Name ____________________

Mar. 30, 2006

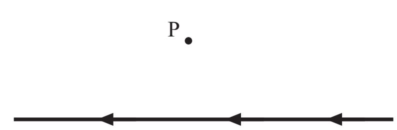
Phys 2020, NSCC
Exam #2 — Spring 2006

1.	______	(15)
2.	______	(11)
3.	______	(8)
4.	______	(11)
5.	______	(8)
6.	______	(6)
7.	______	(14)
8.	______	(17)
MC	______	(10)
Total	______	(100)

Multiple Choice

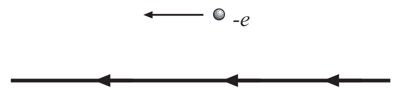
Choose the best answer from among the four!

1. If current flows in the wire as shown, then the direction of the magnetic field at P is



- **a)** Up
- **b)** Down
- **c)** Out of the Page
- **d)** Into the Page

2. Now consider an electron moves parallel to the wire as shown. The force on the electron is



a) Up

b) Down

c) Out of the page

d) Into the page.

3. Which of the following is a possible wavelength for visible light?

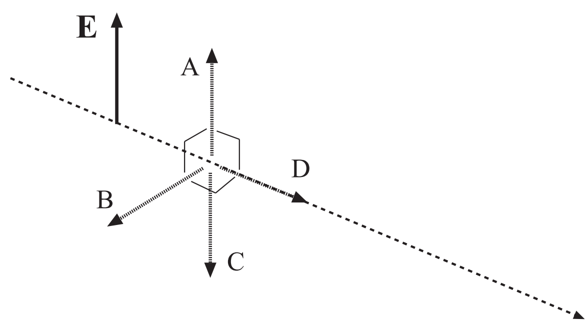
a) 46.0 m

b) 4.6 mm

c) 460 nm

d) 0.460 nm

4. In the picture at the right, the long arrow represents the direction of propagation of an EM wave. The direction of the electric field **E** is shown. Which of the four short arrows gives the direction of the magnetic (**B**) field?



a) A

b) B

c) C

d) D

5. An image formed by a convex mirror

a) Is always real.

b) Is always virtual.

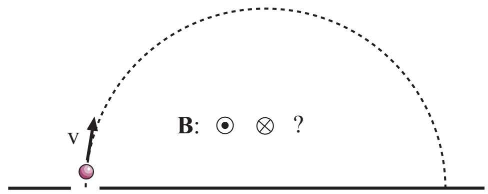
c) Can be real or virtual depending on the distance of the object.

d) Is neither real nor virtual

Problems

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

1. In a mass spectrometer, ions with a charge of $+e$ are given a speed of $1.90 \times 10^5 \frac{\text{m}}{\text{s}}$. They go into a region where a perpendicular B field of magnitude 0.30 T makes them go in a circular path with a radius of 8.00 cm.



a) Does the magnetic field point into the page or out of the page? How do you know? (5)

The magnetic field must point $\boxed{\text{out of the page}}$. Since the force on the charge must point toward the center of the circle and it is a positive charge, using the right hand rule with a field out of the page gives the proper force.

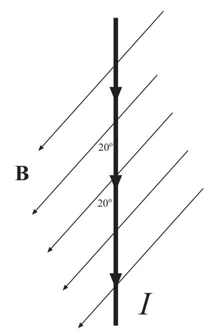
b) What is the mass of each ion? (10)

Use

$$r = \frac{mv}{qB} \qquad \Longrightarrow \qquad m = \frac{rqB}{v} = \frac{(0.080)(1.60 \times 10^{-19})(0.30)}{(1.90 \times 10^5)} \text{ kg} = 2.02 \times 10^{-26} \text{ kg}$$

2. A long wire carries a current of 3.0 A in the plane of the page, as shown. There is a uniform magnetic field of magnitude 0.100 T also in the plane of the page (as shown) whose direction is different from that of the current by 20°.

Find the magnitude and direction of the force on a 10.0 cm segment of the wire. (11)



The magnitude of the force is

$$F = LIB\sin\theta = (0.10)(3.0)(0.100)(\sin 20^\circ) \text{ N} = 1.0 \times 10^{-2} \text{ N}$$

Using the right hand rule, the force on the wire is $\boxed{\text{into the page}}$.

