UNIT 1:

Applying Gauss' law, develop an expression for electric field intensity due to infinite line charge

The three vertices of a triangle are located at A(-6,4,7) with Q_A = -20uC and Charge Q_B = 50uC is at B(5,8,-2) in free space. (Distances given in meter). Find

i)$\overrightarrow{R_{AB}}$

ii) R_{AB}

iii) Determine the vector force exterted on Q_A by Q_B if $\varepsilon_o = 10^{-9}/36\pi$ F/m

Explain the vector form of Coulomb's Law

Write any three properties of flux

Obtain the force exerted on Q_2 by Q_1,when a charge of Q_1 = 3x10^{-4} C is located at M (1, 2, 3) and charge Q_2 = -10^{-4} C is located at N (2, 0, 5) in vacuum.

Obtain an expression for the Electric field intensity ($\vec{E}$) due to an infinite sheet charge of uniform density ρ_S .

Derive the expression for electric field intensity at a point due to electric dipole?

Compute the total charge within following volume

0.1 ≤|x|,|y|, |z| ≤ 0.2 and $\rho_v = 1/(x^3\ y^3\ z^3\ )$

Analyze and verify the divergence theorem for the region bounded by a closed cylinder having flux density $\vec{D} = 2xy\ \hat{a}_x + x^2\ \hat{a}_y \quad C/m^2$ Where $x = 0\ to\ 1$; $y = 0\ to\ 2$; $z = 0\ to\ 3$

Given a 60uC point charge located at the origin find the total electric flux passing through

i) The closed surface defined by ρ = 26cm and z= ± 26cm.

ii) The plane z = 26cm

Deduce the electric field intensity due to an infinite line charge using Gauss Law. Clearly mention the assumptions made

Derive an expression for electric field intensity due to point charge using Gauss's law

Derive an expression for electric field intensity due to line charge using Gauss's law

An electric field is expressed in Cartesian coordinates by

$$E = 6x^2\ a_x + 6y + 4a_z \text{ V/m. Determine the following:}$$

(a) V_{MN}if points M and N are specified by M(2, 6, −1) and N(−3, −3, 2);

(b) V_N if V = 2 V at P(1, 2, −4)

Given the Electric flux density $\vec{D} = z\rho cos^2\phi\ \hat{a}_z$ C/m^2, find the total charge enclosed by the cylinder of radius 1 m with $-2 \leq z \leq 2$ m.

Calculate the electric field intensity at P(1,1,1) caused due to four identical charges 3nC each located at P_1 (1,1,0), P_2 (-1,1,0), P_3 (-1,-1,0) and P_4 (1,-1,0).

" The electric flux passing through any closed surface is equal to the total charge enclosed by that surface"

Identify the law with reference to the above statement and prove the same with relevant equations.

Obtain an expression for the Electric field intensity ($\vec{E}$) due to an infinite line charge of uniform density ρ_L using Gauss's law.

Analyze and verify the divergence theorem for the region bounded by a closed cylinder having flux density

$$\underset{D}{\rightarrow} = 6\rho \sin(1/2\emptyset) \underset{a_\rho}{\rightarrow} + 1.5\rho \cos\left(\frac{1}{2}\emptyset\right) \underset{a_\emptyset}{\rightarrow} \quad c/m^2$$

$$\rho = 2, \emptyset = 0 \,\&\, \pi, z = 0 \,\&\, 5$$

Evaluate the electric field density vector D in rectangular coordinates at point p(2, -3, -6) produced by:

(i) A point charge QA = 55 mc at Q(-2, 3, -6)

(ii) A line charge ρ_{LB} = 20 mC/m on the z-axis

What are equipotential surfaces? A 15nC point charge is at the origin in free space. Calculate V1 if point P1 is located at P1(-2,3,-1) and

i) V=0 at (6,5,4)

ii)V= 0 at infinity

iii) V= 5V at (2,0,4)

State and explain Coulomb's law indicating clearly the units of quantities in the equation of force?

State and prove Gauss's law

Derive an expression for electric potential due to point charge

Analyze the electric field intensity for an infinite line charge using Gauss law

Force on one charge due to other

A charge of $Q_1 = 3\times10^{-4}$ C is located at $M(1,2,3)$ and a charge of $Q_2 = -10^{-4}$ C at $N(2,0,5)$ in a vacuum. Find the force exerted on Q_2 by Q_1.

E due to multiple charges

Find $\vec{E}$ at $P(1,1,1)$ caused by four identical 3 nC charges located at $P_1(1,1,0)$, $P_2(-1,1,0)$, $P_3(-1,-1,0)$ and $P_4(1,-1,0)$

E due to infinite line charges

Infinite uniform line charges of 5 nC/m lie along the x and y axes in free space find $\vec{E}$ at

a) $P_A(0,0,4)$ b) $P_B(0,3,4)$

E due to infinite sheet charges

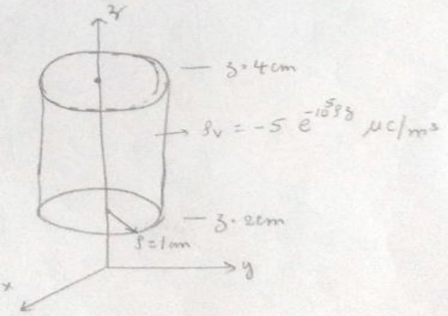
Three infinite uniform sheets of charge are located in free space as follows: 3 nC/m² at $z=-4$, 6 nC/m² at $z=1$ and -8 nC/m² at $z=4$. Find $\vec{E}$ at the point

a) $P_A(2,5,-5)$ b) $P_B(4,2,-3)$ c) $P_C(-1,-5,2)$ d) $P_D(-2,4,5)$

a) $P_A(2,5,-5)$

Obtaining total charge given charge densities

Find the total charge contained in a electron beam shown in figure.



$$Q = \int_v \rho_v \, dv$$

Electric Flux density due to point charge,line charge and sheet charge

Calculate $\vec{D}$ in rectangular coordinates at point $P(2,-3,6)$ produced by (a) a point charge $Q_A = 55$ mC at $Q(-2,3,-6)$
(b) a uniform line charge $\rho_{LB} = 20$ mC/m on the x-axis.
(c) a uniform surface charge density $\rho_{SC} = 120\ \mu C/m^2$ on the plane $z = -5$m.

Verifying divergence theorem

A.

Given the field $\vec{D} = 6\rho \sin(\frac{1}{2}\phi)\,\hat{a}_\rho + 1.5\rho \cos(\frac{1}{2}\phi)\,\hat{a}_\phi$ C/m², evaluate both sides of the divergence for region bounded by $\rho = 2$, $\phi = 0$ & $\phi = \pi$, $z = 0$ & $z = 5$

B.

Verify the divergence theorem for the field $\vec{D} = 2xy\,\hat{a}_x + x^2\,\hat{a}_y$ C/m² in the region bounded by plane $x = 0$ & 1; $y = 0$ & 2; $z = 0$ & 3.

On dipole moment:

D4.9. An electric dipole located at the origin in free space has a moment $\mathbf{p} = 3\mathbf{a}_x - 2\mathbf{a}_y + \mathbf{a}_z$ nC · m. (*a*) Find V at $P_A(2, 3, 4)$. (*b*) Find V at $r = 2.5$, $\theta = 30°$, $\phi = 40°$.

