Exam 1 Solutions

Multiple Choice Key

1. d
2. a
3. c
4. b
5. a
6. d
7. c
8. b
9. e
10. c

Worked Problems

1. To find the total force:
   - Find the interior angle of the right triangle next to Q_1.

$$\theta = \arctan \frac{30\ cm}{70\ cm} = 23.2^\circ$$

   - Find the distance from charge 1 to charge 3

$$r = \sqrt{(70\ cm)^2 + (30\ cm)^2} = 76.2\ cm$$

   - Find the magnitude of both forces

$$F_{12} = k\frac{Q_1 Q_2}{r_{12}^2} = 0.11\ N$$

$$F_{13} = k\frac{Q_1 Q_3}{r_{13}^2} = 0.12\ N$$

- Find the x and y components of both vectors (taking the $+x$ axis to the right, and the $+y$ axis upward).

$$\mathbf{F}_{12} = -(0.11\ N)\hat{y}$$

$$\mathbf{F}_{13} = -(0.12\ N)\cos 66.8^\circ\hat{x} - (0.12\ N)\sin 66.8^\circ\hat{y} = -(0.047\ N)\hat{x} - (0.11\ N)\hat{y}$$

- Add the two forces together by component to find the total force.

$$\mathbf{F}_{tot} = \mathbf{F}_{12} + \mathbf{F}_{13} = (0 - 0.047\ N)\hat{x} + (-0.11 - 0.11\ N)\hat{y} = -(0.047\ N)\hat{x} - (0.22\ N)\hat{y}$$

- Use the Pythagorean Theorem to determine the magnitude of the force.

$$F_{tot} = \sqrt{(-0.047\ N)^2 + (-0.22\ N)^2} = 0.23\ N$$

2. Start with conservation of energy:

$$K_i + U_i = K_f + U_f$$

- The potential energies depend on the values of the potential, $U = qV$. The final potential at infinity will be zero (by definition), the initial will just be the total potential due to Q_2 and Q_3 at the position of Q_1:

$$V_i = \frac{kQ_2}{r_2} + \frac{kQ_3}{r_3} = 86,400\ V$$

- Energy conservation (with $v_i = 0$ since the charge starts from rest) is then:

$$\frac{1}{2}mv_f^2 = Q_1 V_i$$

- Solving for the speed gives:

$$v_f = \sqrt{\frac{2Q_1V_i}{m}} = \sqrt{\frac{0.34}{m}}\ m/s.$$