3. We want to make a solenoid of length 12.0 cm which has a magnetic field of magnitude 0.020 T in its interior. The solenoid will carry a current of 2.0 A.

How many turns of wire should we wrap over the 12.0 cm? (Hint: Find n first.) (8)

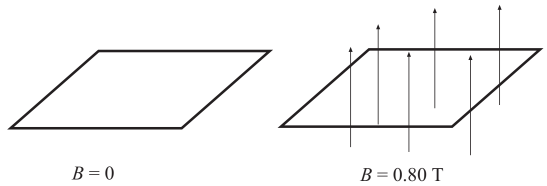
Use $B = \mu_0 n I$ to find the turns per unit length for the solenoid:

$$n = \frac{B}{\mu_0 I} = \frac{(0.020)}{(4\pi \times 10^{-7})(2.0)} \text{ m}^{-1} = 7.96 \times 10^3 \text{ m}^{-1}$$

The number of turns for a solenoid of length $L = 0.12$ m is then

$$N = Ln = (0.12 \text{ m})(7.96 \times 10^3 \text{ m}^{-1}) = 9.5 \times 10^2$$

4. A square loop of side 5.0 cm is in a region of space where a uniform magnetic field is perpendicular to the plane of the square and whose strength increases from 0 to 0.800 T in 0.50 s.



a) Find the the average emf induced in the loop during this period. (8)

Here, the B field keeps the same direction but its magnitude chages, so the magnitude of the change in flux is

$$\Delta\Phi = (\Delta B)A = (0.800\ \mathrm{T})(0.050\ \mathrm{m})^2 = 2.00 \times 10^{-3}\ \mathrm{T \cdot m^2}$$

The average emf is then

$$\mathcal{E} = \frac{\Delta\Phi}{\Delta t} = \frac{(2.00 \times 10^{-3})}{(0.50)}\ \mathrm{V} = 4.00 \times 10^{-3}\ \mathrm{V}$$

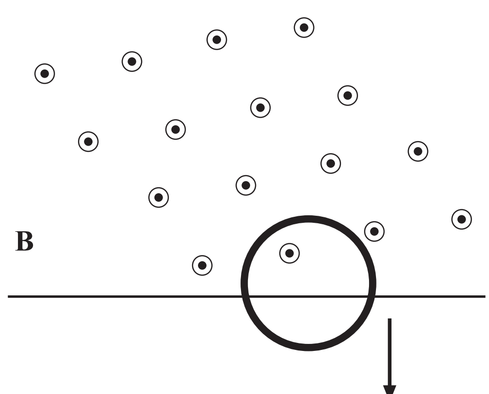
b) If the loop has resistance $50.0\,\Omega$, find the average current in the loop during this time. (3)

From Ohm's law, the average current in the loop is

$$I = \frac{\mathcal{E}}{R} = \frac{(4.00 \times 10^{-3}\ \mathrm{V})}{(50.0\,\Omega)} = 8.00 \times 10^{-5}\ \mathrm{A}$$

5. A conducting ring (in the lane of the page) is moved from a region where there is a uniform magnetic field coming out of the page to one where the field is zero (as shown).

Determine the direction in which the induced current flows and *explain your choice*. (8)



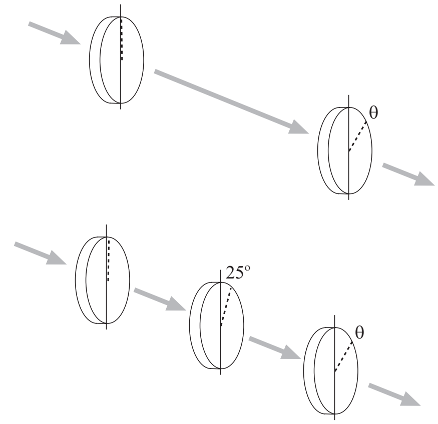
The flux is directed out of the page and is *decreasing*. To oppose this change the induced current must generate magnetic field in the interior of the loop which is *out of the page*. By an appropriate use of the right-hand rule, we will get such a field if the current in the loop goes $\boxed{\text{counterclockwise}}$.

