Georgia Tech | Center for Academic Success

# PHYS 2212 TRADITIONAL READING DAY STUDY SESSION WORKSHEET

PROBLEMS

CHARGE AND CHARGE DISTRIBUTION

1. A thin insulating rod is bent into a semi-circle with radius R. The linear charge density, λ, of the rod depends on the angle, θ, according to $\lambda = \lambda_0 \frac{\theta^2}{\sin\theta}$ where λ_0 is a positive constant. What is the magnitude of the electric field at the center of the semi-circle? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants.
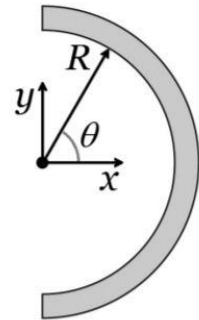
2. If $q = 2.0\,nC$, $q' = 5.0\,nC$, $L = 3.0\,mm$, and $\theta = 41$ degrees. Calculate the magnitude of the net electrostatic force on charge q'. Draw a vector representing the direction of the electric field at charge q' due to the other two charges.
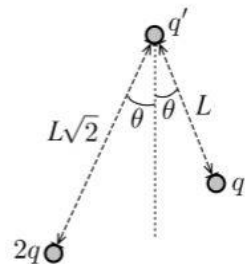

3. A $2.0\,\mu g$ dust particle, that has a charge of $q = +3.0\,nC$, leaves the ground with an upward initial speed of $v_0 = 1.0\,m/s$. It encounters a $E = 400.0\,N/C$ electric field which is slanted $\theta = 30.0°$ from the vertical, as shown. What maximum height above the ground does the particle reach? (Neglect gravity and drag)

Georgia Tech | Center for Academic Success
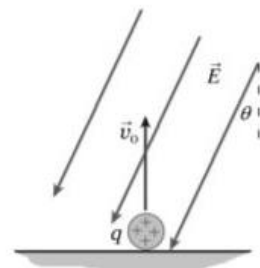
Flux, Energy, and Potential

4. The figure shows two locations inside an ideal parallel plate capacitor.

   (a) If the potential is zero at the negative plate, what is the ratio of the potential at point 2 to that at point 1?

   (b) If the potential is zero at the positive plate, what is the ratio of the potential at point 2 to that at point 1?

   (c) What is the direction of the potential half-way between points 1 and 2?

   (d) If an electron at point 2 has velocity v towards the positive plate, is potential energy increasing or decreasing? What about for a proton?
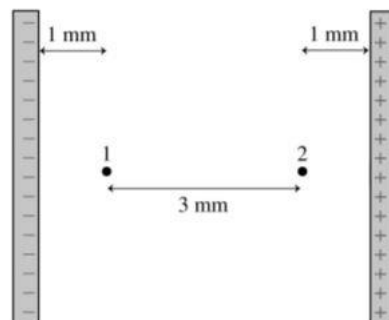

5. A very long, uniformly charged insulating cylinder has radius R and linear charge density λ. FInd the electric field magnitude at a distance $r = R/2$ from the cylinder axis. Express your answer in terms of parameters defined in the problem, and physical mathematical constants.

6. A system of two charged particles $3.0\,cm$ apart has an electric potential energy of $93.5\,\mu J$, with respect to zero at infinite separation. The total charge in the system is $37\,nC$. What is the charge of each particle?

Circuits

7. Use the circuit diagram to the right to answer the following questions.

   (a) The switch S has been open for a long time. Immediately upon closing it, what current is supplied by the battery?

   (b) The switch S has been closed for a long time. What current is supplied by the battery?
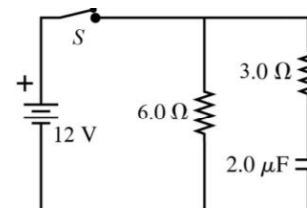

8. Use the circuit diagram to the right to answer the following questions.

   (a) The network of capacitors shown is connected to a battery of emf $E = 24\,V$ where $C = 6.0\,nF$. Calculate the potential energy U_0 stored in the network of capacitors once equilibrium is reached, relative to zero in the uncharged state.

   (b) The emf of the battery is increased to $E = 48\,V$. How much potential energy U is now stored in the network of capacitors?
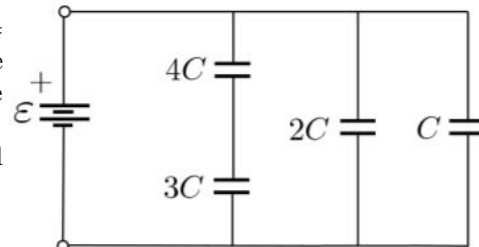

9. The starter motor of a car engine draws a current of $220\,A$ from the battery. The copper wire to the motor has a conduction-electron density of 8.5×1028 per cubic meter. It is $3.8\,mm$ in diameter and $1.5\,m$ long. The starter motor runs for $1.2\,s$ until the car engine starts.

   (a) How far does an electron travel along the wire while the starter motor is on?

