V) <u>**28%**</u> Consider a cylindrical capacitor of length l, inner radius a (positively charged) and outer radius b (negatively charged).

a) By using Gauss' law, find the electric field at any r between a and b, then find the potential difference between the 2 cylinders and subsequently the capacitance of such configuration **(4 points)**

b) Starting with the energy density formula, what is the total electrostatic energy stored in the region between the 2 cylinders? Then, find the capacitance of this specific configuration (any resemblance with the result in a)?) **(4 points)**

c) What is the radius of the cylindrical volume within which half of the total energy is stored? **(4 points)**

Now, a dielectric of constant k has been placed in the region of the capacitor between $a \leq r \leq (a+b)/2$, while the remaining volume for $(a+b)/2 \leq r \leq b$ is kept empty.

d) Depending on the result in part a) deduce the expressions of the capacitances in the 2 different regions between the spheres **(3 points)**

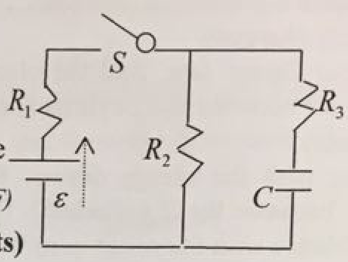
e) Considering the configuration to be consisting of 2 capacitors in series, find the total equivalent capacitance **(3.5 points)**

f) Then for the same configuration, what are the electric fields at any r within the 2 different regions **(3 points)**

g) Find the potential difference between the inner and outer cylinders **(3.5 points)**

h) Find the capacitance of the configuration (any resemblance with the result in e)?) **(3 points)**

IV) **18%** In the following circuit where $\varepsilon = 12V$:



a) at t = 0, what is the value of R_3 that maximizes the dissipation rate in R_3 (if $R_1 = R_2 = 730\Omega$ & $C = 6.5*10^{-3}\ F$) Any conclusion about this specific value of R_3? **(6 pts)**

b) Find he different currents at $t = \infty$; **(4 points)**

c) Now substituting R_3 by another one that is equal to R_1 or R_2 (*i.e.* 730Ω), What is the potential difference V_2 across R_2 at $t = 0$ & $t = \infty$? Sketch V_2 versus t between these 2 extreme times. **(8 points)**

10. The resistance in an RC circuit is comprised of a 1.5-MΩ resistor in parallel with a 2.0-MΩ resistor. What is the time constant for this circuit if the capacitance is 2.33 μF?
a) 2.0 s.
b) 7.0 ms.
c) 5.0 μs.
d) 120 s.
e) 4000 s.

11. A charged particle is moving in a magnetic field. What is the direction of the force on the particle due to the magnetic field?
a) in the direction of the magnetic field.
b) in the direction opposite to which the particle is moving.
c) in the direction that is perpendicular to both the magnetic field and the velocity.
d) in the same plane as the magnetic field and the velocity, but not in either of those two directions.
e) in the direction of motion.

12. At what orientation angle relative to the magnetic field direction does the torque of a magnetic dipole have its largest value?
a) 0°
b) 45°
c) 90°
d) 135°
e) 180°

<u>70%</u> 5 Problems (as you can chose only one problem out of the first 3 problems):

I) **<u>10%</u>** What are the charges and the potential differences across a $2\mu F$ capacitor and an $8\mu F$ capacitor if:

a) a potential difference of 300V is applied to the 2 capacitors when connected in series **(4 points)**
b) no external voltage being applied and the 2 charged capacitors are reconnected in parallel (i.e. the positive plates together and the negative together) **(3 points)**
c) no external voltage being applied and the 2 capacitors charged as in a) were reconnected in such a way that the plates of opposite polarity are together. **(3 points)**

Test II
Spring 2015-16

Electricity and Magnetism (PHY 201) LAU

Instructor: Mr. Samir Obeid

Student's name:________________________ ID#: ____________

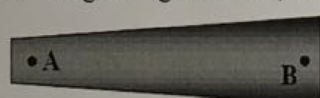
24% 12 Multiple choice questions (please circle neatly your choice):

1. In calculating both the electric field and the capacitance of two closely spaced conducting plates, it is frequently assumed that the area of the plates is somewhat larger than the distance between the plates. Why is this assumption made?
   a) The capacitance is too small to calculate if the plates are too far apart.
   b) The electric field near the edges of the plates is not uniform.
   c) The charge would otherwise be too small to generate a significant electric field.
   d) Coulomb's law would not otherwise apply.
   e) Gauss' law would not otherwise apply.

2. The plates of an isolated parallel plate capacitor with a capacitance C carry a charge Q. What is the capacitance of the capacitor if the charge is increased to $4Q$?
   a) $C/2$.
   b) $C/4$.
   c) $4C$.
   d) $2C$.
   e) C.

3. The plates of an isolated parallel plate capacitor are separated by a distance d and carry charge of magnitude q. The distance between the plates is then reduced to $d/2$. How is the energy stored in the capacitor affected by this change?
   a) The energy increases to twice its initial value.
   b) The energy increases to four times its initial value.
   c) The energy is not affected by this change.
   d) The energy decreases to one fourth of its initial value.
   e) The energy decreases to one half of its initial value.

