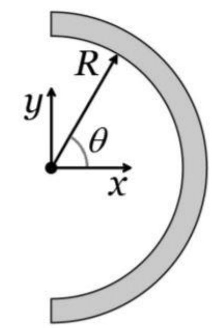
PHYS 2212 TRADITIONAL READING DAY STUDY SESSION WORKSHEET

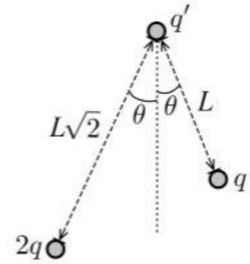
Problems

Charge and Charge Distribution

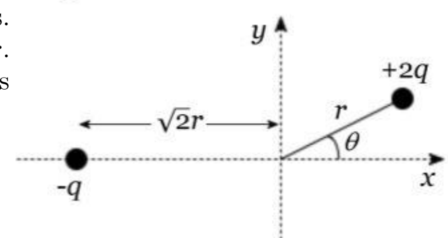
1. A thin insulating rod is bent into a semi-circle with radius R. The linear charge density, λ, of the rod depends on the angle, θ, according to $\lambda = \lambda_0 \frac{\theta^2}{\sin\theta}$ where λ_0 is a positive constant. What is the magnitude of the electric field at the center of the semi-circle? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants.



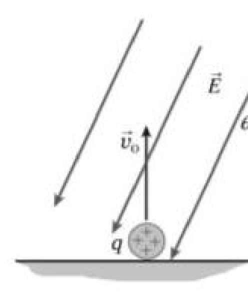
2. If $q = 2.0\,nC$, $q' = 5.0\,nC$, $L = 3.0\,mm$, and $\theta = 41$ degrees. Calculate the magnitude of the net electrostatic force on charge q'. Draw a vector representing the direction of the electric field at charge q' due to the other two charges.



3. A particle with positive charge $+2q$ can be positioned anywhere on a circle of radius r around the origin, making an angle θ with respect to the $+x$-axis. A particle with negative charge $-q$ is located on the x-axis at $x = -\sqrt{2}r$. In terms of q, r, θ and fundamental physical and mathematical constants as needed, what is the magnitude of the net electric field at the origin.

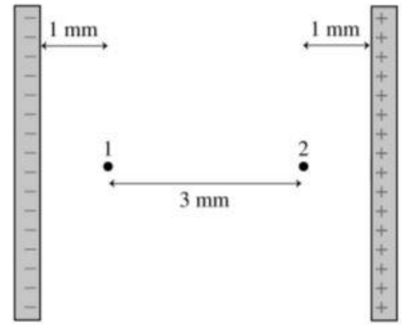


4. A $2.0\,\mu g$ dust particle, that has a charge of $q = +3.0\,nC$, leaves the ground with an upward initial speed of $v_0 = 1.0\,m/s$. It encounters a $E = 400.0\,N/C$ electric field which is slanted $\theta = 30.0°$ from the vertical, as shown. What maximum height above the ground does the particle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



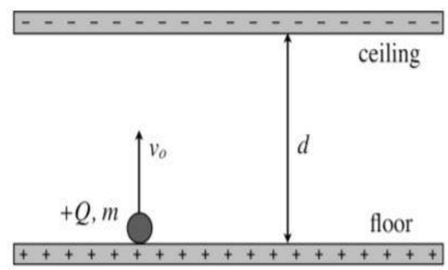
Flux, Energy, and Potential

5. 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?



6. 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.

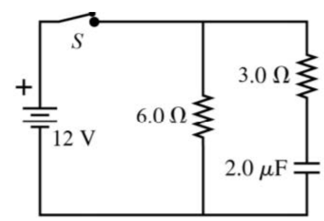
7. A room with separation d between the floor and ceiling has a positively charged plate on the floor and a negatively charged plate on the ceiling. A glass bead with mass m and positive charge $+Q$ is launched straight up from the floor with speed v_0. The bead travels for an interval of time Δt before it stops and reverses its motion towards the floor.
   (a) Find the electric potential difference ΔV between the plates in terms of parameters defined in the problem and physical or mathematical constants. (On Earth)
   (b) What voltage difference would allow the bead to drift to the ceiling with initial speed v_0 after it is launched?



