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

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Department	: Physics
Level	: 03
Name of the Examination	: Final Examination
Course Title and - Code	: Basic Electromagnetism – PHU3301 / PYU1161
Academic Year	: 2019/2020
Date	:25.10.2020
Time	: 1.30 p.m. – 3.30 p.m.
Duration	: 02 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(04)questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Draw fully labelled diagrams where necessary
6. Involvement in any activity that is considered as an exam offense will lead to punishment
7. Use blue or black ink to answer the questions.
8. Clearly state your index number in your answer script

The Open University of Sri Lanka
B.Sc. Degree Programme- Level 03
Final Examination 2019/2020
PHU3301/PYU1161 – Basic Electromagnetism
Duration: Two (2) Hours

Date: 25.10.2020 **Time: 1.30 p.m. – 3.30 p.m.**

ANSWER ANY FOUR (04) QUESTIONS ONLY.
Non programmable calculators are allowed.

$\varepsilon_o = 8.85\text{x}10^{-12}\ C^2N^{-1}m^{-2}$ $\mu_o = 4\pi\text{x}10^{-7}\ TA^{-1}m$ $e = 1.6\text{x}10^{-19}\ C$ $g = 10\ kgms^{-2}$

1. Student wants to determine the permeability (μ_o) of air using current balance. Experimental set up and other components are given in the figure 01.

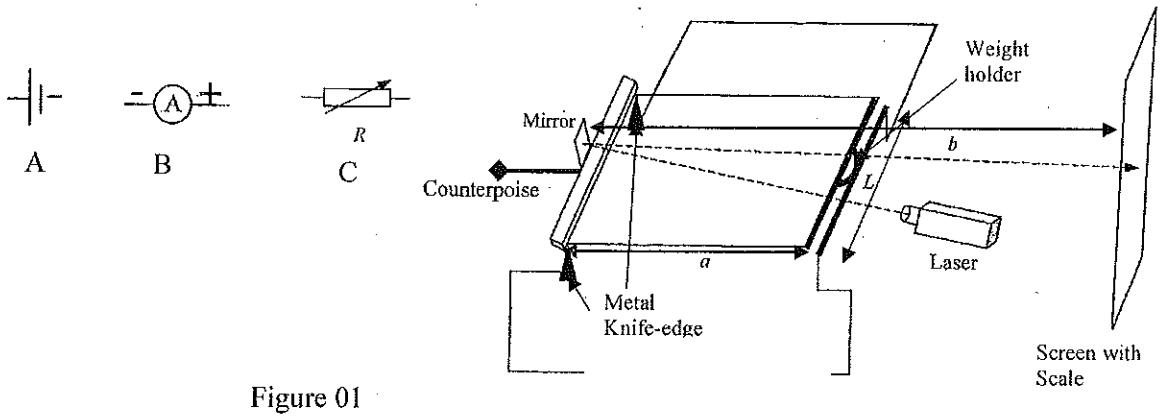


Figure 01

i. Draw the complete experimental set up by connecting the components (A, B, C) given in the figure 01.
ii. Show the direction of the current in the conducting bars of your drawn experimental set up.
iii. Write down an expression for the force (F) on the two parallel conductors of length L, placed distance d apart and carrying same current I.
iv. Explain why conducting bars are kept in the North -South direction.
v. Briefly explain the experimental procedure after balancing the conducting bars.
vi. Student is supposed to plot a graph using data obtained. Identify the variables chosen for X and Y axis (Hint: Use the expression in iii)
vii. Using the displacement (D) of image of the laser spot on the scale when the two conducting bars toughing each other and when they are separated at distance d_o, it can be shown that $d_o = \frac{Da}{2b}$,where a and b shown in the figure (01). The distance between centers of the cross-sections of conducting bars (d) is $d = d_o + 2r$ where r is the radius of the conducting bar. Calculate the separation (d) of conducting bars if the student has recorded r, a, b and D are 0.93 mm, 14 cm, 130 cm and 50 cm respectively.
viii. Explain how the student determine the permeability (μ_o) using the graph plotted in part (vi).

2. a)

i. State the Ohm's law

ii. What are parameters that change Resistance of a piece of wire?

iii. Write down an expression for the temperature dependence of Resistance of a wire. Introduce symbols in your expression.

iv. Write down an expression for power dissipation of a resistor (R) when Voltage (V) is applied across it.

b) A heating coil is designed by using a piece of conducting wire to operate with a power of 1000 W at 100 V.

i. Calculate resistance of the heater coil.

ii. Calculate the length of required conducting wire to make the heating coil. Resistivity and cross-sectional area are $4.0\text{x}10^{-5}\ \Omega m$ and 2.0 mm^{-2} respectively.

iii. Find the voltage across the heater when the heater operates at power of 62.5 W.

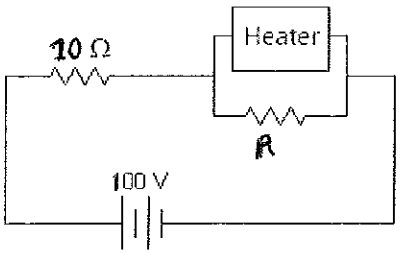


Figure 02

iv. The heating coil is connected with a resistor of 10 Ω and resistor of R as shown in the figure 02. What should be the value of R given in figure 02 so that heater operates at the rate 62.5 W?

3. a)

i. Write the reactance of a Resistor (X_R), Inductor (X_L) and a Capacitor (X_C) when it is connected to an AC source so that current through the circuits is $I_o Sin\omega t$.

ii. Sketch the variation of Voltage and Current with respect to time for each component mention in (i).

b) AC voltage $V=283Sin100\pi t$ is applied to a LCR series circuit containing a resistor of 3.0 Ω, an inductor of 25.48 mH and a capacitor of $7.96\text{x}10^{-4}$ F.

i. Find the frequency of the AC voltage

ii. Calculate the inductive reactance and capacitive reactance.

iii. Determine the impedance of the circuit.