6. Find the wavelength of electromagnetic radiation which has a frequency of 30 GHz. (Recall "G" = 10^9.) (6)

Use $\lambda f = c$, then

$$\lambda = \frac{c}{f} = \frac{(3.00 \times 10^8 \,\frac{\mathrm{m}}{\mathrm{s}})}{(30 \times 10^9 \ \mathrm{s}^{-1})} = 1.00 \times 10^{-2} \ \mathrm{m} = 1.00 \ \mathrm{cm}$$

7. Unpolarized light is incident on a pair of polaroids. The first polaroid has its axis in the vertical direction while the second has its axis inclined at some angle θ with the vertical.



It is found that the intensity of the light which gets though both sheets has 0.140 the intensity of the original light.

a) What is the angle θ? (8)

The first polaroid reduces the intensity by a factor of $\frac{1}{2}$ and gives it a vertical polarization. The second then reduces its intensity by another factor of $\cos^2\theta$. Then

$$0.140 = \tfrac{1}{2}\cos^2\theta \qquad \Longrightarrow \qquad \cos\theta = 0.529 \qquad \Longrightarrow \qquad \theta = 58.1^\circ$$

b) If another polaroid is placed between the other two with its axis inclined at 25.0° from the vertical, what fraction of the light gets through all three sheets? (6)

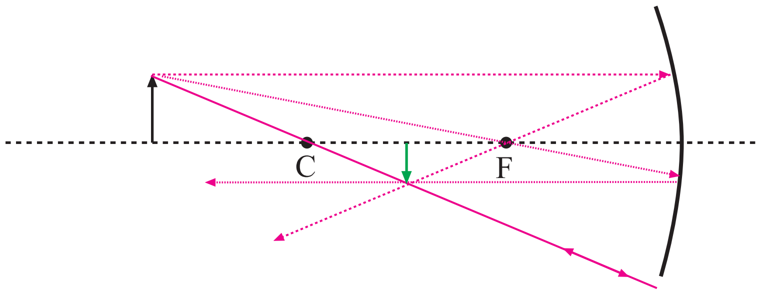
Now we get a factor of $\frac{1}{2}$ from the first sheet, a factor of $\cos^2 25^\circ$ from the next sheet and a factor of

$$\cos^2(58.1^\circ - 25^\circ) = \cos^2(33.1^\circ)$$

from the last one. The overall factor is

$$\tfrac{1}{2}\cos^2(25^\circ)\cos^2(33.1^\circ) = 0.288$$

8. On the diagram below show how a concave mirror forms an image of an object which is farther than the focal point (and center of curvature). (9)



The usual rays are drawn; the image is in front of the mirror and is inverted.

If the mirror has a focal length of 30.0 cm and the object is 80.0 cm in front of it, where is the image located? (8)

With $f = 30.0\ \mathrm{cm}$ and $d_o = 80.0\ \mathrm{cm}$, we get

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = 2.08 \times 10^{-2}\ \mathrm{cm}^{-1} \qquad \Longrightarrow \qquad d_i = 48.0\ \mathrm{cm}$$

The image is $48.0\ \mathrm{cm}$ in front of the mirror. (So it is a real image.)

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

$$e = 1.60 \times 10^{-19}\ \mathrm{C} \quad k = 8.99 \times 10^{9}\ \frac{\mathrm{N \cdot m^2}}{\mathrm{C^2}} \quad \epsilon_0 = 8.85 \times 10^{-12}\ \frac{\mathrm{C^2}}{\mathrm{N}} \quad c = 2.998 \times 10^{8}\ \frac{\mathrm{m}}{\mathrm{s}} \quad \omega = 2\pi f$$

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

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

$$\text{Rt hand rules!} \qquad B_{\mathrm{wire}} = \frac{\mu I}{2\pi r} \qquad B_{\mathrm{loop}} = \frac{\mu_0 I}{2R} \qquad B_{\mathrm{sol}} = \mu_0 n I \qquad \Phi = BA\cos\phi$$

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

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