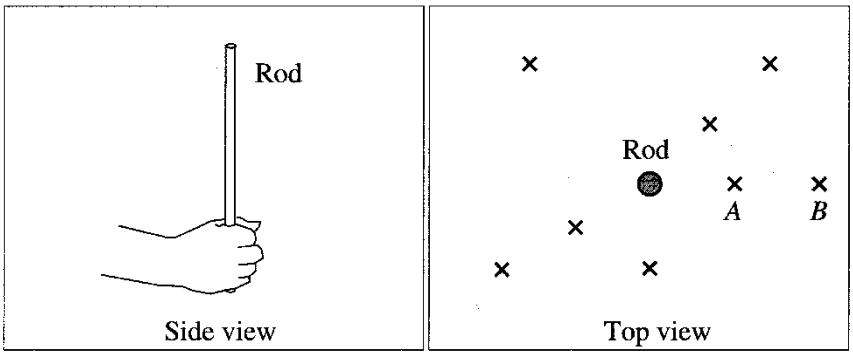
PHYC10007 Physics for Biomedicine
Tutorial Sheet 8 — *Electric Field, voltage, capacitance*

Electric Field

Last updated: 24/12/2019

1. Consider an acrylic rod and a pith ball carrying a charge q_{test} of the same sign as the charge on the rod.

   The pith ball is moved to different locations "x" in the diagram.



   a. Sketch *vectors* at each of the marked points to represent the electrostatic force centred on the ball at that location.
   b. How does the magnitude of the force exerted on the ball at point *A* compare to the magnitude of the force on the ball at point *B*?
   c. Suppose that the charge, q_{test} on the pith ball is halved. Would the electrostatic force centred on the ball at each location change? If so, how? If not, explain why not.
   d. Would the magnitude or direction of the electric field at point *A* change if:
      - The charge on the *rod* is increased? Explain.
      - The magnitude of the test charge is increased? Explain.
      - The sign of the test charge is changed? Explain.

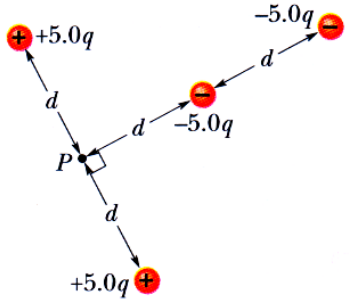
Voltage (electric potential)

Short calculations

2. In a lightning flash, the voltage difference between a cloud and the ground is 1.0×10^9 V and 30 C of charge is transferred.
   a) What is the change in energy of that charge?
   b) Is the change an increase or decrease?
   c) If all that energy could be used to accelerate a 70 kg human from rest, what would be the person's final speed?
   d) If the energy could be used to melt ice, how much ice (initially at 0°C) would it melt? (To melt ice at 0°C requires 3.33×10^5 J/kg).

3. An electron is accelerated along an electric field a distance of 50cm. The field does 4.8×10^{-15} J of work on the electron. Assume the field is uniform.
   a) What is the voltage difference between initial and final positions?
   b) What is the electric field strength?
   c) What is the force on the electron initially, and at the final position?

4. From the figure at right, what is the voltage at point *P* due to the four point charges, if $V = 0$ at infinity?



Capacitors

5. Consider a simple parallel-plate capacitor with plates separated by a distance d, given equal and opposite charges. Suppose the plates are pulled apart until they are separated by a distance $D > d$. The electrostatic energy stored in the capacitor is
    a. greater than
    b. the same as
    c. smaller than

    before the plates were pulled apart?

6. Two plates with area A_1 are held a distance d apart and have net charges Q_1 and $-Q_1$. Assume that all the charge is uniformly distributed on the inner surfaces of the plates.

    Discuss: why should the charge be on the inner surfaces only?

    a. Write an expression for the capacitance in terms of A_1 and d.

    Two initially uncharged plates of surface area A_2 are then attached to the original plates as shown.

    b. Find the voltage difference between the plates. Explain (group discussion).
    c. The right plate is moved further to the right, increasing the separation to D. Describe how each of the following quantities will change (if at all).
        i. The charge density on each plate
        ii. The electric field both outside and between the plates
        iii. The potential difference between the plates.