Name ______________________________

Mar. 27, 2008

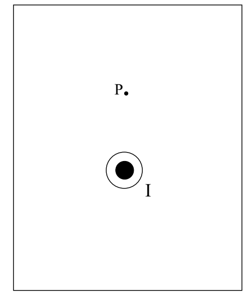
Phys 2020, NSCC
Exam #2 — Spring 2008

1.	________________	(13)
2.	________________	(12)
3.	________________	(9)
4.	________________	(7)
5.	________________	(10)
6.	________________	(8)
7.	________________	(9)
8.	________________	(9)
9.	________________	(6)
10.	________________	(7)
MC	________________	(10)
Total	________________	(100)

Multiple Choice

Choose the best answer from among the four! (2) each.

1. At the right, I indicates a very long wire carrying a current I that comes out of the page. The magnetic field at point P points



a) Left.

b) Right.

c) Down.

d) Up.

2. The strength of the earth's magnetic field is typically

a) 10^{-15} T

b) 10^{-5} T

c) 10 T

d) 10^4 T

3. In typical applications, an inductor (L) in an electric circuit prevents the current from

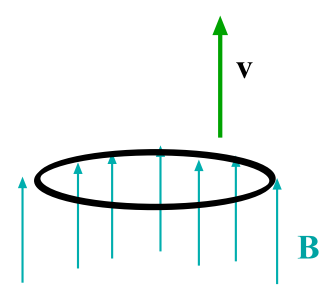
a) Changing too slowly.

b) Changing too rapidly.

c) Becoming too large.

d) Flowing in the "backward" direction.

4. A circular loop moves in a uniform magnetic field which is perpendicular to the plane of the loop. The velocity of the loop is *parallel* to the magnetic field. As seen from above, the induced current in the loop



a) Goes clockwise

b) Goes counterclockwise

c) There is no induced current in the loop.

5. The intensity of an electromagnetic wave is measured in

a) $\frac{\mathrm{J}}{\mathrm{s}}$

b) $\frac{\mathrm{N}}{\mathrm{m}^2}$

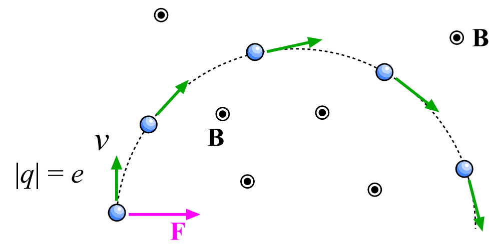
c) $\frac{\mathrm{N \cdot m}}{\mathrm{s}}$

d) $\frac{\mathrm{W}}{\mathrm{m}^2}$

Problems

Show your work and include the correct units with your answers!

1. A particle whose charge has *absolute value* e moves in a uniform magnetic field of magnitude 0.400 T. (As shown, $\mathbf{B}$ comes out of the page.) Its speed is $2.7 \times 10^5 \frac{\mathrm{m}}{\mathrm{s}}$ and since the velocity is perpendicular to the field, it moves in a circular path of radius 9.00 cm. (8)



a) Is the charge positive or negative? (That is, is it $+e$ or $-e$?) You must *explain how you know*. (5)

If the charge is positive then the right hand rule (applied at the first position) gives a force in the direction shown on the diagram. That is the direction that the force *has* to go because the force has to point inward to the center of the circle. So the charge is positive.

b) What is the mass of the particle? (8)

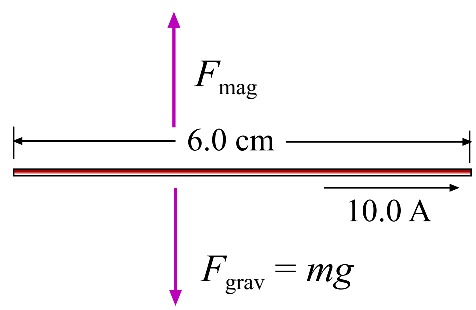
Use

$$r = \frac{mv}{qB} \qquad \Longrightarrow \qquad m = \frac{rqB}{v}$$

Plug in numbers:

$$m = \frac{(0.090\ \mathrm{m})(1.60 \times 10^{-19}\ \mathrm{C})(0.40\ \mathrm{T})}{(2.7 \times 10^5 \frac{\mathrm{m}}{\mathrm{s}})} = 2.1 \times 10^{-26}\ \mathrm{kg}$$

