Department of Physics, Bennett University

EPHY105L (I Semester 2018-2019)

Problem Sheet 2

1. Write down an expression for the electric field $\vec{E}(x, y, z)$ produced by a point charge Q placed at a point with coordinates (x_0, y_0, z_0).
2. Consider a pair of charges $+Q$ and $-Q$ placed at two points with coordinates $(-a, 0,0)$ and $(+a, 0,0)$.
   a) Obtain an expression for the electric field $\vec{E}(x, y, z)$ generated by the pair of charges.
   b) Calculate $\nabla . \vec{E}$ at the origin.
   c) Obtain the electrostatic potential $V(x, y, z)$ of the pair of charges and show that the electric field obtained from the potential is the same as obtained in part (a).
3. A charge Q is distributed uniformly over a ring of radius R centered at the point C. Find the electric field at a point P lying along the axis of the ring and at a distance a from the point C.
4. A charge Q is distributed uniformly on the surface of a circular disc of radius R. Calculate the electric field along the axis of the disc at a distance z from the center of the disc.
5. A positive charge Q = 10mC is placed at the center of a cavity formed inside a spherical conducting shell having an inner radius R_1 and outer radius R_2.
   a) Obtain the total charges induced at the inner and outer surfaces of the shell.
   b) Will the charge be distributed uniformly or non uniformly on the inner and outer surfaces?
   c) How would your answer change if the point charge is not placed at the center of the cavity?
6. Consider a spherical shell formed by two concentric spheres of radii R_1 and R_2 ($R_2 > R_1$) and having a uniform volume charge density of ρ. There is no charge anywhere else. Using Gauss's law obtain the electric field produced by the charge distribution everywhere. Also evaluate $\nabla . \vec{E}$ everywhere.
7. Consider a spherical volume charge distribution given by
$$\rho(r) = \rho_0 + \alpha r \qquad 0 < r < R$$
$$= 0 \qquad r > R$$
where r is the distance from the center of the sphere and ρ_0 and α are constants.
   a) Calculate the total charge contained inside the sphere of radius R.
   b) Use Gauss's law to obtain the electric field everywhere due to the charge distribution.
   c) Obtain $\nabla . \vec{E}$ within and outside the sphere of radius R.
   d) Obtain $\nabla \times \vec{E}$ within and outside the sphere.
8. A charge of 50 nC is distributed uniformly around a circular ring of radius 2m.
   a) Obtain the electrostatic potential at a point P on the axis at a distance of 5 m from the plane of the ring. [Ans: 83.5 V]

b) What is the work done in moving a point charge of 10 nC from the center of the ring to the point P? [Ans: 1.41 μJ]

c) What is the net work done in moving the point charge of 10 nC from a point on the axis at a distance 5 m above the plane to a point on the axis at a distance of 5 m below the plane?

9. Consider an electrostatic field given by

$$\vec{E} = 2(x + 4y)\hat{\imath} + 8x\hat{\jmath}$$

Obtain the potential difference between the origin and a point with coordinates (4, 2, 0). [Ans: 80 V]

10. A point charge 1.2 nC is located at a point with coordinates $(x_0 = 2, y_0 = 3, z_0 = 3)$. Calculate the potential difference between two points with coordinates (in the Cartesian system) (2, 2, 3) and (-2, 3, 3).