Question Paper

Exam Date & Time: 07-Jun-2019 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIECES
II SEMESTER B.Sc. (APPLIED SCIENCES) IN ENGINEERING
END SEMESTER THEORY EXAMINATION-APRIL/MAY 2019
Physics - II [IPH 121]

Marks: 100 **Duration: 180 mins.**

Answer 5 out of 8 questions.

PHYSICAL CONSTANTS

Elementary charge, e	:	**1.602×10^{-19}C**
Electron mass, me	:	**9.11×10^{31}kg**
Proton mass, me	:	**1.67×10^{27}kg**
Boltzmann constant	:	**1.38×10^{23}J/K**
Planck's constant	:	**6.626×10^{-34}J.s**
Electric constant(permittivity) ϵo	:	**8.85×10^{8} F/m**
Magnetic constant(permeability) μo	:	**1.26×10^{-6} H/m**
Speed of light in vacuum	:	**3.0×10^{8}m/s**

Note: Any missing data may be suitably assumed.

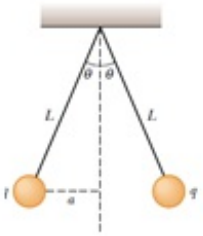
1) Using Gauss' law find electric field near an infinite sheet of charge. (4)

A)

B) Use Gauss' law to obtain expressions for the electric field, both inside and outside of a spherically symmetric charge distribution. (6)

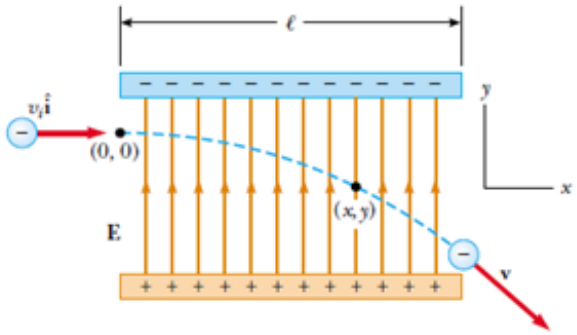
C) Two identical small charged spheres, each having a mass of 3.0×10^2 kg, hang in equilibrium as shown in the figure given below. The length of each string is 0.15 m, and the angle θ is 5.0°. Find the magnitude of the charge on each sphere. (4)

Acceleration due to gravity is 9.8m/s^2.



D) An electron enters the region of a uniform electric field as shown in Figure given below, with $v_i = 3.00 \times 10^6$ m/s and E = 200 N/C. The horizontal length of the plates is l= 0.100 m.(i) Find the acceleration of the electron while it is in the electric field. (ii) If the electron enters the field at time *t* = 0, find the (6)

time at which it leaves the field.

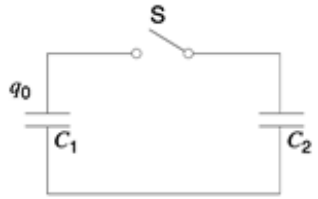


2) Find the equivalent capacitance of a parallel combination of two capacitors. (4)

A)

B) Obtain an expression for the capacitance of a spherical capacitor. (6)

C) A 3.55μF capacitor C_1 is charged to a potential difference of 6.30 V, using a battery. The charging battery is then removed, and the capacitor is connected as shown in the figure below to an uncharged 8.95μF capacitor C_2. After the switch S is closed, charge flows from C_1 to C_2 until an equilibrium is established, with both capacitors at the same potential. (a) What is this common potential difference? (b) What is the energy stored in the electric field before and after the switch S in the figure is closed? (5)



D) A uniformly charged conducting sphere of 1.22 m radius has a surface charge density of 8.13 μC/m^2. (a) Find the charge on the sphere. (b) What is the total electric flux leaving the surface of the sphere? (c) Calculate the electric field at the surface of the sphere. (5)

3) Calculate the potential at a point due to an electric dipole. (4)

A)

B) Find the potential due to a uniform line of positive charge at a point on its perpendicular bisector. (6)

C) 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 (a) the final charge on and (b) the potential of each sphere, assuming V = 0 at infinity. (5)

D) A disk of radius a= 4.8cm carries a total charge +2.5 nC that is uniformly distributed over its surface and held in fixed locations (consider the surface to behave like an insulator). An electron is initially at rest a distance x=3.0 cm from the disk along its axis. When the electron is released, it is attracted (5)

toward the disk. What is the speed of the electron when it strikes the center of the disk? The potential at a point on the axis of the disk is given by

$$V = 2\pi k_e \sigma [(x^2 + a^2)^{1/2} - x]$$

Where the terms have their usual meaning.

