UNIVERSITY OF COLOMBO, SRI LANKA

FACULTY OF TECHNOLOGY

LEVEL I EXAMINATION IN TECHNOLOGY - SEMESTER I - 2021

IA 1202/IA 1006 - ELECTRICITY AND MAGNETISM

Two (02) hours

Answer 4 questions only.

Electronic calculators are allowed.

Electrical permittivity of free-space (ϵ_0): 8.854×10^{-12} F/m
Magnetic permeability of free-space (μ_0): $4\pi\times10^{-7}$ H/m
Speed of light in free-space: 2.998×10^{8} ms^{-1}
Charge of electron: 1.602×10^{-19} C
Mass of electron: 9.109×10^{-31} kg
Mass of proton: 1.673×10^{-27} kg

1.

Eight (8) equally spaced particles are located on the circumference of a circle with a radius of 2 m. The charge of each particle is 3×10^{-8} C. A point P is located on the axis of the circle. The distance between P and the centre of the circle is 4 m. Note: Assume that charges are in free-space and that the electric potential is zero at infinity.

a). Calculate the electric field at the centre of the circle.

(4 marks)

b). Calculate the electric potential at the centre of the circle.

(4 marks)

c). Calculate the electric field at P.

(5 marks)

d). Calculate the electric potential at P.

(5 marks)

e). Calculate the electrostatic force on a point charge with a charge of 0.07 C when placed at P.

(3 marks)

f). Calculate the work that needs to be done in order to bring a point charge with a charge of 0.005 C from infinity to P.

(4 marks)

2.

a). A straight wire is placed in a temperature chamber at 20°C. The length of the wire is 30 cm and the wire has a circular cross-section with a radius of 0.5 mm. Density of the free electrons inside the conductor is 7×10^{28} m^{-3}. The resistance of the wire is 1.5 kΩ.

(i). Calculate the resistivity of the material of the wire.

(4 marks)

(ii). Calculate the drift speed of the free electrons in the wire when 230 V is applied along the wire.

(5 marks)

(iii). Calculate the power dissipated by the wire when 230 V is applied along the wire.

(3 marks)

(iv). When the temperature of the chamber and hence the temperature of the wire is increased by 11°C, the resistance of the wire is increased by 350 Ω. Calculate the temperature coefficient of resistivity of the material of the wire.

(4 marks)

b). A 1 kΩ resistor (R_1), a 3 kΩ resistor (R_2), a 20 nF capacitor (C_1), a 45 nF capacitor (C_2) and a switch are connected to a 6 V battery as shown in Figure 2.1. Initially, the switch is open and the capacitors are uncharged.

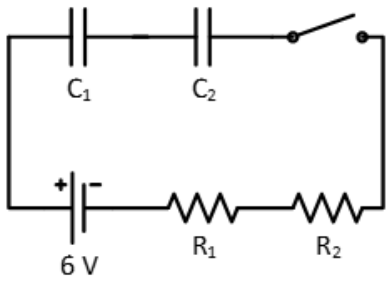

Figure 2.1

(i). Calculate the maximum charge that can be stored in the circuit (inside the capacitors). (4 marks)

(ii). If the switch is closed at t=0, how long would it take to reach 70% of the maximum charge calculated in 2. b). (i).? (5 marks)

3.

A solid conducting sphere has a radius of 10 cm and a net charge of 0.05 C. This sphere is concentric with an uncharged conducting shell with an inner radius of 20 cm and an outer radius of 30 cm.
Note: Assume that the sphere and shell are in free-space.

