

Exercise Sheet 7

Discussion 29.10.2025

Discussion 1 - Gauss's law

- You have a charge Q placed in the middle of a regular tetrahedron. What is the flux of the electric field over each face of the regular tetrahedron?
- You have a charge Q placed at the corner of a cube. What is the flux over each face of the cube?

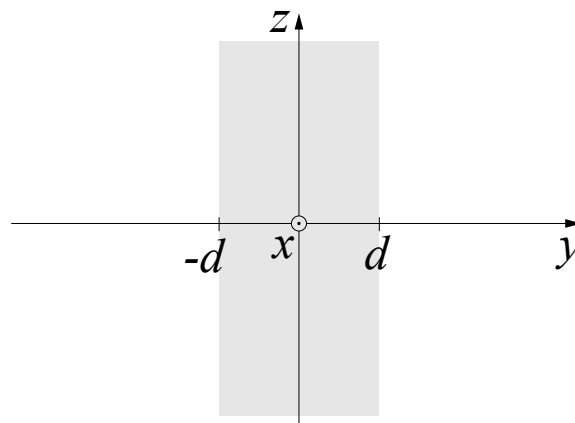
Exercise 1 - Electron Beam

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

Distinguish the electric field at a distance r from the beam centre for $r > a$ and $r < a$. Assume a line charge density of λ of the electron beam.

Exercise 2 - Charged slab

A infinite plane slab, of thickness $2d$ and parallel to the xz plane, carries a uniform volume charge density ρ . Find the electric field as a function of y , with $y = 0$ at the center of the slab. Plot E versus y , defining E positive when it points in the $+y$ direction and negative when it points in the $-y$ direction.



Discussion 2 - Cavities in a conductor

Two spherical cavities, of radii r_a and r_b , are hollowed out from the interior of a neutral, conducting sphere of radius R . A point charge is placed at the centre of each cavity, q_a and q_b respectively.

- a) Find the surface charges σ_a , σ_b , and σ_R .
- b) What is the electric field outside the conductor? Does it depend on the shape, size, and position of the cavities, and why?
- c) What is the force on q_a and q_b ?

Exercise 3 - Corona Discharge

- a) Air ionizes at a potential gradient of 30 kV cm^{-1} . What is the maximal charge that can be carried by a sphere with a diameter of $d = 18 \text{ cm}$ without the occurrence of corona discharge?
- b) For an apparatus operating at 90 kV , what is the smallest external curvature radius you should use to avoid corona discharge?

Exercise 4 - Atmosphere charge density

Because of the free charges in the Earth, an electric field E_1 is measured at sea level oriented perpendicular to the surface. An electric field E_2 is measured at the edge of the ionosphere along the same direction of E_1 . Knowing the radius of the Earth R_1 and the radius of the ionosphere R_2 measured from the center of the Earth, evaluate the volume charge density ρ of all the atmosphere assuming that it is homogeneous.