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INTERNATIONAL CENTRE FOR APPLIED SCIENCES

(Manipal University)

II SEMESTER B.S. DEGREE EXAMINATION – NOV. 2017

SUBJECT: PHYSICS II (PH 121)

Thursday, 16 November 2017

Time: 3 Hours **Max. Marks: 100**

PHYSICAL CONSTANTS

Elementary charge, e	:	1.60×10^{-19} C
Electric constant [permittivity], ε_0	:	8.85×10^{-12} F/m
Magnetic constant [permeability], μ_0	:	1.26×10^{-6} H/m
Electron mass, m_e	:	9.11×10^{-31} kg
Proton mass, m_p	:	1.67×10^{-27} kg
Neutron mass, m_p	:	1.67×10^{-27} kg
Avogadro constant, N_A	:	6.02×10^{23} mol^{-1}
Unified atomic mass unit, 1u	:	1.66×10^{-27} kg
Speed of light in a vacuum, c	:	3.00×10^{8} m/s

- ✓ **Answer ANY FIVE full Questions.**
- ✓ **Missing data, if any, may be suitably assumed**

1A. (a) State two important properties of a uniformly charged spherical shells. Define flux of an electric field.

(b) Force exerted by the nucleus of an atom on its electrons can not give us any information about the distribution of positive charge within the nucleus. Justify.

1B. Show that Coulomb's law can be deduced from Gauss's law. Using Gauss's law calculate the electric field at points near (i) infinite nonconducting sheet of charge (ii) conducting surface.

1C. (a) Two charged, concentric, thin, spherical shells have radii of 10.0 cm and 15.0 cm. The charge on the inner shell is 40.6 nC and that on the outer shell is 19.3 nC. Find the electric field (i) at r = 12.0 cm, (ii) at r = 22.0 cm, and (iii) at r = 8.18 cm from the center of the shells.

(b) It is found experimentally that the electric field in a certain region of the Earth's atmosphere is directed vertically down. At an altitude of 300 m the field is 58 N/C and at an altitude of 200 m it is 110 N/C. Find the net amount of charge contained in a cube 100 m on edge that is located at an altitude between 200 m and 300 m. Neglect the curvature of the Earth. **(4+8+8)**

2A. State ohm's law and show that the resistance of a conductor varies directly as its length and inversely as cross-sectional area. Distinguish between resistance and resistivity.

2B. (a) Find the electric potential due to a uniformly charged ring at a point on its axis.

(b) Obtain an expression for the capacitance of a parallel plate capacitor.

2C. (a) Calculate (i) the electric potential established by the nucleus of a hydrogen atom at the average distance of the circulating electron ($r = 5.29 \times 10^{-11}$m): (ii) the electric potential energy of the atom when the electron is at this radius; and (iii) the kinetic energy of the electron, assuming it to be moving in a circular orbit of this radius centered on the nucleus. (iv) How much energy is required to ionize the hydrogen atom? Express all energies in electron-volts, and take V = 0 at infinity.

(b) Two objects, one with mass $m_1 = 0.0022$ kg and charge $q_1 = +32$ μC and the other with mass $m_2 = 0.0039$ kg and charge $q_2 = -18$ μC, are initially a distance 4.6 cm apart. With object 1 held in fixed position, object 2 is released from rest. What is the speed of the object 2 when the separation between the objects is 2.3 cm? Assume that the objects behave like point charges. **(4+8+8)**

3A. (a) State Kirchhoff's laws. What are the two conservation laws embodied in Kirchhoff's laws?

(b) A proton (charge +e), traveling perpendicular to a magnetic field, experiences the same force as an alpha particle (q = +2e, m = 4.0 u) which is also traveling perpendicular to the same field. Find out the ratio of their speeds, V_{proton}/V_{alpha}.

3B. In an RC circuit, obtain an expression for the charges present on the plates of a capacitor at any instant of time during its discharging process. What is the significance of RC time constant? Show the graphical variation of potential difference across capacitor and resistor with time.

3C. (a) Internal energy is to be generated in a 108-mΩ resistor at the rate of 9.88 W by connecting it to a battery whose emf is 1.50 V. (i) What is the internal resistance of the battery? (ii) What potential difference exists across the resistor?

(b) (i) Calculate the current through each source of emf in Figure 1. (ii) Calculate $V_b - V_a$. Assume that $R_1 = 1.20\ \Omega$, $R_2 = 2.30\ \Omega$, $\mathscr{E}_1 = 2.00$ V, $\mathscr{E}_2 = 3.80$ V, and $\mathscr{E}_3 = 5.00$ V. **(4+8+8)**

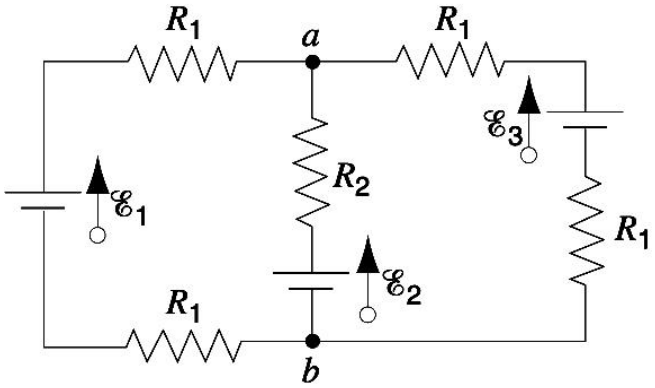

Figure 1

4A. (a) What is Hall effect. Mention two important applications of Hall effect.

