The Open University of Sri Lanka
B.Sc. Degree Programme- Level 03
Final Examination 2023/2024
PHU3301 – Basic Electromagnetism
Duration: Two (2) Hours

Date: 26.03.2024 **Time: 1.30 p.m. – 3.30 p.m.**

ANSWER ANY FOUR (04) QUESTIONS ONLY.

$\varepsilon_o = 8.85\text{x}10^{-12}\ C^2N^{-1}m^{-2}$ $\mu_o = 4\pi\text{x}10^{-7}\ WbA^{-1}m^{-1}$ $g = 10\ N\,kg^{-1}$

01. (a)

i. State the Coulomb's law for the forces between two charges.

ii. Figure 01 shows the positive charge of A with $4\text{x}10^{-8}$ C and the negative charge of B with $25\text{x}10^{-8}$ C. In line with another P positive charge of $1\text{x}\ 10^{-8}$ C distances between the charges are shown in Figure 01. Calculate the force on the charge P.

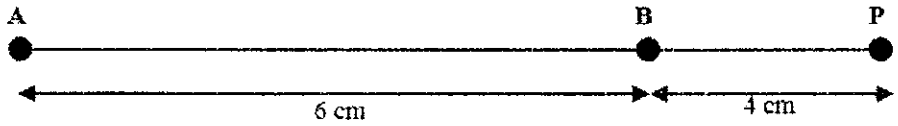


Figure 01

iii. Now Charge P has been removed, find the neutral point.

iv. Draw the diagram of electric field lines for A and B charges.

(b)

i. State the Gauss' theorem.

ii. Using Gauss's law, determine the electric field intensity at a distance r away from an infinite line of charge with a linear charge density λ.

iii. Determine the linear charge density (λ) of a wire with a length of 2 m and given 10 μC.

iv. Find the electric field intensity 20 cm away from the wire.

02. (a)

i. Write down an expression for the charge (Q) stored in a capacitor (C) connected to potential V.

ii. Draw the variation for the charge (Q) and potential (V). Hence derive an expression for the energy stored in the capacitor.

iii. The total energy stored in the capacitors is 10 J when three (03) identical capacitors are connected in series to a voltage. What is the total energy stored in the capacitors when the same capacitors are connected in parallel to the same potential?

(b)

Briefly describe the followings,

i. Electronic polarizability
ii. Ionic polarizability
iii. Dipolar polarizability

Figure 02 shows that the parallel plate capacitor is inserted with a dielectric medium.

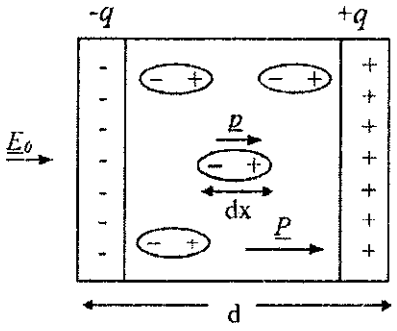


Figure 02

iv. Show that the dipole moment per unit volume (P) is given by surface charge density σ_p.

v. When a dielectric slab of thickness 2 cm and area 20 cm^2 is placed in an electric field, a 50 μC charge is induced on the surface. Calculate the dipole moment of the induced charge and magnitude of the polarization vector.

03. (a)

i. State Faraday's law of electromagnetic induction. Hence derive an expression for induced e.m.f of a moving conductor in a magnetic field. Describe the symbols in your derived expression.

ii. Figure 03 shows an inductor and resistor of 10 Ω are connected in series. Magnetic flux (Ψ) varies with time t in the inductor according to the following expression.

$$\psi = 5t + 2$$

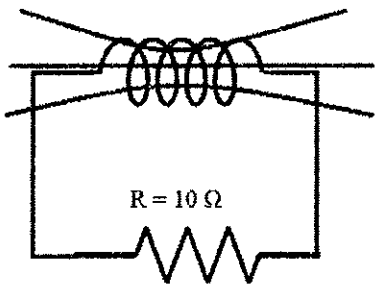


Figure 03

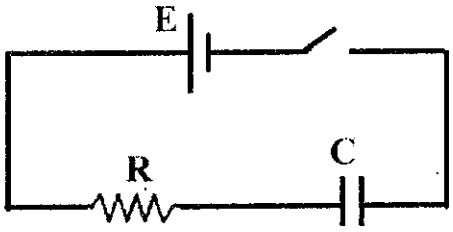
iii. Determine the induced e.m.f. across the inductor.
iv. Determine the current passing through the 10 Ω resistor.

