Name: Key

Physics 2020 – Fall 2001

Exam #2 – Nov. 6, 2001

Multiple Choice (30): ____________

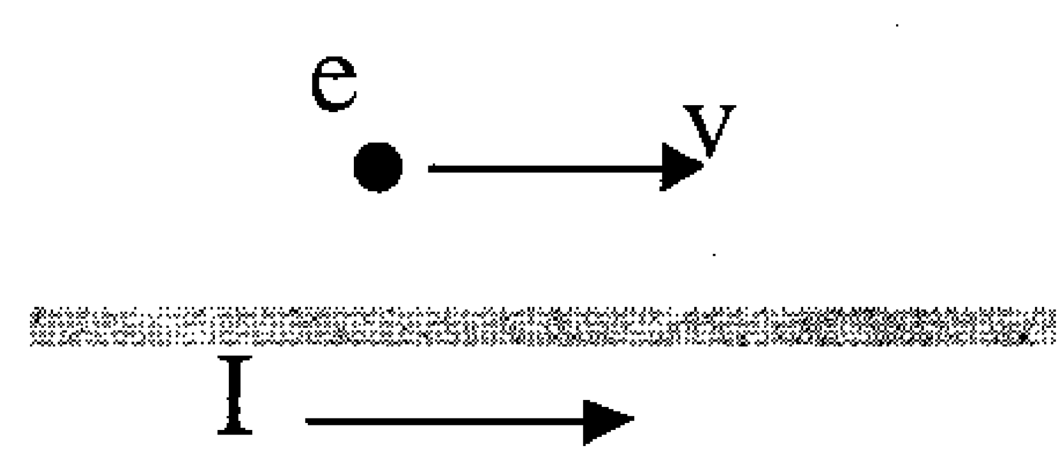
Q1 (15): ________ Q2 (20): ________ Q3 (15): ________ Q4 (20): ________

TOTAL (100): ____________

Part I: Multiple Choice (3 points each)

Circle the most suitable answer from among those given. If you do not agree with any of the answers write your own.

An electron travels parallel to a long straight current-carrying wire, at a velocity v, in the same direction as the current I, as shown. Answer the following **three** questions concerning this situation.



1. At the location of the electron, as shown in the diagram, the direction of the magnetic field (B) is:

a) Pointing upward, away from the wire.
b) Pointing out of the paper, toward you.
c) Pointing in the same direction as the velocity.
d) Pointing into the paper, away from you.

2. The direction of the magnetic force on the electron is:

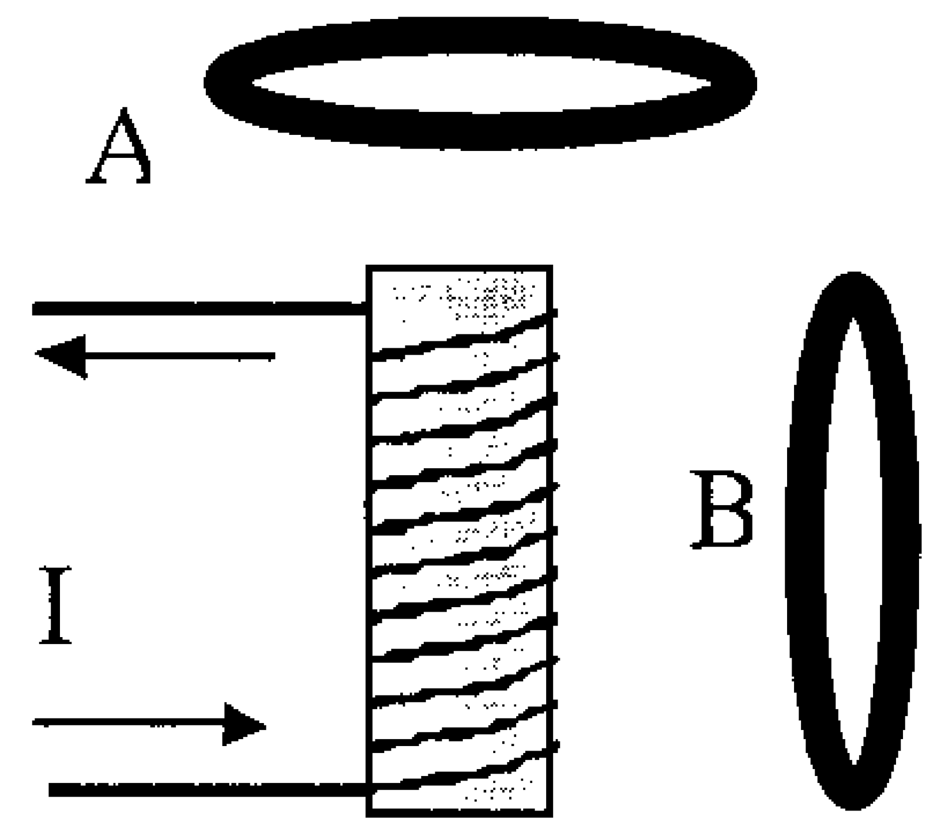
a) Downward, directly toward the wire
b) Upward, directly away from the wire.
c) Pointing in the same direction as the velocity.
d) No direction, the electron does not feel a magnetic force.

