Department of Physics
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PH1020 Physics II Problem set 1

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1. The electric field in a region of space is given by $\vec{E} = \alpha[y^2\hat{e}_x + (2xy + z^2)\hat{e}_y + 2yz\hat{e}_z]$, where α is a constant with appropriate units. Find the equation of the lines of force in the plane $z = 0$.

2. A charge q is uniformly distributed over an arc of radius a and angle α that extends from the x-axis counter-clock wise. Find the force on a charge Q placed at the origin.

3. Find the force on a charge Q lying on the z-axis above the center of a circular hole of radius a in an infinite uniformly charged flat plate occupying the xoy plane, carrying a surface charge density σ. If the charge is negative, (i.e, $Q < 0$) and it is released at a distance close to the origin (i.e, $z << a$), investigate the motion.

4. Consider a point charge, q at a point P. Show that the electrical flux through a region, D, on the surface of a unit sphere centered at P is $\frac{q}{4\pi\varepsilon_0}$ times the solid angle subtended by D at P. Now consider a cube centered at P. What is the electrical flux through a face of the cube? Does it depend on the size of the cube? Does it depend on the orientation of the cube?

5. A ring of radius R and uniform charge density λ is located in the yz-plane, with its center at origin O. A particle of mass m and charge $-Q$ is constrained to move along the x-axis. Show that the time period of oscillation of the particle, when it is displaced slightly from O along the x-axis and released, is

$$T = 2\pi\sqrt{\frac{2\varepsilon_0 mR^2}{\lambda Q}}$$

6. A sphere of radius R carries a uniform charge density ρ. Determine the electric field using Gauss law for the cases $r \leq R$ and $r \geq R$ separately.

7. A sphere of radius R centered at the origin carries a surface charge density $\sigma(r) = (\vec{k}.\vec{r})$ where $\vec{k}$ is constant vector of appropriate dimensions. Determine the electric field at the center of a sphere.