KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2016/2017 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER
SPECIAL / SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICS

ANDBACHELOR OF EDUCATION (SCIENCE)

COURSE CODE: SPH314

COURSE TITLE: ELECTROMAGNETISM

DURATION: 2 HOURS

DATE: 22ND SEPTEMBER 2017 TIME: 3 - 5PM

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other **TWO** (2) Questions.
- Question **ONE** carries **30 MARKS** and the remaining carry **20 MARKS** each.
- Symbols used bear usual meaning.
- Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$
- Speed of light $c = 3.0 \times 10^8\ ms^{-1}$
- Susceptibility of free space $\mu_0 = 4\pi \times 10^{-7} T.mA^{-1}$
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of 5 printed pages. Please Turn Over

KIBU observes ZERO tolerance to examination cheating

QUESTION ONE (30 MARKS)

a) List two aspects of electromagnetism **(2 marks)**

b) In terms of direction of magnetic field flux and magnetization differentiate between paramagnets and Diamagnets **(2marks)**

c) Define the following terms **(3marks)**

i. Magnetic flux

ii. Magnetic saturation

iii. Magnetic field

d) Consider an electron rotating around its orbit with current I, sweeping an area ds. Show that its magnetic moment$m = \frac{1}{2}evr$. **(4marks)**

e) State Curie-Weiss law **(2marks)**

f) A loop of wire is placed in a uniform magnetic field.

i. For what orientation of the loop is the magnetic flux a maximum? **(1mark)**

ii. For what orientation is the flux zero? **(1mark)**

g) Define the term Eddy currents **(1mark)**

h) A coil consists of 400 turns of wire. Each turn is a square of side 20 cm, and a uniform magnetic field directed perpendicular to the plane of the coil is turned on. If the field changes linearly from 0 to 0.70 T in 0.80 s, what is the magnitude of the induced emf in the coil while the field is changing? **(5 marks)**

i) Calculate the electric field of an electromagnetic wave in a magnetic field of strength 17.5×10^{-9}T. **(3marks)**

j) Calculate the energy per unit area per unit time (S), for an electromagnetic wave whose root mean square magnetic field strength is 28.5×10^{-9} T. **(3 marks)**

k) A sinusoidal electromagnetic wave of frequency 40.0 MHz travels in free space in the x direction. Determine the wavelength and period of the wave **(3 marks)**

QUESTION TWO (20 MARKS)

a) Explain two applications of eddy currents **(4marks)**

b) A rectangular loop of area A is placed in a region where the magnetic field is perpendicular to the plane of the loop. The magnitude of the field is allowed to vary in time according to $B = B_{max}e^{-t/\tau}$, where B_{max} and τ are constants. The field has the constant value B_{max} for $t < 0$.

(i). Use Faraday's law to show that the emf induced in the loop is given by$\varepsilon = \frac{AB_{max}}{\tau}e^{-t/\tau}$ **(4 marks)**

(ii).Obtain a numerical value for ε at $t = 4.00$ s when $A = 0.160$ m^2, $B_{max} = 0.350$ T, and $t = 2.00$ s. **(3 marks)**

(iii). For the values of A,B_{max}, and τ given in (b), what is the maximum value of ε? **(3 marks)**

c) A loop of wire enclosing an area A is placed in a region where the magnetic field is perpendicular to the plane of the loop. The magnitude of B varies in time according to the expression $B = B_{max}e^{-at}$, where a is some constant. That is, at t= 0 the field

is B_{max}, and for $t > 0$, the field decreases exponentially. Find the induced emf in the loop as a function of time **(3 marks)**

d) A strong electromagnet produces a uniform magnetic field of 1.60 T over a cross-sectional area of 0.200 m^2. We place a coil having 200 turns and a total resistance of 20.0Ω around the electromagnet. We then smoothly reduce the current in the electromagnet until it reaches zero in 20.0 ms.What is the current induced in the coil? **(4 marks)**

QUESTION THREE (20 MARKS)

(a) A conducting bar of length l rotates with a constant angular speed ω about a pivot at one end. A uniform magnetic field $\vec{B}$ is directed perpendicular to the plane of rotation, as shown in the Fig.1 below. Find the motional emf induced between the ends of the bar. **(5marks)**

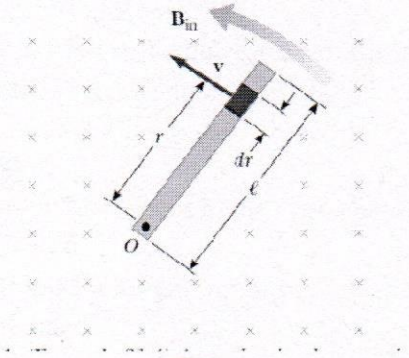

Fig.1

(b) An AC generator consists of 8 turns of wire, each of area A = 0.0900m^2 , and the total resistance of the wire is 12.0 Ω The loop rotates in a 0.500-T magnetic field at a constant frequency of 60.0 Hz.

