INTERNATIONAL CENTRE FOR APPLIED SCIENCES
MAHE, MANIPAL
B.Sc. (Applied Sciences) in Engg.
End – Semester Theory Examinations – MAY 2021
II SEMESTER - PHYSICS - II (IPH 121) – Repeaters (2018 Batch)
(Branch: Common to all)

Time: 3 Hours **Date: 13 May 2021** **Max. Marks: 100**

Note: Answer any FIVE FULL questions. Each question carry 20 marks.
Write specific and precise answers. Missing data may suitably be assumed.
Draw neat sketches wherever necessary with axes shown properly.

Speed of light in vacuum = 3.00×10^{8} m/s, Electron charge = 1.60×10^{-19} C, Mass of proton / neutron = 1.67×10^{-27}kg, Electron mass = 9.11×10^{-31} kg, Boltzmann constant = 1.38×10^{-23} J/ K, Planck's constant = 6.63×10^{-34} J-s, Permittivity of vacuum = 8.85×10^{-12} F/m, Permeability of vacuum = $4\pi \times 10^{-7}$ H/m, Avogadro constant = 6.02×10^{23} /mol.

1A. Arrive at an expression for the torque acting on a dipole placed in a uniform electric field and hence obtain an expression for the energy of field and dipole system. **(4)**

1B. a) Obtain an expression for the electric field at a point along the perpendicular bisector of a line of charge.
b) State Coulomb's Law and write its mathematical form. What is the force of repulsion between two electrons separated by a distance10.0 pm? **(8)**

1C. (a) In a uniform electric field near the surface of the earth, a particle having a charge of -2.0 x10^{-9} C is acted on by a downward electric force of 3.0 x 10^{-6}N. (i) Find the magnitude of the electric field. (ii) What are the magnitude and direction of the electric force exerted on the proton placed in this field? (iii) What is the gravitation force on the proton? (iv) what is ratio of the electric force to the gravitational force in this case?
(b) An electric dipole consists of charges +2e and –2e separated by 0.78 nm. It is in an electric field of strength 3.4×10^{6} N/C. Calculate the magnitude of the torque on the dipole when the dipole moment is (i) parallel, (ii) at right angle, and (iii) opposite to the electric field. **(8)**

2A. Explain "electric flux" giving an example and write its mathematical form. **(4)**

2B. State Gauss' Law and prove Coulomb's Law using Gauss' Law. Prove that the electric field near a non-conducting sheet of charge is **(8)**

$$E = \frac{\sigma}{2\varepsilon_0}.$$

2C. (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) A proton orbits with a speed 294km/s just outside a charged sphere of radius 1.13cm. Find the charge on the sphere. **(8)**

3A. (a) Define electrical potential at a point in an electric field. How does it differ from potential energy?

(b) State why the potential along a line perpendicular bisector of an electrical dipole is zero at every point. **(4)**

3B. a) Arrive at an expression for the potential at a point near a uniform line of charge of length 'L' perpendicular to its length.

b) Derive an expression for the electric potential at a point on the axis of a uniformly charged circular disc. **(8)**

3C. (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 conducting spheres, one of radius 5.88 cm and the other of radius 12.2 cm, each have a charge of 28.6 nC and are very far apart. If the spheres are subsequently connected by a conducting wire, find (i) the final charge on and (ii) the potential of each sphere, assuming V = 0 at infinity. **(8)**

4A. What is a capacitor? Derive an expression for the energy stored in a charged capacitor. Where does this energy reside? **(4)**

4B. a) Prove that resistivity $\rho = m/(nq^2\tau)$ wherein symbols have usual meanings

b) Arrive at an expression for the capacity of a spherical capacitor. **(8)**

4C. a) A wire 4.0 m long and 6.0 mm in diameter has a resistance of 15 mΩ. A potential difference of 23 V is applied between the ends. (i) What is the current in the wire? (ii) Calculate the current density. (iii) Calculate the resistivity of the wire material.

b) A 6μF capacitor is connected in series with a 4μF capacitor; a potential difference of 200V is applied across the pair. (i) Calculate the equivalent capacitance. (ii) What is the charge on each capacitor? (iii) What is the potential difference across each capacitor? **(8)**

