Physics 214 Test 2A

Section 1: Dr. Gladden, April 2, 2009

NAME: KEY   UM ID#: ____________________

Conceptual Multiple Choice (*2 points each*): Clearly write the letter corresponding to the BEST possible answer in the space provided. You may also circle the answer to be sure.

1. A All electromagnetic waves travel through a vacuum at
   A) the same speed.
   B) speeds that are proportional to their frequency.
   C) speeds that are inversely proportional to their frequency.
   D) none of the given answers

2. D The E and B fields in electromagnetic waves are oriented
   A) parallel to the wave's direction of travel, as well as to each other.
   B) parallel to the waves direction of travel, and perpendicular to each other.
   C) perpendicular to the wave's direction of travel, and parallel to each other.
   D) perpendicular to the wave's direction of travel, and also to each other.

3. C Of the following, which is not electromagnetic in nature?
   A) microwaves
   B) gamma rays
   C) sound waves
   D) radio waves

4. C The energy an electromagnetic wave transports per unit time per unit area is the
   A) energy density.
   B) power.
   C) intensity.
   D) radiation pressure.

5. B Electromagnetic waves are
   A) longitudinal.
   B) transverse.
   C) both longitudinal and transverse.
   D) neither longitudinal or transverse.

6. B If a bar magnet is divided into two equal pieces,
   A) the north and south poles are separated.
   B) two magnets result.
   C) the magnet properties are destroyed.
   D) an electric field is created.

7. C Which of the following is correct?
A) When a current carrying wire is in your right hand, thumb in the direction of the magnetic field lines, your fingers point in the direction of the current.
B) When a current carrying wire is in your left hand, thumb in the direction of the magnetic field lines, your fingers point in the direction of the current.
C) When a current carrying wire is in your right hand, thumb in the direction of the current, your fingers point in the direction of the magnetic field lines.
D) When a current carrying wire is in your left hand, thumb in the direction of the current, your fingers point in the direction of the magnetic field lines.

8. C A vertical wire carries a current straight down. To the east of this wire, the magnetic field points
A) north.
B) east.
C) south.
D) down.

9. D A current carrying loop of wire lies flat on a table top. When viewed from above, the current moves around the loop in a counterclockwise sense. What is the direction of the magnetic field caused by this current, outside the loop? The magnetic field
A) circles the loop in a clockwise direction.
B) circles the loop in a counterclockwise direction.
C) points straight up.
D) points straight down.

10. A The force on a current-carrying wire in a magnetic field is equal to zero when
A) the current is parallel to the field lines.
B) the current is at a 30 angle with respect to the field lines.
C) the current is at a 60 angle with respect to the field lines.
D) the current is perpendicular to the field lines.

11. D A vertical wire carries a current straight up in a region where the magnetic field vector points due north. What is the direction of the resulting force on this current?
A) down
B) north
C) east
D) west

12. D A charged particle moves and experiences no magnetic force. From this we can conclude that
A) no magnetic field exists in that region of space.
B) the particle is moving parallel to the magnetic field.
C) the particle is moving at right angles to the magnetic field.
D) either no magnetic field exists or the particle is moving parallel to the field.

13. C At double the distance from a long current-carrying wire, the strength of the magnetic field produced by that wire decreases to

A) 1/8 of its original value.
B) 1/4 of its original value.
C) 1/2 of its original value.
D) none of the given answers

14. C Faraday's law of induction states that the emf induced in a loop of wire is proportional to
A) the magnetic flux.
B) the magnetic flux density times the loop's area.
C) the time variation of the magnetic flux.
D) current divided by time.

15. A Doubling the diameter of a loop of wire produces what kind of change on the induced emf, assuming all other factors remain constant?
A) The induced emf is 4 times as much.
B) The induced emf is twice times as much.
C) The induced emf is half as much.
D) There is no change in the induced emf.

16. A A circular coil lies flat on a horizontal table. A bar magnet is held above its center with its north pole pointing down. The stationary magnet induces (when viewed from above)
A) no current in the coil.
B) a clockwise current in the coil.
C) a counterclockwise current in the coil.
D) a current whose direction cannot be determined from the information given.

17. C A circular coil lies flat on a horizontal table. A bar magnet is held above its center with its north pole pointing down, and released. As it approaches the coil, the falling magnet induces (when viewed from above)
A) no current in the coil.
B) a clockwise current in the coil.
C) a counterclockwise current in the coil.
D) a current whose direction cannot be determined from the information provided.

18. B An electric generator transforms
A) electrical energy into mechanical energy.
B) mechanical energy into electrical energy.
C) direct current into alternating current.
D) alternating current into direct current.

