Physics 52 **Final** **December 17, 1994**

Name _____

Section: Wed. Rec.____ , Thur. Rec.____

Work directly on these pages and show your work clearly. Properly labeled figures are important and will figure into the grading.

Use the proper symbols to show your vectors clearly.

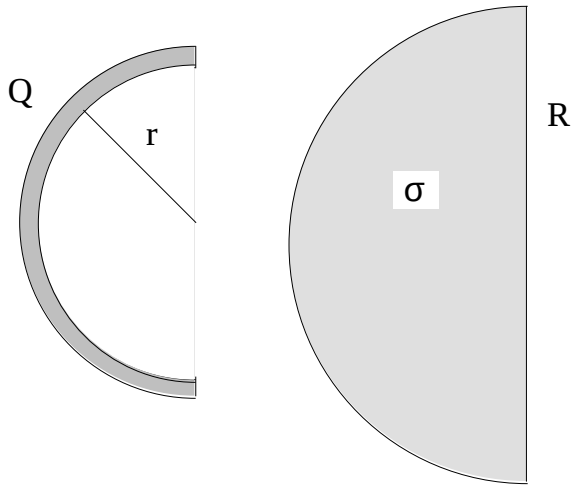
Some basic equations are given at the end of the last page.

1.
2.
3.
4.
5.
6.
7.
8.
Total

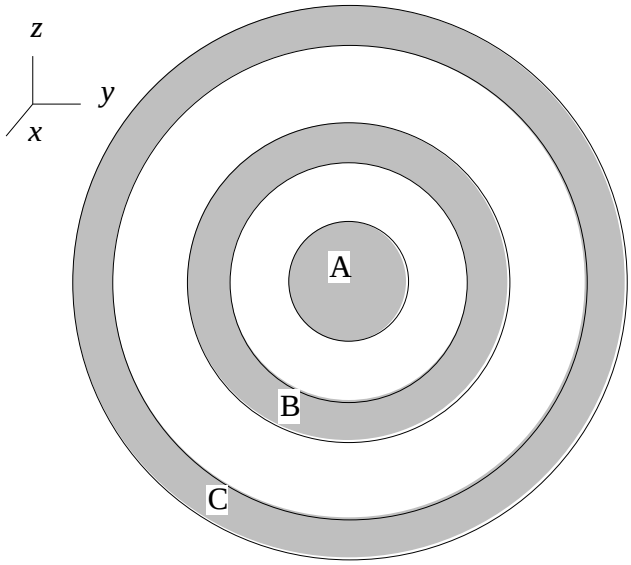
1. [*25 pts*] Relative to zero volts at infinity, the electric potential V at the center of the semicircular strip of uniformly charged dielectric shown is given by $V = kQ/r$.

(a) Use this information to determine an expression for the electric potential at the center of the half disk of flat dielectric shown. This piece of dielectric has a constant charge per unit area σ.

(b) Now, if the half disk contains a total charge Q_D, determine a simplified expression for the electric potential that does not contain σ.



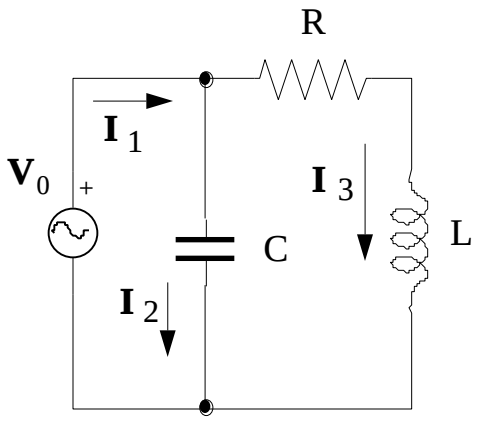
2. [*25 pts*] OK, here is the problem we tried without much success in recitation early in the semester. *A*, *B*, and *C* in the figure are three concentric spherical conductors. A charge $+Q$ is located on *A*, $-3Q$ is located on *B*, and $+Q$ is located on *C*.



(a) With attention to the vector notation details, use Gauss' law to determine an expression for the electric field in the empty space between the *B* and *C* conductors?

(b) How much charge is located on the **inner** surface of the *C* shell?

