General Physics - E&M (PHY 1308) Lecture Notes

Homework002

SteveSekula, 29 August 2010 (created 26 August 2010)

no tags

Homework 2

Expectations for the quality of your handed-in homework are available at http://www.physics.smu.edu/sekula/phy1308/homework.pdf. Failure to meet these guidelines will result in loss of points as detailed in that document. This assignment covers material from Wolfson Chapter 20.4-20.5, and 21.1-21.3. Each problem is worth 20 points, and the total assignment is worth 80 points. You are not required to do the Bonus Exam Points Competition (it doesn't count against you to not participate, but it IS worth extra points on the first in-class exam if you come in 1st, 2nd, or 3rd place - see the rules below).

This homework is due in my mailbox in Fondren Science 102 no later than 5:00pm on Tuesday, September 7

Reading Assignment:

Chapter 20.4-20.5, Chapter 21.1-21.3

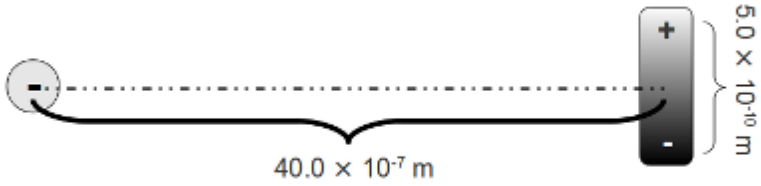
Problems:

Problem SS-4

A dipole (see illustration below), with charges $+4.0 \times 10^{-8}$ C and -4.0×10^{-8} C and separation between the charges of 5.0×10^{-10} m, is located 40.0×10^{-7} m from another charge $Q = -20.0 \times 10^{-8}$ C. The dipole moment vector is oriented perpendicular to the line between Q and the point halfway

between the ends of the dipole. Using this information,

- What is the net torque on the dipole?
- What is the net force on the dipole?
- What is the direction of the net force?

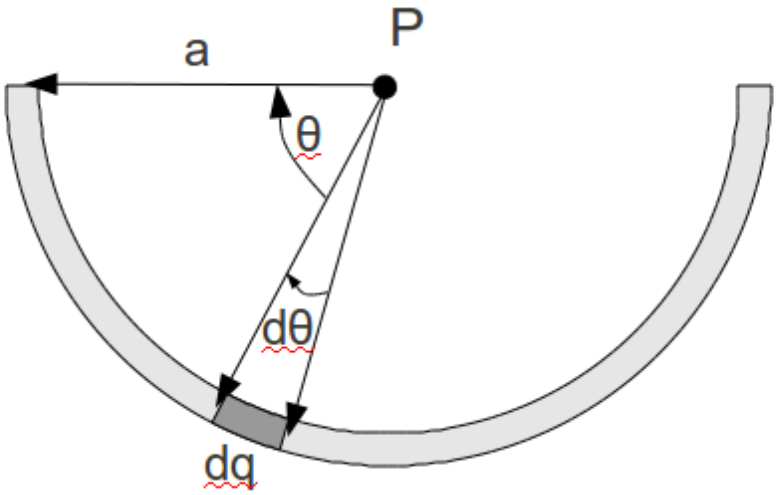


Problem SS-5

Phototubes are light detector devices that are critical components in medical imaging technology (for instance, in combination with light-sensitive crystals in PET scanners. c.f. Johannes Czernin, Magnus Dahlbom, O. Ratib, and Christiaan Schiepers, "Atlas of PET/CT Imaging in Oncology", 2004). A key part of the phototube is a "dynode" - a small, cup-shaped piece of metal that is used to accelerate electrons (amplifying the signal) produced when photons strike the phototube.

