EGERTON UNIVERSITY

UNIVERSITY EXAMINATIONS

NJORO CAMPUS

RESIT/SPECIAL EXAM

REGULAR PROGRAMME

2019/2020 ACADEMIC YEAR
SECOND YEAR EXAMINATION

PHYS 212: ELECTRICITY AND MAGNETISM 1

STREAMS: B. Sc., B. Ed., & B. Sc. (COMPUTER) TIME: 2 HRS

EXAMINATION SESSION: AUGUST YEAR: 2021

INSTRUCTIONS

- Read the question paper carefully
- Answer question ONE and any other THREE questions
- Show all the workings clearly
- Use the constants provided below whenever necessary

Permittivity of free space (ϵ_o). $\epsilon_o = 8.85 \times 10^{-12}\ C^2.N^{-1}.m^{-2}$
Coulomb's constant (k_e). $k_e = 8.99 \times 10^9\ N.m^2.C^{-2}$
Electron's charge (q_e). $q_e = -1.602 \times 10^{-19}\ C$

QUESTION ONE (40 MARKS)

a) State the coulomb's law and express it mathematically. (2 mks)

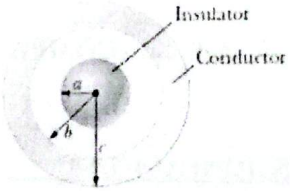
b) Two-point clusters of charge situated in free space are placed on a line in the x-axis. The first, with a positive charge of $Q_1 = +8e$, is at the origin. The second, with a negative charge of $Q_2 = -4e$, is to the right at a distance equal to 0.2m. What is the magnitude of the force between them? **(3 mks)**

c) Explain the three properties of an electric charge. **(3 mks)**

d) A spherical gaussian surrounds a point q. Describe what happens to the total flux through the surfaces if: **(4 mks)**

i. The charge is tripled.
ii. The radius of the is doubled.
iii. The surface is changed to a cube.
iv. The charge is moved to another location inside the surface.

e) A solid insulating sphere of radius $a = 5\ cm$, carries a net positive charge of $Q = 3\ \mu C$ uniformly distributed throughout its volume. Concentric with this sphere is a conducting spherical shell with inner radius $b = 10\ cm$ and outer radius $c = 15\ cm$ as shown below having a net charge of $= -1\ \mu C$. Prepare a graph of the magnitude of the electric field due to this configuration versus r for $0 < r > 25\ cm$. **(5 mks)**



f) Starting from Coulomb's law, show that the electric potential a distance r from a point charge q is given by $V = \frac{q}{4\pi\varepsilon_0 r}$ **(4 mks)**

g) Define magnetic flux and state Faraday's law, describing the relationship between the magnetic flux linked through a circuit and the current induced in the circuit. What is the force on a straight wire of length l carrying a current I in the presence of a magnetic field B? **(4 mks)**

h) A capacitor of capacitance $C = 500\mu F$ is charged to a voltage of 900V and is then discharged through a resistance $R = 200\ k\Omega$ when a switch is closed.

i) Find the initial charge stored in the capacitor. **(2 mks)**
ii) Find the initial discharge current when the switch is closed. **(2 mks)**
iii) Find the voltage across the capacitor in a time $t = 25$ s after the start of discharge. **(2 mks)**
iv) Find the time constant of this capacitor resistor network combination. **(2 mks)**
v) Work out an equation to show the time it takes for the charge in the capacitor to drop by one-half of its starting value and find this time. **(2mks)**

i) What resistance must be placed in parallel with $12\ \Omega$ to obtain a combined resistance of $4\ \Omega$?

j) An electric power line carries a current of $1.2 \times 10^6\ mA$ in a location where the earth's magnetic field is $5.0 \times 10^{-3}\ T$. The line makes an angle of 60^o with respect to the field. Determine the magnitude of the magnetic force on a $1.5 \times 10^4\ cm$ length of line. **(3 mks)**

(2 mks)

QUESTION TWO (10 MARKS)

a) Define electric field while giving its unit of measurement. **(2 mks)**

b) A rod of length l has a uniform positive charge per unit length λ and a total charge Q. Show that the electric field, E, at a point p that is located along the axis of the rod and distance a from one end is given by $E = \frac{kQ}{a(l+a)}$ where k is coulomb's constant. **(5 mks)**

c) Apply Gauss' law to find an electric field at a point x; a distance r from a line of positive of infinite length and a constant charge per length λ. **(3 mks)**

QUESTION THREE (10 MARKS)

a) Show that the capacitance of a solid cylindrical conductor of radius a and charge Q coaxially with a cylindrical shell of negligible thickness, radius $b > a$ and charge $-Q$ is $c = \frac{l}{2kln(b/a)}$. **(5 mks)**

b) Two capacitors $C1$ and $C2$ are connected in parallel and their combined capacitance is measured as $9\mu F$. When they are combined in series their capacitance is $2\mu F$. What are the individual capacitances? **(5 mks)**

QUESTION FOUR (10 MARKS)

a) Write an expression for the force acting on a charge q moving with velocity v in a magnetic field B. A charged particle of mass m and charge q is accelerated through a potential difference of V and then injected into a region with a magnetic field B perpendicular to the plane in which the charge moves. Derive an expression for the radius of curvature, r, of the path of the particle when in the magnetic field. **(5 mks)**

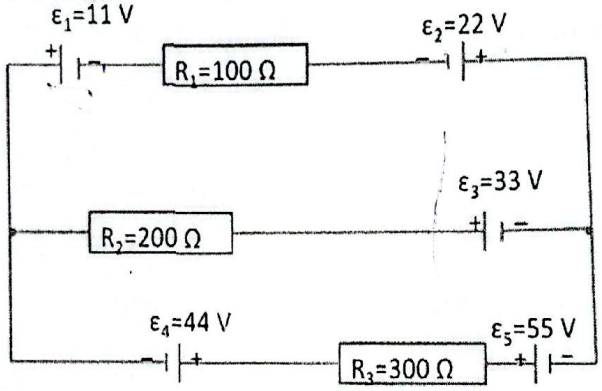
b) Derive an expression for the energy stored in an inductor. **(5 mks)**

PHYS 212

QUESTION FIVE (10 MARKS)

(a) State Kirchhoff's two rules. **(2 mks)**

(b) Hence, use the circuit below to produce three equations with three unknown branch currents and solve them. **(8 mks)**



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