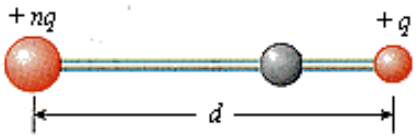
Physics 196 Name _____
Final Test - 120 Point

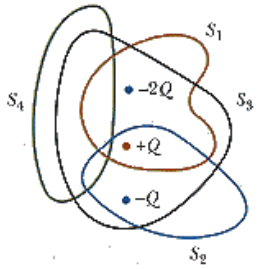
You need to complete **six 5-point problems** and **six 10-point problems**.
*Cross off one 5-point problem and one 10-point problem.*

1. Two small silver spheres, each with a mass of 15.5 g, are separated by 0.075 m. Calculate the fraction of the electrons in one sphere that must be transferred to the other to produce an attractive force of 1.00 x$10^4$ N (about 1 ton) between the spheres. (The number of electrons per atom of silver is 47, molar mass of Ag is 107.87 g/mol.) **(5 points)**

2. Two small beads having positive charges 7$q$ and $q$ are fixed at the opposite ends of a horizontal, insulating rod, extending from the origin (the location of the larger charge) to the point $x = d$. A third small charged bead is free to slide on the rod. At what position is the third bead in equilibrium? (10 Points)




3. Four closed surfaces, $S_1$ through $S_4$, together with the charges 5$Q$, $Q$, and -2$Q$ are sketched. Find the electric flux through each surface. Use the above charges not the charges in the diagram. **(5 Points)**

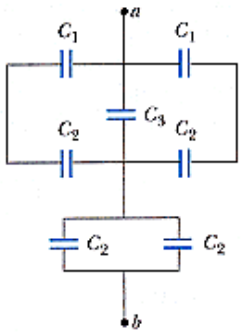


4. A 21.4 g piece of Plastic carries a net charge of -0.920 μC and floats above the center of a large horizontal sheet of plastic that has a uniform charge density on its surface. What is the charge per unit area on the plastic sheet? (10 Points)

5. Electric charge can accumulate on an airplane in flight. You may have observed needle-shaped metal extensions on the wing tips and tail of an airplane. Their purpose is to allow charge to leak off before much of it accumulates. The electric field around the needle is much larger than the field around the body of the airplane and, can become large enough to produce dielectric breakdown of the air, discharging the airplane. To model this process, assume that two charged spherical conductors are connected by a long conducting wire and a charge of 18.6 μC is placed on the combination. One sphere, representing the body of the airplane, has a radius of 7 cm, and the other, representing the tip of the needle, has a radius of 2.50 cm. (a) What is the electric potential of each sphere? (b) What is the electric field at the surface of each sphere? (10 Points)

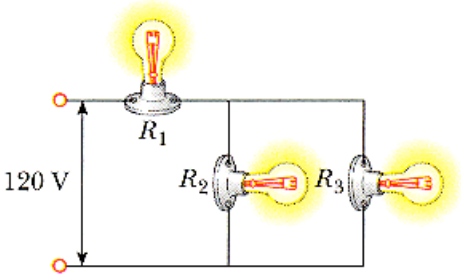
6. Regarding the Earth and a cloud layer 1100 m above the Earth as the "plates" of a capacitor, calculate the capacitance. Assume the cloud layer has an area of 1.5 $km^2$ and that the air between the cloud and the ground is pure and dry.Assume charge builds up on the cloud and on the ground until a uniform electric field of $3.00 \times 10^6$ N/C throughout the space between them makes the air break down and conduct electricity as a lightning bolt. What is the maximum charge the cloud can hold? **(5 Points)**

7. Find the equivalent capacitance between points *a* and *b* for the group of capacitors connected as shown. Take $C_1$ = 6.80 μF, $C_2$ = 14.2 μF, and $C_3$ = 2.50 μF. **(5 Points)**

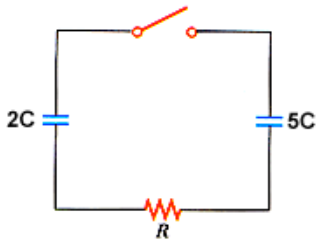



8. A teapot with a surface area of 1250 $cm^2$ is to be silver plated. It is attached to the negative electrode of an electrolytic cell containing silver nitrate ($Ag^+ NO_3^-$). If the cell is powered by a 23 V battery and has a resistance of 2.7 ohms , how long does it take for a 0.283 mm layer of silver to build up on the teapot? (The density of silver is 10.5 x $10^3$ $kg/m^3$.) (10 Points)

9. Three 100.0 W, 120 V lightbulbs are connected across a 120 V power source, as shown. (a) Find the total power delivered to the three bulbs. (b) Find the voltage across each. (Assume that the resistance of each bulb is constant). **(5 Points)**

