PHYS231

Practice Exam #2

1. $\vec{v} \neq \overline{V}$
2. $\ln(0) \neq 1$
3. Read each question carefully before attempting to solve.
4. Don't work too long on one problem. Attempt questions you can do quickly first, then move on to the problems you can't do.

Given:

$\varepsilon_o = 8.85 \times 10^{-12}$ F/m

$\mu_o = 4\pi \times 10^{-7}$ H/m

$V = iR$

$P = iV$

$Q = CV$

$U = qV$

$F_c = qE$

$\oint \vec{E} \cdot d\vec{A} = q/\varepsilon_o$

$\oint \vec{B} \cdot d\vec{A} = 0$

$\oint \vec{E} \cdot d\vec{s} = -d\Phi_B/dt$

$\oint \vec{B} \cdot d\vec{s} = \mu_o i_{enc} + \mu_o \varepsilon_o (d\Phi_E/dt)$

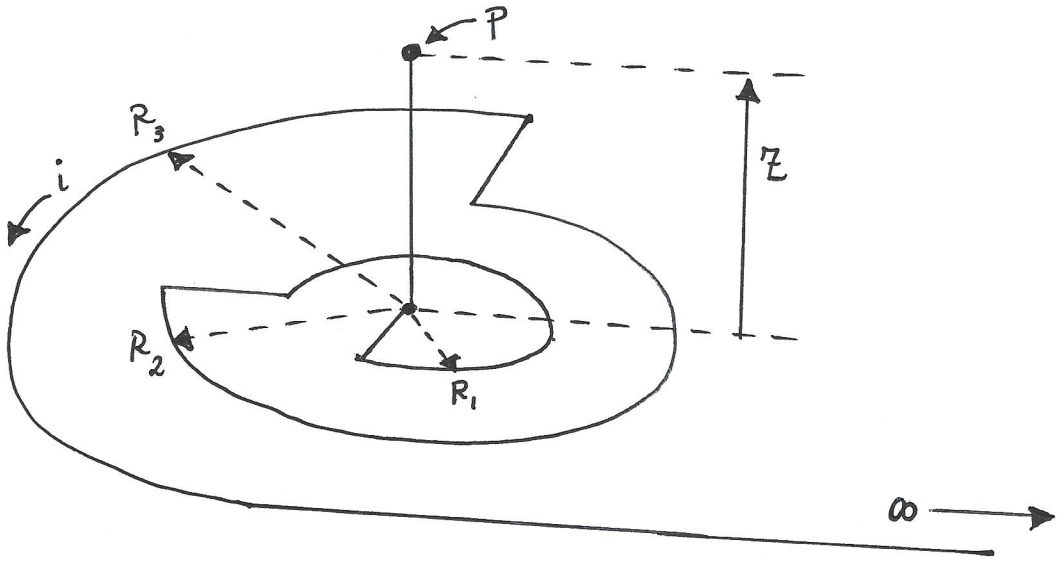
$d\vec{B} = \frac{\mu_o i}{4\pi} \cdot \frac{d\vec{s} \times \vec{r}}{r^3}$

$\int \sec(\theta)\, d\theta = \ln | \sec(\theta) + \tan(\theta) | + C$

elementary charge:	1.60×10^{-19} C
electron rest mass:	9.11×10^{-31} kg
proton rest mass:	1.67×10^{-27} kg

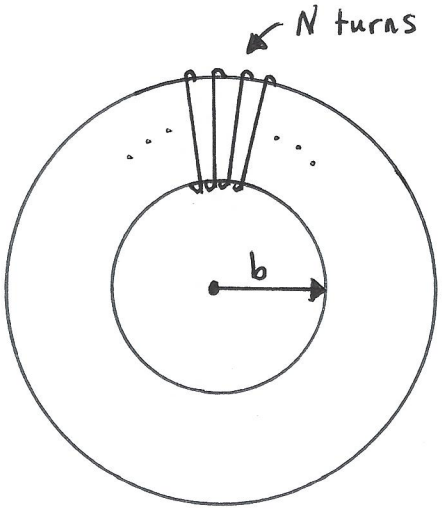
Question 1:

