
General Physics: Electromagnetism, Problem Set 3

Exercise 1 :

Two infinite parallel planes carry equal but opposite uniform charge densities $\pm\sigma$.

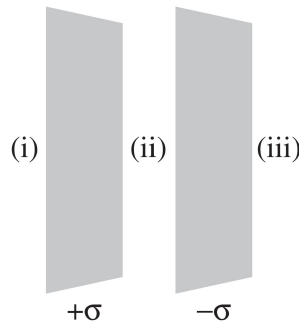


Figure 1: Two infinite parallel planes carrying opposite uniform charges.

Find the field in each of the three regions:

- (i) To the left of both;
- (ii) Between them;
- (iii) To the right of both.

Exercise 2 :

We assume an electron beam is a stationary uniform charge distribution in cylindric form with radius a and infinite length.

- (a) Find the electric field at a distance r from the beam center for $r > a$ and $r < a$. Assume a line charge density of λ of the electron beam.
- (b) What is the force on an electron in the beam at a distance r from the beam axis if you assume a volume charge density of n electrons per unit volume V ?

Exercise 3 :

A sphere of radius r_0 carries a volume charge density ρ_E (see Figure 2). A spherical cavity of radius $r_0/2$ is then scooped out and left empty, as shown.

- (a) What is the magnitude and direction of the electric field at point A ?
- (b) What is the direction and magnitude of the electric field at point B ?

Points A and C are at the centers of the respective spheres.

Hint: in order to take a symmetric Gaussian surface consider two spheres: a big one centered in A , with radius r_0 and with volume charge density ρ_E and a second smaller one centered in C , with radius $r_0/2$ and with volume charge density $-\rho_E$.

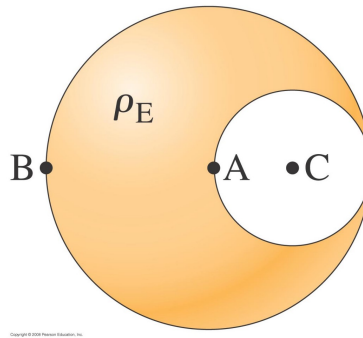


Figure 2: A charged sphere of radius r_0 containing a cavity of radius $r_0/2$.

Exercise 4 :

A solid insulating sphere of radius a carries a net positive charge Q uniformly distributed throughout its volume. A conducting spherical shell of inner radius b and outer radius c is concentric with the solid sphere and carries a net charge $-2Q$. Using Gauss's law, find the electric field in the regions labeled ①, ②, ③, and ④ in Figure 3 and the charge distribution on the shell when the entire system is in electrostatic equilibrium.

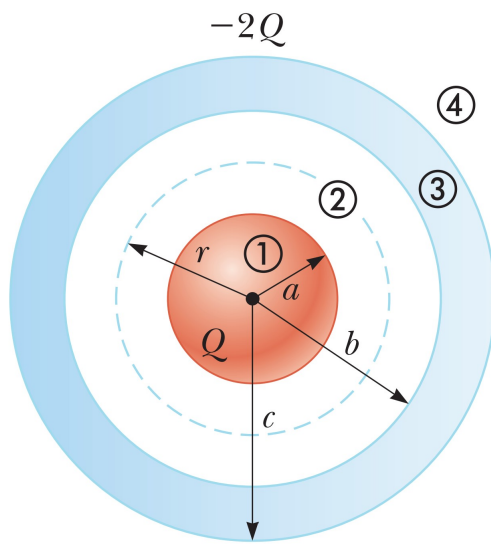


Figure 3: An insulating sphere of radius a and carrying a charge Q surrounded by a conducting spherical shell carrying a charge $-2Q$.

Exercise 5 :

A long, straight wire is surrounded by a hollow metal cylinder whose axis coincides with that of the wire. The wire has a charge per unit length of λ , and the cylinder has a net charge per unit length of 2λ . From this information, use Gauss's law to find:

- (a) The charge per unit length on the inner surface of the cylinder;
- (b) The charge per unit length on the outer surface of the cylinder;
- (c) The electric field outside the cylinder a distance r from the axis.