Name________________________

Oct. 29, 2002

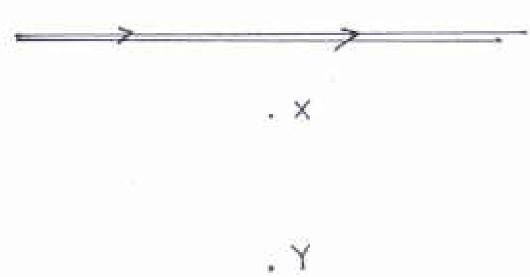
Phys 2020 — Fall 2002

Exam #2

1.	________________	(9)
2.	________________	(12)
3.	________________	(10)
4.	________________	(10)
5.	________________	(5)
6.	________________	(8)
7.	________________	(3)
8.	________________	(10)
9.	________________	(13)
MC	________________	(20)
Total	________________	(100)

Multiple Choice Chose the best answer from the four.

1. Point X is at a distance R from a long straight current–carrying wire. The magnetic field at X has magnitude B. Point Y is at a distance $3R$ from the wire. The magnetic field at Y has magnitude



a) B
b) $B/3$
c) $B/\sqrt{3}$
d) $B/9$

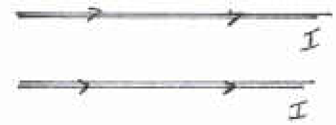
2. When two wires are parallel and carry identical currents in the *same* direction,

a) There is a force of attraction between them.

b) There is a force of repulsion between them.

c) There is a mutual force which is directed parallel to the wires.

d) There is no force between the wires.



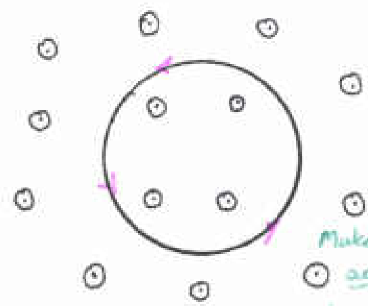
3. A circular loop of wire in the plane of the page is perpendicular to a uniform magnetic field **B** directed out of the page, as shown. If the magnitude of the magnetic field is decreasing, then the induced current in the wire is

a) Clockwise around the loop.

b) Counterclockwise around the loop.

c) Directed upward out of the paper.

d) Zero. (No current induced.)



Make flux out of page to oppose change!

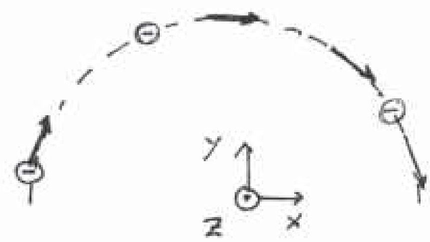
4. Shown here is the circular path of a *negatively* charged particle moving in a uniform magnetic field, in the indicated direction. The direction of the magnetic field must be:

a) In the $-z$ direction.

b) In the $+z$ direction.

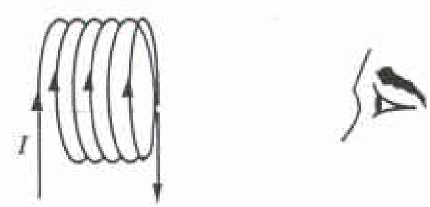
c) In the $+y$ direction.

d) In the $+x$ direction.



5. A long wire that carries a current I is bent into five concentric loops as shown at the right.

If the observer could "see" the magnetic field inside this arrangement of loops, how would it appear?

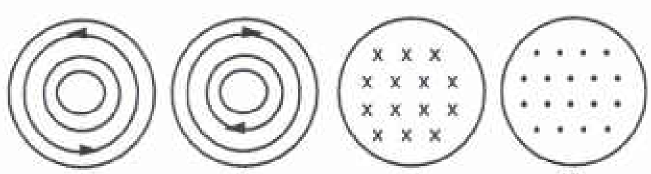


a)

b)

c)

d)



(a) (b) (c) (d)

(self) !

6. The quantity known as *inductance* is measure of the relation between

a) The flux in a circuit element and the current in that element.

b) The rate of change of flux in a circuit element and the rate of change of the current in that element.

c) The induced emf in a circuit element and the rate of change of the current in that element.

d) The rate of change of the induced emf in a circuit element and the current in that element.