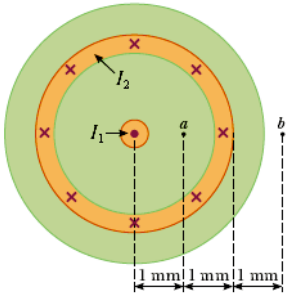


10. A charge $Q$ is placed on a capacitor of capacitance $2C$. The capacitor is connected into the circuit shown, with an open switch, a resistor, and an initially uncharged capacitor of capacitance $5C$. The switch is then closed and the circuit comes to an equilibrium. (a) In terms of $Q$ and $C$, find the final potential difference between the plates of each capacitor. (b) Find the charge on each capacitor. (c) Find the final energy stored in each capacitor. (10 Points)

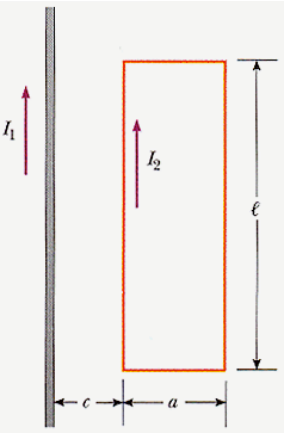



11. A singly charged positive ion has a mass of $3.20 \times 10^{-26}$ kg. After being accelerated from rest through a potential difference of 813 V, the ion enters a magnetic field of 0.840 T along a direction perpendicular to the direction of the field. Calculate the radius of the path of the ion in the field. **(5 Points)**

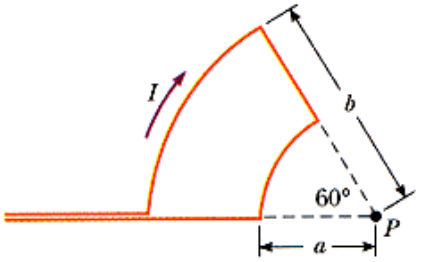
12. A cross-sectional view of a coaxial cable. The center conductor is surrounded by a rubber layer, which is surrounded by an outer conductor, which is surrounded by another rubber layer. The current in the inner conductor is $I_1 = 1.20$ A out of the paper, and the current in the outer conductor is $I_2 = 3.18$ A into the paper. Determine the magnitude and direction of the magnetic field at point $a$. Determine the magnitude and direction of the magnetic field at point $b$. **(5 Points)**



13. The current in the long, straight wire is $I_1 = 6.00$ A and the wire lies in the plane of the rectangular loop, which carries the current $I_2 = 10.0$ A. The dimensions are $c = 0.100$ m, $a = 0.150$ m, and $l = 0.600$ m. Find the magnitude and direction of the net force exerted on the loop by the magnetic field created by the wire. (5 Points for answer) (5 points for deriving the equation)




14. Consider the current-carrying loop shown in Figure P30.12, formed of radial lines and segments of circles whose centers are at point *P*. Find the magnitude and direction of **B** at *P*. What is the direction of the magnetic field? (10 points)



You need to do one of the following two problems.

1. Suppose the switch has been closed for a length of time sufficiently long for the capacitor to become fully charged. ( V= 18.90 V, $r_1$ = 8.0 kohms, and $r_2$ = 22.0 kohms.) (a) Find the steady-state current in each resistor. (b) Find the charge $Q$ on the capacitor. (c) The switch is opened at $t$ = 0. Write an equation for the current $I_{R2}$ in $R_2$ as a function of time. You need to draw two diagrams explaining what is happening.

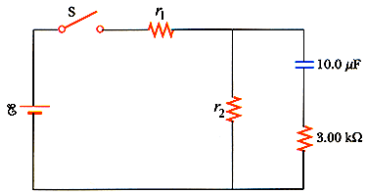



Diagram 10 Reasoning 10 Solution 10

You need to do one of the following two problems.

2. A nonconducting sphere has mass 105 g and radius 24 cm. A flat compact coil of wire with 5 turns is wrapped tightly around it, with each turn concentric with the sphere. The sphere is placed on an inclined plane that slopes downward to the left, making an angle of $\theta$ with the horizontal, so that the coil is parallel to the inclined plane. A uniform magnetic field of 0.568 T vertically upward exists in the region of the sphere. What current in the coil will enable the sphere to rest in equilibrium on the inclined plane? Draw your own Diagram and FreeBody Diagram.

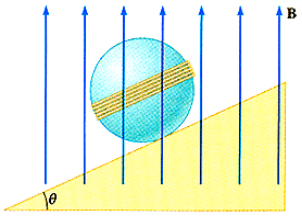



Diagram 10 Reasoning 10 Solution 10