Name: ______________________________

3. As a result of the interaction between the electron and the current-carrying wire:

a) The speed of the electron changes, but its direction does not change.
b) The speed of the electron and its direction both change.
c) Neither the speed nor the direction of the electron change.
d) The speed of the electron does not change, but its direction does.

A wire is wrapped around an iron core to make a solenoid, as shown, and carries a current in the direction shown. (The wire passes in front of the core at the bottom, and emerges from behind the core at the top.)



Two circular aluminum rings are placed near the solenoid. One (ring A) is place in a horizontal plane above the solenoid. The other (ring B) is place in a vertical plane next to the solenoid.

Answer the following **three** questions based on this set-up.

4. When a constant current I flows in the solenoid

a) The upper end of the solenoid behaves like a magnetic North pole
b) The upper end of the solenoid behaves like a magnetic South pole.
c) The solenoid does not produce a magnetic field.
d) The solenoid behaves like a magnetic monopole.

5. When the current in the solenoid is decreased:

a) The magnetic flux through both rings decreases.
b) The magnetic flux through ring A decreases and the flux through ring B increases.
c) The magnetic flux through ring A decreases and the flux through ring B stays constant.
d) The magnetic flux through ring A increases, and the flux through ring B decreases.

Name: ______________________________

6. When the current in the solenoid is decreased:

a) An induced current flows clockwise in ring A (as viewed from above)
b) An induced current flows counter-clockwise in ring A (as viewed from above)
c) No induced current flows in ring A.
d) None of the above occurs.

7. Polaroid sunglasses work well to cut out 'glare' because:

3. Ordinary sunlight is polarized.
4. Sunlight reflected from smooth surfaces is polarized.
5. They reduce the amount of energy carried by the light waves.
6. They cut out the magnetic field component of the light waves.

8. In an electromagnetic wave:

a) The magnetic and electric field components oscillate in the same direction.
b) The electric and magnetic field components oscillate in the direction of motion.
c) The electric field component carries most of the energy.
d) The magnetic and electric field components oscillate in perpendicular directions.

9. When you look at yourself close up in a concave mirror (to shave, or apply make-up) you are seeing:

a) A magnified, real, upright image.
b) A magnified, real, inverted image.
c) A magnified, virtual, inverted image.
d) A magnified, virtual, upright image.