7. What are the units of self-inductance, L?

a) Farads

b) Henrys

c) Webers

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

8. Wires A and B are very long and straight, and each carries a current of 1.0 A, out of the page. At a point P midway between them, the magnetic field.

a) Is non-zero and points up.

b) Is non-zero and points down.

c) Is non-zero and points toward wire A.

d) Is zero.

9. Which of the following is a possible wavelength for radio waves?

a) 1.6 m

b) 1.6×10^{-6} m

c) 1.6×10^{-9} m

d) 1.6×10^{-15} m

10. In general, the index of refraction n for a transparent material satisfies

a) $n < -1$

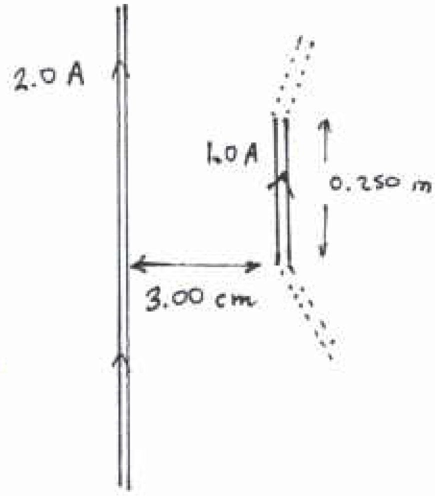
b) $-1 < n < 0$

c) $0 < n < 1$

d) $1 < n$

Problems

1. A long wire carries 2.0 A of current in the direction shown. A 0.250 m–long segment of wire is parallel to the long wire at a distance of 3.00 cm and carries 1.0 A in the direction shown.



a) What is the direction of the magnetic force on the short length of wire? *Be sure to explain your reasoning, using the right–hand rules.* (4)

By RHR-2, magnetic field from long wire goes into page at the wire segment. Then by RHR-1, force on the wire segment is to the left, i.e. it is attracted to the long wire.

b) What is the magnitude of the force on the short section of wire? *[Hint: What is the* **B** *field from the long wire at a distance of* 3.00 cm*?]* (5)

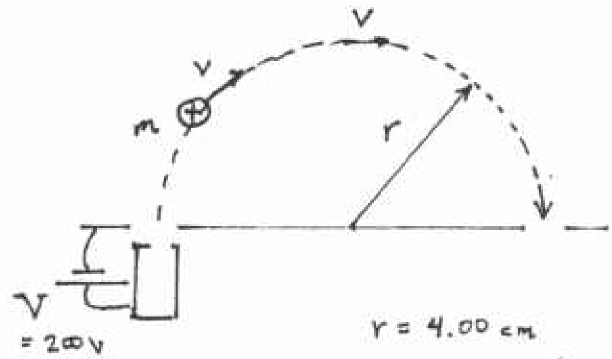
Magnitude of the $\vec{B}$ field from long wire at distance of 3.00 cm is

$$B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7})(2.0\text{ A})}{2\pi\,(3.00\times10^{-2}\text{ m})}\text{ T} = \boxed{1.33\times10^{-5}\text{ T}}$$

Then the force which is exerted on the wire segment has magnitude

$$F = ILB\cdot\sin 90° = (1.0\text{ A})(0.250\text{ m})(1.33\times10^{-5}\text{ T})$$
$$= \boxed{3.33\times10^{-6}\text{ N}}$$

2. A singly–charged ($+e$) positive ion has a mass of 3.14×10^{-26} kg. After being accelerated (from rest) through a potential difference of 200 V, the ion enters a uniform magnetic field, in a direction perpendicular to the field.



$r = 4.00$ cm
$m = 3.14 \times 10^{-26}$ kg

a) What is the kinetic energy of the ion after it is accelerated through the potential? Give the answer in eV and in joules. (3)

The lost of EPE by the ion is

$\Delta EPE = q\Delta V = (+e)(200\,V) = 200\,eV$

This is the same as the gain in KE! So KE of ion is

$$KE = 200\,eV = (200\,eV)\frac{(1.602\times10^{-19}\,J)}{(1\,eV)} = \boxed{3.20\times10^{-17}\,J}$$

b) What is the speed of the ion as it enters the magnetic field? (4)

