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INTERNATIONAL CENTRE FOR APPLIED SCIENCES

(Manipal University)

II SEMESTER B.S. DEGREE EXAMINATION – APRIL/ MAY 2017

SUBJECT: PHYSICS - II (PH 121) - OLD SCHEME

(COMMON TO ALL BRANCHES)

Saturday, 22 April 2017

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

Speed of light in vacuum, $c = 3.00 \times 10^8$ m/s, Electron charge, $e = 1.60 \times 10^{-19}$ C, Mass of proton/ neutron, $m_n = m_p = 1.67 \times 10^{-27}$kg, Electron mass, $m_e = 9.11 \times 10^{-31}$ kg , Planck's constant, $h = 6.63 \times 10^{-34}$ J-s, Permittivity of vacuum $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m, Permeability of vacuum $\mu_0 = 4\pi \times 10^{-7}$ H/m, Avogadro constant $= 6.02 \times 10^{23}$/mol.

- ✓ **Answer any FIVE FULL questions. Each question carries 20 marks.**
- ✓ **Any missing data may suitably be assumed.**

1A. (a) Calculate the force of repulsion between two electrons separated by a distance 1.0mm in free space.

(b) Draw a graph of Electric field verses distance for a uniformly charged conducting sphere of radius 'R' and justify the nature of graph.

1B. Arrive at an expression for the electric field along the axis passing through the center and perpendicular to the plane of ring of charges assuming uniform charge distribution. What is the field at its center?

1C. (a) An electric dipole, consisting of charges of magnitude 1.68nC separated by 6.93μm, is in an electric field of strength 3.4×10^6 N/C. (a) What is the magnitude of the electric dipole moment? (b) What is the torque on the dipole when orientated (i) parallel (ii) perpendicular and (iii) opposite to the field?

(b) A charged oil drop of radius 2.76 μm and density 918 kg/m^3 is suspended in which is in equilibrium under gravity and electric field $E = 1.65 \times 10^6$N/C. Calculate the magnitude and sign of the charge on it. Express the result in terms of elementary charge 'e'.

(4+8+8)

2A. Prove that the electric field at a point near an infinite non-conducting sheet of charge is $= \sigma/2\varepsilon_0$, using Gauss' Law.

2B. (a) State Gauss' Law and obtain Coulomb's Law from it.

(b) Arrive at an expression for the electric field near a line of charge using Gauss' Law. Explain why electric field inside a charged conductor is zero.

2C. (a) A 115-KeV electron is fired directly toward a large, flat, plastic sheet that has a surface charge density of $-2.08\ \mu C/m^2$. From what distance must the electron be fired, if it is just to fail to strike the sheet? (Ignore relativistic effects).

(b) The electric field present in the earth's atmosphere just above its surface is 152N/C, directed downwards radially towards its center. What is the total net charge carries by the earth assuming it to be a spherical conductor of radius $R=6.37 \times 10^6 m$.

(4+8+8)

3A. (a) A potential of zero at a point does not necessarily mean that the electrical force is zero at that point. Substantiate this statement with reasoning.

(b) Draw the diagram indicating the equi-potential surfaces in case of a positive point charge and a infinite sheet of positive charge.

3B. Arrive at an expression for the potential at a point along the axis passing through the center and perpendicular to the plane of a uniformly charged disc. How this expression will be reduced if the point reaches the center of the disc? Write the expression for the potential at a point along the axis of a ring of charge

3C. (a) A disc of radius 4.8 cm carries a total charge q=+2.5 nC uniformly distributed over its surface and held fixed. An electron initially at rest is at a distance 30.0cm from the center of the disc is released it strikes the surface with a speed. Calculate the speed of the electron assuming that the potential at 30cm from the disc is 4.0 V and the surface charge density.

(b) Two large parallel conducting pate are 12.0 cm apart and carry equal but opposite charges on their facing surfaces. An electron placed midway between them experience a force of $3.9 \times 10^{-15} N$. Find (i) electric field at the position of the electron and (ii) potential difference between the plates. **(4+8+8)**

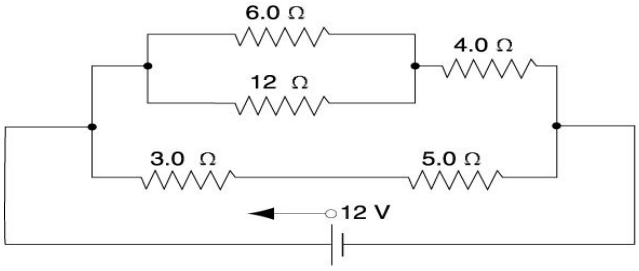
4A. (a) Define the terms; current density and drift speed

(b) Prove that current density $j = -nev_d$ (symbols have usual meanings).