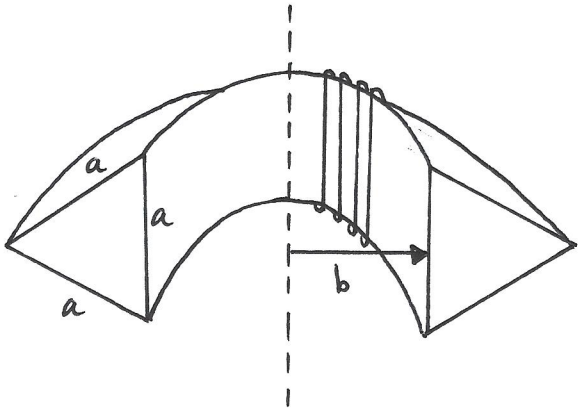
The following spiral was forged by troll-elves in the darkest depths of NS-258 using black magic and wizardry. As shown below, a free-energy source located at the center of the spiral produces a current "i" that follows the spiraling wire through 2 full revolutions, which then turns into a straight wire of length ∞/2. Find the magnetic field at point P *in the z-direction*.



Question 2:

The following inductor is connected in series with a 300 Ω resistor and an unknown capacitor. An alternating current is applied to the circuit and the resonance frequency is determined to be 386.0077983 mHz. Given the following information, find the capacitance of the unknown capacitor.





