Tutor Marked Assignment
ELECTRIC AND MAGNETIC PHENOMENA

Course Code: PHE-07
Assignment Code: PHE-07/TMA/2021
Max. Marks: 100

Note: Attempt all questions. The marks for each question are indicated against it. Symbols have their usual meanings.

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1. a) Two positively charged particles each having charge 20 μC, are kept at a distance of 2.0 m from each other. Determine the force on each charge and the electric field due to each charge. Show the force and electric field vectors on appropriate diagrams. What is the resultant force at a point midway from the two charges along the straight line joining them? (2+2+4+2)

   b) What does cylindrically symmetric charge distribution mean? Use Gauss's law to determine the electric field of an infinite solid cylinder of radius R having volume charge density ρ at a point outside it. (4+6)

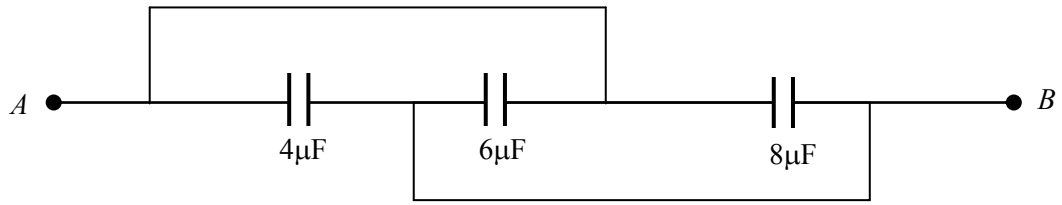
   c) Three charges $2q$, $4q$ and $2q$ are to be placed on a 1.0 m long straight wire. Determine the positions where the charges should to be placed so that the potential energy of the system is a minimum. (5)

2. a) Discuss the behaviour of a dielectric in an electric field and thereby define molecular polarisability and polarisation. (5+5)

   b) Explain how Gauss's law is modified for dielectric material and establish the relation:

   $$\nabla . \vec{\mathbf{D}} = \rho_f$$ (10)

   c) Three capacitors are connected to each other as shown below:



   Calculate the equivalent capacitance between points A and B. (5)

3. a) What is a linear conductor? Discuss the conditions under which a metal does not behave as a linear conductor. (5)

   b) The number density of electrons in the aluminium metal is 9.64×10^{28} m^{-3}. Calculate the drift velocity of electrons in an aluminium wire of cross-sectional area 4.0 mm^2 in which a current of 2 A is flowing. (5)

   c) Using Biot-Savart's law, obtain an expression for the magnetic field due to electric current flowing in a long straight wire at a distance R from the wire along a line perpendicular to the wire. (10)

   d) Show that in the presence of external magnetic field, the magnetisation of a paramagnetic material depends on the strength of the magnetic field and the temperature of the material. (5)

4. a) Using Maxwell's equations in free space, derive the wave equation for the *y*-component of the electric field vector. (10)

b) A uniform plane electromagnetic wave of 100 MHz travelling in free space strikes a large block of a material having $\varepsilon = 4\ \varepsilon_0$, $\mu = 9\ \mu_0$ and $\sigma = 0$ normal to the surface. The incident electric field vector is given by

$$\mathbf{E} = 500 \cos(\omega t - \beta y)\ \hat{\mathbf{z}}\ \text{Vm}^{-1}$$

Write the complete expressions for the reflected and transmitted electric field vectors, and the incident, reflected and transmitted magnetic field vectors. (3×5)

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