KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS

2010/2011 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHYS 323**

COURSE TITLE: **ELECTROMAGNETIC THEORY**

STREAM: **SESSION V & VII**

DAY: **WEDNESDAY**

TIME: **9.00 – 11.00 A.M.**

DATE: **13/04/2011**

INSTRUCTIONS:
Answer question **ONE** and any **TWO** other questions.
Question **ONE** carries **40** marks while all the other questions carry **15** marks each.

You may use the following constants:
$\varepsilon_o = 8.85 \times 10^{-12}$ F/m; $\mu_o = 4\pi x 10^{-7}$Tm/A; **$c = 3.0 \times 10^8$ m/s;** $Z_o = 377\Omega$
Electron charge $e = 1.6 \times 10^{-19}$C; Rest mass of an electron $M_e = 9.1 \times 10^{-31}$kg
Rest mass of a proton $Mp = 1.672 \times 10^{-27}$kg ; Resistivity of copper $\rho = 1.7 \times 10^{-8}$

PLEASE TURN OVER

QUESTION ONE

a) State Lenz's law [1 mark]

b) A current of 5.00mA flows into a 10.0pF capacitor with circular plates of radius 2.00cm. Find

i) The displacement current, [1 mark]

ii) the rate of change of the electric flux, [2 marks]

iii) the rate of change of electric field, [3 marks]

iv) the magnetic field 3.00cm from the center of the plates [2 marks]

v) The magnetic field 1.00cm from the center of the plates. [2marks]

c) State any FOUR properties of electromagnetic waves [2 mark]

d) Define 'pointing vector' [1 mark]

e) The electric field E_y of a TransverseElectroMagnetic (TEM) wave equals $100 Vm^{-1}$ rms. Find:

i) velocity and pointing vector magnitude $|PV|$ in air [2 marks]

ii) velocity and $|PV|$ in a lossless dielectric medium with $\varepsilon_r = 9$ [2 marks]

f) Sunlight strikes earth with an average intensity of $1400 W/m^2$. Find the peak electric and magnetic fields. [4 marks]

g) Describe briefly what you understand by eddy current. How can it be reduced? [3 marks]

h) In some region of space the electric field and the magnetic field give equal contributions to the energy density. Find the ratio of E to B. [2 marks]

i) An electron in the ground state of the hydrogen atom has an orbital angular momentum of $1.05 \times 10^{-34} J \cdot s$. Find the orbital magnetic moment. [2 marks]

j) A conducting rod of length l is free to slide on two parallel conducting bars as in Figure 1 below

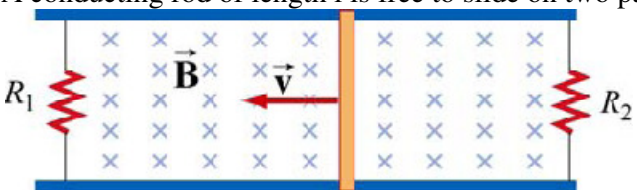


Figure 1

In addition, two resistors R_1 and R_2 are connected across the ends of the bars. There is a uniform magnetic field pointing into the page. Suppose an external agent pulls the bar to the left at a constant speed. Evaluate the following quantities:

i) The currents through both resistors; [3 marks]

ii) The total power delivered to the resistors; [2 marks]

iii) The applied force needed for the rod to maintain a constant velocity [2 marks]

k) Study the figure below

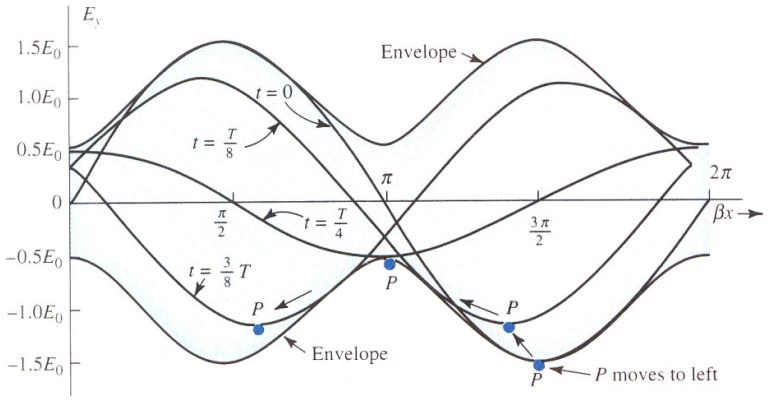


Figure 3

From the figure, find:

i) Voltage standing wave ratio(VSWR) [2 marks]

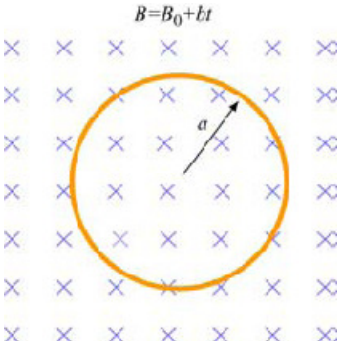
ii) Reflection coefficient ρ for the wave of the figure [2 marks]

QUESTION TWO

a) State and briefly explain THREE types of magnetic behaviour [6 marks]

b) A circular loop of wire of radius a is placed in a uniform magnetic field, with the plane of the loop perpendicular to the direction of the field, as shown in Figure below.The magnetic field varies with time according to $B = B_o + bt$ where B_o and b are positive constants.

i) Calculate the magnetic flux through the loop at t = 0 [3 marks]



ii) Calculate the induced e.m.f in the loop. [2 marks]

iii) What is the induced current and its direction of flow if the overall resistance of the loop is R? [2 marks]

iv) Find the power dissipated due to the resistance of the loop [2 marks]

QUESTION THREE

a) Show that $E = E_m \sin(kz - \omega t)$ is a wave moving in the positive z direction. Express k and w in terms of the wavelength, λ, and the frequency, f and find their relationship to the velocity. [5 marks]

b) Calculate the ocean depths at which a 1 μVm^{-1} field will be obtained with E at the surface equal to 1 Vm^{-1} at frequencies of 1, 10, 100, and 1000 kHz. What is the most suitable frequency for communication by wireless with undersea craft? (assume at the sea, $\sigma = 4\ \Omega m^{-1}$, and $\varepsilon_r = 80$) [5 marks]

a) Suppose a magnetic monopole is found experimentally. Fix Maxwell's Equations and find the SI units of magnetic charge [5 marks]

QUESTION FOUR

a) A solenoid (shown in figure 4) has 1000 turns of wire. It is 10.0cm long and 1.00cm in diameter. Estimate the self inductance. [5 marks]

Figure 4

b) The inductor in a) above is made of copper. Find:

i) Its resistance, [5 marks]

ii) The equilibrium current when it is connected to a 1.50V battery [2 marks]

iii) The time required for it to reach 99% of this equilibrium current. [3 marks]