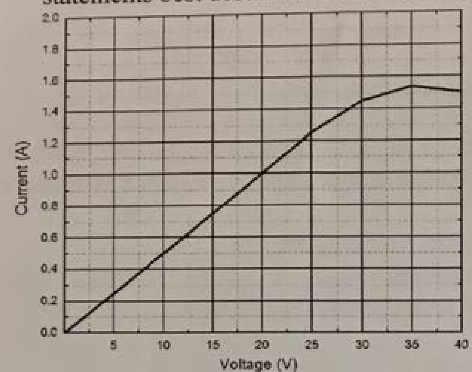
4. A copper wire is fabricated that has a gradually increasing diameter along its length as shown. If an electric current is moving through the wire, which quantities vary along the length of the wire?



   a) current only.
   b) current and current density only.
   c) current density and electric field only.
   d) resistivity and current only.
   e) current, resistivity, current density, and electric field.

5. How does the resistivity of a metal wire change if either the number of electrons per unit volume increases or the mean free time increases?
   a) In both cases, the resistivity will increase.
   b) In both cases, the resistivity will decrease.
   c) Increasing the number of electrons will increase the resistivity, but it will decrease if the mean free time increases.
   d) Increasing the number of electrons will decrease the resistivity, but it will increase if the mean free time increases.
   e) Too little information is given to make a determination.

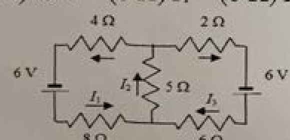
6. A certain circuit contains a battery and a resistor. An instrument to measure the current in the circuit, an ammeter, is connected in between one of the terminals of the battery and one end of the resistor. The graph shows the current in the circuit as the voltage is increased. Which one of the following statements best describes the resistor in this circuit?



a) The resistor does not obey Ohm's law.
b) The resistor obeys Ohm's law for voltages between zero and 25 volts.
c) The resistor obeys Ohm's law for voltages between zero and 35 volts.
d) The resistor obeys Ohm's law for voltages between zero and 40 volts.
e) The resistor obeys Ohm's law for voltages between thirty and 40 volts.

7. The insulated wiring in a house can safely carry a maximum current of 18 A. The electrical outlets in the house provide an alternating voltage of 120 V. A space heater when plugged into the outlet operates at an average power of 1500 W. How many space heaters can safely be plugged into a single electrical outlet and turned on for an extended period of time?
a) zero.
b) one.
c) two.
d) three.
e) four.

8. Which one of the following equations is not correct relative to the other four equations determined by applying Kirchoff's Rules to the circuit shown?
a) $I_2 = I_1 + I_4$.
b) $I_2 = I_3 + I_5$.
c) $6\text{ V} - (8\ \Omega) I_1 - (5\ \Omega) I_2 - (4\ \Omega) I_3 = 0$.
d) $6\text{ V} - (6\ \Omega) I_4 - (5\ \Omega) I_2 - (2\ \Omega) I_5 = 0$.
e) $6\text{ V} - (8\ \Omega) I_1 - (6\ \Omega) I_4 - 6\text{ V} - (2\ \Omega) I_5 - (4\ \Omega) I_3 = 0$.



9. Two 20-Ω resistors are connected in parallel. A potential difference of 9 V is then applied across both resistors. What is the resulting total current through the two resistors?
a) 0.23 A.
b) 0.45 A.
c) 0.90 A.
d) 2.2 A.
e) 4.4 A.

II) **10%** Suppose that the current density in a cylindrical wire of inner radius a and outer radius b varies with r according to $j = kr^2$ (where k is a constant).

Find the magnitude of the current for:

a) $a \le r < b$, then **(5 points)**

b) $r \ge b$. **(5 points)**

III) **10%** A rectangular carbon block has dimensions $0.02 \times 0.02 \times 0.20m$, and knowing that the resistivity of carbon at 20^{o} C is $\rho_{carbon} = 3.5 \times 10^{-5}\,\Omega.m$.

a) What is the resistance of the block when measured between the two square ends? **(5 points)**

b) What is the resistance of the block when measured between the two opposing rectangular faces? **(5 points)**

VI) **10%** A length l of wire carries a current i:

a) If the wire is turned to a 3-windings circular coil; write an expression for the magnetic dipole moment $\vec{\mu}$ in terms of l and i. **(3.5 points)**

b) In a given homogeneous magnetic field with which the normal to the coil makes an angle θ, express the torque $\vec{\tau}$ properly in terms of l, i and θ, and show the directions of $\vec{\mu}$ and $\vec{\tau}$ on your figure. **(3.5 points)**

c) What is the work required to rotate the coil from θ to 90^o? **(3 points)**

VII) **10%** A metal wire of mass m = *24.1 mg* can slide with negligible friction on 2 horizontal parallel rails separated by distance d = *2.56 cm.* The track lies in a vertical uniform magnetic field of magnitude 73.5 mT. At time t = 0, device G is connected to the rails, producing a constant current i = *9.13 mA* in the wire and rails (even as the wire moves). At t = 61.1 ms, what are the wire's:

a) speed and **(6 points)**

b) direction of motion (left or right)? **(4 points)**