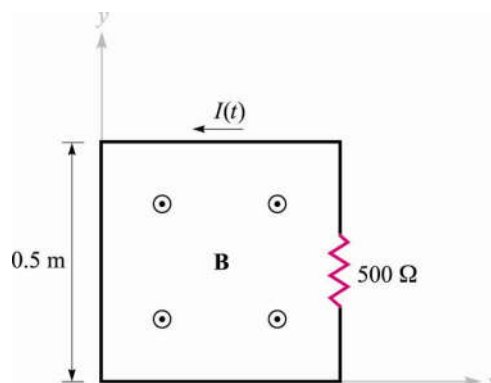


EE2104 Introduction to Electromagnetics
Assignment 4

Deadline (for uploading): 7:00 pm, 5 Dec 2020

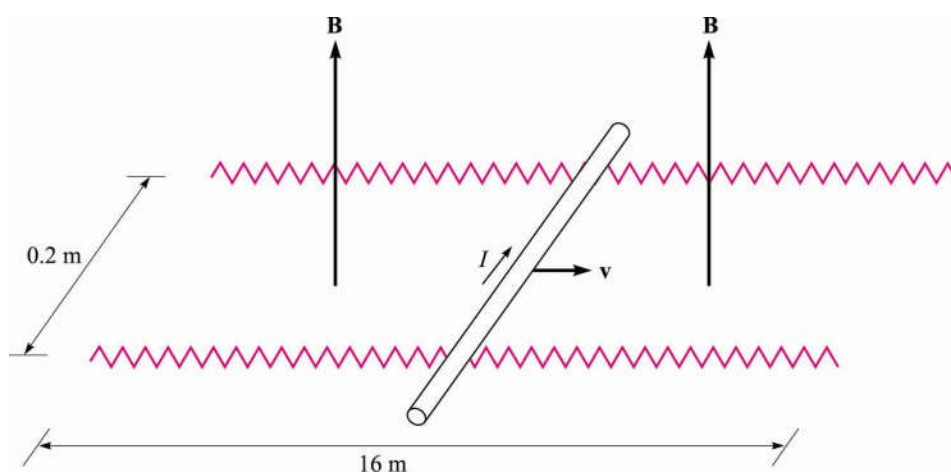
Please put down your name and university ID.

1. A perfectly conducting filament containing a small $500\text{-}\Omega$ resistor is formed into a square, as illustrated below.



Find $I(t)$ if $\mathbf{B} = B_0 \sin(2\pi f_0 t + \phi_0) \hat{\mathbf{a}}_z$, where $B_0 = 1\text{ mT}$, $f_0 = 70\text{ Hz}$, and $\phi_0 = \frac{\pi}{4}$.

2. The rails in the figure below each have a resistance of $5\text{ }\Omega/\text{m}$. The bar with no resistance moves to the right at a constant speed of 9 m/s in a uniform magnetic field of 80 mT . Find $I(t)$, $0 < t < 1\text{ s}$, if the bar is at $x = 2\text{ m}$ at $t = 0$ and a $3\text{-}\Omega$ resistor is present across the left end.



3. 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 formula for the fields associated with infinite line charge and current.
- Find the capacitance C .
 - Find the inductance L .

In the next course on electromagnetics, the concept of characteristic impedance $Z = (L/C)^{1/2}$ will be introduced. For $\epsilon_r = 4$, $\mu_r = 1$, $b = 2\text{mm}$, and $a = 0.2\text{ mm}$, evaluate Z and state its unit.

4. Sun light reaches the earth surface at intensity of 1 kW/m^2 . Although the radiation consists of a wide spectrum, the following calculation assumes a wavelength of $\lambda = 1\text{ }\mu\text{m}$ in the infra-red range. We also assume, for simplicity, that the field is polarized along one direction so that the electromagnetic wave is described by:

$$\begin{aligned}\mathbf{E} &= E_0 \cos(kz - \omega t) \hat{\mathbf{a}}_x \\ \mathbf{H} &= H_0 \cos(kz - \omega t) \hat{\mathbf{a}}_y\end{aligned}$$

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.

- Express k and ω in terms of λ .
 - Using the Maxwell's equations, express H_0 in terms of E_0 .
 - By calculating the energy density carried by the sun light, find the value of E_0 .
5. Consider the following DC generator where a rotating disc is put under a magnetic field. The field is uniformly pointing perpendicular to the disc as

$$\mathbf{B} = B_0 \hat{\mathbf{a}}_z$$

where B_0 is a constant. The disc is rotating in the counter-clockwise sense at frequency f . Using the Faraday's law of electromagnetic induction, find the e.m.f. maintained between radii a and b .

