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INTERNATIONAL CENTRE FOR APPLIED SCIENCES

(Manipal University)

II SEMESTER B.S. DEGREE EXAMINATION – JUNE 2016

SUBJECT: PHYSICS - II (PH 121)

(NEW SCHEME)

(COMMON TO ALL BRANCHES)

WEDNESDAY, 8th JUNE, 2016

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

- ✓ **Answer ANY FIVE FULL Questions.**
- ✓ **Any missing data may be suitably assumed**
- ✓ **Write the correct question nos. at the margin clearly.**

PHYSICAL CONSTANTS

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,
Boltzman 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,
Rydberg constant = 1.10×10^7/m,
Permeability of vacuum = $4\pi \times 10^{-7}$ H/m,
Avogadro constant = 6.02×10^{23} /mol.

1A. (a) How can you charge a copper rod negatively by induction?
(b) What is the force of repulsion between two protons separated by a distance10.0 nm?

1B. Arrive at an expression for the electric field at a point just on the (i) outer surface of a charged conductor and (ii) near an infinite non conducting sheet of charge using Gauss' Law.

1C. (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 150N/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 = 6.37×10^6 m.

(4+8+8=20 marks)

2A. (a) Define electrical potential near a charged particle. 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

2B. 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) If the wire is bent into a circle and the potential is to be measured at a point along the axis passing through its center, perpendicular to its plane, how do you arrive at the expression for the potential?

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. (d) How much energy is required to ionize the hydrogen atom? Express all energies in electron-volts, and take V = 0 at infinity.

(b) Two charges q = +2.13 μC are fixed in space a distance d = 1.96 cm apart, as shown in Fig.1 below. (a) What is the electric potential at point C? Take V = 0 at infinity. (b) You bring a third charge Q = +1.91 μC slowly from infinity to C. How much work must you do? (c) What is the potential energy U of the configuration when the third charge is in place?

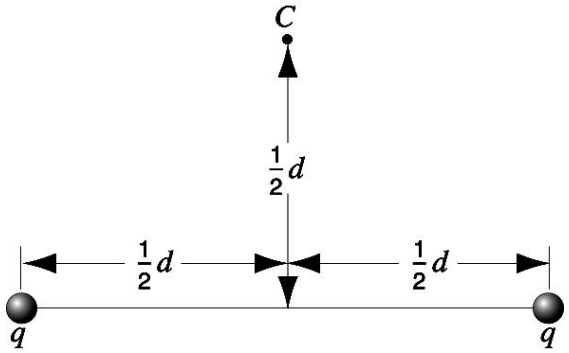

Figure 1

. **(4+8+8=20 marks)**

3A. (a) Write two difference between current and current density.

(b) Explain in brief any two ways one can increase the capacitance of a capacitor.

3B. (a) Arrive at an expression for the capacitance of a parallel plate capacitor.

(b) Derive the equations for the energy stored and energy density in a parallel plate capacitor

3C. (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. (c) Calculate the resistivity of the wire material?

(b) When switch S is thrown to the left (see Fig. below) the plates of the capacitor C_1 acquire a potential difference ΔV_0. C_2 and C_3 are initially uncharged. The switch is now thrown to the right. What are the final charges q_1, q_2, q_3 on the corresponding capacitors? (Given $\Delta V_0 = 12$ V, $C_1 = 10$ μF, $C_2 = 20$ μF, $C_3 = 30$ μF).

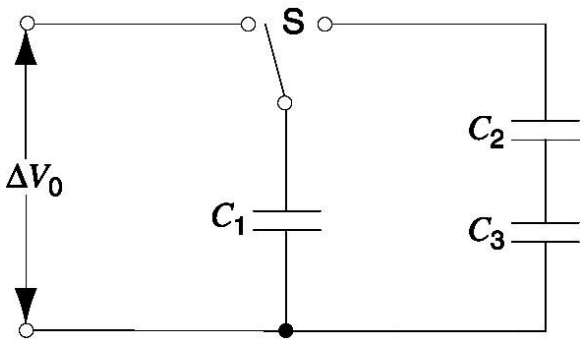

Figure 2

(4+8+8=20 marks)

4A. (a) A battery with an internal resistance ‘r’ is connected to an external load resistance ‘R’. Whether the voltage across the load ‘R’ and the applied emf will have the same value? Justify your answer.

(b) State Kirchhoff’s Laws in electrical circuits.

4B. Arrive at an expression for the instantaneous charge and current through a circuit containing R and C in series with am 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.

4C. (a) A capacitor C discharges through a resistor R. (i) After how many time constants does its charge fall to one-half its initial value? (ii) After how many time constants does the stored energy drop to half its initial value?

