

Exercise Sheet 5

Discussion 9.10.2024

Exercise 1 - Longitudinal Poiseuille flow in a ring gap

Consider a long, horizontal cylinder of radius R_1 coaxial with a hollow cylinder of radius R_2 . The two cylinders are immobile. A viscous (η) and incompressible (ρ) fluid occupies the space between them ($R_1 \leq r \leq R_2$). A pressure gradient $\partial p / \partial x = -K$ is applied between the extremities of the system.

Hypothesis: a steady, fully developed flow is established; neglect gravitational forces.

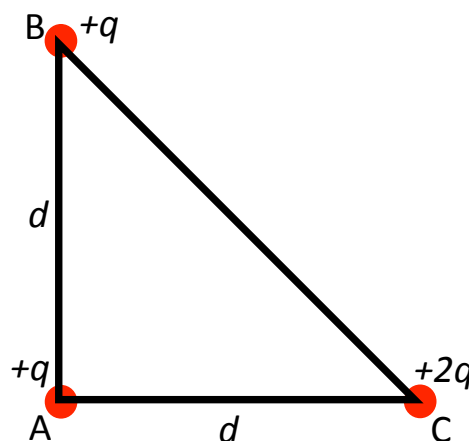
Determine the expression for the velocity of the fluid.

Exercise 2 - Charge Density

- a) What is the total charge on a sheet with the size $L_x=60$ cm and $L_y=50$ cm, if the charge distribution in $\frac{\text{C}}{\text{m}^2}$ is given by $\sigma(x, y) = x^2 y^3 + \ln(x)$?
(assume that one of the corners of the sheet is located at $(0/0)$, and it's expanding in positive x- and y-direction)
- b) A disc shows a radial charge distribution given by $\sigma(r) = e^r$. What is the mean surface charge density as a function of the disc radius R ?

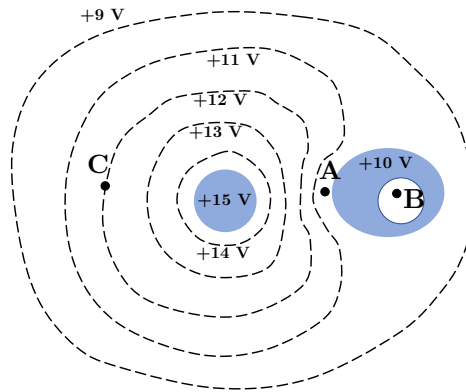
Exercise 3 - Point charges: triangle

Consider a $45^\circ - 90^\circ$ triangle of side d and three point charges $+q$, $+q$ and $+2q$ fixed at the three corners A , B , C respectively as shown in Figure 1. Evaluate the Coulomb force vector acting on a positive charge q_0 fixed in the midpoint of the hypotenuse.



Discussion 1 - E-field Lines and Equipotential surfaces

In the Figure below, draw some of the E-field lines between the objects and identify the sign of the surface charge on the object at point A.



Exercise 4 - Unstable Uranium Core

- After being hit by a neutron, a U_{92}^{235} core becomes unstable and splits into two equal parts with equal charges (number of protons). Assuming a typical core dimension of $d = 10^{-14}$ m, calculate the potential energy stored in this system.
- From nuclear reactors we know that Uranium-235 produces 8×10^7 MJ/kg of nuclear energy. How does this compare to the Coulomb energy found in a)?