PH102 Tutorial Sheet 4 (Jan 23, 2015)
Department of Physics, IIT Guwahati
Professor Alika Khare & Professor Pratima Agarwal

1. The phosphate ore consists of the small particles of phosphate and quartz (SiO_2). The phosphate is separated from the quartz by applying a uniform electric field as shown in fig 1. below. Assuming that particles enter into an uniform electric field of magnitude E=500kV/m with zero initial velocity and zero relative separation, determine the separation between the phosphate ions (+ve charge) and quartz ions (-ve charge)after falling down to a distance of 80m. Assuming charge to mass ratio (Q/M) for both the ions is same and is 9μC/kg. (this system is called as electrostatic separator).
2. Find the electric field at a distance z above the centre of a circular loop of radius R carrying a line charge density λ C/m. Check the case when $z >> R$.
3. A thick spherical shell of inner radius a and outer radius b (as shown in fig 2) carries a non-uniform volume charge density $\rho_v = \frac{c}{r^2}, (a < r < b)$, where c is a constant . Find the electric fields in the region i). $r < a$, ii). $a < r < b$ and iii). $r > b$. Plot the electric field as a function of r.
4. A long coaxial cable as shown in Fig 3, carries a uniform volume charge density $+\rho_v$ on the inner cylinder (solid) of radius a and a uniform surface charge density - σ on the outer cylindrical shell of radius b . The magnitudes of the charge densities are such that the cable as a whole is electrically neutral. Find the electric field at any point i). inside the inner cylinder, ii). space in between the cylinder and the cylindrical shell and iii). outside the cable. Plot the electric field as a function of distance from the axis of the cylinder.
5. The electric field in the atmosphere at the earth's surface is 200V/m directed downward. At 1400m above the earth's surface the electric field is only 20V/m again directed downward. What is the average volume charge density in this region. Does it consist of predominantly positive or negative ions?
6. Three concentric spherical shells having radius R_1 =1m, R_2 =2m and R_3 = 3m carry a surface charge densities 2, -4 and 5 $\mu C/m^2$ respectively. Calculate the total flux through the surface i). r=0.5m, ii. r=2.5m and r=3.5 m. Calculate the electric field in region i). $r < R_1$, ii). $R_1 < r < R_2$, iii). $R_2 < r < R_3$ and iv). $R > R_3$. Plot the field as a function of r.
7. If the potential in a region is given by $V = \rho^2 z sin\varphi$ (in cylindrical coordinate system) calculate the corresponding electric field.
8. In a vacuum tube, electrons are emitted from a hot plane metal surface (emitter) and collected by another metal plate (collector) placed parallel to the emitter a distance d away as shown in fig 4. The distance d is small compared to the dimensions of the plates. The electric potential between the plates is given by $V(x) = Cx^{4/3}$ where x is the distance from the emitter plate and C is a constant. What is the surface charge density σ on the emitter and collector plates. What is the volume charge density $\rho_v(x)$ in the region between the two plated. Plot the charge density as a function of x? (neglect the space charge effect).

9. Consider a uniformly charged sphere of radius R containing the total charge Q . Find the potential difference between any point r inside the sphere and at the origin, $V(r) - V(0)$ for the case i). $V(0)=0$ and ii). $V(\infty)=0$. Plot the potential difference as a function r in both the cases.

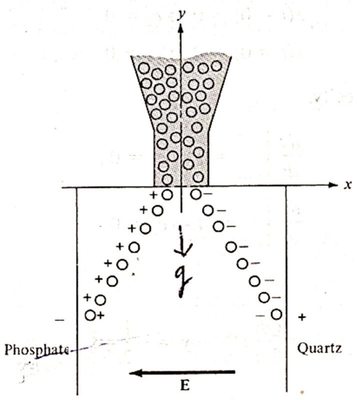


Fig 1

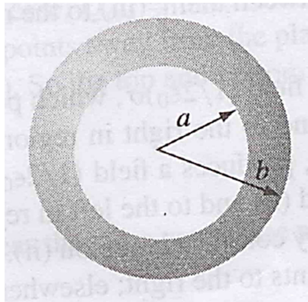
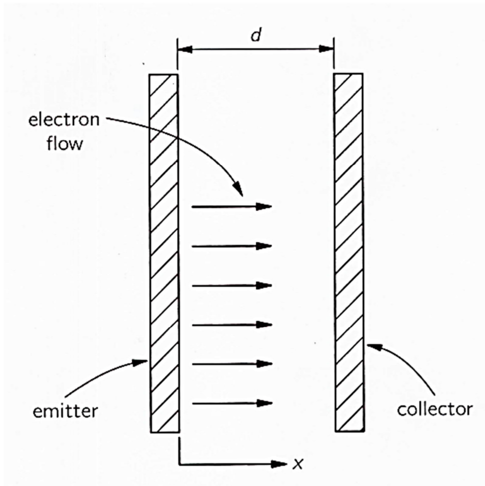


Fig 2



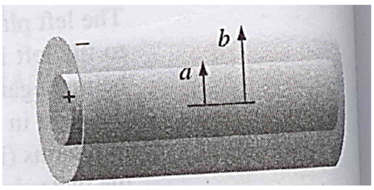


Fig 3

Fig 4

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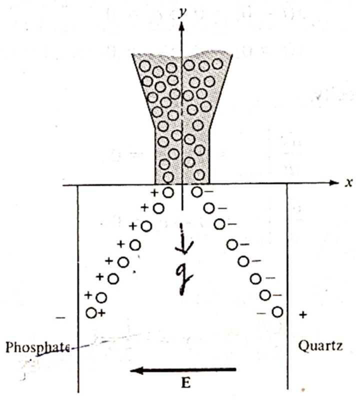

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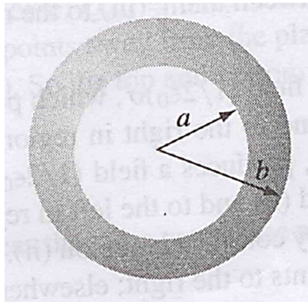

Fig 2

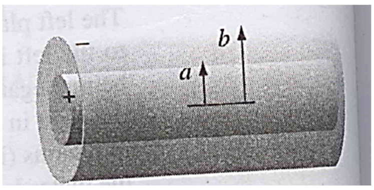

Fig 3

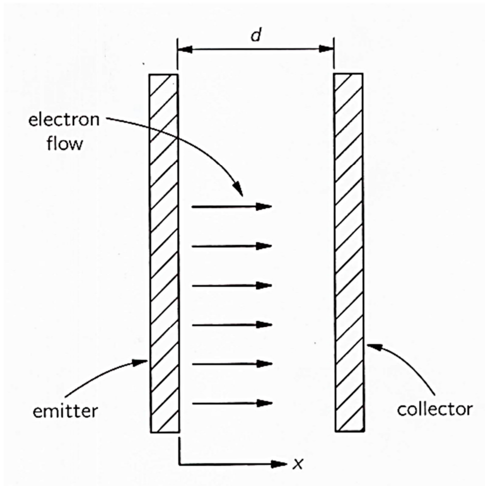

Fig 4