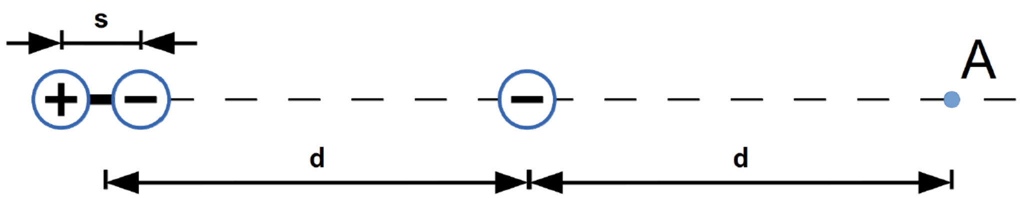
PHYS 2212 (Modern) Review

Electric Force and Fields

A permanent dipole and a charged particle lie on the x-axis and are separated by a distance d as indicated in the figure. The dipole consists of positive and negative charge q separated by a distance s where s << d. The particle has a negative charge –q and is located at x = 0.



a. Determine the magnitude and direction of the force on the point charge due to the permanent dipole. To earn full credit, you must show your work.
b. What is the magnitude and direction of the net electric field at location A, a distance d to the right of the charged particle?
c. A neutral atom that consists of positive and negative charge 2q is placed at location A. This neutral atom has a known polarization α. Sketch the polarized atom at location A and determine the separation length of the induced dipole.

vPython (Electric and Magnetic Fields)

The following program is intended to calculate and display the electric and magnetic field at a specified observation location. Complete the program below by filling in the missing VPython code. When possible, please use the names already defined in the program.

```
from visual import * ## Constants
mzofp = 1e-7
oofpez = 9e9

qe = 1.6e-19

## Objects
proton = sphere(pos=vector(3e-10,0,0), radius=1e-11, color=color.red) velocity =
vector(-5.2e4,0,0) # The proton's velocity
r_obs = vector(0,8e-11,0) # The observation location
deltat = 1e-19 # Timestep

while proton.x < 5e-10:
```

Fill in the missing code needed to calculate the electric and magnetic field vector at the observation location

```
# Update the proton's position
proton.pos = proton.pos + velocity*deltat
```

Polarization

A neutral rod made of an unknown material is brought near a charged metal sphere. (The rod is held by rubber insulating supports). Once end of the rod touches the metal sphere, and then the rod is pulled away. You bring a negatively charged piece of tape near the rod and observed that the tape is repelled. The tape is repelled no matter what part of the rod you held the tape near to.

a. Circle “T” next to each true statement below or “F” for every false statement.

T F The rod is conductive.

T F The rod has a net positive charge after touching the metal sphere.

T F The magnitude of the charge on the metal ball is lower after the rod touches it.

T F Electrons flowed from the metal sphere to the rod while they were in contact.

You now touch the rod. After doing this, you observe that the charged tape is no longer repelled by any part of the rod.

b. Circle “T” next to each true statement below or “F” for every false statement.

T F While touching the rod, chloride ions (Cl^-) from the salt water on your skin moved onto the rod.

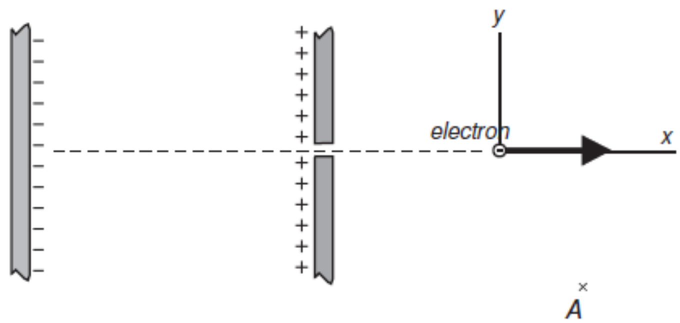
T F While touching the rod, sodium ions (Na^+) from the salt water on your skin moved onto the rod.

T F Electrons from the mobile electron sea in your hand move onto the rod.

T F Protons are pulled out of the nuclei of atoms in your hand and move onto the rod.