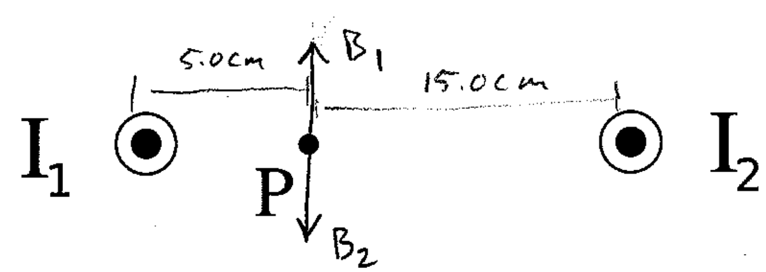
19. A In a transformer, if the secondary coil contains more loops than the primary coil then it is a
A) step-up transformer.
B) step-down transformer.

20. B An electric generator transforms

A) electrical energy into mechanical energy.
B) mechanical energy into electrical energy.
C) direct current into alternating current.
D) alternating current into direct current.

Problems: Work each of the following problems. Make sure to **show your work** and put a box around your final answer. **Be careful about units!!**

1. (*15 points*) The figure shows two parallel wires carrying currents $I_1 = 3.5$ A and $I_2 = 4.0$ A, both out of the page, separated by a distance of 20.0 cm.



(a) (3 points) Sketch the direction of the magnetic fields from wires 1 and 2 at point P. (You should draw 2 vectors here.)

(b) (7 points) Determine the net B field at a point (P) 5.0 cm right of wire 1.

$$B_1 = \frac{\mu_0}{2\pi}\frac{I_1}{r_1} = 2\times10^{-7}\left[\frac{3.5\text{ A}}{0.05\text{ m}}\right] = +1.4\times10^{-5}\text{ T} \quad (\text{up})$$

$$B_2 = \frac{\mu_0}{2\pi}\frac{I_2}{r_2} = 2\times10^{-7}\left[\frac{4.0\text{ A}}{0.15\text{ m}}\right] = -5.3\times10^{-6}\text{ T} \quad (\text{down})$$

$$\vec{B}_{net} = \vec{B}_1 + \vec{B}_2 = \boxed{+8.67\times10^{-6}\text{ T up}}$$

(c) (5 points) Determine the magnitude and direction of the force per unit length exerted on wire 2 from wire 1.

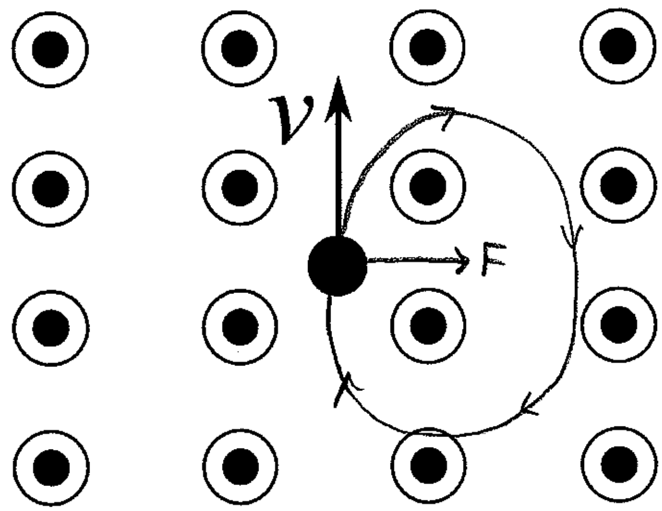
$$\frac{F_2}{\ell} = I_2 B_1 \cancel{\sin\theta}^{1} = I_2\frac{\mu_0}{2\pi}\frac{I_1}{r} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

$$= 2\times10^{-7}\left[\frac{(3.5\text{ A})(4.0\text{ A})}{0.20\text{ m}}\right]$$

$$\boxed{= 1.4\times10^{-5}\ \frac{\text{N}}{\text{m}}}$$

direction is to the left - toward I_1

2. (*15 points*) A charge of + 0.2 C and mass 0.025 kg is moving as shown in a magnetic field of 2.5 T directed out of the page. $|v| = 3.5\ m/s$



(a) (3 points) In the figure, sketch the trajectory of the charge.

