

Addis Ababa University
 Addis Ababa Institute of Technology
School of Electrical and Computer Engineering
 Electromagnetic Fields ECEG – 2122 Worksheet – 1

1. A circular ring of radius a carries a uniform charge ρ_L C/m and is placed on the xy -plane with axis the same as the z -axis.

(a) Show that

$$\mathbf{E}(0, 0, h) = \frac{\rho_L a h}{2\epsilon_0 [h^2 + a^2]^{3/2}} \mathbf{a}_z$$

(b) What values of h gives the maximum value of \mathbf{E} ?

(c) If the total charge on the ring is Q , find \mathbf{E} as $a \rightarrow 0$.

2. The finite sheet $0 \leq x \leq 1$, $0 \leq y \leq 1$ on the $z = 0$ plane has a charge density $\rho_S = xy(x^2 + y^2 + 25)^{3/2}$ nC/m². Find

(a) The total charge on the sheet

(b) The electric field at $(0, 0, 5)$

(c) The force experienced by a -1 mC charge located at $(0, 0, 5)$

3. In a certain region, the electric field is given by

$$\mathbf{D} = 2\rho(z + 1)\cos \phi \mathbf{a}_\rho - \rho(z + 1)\sin \phi \mathbf{a}_\phi + \rho^2 \cos \phi \mathbf{a}_z \mu\text{C/m}^2$$

(a) Find the charge density.

(b) Calculate the total charge enclosed by the volume $0 < \rho < 2$, $0 < \phi < \pi/2$, $0 < z < 4$.

(c) Confirm Gauss's law by finding the net flux through the surface of the volume in (b).

4. Three point charges $Q_1 = 1$ mC, $Q_2 = -2$ mC, and $Q_3 = 3$ mC are, respectively, located at $(0, 0, 4)$, $(-2, 5, 1)$, and $(3, -4, 6)$.

(a) Find the potential V_P at $P(-1, 1, 2)$.

(b) Calculate the potential difference V_{PQ} if Q is $(1, 2, 3)$.

5. State Gauss's law. Deduce Coulomb's law from Gauss's law thereby affirming that Gauss's law is an alternative statement of Coulomb's law and that Coulomb's law is implicit in Maxwell's equation $\nabla \cdot \mathbf{D} = \rho_v$.

6. Three point charges -1 nC, 4 nC, and 3 nC are located at $(0, 0, 0)$, $(0, 0, 1)$, and $(1, 0, 0)$, respectively. Find the energy in the system.

7. If $\mathbf{J} = \frac{1}{r^3} (2 \cos \theta \mathbf{a}_r + \sin \theta \mathbf{a}_\theta)$ A/m², calculate the current passing through

(a) A hemispherical shell of radius 20 cm

(b) A spherical shell of radius 10 cm