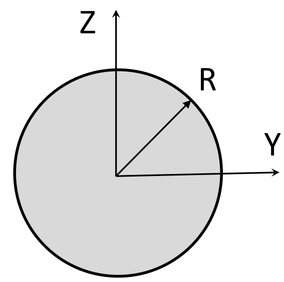
P1. ***(2 p)*** Consider a parallel plate capacitor of surface area A and distance d_0 between the plates. The capacitor is connected to a battery of potential V_0. Once charged, the capacitor is disconnected from the battery. Subsequently, the negative plate begins to move away from the positive plate with a constant speed v_0.

a) If the rate of change of the electrostatic energy stored in the capacitor is $\frac{d\,U_e(t)}{d\,t} = 6.35 \times 10^{-3}\ J/s$, calculate the speed v_0 with which the plate moves.
b) Calculate the electric field inside the capacitor before the plate motion starts and 3 s after the plate motion starts.

DATA: A= 0.5 m^2; d_0= 2 mm; V_0= 1500 V

P2. ***(3 p)*** Consider the following charge distributions: Charge is uniformly distributed over the volume of a sphere centred at the origin and of radius R. The volume charge density varies with time according to the equation $\rho(t) = \rho_0\,(1 + \alpha t)$, where ρ_0 and α are constants. In addition, charge is uniformly distributed on the surface of radius R with constant surface charge density σ.



a) Given the point A (0, 0.6,-0.3), calculate at which time t_1 the electric field at point A, $\vec{E}(A) = 0$.
b) Calculate the general expression for the electric potential at point A as a function of time.
c) Calculate the acceleration vector experienced by a nucleus of ${}^4_2He$ that is placed at point A at time t_2 = 50 s. Express the acceleration vector in Cartesian components.

DATA: ρ_0 = 3.5×10^{-6} C/m^3 ; α= 0.5 s^{-1}; σ= -1.5×10^{-5} C/m$^{2;}$ R= 0.24 m

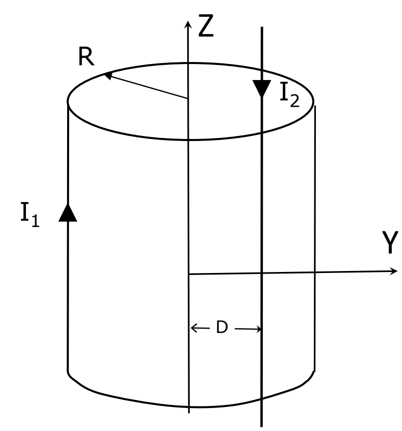
NOTE: the coordinates of point A are given in meters

P3. ***(3 p)*** Consider the following distribution of currents:

- Current I_1 uniformly distributed over a conductive surface of infinite length, radius R, and whose axis coincides with the Z axis of the coordinate system.

- An infinite line, parallel to the Z axis, that carries current I_2 and passes through the point (0,D,0).

The directions of the currents are indicated in the figure.



a) Using Ampère's law, deduce the general expression of the magnetic field $\vec{B}$ at a generic point along the Y axis with y>0. Divide the area along the y axis into as many regions as necessary. Express the vector $\vec{B}$ in Cartesian components.

b) Is it possible to find a point on the Y axis (y>0) where the magnetic field is zero? If so, calculate the y-coordinate of that point. If not, demonstrate that it is not possible to find that point. Do not consider as a solution y=∞.

DATA: I_1= 2.4 A; I_2= 3.5 A; R= 60 cm; D= 40 cm