5A. Define the terms i) drift speed ii) current density and derive a relation between them. **(4)**

5B. Arrive at an expression for the instantaneous charge and current through a circuit containing R and C in series with an emf source when the capacitor is in the process of charging. Draw the relevant graphs indicating the variation of potential difference across the circuit components with time. Write the significance of RC time constant in a circuit. **(8)**

5C. a) A 4.0-cm-long caterpillar crawls in the direction of electron drift along a 5.2-mm diameter bare copper wire that carries a current of 12 A. (i) Find the potential difference between the ends of the caterpillar. (ii) How much time could it take the caterpillar to crawl 1.0 cm and still keep up with the drifting electrons in the wire? For copper number density, n, of electrons is $8.49 \times 10^{28}/m^3$ and resistivity ρ is $1.69 \times 10^{-8}\Omega.m$.

b) A coil of Nichrome wire is 25.0m long. The wire has a diameter of 0.400mm and is at $20.0^{\circ}C$. If it carries a current of 0.500 A, what are i) the magnitude of the electric field in the wire, and ii) the power delivered to it? Iii) What if? If the temperature is increased to $340^{0}C$ and the voltage across the wire remains constant, what is the power delivered? **(8)**

6A. The magnetic force acting on a charged particle is maximum when it travel perpendicular to the uniform magnetic field. Justify the statement and hence define Tesla. **(4)**

6B. Explain the term Hall effect and derive an expression for the Hall coefficient. Write a short note on mass spectrometer. **(8)**

6C. a) The electron in the beam of a television tube have a kinetic energy of 12.0 keV. The tube is oriented so that the electrons move horizontally from magnetic south to magnetic north. The vertical component of the Earth's magnetic field points down and has a magnitude of 55.0 μT. (i) What is the acceleration of a given electron due to the magnetic field? (ii) How far will the beam deflect in moving 20.0 cm through the television tube?

b) A 1.22 keV electron circulating in a plane right angle to a magnetic field with a radius 24.7cm, what is the i) frequency of revolution, ii) period of the motion. **(8)**

7A. State Ampere's Law and Biot-Savart's Law and write their mathematical expressions. **(4)**

7B. a) Using Ampère's Law, arrive at an expression for the magnetic field due to a long straight wire both at a point outside and at its interior. Plot a graph of 'B' verses 'r' the radius of the wire.

b) Using Ampère's Law, Prove that the magnetic field inside a solenoid is = $\mu_0 ni$, where 'n' is the number of turns per unit length. **(8)**

7C. a) A long, straight wire carries a current of 48.8 A. An electron, traveling at 1.08×10^{7} m/s, is 5.20 cm from the wire. Calculate the force that acts on the electron if the electron velocity is directed (i) toward the wire, (ii) parallel to the current.

b) A circular loop of radius 12 cm carries a current of 13 A. A second loop of radius 0.82 cm, having 50 turns and a current of 1.3 A, is at the center of the first loop. (i) What magnetic field does the large loop set up at its center? (ii) Calculate the torque that acts on the small loop. Assume that the planes of the two loops are at right angles and that the magnetic field due to large loop is essentially uniform throughout the volume occupied by the small loop. **(8)**

8A. Write a note on motional emf. **(4)**

8B. Explain the term self-inductance of a coil and prove that the self-inductance of a solenoid per unit length is = $\mu_o n^2 A$, where symbols have usual meanings. Write one application each of self and mutual inductance. **(8)**

8C. a) A 32-µF capacitor is connected across a programmed power supply. During the interval from t = 0 to t = 3 s, the output voltage of the supply is given by V(t) = (6 V) + (4 V/s)t – (2 V/s^2)t^2. At t = 0.50 s, find (i) the charge on the capacitor, (ii) the current into the capacitor, and (iii) the power output from the power supply.

b) A 45.2 mH inductor has a reactance of 1.28kΩ at certain frequency. i) Find the frequency. ii) What is the capacitance of a capacitor with the same reactance at that frequency? iii) If the frequency is doubled, what is the reactance of inductor and capacitor? **(8)**

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