(b) (7 points) What is the magnetic force exerted on the charge (magnitude AND direction!)?

$$F = qvB \cancel{\sin\theta}^{\,1}$$

$$= 0.2\,C\left(3.5\tfrac{m}{s}\right)(2.5\,T) = \boxed{1.75\,N \text{ to the right by RHR}}$$

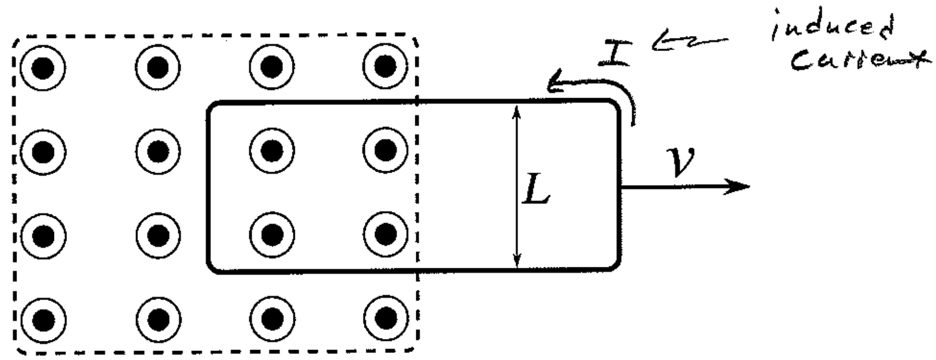
(c) (5 points) What would the radius of the trajectory be?

Set $F_B = F_c$

$$qvB = \frac{mv^2}{r}$$

so $r = \dfrac{mv}{qB} = \dfrac{0.025\,kg\,(3.5\,m/s)}{0.2\,C\,(2.5\,T)} = 0.175\,m = \boxed{17.5\,cm}$

3. (*15 points*) The figure shows a rectangular loop of wire with one dimension: $L = 5.0$ cm. It is moving out of a region of uniform magnetic field (B=1.5 T out of the paper) with a velocity of 8.5 m/s to the right.



(a) (10 points) What is the induced EMF and what direction will it drive current around the loop?

$$|\mathcal{E}| = \frac{\Delta \Phi_B}{\Delta t} = B\frac{\Delta A}{\Delta t} = B v L = 1.5\,T(8.5\,\tfrac{m}{s})(0.05\,m)$$

$$= \boxed{0.638\ V}$$

It will drive the current Counter Clockwise

(b) (5 points) If the electrical resistance of the loop is 0.035 Ω, what will the induced current be?

Ohm's Law:

$$I = \frac{|\mathcal{E}|}{R} = \frac{0.638}{0.035\,\Omega} = \boxed{18.2\ A}$$

4. (*15 points*) A laser pulse that lasts 12.0 ns (that is 12.0×10^{-9} s) and delivers 255 kW of power to a spot size of 0.15 cm on a target.

(a) (8 points) What is the total energy delivered per pulse?

$$U = P\cdot t = 255\times10^{3}\,\frac{J}{s}\left(12.0\times10^{-9}\,s\right) = 0.0031\,J$$

$$\boxed{= 3.1\ mJ\ \text{per pulse}}$$

(b) (7 points) If the wavelength of the laser is 632 nm, what is the frequency of the EM wave?

$$f = \frac{c}{\lambda} = \frac{3\times10^{8}\,\frac{m}{s}}{632\times10^{-9}\,m} = 4.75\times10^{14}\ Hz$$

$$=$$

Extra Credit(+5 points)
In problem 3, what will the magnitude and direction of the force exerted on the moving loop by the magnetic field?

$F = I \ell B \cancel{\sin\theta}^{\,1}$

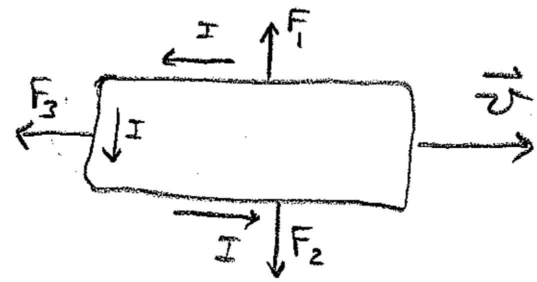
so $|F_1| = |F_2|$

The net force is

$F_3 = I L B \cancel{\sin\theta}^{\,1}$

$= 18.2\,A(0.05\,m)(1.5\,T)$

$= 1.365\,N$



The force opposes the motion which is inducing the Current

Constants:
$k = 1/(4\pi\varepsilon_0) = 9 \times 10^9$ Nm^2/C^2
$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(Nm^2)
Charge of an electron / proton: $e = \pm 1.60 \times 10^{-19}$ C
$\mu_0 = 4\pi \times 10^{-7}$ T m/A
$c = 3.0 \times 10^8$ m/s