Tutorial Sheet 1

1. Vector **A** extends from the origin to the point $(x, y, z) = (4, 5, 2)$ in Cartesian co-ordinates. Vector B extents from the origin to the point $(r, \phi, z) = (4, 75^0, 5)$ in cylindrical co-ordinates. Calculate, in rectangular co-ordinates where appropriate:

    a. $\mathbf{A} + \mathbf{B}$
    b. $\mathbf{A} \cdot \mathbf{B}$
    c. The angle between **A** and **B**
    d. $\mathbf{A} \times \mathbf{B}$

2. If the electric potential V decreases by 2V/m in *x*-direction and by 1V/m in *y*-direction, calculate electric field ***E***

3. The electric scalar potential within a region of space is given by $V = x^2 + yz^3$ (V). Find the electric field ***E***.

4. If the electric scalar potential within a region varies as $V = 10xz + 15\,yz^2$ (V), find V and E at the point $(x, y, z) = (5, 4, 3)$ m.

5. Calculate the electric flux from a point charge of 1.0 (C) which passes through a spherical surface at a radius of 1.3m, extending from $\theta = 0^0$ to 180^0 and from $\phi = 0^0$ to 45^0.

6. The electric flux density, ***D***, over an imaginary sphere is $1.25\mathbf{e_r}$ C/m^2 (in spherical co-ordinates). Assuming that this is due to a single charge of 0.3C, calculate the radius of the imaginary sphere relative to the position of the charge.

7. The electric flux density ***D***, at a point in space is $9yx^3\,\mathbf{e_x} + 6y\,\mathbf{e_y} + 7zxy^2\,\mathbf{e_z}$. Calculate

    a. the electric field ***E*** and
    b. the divergence of ***D***

    at the point $(x, y, z) = (2, 1, 3)$ m.

8. The electric flux density ***D***, at a point in space is $r\boldsymbol{e}_r + r\sin\theta\,\boldsymbol{e}_\theta$, calculate the divergence of ***D***

9. The electric flux density ***D***, at a point in space is $9x^3\,\mathbf{e_x} + 5y^2\,\mathbf{e_y} + 2z\,\mathbf{e_z}$. Calculate the charge density at the point $(x, y, z) = (1, 5, 9)$ m.

10. The electric field, ***E***, at a point is given by $3y\,\mathbf{e_x} + 5xz^4\,\mathbf{e_y} + 2xy^3\,\mathbf{e_z}$. Is there any charge present at the point?

11. Starting from Laplace's equation, derive an expression for the electric field strength mid way between the plates of a parallel plate capacitor which is storing an energy of 0.354 μJ. The capacitor plates are separated by a material with a thickness of 50 μm, a total surface area of 400mm^2 and a relative permittivity of 1.0. Assume that the ratio of capacitor area to plate separation is sufficiently high that the plates can be approximated as being of infinite extent.

12. A p-n semiconductor junction has a depletion layer width of 200nm, a volume charge density of $5\text{x}10^3$ C/m^3, a relative permittivity of 10 and a cross-sectional area of 10^{-9} m^2. Starting from Poisson's equation, and listing any assumptions you make, calculate the maximum value of electric field strength, the voltage across the junction and its capacitance.

13. Derive interface conditions at the boundary between a conductor and dielectric material (*hint conductor is an equi-potential body*).

14. Derive expressions for potential V and electric field strength E in cylindrical coordinate system for the coaxial cable as shown below: