Syllabus for Electromagnetism subject (232)

Chapter (6): Electrostatic Boundary –Value Problems

6.5 Resistance and Capacitance

A. Parallel – Plate Capacitor
B. Coaxial Capacitor
C. Spherical Capacitor

Suggested example: [**6.12, 6.13**]

Suggested problems: [6.27, 6.28, 6.29, 6.30, 6.36, 6.37]

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Chapter (7): Magneto static Fields:

7.1 Introduction.

7.2 Boit-Savatr's Law.

7.3 Ampere's Circuit Law – Maxwell's equation.

7.4 Applications of Ampere's Law.

- **A.** Infinite Line Current.
- **B.** Infinite Sheet of Current.
- **C.** Infinite long Coaxial Transmission Line.

7.5 Magnetic Flux Density –Maxwell's equation.

7.6 Maxwell's equations for Static Electromagnetic Fields.

7.7 Magnetic Scalar and Vector Potentials.

Suggested example: [7.1, 7.3, 7.4, 7.7]

Suggested problems: [7.10, 7.18, 7.20, 7.26, 7.29, 7.33]

Chapter (8): Magnetic Forces, Materials, and Devices.

8.1 Introduction.

8.2 Forces due to Magnetic Fields.

- **A**. Forces on a Charged Particle.
- **B**. Forces on a Current Element.
- **C.** Forces Between Two current Elements.

8.3 Magnetic Torque and Moment.

8.4 Magnetic Dipole.

8.5 Magnetization in Materials.

8.7 Magnetic Boundary Conditions.

8.9 Magnetic Energy (the formula only)

Suggested example: [8.1, 8.2, 8.3, 8.6, 8.7]

Suggested problems: [8.1, 8.2, 8.3 8.4]

Chapter (9): Maxwell's Equations.

TABLE 9.1 Generalized Forms of Maxwell's Equations

Differential Form	Integral Form	Remarks
$\nabla \cdot \mathbf{D} = \rho_v$	$\oint_S \mathbf{D} \cdot d\mathbf{S} = \int_v \rho_v \, dv$	Gauss's law
$\nabla \cdot \mathbf{B} = 0$	$\oint_S \mathbf{B} \cdot d\mathbf{S} = 0$	Nonexistence of isolated magnetic charge*
$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$	$\oint_L \mathbf{E} \cdot d\mathbf{l} = -\frac{\partial}{\partial t} \int_S \mathbf{B} \cdot d\mathbf{S}$	Faraday's law
$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$	$\oint_L \mathbf{H} \cdot d\mathbf{l} = \int_S \left(\mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}\right) \cdot d\mathbf{S}$	Ampere's circuit law

Sheet (1)

Chapter (6): Electrostatic Boundary –Value Problems

6.27 In an integrated circuit, a capacitor is formed by growing a silicon dioxide layer ($\varepsilon_r = 4$) of thickness 1 μm over the conducting silicon substrate and covering it with a metal electrode of area S. Determine S if a capacitance of 2 nF is desired.

6.28 The parallel-plate capacitor of Figure 6.34 is quarter-filled with mica ($\varepsilon_r = 6$). Find the capacitance of the capacitor.

***6.29** An air-filled parallel plate capacitor of length L, width a, and plate separation d has its plates maintained at constant potential difference V_0. If a dielectric slab of dielectric constant ε_r is slid between the plates and is withdrawn until only a length x remains between the plates as in Figure 6.35, show that the force tending to restore the slab to its original position is

$$F = \frac{\varepsilon_0(\varepsilon_r - 1)\, a\, V_0^2}{2d}$$

6.30 A parallel-plate capacitor has plate area 200 cm^2 and plate separation 3 mm. The charge density is 1 μC/m^2 with air as dielectric. Find

(a) The capacitance of the capacitor

(b) The voltage between the plates

(c) The force with which the plates attract each other

6.36 Determine the capacitance of a conducting sphere of radius 5 cm deeply immersed in sea water ($\varepsilon_r = 80$).

