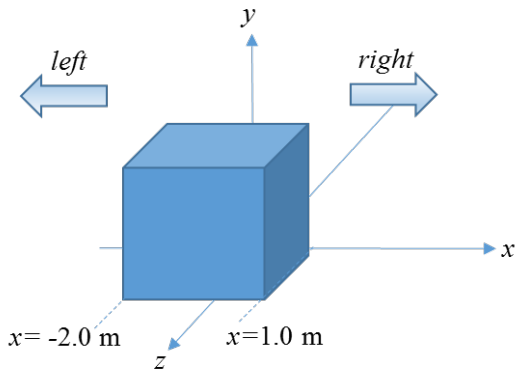
PHY1202
Assignment 2
Due Date: 11:59 pm Sunday, October 18th, 2020
Please submit your assignment to the Assignment Collection Box outside PHY General Office G6702
(Total 100 marks)

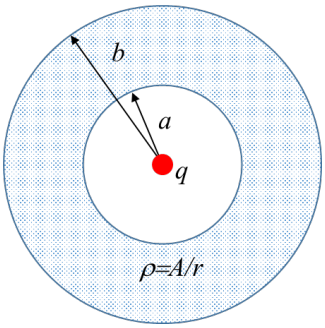
Lecture 04: Gauss's Law

L04-01 (10 marks) A non-uniform electric field $\vec{E} = 3.0x\hat{i} + 4.0\hat{j}$ N/C pierces the Gaussian cube shown in the below figure. (a) What is the electric flux through the right face, the left face, and the top face (b) Find the charge q_{enc} enclosed by the cube.

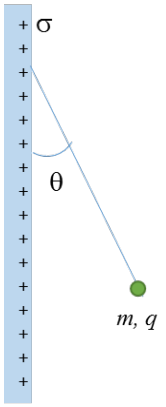


L04-02 (10 marks) A non-conducting spherical shell of inner radius $a=2.00\ cm$ and outer radius $b=2.40\ cm$ has a positive volume charge density $\rho=A/r$, where A is a constant and r is he distance from the center of the shell. In addition, a small point charge $q=45.0$ fC is located at the center. What value should A have if the electric field in the shell $(a \le r \le b)$ is to be uniform?

(Note: $1\,\text{fC} = 1\times10^{-15}\,\text{C}$)



L04-03 (10 marks) A small, nonconducting ball of mass $m = 1.0\,\text{mg}$ and charge $q = 2.0\times10^{-8}\,\text{C}$ (distributed uniformly through its volume) hangs from an insulating thread that makes an angle $\theta = 30°$ with a vertical, uniformly charged nonconducting sheet, as shown in the figure. Consider the gravitational force on the ball and assuming the sheet extends far vertically and into and out of the page, calculate the surface charge σ of the sheet.

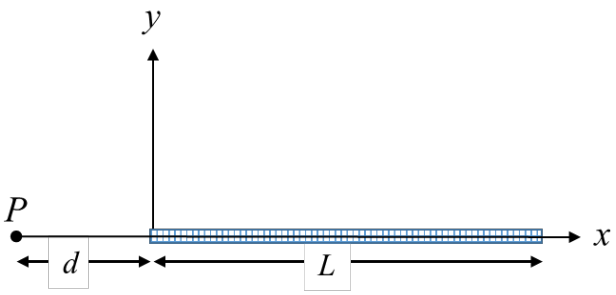


Lecture 05: Electric Potential

L05-01 (10 marks) Two very large, parallel, conducting plates are 12 cm apart and have charges of equal magnitude and opposite sign on their facing surfaces. An electrostatic force of 3.3×10^{-15} N acts on an electron placed in between the plates and away from the edges of the plates. (a) Find the electric field at the position of the electron. (b) What is the potential difference between the two plates?

L05-02 (10 marks) In the rectangle of the below Figure, the sides have lengths 5.0 cm and 15 cm, q_1 = -5.0 μC, and q_2 = +2.0 μC. With V = 0 at infinity, what are the electric potentials (a) at corner A and (b) at corner B? (c) How much work is required to move a third charge q_3 = +3.0 μC from B to A along a diagonal of the rectangle? (d) Does this work increase or decrease the electric energy of the three-charge system? Is more, less, or the same work required if q_3 is moved along paths that are (e) inside the rectangle but not on a diagonal and (f) outside the rectangle?

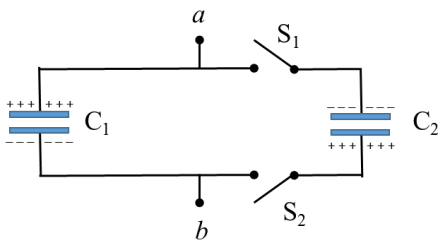
L05-03 (10 marks) A thin plastic rod of length L=12.0 cm and uniform positive charge Q=47.9 fC lying on an x axis. With V=0 at infinity, find the electric potential at point P on the axis at distance d=2.50 cm from one end of the rod.



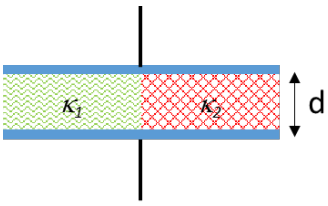
[*Hints*: $\int \frac{1}{a+x}dx = \ln(a+x)+C$] $\quad 1\,fC = 1\times10^{-12}\,C$

Lecture 06: Capacitance

L06-01 (10 marks) In the Figure, the capacitances are $C_1 = 1.0\ \mu\text{F}$ and $C_2 = 3.0\ \mu\text{F}$, and both are charged to a potential difference of $V = 100\ \text{V}$ but with opposite polarity as shown. Switches S_1 and S_2 are now closed. (a) What is now the potential difference between points a and b? (b) What are the charges in capacitors C_1 and C_2 after the switches are closed for a long time?



L06-02 (10 marks) The Figure shows a parallel-plate capacitor with a plate area of $A = 5.56\ \text{cm}^2$ and separation $d = 5.56\ \text{mm}$. The left half of the gap is filled with materials of dielectric constant $\kappa_1 = 7.00$; the right half is filled with material of dielectric constant $\kappa_2 = 10.0$. What is the capacitance?



L06-03 (10 marks) A parallel-plate air-filled capacitor having area 40 cm^2 and plate spacing 1.0 mm is charged to a potential difference of 600 V. Find (a) the capacitance, (b) the magnitude of the charge on each plate, (c) the stored energy, (d) the electric field between the plates, and (e) the energy density between the plates.

L04-04 (10 marks) In the given Figure, battery B supplies 12 V. Find the charge on each capacitor (a) first when only switch S_1 is closed and (b) later when switch S_2 is also closed. Take C_1 = 1.0 μF, C_2 = 2.0 μF, C_3 = 3.0 μF, and C_4 = 4.0 μF.