10. When a light ray light passes from water into air (at non-normal incidence)
it bends away from the normal.

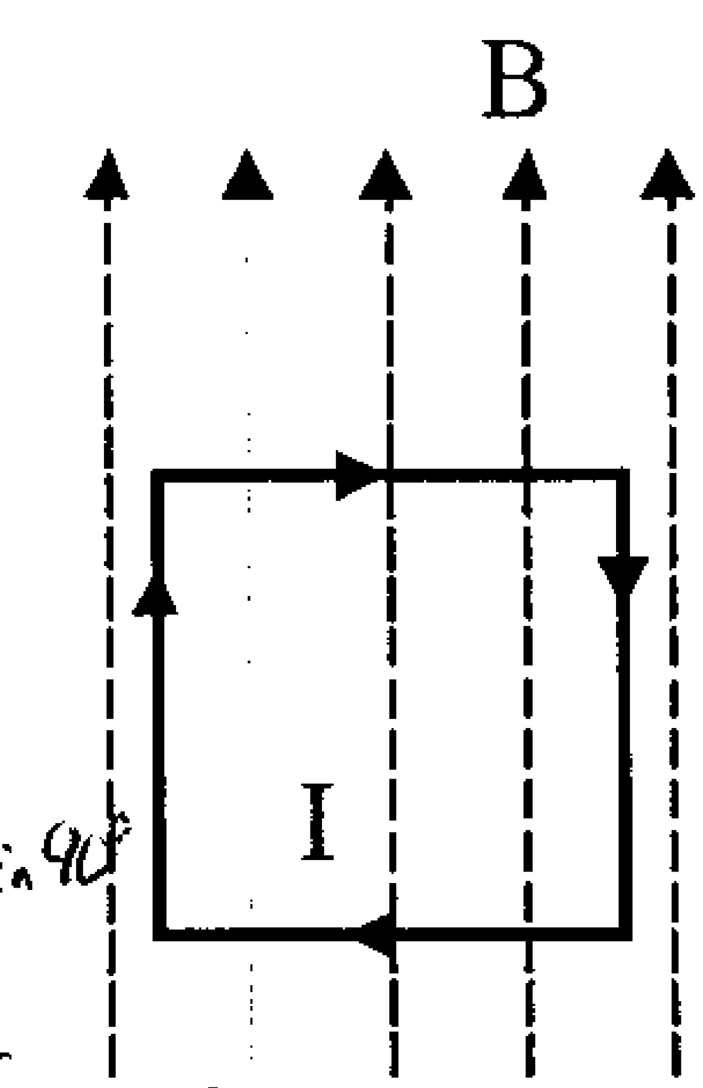
a) ~~A magnified, real, upright image.~~
b) ~~A magnified, real, inverted image.~~
c) ~~A magnified, virtual, inverted image.~~
d) ~~A magnified, virtual, upright image.~~

Name: ____________________

Part II – Short Answers and Problems

You must show your working and/or explain your answers in order to receive full credit.

3. A square coil of wire containing a single turn is placed in a uniform magnetic field of 0.25 T, as the drawing shows. Each side of the coil has a length of 0.32 m and the current in the coil is 12 A.



$F = ILB\sin\theta$

a) Determine the magnitude and direction of the magnetic force acting on each side of the coil. (12 points)

Top side, $\theta = 90°$ $\quad F = 12A \times 0.32m \times 0.25T \times \sin 90°$
$= 0.96\ N$, out of paper (from RHR #1)

