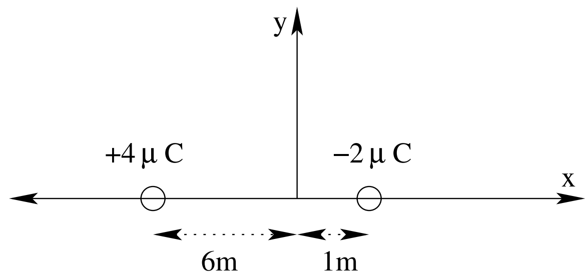
FINAL

1. Shown in the figure below are two point charges located along the x axis. Determine all the following:



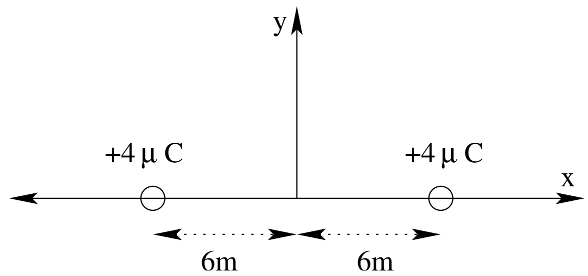
   (a) Find the magnitude and direction of the electric field at the origin.

   (b) Find the magnitude of the potential at the origin.

   (c) Find the place on the x axis at which the field is zero.

   (d) Find the places on the x axis at which the potential is zero.

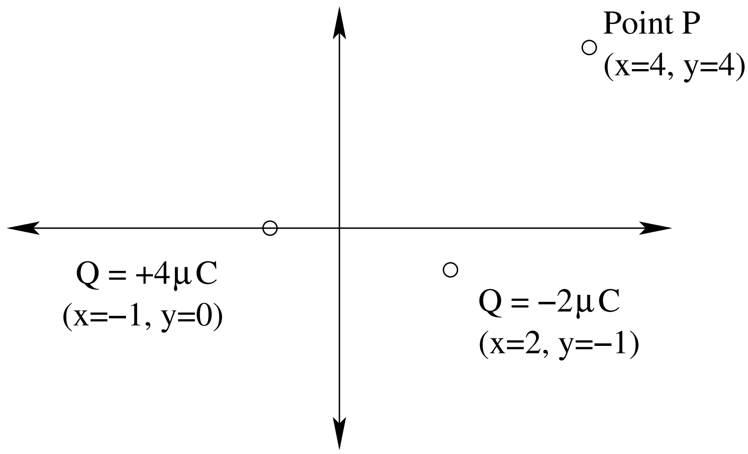
2. Shown in the figure below are two point charges located along the x axis. Determine all the following at the point x = 0 and y = 8m:



(a) The electric field.

(b) The electric potential.

3. Shown in the figure below are two point charges, Q_1 and Q_2, and the location of point P. All locations (x,y) in the figure are labelled in meters. Evaluate all of the following:



(a) Find the magnitude and direction of the electric field, **E** at the point P.

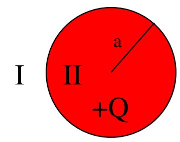
(b) What would be the magnitude of the force on a particle of charge $q = 4\mu C$ placed at point P.

(c) What is the potential, V, at the point P?

(d) How much work is required to bring the $q = 4\mu C$ charge from infinity to the point P.

(e) Assume that the $q = 4\mu C$ charge has a mass of $m = 12\mu g$ and is released from rest starting at the point P. What will be the velocity of this mass when it reaches infinity (note: non-relativistic)?

4. Shown in the figure below is a sphere of charge +Q and radius a. Use

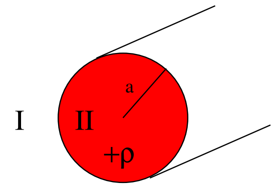


Gauss Law to find the electric field in each of these regions:

(a) Region I ($r > a$).

(b) Region II ($r < a$).