i) Find the maximum induced emf **(4marks)**

ii) What is the maximum induced current when the output terminals are connected to a low-resistance conductor? **(3marks)**

(c) An aluminum ring of radius 5.00 cm and resistance 3.00 $\times 10^{-4}$ Ω (is placed on top of a long air-core solenoid with 1 000 turns per meter and radius 3.00 cm, as shown in Fig.2., below. Over the area of the end of the solenoid, assume that the axial component of the field produced by the solenoid is half as strong as at the center of the solenoid. Assume the solenoid produces negligible field outside its cross-sectional area. The current in the solenoid is increasing at a rate of 270 A/s.

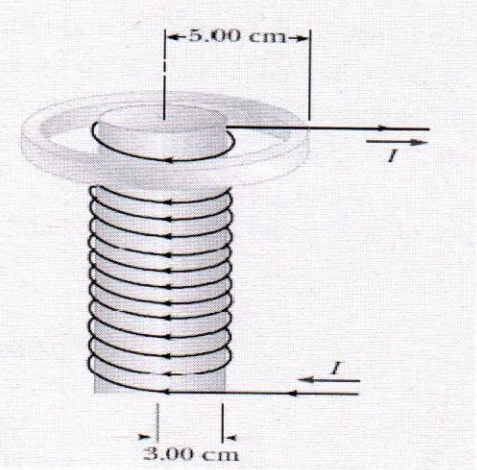

Fig. 2.

i) What is the induced current in the ring? **(6 marks)**

ii) At the center of the ring, what is the magnitude of the magnetic field produced by the induced current in the ring? **(2 marks)**

QUESTION FOUR (20 MARKS)

a) Find the direction of the current in the resistor in the Fig. 3 below

i. at the instant the switch is closed **(1mark)**

ii. after the switch has been closed for several minutes **(1mark)**

iii. at the instant the switch is opened **(1mark)**

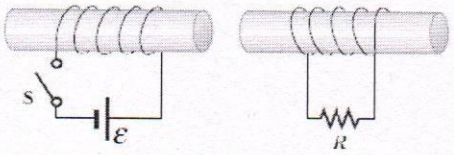

Fig. 3

b) Assume that a motor in which the coil has a total resistance of 10Ω is supplied by a voltage of 120 V. When the motor is running at its maximum speed, the back emf is 70 V. Find the current in the coil

i) when the motor is turned on **(2marks)**

ii) when it has reached maximum speed **(3marks)**

c) A coil of 15 turns and radius 10.0 cm surrounds a long solenoid of radius 2.00 cm and 1.00×10^3 turns/meter (Fig. 4). The current in the solenoid changes as $I = (5.00\ A) \sin(120t)$. Find the induced emf in the 15-turn coil as a function of time **(5 marks)**

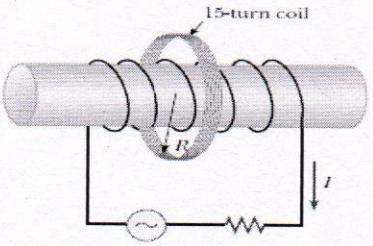

Fig. 4

d) A coil formed by wrapping 50 turns of wire in the shape of a square is positioned in a magnetic field so that the normal to the plane of the coil makes an angle of 30.0° with the direction of the field. When the magnetic field is increased uniformly from 200μT to 600μT in 0.400s, an emf of magnitude 80.0mV is induced in the coil. What is the total length of the wire? **(5 marks)**

e) If the current in an inductor is doubled, by what factor does the stored energy change? **(2 marks)**

QUESTION FIVE (20 MARKS)

i) Define the term self induction **(2marks)**

ii) Define the term inductance **(2marks)**

iii) Find the inductance of a uniformly wound solenoid having N turns and length l. Assume that l is much longer than the radius of the windings and that the core of the solenoid is air. **(5marks)**

iv) a)Calculate the inductance of an air-core solenoid containing 300 turns if the length of the solenoid is 25.0 cm and its cross-sectional area is 4.00 cm^2 **(3 marks)**

a) Calculate the self-induced emf in the solenoid if the current it carries is decreasing at the rate of 50.0 A/s **(4 marks)**

v) Show that the magnitude of Poynting vector for a plane electromagnetic wave is given by $S = \frac{c}{\mu_0} B^2$ **(4 marks)**