4B. Arrive at an expressions for the instantaneous charge and current through a circuit containing R and C in series with a source of emf ($\mathcal{E}$), when the capacitor is in the process of charging. Draw the relevant graphs indicating the variation of potential difference across the circuit components C and R with time. Write the significance of RC time constant.

4C. (a) A parallel-plate capacitor has circular plates of 8.22-cm radius and 1.31-mm separation. (a) Calculate the capacitance. (b) What charge will appear on the plates if a potential difference of 116 V is applied?

(b) A circuit containing five resistors connected to a 12-V battery is shown in Fig. Find the potential difference across the 5.0-Ω resistor. **(4+8+8)**



5A. (a)When two capacitors each of 1.0 μF are connected in series, what is the effective capacitance. Instead of capacitors, if two resistances each of 100MΩ are in series with each other what will be the effective resistance?

(b)Define capacitance of a capacitor and state the two factors to which the capacitance of a parallel plate capacitor depends upon?

5B. With a neat diagram explain the construction, principle and working of cyclotron. Derive the expressions for the kinetic energy of an accelerated charged particle in a cyclotron.

5C. (a) In a Hall effect experiment, a current of 3.2 A lengthwise in a conductor (1.2 cm wide, 4.0 cm long) 9.5 μm thick produces a transverse Hall voltage (across the width) of 40μV when a magnetic field of 1.4 T acts perpendicular to the thin conductor. From these data, find (a) the drift velocity of the charge carriers and (b) the number density of charge carriers.

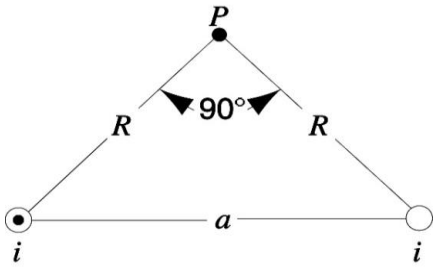
(b) In a Bohr model of hydrogen atom, the electron circulates around the nucleus in a circular orbit of radius 5.29×10^{-11}m at a frequency 6.6×10^{15} Hz. What value of magnetic field is set up at the center of this circular orbit? **(4+8+8)**

6A. (a) State Hall effect. Write one use each of inductor and capacitor.

(b) What is a toroid? Write an expression for the magnetic field inside a toroid.

6B State Biot-Savart Law. Using Biot-Savart Law, arrive at an expression for the magnetic field due to a circular current loop along its axis perpendicular to its plane and passing through its center.

6C (a) Two long, straight parallel wires 12.2 cm apart each carry a current of 115 A. Figure below shows cross section, with the wires running perpendicular to the page and point '*P*' lying on the perpendicular bisector of '*a*'. Find the magnitude and direction of the magnetic field at '*P*' when the current in the left hand wire is out of the page and the current in the right-hand wire is (a) out of the page and (b) into the page.



(b) A long solenoid 1.78m long and 4.6cm in diameter carries a current 20.8 A. The magnetic inside the solenoid is 32.4mT. Find the length of the wire forming the solenoid.

(4+8+8)

7A. (a) State Faraday's Laws on electromagnetic induction.

(b) Write two differences between diamagnetic an paramagnetic materials

7B. (a) With a neat diagram arrive at the expression for the motional emf induced in a current carrying closed loop moved in a transverse magnetic field.

(b) Prove that the self inductance of a solenoid $L=\mu_0 n^2 lA$, where symbols have usual meanings.

7C. (a) A section of a solenoid of length 12.0 cm, circular cross section of diameter d=1.6 cm carries a steady current 3.8 A. the section contains 75 turns along its length. Calculate (i) its inductance when the core empty (ii) If now the current is reduced at a constant rate to 3.2 A in a time of 15.0s, what is the resulting emf developed by the solenoid.

(b) A coil has an inductance 83.0 mH and resistance 0.55 Ω. If a 16.0V emf is applied. How much energy is stored in the magnetic field after the current is built up to its maximum value? **(4+8+8)**

8A. (a) State Ampere's loop law on the magnetic field due to a current.

(b) Calculate the energy density in the magnetic field of a solenoid carrying a current 10.0 A and number of turns per unit length, n=100.

8B (a) Derive the expressions for the energy stored and energy density in the electric field of a parallel plate capacitor.

(b)Arrive at an expression for the instantaneous current through a circuit containing L, C and R in series connected to an AC source.

8C (a) (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 (a) toward the wire, (b) parallel to the current, and (c) at right angles to the direction defined by (a) and (b).

(b) At what angular frequency would 6.28mH inductor and a 21.4 μF capacitor have the same reactance? Calculate the reactance of these circuit components. **(4+8+8)**