Bottom side, $\theta = 90°$ $\quad F = 0.96\ N$, into paper

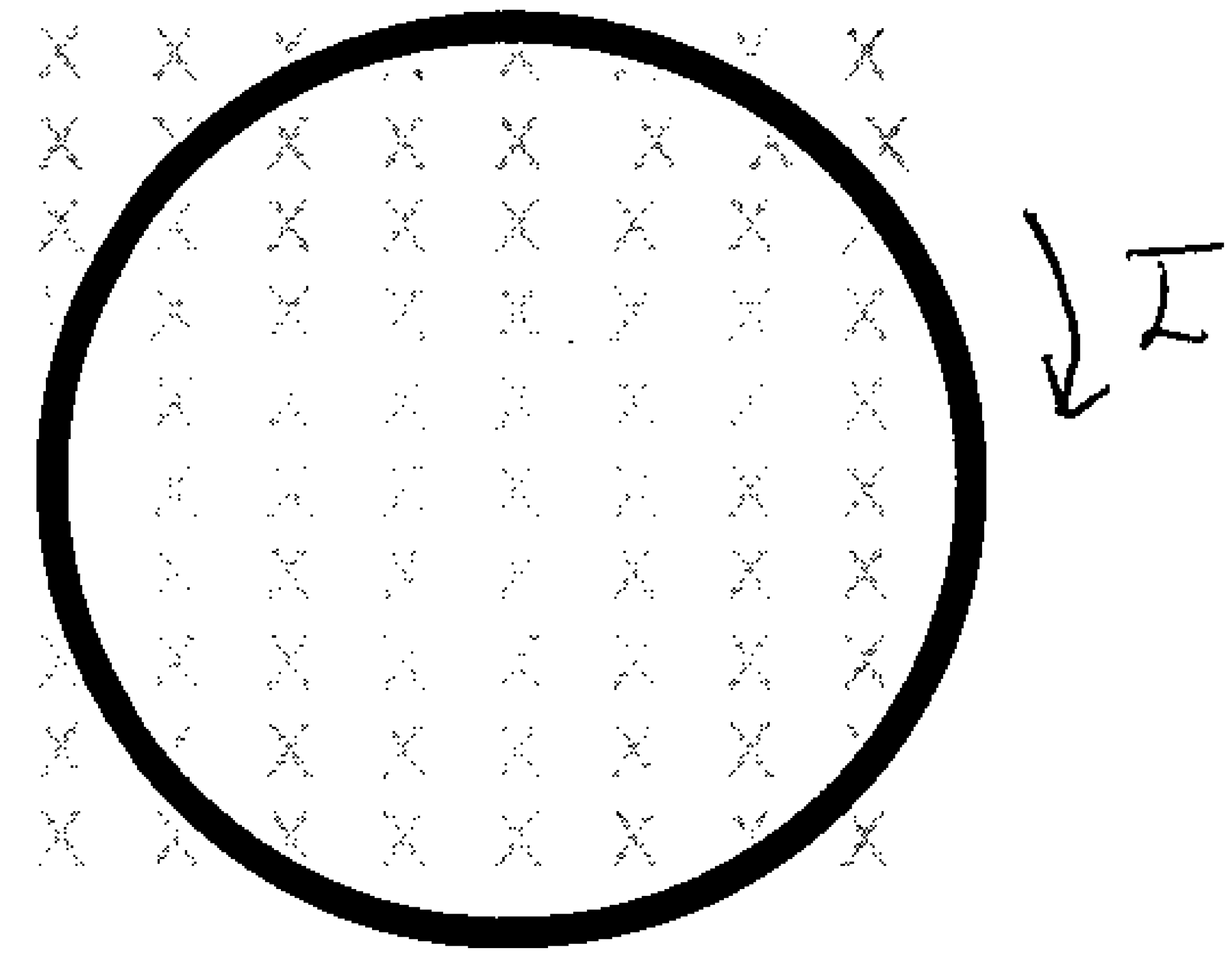
Left and Right sides $\quad \theta = 0°$ or $180° \Rightarrow \sin\theta = 0$
so $F = 0$

b) What is the net force acting on the whole coil? (3 points)

Net force = 0.96N into paper
+ 0.96N out of paper

= 0 N

2. A circular loop of wire, of radius 10 cm, is place in a 0.8 T magnetic field, directed into the paper as shown.



a) What is the area of the loop? (3 points)

$$A = \pi r^2 = \pi (0.10\,m)^2$$
$$= 0.0314\ m^2$$

b) What is the magnetic flux through the loop? (5 points)

$$\Phi = BA = 0.8T \times 0.0314\,m^2$$
$$= 0.0251\ Tm^2$$

c) The magnetic field is changed so that it now has the same strength, but is directed **<u>out</u>** of the paper. This change takes 0.2 seconds to complete. Calculate the induced emf (ε) in the loop during this change. (7 points)

Flux changes from $0.251\ Tm^2$ into paper
to $0.251\ Tm^2$ out of paper

$\Rightarrow \Delta\Phi = 0.502\ Tm^2$

$$\mathcal{E} = -\frac{\Delta\Phi}{\Delta t} = -\frac{0.502\,Tm^2}{0.2\,s} = 2.51\ V$$

d) In what direction does the induced current low round the loop? Explain your reasoning. (5 points)

Original flux is into paper, changes to flux out of paper.

Induced current will flow to try to maintain flux into paper

$\Rightarrow$ Current flows clockwise, as shown above.