5. Shown in the figure below is an infinitely long cylinder of radius a filled with a uniform change density $+\rho \frac{Coulombs}{m^3}$. Use Gauss Law to find the

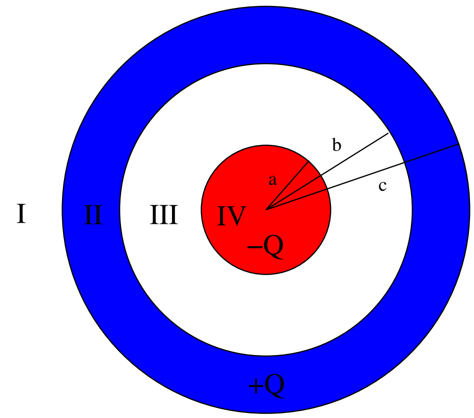


electric field in each of these regions:

(a) Region I ($r > a$).

(b) Region II ($r < a$).

6. Shown in the figure below are two concentric spheres of charge. A charge +Q is uniformly distributed over the outer sphere between r=b and r=c. A charge -Q is uniformly distributed over the inner sphere $r < a$. The space between the spheres, $a < r < b$, is empty. Use Gauss Law to find



the electric field in each of these regions:

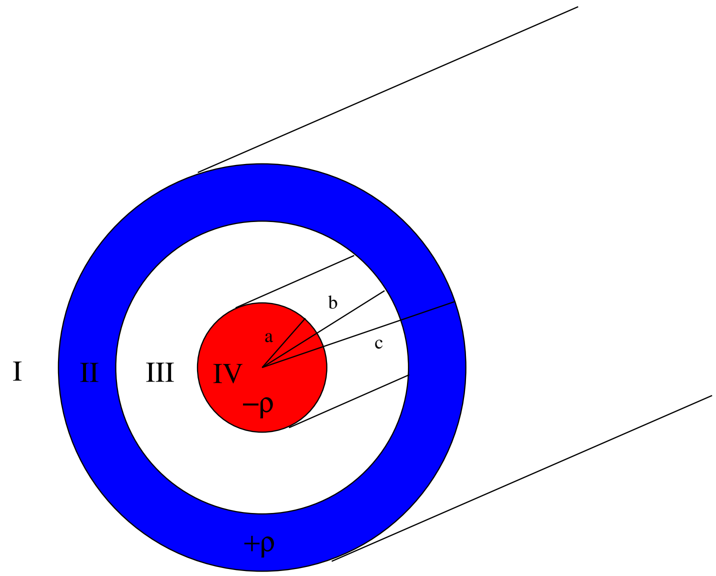
(a) Region I ($r > c$).

(b) Region II ($b < r < c$).

(c) Region III ($a < r < b$).

(d) Region IV ($r < a$).

7. Shown in the figure below are two concentric cylinders of charge. The cylinders are uniformly filled with charge densities $\pm\rho\frac{Coulombs}{m^3}$ as indicated in the figure. The space between the cylinders, $a < r < b$, is empty. Use Gauss Law to find the electric field in each of these regions:



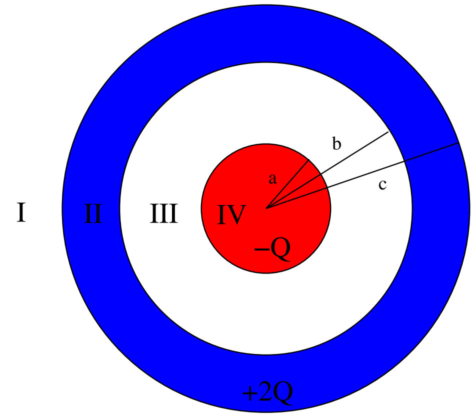
(a) Region I ($r > c$).

(b) Region II ($b < r < c$).

(c) Region III ($a < r < b$).

(d) Region IV ($r < a$).

8. Shown in the figure below are two concentric *CONDUCTING* spheres of charge. Because the spheres are conducting, the charge will not be uniformly distributed over their volumes, but will instead accumulate on the surfaces. The inner sphere has a total charge -Q and the outser sphere has a total charge -2Q. Use Gauss Law to determine all the following:



(a) The electric field in Region I ($r > c$).

(b) The electric field in Region II ($b < r < c$).

(c) The electric field in Region III ($a < r < b$).

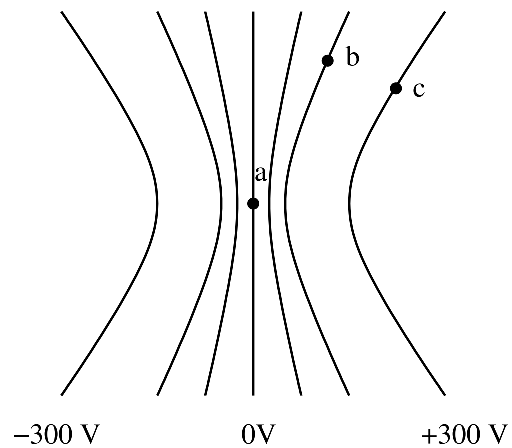
(d) The electric field in Region IV ($r < a$).

