Topic 15

Electric Forces and Fields

QUICK QUIZZES

15.1 Choice (b). Object A must have a net charge because two neutral objects do not attract each other. Since object A is attracted to positively-charged object B, the net charge on A must be negative.

15.2 Choice (b). By Newton's third law, the two objects will exert forces having equal magnitudes but opposite directions on each other.

15.3 Choice (c). The electric field at point *P* is due to charges *other* than the test charge. Thus, it is unchanged when the test charge is altered. However, the direction of the force this field exerts on the test change is reversed when the sign of the test charge is changed.

15.4 Choice (a). If a test charge is at the center of the ring, the force exerted on the test charge by charge on any small segment of the ring will be balanced by the force exerted by charge on the diametrically opposite segment of the ring. The net force on the test charge, and hence the electric field at this location, must then be zero.

15.5 Choices (c) and (d). The electron and the proton have equal magnitude charges of opposite signs. The forces exerted on these particles by the electric field have equal magnitude and opposite directions. The electron experiences an acceleration of greater magnitude than does the proton because the electron's mass is much smaller than that of the proton.

15.6 Choice (a). The field is greatest at point A because this is where the field lines are closest together. The absence of lines at point C indicates that the electric field there is zero.

15.7 Choice (c). When a plane area A is in a uniform electric field E, the flux through that area is $\Phi_E = EA \cos \theta$, where θ is the angle the electric field makes with the line normal to the plane of A. If A lies in the xy-plane and E is in the z-direction, then $\theta = 0°$ and $\Phi_E = EA = (5.00 \text{ N/C})(4.00 \text{ m}^2) = 20.0 \text{ N} \cdot \text{m}^2/\text{C}$.

15.8 Choice (b). If $\theta = 60°$ in Quick Quiz 15.7 above, then $\Phi_E = EA \cos \theta$ which yields $\Phi_E = (5.00 \text{ N/C})(4.00 \text{ m}^2)\cos (60°) = 10.0 \text{ N} \cdot \text{m}^2/\text{C}$.

15.9 Choice (d). Gauss's law states that the electric flux through any closed surface is equal to the net enclosed charge divided by the permittivity of free space. For the surface shown in Figure 15.28, the net enclosed charge

is $Q = -6$ C, which gives $\Phi_E = Q/\epsilon_0 = -(6\text{ C})/\epsilon_0$.

15.10 Choices (b) and (d). Since the net flux through the surface is zero, Gauss's law says that the net change enclosed by that surface must be zero as stated in (b). Statement (d) must be true because there would be a net flux through the surface if more lines entered the surface than left it (or vice-versa).

ANSWERS TO EVEN NUMBERED CONCEPTUAL QUESTIONS

15.2 **(a)** False. Electric charge can only be transferred in multiples of the fundamental charge $+e$.

(b) True.

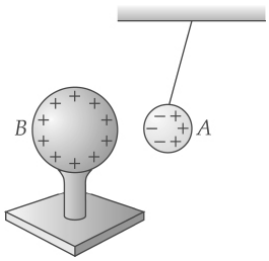
(c) False. All electrons have an electric charge of $-e$.

15.4 **(a)** Removing charge $-Q$ from object A leaves it with a net positive charge of $+Q$. Object B acquires a net charge $-Q$ so that A and B are oppositely charged and the Coulomb force, proportional to $Q_A Q_B = -Q^2$, is attractive.

(b) After another transfer of $-Q$ from A to B, $Q_A = +2Q$ and $Q_B = -2Q$ so that $Q_A Q_B = -4Q^2$ and $F_{\text{new}}/F_0 = 4$.

(c) If B is neutralized so that $Q_B = 0$, the Coulomb force is zero and $F_{new}/F_0 = 0$.

15.6 No. Object A might have a charge opposite in sign to that of B, but it also might be neutral. In this latter case, object B causes object A to be polarized, pulling charge of the sign opposite the change on B toward the near face of A and pushing an equal amount of charge of the same sign as that on B toward the far face. Then, due to difference in distances, the force of attraction exerted by B on the induced charge of opposite sign is slightly larger than the repulsive force exerted by B on the induced charge of like sign. Therefore, the net force on A is toward B.



15.8 **(a)** Yes. The positive charges create electric fields that extend in all directions from those charges. The total field at point A is the vector sum of the individual fields produced by the charges at that point.

(b) No, because there are no field lines emanating from or converging on point A.

(c) No. There must be a charged object present to experience a force.

15.10 Electric field lines start on positive charges and end on negative charges. Thus, if the fair-weather field is directed into the ground, the ground must have a negative charge.

15.12 To some extent, a television antenna will act as a lightning rod on the house. If the antenna is connected to the Earth by a heavy wire, a lightning discharge striking the house may pass through the metal support rod and be safely carried to the Earth by the ground wire.

15.14 **(a)** If the charge is tripled, the flux through the surface is also tripled because the net flux is proportional to the charge inside the surface.

(b) The flux remains constant when the volume changes because the surface surrounds the same amount of charge, regardless of its volume.

(c) The flux does not change when the shape of the closed surface changes.

(d) The flux through the closed surface remains unchanged as the charge inside the surface is moved to another location inside that surface.

(e) The flux is zero because the charge inside the surface is zero. All of