KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION

SPH 101: ELECTRICITY AND MAGNETISM 1

DATE: MONDAY, 2ND APRIL 2012 **TIME: 8.00 A.M. – 10.00 A.M.**

INSTRUCTIONS
This examination paper contains **FIVE** questions. Question **ONE** carries 30 marks and the rest 20 marks each. Answer question **ONE** and any other **TWO** questions.

The following constants may be useful:

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

Electron volt, $1eV = 1.602\times10^{-19}J$

Permittivity constant, $\varepsilon_0 = 8.85\times10^{-12}Fm^{-1}$

Permeability constant, $\mu_0 = 4\pi\times10^{-7}Hm^{-1}$

Coulomb's constant, $k = \dfrac{1}{4\pi\varepsilon_0} = 9.0\times10^{9}Nm^2C^{-2}$

Rest mass of proton $\cong 1.67\times10^{-27}kg$

Q1. a) State and explain two factors that determine the force between charged bodies. (2mks)

b) i) Define an electric field. (1mk)

ii) Calculate the electric field strength at a point which is at a distance equal to a hydrogen atomic radius, $5.0\times10^{-11}m$, from the nucleus of a hydrogen atom given that hydrogen atom has one proton. (3mks)

c) i) Explain what happens to the charge stored in a capacitor and the current flowing through the circuit during the charging of uncharged capacitor through a resistor. (2mks)

ii) Define the time constant for a circuit that is used to charge a capacitor C through a resistor, R. (1mk)

iii) A capacitor of capacitance $200\mu F$ was charged to a maximum of $0.1C$. Calculate the charging voltage. (3mks)

iv) If the capacitor was then connected to a load resistor of 100Ω, calculate the time that it will take for the charge initially present to reduce by 50% (3mks)

d) A galvanometer with an internal resistance of 5Ω has a maximum scale deflection when a current of $20mA$ is flowing through it. Explain showing all your calculation how you can convert it into:

i) a voltmeter with full scale deflection of $15V$. (3mks)

ii) an ammeter with a full scale deflection of $10A$. (3mks)

e) If $R = 20\Omega$ and $L = 10H$, calculate the time constant for the circuit containing the two elements in series. (2mks)

f) State and explain two factors that determine the resistance of a uniform conducting wire. (2mks)

g) Explain the difference between Ohmic and non-Ohmic conductors. Give one example in each case. (2mks)

h) i)Draw a circuit diagram containing a resistor R, an inductor L, an emf source ξ, an ammeter and an open switch S; all in series. (1mk)

ii) Sketch the graph of current I versus time t that is likely to be observed when the switch is closed. (1mk)

i) Define electromotive force. (1mk)

Q2. a) i) What is an electric dipole? (1mk)

ii) Fig.1 shows two positive charges of equal magnitude q placed a distance $2a$ apart. State the direction of **E**, and show that **E** at point P, assuming r>>a, is given by:

$$E = \frac{1}{4\pi\varepsilon_0}\frac{2q}{r^2}$$ (5mks)

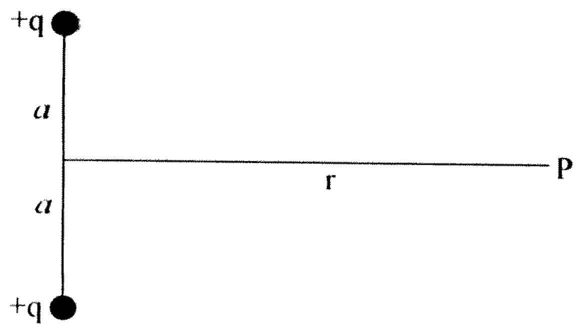

Fig.1

b) Three resistors R_1, R_2, and R_3 are connected in parallel. Derive an expression for their effective resistance. (2mks)

c) For the capacitor network shown in fig.2 do the following:

i) Find the charge on the 18μF capacitor, (3mks)

ii) determine the p.d across the 7μF capacitor. (3mks)

