Answers to selected problems from Essential Physics, Chapter 17

1. (a) No, just because the electric field is zero at a particular point, it does not necessarily mean that the electric potential is zero at that point. A good example is the case of two identical charges, separated by some distance. At the midpoint between the charges, the electric field due to the charges is zero, but the electric potential due to the charges at that same point is non-zero. The potential either has two positive contributions, if the charges are positive, or two negative contributions, if the charges are negative. (b) No, just because the electric potential is zero at a particular point, it does not necessarily mean that the electric field is zero at that point. A good example is the case of a dipole, which is two charges of the same magnitude, but opposite sign, separated by some distance. At the midpoint between the charges, the electric potential due to the charges is zero, but the electric field due to the charges at that same point is non-zero. Both the electric field vectors will point in the direction of the negative charge.

3. (a) Zero. The potential at infinity is zero, and the potential at the midpoint of the dipole, due to the charges on the dipole, is also zero. The potential difference is zero, so no net work is done. (b) Still zero. The path followed does not matter because the electric force is conservative – all that matters is the potential difference between the initial point and the final point, which is zero.

5. 1 is not possible – field lines and equipotentials are perpendicular to one another where they cross. 2 is not possible – for one thing, equipotentials can not cross one another. 3 looks fine – it looks pretty close to a dipole situation.

7. (a) $+4q$ (b) $-6q$ (c) $+4q$

9.

	Potential difference	**Capacitance**	**Charge**	**Field**	**Energy**
Initially	V_0	C_0	Q_0	E_0	U_0
Dielectric removed	V_0	$C_0/3$	$Q_0/3$	E_0	$U_0/3$
Distance halved	V_0	$2C_0/3$	$2Q_0/3$	$2E_0$	$2U_0/3$

11. (a) The capacitor does work on the dielectric, attracting it inside the capacitor.
(b) You do work on the dielectric to bring it back out of the capacitor.

13. 3.1×10^6 m/s

15. 7.5 m/s

17. (a) $-\frac{6kq^2}{r}$ (b) $-\frac{12kq^2}{r}$ (c) $-\frac{2kq^2}{r}$

19. 7.3×10^7 m/s

21. There are two possible solutions. The charge is -1.33×10^{-7} C, and located at x = +8.0 m, or the charge is -4.44×10^{-8} C, and located at x = +4.0 m.

23. (a) and (b) Yes, there can be a place in both of these regions. At some point closer to the $+q$ charge, the smaller distance to the $+q$ charge can make up for the fact that the other charge is larger in magnitude. (c) To the right of the ball that has a charge of $-3q$, the potential will always be negative – being closer to the larger-magnitude charge, that charge will always dominate. (d) The two locations are $x = -2a$ and $x = +a$.

25. +80 volts

27. (a) The forces are equal in magnitude. We can justify this using Newton's third law, or from Coulomb's Law. (b) $\frac{3kq^2}{16a^2}$, to the left (c) $\frac{kq}{2a^2}$, to the left

The other (c) $+\frac{3kq^2}{4a}$ (d) $+\frac{2kq}{a}$

31. (a) The ball with charge $+4q$. (b) $+\left(2+22\sqrt{2}\right)\frac{kq^2}{d} \approx +33\frac{kq^2}{d}$

33.

	Potential difference	**Capacitance**	**Charge**	**Field**	**Energy**
Initially	V_0	C_0	Q_0	E_0	U_0
Distance doubled	V_0	$C_0/2$	$Q_0/2$	$E_0/2$	$U_0/2$
Wires removed	V_0	$C_0/2$	$Q_0/2$	$E_0/2$	$U_0/2$
Dielectric inserted	$V_0/4$	$2C_0$	$Q_0/2$	$E_0/8$	$U_0/8$
Battery re-connected	V_0	$2C_0$	$2Q_0$	$E_0/2$	$2U_0$

35. We can find the capacitance, but to find the energy we need another piece of information, either the potential difference or the charge.

37. (a) The balls repel one another, and because of the symmetry they all accelerate away from the center of the triangle, along lines that go from the center of the triangle through the vertices of the triangle. (b) 550 m/s (c) 780 m/s.

39. (a) This is possible, but only if the charge is negative. The farther away you get from a negative charge, the less negative the potential due to that charge is, so increasing the distance can increase the potential. (b) -8.3×10^{-10} C.

41. (a) 3>1>2 (b) 2>1>3 (c) 2>3>1 (d) 3>1=2

43. (a) Negative. (b) 0.5 s (c) 10 cm

45. (a) 1=2=3 (b) 3>2>1

47. (a), (b), and (c) $+3kq/r$

49. $+(18-\frac{9}{\sqrt{2}})\frac{kq^2}{L} \approx +11.6\frac{kq^2}{L}$

51. (a) Yes, charge 1 must be negative. (b) The magnitude of charge 1 is 3*Q*. (c) No, we cannot say what the sign of charge 3 is. (d) We can't say anything about charge 3's magnitude, either.

53. (a) There are two locations a finite distance from the charge where the net potential is zero. One of these places is to the left of the positive charge, on the negative *x*-axis. The other spot is between the charges, closer to the charge that has a smaller magnitude (closer to the positive charge). (b) At $x = -2.5$ m and at $x = +(5/7)$ m.

55. There are lots of locations off the line at which the net potential is zero – all points that are a distance *d* from the positive charge and a distance of (9/5)*d* from the negative charge.

57. (a) at x = -a and at x = +3a (b) also -2q (c) Yes, at x = +a, where the slope of the graph is zero.

59. (a) 2=3>1 (b) 1=2=3 (c) 2=3>1 (d) 1>2=3