PHYSICS 8B – Spring 2016 - C. Bordel
Lecture 1, Midterm 2
Wednesday, April 13th, 7-9pm

- Student name:
- Student ID #:
- Discussion section #:
- Name of your GSI:
- Day/time of your discussion section:

Score Table

1	
2	
3	
4	
Total	

<u>Problem 1</u> – Magnetic field (25 points)

A conductor is essentially made of a straight line, but there is a section over which the wire is bent to form a semicircle of radius a, with its center P located on the line joining the linear sections of the wire, as shown in Fig.1.1. The wire carries current I from left to right.

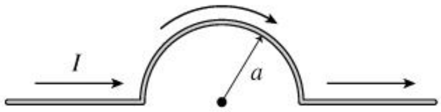

Figure 1.1

a. ***(4 pts)*** Explain in 1-2 sentences which method you will use and why to calculate the magnetic field created by the current-carrying wire at point P.

b. ***(5 pts)*** Calculate the magnetic field $\overrightarrow{B_{lin}}$ produced at point P by the linear sections of the wire.

c. ***(8 pts)*** Calculate the magnetic field $\overrightarrow{B_{circ}}$ produced at point P by the semicircular section.

Now the semicircular section of the wire is replaced by a full circle, made of the same material and with the same radius a (Fig.1.2). The same total current I is passed from left to right.

d. ***(8 pts)*** Determine the total magnetic field produced at point P by this current distribution.

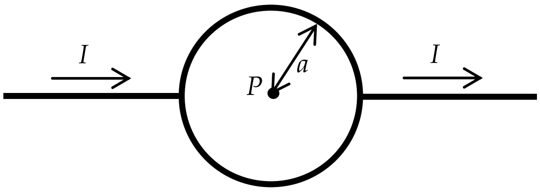

Figure 1.2

Problem 2 – Electromagnetic induction (25 points)

a. ***(7 pts)*** Determine the direction and magnitude of the magnetic field created by a straight and infinite wire carrying current I along the $+y$ direction, at ***any*** point located at distance $|x|$ from the wire.

A narrow rectangular conducting loop is now placed with its center at distance x from the straight wire, as shown in Fig.2. Its width a is small enough that the field can be considered uniform over the entire area of the closed loop ($a \ll x$).

b. ***(5 pts)*** Calculate the magnetic flux through the loop.

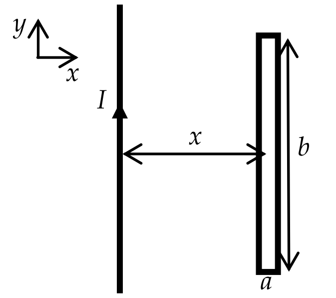

Figure 2

The loop, of electrical resistance R, is now moved at constant speed v in the $+x$ direction.

c. ***(5 pts)*** Use Lenz's law to predict the direction of the induced current i in the closed loop.

d. ***(8 pts)*** Calculate the induced current i in the rectangular loop (in terms of I, a, b, v, R, t) and comment on the sign. *Hint: It may be useful to write the distance x as a function of time in terms of given variables, assuming that $x=0$ at $t=0$.*

<u>Problem 3</u> – Geometrical optics (25 points)

Part 1: The laser beam that reads information from a compact disc has a width D when it strikes the disc and forms a cone with half-angle θ_1 as shown in Fig.3. It then passes through a plastic layer of thickness t and refractive index n before reaching the information layer near the disc's top surface.

a. ***(7 pts)*** What is the beam diameter d at the information layer? Give your answer in terms of D, t, n, and θ_1.

b. ***(2 pts)*** If the goal is to achieve a beam size reduction through the plastic layer, why is it required that the incoming beam have a conical shape instead of a cylindrical shape?

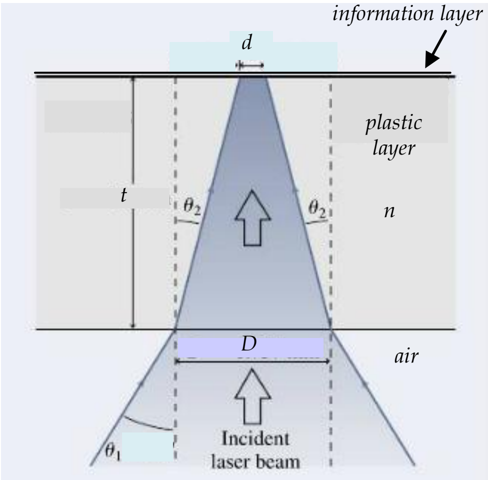

Figure 3

Part 2: A candle is placed in front of a concave spherical mirror with radius of curvature R. An inverted image forms that is twice as big as the object.

c. ***(9 pts)*** Determine the object and image positions in terms of the radius of curvature R.

d. ***(7 pts)*** Do the ray tracing, with the scale of your choice, to show the formation of the image.

<u>Problem 4</u> – Thin lenses and optical instruments (25 points)

A basic compound microscope is made of two converging lenses, separated by a distance L: the objective lens, of focal length f_o (focal point F_o), and the eyepiece, of focal length f_e (focal point F_e). See figure 4.

a. ***(4 pts)*** What should be the nature (real/virtual) of the final image formed through the microscope, assuming that the eye is placed right behind the eyepiece?

b. ***(8 pts)*** Using the small angle approximation, calculate the angular magnification m_e of the eyepiece in terms of f_e and the near point of the normal eye, s_{np}.

c. ***(4 pts)*** The overall magnification of the microscope can be approximated by the following expression: $M = -\frac{L s_{np}}{f_o f_e}$. What can you deduce regarding the orientation of the final image with respect to the initial object?

d. ***(9 pts)*** Do the ray tracing on the figure below to show the formation of the intermediate and final images of the object *(AB)* through the two converging lenses. *Note that the various distances have been chosen to illustrate the working principle of the compound microscope but the diagram is not to scale.*

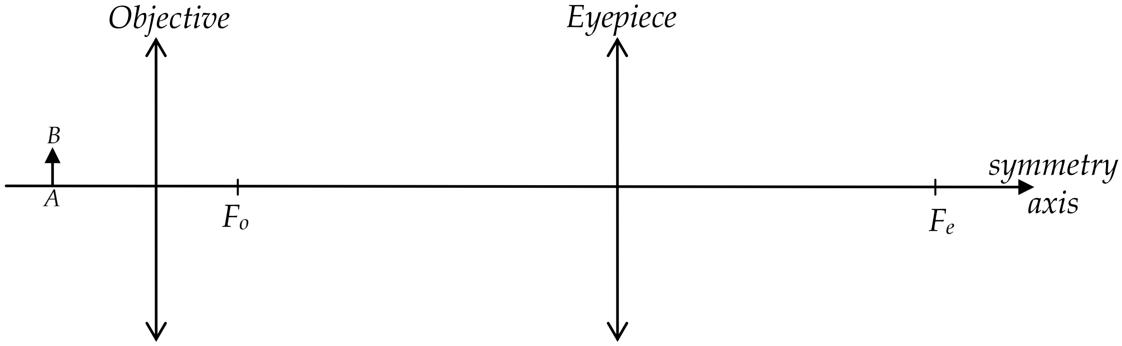

Figure 4