On work done(Potential)

(1) Given the electric field $\vec{E} = \frac{1}{z^2}(8xyz\,\hat{a}_x + 4x^2z\,\hat{a}_y - 4x^2y\,\hat{a}_z)$ V/m find the differential amount of work done in moving a 6nC charge a distance of 2 μm, starting at P(2, -2, 3) and proceeding in the direction $\hat{a}_L =$

a) $-\frac{6}{7}\hat{a}_x + \frac{3}{7}\hat{a}_y + \frac{2}{7}\hat{a}_z$

b) $\frac{6}{7}\hat{a}_x - \frac{3}{7}\hat{a}_y - \frac{2}{7}\hat{a}_z$

c) $\frac{3}{7}\hat{a}_x + \frac{6}{7}\hat{a}_y$

On absolute potential

(5) An electric field is expressed in rectangular coordinates by $\vec{E} = 6x^2\hat{a}_x + 6y\,\hat{a}_y + \hat{a}_z$ V/m find

a) V_{MN} if points M & N are specified by M(2, 6, -1) and N(-3, -3, 2)

b) V_M if V = 0 at Q(4, -2, -35)

c) V_N if V = 2 at P(1, 2, -4)

Finding volume charge density and E,given V

(8) Given the potential field in cylindrical coordinates $V = \frac{100}{z^2+1}\rho\cos\phi$ V, and point P at $\rho = 3$ m, $\phi = 60^\circ$, $z = 2$ m find values at P for a) V b) $\vec{E}$ c) E d) $\frac{dV}{dN}$ e) $\hat{a}_N$ f) ρ_v in free space

UNIT 2:

Obtain the point form of continuity equation

Discuss properties of Conductors and dielectrics

Derive Laplace's equation starting from first principles

Analyze and develop an expression for boundary conditions between conductor and dielectric.

Derive an expression for magnetic field at any point due to infinite long straight conductor using Ampere's circuit law

Explain continuity equation with appropriate equations

Determine whether the following field satisfies Laplace's equation;

i. $V = x^2 + y^2 - z^2$
ii. $V = \rho cos\varphi + z$

Find the energy stored in free space for the region 2mm $\leq$ r $\geq$ 3mm , 0° $\leq \theta \geq$ 90° given the potential field V= 200/r Volts.

Derive the boundary conditions between conductor and free space

Derive an expression for point form of continuity equation

Using Laplace's equation, derive an expression for the potential in the space between the two plates of a parallel-plate capacitor. Also find the capacitance of the system.

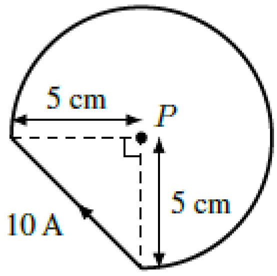
Calculate the value of the current density in cylindrical coordinate system at a point P_B (1.5, 90°,0.5) if $\underset{H}{\rightarrow} = (2/\rho)\cos(0.2\emptyset) \underset{a_\rho}{\rightarrow} \; A/m$

Analyze and obtain the expression for potential distribution in the space between two concentric spherical shells.

Deduce the boundary conditions between of two perfect dielectrics materials. Clearly mention the assumptions made.

Arrive at point form of ohm's law

Analyze and evaluate the magnetic field intensity at point P in the figure below.



Analyze the capacitance between two concentric metallic hollow spheres using Laplace's equation

Calculate the magnitude of the current density in a sample of Silver for which $\sigma = 6.17 \times 10^7$ s/m and $\mu e = 0.0056\ m^2$ /V.s if

(a) The drift velocity is 1.5μm/s

(b) The electric field intensity is 1mV/m

(c) The sample is a cube 2.5mm on a side having a voltage of 0.4mV between opposite faces.

Deduce the boundary conditions between a conductor and dielectric. Clearly mention the assumptions made.

Analyze the interface between a conductor and a dielectric, and obtain the boundary conditions.

Explain Biot-Savart's law in vector notation

Using Ampere's circuital law, determine magnetic field intensity due to infinite long straight conductor

Given the potential field V= 50 sin θ/r^2 Volts in free space.

(a) Determine whether V satisfies the Laplace's equation.

(b) Find the total charge stored inside the spherical shell $1 < r < 2$ m.

Find the magnetic field intensity at (1.5,2,3) due to a current conductor carrying current of 24A along Z-axis extending from 0 to 6.