Since $\frac{1}{2}mv^2 = 3.20\times10^{-17}\,J$, then

$$v^2 = \frac{2(3.20\times10^{-17}\,J)}{m} = \frac{2(3.20\times10^{-17}\,J)}{(3.14\times10^{-26}\,kg)} = 2.04\times10^{9}\,\frac{m^2}{s^2}$$

$$v = \boxed{4.52\times10^{4}\,\frac{m}{s}}$$

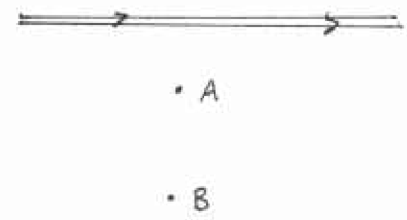
c) If the radius of the ion's circular path is 4.00 cm, what is the magnitude of the magnetic field? (5)

Use relation between m, v, q, r, B for ion on circular orbit in $\vec{B}$ field:

$r = \frac{mv}{qB}$. Then:

$$B = \frac{mv}{qr} = \frac{(3.14\times10^{-26}\,kg)(4.52\times10^{4}\,\frac{m}{s})}{(1.602\times10^{-19}\,C)(4.00\times10^{-2}\,m)} = \boxed{0.221\,T}$$

3. A long wire carries current to the right (in the plane of the page), as shown.



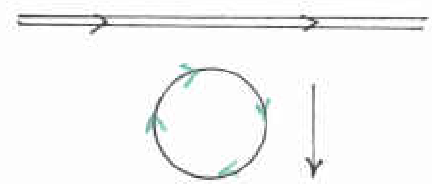
a) What is the direction of the magnetic field at point A? (1)

By RHR-2, $\boxed{\text{into the page}}$

b) What is the direction of the magnetic field at point B? How does its magnitude compare with its magnitude at point A? (3)

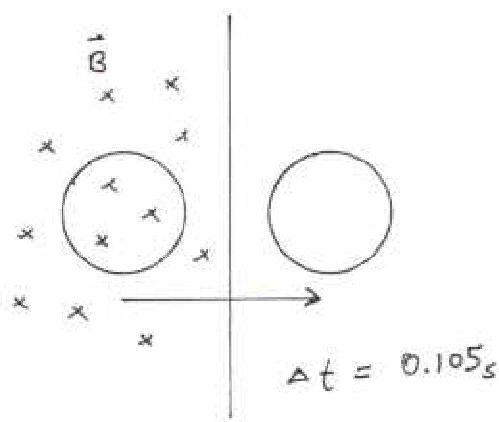
Also $\boxed{\text{into the page.}}$ Magnitude is $\boxed{\text{smaller than mag. of field at A}}$ (by about $\times \frac{1}{3}$).

c) A conducting ring moves away from the wire in the plane of the page, as shown. There is a current induced in the ring. Give the direction of the current induced in the ring and include the *reasoning* that led to this conclusion. (6)



As ring moves away, flux is into the page and decreasing. To oppose this change, need more flux into page. We get this if current goes as shown $\boxed{\text{(clockwise)}}$

4. A circular coil of wire 4.2 cm in diameter has a resistance of 5.13 Ω. It is located in a magnetic field of 0.14 T directed at right angles to the plane of the coil. The coil is removed from the field in 0.105 s.



a) What is the (average) induced emf in the coil? (6)

Initial flux is

$$\Phi = BA = (0.14\,T)\pi(2.1\times10^{-2}\,m)^2 = 1.99\times10^{-4}\,T\cdot m^2$$

and final flux is zero. So avg $\mathcal{E}$ induced is

$$\mathcal{E} = \left|\frac{\Delta\Phi}{\Delta t}\right| = \frac{1.99\times10^{-4}\,T\cdot m^2}{0.105\,s} = \boxed{1.85\times10^{-3}\,V}$$

b) How much electric energy is lost in the process? (4)

Avg power dissipated in coil is

$$P = \frac{V^2}{R} = \frac{\mathcal{E}^2}{R} = \frac{(1.85\times10^{-3}\,V)^2}{(5.13\,\Omega)} = 6.67\times10^{-7}\,W$$

Energy lost is

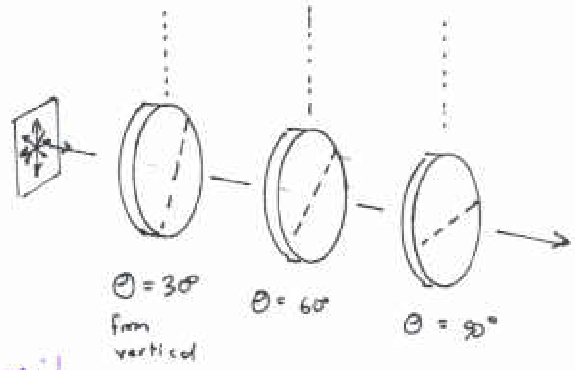
$$\text{Energy} = P\Delta t = (6.67\times10^{-7}\,W)(0.105\,s) = \boxed{7.0\times10^{-8}\,J}$$

