Please read.

• Count to make sure that there are 5 pages in this question booklet
• Check your name, number, on front page, and student ID on each page.
• This examination is conducted with closed books and notes.
• Put all your personal belongings underneath your seat and make sure that pages of books or notebooks are not open.
• Absolutely no talking or exchanging anything (like rulers, erasers) during the exam.
• You must show all your work to get credit; you will not be given any points unless you show the details of your work (this applies even if your final answer is correct).
• Write neatly and clearly; unreadable answers will not be given any credit.
• If you need more writing space, use the backs of the question pages and put down the appropriate pointer marks.
• Make sure that you include units in your results.
• Make sure that you label the axis and have units in your plots.
• You are not allowed to use calculators during this exam.
• Turn off your mobile phones, and put away.
• You are not allowed to leave the class during the first 15 minutes, and last 15 minutes.

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1-(25 Points) The long, straight wire shown in the figure (a) below, carries constant current $I$. A metal bar with length $L$ is moving at constant velocity $\vec{v}$, as shown in the figure. Point $a$ is a distance $d$ from the wire.

(a) Calculate the emf induced in the bar.
(b) Which point, $a$ or $b$, is at higher potential?
(c) If the bar is replaced by a rectangular wire loop of resistance $R$ (shown in the figure (b) below), what is the magnitude of the current induced in the loop?
2-(25 Points)
a) Two inductors, one of self-inductance $L_1$ and the other of self-inductance $L_2$ are connected in parallel. Show that the equivalent inductance of the combination is $L_{eq} = \frac{L_1 L_2}{L_1 + L_2}$.
b) In the circuit shown below switch $S_1$ has been closed and $S_2$ has been open for a long time. Suddenly at $t=0$, switch $S_2$ is closed and $S_1$ is opened. Find out the maximum currents flowing through inductors $L_1$ and $L_2$.
c) Verify your answer above by showing that the total energy stored in the capacitor at $t=0$ is equal to the total energy stored in the inductors when the current flowing through them is maximum.

![Circuit Diagram]

The circuit diagram shows a circuit with a voltage source $\mathcal{E}$, a resistor $R$, a capacitor $C$, and two inductors $L_1$ and $L_2$. The switches $S_1$ and $S_2$ are positioned to close and open the circuit at different times.
3-(25 Points)
(a) A circuit is composed of a single loop with an alternating voltage source 
$V(t) = V_0 \cos(\omega t)$, a capacitor $C$ and a resistor $R$. Derive the current $I(t)$ as a function of 
$(V_0, \omega, t, C, R)$.
(b) A circuit is composed of a single loop with an alternating voltage source 
$V(t) = V_0 \cos(\omega t)$, an inductor $L$ and a resistor $R$. Derive the power $P(t)$ obtained from the 
alternating current source as a function of $(V_0, \omega, t, L, R)$.
4-(25 Points) A linearly polarized microwave of wavelength 12 cm is propagating in vacuum, along the positive x-axis. The electric field vector has an amplitude of 1.5 kV/m and vibrates in the xy-plane.

(i) Write the vector equations for the sinusoidal electric and magnetic fields as functions of time and position. (Take $\pi = 3$ and $c = 3 \times 10^8$ m/s)

(ii) Calculate the Poynting vector and the intensity of the microwave.

\[ \mu_0 = 4\pi \times 10^{-7} \text{Tm/A} \]

(iii) If this wave directed at normal incidence onto a perfectly reflecting metal sheet, with area 6000 cm$^2$ and of mass 1 kg, what would be the acceleration of the sheet?

(iv) Write the vector equations for the reflected and the total fields. List the antinodal planes of the fields.