4) Using the microscopic view (free electron theory) of Ohm's law obtain an expression for resistivity of a conductor. (4)

A)

B) What is Hall effect? Obtain an expression for the charge carrier density in a material in terms of Hall-Voltage, magnetic field and thickness of the material. (6)

C) What is the required resistance of an immersion heater that will increase the temperature of 1.50 kg of water from 10.0°C to 50.0°C in 10.0 min while operating at 110 V? The specific heat of water is 4186J/kg °C. (5)

D) A particular cyclotron is designed with dees of radius 75cm and with magnets that can provide a field of 1.5T .(a) To what frequency should the oscillator be set if deuterons are to be accelerated ? (b) what is the maximum energy of deuterons that can be obtained? Charge and mass of deuteron are electronic charge and 3.34×10^{-27} kg respectively. (5)

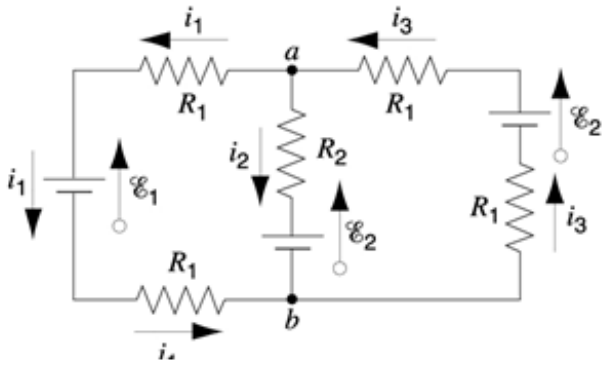
5) Obtain an expression for the charges presents on the plates of a capacitor at any instant of time during its charging process. (5)

A)

B) Derive an expression for the torque acting on a current carrying rectangular loop placed in a uniform magnetic field. (5)

C) A strip of silicon, of cross-sectional width 3.2mm and thickness 250μm carries a current of 190mA.The concentration of carriers is 8.0×10^{21} /m^3 .(a) What is the current density in the strip? (b) What is the drift speed? (4)

D) Find the currents i_1, i_2, and i_3 in the circuit shown in figure below: The elements have the following values: $\mathscr{E}_1$ =2.1V, $\mathscr{E}_2$ =6.3V, R_1 =1.7Ω and R_2 =3.5Ω. (6)



6) Discussing the concept of displacement current obtain the general form of Ampere's law (5)

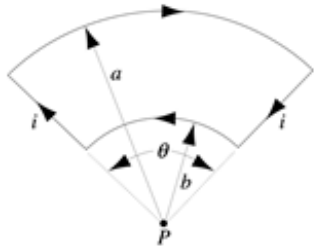
A)

B) (5)

Using Ampere's law find magnetic fields at external and internal points of a long straight wire.

C) The 25-kV electron gun in a TV tube fires an electron beam 0.22 mm in diameter at the screen, 5.6×10^{14} electrons arriving each second. Calculate the magnetic field produced by the beam at a point 1.5 mm from the axis of the beam. (5)

D) Consider the circuit of figure given below, the curved segments are arcs of circles of radii a and b. The straight segments are along the radii. Find the magnetic field at P. Assuming current i in the circuit . (5)

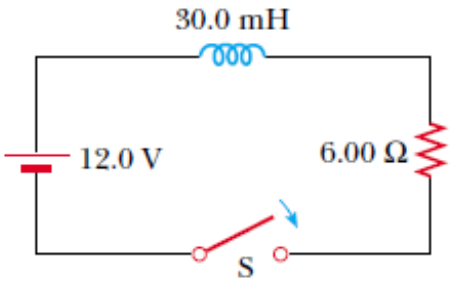


7) A) Define eddy current. Explain how eddy currents are used in electromagnetic brake. What is the disadvantage of eddy currents? How eddy currents can be reduced? (5)

B) A conducting loop of radius r is placed in a uniform magnetic field perpendicular to the plane of the loop. If the magnetic field changes at a uniform rate dB/dt, obtain an expression for the induced electric field in terms of r and dB/dt. Show the direction of the electric field with help of a diagram. (5)

C) Calculate the inductance of an air-core solenoid containing 300 turns if the length of the solenoid is 25.0 cm and its cross-sectional area is 4.00 cm^2. Calculate the self-induced emf in the solenoid if the current it carries is decreasing at the rate of 50.0 A/s. (5)

D) Find the time constant of the circuit shown in Figure given below. The switch in the figure closed at t =0. Calculate the current in the circuit at$t$ =2.00 ms. (5)



8) A) 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. (5)

B) Derive an expression for the frequency of oscillation of a resistance less LC circuit. (5)

C) The output of an AC generator is $\mathscr{E} = \mathscr{E}_m \sin \omega t$, with $\mathscr{E}_m$ = 25.0 V and ω = 377 rad/s. It is connected to a 12.7-H inductor. (a) What is the maximum value of the current? (b) When the current is maximum, what is the emf of the generator? (c) When the emf of the generator is - 13.8 V and increasing in magnitude, what is the current? (5)

D) An air conditioner connected to a 120V, rms ac line is equivalent to a 12.2Ω resistance and a 2.3Ω inductive reactance in series. (a)Calculate the impedance of the conditioner. (b) Find the average power supplied to the appliance. (c) What is the value of the rms current? (5)

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