Physics 112 Fall 2000: Answers to Exam #2

1. ***Answers: B and E.*** The positive charge is moving toward a region of higher electric potential, so its potential energy is increasing (since $PE = q\ V$ and q is not changing).Therefore, its kinetic energy is ***decreasing*** (since its total energy is constant, and $TE = KE + PE$). While traveling from [A to B], the charge gains potential energy equal to $q\Delta V = q$ (1 V), while from [A to C] it gains q (2 V). Therefore it loses twice as much kinetic energy while traveling from [A to C] as it does from [A to B].

2. ***Answer: E.*** Only the electric field (a conservative force) is acting on the object, so its total energy is conserved. Therefore, $TE_f = TE_i$ and so [$KE_f + PE_f = KE_i + PE_i$]. Now, we know that $KE_i = 0$ (since the object is initially at rest) and we know that $PE_i = qV_i$ = (9 C) (6 V) = 54 J. When the object moves out to a distance of 1000 r, its potential energy will be only 0.054 J, since in this situation $PE = kQq/r$. So we have that KE_f = 53.946 J ≈ 54 J, and so

$$\frac{1}{2}mv^2 = 54\,J$$

$$\Rightarrow \quad v^2 = \frac{(2)(54\,J)}{3\,kg} = 36\frac{m^2}{s^2}$$

and so v = 6 m/s.

3. ***Answer: C.*** The electric field in the room is created by source charges outside of the room. No test charge inside the room will have any effect on this electric field. Therefore, if a measurement at some point in space indicates an electric field with magnitude E, another measurement at the same point with any other test charge will also yield a value of E for the electric field.

4. ***Answer: A.*** The power supplied by the battery is given by $P_{bat} = I_{tot}\,\Delta V_{bat}$. The battery voltage is the same for both circuits, so we only need to compare the total current flowing through the battery. In the series circuit, $I_{tot}(series) = \frac{\Delta V_{bat}}{R_{equivalent}} = \frac{\Delta V_{bat}}{2R}$, while in the parallel circuit we have

$$I_{tot}(parallel) = \frac{\Delta V_{bat}}{R} + \frac{\Delta V_{bat}}{R} = \frac{2\,\Delta V_{bat}}{R} = 4\left[\frac{\Delta V_{bat}}{2R}\right] = 4\,I_{tot}(series).$$

Since the total current in the parallel circuit is four times that in the series circuit, the power supplied by the battery in the parallel circuit will be four times the power supplied by the battery in the series circuit.

5. ***Answer: E.*** The electric field between two charged parallel plates is ***uniform.*** Since the field has the same magnitude and direction everywhere between the plates, and the force on the charge is given by $F = qE$, the force on the charge everywhere between the plates will have exactly the same magnitude and direction.

6. ***Answer: F.*** The voltage drop across both resistors in the parallel circuit is equal to the battery voltage. The voltage drop across each of the resistors in the series circuit must be ***less*** than the battery voltage, because it is the ***sum*** of the voltage drops in the series circuit that will add up to the battery voltage.

7. ***Answer: L.*** At point A, the electric field points toward the east because the electric field points toward lower potential and is perpendicular to the equipotential lines. However, a negative charge at point A will move toward the ***west.*** The force is weaker at point A because the field is weaker there, as indicated by the wider spacing of the equipotential lines.

8.

Explanation: If R_1 is replaced by a larger resistance, the current through R_1 will decrease (because ΔV_1 must remain equal to the battery voltage). Since the current through that resistor decreases, the power dissipated by that resistor also decreases (since $P_1 = I_1 \Delta V_1$). Since ΔV_2 also must remain equal to the battery voltage (and the battery voltage doesn't change), the current through R_2 and therefore the power dissipated in R_2 will not change. Finally, we can see that the total current through the battery and the total power supplied by the battery must decrease (since $I_{tot} = I_1 + I_2$, and $P_{bat} = P_1 + P_2$), and so the equivalent resistance of the circuit will increase.

A. $R_{equivalent}$
B. I_1, P_1, I_{tot}, P_{bat}
C. ΔV_1, ΔV_2, ΔV_{bat}, I_2, P_2

9.

A. battery voltage.
B. power supplied by the battery, and the current flowing through the battery.

10.

A. The potential drop across bulbs A, D, and E is the same (equal to the battery voltage), so the current through all three of them will be the same. The potential drop across bulbs B and C are both equal to half the battery voltage, so the current through those bulbs will be smaller than the other three (but equal to each other). Therefore the ranking of the brightness of the bulbs is:

A = D = E > B = C

B. The current through B and C is the same as the current through battery #2. The current through A is the same as the current through battery #1. The current through battery #3 is equal to the ***sum*** of the current through D and the current through E. Therefore, the total current through battery #3 is largest, followed by #1, and then smallest is #2.

#3 > #1 > #2

C. From observations we know that the brightness of A is the same as the brightness of D and E, and that confirms that the current through A is the same as the current through D and the current through E. The current through battery #3 must be equal to the ***sum*** of the currents through D and E, and so it is twice as much as the current through battery #1. B and C are equal to each other in brightness, but dimmer than the other bulbs. Therefore the current through B and C (and through battery #2) is less than the current through the other batteries.

D. Since the power (energy per second) supplied by a battery is given by $P_{bat} = I_{tot}\,\Delta V_{bat}$, and the battery voltage is the same for all three batteries, the battery with the larger current flowing through it will supply the larger amount of power. Therefore the ranking here is the same as in part (B):

#3 > #1 > #2

11.

A. $I_{R3} > I_{R1} > I_{R2}$ [current splits after going through R_3, more than half goes through R_1 since it's the smaller resistance]

B. $\dfrac{\Delta V_{R1}}{\Delta V_{R2}} = 1$ The voltage drops across the two resistors are the same because the potential at the ***left*** side of the two resistors is the same (since they're connected by a conducting path), and the potential at the ***right*** side is the same.

C. $\dfrac{I_{R1}}{I_{R2}} = \dfrac{\Delta V_1 / R_1}{\Delta V_2 / R_2} = \dfrac{\Delta V_1 / R_1}{\Delta V_1 / R_2} = \dfrac{R_2}{R_1} = 3$

D. $\dfrac{\Delta V_{R2}}{\Delta V_{R3}} = \dfrac{I_{R2} R_2}{I_{R3} R_3} = \dfrac{I_{R2} R_2}{\left[I_{R1} + I_{R2}\right] R_3} = \dfrac{I_{R2} R_2}{\left[3I_{R2} + I_{R2}\right] R_3} = \dfrac{120 I_{R2}}{5\left[4I_{R2}\right]} = \dfrac{120}{20} = 6$

So ΔV_{R3} *is smaller than* ΔV_{R2}

E. See answer to (D).

12. All of the current goes past A and C, but only half of the current goes through B. More than half goes through D (and less than half through E) because the resistance of the two-bulb parallel branch (on the right, near E) is greater than the resistance of the one-bulb branch (on the left, near D). So the ranking is:

A = C > D > B > E