Honors Physics – Ch 16 Practice Answers

1)

$q_1 = 1.0 \times 10^5\ \text{C}$

$q_2 = -1.0 \times 10^5\ \text{C}$

$r = 7.0 \times 10^{11}\ \text{m}$

$k_C = 8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$

$$F = k_C \frac{q_1 q_2}{r^2}$$

$$F = (8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)\left(\frac{(1.0 \times 10^5\ \text{C})^2}{(7.0 \times 10^{11}\ \text{m})^2}\right)$$

$$F = \boxed{1.8 \times 10^{-4}\ \text{N}}$$

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2)

$q = 1.00\ \text{C}$

$F_{electric} = 4.48\ \text{m} \times 10^4\ \text{N}$

$k_C = 8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$

$$r = \sqrt{k_C \frac{q^2}{F_{electric}}} = \sqrt{\frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(1.0\ \text{C})^2}{4.48 \times 10^4\ \text{N}}} = \boxed{448\ \text{m}}$$

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3)

$q_p = 1.60 \times 10^{-19}\ \text{C}$

$r_{4,1} = r_{2,1} = 1.52 \times 10^{-9}\ \text{m}$

$k_C = 8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$

$$q_p = q_1 = q_2 = q_3 = q_4$$

$$r_{3,2} = \sqrt{(1.52 \times 10^{-9}\ \text{m})^2 + (1.52 \times 10^{-9}\ \text{m})^2} = 2.15 \times 10^{-9}\ \text{m}$$

$$F_{2,1} = \frac{k_C q_p^2}{r_{2,1}^2} = \frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(1.60 \times 10^{-19}\ \text{C})^2}{(1.52 \times 10^{-9}\ \text{m})^2} = 9.96 \times 10^{-11}\ \text{N}$$

$$F_{3,1} = \frac{k_C q_p^2}{r_{3,1}^2} = \frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(1.60 \times 10^{-19}\ \text{C})^2}{(2.15 \times 10^{-9}\ \text{m})^2} = 4.98 \times 10^{-11}\ \text{N}$$

$$F_{4,1} = \frac{k_C q_p^2}{r_{4,1}^2} = \frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(1.60 \times 10^{-19}\ \text{C})^2}{(1.52 \times 10^{-9}\ \text{m})^2} = 9.96 \times 10^{-11}\ \text{N}$$

$$\varphi = \tan^{-1}\left(\frac{1.52 \times 10^{-9}\ \text{m}}{1.52 \times 10^{-9}\ \text{m}}\right) = 45°$$

$F_{2,1}$: $F_x = 0\ \text{N}$

$F_y = 9.96 \times 10^{-11}\ \text{N}$

$F_{3,1}$: $F_x = F_{3,1} \cos 45° = (4.98 \times 10^{-11}\ \text{N})(\cos 45°) = 3.52 \times 10^{-11}\ \text{N}$

$F_y = F_{3,1} \sin 45° = (4.98 \times 10^{-11}\ \text{N})(\sin 45°) = 3.52 \times 10^{-11}\ \text{N}$

$F_{4,1}$: $F_x = 9.96 \times 10^{-11}\ \text{N}$

$$F_{x,tot} = 0\ \text{N} + 3.52 \times 10^{-11}\ \text{N} + 9.96 \times 10^{-11}\ \text{N} = 1.35 \times 10^{-10}\ \text{N}$$

$$F_{y,tot} = 9.96 \times 10^{-10}\ \text{N} + 3.52 \times 10^{-11}\ \text{N} + 0\ \text{N} = 1.35 \times 10^{-10}\ \text{N}$$

$$F_{tot} = \sqrt{(F_{x,tot})^2 + (F_{y,tot})^2} = \sqrt{(1.35 \times 10^{-10}\ \text{N})^2 + (1.35 \times 10^{-10}\ \text{N})^2}$$

$$F_{tot} = \boxed{1.9 \times 10^{-10}\ \text{N}}$$

$$\varphi = \tan^{-1}\left(\frac{1.35 \times 10^{-10}\ \text{N}}{1.35 \times 10^{-10}\ \text{N}}\right) = \boxed{45.0°}$$

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4)