Name: ____________________________

3. My favorite radio station transmits at a frequency of 93.7 MHz.

a) What is the wavelength of these radio waves? (4 points)

$$c = f\lambda \quad \Rightarrow \quad \lambda = \frac{c}{f} = \frac{3.00\times 10^{8}\,m/s}{93.7\times 10^{6}\,Hz}$$

$$= 3.20\,m$$

b) A distant galaxy is receding (getting further away) from the Earth at a speed of 1.6 x 10^6 m/s. To what frequency should the inhabitants of this galaxy tune their radio dial to receive this station clearly (when the signals eventually get there)? (7 points)

$$f_o = f_s\left(1 + \frac{V_{rel}}{c}\right) = 93.7\,MHz\left(1 \mp \frac{1.6\times 10^{6}\,m/s}{3.00\times 10^{8}\,m/s}\right)$$

$$= 93.2\ MHz$$

c) If the radio signals from the Earth take 2 x 10^6 years to get to this galaxy, how far from the Earth is it? (4 points)

$$c = \frac{d}{t}$$

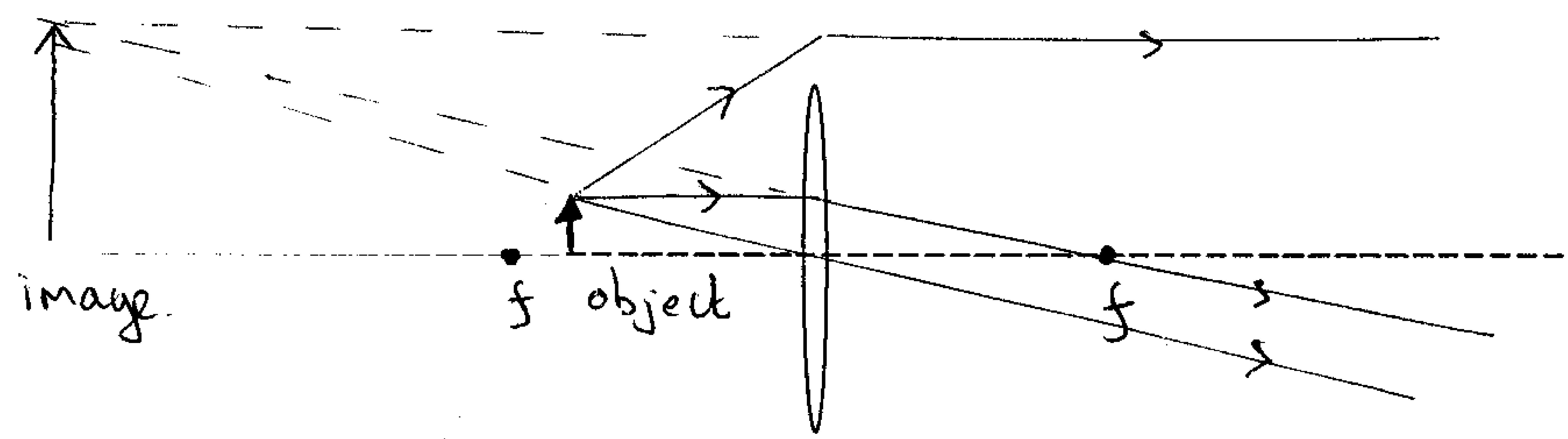
$$d = ct = 3.00\times 10^{8}\,m/s \times 2\times 10^{6}\,yrs \times 365.25\,days/yr$$

$$\times 24\,hrs/day \times 3600\,secs/hr$$

$$1.89\times 10^{22}\,m$$

4. A toy soldier 3 cm high is placed 4 cm in front of a converging lens that has a focal length of 4.5 cm.

a) On the diagram below draw light rays to locate the position of the image. (10 points)



b) Does you diagram indicate whether the image is real or virtual, upright or inverted, magnified or diminished? (3 points)

Image is virtual, upright, magnifeid

c) Now calculate the position and height of the image. (7 points)

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{4.5} - \frac{1}{4.0} = -0.028$$

$$\Rightarrow d_i = \frac{1}{-0.028} = -36\text{ cm}$$

$$m = -\frac{d_i}{d_o} = -\frac{-36}{4} = 9 \qquad \Rightarrow h_i = 9 \times h_o = 9 \times 3\text{cm} = 27\text{cm}$$