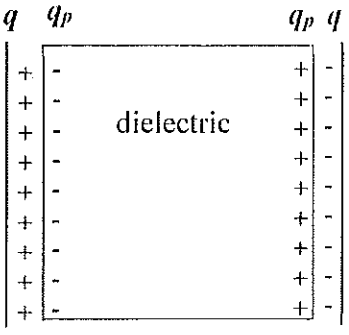
iv. What would be the resonance frequency of the circuit?

4.

a) Parallel plate capacitor has a cross-sectional area A, plate separation d with dielectric medium between two plates. Induced charge on the surface of the dielectric medium and charge on the plate are q_p and q respectively as shown in figure 03.

i. Show that $\int \bar{P}.d\bar{s} = q_p$ where $\bar{P}$ is the dipole moment per unit volume and ds is the element of surface area.

ii. Dipole moment per unit volume can be written as follows $\bar{P} = \chi\varepsilon_o \times \bar{E}$. Name the symbols in this expression.



b) Following four (04) expressions with their usual symbols are given below. Describe each of the expression.

i. $|\bar{E}| = \frac{(q-q_p)}{\varepsilon_o A}$

ii. $|\bar{P}| = \frac{q_p}{A}$

iii. $|\bar{D}| = \frac{q}{A}$

iv. $|\bar{E}_o| = \frac{q}{\varepsilon_o A}$

v. Using the above expressions or any alternative method show that $\bar{D} = \varepsilon_o \bar{E} + \bar{P}$

vi. Hence show that $\varepsilon_r = 1 + \chi$, where ε_r is dielectric constant.

c) Dielectric slab that has dielectric constant of 7, thickness 2 *cm* and cross-sectional area of 20 cm^2 is inserted in an Electric field (E) then 50 μC charge is induced on the surface of the dielectric slab.

i. Find the dipole moment of the induced charge.

ii. Calculate the magnitude of the polarization vector.

iii. What is the susceptibility of the dielectric medium?

5. a)

Figure 04 shows an Inductor (L) and a Resistor (R) connected in series to battery of emf E through a two way switch (K).

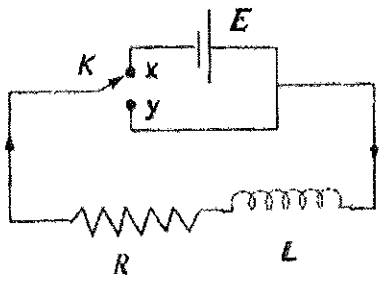


Figure 04

i. Write down the voltages across the inductor (V_L) and the resistor (V_R) when current i is passing through them.

ii. When switch is connected to **X** position. Show that $\frac{di}{dt}$ at the beginning (t =0) is $\frac{E}{L}$

iii. What would be the final steady state current (I_o) of the circuit and comment on the rate of the current $\left(\frac{di}{dt}\right)$ at this state.

iv. Obtain the expression for the current (i) as $i = I_o(1 - e^{-Rt/L})$.

v. "At a time equal to L/R the current has risen to 63% of its final steady state value." Comment on this statement whether it is correct or wrong.

b)

i. An inductor of 20 H and a Resistor of 100 Ω connected in series to DC power source of 10 V. what is final steady state current in the circuit?

ii. Find the Time constant of the circuit.

iii. Calculate time taken to reach 99% of its final steady state value. (Hint: use ln 0.01 = 4.6)

6.

This paragraph is described by determination of the charge of an electron using the Millikan oil-drop experiment. The basic design of the Millikan oil-drop experimental set up is shown in figure 05. Two accurately-aligned, parallel metal plates A and B are separated by a small distance, *d* of the order of few millimeters. The plates are enclosed in a chamber with glass walls. An electric potential difference is applied between the plates to produce an electric field (*E*). Tiny oil-droplets which is produced by atomizer, are sprayed in the region between through a hole in the upper plate A. Some of the droplets acquire electric charge due to friction with air. (This process may be aided by passing X-rays through the air or by keeping radioactive material in the chamber) The chamber is illuminated by sending a light beam horizontally through it. Drops can be seen by using a telescope placed perpendicular to the light beam then drops are like shining stars.

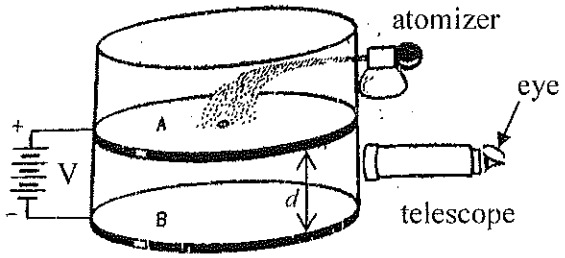


Figure 05

i. Write down methods of charging the oil-droplets mention in the paragraph.
ii. Write down advantages and disadvantages keeping the plates in few millimeters.
iii. Explain why the author has mentioned in the passage that *drops are like shining starts*
iv. State the reason for the negative plate at the bottom.
v. What is the electric field (*E*) in the chamber?
vi. State four (04) possible forces act on the oil droplet.
vii. Derive an expression for **q/m** ratio assuming that the oil droplet is stationary, where *q* and *m* are the charge and mass of the oil-droplet. State any assumptions that you make during this state.
viii. Millikan repeated the experiment many times but found different values for *q*. Explain how did he deduce a charge of electron from these values.