Question Paper

Exam Date & Time: 19-Apr-2018 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIENCES
SECOND SEMESTER B.S. (ENGG)
END-SEMESTER THEORY EXAMINATIONS APRIL - 2018
DATE: 19 APRIL 2018
TIME: 9:30AM TO 12:30PM

Physics - II [PH 121]

Marks: 100 | **Duration: 120 mins.**

Answer 5 out of 8 questions.

Any missing data may be suitably assumed
PHYSICAL CONSTANTS

Elementary charge, e : 1.60 x 10^{-19}C

Electric constant [permittivity], e0 : 8.85 x 10^{-12}F/m

Magnetic constant [permeability], m0 : 1.26 x 10^{-6}H/m

Electron mass, me : 9.11 x 10^{-31}kg

Proton mass, mp : 1.67 x 10^{-27}kg

Avogadro constant, NA : 6.02 x 10^{23}mol^{-1}

Unified atomic mass unit, 1u : 1.66 x 10^{-27}kg

Speed of light in a vacuum, c : 3.00 x 10^{8} m/s

1)

A) **a)** Compare Gauss' law with Coulombs law. (4)
b) A free electron and a free proton are released in identical electric fields. What is the magnitude and direction of electrical force on each particle? Which particle has larger acceleration? Explain.

B) State and explain shell theorems for electric fields of a uniformly charged spherical shell. State Gauss' law. Mention four properties of conductor at electrostatic equilibrium. Use Gauss' law to calculate the electric field just outside the conductor. How do you account for the difference in expression for electric field of a conductor and insulator? (8)

C) **(a)** A uniformly charged conducting sphere of 1.22 m radius has a surface charge density of 8.13 μC/m^2. (8)

(i) Find the charge on the sphere.
(ii) What is the total electric flux leaving the surface of

the sphere?

(iii) Calculate the electric field at the surface of the sphere.

(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

2) A) **(a)** The electric potential inside the conductor is not necessarily zero even though the electric field is zero. Justify. (4)

(b) The current density in a strip of silicon is 2.4 x $10^5 A/m^2$. Calculate the drift speed of electrons if density of electrons is 8.0 x $10^{21} m^{-3}$.

B) (a) Calculate the change in potential energy when a charge q_2 moves from a point 'a' to point 'b' subject to the force due to another charge q_1 at rest and hence deduce the potential energy at a point. (8)

(b) Calculate the potential at a point due to an electric dipole.

C) (a) Two charges q = +2.13 μC are fixed in space a distance d = 1.96 cm apart, as shown in Figure 1. (i) What is the electric potential at point C? Take V = 0 at infinity. (ii) You bring a third charge Q = +1.91μC slowly from infinity to C. How much work must you do? (iii) What is the potential energy U of the configuration when the third charge is in place? (8)

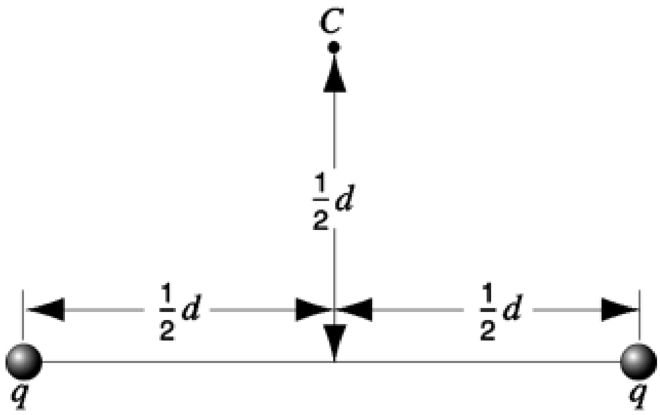

Figure 1

(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 = -18μC, are initially a distance 4.6 cm apart. With object 1 held in a fixed position, object 2 is released from rest. What is the speed of object 2 when the separation between the objects is 2.3 cm? Assume that the objects behave like point charges.

3) A) Derive the expression for capacitance of a parallel plate capacitor. How the expression for capacitance gets modified in presence of a dielectric? (4)

B) What is a capacitor? What is the capacitance of a capacitor? (i) Derive an expression for the energy stored in a charged capacitor. Where does this energy reside? (ii) Using the expression for capacitance of a parallel plate capacitor, derive an expression for energy density. (8)

C) (a) Two sheets of aluminum foil have a separation of 1.20 mm, a capacitance of 9.70 pF, and are charged to 13.0 V. (i) Calculate the plate area. (ii) The separation is now decreased by 0.10 mm with the charge held constant. Find the new capacitance. (iii) By how much does the potential difference change? (8)
(b) A parallel plate capacitor whose capacitance C is 13.5 pF has a potential difference ΔV = 12.5 V across its plates. The charging battery is now disconnected and a porcelain slab (k_e = 6.5) is slipped between the plates. What is the stored energy of the unit, both before and after the slab is introduced?

4) A) (a) Battery is a source of constant current; battery is a source of constant terminal voltage; battery is a source of constant emf. Which statements are correct? Which statements are wrong? Justify your answer. (4)
(b) If the car's headlights are on during the start of the ignition, they dim while the car is starting. Explain.