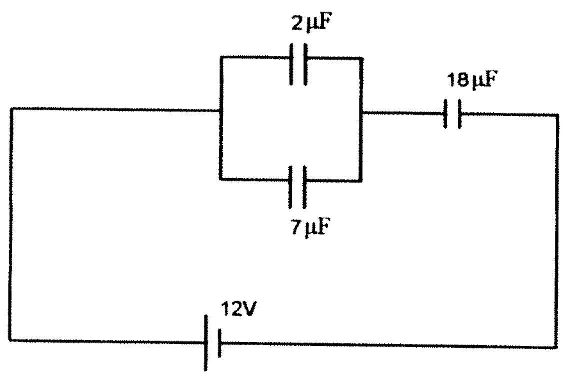

Fig.2

d) A load of 2000 Ω is connected, via a potential divider (AB) of resistance 4000 Ω to a 10 V supply, as in fig.3. What is the potential difference across the load when the slider is:

i) one-quarter, (3mks)

ii) half-way up the divider? (3mks)

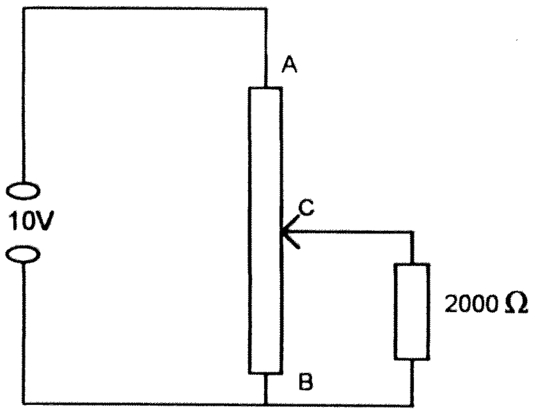

Fig.3

Q3. a) i) State two differences between electric and magnetic forces. (2mks)

ii) The north pole end of a bar magnet is held near a positively charged piece of a plastic. Is the plastic attracted, repelled or unaffected by the magnet? Explain. (1mk)

b) Show that the magnetic field due to a current i in a long straight wire at a point P, a perpendicular distance R from the wire is:

$$B = \frac{\mu_0 i}{2\pi R}$$ (5mks)

c) A uniform magnetic field $\vec{B}$, with magnitude 1.2 mT, is directed vertically upward through out the volume of a laboratory chamber. A proton with kinetic energy 5.3 MeV enters the chamber, moving horizontally from south to north. What is the magnitude and direction of the force acting on the proton as it enters the chamber? (Ignore Earth's magnetic field) (6mks)

d) A battery has an e.m.f 12.0 V and an internal resistance of 0.05Ω. Its terminals are connected to a load resistance of 3.00 Ω.

i) Find the current in the circuit and terminal voltage of the battery. (4mks)

ii) Calculate the power dissipated by the battery through the circuit. (2mks)

Q4. a) i) Define inductive time constant. (1mk)

ii) A capacitor C and a resistor R are connected as in fig.4. After the switch is closed, the charge on the capacitor is given by the expression

$q = CE(1 - e^{-\frac{t}{RC}})$. Derive an expression for the potential difference across the capacitor during the charging process. (2mks)

iii) Sketch a graph of voltage against time during the charging of the capacitor. (1mk)

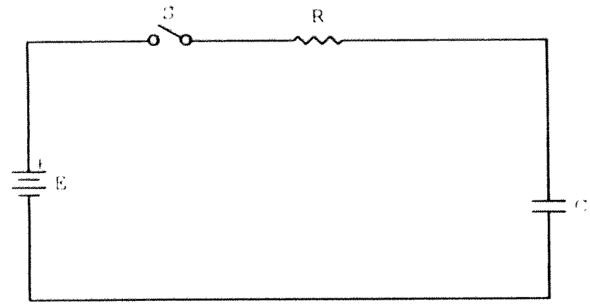

Fig.4

b) A capacitor in an RC circuit is charged to 60% of its maximum value in 0.900 s. What is the time constant of the circuit. (4mks)

c) A capacitor of capacitance C is fully charged by a 200 V battery. It is then discharged through a resistance wire imbedded in a thermally insulated block of specific heat capacity 2.5×10^2 Jkg^{-1} K^{-1} and of mass 0.1 kg. If the temperature of the block rises by 0.4 K, what is the value of C? (4mks)

d) A parallel-plate capacitor of value 8.50 pF is charged to a potential difference of 12.0 V. The battery is then removed and a slab of polystyrene ($\kappa = 2.56$) is inserted between the plates. Find:

i) the charge on the capacitor before and after the slab is inserted,(2mks)

ii) the energy stored in the capacitor before and after the dielectric is inserted. (4mks)

iii) What is the change in energy? Account for the difference. (2mk)

