FY Electricity **Dr Graham S McDonald**

Tutorial 1 (Covering Lectures 1-2)

QUESTIONS:

1. Give a definition of the (unit of charge) *the coulomb*.

2. Give the definition of the *electric field strength*, E, at a point in an electrostatic field.

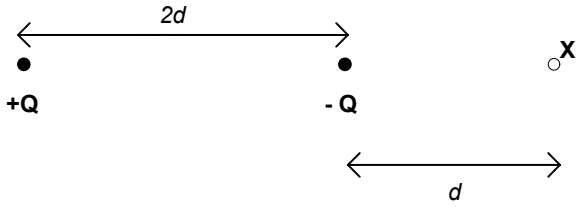
3. Give an expression for the Coulomb force between two charges Q_1 and Q_2, separated by a distance r. Hence, give an expression for the *electric field strength* E at a distance R from an isolated point charge Q.

4. A point charge of $+2\times10^{-2}$ μC is 25 cm from another point charge of -5×10^{-2} μC. Calculate the force each exerts on the other. Is this force attractive or repulsive?

5. Multiple choice:

   In Coulomb's Law the force between two point charges is proportional to:
   i. the square of the distance between them
   ii. the product of the charges
   iii. the permittivity of the medium
   Which statements are true:
   A i and ii only; **B** ii and iii only; **C** ii and iii only; **D** i only ; **E** ii only

6. 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 magnitude of the electric field strength at X is:
   A $\frac{Q}{4\pi\varepsilon_0 d^2}$; **B** $\frac{Q}{36\pi\varepsilon_0 d^2}$; **C** $\frac{3Q}{4\pi\varepsilon_0 d^2}$; **D** $\frac{2Q}{9\pi\varepsilon_0 d^2}$; **E** $\frac{Q}{12\pi\varepsilon_0 d^2}$

7. Two point charges, each of 4 μC, are placed 1 m apart at points A and B, respectively. Calculate the electric field strength 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.]
   Show the direction of the electric field in a diagram in both cases.

8. Calculate the electric field strength at a point P that is a distance of 80 mm from a point charge of +5.0 μC. If a +3.0 μC point charge is now placed at point P, what is the force on it?

9. A high electric field at a sharp point can initiate a breakdown or discharge in air and send a stream of charged atoms/molecules away from the point. What is this phenomenon called and at approximately which electric field strength does it occur in air? Mention one application of this effect.

10. What is the function of a *Faraday cage*? What is the electric field strength inside this cage?

11. Write down the expression for the electric field strength at a point close to a charged conducting surface in terms of the surface density of charge.

12. A Van der Graaff generator is used to produce a beam of protons inside a vacuum tube. Assuming that the protons are accelerated in a uniform electric field of strength 0.4 MV m^{-1}. Given that a proton has a mass of 1.67×10^{-27} kg, calculate:
    a) the force on each proton;
    b) the acceleration of each proton;
    c) the time to travel a tube length of 5 m.

COURSEWORK:

1. A point charge of $+4\,\mu C$ is 50 cm from another point charge of $-5\,\mu C$. Calculate the force each exerts on the other. Is this force attractive or repulsive?

2. Two point charges, each of 1 μC, are placed 100 mm apart at points A and B, respectively. Calculate the electric field strength 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.]
   Show the direction of the electric field in a diagram in both cases.

3. With the aid of a diagram, describe the Van der Graaff generator and explain its operation.

4. A Van der Graaff generator is used to produce a beam of protons inside a vacuum tube. Assuming that the protons are accelerated in a uniform electric field of strength 0.5 MV m^{-1}. Given that a proton has a mass of 1.67×10^{-27} kg, calculate:
    a) the force on each proton;
    b) the acceleration of each proton;
    c) the time to travel a tube length of 2 m.