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4C Quiz #2

This Quizz is closed book.
Make sure to always indicate positive directions and make large and neat figures. Specify the units of numerical answers.
The electron's mass $m = 9.11 \times 10^{-31}$ Kg and its charge $|e| = 1.6 \times 10^{-19}$ C, $1/(4\pi\epsilon_0) = 9 \times 10^9$ Nm^2/C^2.

PROBLEM 1 (points).

A potential relative to infinity is given by

$$V(x, y, z) = \alpha(x^2 + y^2) \ln(\lambda z)$$

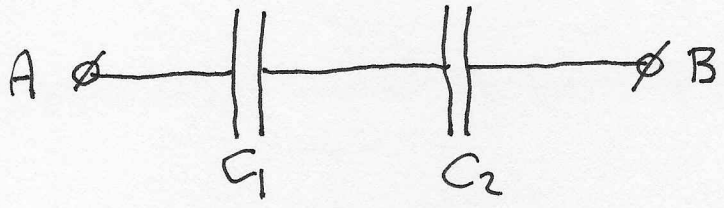
with $\alpha < 0$, $\lambda > 0$ and $z > 0$.

a. Calculate the electric field and plot its z-component.

b. If an electron is positioned somewhere in space in which direction will it move and where will it end up?

PROBLEM 2 (points).

Two capacitors with capacitance C_1 and C_2 are connected in series as shown. Both are initially neutral (no charge). A voltage V is applied between terminals A and B.



a. Calculate the charge on each of the four plates of the two capacitors.

b. Calculate the voltages on each capacitor.

c. Calculate the total potential energy stored in the two capacitors.

PROBLEM 3 (points).

A spherical shell of radius R_2 carries a charge $-q$. At its center is a charge $+Q$ that is located on a spherical shell of radius R_1, $R_1 < R_2$. Do not assume that $|q| = |Q|$. The region between the two shells is filled with a dielectric with dielectric constant κ.

a. Calculate the electric field in the region $R_1 \leq r \leq R_2$.

b. Calculate the electric field in the region $r \geq R_2$.

c. Calculate the potential of the outer shell (relative to infinity).

d. Calculate the potential of the inner shell.

PROBLEM 4 (points).

An infinitely long solid wire with diameter D carries a constant linear charge density λ. It is surrounded by a dielectric cylinder of radius R. Its dielectric constant is κ.

a. Calculate the electric field in the region $r \leq R$.

b. Calculate the electric field in the region $r \geq R$.

c. Calculate the potential at the surface of the wire (relative to infinity).