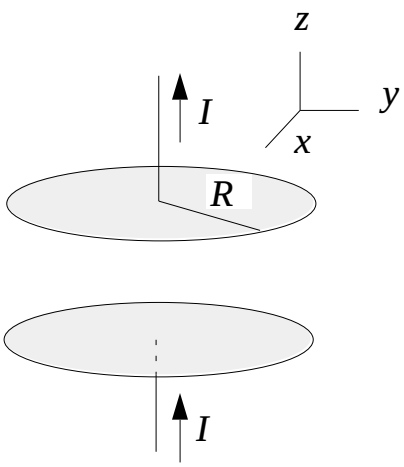
3. [*25 pts*] (a) If the EMF $\mathbf{V}_0$ operates at a frequency ω, write complex expressions for the currents $\mathbf{I}_2$ and $\mathbf{I}_3$ in terms of the EMF and the component values.



(b) If $\frac{1}{\omega C} = 2R$, and $\omega L = \sqrt{3}R$. plot phasors that show the correct phase relationship between $\mathbf{V}_0$, $\mathbf{I}_2$, and $\mathbf{I}_3$.

(c) From your result in (b), what is the phase relationship between $\mathbf{I}_2$ and $\mathbf{I}_3$? In other words, which one leads and by what angle?

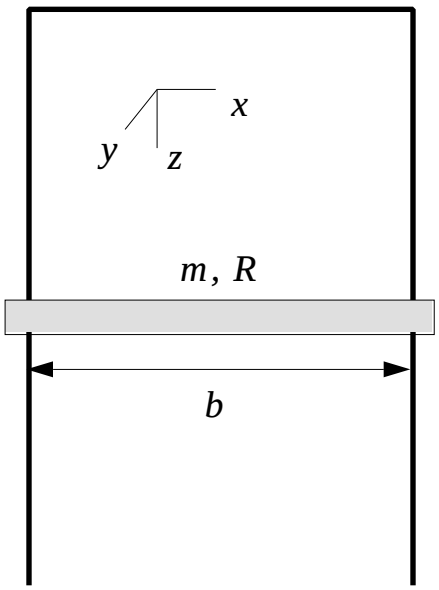
4. [*30 pts*] The current in the upper and lower wires is a constant I, directed upward as shown. The circular plates are conducting.



(a) Recalling that the magnitude of the electric field between the plates of this capacitor is given by $E = \sigma/\varepsilon_0$, determine an expression for the electric field between the plates as a function of I, R, the time t, and appropriate unit vectors. Show the direction of **E** on the figure.

(b) Use Maxwell's extension of Ampere's law to determine an expression for the magnetic field between the plates when $r < R$. Make a top view drawing and show the vector details on this figure and in the equations.

5. [*30 pts*] The inverted ∏ shaped wire is fixed in the vertical plane and filled with a uniform and constant magnetic field $\vec{\mathbf{B}} = B\hat{\mathbf{y}}$. This field is generated by an external source not shown. A rod of mass m, resistance R, and length b is free to slide vertically on the wire without friction. The rod starts from rest and is acted on by the force of gravity $mg\hat{\mathbf{z}}$.



(a) Determine an expression for the current induced in the bar in terms of an assumed velocity $v\hat{\mathbf{z}}$. Indicate the direction of this current on the figure.

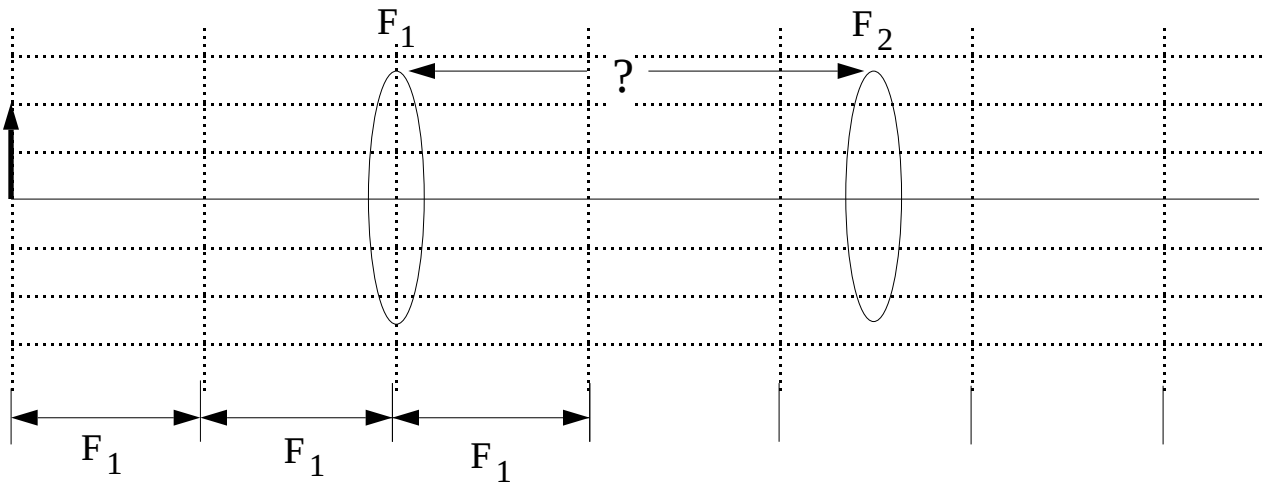
(b) Determine an expression for the force acting on the bar in terms of B, b, v, and R. Show this force on the figure.