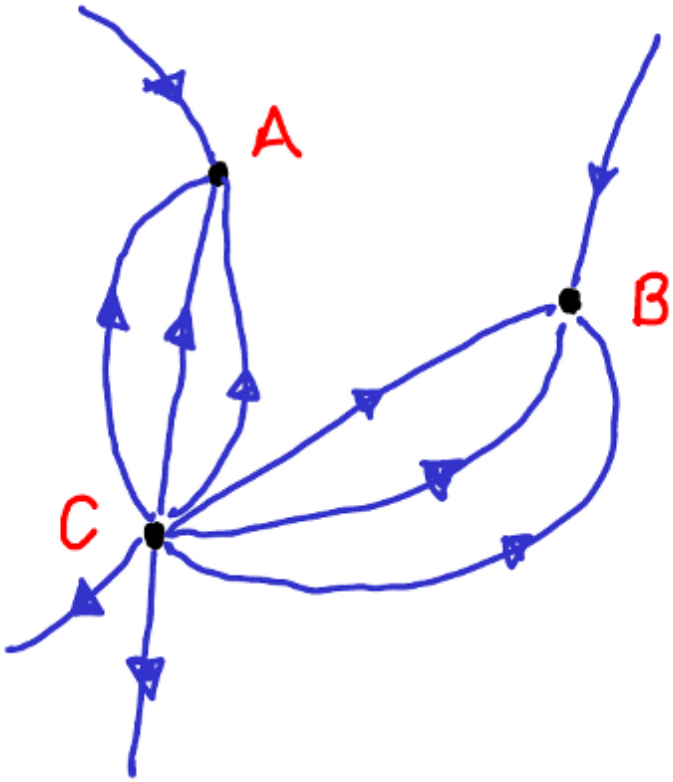
Consider such a cup, in two dimensions, as illustrated below. Treat it as a perfect semicircle of radius a whose center is located at point P. If the cup carries a total electric charge of Q distributed uniformly over its length, determine the electric field $\vec{E}$ at the point P.

Hints: treat the cup as a series of small units of charge, dq (see illustration), and write dq in terms of the small unit of angle $d\theta$ subtended by the small unit of charge. Then integrate over $d\theta$ to obtain the net field at P.



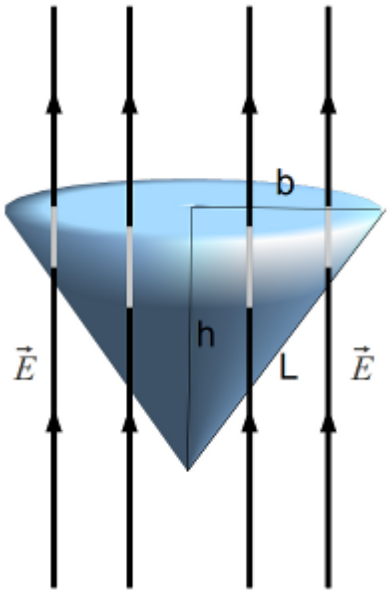
Problem SS-6

Determine the charges of each charge (labeled A, B, and C) in the drawing below. Determine the net charge.