N = 200 turns

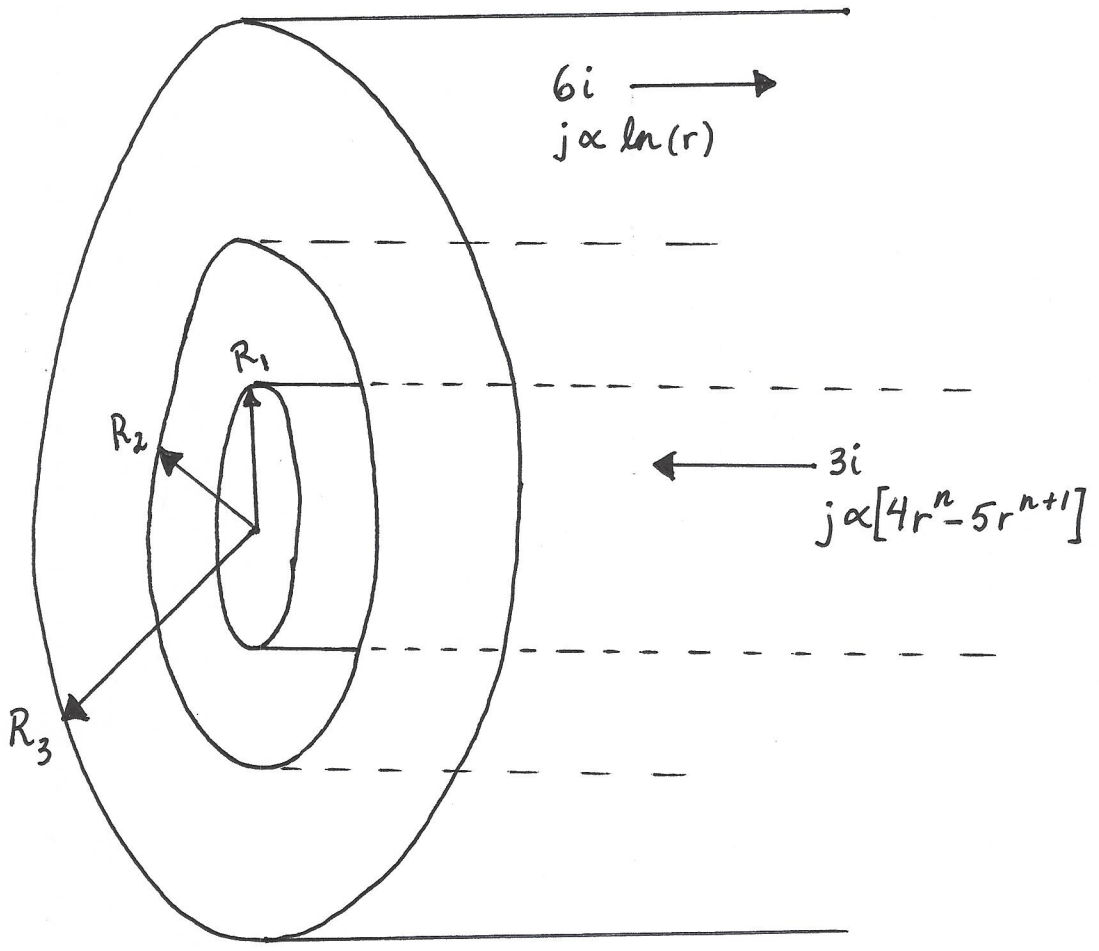
a = 5 m

b = 20 m

Question 3:

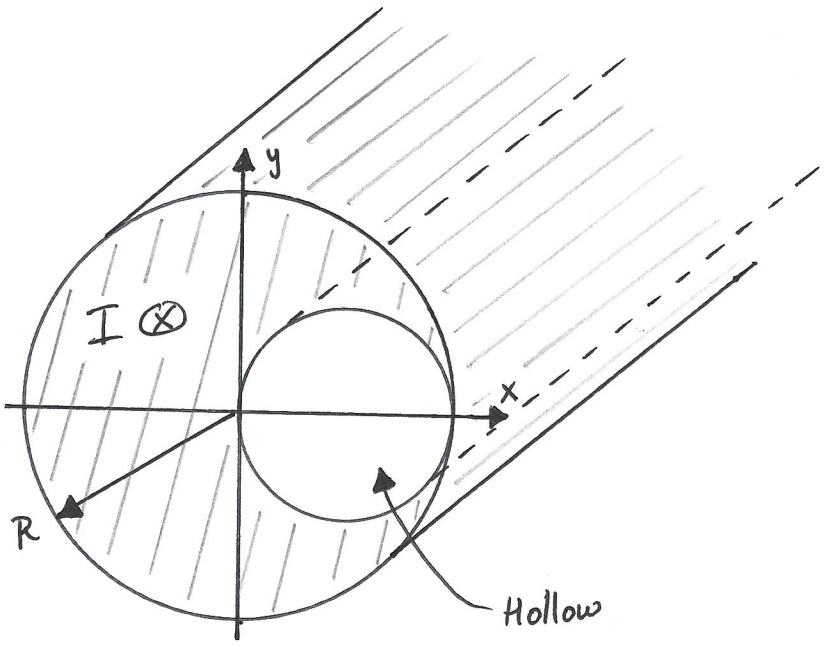
Find the magnetic field as a function of radius "r" in the following regions.

a) $r < R_1$
b) $R_1 < r < R_2$
c) $R_2 < r < R_3$
d) $r > R_3$
e) The magnitude of B within the first cylinder reaches a maximum value at a radius of $R_1/4$. Find "n."
f) Graph B(r).



Question 4:

A long, straight wire of radius "R" has an offset hollow cylindrical section drilled throughout its entire length. A current "I" is passed through the solid region of the wire. Find the magnitude of the magnetic field within the solid region of the wire along the *positive y-axis*.



Question 5:

A charged, circular parallel-plate capacitor is connected to a constant voltage source which provides 8008135 V at all times. Each plate has a radius of 42 km. The plates have an initial separation of 1 cm, and are then pulled apart at a rate of 4 cm/s.

a) Find the resulting current in the circuit as a function of time.
b) When the current in the circuit reaches 174558.3354 A, what is the plate separation?

