ECE 332 Lab 1

Part 1: Faraday's Law

Useful Information:

Faraday's Law:

The magnetic flux density **B** induced by a current I in a long straight wire is given by:

$$B = \hat{\phi}\frac{\mu_0 I}{2\pi r} \qquad (Wb/m^2)$$

where r is the distance away from the current-carrying wire. The magnetic flux going through an area is the magnetic flux density integrated over the area:

$$\phi = \int_s B \cdot ds \qquad (Wb)$$

The electromagnetic force V_{emf} generated by a time-varying flux is:

$$V_{emf} = -N\frac{d\phi}{dt}$$

N is the number of conducting loops, and ϕ is the flux through the wire.

Problem Statement:

A 10cm x 10cm square loop of wire with internal resistance 1 Ω has a small gap in one edge closest to a coplanar long straight current-carrying wire located at 5cm from that edge. The current is time-varying, described by a cosine with peak magnitude 5A and frequency f (see Figure 1, next page).

Using Matlab, find the flux through the loop as a symbolic function of time for symbolic frequency f, then plot the induced V_{emf} in the loop for f stepped by octave from 10 Hz to 160 Hz. Assume the current-carrying wire is along the z axis, pointed in the +z direction, and that all vertices of the loop of wire are in the y-z plane. Plot V_{emf} over the longest period under consideration.

Note: Draft MATLAB code is provided as a separate file in which you are required to insert your code and comments at appropriate places.

In a separate section, comment on the direction of the flux and the polarity of the induced V_{emf}. If there were a 4 Ω resistor bridging the gap in the loop, would the induced current flow clockwise or counterclockwise from the perspective of a viewer looking in the direction (-x)?

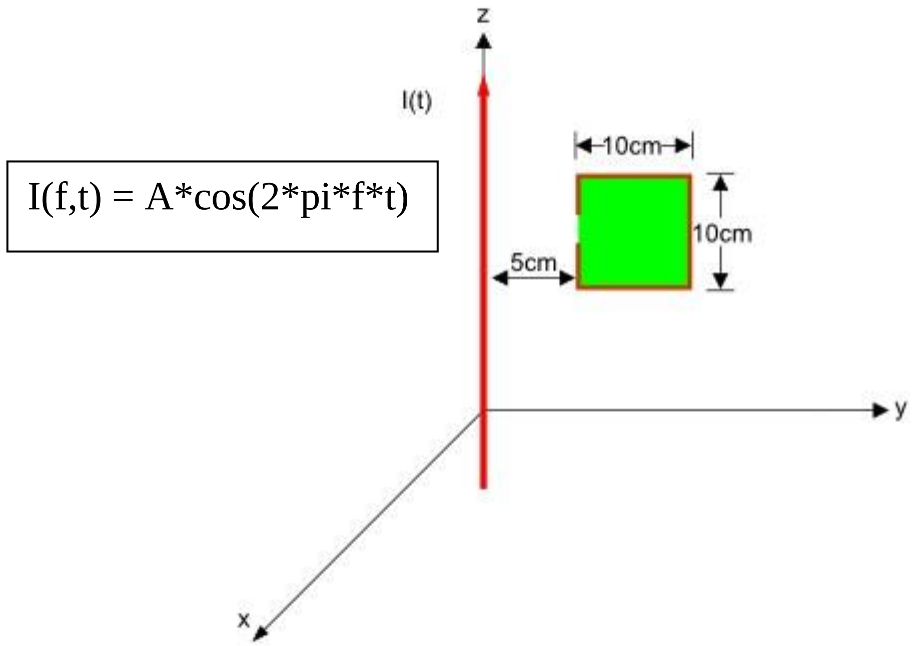

Figure 1. The gap drawn in the image was purposefully drawn large to increase its visibility. However, assume that the gap is negligibly small.

Part 2: Ampere's Law and Vector Field Plotting

Useful Information:

Ampere’s Law (static fields)

The magnetic field is related to the current by **Ampere’s Law**. The integral form of Ampere’s Law for static fields is

$$\oint_C \vec{B} \bullet d\vec{L} = \mu_0 I_{enclosed}$$

The left side of above equation is called the circulation of the magnetic field around a closed path C. The right side is the source of the magnetic field - the conduction current passing through any surface bounded by the closed loop C. Using this law, the magnetic flux density B around an infinitely long wire was derived.

$$B = \hat{\phi}\frac{\mu_0 I}{2\pi r} \qquad (Wb/m^2)$$

Problem Statement:

Make quiver plots to show the magnetic field <u>B</u> between two infinitely-long parallel conductors 1cm apart each carrying 10 A, first as they both carry current in the same direction (+z) and again when one is opposing (I in -z direction). Ignore the effects of mutual inductive coupling and use superposition to obtain the total field vectors at all points.

Note: Draft MATLAB code is provided as a separate file in which you are required to insert your code and comments at appropriate places.

Optional: only the quiver plots are required, but you might explore making contour and surface plots as well (just because they look cool!)

→ In the end you should **Publish** the code that contains both part 1 and part 2 to generate a single pdf document.

Submit a **single** pdf document that contains the codes, results and comments. Please do not turn in individual m-files and plots.