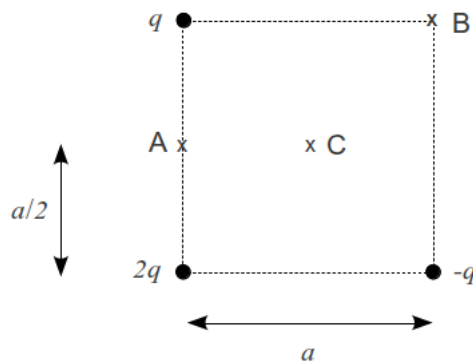## PROBLEM SET 1

Due: 17 September 2020, 12.30 p.m.

Problem 1. Three charges are placed in the vertices of a square. Find the electric field (vector quantity!) at points A, B, and C (the center of the square). For numerical calculations assume: $q = 1$ nC, $a = 10^{-10}$ m.
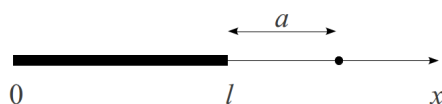
(*3 × 1 points*)

Problem 2. Four circular plastic rods are uniformly charged, each with charge $Q < 0$. Rank the four arrangements according to the magnitude of the electric field at the origin.

(*3 points*)
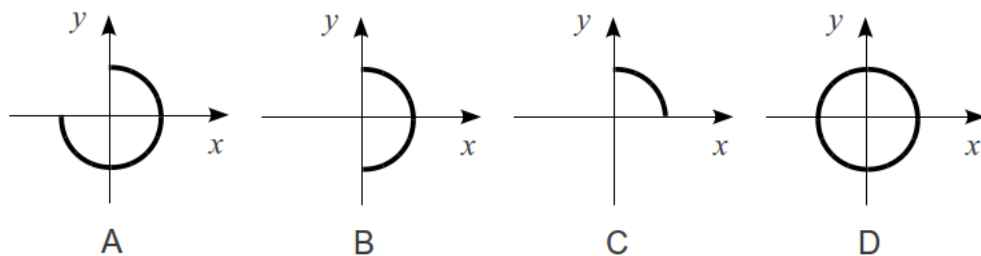
Problem 3. A rod of length l is charged with linear density $\lambda < 0$. Find the electric field on the axis of the rod, at distance a from one of the ends, if

   (a) $\lambda = $ const,

   (b) $\lambda = Ax$, where A is a constant.

(*2 + 3 points*)

Problem 4. Two thin rods of length l lie along the x-axis, one between $x = a/2$ and $x = a/2 + l$, and the other between $x = -a/2$ and $x = -a/2 - l$. Each rod has positive charge Q distributed uniformly along its length.

(a) Show that the magnitude of the force that one rod exerts on the other is

$$F = \frac{Q^2}{4\pi\varepsilon_0 l^2} \ln\left[\frac{(a+l)^2}{a(a+2l)}\right].$$

(b) Show that if $a \gg l$, the magnitude of this force reduces to $F = Q^2/4\pi\varepsilon_0 a^2$. What is the interpretation of this result?

Hint: For $|u| \ll 1$, you may find the expansion $\ln(1 + u) = u - u^2/2 + u^3/3 - \ldots$ helpful.

(4 + 2 points)

Problem 5. A thin disk with a circular hole in its center has its inner radius R_1, and the outer radius R_2. The disk is uniformly charged, with surface charge density $\sigma > 0$.

(a) Find the electric field on the axis of the symmetry of the disk perpendicular to its surface.

Do not solve this problem by direct integration, but rather use the results and formulas derived in the lecture.

(b) Show that at points on this axis, sufficiently close to the geometric center of the disk, the magnitude of the electric field is approximately proportional to the distance from the center. Briefly discuss consequences of this fact (qualitative discussion is sufficient).

(2 + 3 points)