(b) An electron linear accelerator produces a pulsed beam of electrons. The pulse current is 485 mA and the pulse duration is 95.0 ns. (i) How many electrons are accelerated per pulse? (ii) Find the average current for a machine operating at 520 pulses/s. (iii) If the electrons are accelerated to energy of 47.7 MeV, what are the values of average and peak power outputs of the accelerator?

(4+8+8=20 marks)

5A. a) A magnetic force acts on a test charge only when it is moving in a magnetic field and it tend to change the direction of the charged particle and not its kinetic energy. Justify this statement.

b) Explain in brief how a current carrying conductor placed in a transverse uniform magnetic field experience a magnetic force.

5B. a) With a neat diagram explain the construction and working of cyclotron. Write the expression for the kinetic energy of an accelerated charged particle in a cyclotron.

b) State Hall effect. What is the basic principle of magnetic mirror or bottling effect?

5C. (a) (i) A cyclotron is designed with dees of radius R = 75 cm and with magnets that can provide a magnetic field 1.5 T. a) to what frequency should the oscillator be set if deuterons (mass = 3.34×10^{-27} kg) are to be accelerated? (ii) What is the maximum kinetic energy of deuterons that can be obtained?

b) A proton traveling at 23° with respect to a magnetic field of strength 2.63 mT experiences a magnetic force of 6.48×10^{-17} N. Calculate (i) the speed (ii) the kinetic energy in electron volt of the proton.

(4+8+8=20 marks)

6A. (a) State Biot-Savart Law and Ampère’s Law.

(b) Why two parallel conductors carrying currents in the opposite direction repel each other? Give reasons with relevant mathematical expression.

6B. a) Using Ampère’s Law, arrive at an expression for the magnetic field due to a) a long straight wire both at a point outside and at its interior. Plot a graph of ‘B’ verses ‘r’.

b) Using Ampère’s Law, Prove that the magnetic field inside a solenoid is = $\mu_o ni$, where ‘n’ is the number of turns per unit length.

6C. (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, and (iii) at right angles to the direction defined by (a) and (b).

b) A long solenoid with 115 turns/cm and a radius of 7.20 cm carries a current of 1.94 mA. A current of 6.30 A flows in a straight conductor along the axis of the solenoid. (i) At what radial distance from the axis will the direction of the resulting magnetic field be at 40.0° from the axial direction? (ii) What is the magnitude of the magnetic field?

(4+8+8=20 marks)

7A. (a) The magnitude of the induced emf in a coil placed in a varying magnetic field depends upon the rate at which the magnetic field is varied with time. Justify this statement.

(b) Write any two applications of eddy currents.

7B. (a) With a neat diagram arrive at an expression for the power dissipated when a current carrying closed loop in moved in a transverse magnetic field.

(b) Prove that the self inductance of a solenoid per unit length is = $\mu_o n^2 A$ where symbols have usual meanings.

7C (a) The inductance of a closely wound N-turn coil is such that an emf of 3.0 mV is induced when the current changes at a rate of 5.0 A/s. A steady current of 8.0 A produces a magnetic flux of 10 μWb through each turn. (i) Calculate the inductance of the coil. (ii) How many turns does the coil have?

b) A uniform magnetic field is perpendicular to the plane of a circular loop 10.4 cm in diameter and is made up of copper wire of diameter 2.5 mm. (i)Calculate the resistance of the wire (resistivity is 1.69×10^{-8} Ω-m.) (ii) At what rate must the magnetic field change with time if an induced current of 19.66 A is to appear in the loop?

(4+8+8=20 marks)

8A. a) The energy density in the magnetic field of a self inductor depends upon the current where as the energy density in the electric field of a capacitor depends upon the electric field. Justify the statement.

(b) What is the resonance frequency of a circuit containing L=20 mH and C=10 pF?

8B. A single loop containing L, R & C in series with an AC source $\xi = \xi_m \sin \omega t$., assuming that the voltage across the inductance leads the applied current by 90° and across capacitance lags by 90°, arrive at an expression for the "i_{max}" , phase angle and the condition for resonance.

8C. (a) The inductance of a coil is 53mH and resistance 0.35 Ω. If a 12.0 V emf is applied, how much energy is stored in the magnetic field after the current has built up to its maximum value?

(b) A coil of inductance L=80.0 mH, a capacitor C = 900 nF is connected to an unknown resistance R and a AC signal in series working at a frequency 900Hz. The phase angle between the applied emf and the current is 75°. Calculate the resistance of the coil.

(4+8+8=20 marks)