Q5. a) i) Suppose you are provided with the quantity of charge that a body possesses. Explain how you can determine the number of elementary charged particles that it has. (1mk)

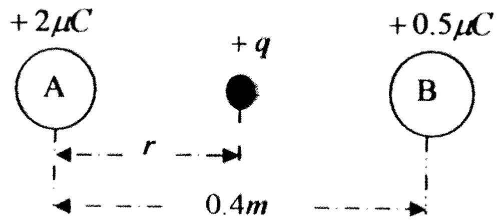

Fig.5

ii) Figure 5 shows bodies A and B which are $0.4m$ apart and whose respective charge is $+2\mu C$ and $+0.5\mu C$. If another body whose charge is $+q$ is placed r meters from A such that it is at an electrostatic equilibrium, calculate the value of r. (3mks)

b) Figure 6 shows a circuit diagram of a potentiometer.

i) State one advantage of a potentiometer over a voltmeter. (1mk)

ii) Use figure 6 to explain how a potentiometer measures an unknown potential difference. (2mks)

iii) Suppose $x_1 = 0.72m$ when the circuit through the un-known *emf* is complete and $x_2 = 0.40m$ when the circuit through the standard cell is complete; what is the potential of unknown V given that there is no current flowing through the galvanometer in both cases?(2mks)

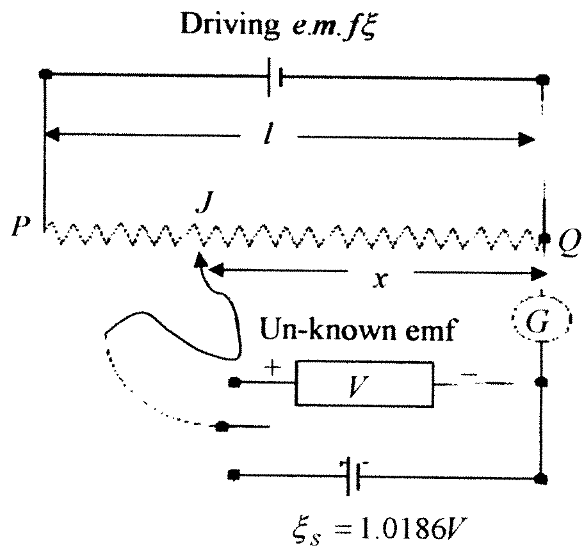

Figure 6

c) i) Differentiate mutual from self inductance. (1mk)

ii) Figure 7 shows a simple circuit of a transformer. Is it a step-up or a step-down transformer? Explain. (1mk)

iii) Why doesn't a transformer operate using direct current? (1mk)

iv) Suppose that the in-put instantaneous voltage is $1000V$, $N_1 = 200$ turns and $N_2 = 800$ turns; calculate the output voltage. (2mks)

v) State one way in which electrical power is lost in the transformer and explain how that loss can be minimized. (2mks)

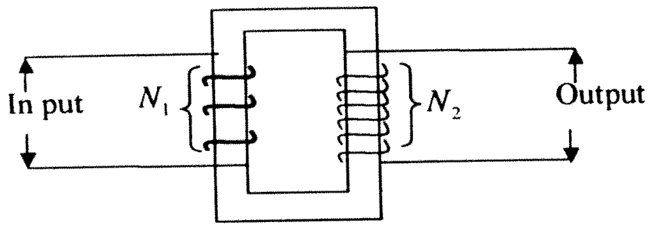

Fig.7

d) State the Faraday's law of electromagnetic induction. (1mk)

e) The self-inductance of a coil is $20mH$. When a current flows in it, $\frac{1}{5}$ of its magnetic flux links the second coil placed near the first coil. What $e.m.f.$ is induced in the second coil if a current in the first coil collapses at a uniform rate of $0.5A.s^{-1}$? (3mks)

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