6. [*15 pts*] An object is placed a distance 2*F* from a convex mirror with focal length -*F*. Make a reasonably accurate sketch of this system, and show three rays that can be used to construct the location and size of the final image. There are actually four possible rays, but I don't want you to use the one that goes toward the *center* and reflects back on inself.

7. [*25 pts*] The two lenses have focal length F_1 and F_2 as shown and form a telescope that is being used to look at an object located a distance $2F_1$ to the left of the first lens.

(a) In terms of the lengths F_1 and F_2 determine the separation between the lenses if the final image is to be located at -∞?

(b) Now if the system is adjusted as found in (a) and an observer's eye is located immediately to the right of the F_2 lens, determine the angular magnification of the telescope, i.e., the ratio of the angular size of the final image and that of the object with the telescope removed and the eye in the same place?



8. [25 *pts*] Parallel light of wavelength λ is incident from the left on a three slit interferometer and the light pattern is viewed on a screen located a distance *D* far to the right of the slits so the small angle approximation can be used. The three slits are arranged with equal spacing *d*, but the center slit passes light with **twice the amplitude** of each of the side slits.

(a) I want you to determine an expression for the angular position (~*Y*/*D*) of the first minimum of the interference pattern in terms of λ, *d*, and *c*, but...

(b) either before (good idea) or after (bad idea) you do that, I want you to produce a phasor diagram that shows how the three amplitudes are arranged when the minimum occurs.

Work page and equations

$$d\vec{\mathbf{E}} = \frac{1}{4\pi\varepsilon_0}\frac{dq\,\hat{\mathbf{r}}}{r^2}$$

$$d\Phi_E = \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}}$$

$$dV = -\vec{\mathbf{E}} \cdot d\vec{\mathbf{r}}$$

$$dV = \frac{1}{4\pi\varepsilon_0}\frac{dq}{r}$$

$$d\vec{\mathbf{B}} = \frac{\mu_0}{4\pi}\frac{dq\,\vec{\mathbf{v}} \times \hat{\mathbf{r}}}{r^2}$$

$$d\Phi_B = \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}}$$

$$\vec{\mathbf{F}} = q\vec{\mathbf{E}} + q\vec{\mathbf{v}} \times \vec{\mathbf{B}}$$

$$\mathbf{Z} = j\omega L, \quad \mathbf{Z} = \frac{1}{j\omega C}$$

$$\oint_S \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{q}{\varepsilon_0}$$

$$\oint_C \vec{\mathbf{E}} \cdot d\vec{\mathbf{r}} = -\frac{d}{dt}\int_S \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}}$$

$$\oint_C \vec{\mathbf{B}} \cdot d\vec{\mathbf{r}} = \mu_0 i + \mu_0\varepsilon_0\frac{d}{dt}\int_S \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}}$$

$$\vec{\mathbf{S}} = \frac{1}{\mu_0}\vec{\mathbf{E}} \times \vec{\mathbf{B}}, \ \eta_{\mathbf{E}} = \frac{\varepsilon_0 E^2}{2}, \ \eta_{\mathbf{B}} = \frac{B^2}{2\mu_0}$$

$$P = \int_S \vec{\mathbf{S}} \cdot d\vec{\mathbf{A}} \text{ with units Watts / m}^2$$

$$E^2 = P^2 + M^2 \text{ with } c = 1$$

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

$$E = E_0 e^{j\omega(t - z/c)}$$

$$A = 4\pi r^2$$

$$V = \frac{4}{3}\pi r^3$$