The Open University of Sri Lanka
Faculty of Natural Sciences
B.Sc/ B. Ed Degree Programme

Department	: Physics
Level	: 03
Name of the Examination	: Final
Course Code and Title	**: PHU3301, Basic Electromagnetism**
Academic Year	: 2020/2021
Date	: 16th March 2022
Time	: 1.30 pm- 3.30 pm
Duration	: 2 hours

General Instructions

1. Read all instructions carefully before answering the questions.

2. This question paper consists of **06** questions in **04** pages.

3. Answer any four (4) questions only . All questions carry equal marks.

4. Answer for each question should commence from a new page.

5. Draw fully labeled diagrams where necessary

5. Relevant log tables are provided where necessary.

6. Having any unauthorized documents/ mobile phones in your possession is a punishable offense.

7. Use blue or black ink to answer the questions.

8. Circle the number of the questions you answered in the front cover of your answer script.

9. Clearly state your index number in your answer script

The Open University of Sri Lanka
B.Sc. Degree Programme- Level 03
Final Examination 2020/2021
PHU3301/PYU1161 – Basic Electromagnetism
Duration: Two (2) Hours

Date: 16.03.2022   **Time: 1.30 p.m. – 3.30 p.m.**

ANSWER ANY FOUR (04) QUESTIONS ONLY.

$$\varepsilon_0 = 8.85 \times 10^{-12} \quad C^2 N^{-1} m^{-2} \qquad \mu_0 = 4\pi \times 10^{-7} \, WbA^{-1}m^{-1}$$

(1) (a)
   i.   Discuss the methods of electrifying a body.
   ii.   Briefly discuss the function of the gold leaf electroscope with a proper diagram.
   iii. Explain the procedure of identifying a type of charge using a gold leaf electroscope.

(b)
   i.   There is a point charge Q at the point O in a free space. Derive an expression for the electric field intensity at a point which is at a distance r from O, using Gauss theorem.

   Figure 01 shows a triangle ABC of and a line PA parallel to BC. $+5 \times 10^{-7}$ C, $+5 \times 10^{-7}$ C and -5×10^{-7} C charges are at the A, B and C corners respectively.
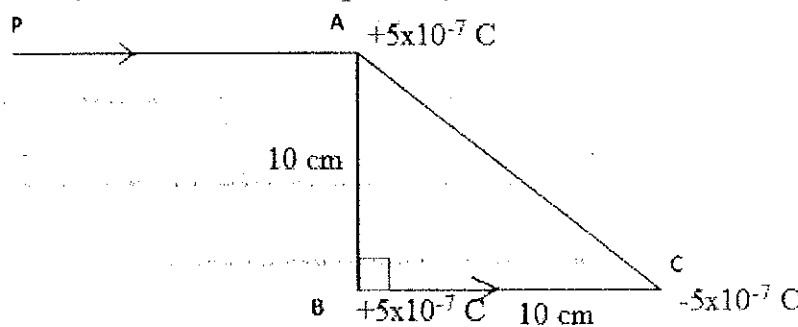

Figure 01

   ii.   Find the electric force and the direction on the charge at point B.
   iii. Determined electric potential at B.
   iv.   When a point charge Q placed on the line AP at distance x from A, point B becomes a null point. Calculate the values of Q and x.

(2)
   i.   Derive an expression for the capacitance of a parallel plate capacitor of which plates are separated with a distance d and cross-sectional area of each plate is A. Assume that the dielectric constant of medium between two plate is K_2.
   ii.   A dielectric slab with dielectric constant K_1 and thickness t is inserted into the above parallel plates capacitor.. Show that the new capacitance C is given by

$$C = \frac{A\varepsilon_0}{\left(\dfrac{t}{K_1} + \dfrac{d-t}{K_2}\right)}$$

   iii. Figure 02 shows 2 μF capacitors and a C unknown capacitor are connected to a 1000 V supply. Total charge stored in the capacitor system is 0.75 mC. Determine the value of the unknown capacitor
   iv.   Calculate the voltage difference across B and C.
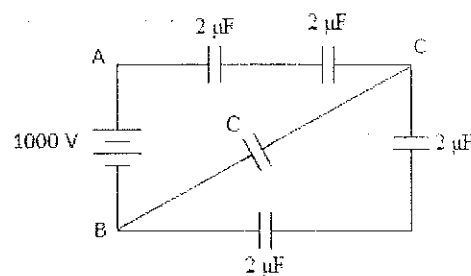   v.   Calculate the energy stored in each capacitor.