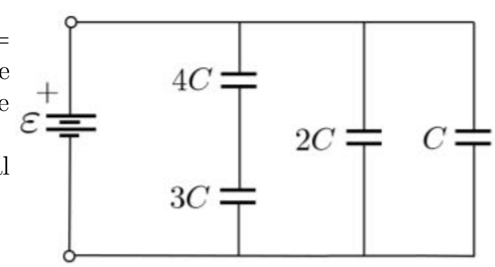
8. A system of two charged particles $3.0\,cm$ apart has an electric potential energy of $93.5\,\mu J$, with respect to zero at infinite separation. The total charge in the system is $37\,nC$. What is the charge of each particle?

Circuits

9. 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?



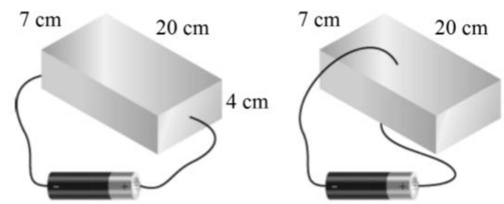
10. Use the circuit diagram to the right to answer the following questions.
   (a) The network of capacitors shown is connected to a battery of emf $E = 24\,V$ where $C = 6.0\,nF$. Calculate the potential energy U_0 stored in the network of capacitors once equilibrium is reached, relative to zero in 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?



11. 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?

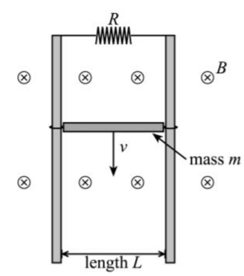
(b) If the 220 A flowed through an iron wire rather than a copper wire, how would the distance traveled by an electron compare? Iron has a conduction-electron density about twice that of copper.

12. 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?

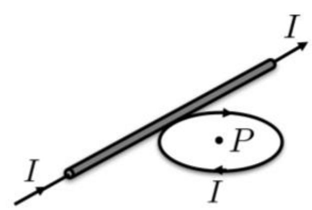


Magnetism

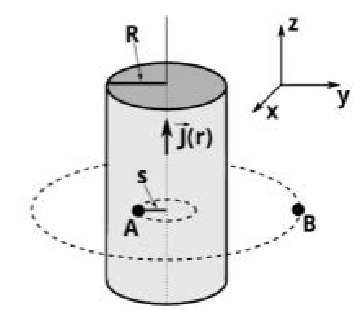
13. A bar (mass m, length L) is connected to two frictionless vertical conducting rails with loops of wire, in the presence of a uniform magnetic field B. The tops of the rails are connected through a resistor R. When released from rest, the bar slides down the rails, accelerating more and more slowly 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.)



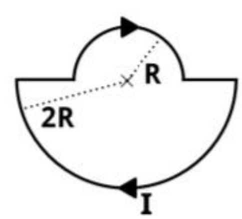
14. A infinitely long thin wire and a current loop of radius R lie in the same plane and are touching as shown. A current I flows in the wire and in the loop in the directions indicated on the drawing. What is the magnitude of the magnetic field at point P?



15. An infinitely long straight wire of radius R carries a non-uniform current density $\vec{J}(r) = J_0 \left(\frac{R}{r}\right) \hat{k}$ 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?



16. 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?



Answers

Charge and Charge Distribution

1. $E = \frac{K\lambda_0\pi^3}{12R}$

2. $F = 1.5 \times 10^{-2}N$, E vector along the axis.

3. $E = \frac{Kq}{r^2}\sqrt{\frac{17}{4} + 2\cos\theta}$.

4. $y = 0.96m$.

Flux, Energy, and Potential

1. (a) $V_2/V_1 = 4$. (b) $V_2/V_1 = 1/4$. (c) Potential does not have direction. (e) Decreasing, Increasing.

2. $E = \frac{\lambda}{4\pi\epsilon_0 R}$.

3. (a) $V = \frac{dm}{Q}\left(g - \frac{v_0}{\Delta t}\right)$ (Opposite, $-V$ is accepable). (b) $V = mgd/Q$.

4. 24 nC and 13 nC

Circuits

1. (a) 6 A. (b) 2 A.

2. (a) $U = 8.1\mu J$. (b) $U = 4U_0$

3. (a) 1.7×10^{-3} m. (b) $.85 \times 10^{-3}$ m (Half as far).

4. 75 A

Magnetism

1. $v = mgR/L^2B^2$

2. $\frac{\mu_0 I}{2R}\frac{1+\pi}{\pi}$

3. (a) $\vec{B} = \mu_0 J_0 R\hat{i}$. (b) $\frac{-B_0}{2}\hat{i}$.

4. $\frac{3\mu_0 I}{8R}$