EEE6001 Tutorial sheet 1 - Electric Fields

1. (a) What is the field at (5,5,0) due to a charge $+10^{-5}$C at (2,2,0)?
   (b) What is the field at (5,5,0) due to a charge -2×10^{-5}C at (7,1,0)?
   (c) What is the total field at (5,5,0) due to these 2 charges?
   (d) What force acts on a charge of 10^{-6}C at (5,5,0) due to these 2 charges?

2. An infinitely long wire parallel to the *z*-axis passes through the point (0,1,0) and carries a charge per unit length of 3×10^{-6}C. Calculate the electric field at the point (1,0,0).

3. Two infinite plane parallel sheets separated by 10mm, carry charges of density $+10^{-6}$Cm^{-2} and -10^{-6}C^{-2}. What is the force per unit area on these charge sheets?

4. For a wire of length *2L*, with a charge per unit length of q_l , show that the E_y component of the field at point *(x,y)* would be:

$$\frac{q_l}{4\pi\varepsilon_0 y}\left[\frac{x+L}{\left[(x+L)^2+y^2\right]^{1/2}}+\frac{L-x}{\left[(L-x)^2+y^2\right]^{1/2}}\right]$$

   The origin is at the centre of the wire, and the *x*-axis along the wire.

5. A distribution of charge produces an electric potential given by:

$$\phi = 2x^2 + 3yz$$

   What is the electric field at the points (1,2,3) and (-1,-1,-1)?

6. A plane capacitor of capacitance 7.0μF consists of 2 metal foils separated by a thin dielectric layer. The relative permittivity of the dielectric is 8, and the thickness is 0.01mm. If the capacitor is charged to 100V, what is the charge per unit area of the plates, and what is the electric field inside the capacitor?

7. A capacitor is made from two coaxial conducting cylinders of length *L*, separated by air. The inner cylinder is of radius *a* and carries a charge *Q*; the other is of radius *b* and carried a charge *–Q*. Assume that *L* is much greater than *a* and *b* so end effects can be neglected.
   (a) Draw the electric field lines between the cylinders.
   (b) What is the electric field in the region between the two cylinders?
   (c) Integrate the expression for the electric field to calculate the potential difference between the cylinders.
   (d) Hence deduce an expression for the capacitance between the two conductors.

8. Two point charges each of magnitude 1μC are located at (1,3,-1) and (-3,1,-2) respectively. Calculate the force acting on a third charge of magnitude 2μC located at (3,1,-2). All distances are in metres and the environment is free-space.

Figure 1

In Figure 1, seven small beads of equal positive charge are free to move without the affects of gravity or friction along a straight wire (the wire has end-stops to prevent the beads dropping off). Sketch the approximate bead distribution that corresponds

to an equilibrium state. If the wire is now bent to form a perfect closed circle, how would the bead distribution change? Explain all your reasoning.

A circular ring of charge of radius *a* is centred at the origin in the x-y plane. If the ring carries a uniform charge per until length of q_l , derive an expression for the electric potential at a point on the z-axis. Hence, or otherwise, determine an expression for the electric field at the same point.

9. A positive point charge of magnitude 5μC is placed at the centre of a hollow, conducting sphere which has a net charge of -3μC, as shown in Figure 2. Determine:
i) the electric field inside and outside the hollow sphere.
ii) the form of the charge distribution on the conducting part of the sphere.

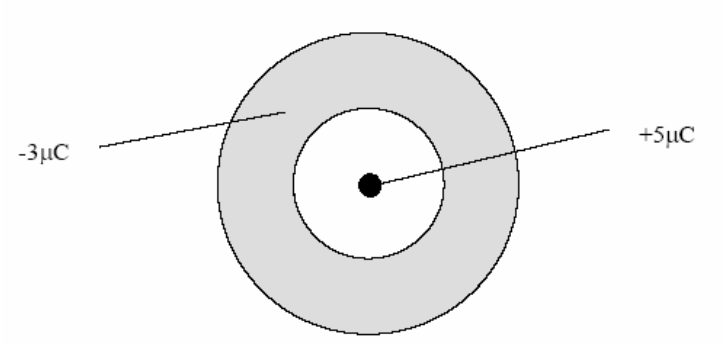

Figure 2

Use Gauss's law to derive an expression for the electric field at a distance *r* from an infinitely long wire carrying a charge per unit length of q_l

Show that the capacitance per unit length of an air spaced coaxial line with inner and outer radii of a and b respectively is

$$C_l = \frac{2\pi\varepsilon_0}{\ln\left(\frac{b}{a}\right)}$$

A parallel plate capacitor consists of two square plates of side *s* separated by a distance *d* containing the composite dielectric material shown in Figure 3. Ignoring fringing fields, derive an expression for the total capacitance of this arrangement.

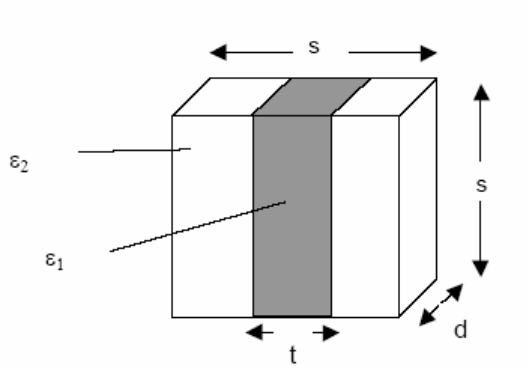

Figure 3

Other practice questions can be found on the Tutorial sheet and past exam questions for EEE220 which are posted on the web.