Figure 02

1

(3)

i. States the Kirchhoff's voltage law.

ii. A potentiometer wire of length 100 cm has a resistance of 10 Ω. 2 V accumulator with negligible internal resistance is used for the potentiometer circuit. Calculate the potentiometer constant (K).

iii. A Cell with 10 mV is connected to the potentiometer circuit with center zero galvanometer if the circuit is balanced. What is the balanced length of the potentiometer wire?

iv. Briefly explain by drawing a diagram, how to alternate the circuit to increase the balanced length to 40 cm in the situation in the part iii.

v. A student wants to determine the internal resistance of an ammeter, and he designed a circuit given in figure 03 then connecting X and Y points to the potentiometer circuit in part (iv) obtaining the balancing lengths 40 cm, 60 cm and 80 cm for ammeter readings of 7.14 mA, 10 mA and 13.33 mA respectively. Calculate the voltages across ammeter in each case.

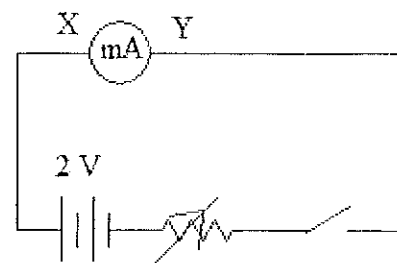vi. Using above results, determine the internal resistance of the ammeter?

Figure 03

(4)

i. Write down the Bio- Sarvat law in the vector form. Name the parameters in your written expression.

ii. Explain the method of finding the direction of the induced magnetic field at a point around the current-carrying conductor

iii. Write the Ampere's law.

iv. Using the ampere's law derive an expression for the magnetic field around a long current-carrying conductor.

v. Figure 4 shows a current-carrying rectangular loop length a and width b. A fixed long straight wire is placed at distance l from the side AB. If a current I is flowing in a long conductor derive expressions for forces acting on each segment of the loop.

vi. If $l = 3$ cm, $a = 4$ cm, $b = 3$ cm I $= 10$ A , $i = 2$ A, determine the forces acting on the rectangular loop.
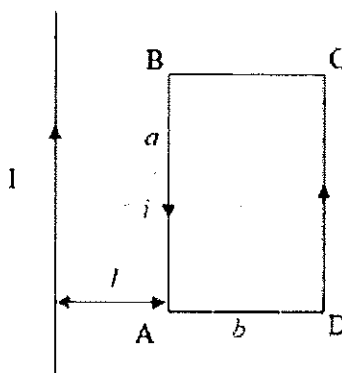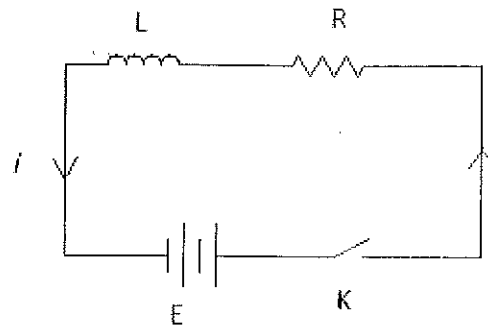
Figure 04

2

(5)

Figure 05 i

i.   Figure 05 shows that L R circuit connected in the series to a battery through a switch K. Write down an expression for voltages across L and R.

ii.   Derive an expression for the final steady value for current I_o in the circuit.

iii.   Using the Ohm's law, show that the current (i) through the circuit can be given as $i = I_o(1 - e^{Rt/L})$

iv.   Draw the variation i Vs t graph

v.   Show that when time t equals to time constant the current in the circuit is $(1 - 1/e)$ of its final value

vi.   Inductor and resistor with 200 mH and 10 Ω are connected series to EMF of 10 V with negligible internal resistance. Calculate the time in which the current will rise to half of its final steady value'

(6)

i.   Draw the phasor/vector diagram for the resistor, inductor and capacitor separately for each component if the current through components $i = i_o \sin\omega t$

ii.   Derive an expression for reactance (X) of each of the components.

iii.   Figure 06 shows that LCR series circuit connected to an AC source. Using the ohm's law derive an expression for E with i_o, R, L, C, and ω
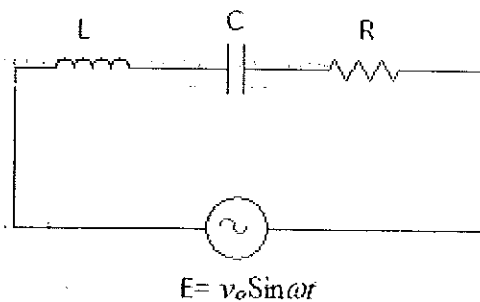

$E = v_o \sin\omega t$

Figure 06

iv.   Find the impedance of the circuit using a phasor/vector diagram.

v.   What is the phase angle of the circuit?

vi.   Components of the above LCR circuit has the following values L = 100 mH, C = 100 μF and R = 120 Ω a of E = 30 Sin100t. What is the total impedance of the circuit?

vii.   Calculate the peak current of the circuit.

viii.   Find the resonance frequency of the circuit.