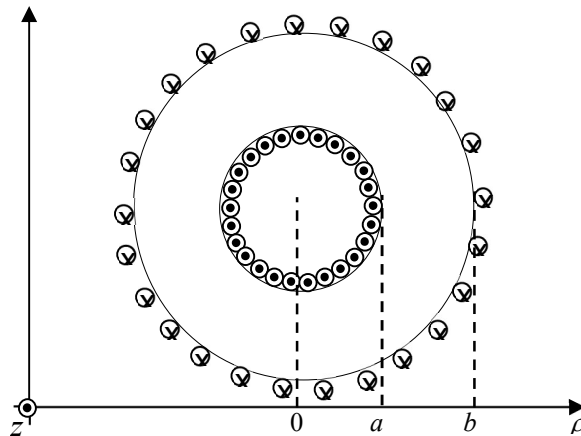


EE2104 Introduction to Electromagnetics
Assignment 4

Deadline (for uploading): 11:59 pm, 4 Dec 2021
Please put down your name and university ID.

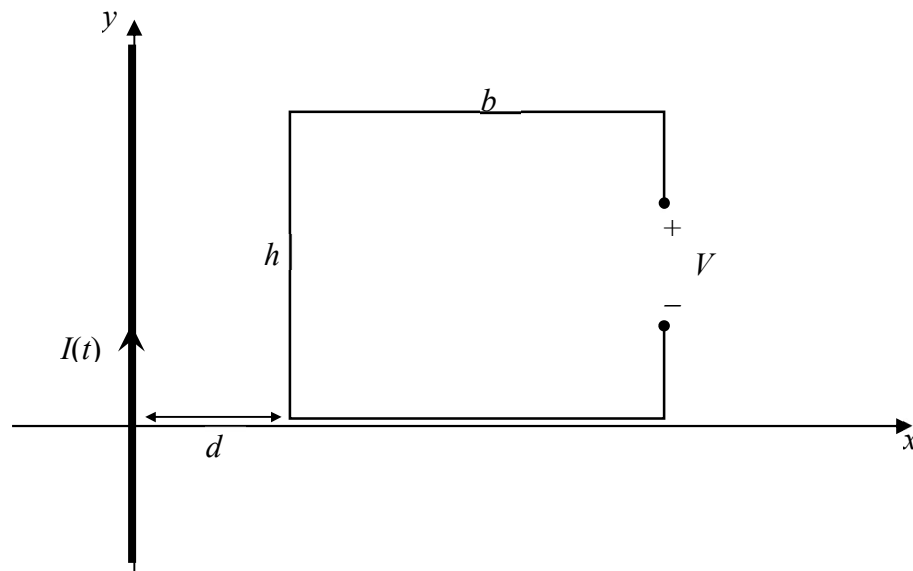
1. Consider a long coaxial cable of inner and outer radii a and b , respectively. The gap is filled with material of relative permittivity ϵ_r and relative permeability μ_r . The length of the cable is l . Using the formulae for the fields associated with infinite line charge and current, find
 - (a) the capacitance C
 - (b) the inductance L
 - (c) The concept of characteristic impedance $Z = (L/C)^{1/2}$ will be introduced. For $\epsilon_r = 6$, $\mu_r = 1$, $b = 5$ mm, and $a = 1$ mm, evaluate Z and state its unit.
2. Consider a torus of $N = 25$ turns with inner and outer radii $a = 20$ mm and $b = 60$ mm, respectively. The torus is put at the origin with the z -axis as the axis of rotation. The direction of the current $I = 5$ A is such that the inner current flows towards the $+z$ -direction. In the cylindrical coordinates, the following figure shows a cross-section of the torus. Find the magnetic flux density $\mathbf{B}$ at $\rho = \frac{a+b}{2}$ in the middle of the torus.



3. An infinitely long wire of current I flowing towards the $+y$ -direction is put on the y -axis. The current is oscillating as:

$$I = I_0 \cos(2\pi f_0 t)$$

where I_0 is the amplitude and f_0 is the frequency. A rectangular open wire loop of height h and width b is put at distance d away, as the following figure shows. Find the induced voltage V across the loop.



4. The following considers electromagnetic wave propagating in a dielectric of permittivity ϵ . The permeability remains as μ_0 . There are no free charges inside the dielectric.
- State the Maxwell's equations in terms of $\mathbf{E}$ and $\mathbf{H}$.
 - Derive the wave equation for $\mathbf{E}$.
 - An electromagnetic wave is described by:

$$\mathbf{E} = E_0 \cos(kz - \omega t) \hat{\mathbf{a}}_x$$

$$\mathbf{H} = H_0 \cos(kz - \omega t) \hat{\mathbf{a}}_y$$

where the amplitudes E_0 and H_0 , the wavenumber k , and the angular frequency ω are constants. The propagation direction is denoted as the z -direction. Find H_0 in terms of E_0 .

5. Answer the following briefly.
- What is the frequency of your cell-phone? Calculate the corresponding wavelength in free-space.
 - What is the frequency of the power lines in Hong Kong? Calculate the corresponding wavelength in free-space.