TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED &HEALTH SCIENCES

MATHEMATICS & PHYSICS DEPARTMENT

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN APPLIED PHYSICS AND BACHELOR OF TECHNOLOGY IN ENVIRONMENTAL PHYSICS & RENEWABLE ENERGY

APS 4202: ELECTRICITY & MAGNETISM II

END OF SEMESTER EXAMINATION

SERIES: MAY 2016

TIME: 2 HOURS

DATE: MAY 2016

<u>Instructions to Candidates</u>

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of 4 questions. **Do not write on the question paper. Answer question ONE (compulsory) and any other two questions.**

DATA: Permeability of vacuum/free space, $\mu_0 = 4\pi \times 10^{-7}\,Hm^{-1}$

Permittivity of vacuum/ free space, $\varepsilon_0 = 8.85\times10^{-12}\,Fm^{-1}$

Electron charge, $q = 1.602\times10^{-19}\,C$

Mass of electron, $m_e = 9.11\times10^{-31}\,kg$

Proton mass, = $m_p = 1.67x10^{-27}\,kg$

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Question ONE

(a) An air – core toroid of area A and radius R has N turns and carries a current I in each turn.

(i) Give the magnetic field intensity $\overrightarrow{B_o}$ for the toroid (2 marks)

(ii) The same winding is placed on an iron-ring of the same area and radius. The effect of the iron ring is noted to be identical to that of the same air-core toroid with fine winding of N_m turns where $N_m > N$. Derive the magnetic field density $\overrightarrow{B_m}$ in the air-core toroid of fine winding. (3 marks)

(iii) The relative permeability of the iron ring is μ_r, show that:

I. The total magnetic field density for an iron core toroid is given by $\overrightarrow{B_0} = \mu_0(\overrightarrow{H} + \overrightarrow{M})$ (2 marks)

II. $\nabla x\vec{B} = \mu_0\left(\vec{J} + \overrightarrow{J^1}\right)$, and define the parameter within the brackets.(3 marks)

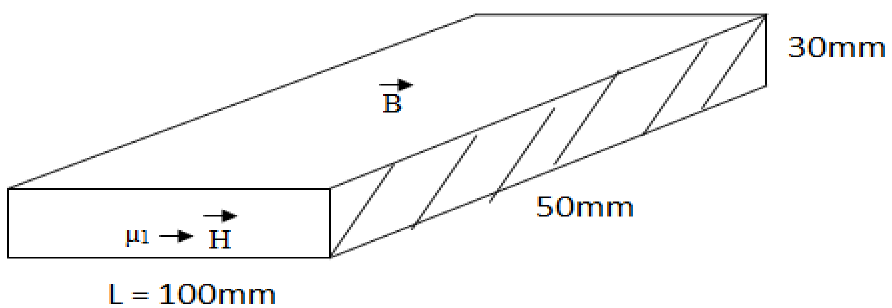
III. $\mu_r = 1 + \frac{\overrightarrow{M}}{\overrightarrow{H}}$ (3 marks)

(b) Explain clearly the difference between antiferri magnetic materials and ferromagnetic materials giving examples in each case. (4 marks)

(c) (i) What is an inductor? (1 mark)

(ii) Show that if along solenoid is bent into a circle and closed on itself the inductance of toroid formed is given by $L = \mu\frac{N^2r^2}{2R}$ where r is the radius of the winding of many turns, R is the radius of the toroid and N is the number of the turns in the toroid. (5 marks)

(d) Find the reluctance and permeance between the ends of the rectangular block of iron in figure 1. Assume $\vec{B}$ is uniform and normal to the ends and $\mu_1 = 500\mu_0$ (5 marks)



(e) Compute the final velocity of an election that accelerates from rest through a potential difference of 1V (2 marks)

Question TWO

Define the terms:

(i) Magnetic field intensity (1 mark)

(ii) Magnetic flux linkage (1 mark)

(iii) Inductance (1 mark)

(b) Compute the inductance of a solenoid of 2000 turns wound uniformly over a length on a cylindrical paper tube 4cm in diameter. Assume air medium $(\mu = \mu_0)$ (5 marks)

(c) (i) A solenoid consist of N turns of fine wire carrying a current 1. The coil has length L and radius R. Show that the flux $\vec{B}$ at the centre of the solenoid is given by

$$\vec{B} = \frac{\mu NI}{\sqrt{4R^2 + L^2}}$$ (5 marks)

(ii) Hence simplify the value of $\vec{B}$ for $L >> R$ and write down the expression for the inductance of the solenoid. (3 marks)

(d) A very long solenoid coil of radius r is bent into a circle to from a toroid of radius R. If $R >> r$ then determine:

(i) The flux linkage of the toroid (2 marks)

(ii) The inductance of the toroid (2 marks)

Question THREE

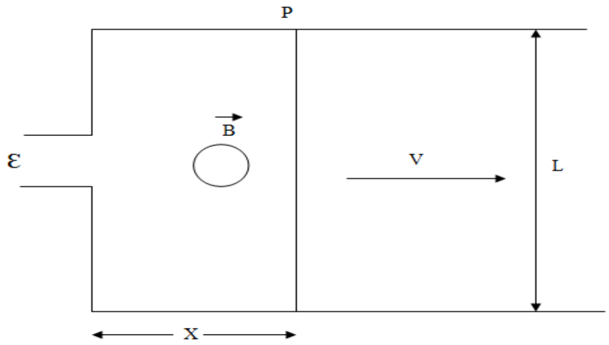
(a) (i) State Faraday's law and show the e.m.f ε induced in a stationary due to a change in a magnetic flux through the loop is given by $\xi = -\int \frac{\partial B}{\partial t} ds$ (6 marks)

(ii) The loop in 3a (i) above is now made to move in the time changing $\vec{B}$ field. Show that the e.m.f induced becomes $\xi = \oint (Vx\vec{B})dL - \int \frac{\partial B}{\partial t} ds$ (4 marks)

(b) The figure below shows a conductor PQ that slides over a rectangular loop conductor whose plane is perpendicular to a $\vec{B}$ field that is out of paper. The sliding conductor moves with a velocity V. The field $\vec{B}$ is uniform over the loop area but varies harmonically with time as given by $B = B_0 Cos\,\omega t$.

Determine the direction of the induced current and the total e.m.f ε induced in the loop.

(6 Marks)



(c) State Maxwell's equations in free space (4 marks)

Question FOUR

(a) A toroid of cross sectional area A and length L, has two coils inter wound such that the number of turns in the primary is N_1 and that in the secondary is N_2. The current flowing in the primary is 1_1 and the permeability of the medium in the toroid is μ. There is no electrical connection between the two coils. Show that the mutual inductance is given by $\mu = \mu \frac{N_1 N_2 A}{L}$

(6 marks)

(b) A magnetic field $\vec{B}$ is incident on a plane boundary between two media of permeability μ_1 and μ_2 as shown in figure 1 below. Assume that the media are isotropic with $\vec{B}$ and $\vec{H}$ in the same direction. Show that (4 marks)

DIAGRAM

(c) Explain the following terms used in static electric field

(i) Homogeneity (1 mark)
(ii) Linearity (1 mark)
(i) Isotropy (1 mark)

(d) The magnitude of magnetic field intensity $\vec{H}$ at a radius $1m$ from along linear conductor is $4Am^{-1}$. Determine the current in the wire. (3 marks)

(e) (i) What is a transmission line (1 mark)
(ii) Name three classes of transmission lines (3 marks)