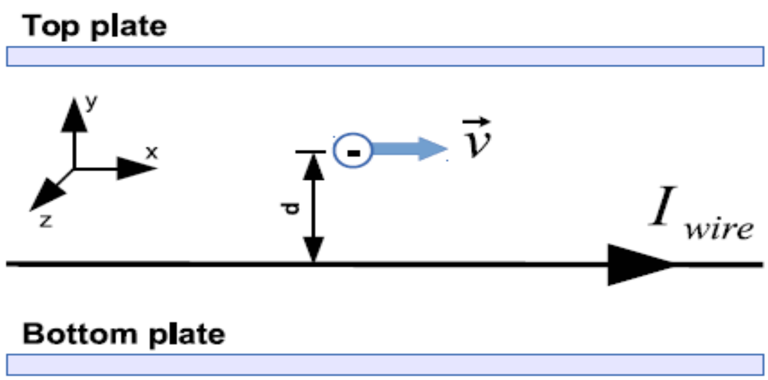
T F Protons are pulled out of the nuclei of atoms in the rod and move onto your hand.

Magnetic Field & Forces



An electron starts from rest near a negatively charged metal plate, and is accelerated toward a positive plate, through a potential difference of 1500 volts. The electron passes through a hole in the positive plate, into a region where the electric field is negligible, Take the position of the electron at the instant shown in the diagram to be the origin with the x and y axes as shown, and the z axis out of the page (toward you). Find the magnetic field at location A <0.005, -0.01, 0> meters, due to the moving electron. Your answer must be a vector. Clearly show all steps in your work.

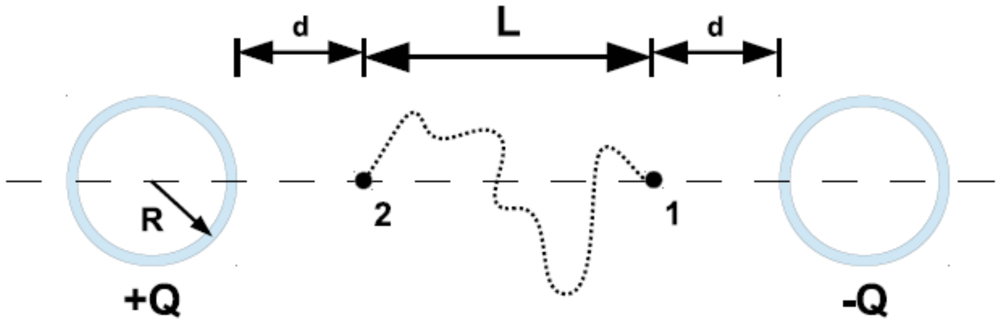
A long straight wire lies between two **uncharged** capacitor plates of area A. The wire is oriented along the x-axis and a conventional current I runs through the wire in the +x direction. At a particular instant, an electron travelling in the +x direction with speed v passes a distance d above the center of the wire. The distance d is much less than the length of the wire.



a. Calculate the force on the electron at this instant. Your answer must be a vector. Show your work. If you made any assumptions or approximations, state them.
b. This experiment is now repeated with **charged** plates and the electron is observed to travel in a straight line at a constant speed. Determine the magnitude of the charge of the plates.
c. What is the sign of the charge on the top plate from part (b)?
d. How would your answer to part (b) change if the charged particle (the electron were replaced with a proton? Briefly explain.

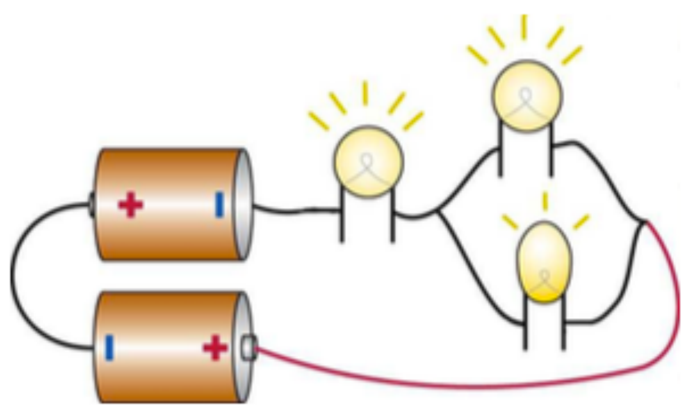
Electric Potential

A thin spherical glass shell of radius R carries a uniformly distributed charge +Q. An identical shell carries a uniformly distributed charge −Q. The distance between the center of each shell is 2(R+d)+L. Calculate the potential difference V_1-V_2 between the two shells along the indicated meandering path (as shown in the diagram). Be sure to show all of you work to earn partial credit.

