Physics 112 Fall 2000: Answers to Exam #3

1. ***Answers: A*** Since there is no force when the current is flowing along the x axis, the magnetic force must be pointing along the x axis. When the current is flowing along the z axis, the force (which must be perpendicular to both the current and the field) must be pointing along the y axis.

2. ***Answer: C.*** There will be no flux when the magnetic field is parallel to the plane of the loop. (In that case, the angle between the magnetic field and the normal to the plane of the loop is 90° and so $\Phi = BA\cos\theta = 0$.) The maximum flux will be when the angle is 0°, i.e. when the field is perpendicular to the plane of the loop. Among those choices (A-D), the one with the most rapid variation in B is choice C, and that will give the largest value for the ratio of $\Delta B/\Delta t$.

3. ***Answer: B.*** A force is exerted on a current-carrying conductor, so there must be a magnetic field present. No force is exerted on the charged object, so there can be no electric field present and so there is no source charge producing the electric field. There must be a magnet present (either a permanent magnet, or an electromagnet) to produce the magnetic field.

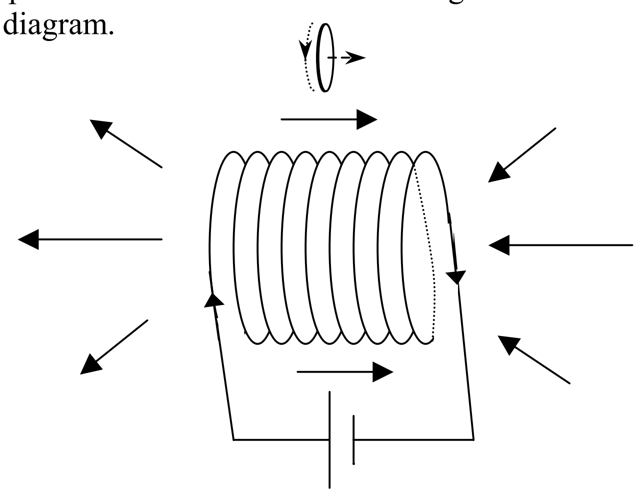
4. ***Answer: C.*** We know that all of the current flows through Resistor A, but only one third of the current flows through resistor C. This is because the current splits between resistors B and C, and $\Delta V_B = \Delta V_C$ (since they are in parallel with each other), and so we have:

$$\frac{I_B}{I_C} = \frac{\frac{\Delta V_B}{R_B}}{\frac{\Delta V_C}{R_C}} = \frac{\frac{\Delta V_B}{R_B}}{\frac{\Delta V_B}{R_C}} = \frac{R_C}{R_B} = 2$$

Since $I_B = 2\,I_C$ and $I_B + I_C = I_A$, we have that $I_C = (1/3)\,I_A$. Then we get:

$$\frac{\Delta V_C}{\Delta V_A} = \frac{I_C R_C}{I_A R_A} = \frac{\left(\frac{1}{3} I_A\right)(2R_A)}{I_A R_A} = \frac{2}{3}$$ and so finally we have that $\Delta V_C = (2/3)\,\Delta V_A$.

5. ***Answer: B.*** The magnetic field of the solenoid (indicated by the arrows) closely resembles the magnetic field of a bar magnet. There will be a torque on the current loop that will cause it to twist until the "north pole" of the current loop (indicated here by the arrow pointing perpendicular to the plane of the current loop) points in the direction of the magnetic field along the side of the solenoid, as indicated in the diagram.



6. ***Answer: C.*** A bar magnet and a current loop will be eventually orient themselves so that an arrow pointing *from* the south pole *to* the north pole of the magnet (or current loop) will point in the direction of the external magnetic field. In almost any other orientation, there will be a torque on the loop or magnet causing it to twist. (The orientation where the arrow points in exactly the opposite direction [of the external magnetic field] is unstable and unlikely to persist, although there is no torque on the loop or magnet in that orientation.)

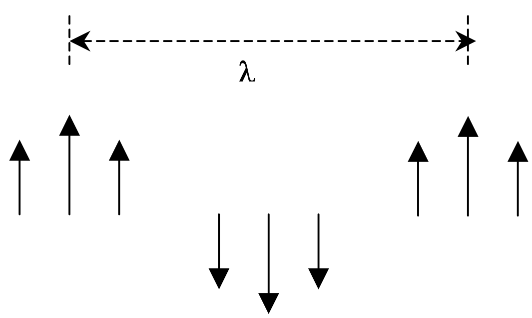
7. ***i) A:*** The reason the motor rotates is that a torque is exerted on a current loop (or a permanent magnet) by a magnetic field. ***ii) C:*** An electric generator causes a changing magnetic flux by continuously changing the orientation of a conducting loop located in the presence of a magnetic field (produced by permanent magnets or electromagnets). ***iii) A:*** The compass needle behaves just like a current loop (in fact it contains many microscopic current loops) and so will experience a torque in the earth's magnetic field which causes it to twist. ***iv) B:*** the nonuniform magnetic field of the magnet results in a net force being exerted on a current loop, or on another magnet (which behaves just as does a current loop).

