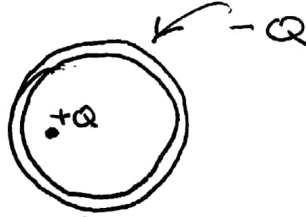


Do at home

Physics 220
Mid-term Exam
Time : 2.5 hours

1. Sketch qualitatively the electric field lines

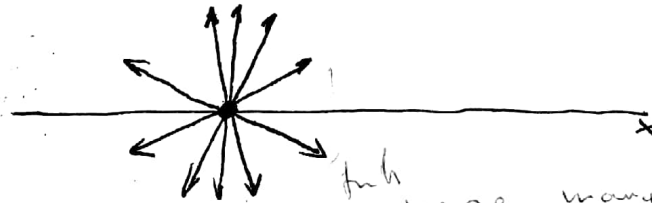
i) for a conducting spherical shell with a net charge of $-Q$ and a point charge $+Q$ in the cavity off-center;



ii) same as i) but the shell is non-conducting and the $-Q$ charge is smeared uniformly over the outer surface of the shell;

iii) same as i), the spherical shell is conducting and has zero net charge;

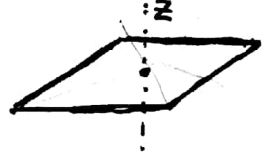
2. Does the following picture represent a legitimate electrostatic field (there is axial symmetry with respect to X axis)? Give reasoning.



- close to charge is low but contracted in x direction
∴ field piles up

3. A square of side l is formed by thin rods that carry a uniform linear density of charge λ .

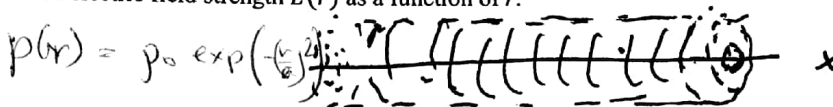
a) Find the electric potential $\varphi(z)$ at height z from the plane of the square above its center.



b) Sketch qualitatively the function $\varphi(z)$ for positive and negative z . We are specifically interested in the two limits: small distances $|z| \ll l$ and large distances $|z| \gg l$

c) A test charge particle of the opposite sign is confined to move in the z direction along the line passing through the center of the square. What can you say about the possible types of motion (the test particle has a mass; friction is negligible)

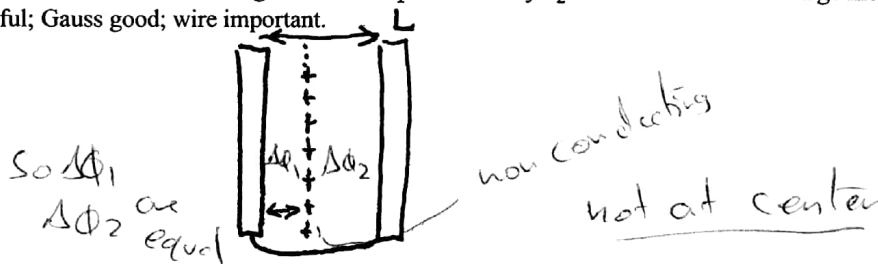
4. The charge distribution has the symmetry of an infinite cylinder with the volume charge density of the form $\rho(r) = \rho_0 \exp\left(-\frac{r}{a}\right)$ where r is the distance from the axis. Specify the picture of the field and find the electric field strength $E(r)$ as a function of r .



5. A charge $+Q$ is placed at distance d from an infinite conducting plane. How much external work is required to move the charge away from the plane to distance $2d$?

Compare the work obtained by integrating the force over a path to the change in "potential energy" of the charge-image pair. If the two quantities differ, which gives the correct answer, and what is wrong with the other?

6. A sheet of charge with surface charge density σ is placed between two conducting slabs connected by a wire. The separation between slabs is L , the distance from the left slab to the sheet is x . Find the induced surface charge densities σ_1 and density σ_2 on the slabs. Hints: Image method not helpful; Gauss good; wire important.



7. In a Van de Graaf generator, a rubber belt 0.3 m wide travels at a velocity of 20 m/s. The belt is given a surface charge at the lower roller, the surface charge density being such that the electric field strength is 10^6 V/m on each side of the belt.

Find the current produced by the moving belt.



8. In a certain region in space, there are 10^{17} doubly charged positive ions per m^3 moving east with a speed of 10^6 m/s, and also 10^{16} electrons per m^3 moving south with a speed of 10^7 m/s.

Find the magnitude and direction of the current density vector.

Is the current density large compared to that in a typical wire carrying 1 A current?