Answer question o ne and any two other questions

* Do not write on the question paper
* Switch off and keep away your mobile phones
* Begin each question on a new page

The following information may be useful:

Permitting of free space, εo = 8.85 x 10-12C2/N.m2

Permeability of free space, µo = 4π x 10-7N/A2.

Electrostatic constant, 

Avogadro’s number, NA=6.02 x 1023

**Question One (40 marks)**

1. Calculate the potential at a point 1.00 cm from an electro. [3 marks]
2. Fig. 1 shows a capacitor network in which each capacitor C=1μF.



Fig.1

1. Derive an expression for the equivalent.
2. Calculate the equivalent capacitance between points A and B. [2 marks]
3. An aluminium wire having cross-sectional area of 4.00 x 10-6 m2 carries a current of 5.00 A. Calculate the drift speed of the electrons in the wire. The density of aluminium is 2.70 g/cm3 and assume that one conduction electron is supplied by each atom. The molar mass of aluminium is 27g/mole. [6 marks]
4. A charge qa =  is placed at point (,0) of a Cartesian coordinate system. A second charge qb = is placed at point 92,0).
5. Determine the magnitude of the resultant electric field at point (P(0,3) in the same coordinate system. [5 marks]
6. Determine the direction of the resultant electric field at point P. [1 mark]
7. Calculate the force on a 3μC charge placed at point P. [3 marks]
8. An electron is moving with a velocity in a magnetic field T. Calculate the magnetic force on the electron. [5 marks]
9. A long, tightly wound solenoid carries a current in each turn. The solenoid has N turns per unit length. Derive an expression for the magnetic field B of the idealized solenoid. [5 marks]
10. A 100-turn coil, 8cm by 15cm is placed in a constant uniform magnetic field with field strength of B=0.5T. The coil is initially oriented so that the field is perpendicular to the plane of the coil. The coil is turned at a constant rate of f=60 rev/s about an axis perpendicular to the field lines. Determine the induced emf of the coil after 1min. [6 marks]

**Question Two [15 marks]**

A parallel-plate capacitor is charged to qo=2µC. The battery is then removed and a slab of dielectric material of relative permittivity ε=2.2 inserted between the plates. If the plate area is 9cm2 and the plate separation is 1mm,

1. Derive expressions for
2. The electric field of the capacitor before the dielectric. [4 marks]
3. The electric field of the capacitor after the dielectric is inserted. [2 marks]

(ii) Derive an expression for the energy density before the dielectric is introduced. [5 marks]

(iii) Calculate the energy densities before and after the dielectric is inserted. [4 marks]

**QUESTION THREE: [15 marks]**

1. Define the following terms:
2. Potential at a point
3. Potential difference between two points [2 marks]
4. Derive an expression for the potential difference between two points in an electric field E. [4 marks]
5. A conducting spherical shell is concentric with a spherical conductor as shown in Fig.2

An electric potential difference of 100v is maintained between the two, with the sphere at the higher potential. The sphere has a radius of 2.0cm; the shell has an inner radius of 3.0cm.

Determine:

(i) The charge density on the surface of the sphere. [6 marks]

(ii) The charge density on the inner surface of the shell. [3 marks]

**QUESTION FOUR: [15 marks]**

1. What is meant by:

(i) Electric dipole moment. [1 mark]

(ii) Magnetic dipole moment. [1 mark]

1. An electric dipole moment and is oriented at 30o clockwise from the electric field direction. The dipole is in a uniform electric field of magnitude 3,000 N/C.

(i) Calculate the magnitude of the torque on the dipole. [3 marks]

(ii) Determine the direction of the torque on the dipole. [4 marks]

1. A 50-turn coil with a radius of 25cm carries a current of 4.5A. Determine:
2. The magnitude of its magnetic-dipole moment, . [3 marks]
3. The magnitude of the torque on the coil if it is in a uniform magnetic field of 0.02T with an angle of 20o between and. [3 marks]

**QUESTION FIVE: [15 marks]**

1. (i) State Faraday’s Law of Induction. [1 mark]
2. Under what conditions will an induced electromotive force occur in a circuit? State three such conditions. [3 marks]
3. A uniform magnetic field is directed downward into the paper within a circular area with a radius of R=4.0 cm. Outside this area the field is zero, as shown in Fig.3.

If the field strength is given by B(t) = 0.07e-9.0t, t>0, t in sec., B in T. Determine the induced emf on:

1. Path 1 with a radius r1<R, [5 marks]
2. Path 2 with a radius r2>R. [6 marks]