(e) The charge on the surface r=c.

(f) The charge on the surface r=b.

(g) The charge on the surface r=a.

9. The figure below shows a set of equipotential lines that were created by some set of charges. The lines represent potentials ranging from -300 V to + 300 V in steps of 100 V. Also labelled in the plot are the points a = (0,0), b = (1.5 m, 3 m), and c = (3 m, 2.5 m).



(a) Which point (a, b, or c) has the highest $\vec{E}$?

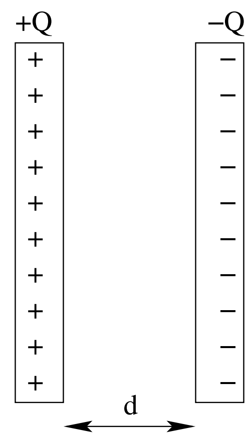
(b) Which point (a, b, or c) has the lowest $\vec{E}$?

(c) Estimate the strength of the electric field at a point 1/2 way between b and c.

(d) Draw several (roughly 6) electric field lines on the plot.

(e) If these lines were generates by two point charges (one to the left and one to the right), determine which side of the graph contains which charge (*i.e.* either +left/-right or -left/+right).

10. Shown in the figure below is a parallel plate capacitor. The area of each plate is 1 m^2 and the separation between the plates is 1 mm (0.001 m). The region between the plates is filled with a dielectric material of dielectric constant K=2.



(a) Determine the capacitance of this device.

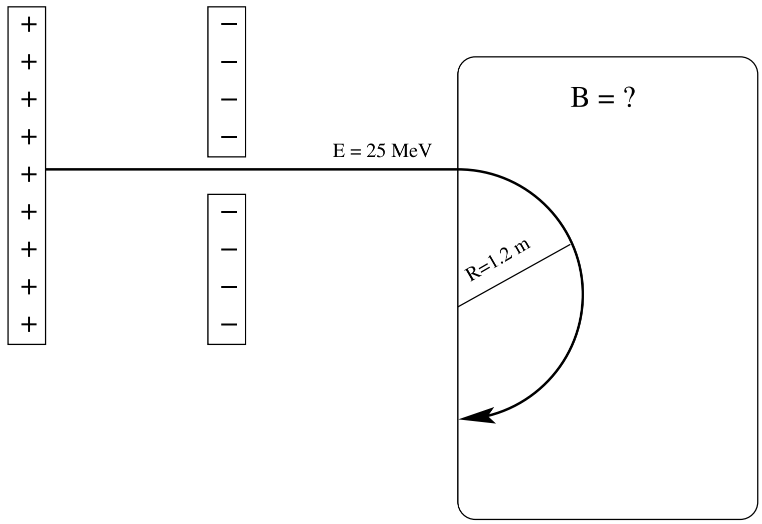
(b) If the capacitor is charged to $Q = 6\mu C$, when is the voltage difference between the plates?

(c) What is the electric field between the plates?

(d) What is the stored energy in the system?

(e) In what form is the energy stored?

11. Shown in the figure below is a mass analyzer system. This system operates by accelerating a charged particle across the gap between two capacitor plates, giving it energy. After it has been accelerated, it enters a magnetic field and is bent in a circular trajectory until it reaches the exit. You



are to design the mass anayzer system so that ^{12}C ions with charge, $q = +1.6 \times 10^{-19}$, and mass $m = 12 * 1.67 \times 10^{-27} kg = 2.00 \times 10^{-26} kg$ are accelerated to an energy of 25 MeV. Answer all the following:

(a) What should be the voltage difference across the capacitor?

(b) If the separation between the plates is 1 meter, what would be the electric field between the plates?

(c) If the area of each plate is $50m^2$, what is the capacitance and charge of this device?

(d) What will be the velocity of the ions after they are accelerated by the capacitor?