   (b) If the $220\,A$ flowed through an iron wire rather than a copper wire, how would the distance traveled by an electron compare? Iron has a conduction-electron density about twice that of copper.

10. When a $6\,V$ battery is connected across a solid conducting slab as shown on the left diagram, a current of $3.0\,A$ flows through the circuit. What is the current if instead the battery is connected as shown on the right diagram?

Georgia Tech | Center for Academic Success
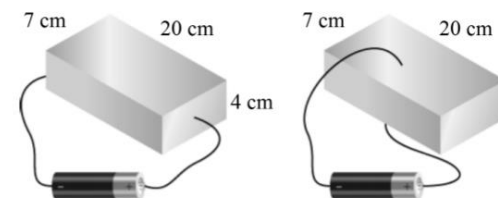
MAGNETISM

11. A bar (mass m, length L) is connected to two frictionless vertical conducting rails with loops of wire, in the presence of a uniform magnetic field B. The tops of the rails are connected through a resistor R. When released from rest, the bar slides down the rails, accelerating more and more slowly until it reaches a constant terminal speed v. Find an expression for v in terms of parameters defined in the problem and physical or mathematical constants. (On Earth. Do NOT neglect gravity.)
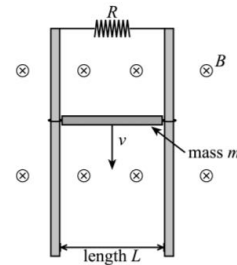
12. An infinitely long thin wire and a current loop of radius R lie in the same plane and are touching as shown. A current I flows in the wire and in the loop in the directions indicated on the drawing. What is the magnitude of the magnetic field at point P?
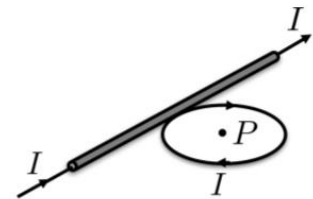
13. An infinitely long straight wire of radius R carries a non-uniform current density $\vec{J}(r) = J_0\left(\dfrac{R}{r}\right)\hat{k}$ distributed along its cross-section, where r is the distance from the center of the wire. The value J_0 is the current density magnitude at the surface of the wire.
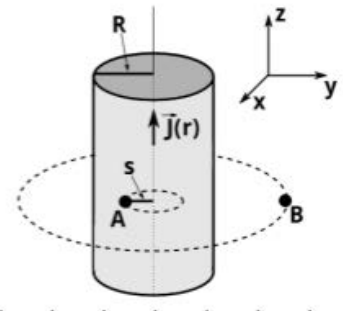
(a) Determine the magnitude and direction of the magnetic field at the point A that is distance s away from the wire center and inside the wire. Express your answer in terms of the parameters defined in the problem and physical or mathematical constants.

(b) What is the magnitude and direction of the magnetic field at point B that is a distance $r = 2R$ away from the wire center?

14. A wire is bent into a loop that is composed of two semicircular arcs that are joined at their ends as shown in the diagram. The upper arc has radius R and the lower arc has a radius of $2R$. A current passes through the wire clockwise. What is the magnitude of the magnetic field at the center of both semicircular arcs?
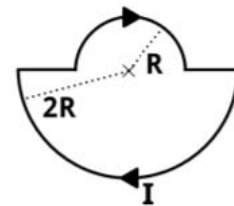
15. A solenoid coil having self-inductance L is placed in a circuit. A time-dependent current is driven through the inductor, given by the expression:

$$i(t) = I_1\left(\frac{t}{T} - \frac{t^2}{T^2}\right) \quad for \quad 0 \le t \le T$$

Where I_1 is a constant having units of current, and T is a constant having units of time. (Note that at $t = 0$ and $t = T$, the current is precisely <u>zero</u>.)

(a) Determine the potential difference $\Delta V_L \equiv V_b - V_a$ across the inductor, as a function of time. During what times in the range $[0, T]$ is the inductor acting to *oppose* the flow of current, and during what time is it acting to *sustain* the flow?

(b) What is the maximum energy stored in the inductor? At what time in the range $[0, T]$ does this occur?
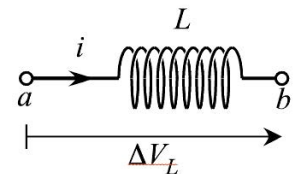
16. The figure at right shows a five-turn coil of diameter $d = 1.0$ cm, having resistance $R = 2\Omega$, which lies inside a solenoid of diameter $D = 2.0$ cm. The solenoid has length $L = 6$ cm, and $N = 100$ turns. Below the figure is a plot of the current in the solenoid as a function of time, with a positive value for the current denoting a counterclockwise flow of charge around the solenoid, when seen from the left.

   (a) Determine the magnitude and direction of the current in the coil at $t = 1.5$ sec.

   (b) At right is an end-on view of the coil inside the solenoid (seen from the left) at time $t = 1.1$ sec. Consider a small segment of length $ds = 1mm$ at the top of each loop. What is the magnitude and direction of magnetic force acting on this segment of the <u>coil</u> at this moment of time? (Hint: include all five loops in your analysis.)