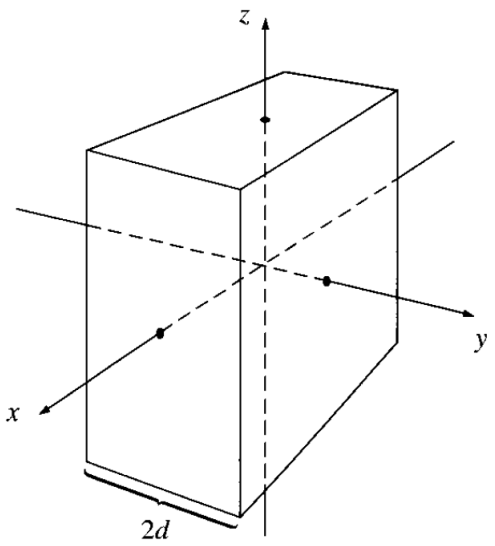
You must show your work to receive credit. An answer written down with no work will receive no credit.

Problem 1

80 points

Consider an infinite insulating slab of thickness $2d$ with charge density $\rho = \rho_0 e^{-|y|/y_0}$, where $\rho_0 > 0$ and $y_0 > 0$ are some positive constants, and y is the distance from the xz-plane. The slab extends infinitely in the x and z directions.



(a): 10 points

What is the direction of the electric field everywhere in space? Your answer can either be mathematical or just words. Justify your answer.

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(b): 5 points

Are there any locations where the electric field vanishes? If so, where?

(c): 20 points

Calculate the electric field magnitude everywhere in space. [In terms of d, ρ_0, y_0, ϵ_0, and/or any spatial coordinates]. You may find your results from parts (a) and (b) useful.

Problem 1 continued on next page...

(d): 15 points

Calculate the potential difference between the origin and a point a distance y along the positive y-axis. Be sure to state which point is at a higher potential.

(e): 15 points

Suppose a negatively-charged particle $-|q|$ of mass m is placed at the origin and then displaced a small distance $y \ll y_0$ along the y axis. Show that the resulting motion will be approximately simple harmonic. [You may ignore gravity in this and the following parts.]

Problem 1 continued on next page...

(f): 5 points

Find the frequency (or angular frequency) of small oscillations of the particle from part (e). [In terms of d, ρ_0, y_0, m, q, and/or ϵ_0]

(g): 10 points

Suppose a small electric dipole is placed a distance $y = d/2$ away from the xz plane such that its dipole moment is $\vec{p} = p\hat{y}$. Calculate the torque (**5 points**) and net force (**5 points**) on this dipole.

Problem 2

20 points

Find the equivalent capacitance of this network of capacitors if all of the capacitors have a capacitance of 2 μF.