$q_1 = -2.34 \times 10^{-8}\ \text{C}$

$q_2 = 4.65 \times 10^{-9}\ \text{C}$

$q_3 = 2.99 \times 10^{-10}\ \text{C}$

$r_{1,2} = 0.500\ \text{m}$

$r_{1,3} = 1.00\ \text{m}$

$k_C = 8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$

$$F_{1,2} = \frac{k_C q_1 q_2}{r_{1,2}^2} = \frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(-2.34 \times 10^{-8}\ \text{C})(4.65 \times 10^{-9}\ \text{C})}{(0.500\ \text{m})^2}$$

$$F_{1,2} = F_y = -3.91 \times 10^{-6}\ \text{N}$$

$$F_{1,3} = \frac{k_C q_1 q_3}{r_{1,3}^2} = \frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(-2.34 \times 10^{-8}\ \text{C})(2.99 \times 10^{-10}\ \text{C})}{(1.00\ \text{m})^2}$$

$$F_{1,3} = F_y = -6.29 \times 10^{-8}\ \text{N}$$

$$F_{y,tot} = -3.91 \times 10^{-6}\ \text{N} + -6.29 \times 10^{-8}\ \text{N} = 3.97 \times 10^{-6}\ \text{N}$$

There are no x-components of the electrical force, so the magnitude of the electrical force is $\sqrt{(F_{y,tot})^2}$.

$F_{tot} =$ $\boxed{3.97 \times 10^{-6}\ \text{N directed along the } -y\text{-axis}}$

5)

$q_1 = 55 \times 10^{-6}\ \text{C}$

$q_2 = 137 \times 10^{-6}\ \text{C}$

$q_3 = 14 \times 10^{-6}\ \text{C}$

$L = 87\ \text{m}$

$$F_{net} = 0 = F_1 + F_2$$

$$k_C \frac{q_1 q_3}{x^2} = \frac{k_C q_2 q_3}{(L-x)^2}$$

$$\frac{q_1}{x^2} = \frac{q_2}{(L-x)^2}$$

$$(L-x)\sqrt{q_1} = x\sqrt{q_2}$$

$$\frac{L}{x} - \frac{x}{x} = \sqrt{\frac{q_2}{q_1}}$$

$$\frac{L}{x} = \sqrt{\frac{q_2}{q_1}} + 1$$

$$x = \frac{L}{\sqrt{\frac{q_2}{q_1}} + 1} = \frac{87\ \text{m}}{\sqrt{\frac{137 \times 10^{-6}\ \text{C}}{55 \times 10^{-6}\ \text{C}}} + 1} = \boxed{34\ \text{m}}$$

6)

$q_1 = 2.5 \times 10^{-9}\ \text{C}$

$q_3 = 1.0 \times 10^{-9}\ \text{C}$

$r_{2,1} = 5.33\ \text{m}$

$r_{3,1} = 1.90\ \text{m}$

$$r_{3,2} = r_{2,1} - r_{3,1} = 5.33\ \text{m} - 1.90\ \text{m} = 3.43\ \text{m}$$

$$F_{3,1} = F_{3,2} = k_C\left(\frac{q_3 q_1}{(r_{3,1})^2}\right) = k_C\left(\frac{q_3 q_2}{(r_{3,2})^2}\right)$$

$$q_2 = q_1\left(\frac{r_{3,2}}{r_{3,1}}\right)^2$$

$$q_2 = (2.50 \times 10^{-9}\ \text{C})\left(\frac{3.43\ \text{m}}{1.90\ \text{m}}\right)^2 = \boxed{8.15 \times 10^{-9}\ \text{C}}$$

7)

$q_1 = 1.80 \times 10^{-5}\ \text{C}$

$q_2 = -1.20 \times 10^{-5}\ \text{C}$

$\mathbf{E_{net}} = 22.3\ \text{N/C toward } q_2$

$k_C = 8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$

$$\mathbf{E_{net}} = \frac{k_C}{r^2}(q_1 + q_2) \qquad r^2 = \frac{k_C}{\mathbf{E_{net}}}(q_1 + q_2)$$

$$r = \sqrt{\frac{k_C(q_1 + q_2)}{\mathbf{E_{net}}}}$$

$$r = \sqrt{\frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)[(1.80 \times 10^{-5}\ \text{C}) + (1.20 \times 10^{-5}\ \text{C})]}{22.3\ \text{N/C toward } q_2}}$$

$r =$ $\boxed{1.10 \times 10^2\ \text{m}}$