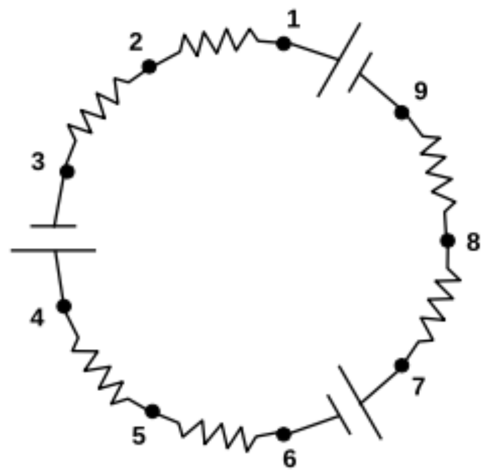


Circuits

In lab, you used round and oblong light bulbs and measured the current in these bulbs when you hooked them up to a battery. You connect a single round bulb to a single battery and measure a current I_r in the bulb. You then connect a single oblong bulb to a single battery and measure a current I_o in the bulb. Two round bulbs and a single oblong bulb are now connected with two batteries as indicated in the diagram. Determine the current through the oblong bulb. Be sure to show all of you work and start from a fundamental principle.



Three identical batteries (each with an emf equal to V) are connected to six identical resistors (each with resistance R) as shown in the diagram below.



a. The current I in the circuit is (circle one)

0 2V/R 3V/R V/2R V/3R 6V/R

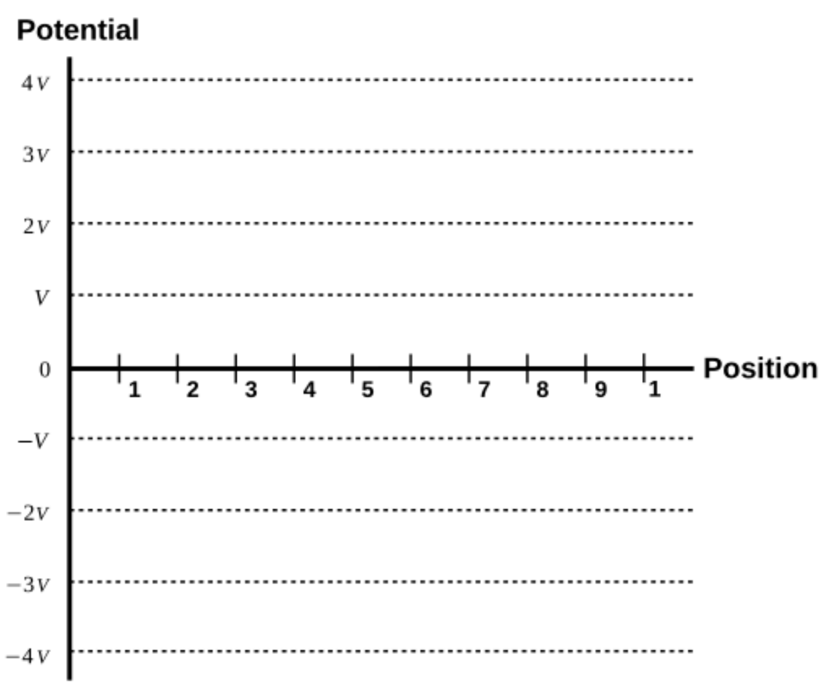
b. The potential difference V_1-V_3 is (circle one)

V V/2 0 3V/2 V/3 3V

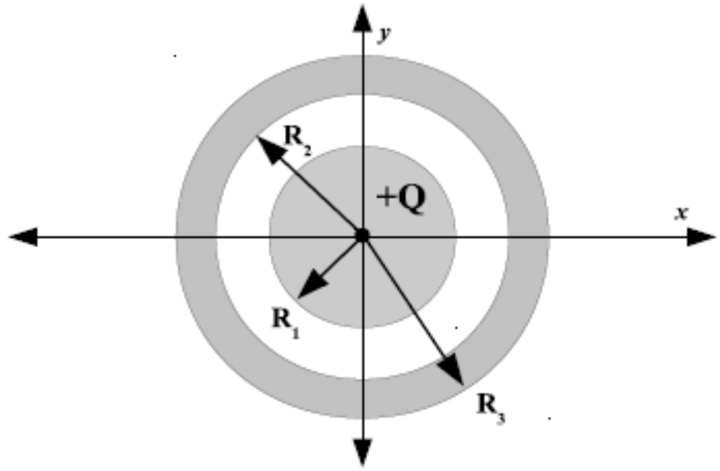
c. The potential difference V_5-V_8 is (circle one)

V V/2 0 3V/2 V/3 3V

d. On the plot below, draw an accurate graph of how the electric potential varies around the circuit.