(b) Briefly explain the basic design of the following with a diagram.

i. Suspended moving coil Galvanometer (Ballistic Galvanometer)
ii. AC Generator

04.

The circuit diagram 01 shows a battery with e.m.f. of E connected in series to a resistor R and a capacitor C through a switch.



circuit diagram 01

The charge (q) stored in the capacitor after time t is given by the following expression.

$$q = EC\left(1 - e^{-t/CR}\right)$$

i. Determine the total charge (q_o) stored in the capacitor.

ii. Derive an expression for the current after time t passing in the circuit using the above expression.

iii. Sketch the variation of the current with the time.

iv. Explain how you would obtain the maximum current passing in the circuit. What would be the maximum current?

v. Show that the time taken ($t_{1/2}$) to decrease the current to half of its initial current is $t_{1/2} = RC \ln 2$

vi. In the previous circuit E, R and C values are 5 V, 2 MΩ and 4 μF respectively. Calculate the Time Constant of the circuit.

vii. Calculate the time taken to charge the capacitor to half of its maximum charge.

05. (a)

i. Write down the expressions for capacitive reactance (X_C) and Inductive reactance (X_L). Name the symbols used in the expressions.

ii. Draw the phasor diagrams for the resistor, pure capacitor and pure inductor separately.

iii. L R C series circuit is shown in the following figure 04. current $i = i_o \, Sin \, \omega t$ is passing through the circuit.

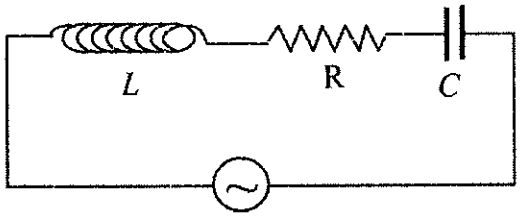


Figure 04

iv. Draw the phasor diagram for the above circuit for $X_L > X_C$

v. Derive an expression for the total impedance of the circuit using the phasor diagram or any other method.

vi. Determine the phase angle (ϕ).

vii. Show that the resonance frequency of the circuit is given by $f = \frac{1}{2\pi}\frac{1}{\sqrt{LC}}$.

06. (a)

i. State the four experiments that can be done using the potentiometer.

ii. State the advantage of conducting experiments using the potentiometer.

iii. A potentiometer wire of length 100 cm has a resistance of 10 Ω connected with a 2 V driver cell of negligible resistance. Briefly explain how you balance 10 mV in 40 cm length.

(b)

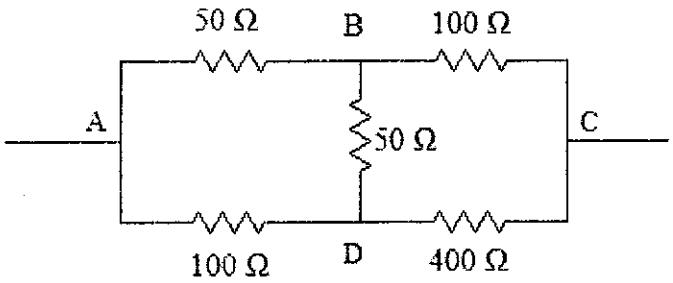


Figure 05

i. Five (05) Resistors are connected in the circuit given in Figure 05. A 10 V Battery is connected across A and C. A voltmeter with an internal resistance of 400 Ω is connected across a 400 Ω Resistor. What is the reading of the voltmeter?

When the above voltmeter is connected to the circuit,

ii. Calculate the current in each resistor.

iii. Determine the equivalent resistance of the circuit.

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