Department of Physics, Bennett University

EPHY105L (I Semester 2018-2019)

Problem Sheet 3

1. In a certain region of space the electrostatic potential is given by $V = \frac{5}{r^2} cos\theta$ (in spherical polar coordinates). What will be the electric field at a point with coordinates $r = 2, \theta = \frac{\pi}{2}, \phi = 0$? All distances are in meters.
2. A conducting plate of thickness *d* and with parallel surfaces is placed in a uniform electric field $\vec{\boldsymbol{E}} = E_0\hat{\boldsymbol{k}}$ such that the surfaces are parallel to the *x*-*y* plane. What is the surface charge density on the surface of the conductor?
3. Can the following vector function represent an electrostatic field? Give reasons for your answer.

$$\vec{\boldsymbol{F}}_1 = x^2\hat{\boldsymbol{\imath}} + 3xz^2\hat{\boldsymbol{\jmath}} - 2xz\hat{\boldsymbol{k}}$$

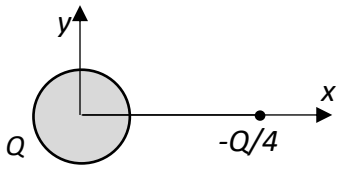
4. A point charge with q = 1μC is placed at a point with coordinates x = 3, y = 2, z = 0. Obtain the electrostatic field $\vec{\boldsymbol{E}}$ at a point with coordinates x = 3, y = 5, z = 0. (All distances in meters.
5. Consider a spherical charge distribution with volume charge density given by

$$\rho(r) = \rho_0\left(1 - \frac{4r}{3R}\right) \qquad 0 < r < R$$
$$= 0 \qquad r > R$$

where r is the distance from the center of the sphere and ρ_0 is a constant.

   a) Use Gauss's law to obtain the electric field everywhere due to the charge distribution.
   b) What are the values of $\nabla.\vec{\boldsymbol{E}}$ and $\nabla \times \vec{\boldsymbol{E}}$ at $r = \frac{4R}{5}$?

6. Consider a uniform spherical charge distribution with total charge $+Q$ and a point charge having a charge $-Q/4$ placed at a distance d from the centre of the sphere as shown in the figure. Obtain the position/positions where the net electric field will be zero.



7. A negative charge of 1 μC is placed at the center of a cavity formed inside a spherical conducting shell having an inner radius 0.2 m and an outer radius 1 m. What is the charge density on the outer surface of the sphere?
8. If a spherical metallic object is to be operated at 90 kV, what is the smallest radius of curvature which should be permitted so that it does not cause a breakdown in air. Breakdown strength of air is 30 kV/cm.