B) Explain with relevant theory the variation of potential difference across the resistor and capacitor during the charging and discharging processes. (8)

C) (i) Calculate the current through each source of emf in Figure 2. Assume that R1 = 1.20 Ω, R2 = 2.30Ω, $\mathscr{E}_1$ = 2.00 V, $\mathscr{E}_2$ = 3.80 V, and $\mathscr{E}_3$ = 5.00 V. (8)

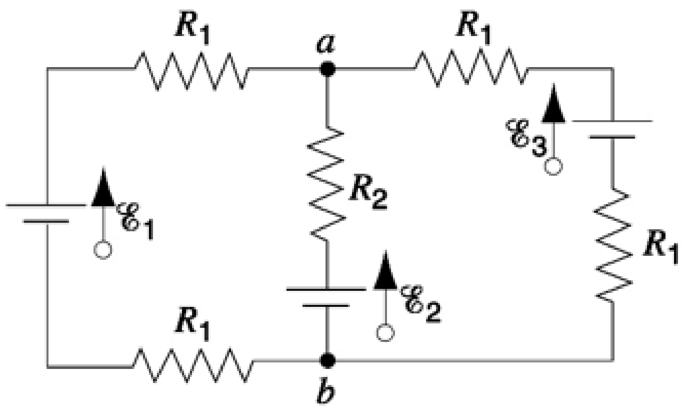

Figure 2

(b) A certain 12.0V car battery can "pump" a total of 125 A.h before it runs down. Assuming that the potential difference across the terminals stays constant, how long can it deliver energy at the rate of 110 W?

5) A) (a) Explain why it is impossible for a constant (a time-independent) magnetic field to alter the speed of a charged particle. (4)

(b) In the cyclotron particles having different speeds take the same amount of time to complete a one-half circle trip around one dee. Explain.

B) a) Obtain expressions for the Hall coefficient for the specimen and Hall voltage developed in a current carrying specimen kept in a transverse magnetic field. (8)

(b) Obtain the expression for magnetic force on a current-carrying wire.

C) (a) A 1.22 keV electron is circulating in a plane at right angles to a uniform magnetic field. The orbit radius is 24.7 cm. Calculate (i) the speed of the electron, (ii) the magnetic field, (iii) the frequency of revolution, and (iv) the period of the motion. (8)

(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 58.0μT 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.

6) A) (a) State and explain Ampere's law (4)

(b) A loose spiral spring carrying no current is hung from the ceiling. When a switch is thrown so that a current exists in the spring, the coils move closer. Explain.

B) State Biot-Savart's law. Using it, find magnetic field at an (8) axial point of a circular current loop. What is the direction of magnetic field? Get the expression for magnetic field at the center of the loop.

C) (a) A long, straight wire carries a current of 48.8 A. An electron, traveling at 1.08 x 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 (i) and (ii). (8)

(b) Figure 3 shows five long, parallel wires in the xy plane. Each wire carries a current i = 3.22 A in the positive x direction. The separation between adjacent wires is a = 8.30 cm. Find the magnetic force per meter, magnitude and direction, exerted on each of these wires.

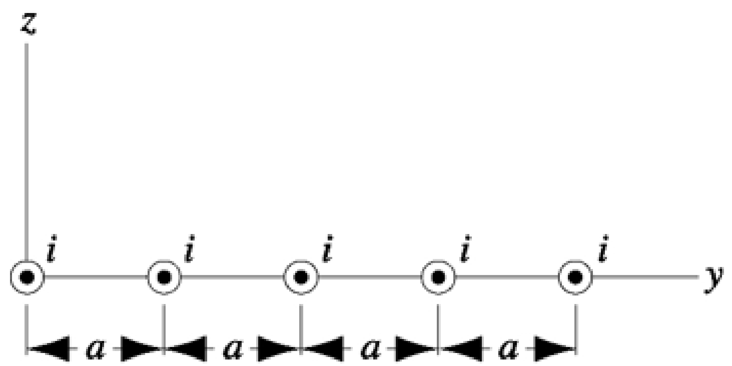

Figure 3

7)

A) (a) State Faraday's law of electromagnetic induction. (4)
(b) A piece of aluminum is dropped vertically downward between the poles of an electromagnet. Explain the effect of magnetic field on velocity of the aluminum.

B) What is motional emf? 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. Mention the advantages and disadvantages of eddy currents. (8)

C) **(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: ρ_{copper} = 1.69 x $10^{-8}\Omega$.m. (8)

(b) A long solenoid has a diameter of 12.6 cm. When a current i is passed through its windings a uniform magnetic field B = 28.6 mT is produced in its interior. By decreasing i, the field is caused to decrease at the rate 6.51 mT/s. Calculate the magnitude of the induced electric field (i) 2.20 cm and (ii) 8.20 cm from the axis of the solenoid.

8) A) (a) The core of the solenoid with inductance 12 μH is filled with iron while the current is held constant at 3.20 A. The magnetization of the iron is saturated such that B = 1.4 T. What is the resulting inductance? (4)

(b) Draw the phasor diagram representing the current and potential difference for a capacitive element in an AC circuit.

B) (a) Find the inductance of an inductor of any size or shape and hence derive expression for inductance of a solenoid. (8)

(b) Obtain an expression for power in the series RLC AC Circuit.

C) (a) A 3.56-H inductor is placed in series with a 12.8-Ω resistor, and an emf of 3.25 V is suddenly applied to the combination. At 0.278 s (which is one inductive time constant) after the contact is made, find (i) rate P at which energy is being delivered by the battery, (ii) the rate P_R at which internal energy appears in the resistor. (8)

(b) A 45.2-mH inductor has a capacitance of 1.28 kΩ. (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 are the reactances of the inductor and capacitor?

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