a). Calculate the electric field at a point 5 cm away from the centre of the sphere.
(3 marks)

b). Calculate the electric field at a point 15 cm away from the centre of the sphere.
(3 marks)

c). Calculate the electric field at a point 25 cm away from the centre of the sphere.
(3 marks)

d). Calculate the electric field at a point 35 cm away from the centre of the sphere.
(3 marks)

e). Plot the variation of the electric field as a function of the radial distance from the centre of the sphere.
(5 marks)

f). Comment on the potential at the surface of the sphere.
(2 marks)

g). Comment on the potential inside the sphere.
(2 marks)

h). If the conducting sphere is replaced by a nonconducting sphere with a radius of 10 cm and a net charge of 0.05 C (the charge is uniformly distributed through the volume), calculate the electric field at a point 3 cm away from the centre of the sphere.
Note: Assume that the electrical permittivity of the insulating material is equal to that of free-space.
(4 marks)

4.

Two large nonconducting sheets in free-space are parallel to each other and also to the vertical axis. The separation between sheets is 0.9 m. One sheet is positively charged with a charge density of 6×10^{-10} Cm^{-2} and the other sheet is negatively charged with a charge density of -6×10^{-10} Cm^{-2}.

a). Calculate the electric field between the two sheets.

(3 marks)

b). What is the electric potential difference between the sheets?

(3 marks)

A particle *M* with a charge of 7×10^{-10} C and zero initial velocity is placed between the sheets, 20 cm away from the positively charged sheet. The mass of the particle is 6×10^{-9} g.

c). Calculate the electric force on particle *M*.

(3 marks)

d). Calculate the acceleration of particle *M* due to the electric field.

(3 marks)

e). If the initial velocity of the particle is zero, calculate the time required for particle *M* to move 10 cm in the horizontal direction between the sheets.

(3 marks)

f). If the gravitational acceleration is 9.8 ms^{-1} and is the vertically downward direction, calculate the magnitude and the direction of the net force on particle *M*.

(5 marks)

g). Calculate the velocity of particle *M* just before hitting a sheet.

(5 marks)

5.

a). The direction of a particle has to be changed by 90° by applying a magnetic field. The particle has a speed of 2×10^6 ms^{-1}. The charge and the mass of the particle is equal to that of a proton. A 0.7 T magnetic field can be generated in a 4 cm × 4 cm area. Do necessary calculations, draw diagrams and explain how this can be done.
Note: The location at which the particle enters the magnetic field has to be specified.
(6 marks)

b). A straight conductor in free-space carries a current of 12 A. the current is uniformly distributed across the cross-section of the conductor. The circular cross-section of the conductor has a radius of 6 mm.
Note: Assume that magnetic permeability of the conductor is equal to that of free-space.

(i). Calculate the magnetic field at a radial distance of 3 mm from the axis of the conductor.
(5 marks)

(ii). Calculate the magnetic field at a radial distance of 10 mm from the axis of the conductor.
(5 marks)

c). Comment on the magnetic susceptibilities of paramagnetic, diamagnetic and ferromagnetic materials.
(3 marks)

d). Calculate the magnetic field at point *s* in Figure 5.1 due to the three (3) current carrying wire segments.
Note: Assume that the wires are in free-space.
(6 marks)

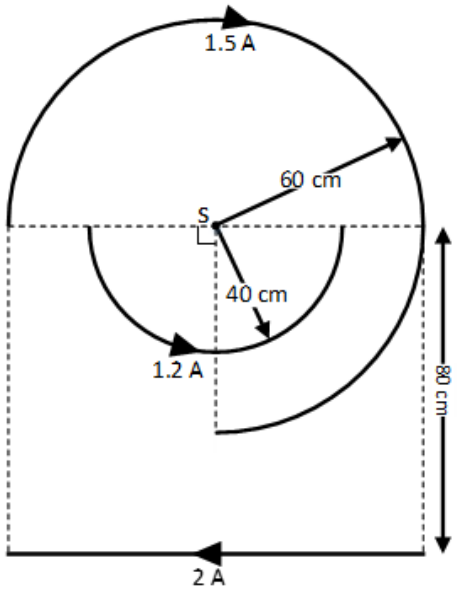

Figure 5.1

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