2. A section of wire of length 6.0 cm and mass 30.0 g is *levitated* by a magnetic field, that is, the magnetic force cancels the gravity force. This is shown at the right, where the gravity force mg goes down and the magnetic force on the wire points upward.



a) The magnetic field is perpendicular to the page. Does it go into the page or out of the page? *Explain* (3)

The magnetic field must go $\boxed{\text{into}}$ the page. Then the right-hand rule (thumb=current, fingers=field, palm=force) gives a force upward.

b) What is magnitude of the magnetic field? (9)

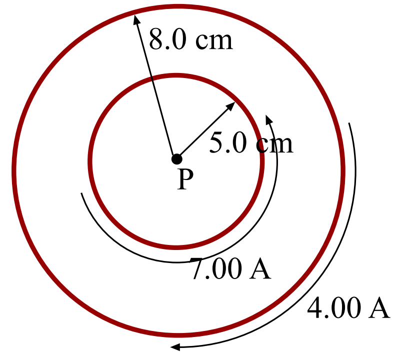
The magnetic force on the wire is $F_{\mathrm{mag}} = ILB$. The force of gravity if mg. To balance, we need

$$ILB = mg \qquad \Longrightarrow \qquad B = \frac{mg}{IL}$$

Plug in numbers:

$$B = \frac{(0.030)(9.80)}{(10.0)(0.060)} = 0.49\ \mathrm{T}$$

3. Two concentric circular loops lie in a plane. They have radii of 5.0 cm and 8.0 cm and carry currents *in opposite directions* of 7.0 A and 4.0 A, respectively. See the figure at the right



Find the direction and magnitude of the (total) magnetic field at the center of the loops. (Hint: Add the contributions of the individual loops!) (9)

The inner loop gives a contribution that goes out of the page and has magnitude

$$B_1 = \frac{\mu_0 I}{2R} = \frac{(4\pi \times 10^{-7})(7.0)}{2(0.050)} = 8.80 \times 10^{-5}\ \mathrm{T}$$

The outer loop gives a contribution that goes into the page and has magnitude

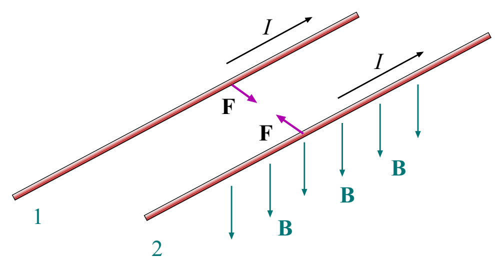
$$B_1 = \frac{\mu_0 I}{2R} = \frac{(4\pi \times 10^{-7})(4.0)}{2(0.080)} = 3.14 \times 10^{-5}\ \mathrm{T}$$

Adding these together (vectorially) the total magnetic field comes out of the page and has magnitude

$$B_{\mathrm{tot}} = 8.80 \times 10^{-5}\ \mathrm{T} - 3.14 \times 10^{-5}\ \mathrm{T} = 5.66 \times 10^{-5}\ \mathrm{T}$$

4. Two parallel long wires which carry current in the same direction will attract one another.

Explain why. Your explanation should include the magnetic field produced by one wire and how this gives a force on the *other* wire. And you will need to draw some kind of diagram or show some vectors on the picture at the right. (7)



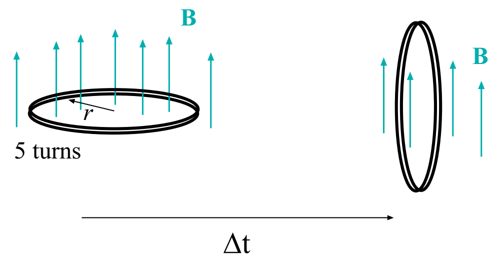
Labelling the wires 1 and 2 (see the figure, with additions in blue), using the right-hand rule wire 1 give a magnetic field at wire 2 in the direction shown. Now use the right-hand rule for the magnetic force on a wire so that with current=thumb, fingers=field the palm gives the direction of the force on wire 1 which *is* toward wire 1, as advertised.

