ m.$$

$$\sum E_x = \frac{k_e(8.00 nC)}{(2.50m)^2} + \frac{k_e(5.00 nC)}{(2.50m)^2} \approx 18.70\times 10^{3}\ N/C$$

$$\sum E_y = \frac{k_e(3.00 nC)}{(.433m)^2} = 144\ N/C$$

$$E_R = \sqrt{(18.7\times 10^{3} N/C)^2 + (144 N/C)^2} = 18.7\times 10^{3}\ N/C$$

24. $\theta = \tan^{-1}\left(\frac{\Sigma E_y}{\Sigma E_x}\right) = -4.40°$

$\Rightarrow \boxed{\vec{E}_R = 1.88 \times 10^3 \text{ N/C at } 4.40° \text{ below the } +x\text{-axis.}}$

39. $\phi_E = EA\cos\theta$

$A = (0.350\text{ m})(0.700\text{ m}) = 0.245\text{ m}^2$

a) $\theta = 0°$

$\Rightarrow \phi_E = (3.50 \times 10^3 \text{ N/C})(0.245\text{ m}^3)\cos(0°)$

$\phi_E = 858 \text{ N}\cdot\text{m}^2/\text{C}$

b) $\theta = 90° \Rightarrow \phi_E = 0$

c) $\phi_E = (3.50 \times 10^3 \text{ N/C})(0.245\text{ m}^3)\cos(40°)$

$\phi_E = 657 \text{ N}\cdot\text{m}^2/\text{C}$

40. b) Before calculating the electric field, we must find out certain properties of the field.

Since the field is radial everywhere, the charge distribution must be spherically symmetric.

Since the field is radially inward, the net charge is negative

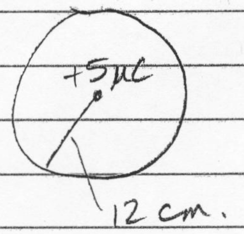
40. a) Electric field outside is $E = \frac{k_e Q}{r^2}$

Where $r = R$, $E = \frac{k_e |Q|}{R^2}$

$$\Rightarrow |Q| = \frac{R^2 E}{k_e} = \frac{(0.750\ m)^2 (890\ N/C)}{8.99 \times 10^9\ N \cdot m^2/C^2} = 55.7\ nC$$

$$\Rightarrow \boxed{Q = -55.7\ nC}$$

42.



$$\phi_E = EA\cos\theta = \left(\frac{k_e q}{R^2}\right)(4\pi R^2)\cos(0°)$$

$$\Rightarrow \phi_E = 4\pi q k_e$$

$$\Rightarrow \phi_E = 4\pi(8.99 \times 10^9\ N \cdot m^2/C^2)(5.00 \times 10^{-6} C)$$

$$= \boxed{5.65 \times 10^5\ N \cdot m^2/C}$$

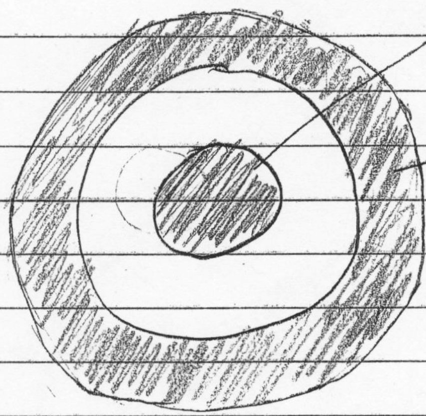
48. a) $F = \frac{k_e e^2}{r^2} = \frac{(8.99 \times 10^9\ N \cdot m^2/C^2)(1.60 \times 10^{-19} C)^2}{(0.53 \times 10^{-10}\ m)^2}$

$$= \boxed{8.2 \times 10^{-8}\ N}$$

b) $F = m_e a_c = m_e\left(\frac{v^2}{r}\right)$

$$\Rightarrow v = \sqrt{\frac{r \cdot F}{m_e}} = \sqrt{\frac{(0.53 \times 10^{-10}\ m)(8.2 \times 10^{-8}\ N)}{9.11 \times 10^{-31}\ kg}} = \boxed{2.2 \times 10^6\ m/s}$$

53.



a) At r = 1.00 cm, E = 0, because electric field does not exist in a conducting material.

b) At 3 cm., net charge is Q = +8.00 μC

$$E = \frac{k_e Q}{r^2}$$

$$= \frac{(8.99 \times 10^9 \ N \cdot m^2/C^2)(8.00 \times 10^{-6} C)}{(3.00 \times 10^{-2} m)^2}$$

$E = 7.99 \times 10^7$ N/C (outward)

c) At r = 4.5 cm, E = 0 since within conducting material.

d) At r = 7 cm., Q = +4 μC

$$\Rightarrow E = \frac{(8.99 \times 10^9 \ N \cdot m^2/C^2)(4 \times 10^{-6} C)}{(7 \times 10^{-2} m)^2}$$

$= 7.34 \times 10^6$ N/C (outward)