The same capacitor as used above is now connected to an AC power source providing a voltage of $\varepsilon(t) = \varepsilon_{max}\sin(\omega t)$, where $\varepsilon_{rms} = 2500$ V and $\omega = 69$ rad/s. The plates are held at a separation of 0.1181675225 nm.

c) Determine the RMS value for the magnetic field at a radius of 43 km in the region between the plates.
d) Calculate the maximum displacement current.

Question 6:

A circuit is constructed as shown below. All switches have been open for a long time. "S_2" is closed, then "S_1" is closed. After "S_1" has been closed for a long time, find:

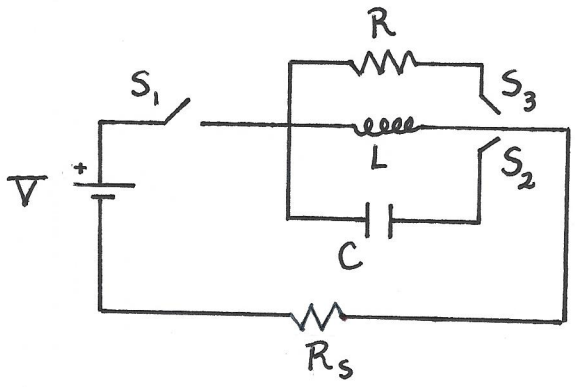
a) The energy stored in the inductor.
b) The energy stored in the capacitor.

The switch "S_1" is opened. Find:

c) i(t) through the inductor.
d) V(t) across the inductor.

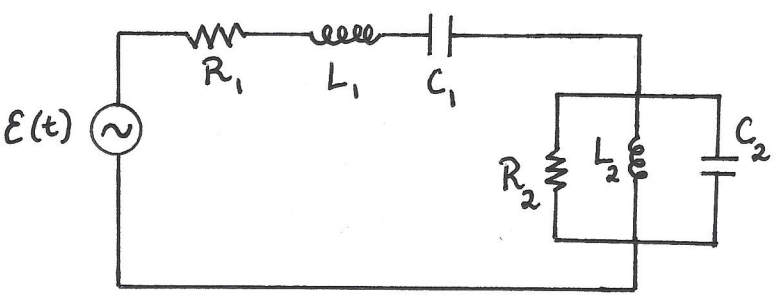
When the energy stored in the capacitor is minimum, "S_2" is opened and "S_3" is closed.

e) Find the energy dissipated by the resistor after "S_3" is closed for a long time.



$V = 25\ V$
$R = 15\ \Omega$
$L = 60\ mH$
$C = 12\ \mu F$
$R_S = 20\ \Omega$

Question 7:



$\mathcal{E}_{rms} = 120\ V$
$\upsilon = 60\ Hz$

$R_1 = 30\ \Omega$ $R_2 = 25\ \Omega$
$L_1 = 17\ mH$ $L_2 = 15\ mH$
$C_1 = 500\ \mu F$ $C_2 = 300\ \mu F$

a) Determine the total impedance of the circuit.
b) Which leads which by how many?
c) Find the voltage across each component of the circuit when $i(t) = -0.5i_{max}$ and increasing.
d) If all resistors, capacitors, and inductors were unknown, how could you determine the resonance frequency of this circuit in the lab room?

Question 8:

There is gravity and friction in this problem. A rod of mass "m" and resistance "R" is placed on a slope of angle "θ." The slope has conducting wires along it's top and side edges (the circuit is open at the bottom of the slope). The coefficient of kinetic friction between the rod and slope system is "μ." The rod is released from rest, and begins sliding down the slope. Assume static friction is broken.

a) Determine the direction of the induced current in the closed circuit.
b) Find the rod's position "x" as a function of time.
c) Find the energy dissipated within the circuit as a function of time.