Gauss's Law

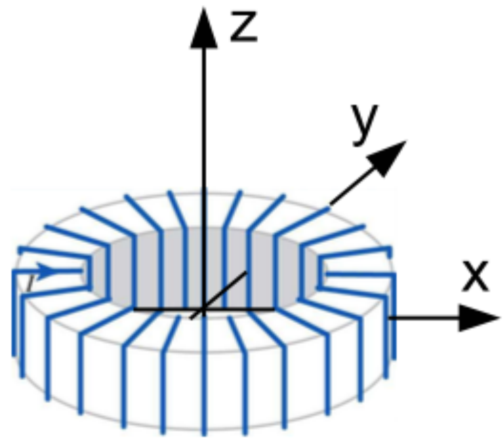


The figure above shows a solid glass sphere of radius R_1 with charge +Q (Q > 0) distributed uniformly throughout the volume. This sphere is centered within a neutral conducting spherical shell. The inner radius of this shell is R_2, and the outer radius is R_3. For the following questions, consider a spherical Gaussian surface center on the origin. The system is in equilibrium.

a. At a distance r, such that $0 < r < R_1$, use Gauss's law to determine the magnitude of the net electric field. Please show your work.
b. At a distance r, such that $R_1 < r < R_2$, use Gauss's law to determine the magnitude of the net electric field. Please show your work.
c. On the diagram indicate how the neutral shell is polarized. Briefly explain how you know this.
d. At a distance r exterior to the shell, such that $r > R_3$, use Gauss's law to determine the magnitude of the net electric field. Please show your work.

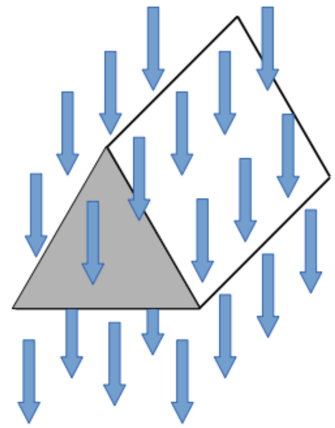
Ampere's Law

A toroid, is a "doughnut" wrapped with loops of current that is essentially a solenoid bent around to make the ends meet. The toroid shown in the diagram has an inner radius R_i and an outer radius R_o and is centered at the origin as indicated in the diagram. The z-axis passes through the center of the doughnut hole. This toroid is wrapped with N loops of current I flowing up the outside surface of the toroid, radially inward, down the inner surface, and then radial outward. Assume that the magnetic field produced by this toroid has the form $\vec{B} = B(r, z)\hat{\phi}$ **at every point in space** where r is the perpendicular distance from the z-axis and $\hat{\phi}$ is a unit vector which "curls" around the z-axis, i.e., it is always tangent to any circle with rotational symmetry around the z-axis.



a. Consider a z-axis centered Amperian loop in the plane of the toroid, at $z = 0$, with a radius $r < R_i$ and use it to find the magnitude of the magnetic field inside the inner radius of the toroid.
b. Consider a z-axis centered Amperian loop in the plane of the toroid, at $z = 0$, with a radius $r > R_o$ and use it to find the magnitude of the magnetic field outside the outer radius of the toroid.
c. Consider a z-axis centered Amperian loop in the plane of the toroid, at $z = 0$, with a radius $R_i < r < R_o$ and use it to find the magnitude of the magnetic field inside the loops of the toroid.
d. Consider a z-axis centered Amperian far above the toroid $z >> R_o$, with a radius $R_i < r < R_o$ and use it to find the magnitude of the magnetic field far above the toroid.

