Physics 4B
Fall 2017

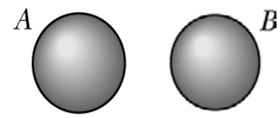
Name: ________________________________

Lab (circle one): 8:00 am 11:15 am 2:45 pm

Celebration #1: Chapters 21 – 25

Short Answer Questions (5 or 6 points each)

Question 1 (5 points)
The initial charges on two identical metal spheres are $q_A = +4.00\ \mu C$ and $q_B = -7.50\ \mu$ C. If the two spheres are touched together, how many electrons will get transferred from sphere B to sphere A?



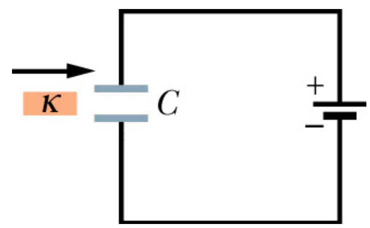
Question 2 (6 points)
A parallel plate capacitor is connected to a power supply as shown in the figure to the right. While the capacitor is still connected to the power supply, a dielectric is inserted between the plates. After the dielectric is inserted, does each of the following quantities increase, decrease or remain the same:

a) capacitance

b) voltage across the capacitor

c) charge stored on the plates

d) electric field between the plates



Question 3 (6 points)
Shown below are three hollow conducting spheres of the same size; the net charge of each sphere is given (+3Q, -4Q, and +5Q). Rank the spheres according to the *magnitudes* of the electric fields they produce, *from greatest to least*, at **(a)** points P_1, which are the same radial distance within the hollows; **(b)** points P_2, which are at the same radial distance within the spheres; and **(c)** points P_3, which are at the same radial distance outside the spheres. Rank the spheres according to the electric potential, *from most positive to most negative*, at **(d)** points P_1, **(e)** points P_2, and **(f)** points P_3.

a)

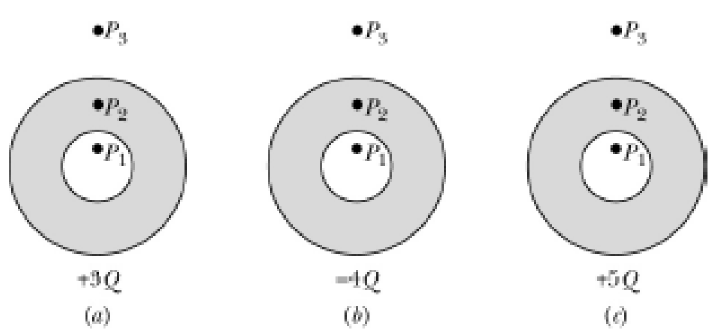
b)

c)

d)

e)

f)



Question 4 (6 points)
Are each of the following statements True or False?

a) If the electric potential is zero at a point, the electric field must also be zero at that point.

b) If the electric field is zero in some region of space, the electric potential must also be zero in that region.

c) If the electric potential is zero in some region of space, the electric field must also be zero in that region.

d) Electric field lines always point toward regions of lower potential.

e) In electrostatics, the surface of a conductor is an equipotential surface.

f) Physics rules! (careful how you answer – it's worth 1 point ☺)

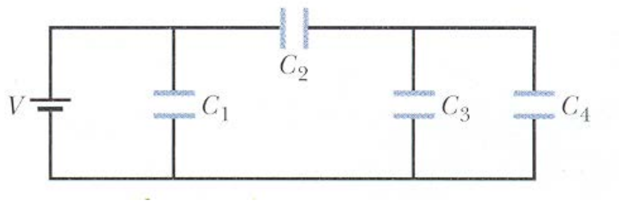
Question 5 (5 points)
Use the binomial expansion to show that the expression for the electric field a distance z above a charged circular disk of radius R:

$$E = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{z}{\sqrt{z^2 + R^2}}\right)$$

reduces to the equation for a point charge ($E = \frac{1}{4\pi\varepsilon_0}\frac{q}{z^2}$) when z → ∞. Show all steps of your work.

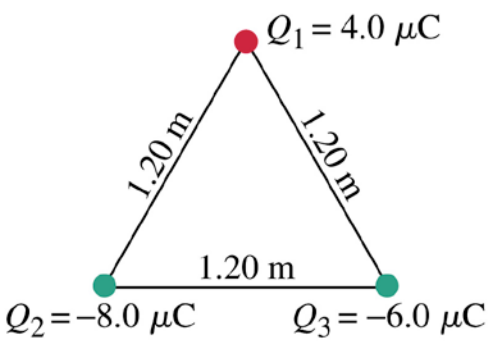
Problem 1

In the figure below, $V = 12$ V, $C_1 = C_2 = 2.0$ μF, $C_3 = 1.0$ μF, and $C_4 = 3.0$ μF. What are the charge on and the voltage across each capacitor?