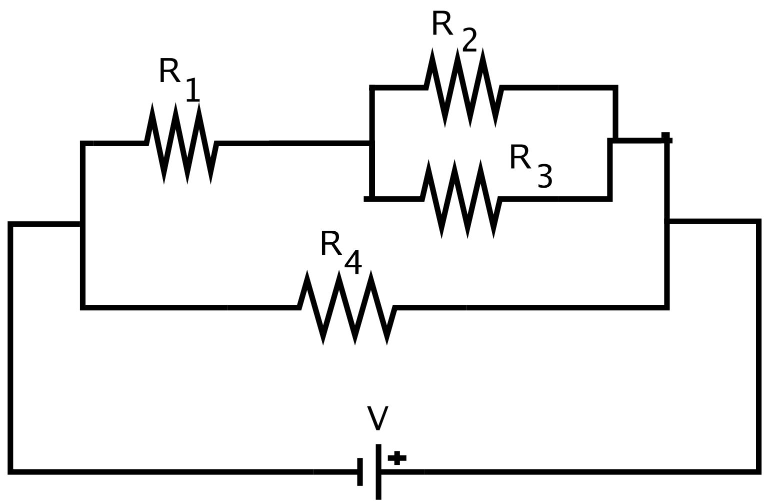
(e) What magnetic field should be used so that the ions travel in a circular path with radius, $R = 1.2 meters$.

(f) How would this differ if the ions were instead $^{14}_{6}C$ ions? Answer in a few sentences, not a calculation.

(g) What would be the usefulness of this device?

(h) What electric field would you put inside the magnet so as to make the ions travel in a straight line instead of a curved path?

12. Shown below is a circuit containing a resistor network. Let the values of the labelled components be as follows: $R_1 = 2k\Omega, R_2 = 3k\Omega, R_3 = 4k\Omega, R_4 = 6k\Omega, V = 10V$



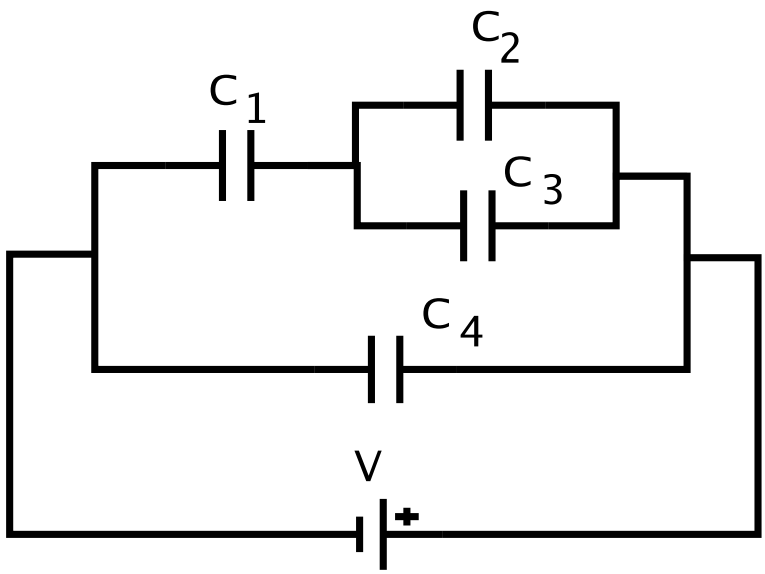
(a) Find the equivalent resistance of the network.

(b) Find the current through each resistor.

(c) Find the voltage across each resistor.

(d) Find the power dissipated by each resistor.

13. Shown below is a circuit containing a capacitor network. Let the values of the labelled components be as follows: $C_1 = 2\mu F, C_2 = 3\mu F, C_3 = 4\mu F, C_4 = 6\mu F, V = 10V$



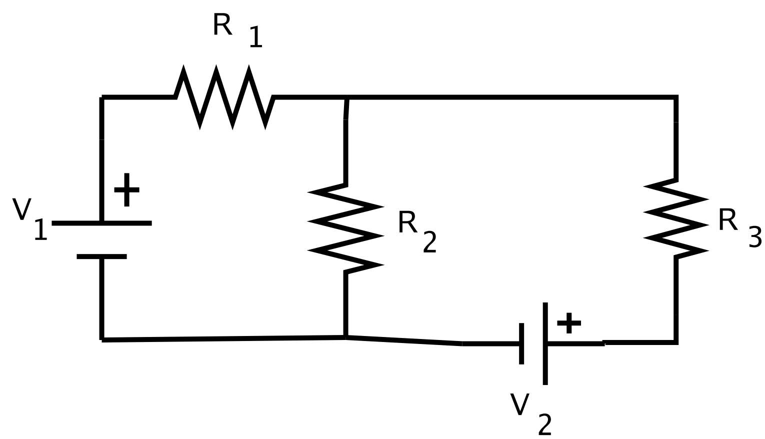
(a) Find the equivalent capacitance of the network.

