Answer ALL SIX questions from Section A and THREE questions from Section B.
The numbers in square brackets on the right-hand side indicate the provisional allocations of maximum marks per sub-section of a question.

electron charge, $e = 1.60 \times 10^{-19}$ C
permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}$ Fm^{-1}
permeability of free space, $\mu_0 = 1.26 \times 10^{-6}$ Hm^{-1}

SECTION A

[Part marks]

1. (a) Define the electric field **E**. [2]

(b) State Gauss' law for electrostatics in integral form. [2]

(c) By using this law, determine the electric field **E** *inside* an insulating sphere, at a distance r from the centre, assuming a uniform charge density ρ. [4]

2. (a) What is the electric field inside a conductor at electrostatic equilibrium? Briefly explain your answer. [2]

(b) If an isolated conductor carries a net charge, where is the charge distributed? [1]

(c) Two parallel metal plates of cross-sectional area A and separation d are charged to $+Q$ and $-Q$ in a vacuum. Determine the capacitance of the system. [4]

3. The potential of an electric dipole is approximated by

$$\varphi = \frac{qd\cos\theta}{4\pi\varepsilon_0 r^2}$$

(a) Define the symbols q, d, r and θ used in this expression. [2]

(b) For what values of r is this approximation justified? [1]

(c) Derive an expression for the radial component of the electric field for a given direction from the axis of the dipole. [2]

(d) Sketch the electric field lines in the vicinity of the dipole. [2]

PLEASE TURN OVER