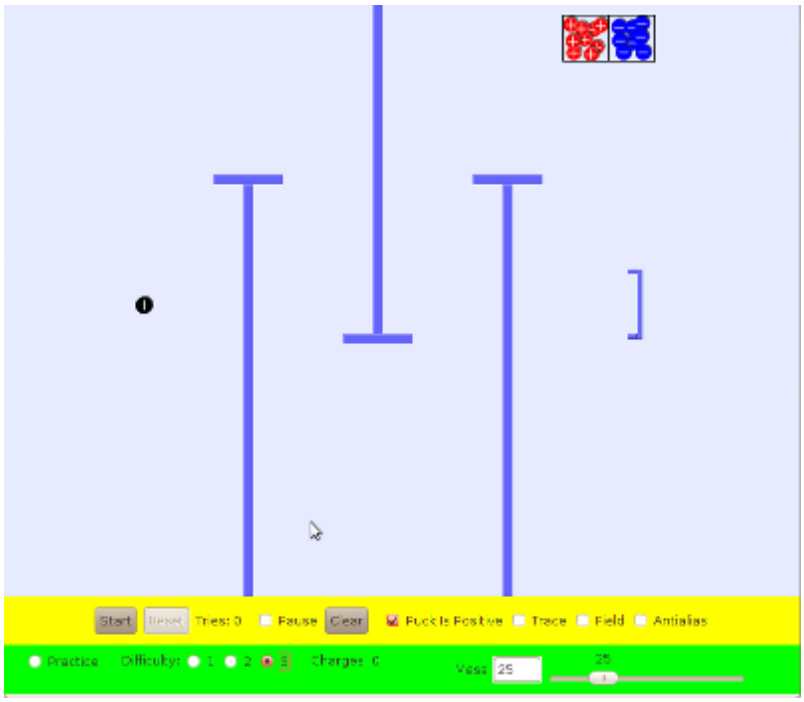


Problem SS-7

The tip of a scanning-tunneling electron microscope, a common tool for imaging the fine detail of viruses and other microscopic structures, can be described as a right cone. That cone is a closed surface with a circular base of radius b, a height of length h, and a hypotenuse of length L (for each right-triangle that makes up a vertical slice of the cone), as in the illustration below. Consider the case where this tip is immersed in a uniform electric field, $\vec{E}$, parallel to the height-axis of the cone. Show that the flux through the tip is consistent with the prediction from Gauss's Law.



Bonus Exam Points Competition: Electric Field Hockey



Welcome to your first bonus points competition. Your job is simple: get the electrically charged puck in the game "Electric Field Hockey" (available from http://phet.colorado.edu/en/simulation/electric-hockey) from its starting point to the goal in the shortest time possible, using as few charges as possible. Results must be submitted electronically (see below) by 5pm on Tuesday, Sept. 7. *If you need access to a computer, let me know.*

Here are the rules:

Rules

1. You must do this on Level 3 of the game (click the "Level 3" radio button at the bottom of the game)
2. You must use the default puck settings (mass=25 and "puck is positive"). Don't change any of these settings.
3. You must put a movie of your performance up on *YouTube* and submit the link to the video as proof of your accomplishment. The movie will tell me the time it took for the puck to go from start to goal. Tips on recording the game are given below.
4. You can work as a team or alone (see below)

Scoring

Your score will be a time. That time will be determined as follows: *the time*

it takes to get to the goal, plus a 0.2 second time penalty for every electric charge you place on the board. Shortest time, determined by this method, wins first place.

Ranking and Points

The shortest time gets 15 bonus points on the first in-class exam. The second-shortest time gets 10 points. The third-shortest time gets 5 points.

Working together is strongly encouraged, but incurs a sharing of points. If two people work together, and they come in first place, they each get 66% of the points (0.66*15=10). If three people work together and come in first place, they each get 33% of the points (0.33*15=5). If four people work together, they each get 15% of the total. Etc. The fraction of points is halved each time after the first team of two. Similarly for second and third place.

Recording the Game

You need to record the game and make a movie, which you can then upload to *YouTube*. Here are programs that let you easily record such a movie on different operating systems:

- Windows: *CamStudio* (http://camstudio.org/) - note, this records audio from your microphone, too, so if you don't want your voice in the movie make sure to disable audio recording.
- Mac: Copernicus (http://www.danicsoft.com/software/copernicus/)
- Linux: "Record My Desktop" (http://recordmydesktop.sourceforge.net/about.php)

I recommend you work on your layout of the charges for directing the puck. Once you have it setup the way you want, then click the "Reset" button one last time, start recording your desktop, and click the "Start" button in the game. Upload the video to *YouTube*, and then send me the link to the video. If you're having trouble getting the video uploaded, let me know and we can arrange a dropoff on a thumbdrive, etc.

Strategy

Remember your basic knowledge about charge! Like charges repel, unlike charges attract. Charges exert a force on each other, accelerating the motion of the puck. You can speed up the puck by attracting it toward a

location or repelling it from a location. Combinations of charges will be needed to keep the puck from touching the walls or flying off the board. If you'd like to see the path of the puck, turn on "Trace" (at the bottom of the game window)

Good luck, and have fun!