Tutorial 2 (Covering Lectures 3-4)

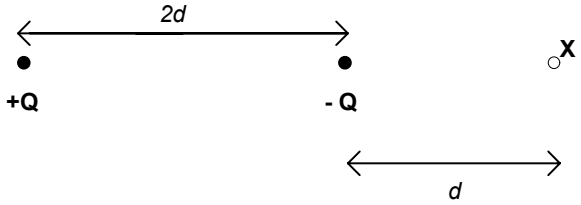
QUESTIONS:

1. Define the *electric potential V* and the *electric field strength E* at a point in an electrostatic field. How are they related?

2. For each of the following, state whether it is a scalar or a vector and give an appropriate unit:
   i. *electric potential*
   ii. *electric field strength*.

3. Calculate the electric potential at a point P that is 80 mm from a 5.0 μC positive point charge.

4. Multiple choice:



   The above figure shows a charge +Q at a distance 2d from charge -Q. Point X is a distance d from -Q. The potential at X, due to the charges +Q and –Q, is:

   A $\frac{-2Q}{9\pi\varepsilon_0 d}$; **B** $\frac{-Q}{6\pi\varepsilon_0 d}$; **C** $\frac{3Q}{4\pi\varepsilon_0 d}$; **D** $\frac{Q}{6\pi\varepsilon_0 d}$; **E** $\frac{-2Q}{9\pi\varepsilon_0 d}$

5. Starting from Coulomb's Law, derive expressions for the *electric field strength E* and for the *electric potential V* at a distance R from a point charge Q. Draw sketches to show how the potential and the field strength depend on the distance from the point charge.

6. Two point charges, each of 4 μC, are placed 1 m apart at points A and B, respectively. Calculate the *electric potential* at a point P, which is a distance of 1 m from both A and B, in the cases when:-
   (i) both charges are positive, and
   (ii) one charge is positive and the other is negative.
   [Hint: Points A, B and P lie at the corners of an equilateral triangle.]

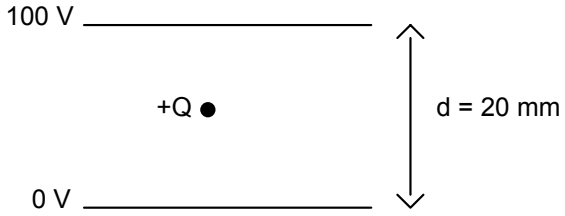
7. Calculate the force between two metal spheres, each of diameter 10 mm, with their centers 100 mm apart in air, when each is charged to a potential of 100 V.

8. Define the *potential difference* between two points, X and Y, where Y has the higher potential.

9. Calculate the energy, in joules, of an electron accelerated through a potential difference of 25 keV.

10. Write down an equation relating the *potential gradient* and the *electric field strength* between two parallel plane conductors. What is the electric field strength between two such conductors when their separation is 20 mm and a potential difference of 400 V is applied to them?
    Calculate the force on an oil drop between the two plates when the drop carries a charge of 8×10^{-19} C.

11. Multiple choice:



    The above figure shows a point charge of +Q between two parallel plates separated by a distance of 20 mm. A potential difference of 100 V is applied to the plates, as shown.
    The force on the charge +Q is:
    A $\frac{Q}{5}$ upwards; **B** 50Q downwards; **C** 200Q upwards; **D** 2000Q downwards; **E** 5000Q downwards

12. A negatively charged oil drop of mass 9.75×10^{-15} kg is observed to reamin stationary in the space between two horizontal charged metal plates. Calculate the number of electrons on the drop if the potential difference between the plates is 3000 V and their distance apart is 100 mm. Which plate has the higher potential?

13. Write down the expression for the electric field strength at a point close to a charged sphere in terms of the surface charge density of the conducting surface. Given that a spark will pass in air if the potential gradient is greater than 3 MVm^{-1}, what must be the minimum radius of the sphere in air if its potential is 0.6 MV?

<u>COURSEWORK (Questions 1. to 5.):</u>

1. Calculate the force between two metal spheres, each of diameter 4 cm, with their centers 50 cm apart in air, when each is charged to a potential of 900 V.

2. Two point charges, each of 1 μC, are placed 100 mm apart at points A and B, respectively. Calculate the *electric potential* at a point P, which is a distance of 100 mm from both A and B, in the cases when:-
   (i) both charges are positive, and
   (ii) one charge is positive and the other is negative.
   [Hint: Points A, B and P lie at the corners of an equilateral triangle.]

3. Calculate the energy, in joules, of an electron accelerated through a potential difference of 15 kV.

4. A negatively charged oil drop of mass 5×10^{-15} kg is observed to remain stationary in the space between two horizontal charged metal plates. Calculate the number of electrons on the drop if the potential difference between the plates is 1000 V and their distance apart is 25 mm. Draw a sketch of the electric field between the plates and state if the field is everywhere uniform.

5. Given that a spark passes in air when the potential gradient at the surface of a charged conductor exceeds 3 MVm^{-1}, what must be the minimum radius of an isolated metal sphere of potential 1.5 MV if a spark is generated?