Tutorial 2, Physics-2 (15B11PH211), 2022

[CO1]

1) (a) Write down Gauss's law in differential and integral form.
   (b) The electric flux through any closed surface is a measure of the ……..
   (c) A charge outside the closed surface will contribute …… to the total flux.
   (d) Express Gauss's law in terms of potential V.
   (e) The line integral of electric field is path independent then we can write $\nabla \times \vec{E} = \cdots$ and $\vec{E} =$……

[CO2]

2) (a) The lectric field of a sphere falls off like $1/r^2$; the electric field of an infinite line falls off like 1/r; and the electric field of an infinite plane does not fall off at all. What about the $1/r^2$ dependence in Coulobm's law? Explain.
   (b) The normal component of the electric field is …… by an amount …… at any boundary carring surface charge density σ and the tengential component of the electric field is ……
   (c) Show that a conductor is an equipotential surface.
   (d) The electric field just outside the conductor is …….. and the outward electrostatic pressure on the surface of the conductor is …….

[CO3]

3) Find the charge density ρ and the total charge contained in a sphere of radius R centered at the origin if the electric field produced by this charge distribution is $\vec{E} = kr^3\hat{r}$.
4) Find the electic field everywhere due to a uniformly charged solid shpere of radius R and charge density ρ.
5) Find the electric filed inside and outside a uniformly charged long cylinder of radius R and charge density ρ.
6) In cylindrical coordinates, $\varphi = \text{constant}$ planes are insulated alomg the z-axis. Find $\vec{E}$ between the planes assuming 100 volts for $\varphi = \alpha$ and zero at $\varphi = 0$.

[CO4]

7) Evaluate the electric filed inside and outside a sphere of radius R which carries a charge density proportional to the distance from the origin, $\rho = kr$, for some constant k.
8) A long cylinder of radius R carries a charge density $\rho = ks$, for some constant k. Evaluate the electric field inside and outside this cylinder.
9) Two parallel conducting disks are separated by 5 mm (lower disk at 100 volts and upper disk at 250 volts) and contain a dielectric for which $\varepsilon_r = 2.2$. Evaluate the charge densities on the disks.

For Self Study

[CO3]

1) Find the elctric field due to an infinite plane carring a uniform surface charge density σ.

2) Two infinite parallel planes carry equal but opposite uniform charge densities $\pm\sigma$. Find the electric field in each of the three regions: (i) to the left of both, (ii) between them, and (iii) to the right of both.
3) Find the electric inside and outside a spherical shell of radius R, which carries a uniform surface charge density σ.
4) Find the electric field a distance s from an infinitely long straight wire, which carries a uniform line charge density λ.

[CO4]

5) A hollow spherical shell carries charge density $\rho = k/r^2$ in the region $a \leq r \leq b$. Evaluate the electric field in the three regions: (i) $r < a, (ii)\ a < r < b\ (iii)\ r > b$. Also plot $|\vec{E}|$ as a function of r.
6) A long coaxial cable carries a uniform volume charge density ρ on the inner cylinder (radius *a*), and a uniform surface density on the outer cylindrical shell (radius *b*). The surface is negative and f just the right magnitude so that the cable as a whole is electrically neutral. Find the electric field in each of the three regions: (i) inside the inner cylinder (*s*<*a*), (ii) between the cylinders (*a*<*s*<*b*), (iii) out side the cable (*s*>*b*). Also plot $|\vec{E}|$ as a function of s.
7) Two sphers, each of radius R and carrying uniform charge densities $+\rho$ and $-\rho$, respectively, are placed so that they partially overlap. Call the vector from positive charge centre to the negative charge centre $\vec{d} = \overrightarrow{OO'}$. Show that the electric field in the region of overlap is constant and evaluate its value.
8) In cylindrical coordinates, two conducting planes at $\varphi = 0\ (V = 0)\ \text{and}\ \varphi = \pi/3\ (V = 100\ \text{volts})$ are insulated along z-axis. The space between the planes is filled with the dielectric ($\varepsilon_r = 3.14$). Evaluate the charge densities on the planes.