(b) Find the charge on each capacitor.

(c) Find the voltage across each capacitor.

(d) Find the energy stored in each capacitor.

14. Shown in the figure below is an electrical circuit. The values of the components are as follows: $R_1 = 1k\Omega, R_2 = 2k\Omega, R_3 = 3k\Omega, V_1 = 10V, V_2 = 20V$.



(a) Write the Kirchoff voltage law for the loop containing $V_1, R_1, and R_2$.

(b) Write the Kirchoff voltage law for the loop containing $V_2, R_3, and R_2$.

(c) Write the Kirchoff current law.

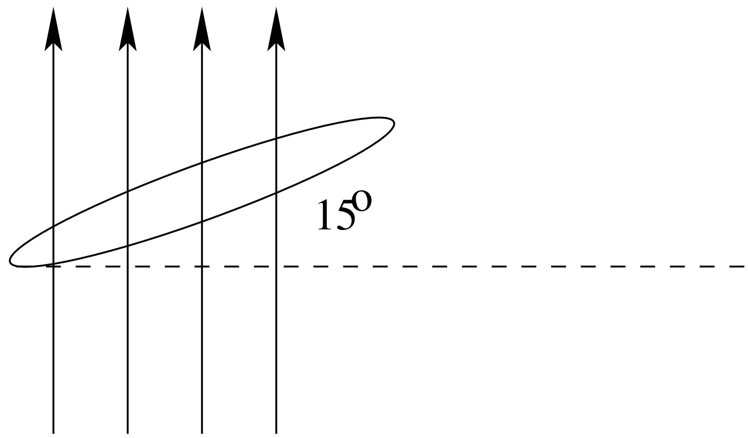
(d) Find the current through R_1.

(e) Find the current through R_2.

(f) Find the current through R_3.

(g) Find the power dissipated by each resistor.

15. Shown in the figure below is a loop of current placed into a uniform magnetic field of B=0.55 Tesla. The field is exactly vertical. The plane of the loop, is tipped 15 degrees off the horizontal. The radius of the loop is $20cm$ and it carried a current of 0.75 Amperes. The current would appear to flow counter-clockwise if you viewed the loop from above.

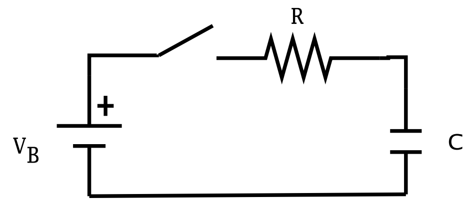


(a) Calculate the magnetic moment of the loop.

(b) Calculate the torque on the loop.

(c) Calculate the potential energy resulting from having the loop oriented as shown.

16. The circuit below begins with the switch in the open position and the capacitor carrying zero charge. The battery has $V_B = 10V$, the resistor has $R = 5k\Omega$, and the capacitor has $C = 12\mu F$. At time=0, the switch in the circuit is closed.



(a) Determine the time constant of this circuit.

(b) Draw sketches of the time dependence of each of the following:

i. The voltage on the capacitor as a function of time, $V_C(t)$.

ii. The charge on the capacitor as a function of time, $Q_C(t)$.

iii. The voltage on the resistor as a function of time, $V_R(t)$.

iv. The current through the resistor as a function of time.

To be counter for full credit the vertical axis of each sketch should be labelled with a **numerical value** indicating either the initial or asymptotic value of the quantity plotted.

(c) Write an equation for each of the following:

i. The voltage on the capacitor as a function of time, $V_C(t)$.

ii. The charge on the capacitor as a function of time, $Q_C(t)$.

iii. The voltage on the resistor as a function of time, $V_R(t)$.

iv. The current through the resistor as a function of time.

(d) At what time does the voltage on the capacitor reach 3 V?