So the wires will attract.

5. A conducting circular coil of radius 2.0 cm and 5 turns is initially in a uniform magnetic field of magnitude 0.12 T and direction parallel to the axis of the loop.

The loop rapidly flips by 90° in a time Δt so that its axis is perpendicular to the field. In that time the average emf in the coil is 0.30 V.

Find the time Δt in which the coil flipped. (10)



The area of the coil is

$$A = \pi r^2 = \pi (0.020 \text{ m})^2 = 1.26 \times 10^{-3} \text{ m}^2$$

In the initial position there is a flux $\Phi = BA$ through the loop and in the final position there is no flux since the normal to the loop is perpendicular to the field. The change in flux is

$$|\Delta\Phi| = BA = (0.12 \text{ T})(1.26 \times 10^{-3} \text{ m}^2) = 1.51 \times 10^{-4} \text{ Wb}$$

Use (just worry about absolute values)

$$\mathcal{E} = N\frac{\Delta\Phi}{\Delta t} \qquad \Longrightarrow \qquad \Delta t = N\frac{\Delta\Phi}{\mathcal{E}}$$

Plug in numbers:

$$\Delta t = 5\frac{(1.51 \times 10^{-4} \text{ Wb})}{(0.30 \text{ V})} = 2.5 \times 10^{-3} \text{ s}$$

6. What is the (average) potential difference across a 10 mH inductor if the current through the inductor drops from 150 mA to 50 mA in 10 μs? (8)

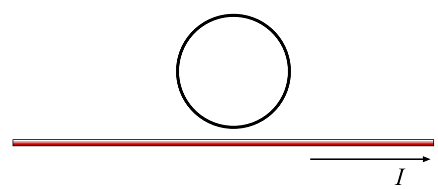
Use

$$\mathcal{E} = -L\frac{\Delta I}{\Delta t}$$

Plug in numbers (just worry about the magnitude):

$$\mathcal{E} = (10 \times 10^{-3} \text{ H})\frac{(150 \times 10^{-3} \text{ A} - 50 \times 10^{-3} \text{ A})}{(10 \times 10^{-3} \text{ s})} = 100 \text{ V}$$

7. A long straight wire is in the same plane as a circular conducting loop (as shown here). The current in the wire goes to the right but it is *decreasing*. As a result, there will be an induced current in the loop; we want to find its direction using Lenz's law.



a) How is the magnetic flux through the loop changing? (Increasing, decreasing, and in what direction?) (4)

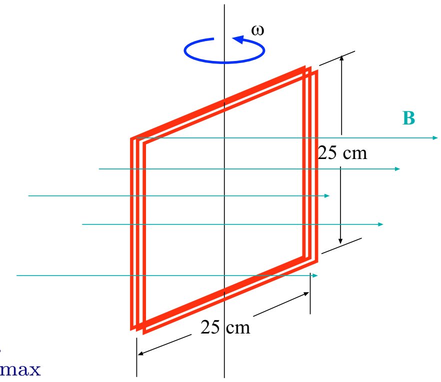
The wire gives a magnetic field *out of the page* (for the loop's interior, that is). So the flux is *out of the page* and *decreasing*.

b) In order to oppose this change, what is the direction of the current induced the loop? (You need to *explain your choice*.) (5)

To oppose the change given in (a) we need to generate a flux *out of the page*. Using various right-hand rules, we see that this will happen if the current in the loop goes counter-clockclockwise.

8. An electric generator is formed from a 25 cm × 25 cm rectangular loop with 50 turns rotating in a uniform magnetic field of magnitude 0.20 T. It delivers an alternating voltage of which the peak value is 0.35 V.

