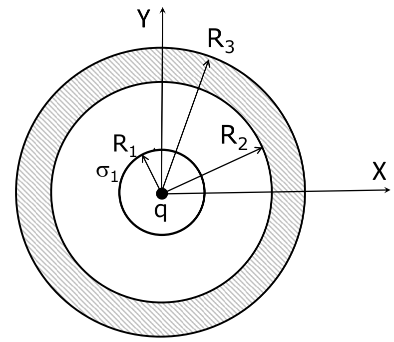
JANUARY 2022

P1. ***(2.5p)*** A point charge q is placed at the origin of the reference frame. Concentric to the charge consider the following charge distributions:
- A spherical surface of radius R_1 and with charge density σ_1.
- A charged hollow sphere made of Copper (Cu) of inner radius R_2, outer radius R_3 and total charge Q.

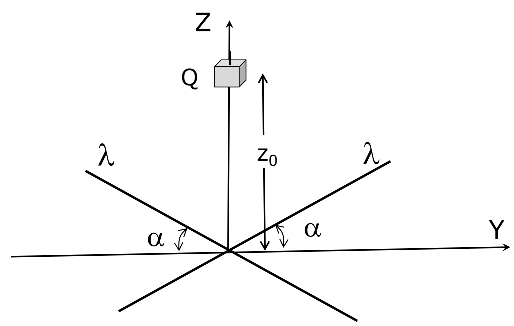
Knowing that the electric field flux through an imaginary spherical surface of radius $R= 3R_3$ and centered at the origin, is Φ_0:



a) Calculate Q.
b) Calculate the charge densities of the hollow sphere.
c) Derive the expression of the electric potential for any point of the hollow sphere.

NOTE: q, σ_1, Φ_0, R_1, R_2 and R_3 are known parameters.

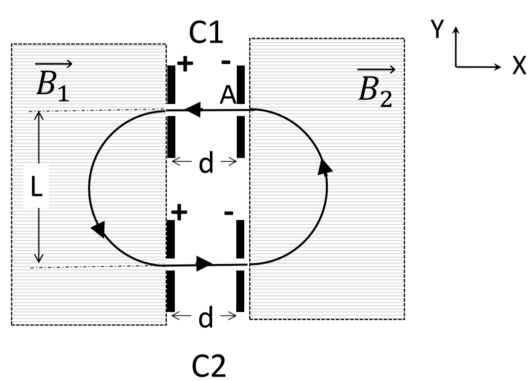
P2. ***(3p)*** Consider two straight and infinite lines, located in the YZ plane as indicated in the figure, each uniformly charged with a linear charge density λ. A point object of mass M and charge Q located at the point $P(0,0,z_0)$ is in equilibrium.



a) Derive the general expression of the electric field created by an infinite uniformly charged line at any point in space.
b) Calculate the electric fields $\overrightarrow{E_1}$ and $\overrightarrow{E_2}$ created by each of the charged lines at point P and express them in Cartesian components.
c) Calculate the mass M of the object.
d) Calculate the acceleration vector that the object would experience if it were located at $(0, 0, 2z_0)$

Data: $\alpha= 25°$; $z_0 = 50$ cm; $Q = 0.32$ µC; $\lambda= 7\times10^{-6}$ C/m; $g=9.8$ m/s^2

P3. ***(2.5 p)*** Consider two identical parallel plate capacitors with d the distance between their plates. The potential difference between the plates of capacitor C1 is V1, while the potential difference between the plates of capacitor C2 is V2. The polarity of the capacitor plates is indicated in the Figure. Additionally, the shaded regions on the left and right hand side of the capacitors are regions of uniform magnetic fields $\overrightarrow{B_1}$ and $\overrightarrow{B_2}$ respectively, that are perpendicular to the XY plane. An electron starts from rest at point A (negative plate of C1) and describes the closed trajectory indicated in the Figure.



a) Calculate the vectors $\overrightarrow{B_1}$ and $\overrightarrow{B_2}$ expressed in Cartesian components.

b) Calculate the total time it takes the electron to return to point A.

Data: d= 5 cm; V1= 3500 V; V2=1500 V; L= 40 cm