ECE 3318
Applied Electricity and Magnetism
Spring 2023

Homework #3

Date Assigned: Thursday, Feb. 9, 2023
Due Date: Thursday, Feb. 16, 2023

1) Point charge 1 having 2 [C] is at the point (1, 2, 3) [m] in space. Point charge 2 having -3 [C] is at the point (-1, 4, 2) [m] in space. Find the force vector that would be exerted on a charge q of –2 [C] if this charge were located at (0,-2,-3) [m].

2) Two charges, q and $5q$, are separated by a distance d in air. Assume that the charge q is at the origin and the charge $5q$ is on the x axis at $x = d$. A third charge is placed on the x axis so that the *entire system* is in equilibrium (there is no net force on any of the three charges). Determine the location x_3 of the third charge and its charge q_3 (which will be in terms of q).

   (Hint: First consider whether the third charge must be located between the other two or outside of the other two. Also, note that if the net force on any two of the charges is zero, then the force on the third one will automatically be zero, by Newton's law.)

3) A line charge of density ρ_l [C/m] is in the form of a semicircle of radius a lying in the x-y plane with its center located at the origin. The semicircle starts at $\phi = \pi / 2$ and ends at $\phi = 3\pi / 2$ in cylindrical coordinates. Find the electric field vector $\underline{E}$ at the origin for the cases in which (a) the line charge density $\rho_l = \rho_{l0}$ is a constant, and (b) the line charge density varies along the semicircular ring as $\rho_l = A\cos\phi$ (where A is a constant).

   Note: The charge density is being described as a function of the angle ϕ in cylindrical coordinates. But remember to call this angle ϕ' when you set up the integral in Coulomb's law. (We always put primes on the source (integration) variables.)

4) A uniform (homogeneous) surface charge density ρ_{s0} [C/m^2] is distributed over a cylindrical surface at $\rho = a$, extending from $z = -h / 2$ to $z = h / 2$. (There are no top or bottom surfaces for the cylindrical charge.) Find the electric field vector in free space at a point on the z axis at a height z above the origin, where $z > h / 2$.

5) A uniform (homogeneous) volume charge density ρ_{v0} [C/m^3] exists inside of a cylinder of radius a and height h. The cylinder is centered at the origin, with the cylinder axis running along the z axis. Calculate the electric field at a point that is on the z-axis at a height z above the origin, where $z > h / 2$.

(Hint: Take advantage of your solution to the previous problem to help you do two of the integrals.)

6) A continuous volume charge density is defined as $\rho_v = \left(x^2 + y^2 + z^2\right)^{3/2}$ [C/m^3]. This volume charge density is distributed in the region

$$0 \le x \le 1,\ \ 0 \le y \le 3,\ \ -1 \le z \le 1,$$

and is zero elsewhere. Find E_y at the origin. (Note that this problem can be done in closed form because of the very special form of the charge density!)

Note: The charge density is being described as a function of the coordinates (x, y, z) in rectangular coordinates. But remember to call the variables (x', y', z') when you set up the integral in Coulomb's law. (We always put primes on the source (integration) variables.)

7) An infinite sheet of uniform (constant) surface charge density ρ_{s0} [C/m^2] is situated coincident with the x-y plane at $z = 0$. The sheet has an annular slot of inner radius a and outer radius b, where an annular region of surface charge density has been removed. Find the electric field vector at points along the z-axis. (Your answer should include the cases where z is positive and z is negative.) You may use superposition in any way that you wish. You do not have to re-derive anything that is in the class notes.

(Hint: If the annular slot were not there, you would have an infinite sheet of uniform surface charge density ρ_{s0}. Do you know what the electric field from this is, from the class notes? Also, do you know what the field of an annular region of surface charge density is from the class notes?)