What is the rate of revolution of the loop? Express the final result in revolutions per minute. (9)



Use the formula for the peak voltage produced by a simple coil generator,

$$\mathcal{E}_{\max} = NAB\omega \qquad \Longrightarrow \qquad \omega = \frac{\mathcal{E}_{\max}}{NAB}$$

With

$$A = (0.25\ \mathrm{m})(0.25\ \mathrm{m}) = 6.25 \times 10^{-2}\ \mathrm{m}^2$$

then

$$\omega = \frac{(0.35\ \mathrm{V})}{(50)(6.25 \times 10^{-2}\ \mathrm{m}^2)(0.20\ \mathrm{T})} = 0.56 \tfrac{\mathrm{rad}}{\mathrm{s}}$$

To get the *frequency* from this, use $f = \omega/(2\pi)$, so

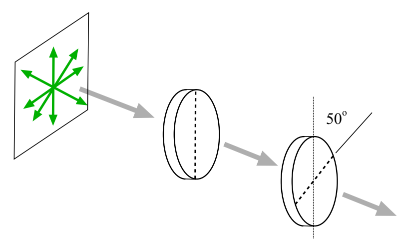
$$f = 0.56 \tfrac{\mathrm{rad}}{\mathrm{s}} \frac{1}{2\pi} \left(\frac{60\ \mathrm{s}}{1\ \mathrm{min}}\right) = 5.3 \tfrac{\mathrm{rev}}{\mathrm{min}}$$

9. What is the frequency of electromagnetic radiation which has a wavelength of 21 cm? (6)

Use $\lambda f = c$. Then

$$f = \frac{c}{\lambda} = \frac{(3.00 \times 10^8 \tfrac{\mathrm{m}}{\mathrm{s}})}{(21 \times 10^{-2}\ \mathrm{m})} = 1.43 \times 10^9\ \mathrm{Hz}$$

10. Unpolarized light is incident on two polarizing sheets. The axis of the first polarizer is vertical and the axis of the second is 50° from the vertical.



a) When light emerges from the second polarizer, what fraction of the original intensity is transmitted? (5)

The first polarizer permits light with half the intensity to pass and *that* light is polarized vertically. The second polarizer reduces it by a further factor of $\cos^2 50°$ so the initial intensity is reduced by an overall factor of

$$\tfrac{1}{2}\cos^2 50° = 0.207\ ,$$

the fraction of the original intensity which passes thru both.

b) Describe the polarization of the light that emerges from the second polarizer. (2)

The light which emerges from the second polarizer is polarized at $\boxed{50° \text{ from the vertical}}$ and has an intensity which is 0.207 times that of the incident light.

You must show all your work and include the right units with your answers!

$e = 1.602\times10^{-19}$ C $\quad k = 8.99\times10^{9}\,\frac{\mathrm{N\cdot m^2}}{\mathrm{C^2}} \quad \epsilon_0 = 8.854\times10^{-12}\,\frac{\mathrm{C^2}}{\mathrm{N\cdot m^2}} \quad c = 2.998\times10^{8}\,\frac{\mathrm{m}}{\mathrm{s}} \quad \omega = 2\pi f$

$$V = IR \qquad P = IV = I^2R \qquad R_{\text{ser}} = R_1 + R_2 \ldots \qquad \frac{1}{R_{\text{par}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$

$$\mu_0 = 4\pi \times 10^{-7}\,\frac{\mathrm{N}}{\mathrm{A^2}} \qquad F = qvB\sin\theta \qquad F = LIB\sin\theta \qquad r = \frac{mv}{qB} \qquad m = \left(\frac{qr^2}{2V}\right)B^2$$

$$B_{\text{wire}} = \frac{\mu I}{2\pi r} \qquad B_{\text{loop}} = \frac{\mu_0 I}{2R} \qquad B_{\text{coil}} = N\frac{\mu_0 I}{2R} \qquad B_{\text{sol}} = \mu_0 nI = \mu_0 I\frac{N}{L} \qquad \Phi = BA\cos\phi$$

$$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t} \qquad \mathcal{E} = -L\frac{\Delta I}{\Delta t} \qquad L_{\text{sol}} = \mu_0 n^2\pi r^2 l \qquad \mathcal{E}_{\max} = NAB\omega \qquad \lambda f = c \quad c = \frac{1}{\sqrt{\epsilon_0\mu_0}}$$

$$S = \frac{c\epsilon_0}{2}E_0^2 \quad B_0 = \frac{1}{c}E_0 \quad \text{Malus:} \quad S = S_0\cos^2\theta \qquad \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \quad f = \frac{R}{2} \quad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$