Problem 2

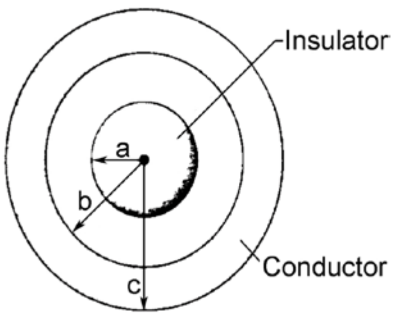
Three charged particles are placed at the corners of an equilateral triangle of side 1.20 m (see the figure below). The charges are $Q_1 = +4.0\ \mu C$, $Q_2 = -8.0\ \mu C$, and $Q_3 = -6.0\ \mu C$. **(a)** Calculate the magnitude and direction of the net force on charge Q_1. **(b)** Calculate the magnitude and direction of the net force on charge Q_2.



Problem 3

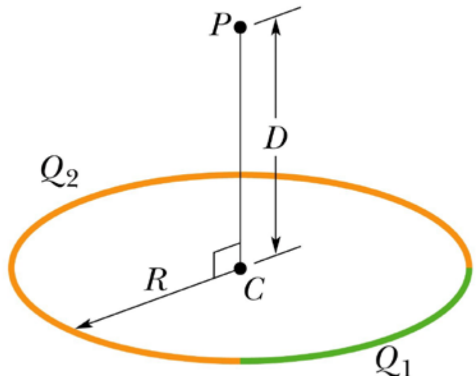
A solid, insulating sphere of radius a has a uniform charge density ρ and a total charge Q. Concentric with this sphere is an *uncharged, conducting shell* whose inner and outer radii are b and c (c > b > a). **Use Gauss' law to derive** the magnitudes of the electric field: **(Show all of your work!)**

a) inside the insulating sphere (r < a)
b) in-between the sphere and the shell (a < r < b)
c) inside the conducting shell (b < r < c)
d) outside the shell (r > c).
e) Make a plot of the magnitude of the electric field versus r for all of the regions.

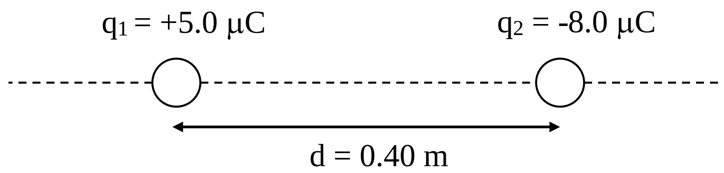


Problem 4

A plastic rod has been bent into a circle of radius R = 8.20 cm. It has a charge Q_1 = +4.20 pC uniformly distributed along one quarter of its circumference and a charge $Q_2 = -6Q_1$ uniformly distributed along the rest of the circumference (see figure below). With V = 0 at infinity, what is the electric potential at **(a)** the center C of the circle and **(b)** point P, on the central axis of the circle at distance D = 6.71 cm from the center?



Problem 5
Two charged conducting shells (fixed in place) of are separated by d = 0.40 m and have charges of $q_1 = +5.0\ \mu C$ and $q_2 = -8.0\ \mu C$ as shown in the figure below.

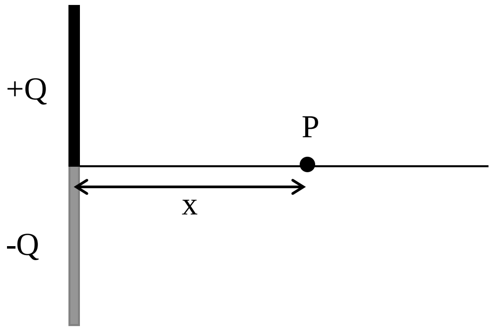


a) Find the point in space along the line containing the two spheres (not at infinity) where the electric field is zero.

b) A proton ($m = 1.67 \times 10^{-27}$ kg) is released from rest 0.20 m to the left of the +5.0 μC sphere. What is the speed of the proton a very long time later?

Problem 6

A thin rod of length L is placed along the y-axis such that it's two ends lie at (0, -L/2) and (0, L/2) as shown in the figure below. A charge of +Q is uniformly distributed along the positive half of the rod and a charge of -Q is uniformly distributed along the negative half of the rod. Find the magnitude and direction of the electric field at the point P, a distance x from the center of the rod. Express your answer in terms of Q, L, and x.



Possible useful integrals:

$$\int \frac{dx}{\sqrt{x^2+a^2}} = \ln(x+\sqrt{x^2+a^2})$$

$$\int \frac{x\,dx}{(x^2+a^2)^{3/2}} = -\frac{1}{(x^2+a^2)^{1/2}}$$

$$\int \frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^2(x^2+a^2)^{1/2}}$$