(b) A free electron and a free proton are released in identical electric fields. Compare the electric forces on the two particles. Compare their accelerations.

4B. Obtain an expression for magnetic force on the current carrying wire. Derive an expression for the torque acting on a current carrying rectangular loop placed in a uniform magnetic field.

4C. (a) An alpha particle (q = +2e, m = 4.0 u) travels in a circular path of radius 4.5 cm in a magnetic field with B = 1.2 T. Calculate (i) its speed, (ii) its period of revolution, (iii) its kinetic energy in eV, and (iv) the potential difference through which it would have to be accelerated to achieve this energy.

(b) A horizontal conductor in a power line carries a current of 5.12 kA from south to north. The Earth's magnetic field in the vicinity of the line is 58.0 μT and is directed toward the north and inclined downward at 70.0° to the horizontal. Find the magnitude and direction of the magnetic force on 100 m of the conductor due to Earth's field.

(4+8+8)

5A. Using Ampere's law find magnetic field at the external and internal points of a long straight wire.

5B. Using Biot-Savart's law, find magnetic field at an axial point of a circular current loop. What is the magnetic field at the center of the loop? What is the magnetic field if current flows not in a complete circle but in an arc of the circle?

5C. (a) A long hairpin is formed by bending a piece of wire as shown in Figure 2. If the wire carries a current i = 11.5 A, (i) what are the magnitude and direction of $\vec{B}$ at point a? (ii) At point b, very far from a? Take R = 5.20 mm.

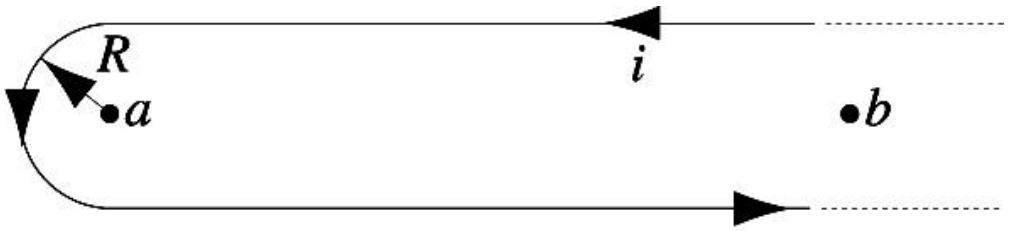

Figure 2

(b) Two long, parallel wires are 8.10 cm apart. What equal current must flow in the wires if the magnetic field halfway between them is to have a magnitude of 296 μT?

(4+8+8)

6A. Show that electric potential has no meaning for electric fields produced by a changing magnetic flux.

6B. State Faraday's law of induction in terms of magnetic flux. Mention any four methods for changing flux. Obtain an expression for the power required to withdraw a closed conducting loop from a magnetic field. Show that the work done by the external agent is dissipated as Joule heating of the loop.

6C. (a) A generator consists of 100 turns of wire formed into a rectangular loop 50 cm by 30 cm, placed entirely in a uniform magnetic field with magnitude B = 3.5 T. What is the maximum value of the emf produced when the loop is spun at 1000 revolutions per minute about an axis perpendicular to magnetic field?

(a) A uniform magnetic field is perpendicular to the plane of the circular loop 10.4 cm in diameter made of copper wire (diameter = 2.50 mm). (i) Calculate the resistance of the wire. (ii) At what rate must the magnetic field change with time if an induced current of 9.66 A is to appear in the loop? Given: $\rho_{copper} = 1.69 \times 10^{-8}\ \Omega$.m.

(4+8+8)

7A. (a) Compare the properties of a capacitor with an inductor.

(b) A piece of aluminium is dropped vertically downward between the poles of an electromagnet. Does the magnetic field affect the velocity of aluminium? Explain.

7B. Find the inductance of an inductor of any size or shape. Derive an expression for the energy stored in the magnetic field of an inductor of inductance 'L' carrying a current 'i' and hence obtain an expression for the energy density in a magnetic field.

7C. (a) The number of flux linkages through a certain coil of 745-mΩ resistance is 26.2 mWb when there is a current of 5.48 A in it. (i) Calculate the inductance of the coil. (ii) If a 6.00-V battery is suddenly connected across the coil, how long will it take for the current to rise from 0 to 2.53 A?

(b) A solenoid 85.3 cm long has a cross-sectional area of 17.2 cm^2. There are 950 turns of wire carrying a current of 6.57 A. (i) Calculate the magnetic field energy density inside the solenoid. (ii) Find the total energy stored in the magnetic field inside the solenoid. (Neglect end effects). **(4+8+8)**

8A. What is an electric dipole? Calculate the potential at a point due to an electric dipole.

8B. Using trigonometric analysis, obtain an expression for the impedance and current amplitude in the series RLC alternating circuit. Discuss the condition of resonance and get the expression for resonance frequency.

8C. (a) An air conditioner connected to a 120 V, rms AC line is equivalent to a 12.2 Ω resistance and 2.30 Ω inductive reactance in series. (i) Calculate the impedance of the air conditioner. (ii) Find the average power supplied to the appliance. (iii) What is the value of the rms current?

(b) In a series RLC AC circuit, let R = 160 Ω, C = 15 μF, L = 230 mH, f = 60 Hz, and $\mathscr{E}_m$ = 36 V. Find (i) the inductive reactance X_L, (ii) the capacitive reactance X_C, (iii) the impedance Z for the circuit, (iv) the current amplitude i_m, and (v) the phase constant ϕ.

(4+8+8)