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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2021/2022 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: PHY 221

COURSE TITLE: ELECTRICITY AND MAGNETISM II

DATE: 9TH JULY, 2022 **TIME: 0900 – 1200 HRS**

INSTRUCTION TO CANDIDATES

- **SEE INSIDE**

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REGULAR-MAIN EXAMINATION

PHY 221: ELECTRICITY AND MAGNETISM II

STREAM: BED (Scie) **DURATION: 3 Hours**

INSTRUCTIONS TO CANDIDATES

i. *Answer questions **ONE** and **TWO** in section **A** and any other **THREE** questions from section **B**.*

ii. *The following constants might be useful:*

$1eV = 1.6\times10^{-19}J$

$\mu_o = 4\pi\times10^{-7}$ H/m

$\varepsilon_o = 8.85\times10^{-12}$ $C^2/N.m^2$

SECTION A (28 MARKS)

Question One (14 Marks)

a. Write down the expressions for the following laws hence give their physical interpretations.
   i. Faraday's law (2 marks)
   ii. Gauss's law for E (2 marks)

b. Define capacitive reactance (χ_C) and inductive reactance (χ_L). (2 Marks)

c. A 10.0 Mh inductor carries current $i = I_{max}\sin\omega t$, with $I_{max} = 5.00$ A and $f = \omega/2\pi = 60.0Hz$. What is the self-induced emf? (5 Marks)

d. How does a dielectric material impact on the capacitance of a capacitor? (3 marks)

Question Two (14 marks)

a. Define the term *alternating current*, hence give its symbol (2 marks)

b. State five features of electromagnetic waves described by one dimensional wave equation (5 marks)

c. Two dielectrics with dielectric constants k1 & k2 each fill half the space between the plates of a parallel-plate capacitor as shown in *Figure 1* below

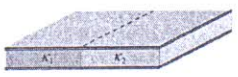

Figure 1

Given that each plate has an area A and the separation distance is d. compute the capacitance of the system. (5 marks)

d. Distinguish between an *electric* and *magnetic* field (2 marks)

SECTION B (42 MARKS)

Question Three (14 marks)

An infinite straight wire carrying current *I,* is placed to the left of a rectangular current loop of wire of width *w* and length l, as shown on the *Figure 2* below

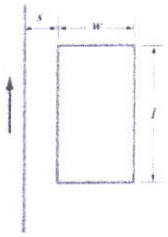

Figure 2

a. Determine the magnetic flux through the rectangular loop due to the current *I* (5 marks)
b. Given that, the current *I* is a function of time $I(t) = a + bt$, where *a* and *b* are positive constants. Determine:
   i. Induced emf in the loop (4 marks)
   ii. Direction of the induced current (2 marks)
c. Briefly describe an ac RCL circuit (3 marks)

Question Four (14 marks)

A conducting rod of length *l* is free to slide on two parallel conducting bars as shown in the *Figure 3* below.

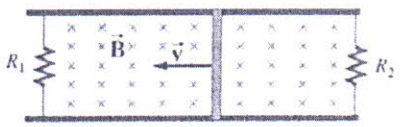

Figure 3

In addition, two resistors R_1 & R_2 are connected across the ends of the bars. There is a uniform magnetic field pointing into the page. Given that, the bar is pulled to the left externally with a constant speed *v.* Determine:

a. The current through both resistors (4 marks)
b. The total power delivered to the resistors (5 marks)
c. The applied force needed for the rod to maintain a constant velocity (5 marks)

Question Five (14 Marks)

a) A resistor ($9\times10^{2}\,\Omega$), a capacitor $C = 0.25\ \mu\text{F}$, and an inductor ($L = 2.50\ \text{H}$) are connected in series across a 2.40×10^{2} Hz AC source for which $\Delta V_{\max} = 1.40\times10^{2}\ \text{V}$.

i. Calculate the impedance of the circuit. (4 Marks)
ii. the maximum current delivered by the source, and (4 Marks)
iii. the phase angle between the current and voltage. (4 Marks)
iv. Is the current leading or lagging the voltage? (2 marks)

Question Six (14 marks)

a. Distinguish between a capacitor and an inductor (2 marks)

b. Define self-inductance and self-induced emf. (2 Marks)

c. Show that at resonant frequency (f_o), $f_o = \dfrac{1}{2\pi\sqrt{LC}}$ and the applied voltage and current are in phase. (5 Marks

d. A 30-turn circular coil of radius 4.00 cm and resistance 1.00 Ω is placed in a magnetic field directed perpendicular to the plane of the coil. The magnitude of the magnetic field varies with time according to the expression $B = 0.01t + 0.04t^{2}$, where B is in Tesla and t is in seconds. Calculate the induced emf in the coil at $t = 0.5\ \text{s}$. (5 Marks

Question Seven (14 marks)

a. Write down the Maxwell's equations in the absencse of sources where $Q = 0$ and $I = 0$. (4 Marks)

b. By taking partial derivatives of the following expressions with respect to x and then t, $\dfrac{\partial E_y}{\partial x} = -\dfrac{\partial B_z}{\partial t}$ and $-\dfrac{\partial B_z}{\partial x} = \mu_o\varepsilon_o\left(\dfrac{\partial E_y}{\partial t}\right)$, verify that both electric and magnetic fields satisfy the one-dimensional wave equation. (5 Marks)

c. Define the poynting vector and give its's physical meanig. (2 Marks)

d. Derive the expression of intensity of the wave, *I*, defined as the time average of the pointing vector. (3 Marks)

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