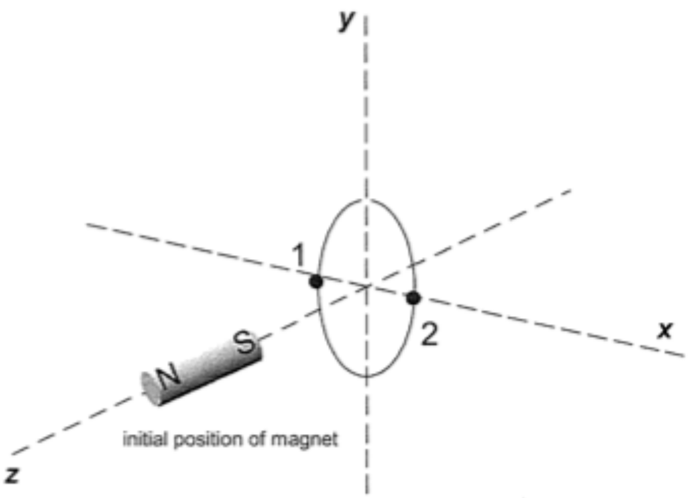
Electric Flux



Two equilateral triangles (each with sides of length *d*) are connected to three identical rectangles (each with sides of length *d* and *L*). these five surfaces form a tent which completely encloses the volume indicated in the diagram. At every point in the space, there is a constant, downward-pointing electric field with magnitude *E*.

a. Calculate the electric flux through the front surface of the tent (the shaded triangle). Show your work here and in all subsequent parts.
b. Calculate the electric flux through the back surface of the tent (the triangle not seen in the diagram).
c. Calculate the electric flux through the top right rectangular surface of the tent (the white rectangle seen in the diagram).
d. Calculate the electric flux through the bottom rectangular surface of the tent (not seen in the diagram but connected to the flat bottom of both triangles).
e. Calculate the total charge enclosed in the tent. To earn credit, you must show how you determined this.

Magnetic Flux/Induced Current



The north pole of a bar magnet points away from a thin circular loop of wire. The thin loop has a radius of 0.01m and lies in the xy plane centered at the origin. The magnet is moving away from the loop along the positive z-axis at a constant speed. At time t_1, the center of the bar magnet is 0.09m from the center of the loop, and 0.01 seconds later (at time t_2) the center of the magnet is 0.13m from the center of the loop. Assume that at any given instant in time the magnetic field produced by the magnet is uniform over the area enclosed by the loop. *Note that the diagram is not to scale.*

Pick one of the following for each of the questions (a) – (e):

+x **-x** **+y** **-y** **+z** **-z** **zero**

a. At time t1, what is the direction of the magnetic field $\vec{B}_i$ at the center of the loop, due to the magnet?
b. At time t2, what is the direction of the magnetic field $\vec{B}_f$ at the center of the loop? *Your answer must be consistent with part (a).*
c. What is the direction of $-\frac{d\vec{B}}{dt}$ at the center of the loop as the magnet is being moved? *Your answer must be consistent with parts (a) and (b).*
d. What is the direction of the conventional current in the loop at location 1 as the magnet is being moved? *Your answer must be consistent with part (c).*
e. What is the direction of the conventional current in the loop at location 2 as the magnet is being moved? *Your answer must be consistent with part (d).*
f. The bar magnet has a magnetic dipole moment of 1.5Am2 and the loop has a total resistance of 10 ohms. Determine the magnitude of the conventional current induced in the loop.

PHYS 2212 Modern Reading Day Study Session - Fall 2017 (Solutions)

Electric Force and Fields

1. -

vPython (Electric and Magnetic Fields

1. .

```
r=r-obs-proton.pos
rhat=r/mag(r)
Efield=oofpez*qe*rhat/(mag(r)**2)
Bfield=mzofp*qe*cross(velocity,rhat)/(mag(r)**2)
```

Polarization

1. -

Magnetic Field & Forces

1. -

2. -

Electric Potential

1. -

Circuits

1. $2\left(\frac{I_r I_o}{I_0+2I_r}\right)$

2. (a) $\frac{V}{2R}$. (b) V. (c) 0.

Gauss's Law

1. -

Ampere's Law

1. (a) 0. (b) 0. (c) $\frac{N_0 NI}{2\pi r}$: $-0.5, -1.5, -3.0, -8.0$. (d) 0.

Electric Flux

1. (a) 0. (b) 0. (c) $-\frac{1}{2}EdL$. (d) EdL. (e) 0.

Magnetic / Induced Current

1. (a) $+z$. (b) $+z$. (c) $+z$. (d) $-y$. (e) $+y$.