CLASS EXERCISE #3 - 15 June 2005

Consider the electrical force between pairs of electric charges as shown. These are three independent problems, with different charges but the same separation r in each case. Q represents the same number of coulombs in each case. Let F denote the force kQ^2/r^2. Show the magnitude (in terms of F; e.g., $F/2$ or $3F$) and direction of the force on each charge in each pair.

1. $Q \oplus \longleftarrow r \longrightarrow \ominus -Q$

Solution: $Q \oplus \rightarrow F$ $\qquad$ $F \leftarrow \ominus -Q$

2. $2Q \oplus \longleftarrow r \longrightarrow \oplus Q$

Solution: $2F \longleftarrow \oplus 2Q$ $\qquad$ $Q \oplus \longrightarrow 2F$

3. $2Q \oplus \longleftarrow r \longrightarrow \ominus -2Q$

Solution: $2Q \oplus \longrightarrow 4F$ $\qquad$ $4F \longleftarrow \ominus -2Q$

The electrical forces are attractive (towards the other charge) in cases (1) and (3), because the charge are opposite in sign, but repulsive (away from the other charge) in case (2), in which both charges are positive.

Second, the pairs of forces, by Newton's third law of motion, must have the same magnitude in each case, but opposite direction.

Third, the forces are proportional to the product of the masses (Q^2, $2Q^2$, and $4Q^2$ in cases (1), (2), and (3), respectively), so if the two forces in case (1) each have magnitude F, the two in case (2) must each have magnitude $2F$, and the two in case (3) must each have magnitude $4F$.