5. Find the wavelength of EM waves which have a frequency of 6040 kHz. (5)

Using $\lambda f = c$,

$$\lambda = \frac{c}{f} = \frac{2.998\times10^{8}\,\frac{m}{s}}{(6040\times10^{3}\,s^{-1})} = \boxed{49.6\ m}$$

Unpolarized !



6. Light of intensity $5.0\,\frac{W}{m^2}$ is incident on a polarizer which has its axis at 30° from the vertical and then in turn passes through two analyzers with their axes at 60° and 90° from the vertical, respectively.

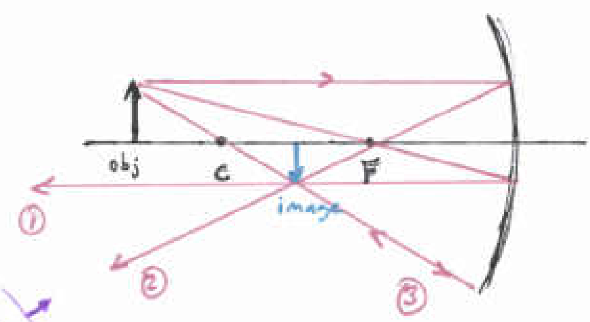
What is the intensity of the light which has passed through all three polaroids? (8)

After passing thru first polaroid, intensity reduced by ½ and light is polarized at 30° from the vertical. Next polaroid reduces intensity by $\cos^2(60-30) = 0.750$ and now light is polarized at 60° from vertical. Next polaroid reduces intensity by $\cos^2(90°-60°) = 0.750$, and emerging light polarized at 90 from vertical. Final intensity is

$$\bar{S} = (5.0\,\tfrac{W}{m^2})\cdot\tfrac{1}{2}\cdot(0.750)\cdot(0.750) = \boxed{1.4\ \tfrac{W}{m^2}}$$

7. Identify (name) a common device which uses a polaroid. (3)

Polaroid sunglasses   Calculator display (LCD)
Digital watch display (LCD)



8. Shown here is a concave mirror along with its center of curvature and focal point. An object is also shown.

a) Complete a ray diagram which gives the location and orientation of the image. (6)

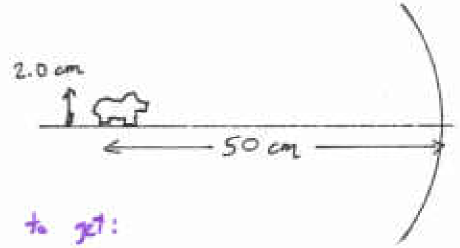
Draw rays going:
① Focal point → parallel
② Parallel → focal point
③ Thru center of curvature

Rays intersect & give image at indicated location

b) Is the image upright or inverted? Is it real or virtual? (4)

Image is $\boxed{\text{inverted.}}$ It is $\boxed{\text{real}}$ (since rays meet & diverge at real point)

9. A small plastic pig of height 2.0 cm is placed 50.0 cm in front of a concave mirror with a focal length of 20.0 cm.



a) What is the location of the image? (Also Specify whether it is in front of the mirror or behind.) (6)

With $d_o = 50$ cm and $f = 20$ cm, use $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ to get:

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{20\text{ cm}} - \frac{1}{50\text{ cm}} = 3.0 \times 10^{-2}\text{ cm}^{-1} \qquad \boxed{d_i = 33.3\text{ cm}}$$

The positive answer means 33.3 cm $\boxed{\text{in front}}$ of the mirror.

b) Find the magnification and give the height of the image; be sure to tell whether it is upright or inverted. (5)

Magnification is $m = -d_i/d_o$, so:

$$m = -\frac{(33.3\text{ cm})}{(50.0\text{ cm})} = -0.667$$

Then from $m = h_i/h_o$,

$$h_i = h_o m = (2.0\text{ cm})(-0.667) = \boxed{-1.33\text{ cm}}$$

Minus sign indicated image is inverted, w/ size 1.33 cm

c) Is the image real or virtual? (2)

$\boxed{\text{Real}}$ (since in front of Mirror)