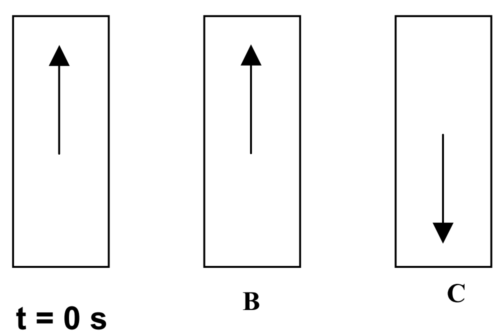
8.

A. $\lambda = \frac{c}{f} = \frac{3\times10^{8}\,m/s}{10^{3}\,s^{-1}} = 3\times10^{5}\,m$

B. One period (T) equal 0.001 s (because $T = 1/f$); after this amount of time passes, the wave pattern repeats itself. Since we started with an upward pointing maximum, after one period we will again have an upward pointing maximum.

C. The wave travels one wavelength in one period; therefore, it travels $1.5\times10^{5}\,m$ in one *half* of a period. During this time, the electric field direction will reverse itself, and so now will point with maximum magnitude in the *opposite* direction.



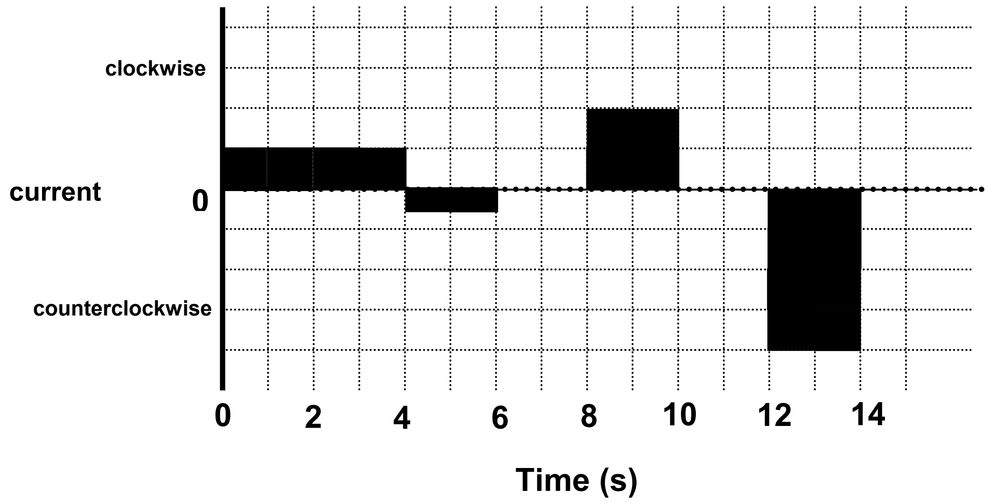


9.

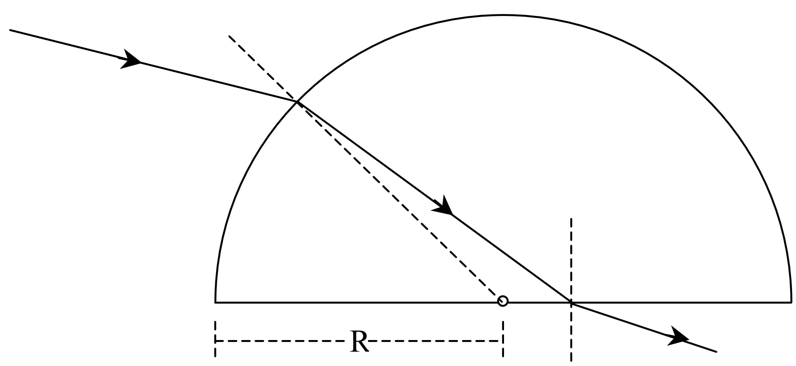
A and B: $F = qvB\sin\theta$, so we have that $B = \frac{F}{qv\sin\theta} = \frac{F}{qv} = \frac{30N}{(+3C)(2m/s)} = 5T$

We know that the force exerted on the charge is in the positive z direction, because that is the direction of the initial acceleration produced by this force. *Of the choices indicated*, only a magnetic field pointing in the *negative x* direction will result in a force in the positive z direction (according to the right-hand rule). Because of that, we know that θ = 90° since in this case the direction of the velocity (y direction) is perpendicular to the direction of the magnetic field (x direction).

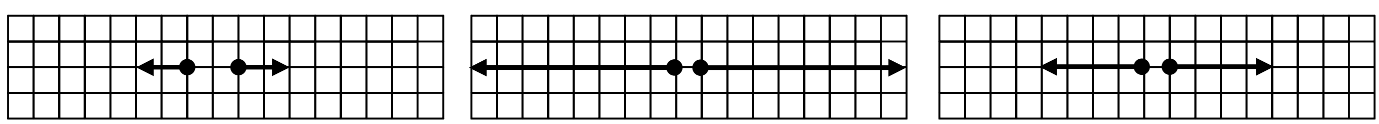
10.



11.



12.



Explanation: Since $\boldsymbol{F} = \frac{\boldsymbol{k q_1 q_2}}{\boldsymbol{r}^2}$, when the separation r is cut in half, the force will increase by a factor of four. Therefore the middle diagram has force vector arrows that are eight squares long, instead of two (as in the left diagram). When one of the charges is cut in half – e.g., charge q_1 is cut to 0.5 q_1 – the force is also cut in half. Therefore the arrows in the right-hand diagram are only four squares long.