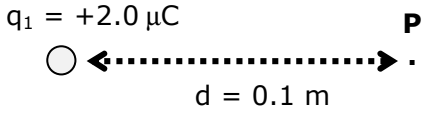
Electric Fields:

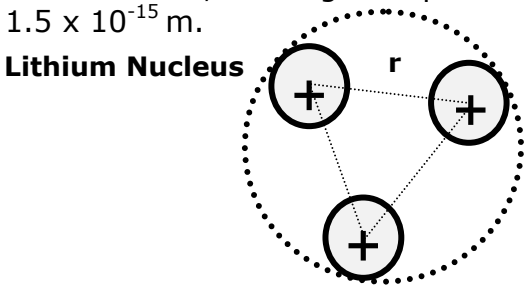
1. Consider a fixed point charge of +2.0 μC (q_1).



a. What is the magnitude and direction of the electric field at a point P, a distance of 0.1 m?

b. A 2nd charge (q_2 = -2.0 μC) is placed at point P. What is the magnitude and direction of the electric force exerted on q_3?

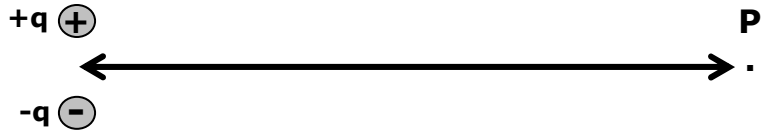
2. Three protons are present in the nucleus of a lithium atom, forming an equilateral triangle. The distance, r, between each pair of protons is 1.5 x 10^{-15} m.



a. What is the magnitude of the electric field vector due to the lithium nucleus at point P, a distance of 2.5x10^{-10}m from the center of the nucleus?

b. What is the magnitude and direction of the total electric force exerted on an electron positioned at point P.

3. Consider an electric dipole, q = 0.1 μC, separated by a distance of $5x10^{-6}$ m.

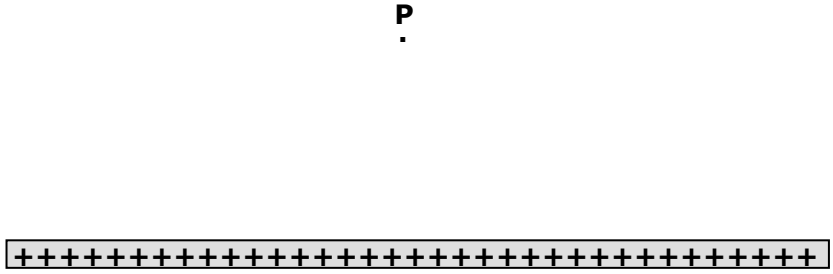


a. Sketch the electric field lines for the electric field vector due to the dipole.

b What is the magnitude and direction of the electric field vector due to the dipole at point P, a distance of 0.5 m to the right of the dipole?

c. What is the magnitude and direction of the electric field due to the dipole at a distance of 0.5 m directly above the dipole?

4. Consider a uniform line of charge with a total charge of 5 pC and a total length of 0.5 m.



a. What is the magnitude of the linear charge density?

b. Sketch the field lines for the line of charge in the diagram above.

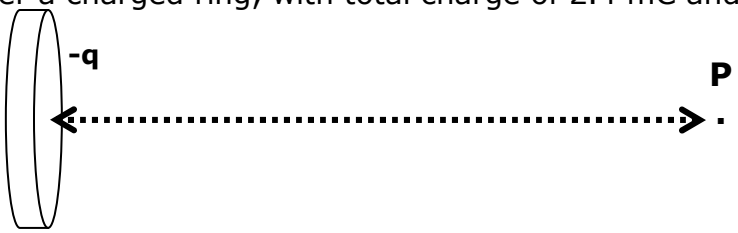
c. Derive an equation for the electric field vector at point P, located 0.3 m above the line and centered between the ends

d. What is the magnitude of the electric field vector at point P?

e. Determine the electric force vector exerted on an electron placed at point P.

f. What is the acceleration of the electron located at point P?

5. Consider a charged ring, with total charge of 2.4 mC and radius of 0.3 m.

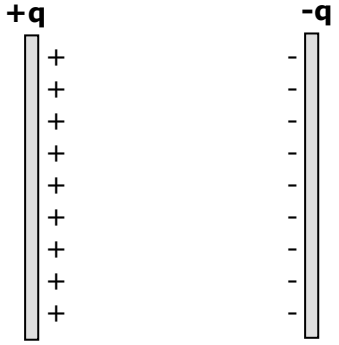


a. What is the magnitude of the surface charge density?

b. Derive an equation for the electric field vector at point P, located 1.5 m to the right of the center of the disc.

d. What is the magnitude and direction of the electric field vector at point P?

5. The plates of a parallel plate capacitor have a uniform charge of +1.0 C and -1.0 C, respectively. Each plate is a square with sides of length of 0.5 m.



a. What is the magnitude of the surface charge density on each plate?

b. What is the magnitude of the electric field vector inside the plates of the capacitor?

c. What is the electric force exerted on an electron placed inside the plates of the capacitor?

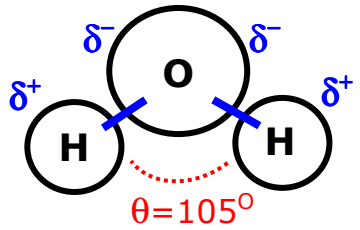
d. What is the acceleration of the electron while it is in between the capacitor plates?

e. For a 0.2 m plate separation, calculate the final speed of an electron (initially at rest), that is placed at the negative charged plate and just reaches the positive plate.

Dipole Moment of Water:

6. Water is a polar molecule that consists of 2 H atoms attached to a central oxygen atom. The H atoms are oriented at an angle of approximately 105°. Each of the H-O bonds has a dipole moment (p_{OH}) associated with it and together the 2 dipole moments have a resulting net dipole moment (p_{H_2O}) of 6.2×10^{-30} C·m. The effective separation distance between the respective positive (δ^+) and negative (δ^-) charges in each O-H bond is 3.9×10^{-12} m.

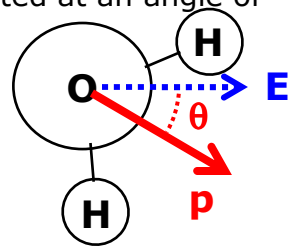
   a. What is the magnitude of the effective dipole moment of the individual O-H bond for water?



   b. Determine the magnitude of the charge (δ) for the individual O-H dipole.

   c. Calculate the torque on a water molecule due to the electric field of a charged sphere ($q_{sphere} = -1.5\times10^{-6}$ C) at a separation distance of 0.05 m, where the direction of the electric field is oriented at an angle of 30° to p_{H_2O}.

   d. Determine the rotational equation of motion for the water molecule in an electric field ($\vec{E} = 10\frac{N}{C}\hat{i}$), when the direction of the electric field is initially oriented at an angle of <10° to p_{H_2O}.



   e. What is the potential energy of the water molecule in this electric field?