6.37 A conducting sphere of radius 2 cm is surrounded by a concentric conducting sphere of radius 5 cm. If the space between the spheres is filled with sodium chloride ($\varepsilon_r = 5.9$), calculate the capacitance of the system.

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Sheet (2)

Chapter (7): Magneto static Fields:

7.10 A square conducting loop of side $2a$ lies in the $z = 0$ plane and carries a current I in the counterclockwise direction. Show that at the center of the loop

$$\mathbf{H} = \frac{\sqrt{2}I}{\pi a}\mathbf{a}_z$$

7.18 (a) An infinitely long solid conductor of radius a is placed along the z-axis. If the conductor carries current I in the $+z$ direction, show that

$$\mathbf{H} = \frac{I\rho}{2\pi a^2}\mathbf{a}_\phi$$

within the conductor. Find the corresponding current density.

(b) If $I = 3$ A and $a = 2$ cm in part (a), find $\mathbf{H}$ at (0, 1 cm, 0) and (0, 4 cm, 0).

7.20 In a certain conducting region,

$$\mathbf{H} = yz(x^2 + y^2)\mathbf{a}_x - y^2xz\mathbf{a}_y + 4x^2y^2\mathbf{a}_z \text{ A/m}$$

(a) Determine $\mathbf{J}$ at $(5, 2, -3)$

(b) Find the current passing through $x = -1, 0 < y, z < 2$

(c) Show that $\nabla \cdot \mathbf{B} = 0$

7.26 Consider the following arbitrary fields. Find out which of them can possibly represent electrostatic or magnetostatic field in free space.

(a) $\mathbf{A} = y \cos ax\mathbf{a}_x + (y + e^{-x})\mathbf{a}_z$

(b) $\mathbf{B} = \dfrac{20}{\rho}\mathbf{a}_\rho$

(c) $\mathbf{C} = r^2 \sin\theta\, \mathbf{a}_\phi$

7.29 The magnetic vector potential of a current distribution in free space is given by

$$\mathbf{A} = 15e^{-\rho} \sin \phi \, \mathbf{a}_z \text{ Wb/m}$$

Find **H** at $(3, \pi/4, -10)$. Calculate the flux through $\rho = 5, 0 \leq \phi \leq \pi/2, 0 \leq z \leq 10$.

7.33 Find the current density **J** to

$$\mathbf{A} = \frac{10}{\rho^2} \mathbf{a}_z \text{ Wb/m}$$

in free space.

Sheet (3)

8.1 An electron with velocity $\mathbf{u} = (3\mathbf{a}_x + 12\mathbf{a}_y - 4\mathbf{a}_z) \times 10^5$ m/s experiences no net force at a point in a magnetic field $\mathbf{B} = 10\mathbf{a}_x + 20\mathbf{a}_y + 30\mathbf{a}_z$ mWb/m^2. Find $\mathbf{E}$ at that point.

8.2 A charged particle of mass 1 kg and charge 2 C starts at the origin with velocity $10\mathbf{a}_z$ m/s in a magnetic field $\mathbf{B} = 1\mathbf{a}_x$ Wb/m^2. Find the location and the kinetic energy of the particle at $t = 2$ s.

***8.3** A particle with mass 1 kg and charge 2 C starts from rest at point (2, 3, −4) in a region where $\mathbf{E} = -4\mathbf{a}_y$ V/m and $\mathbf{B} = 5\mathbf{a}_x$ Wb/m^2. Calculate

(a) The location of the particle at $t = 1$ s

(b) Its velocity and K.E. at that location

8.4 A −2-mC charge starts at point (0, 1, 2) with a velocity of $5\mathbf{a}_x$ m/s in a magnetic field $\mathbf{B} = 6\mathbf{a}_y$ Wb/m^2. Determine the position and velocity of the particle after 10 s assuming that the mass of the charge is 1 gram. Describe the motion of the charge.