<u>Example 2</u>

Use Laplace's equation to find the capacitance per unit length of a co-axial cable of inner radius 'a' m and outer radius 'b' m. Assume $V = V_0$ at $r = a$ & $V = 0$ at $r = b$

Example 1

Solve the Laplace's equation for the potential field in the homogenous region between the two concentric spheres with radii a & b, such that b>a if potential V=0 at r=b & V=V₀ at r=a. Find the capacitance between the two concentric spheres.

UNIT 3:

Analyze and articulate the fundamental principles embodied by Maxwell's equations in the differential form and integral form for time varying fields.

A point charge Q = 18nC has a velocity of 5X10^{6} m/s in the direction of $\widehat{a_V} = 0.6\,\widehat{a_x} + 0.75\widehat{a_y} + 0.3\widehat{a_z}$. Calculate the magnitude of the force exerted on the charge by field

a) $\vec{\vec{B}} = -3\,\widehat{a_x} + 4\widehat{a_y} + 6\widehat{a_z}$ mT

b) $\vec{\vec{E}} = -3\,\widehat{a_x} + 4\widehat{a_y} + 6\widehat{a_z}$ kV/m

c) $\vec{\vec{E}}$ and $\hat{B}$ acting together

Explain Maxwell's equations in point and integral forms for time-varying fields.

Analyze the interface between two media of different permeability and obtain the boundary conditions for magnetic field.

Investigate the interface between two materials with different permeabilities and deduce the boundary conditions governing the behavior of the magnetic field at this interface.

Deduce the force on a differential current element in a steady magnetic field.

Briefly explain the concept of displacement current density and state the corresponding Maxwell's equation.

UNIT 4:

Using Maxwell's equations develop a general wave equation by relating the space and time variations of electric and magnetic fields.

What is loss tangent in the context of electromagnetic wave propagation? How can it be used to identify good dielectrics?

Analyze and develop an expression for electromagnetic waves in free space 8M

Deduce the equations for attenuation constant, phase constant and the intrinsic impedance of electromagnetic wave in a good conductor

Analyze a plane wave traveling in fresh water with parameters

f= 300 MHz, $\varepsilon r = 78$, $\mu r = 1$ and $\sigma = 0$. Calculate the following

1. Whether the medium is lossless or not?
2. Attenuation constant
3. Phase constant
4. Wavelength
5. Intrinsic Impedance

Analyze a plane wave travelling in sea water with parameters $\varepsilon r = 81$, $\mu r = 1$ and $\sigma = 4$ S/m, having the electric field given by

$$\vec{E}(z,t) = 0.2\, e^{-z/\delta} \cos(4\pi \times 10^5\, t - \frac{z}{\delta} + 75^\circ)\, \hat{a}_x \text{ V/m.}$$

Hence determine the skin depth, intrinsic impedance and Poynting vector.

Derive the general wave equation using Maxwell's equations

Analyse and develop an expression for uniform plane wave in good conductor 10M

What is polarization of wave and discuss the different types of polarization

UNIT 5:

Analyze the properties of wave propagation within a homogeneous medium characterized by a linear variation of refractive index with frequency, represented as

$$n(\omega) = (n0\ \omega)/\ \omega0.$$

Calculate both the group velocity and phase velocity of a wave specifically at the frequency $\omega 0$.

Analyze the reflection of plane wave at Normal incidence.

Consider $\eta_1 = 100\Omega$ and $\eta_2 = 300\Omega$. Compute the reflection coefficient for this system. If the magnitude of the incident electric field intensity is 100 V/m. What is the value of the magnitude of the electric field intensity?

With relevant equations, discuss the reflection phenomena of uniform plane waves at normal incidence

Consider a homogeneous medium in which the refractive index varies linearly with frequency over a certain range :

$n(\omega) = (n_0\, \omega)/\, \omega_0$

Determine the group velocity and phase velocity of a wave at a frequency of ω_0.

A uniform plane wave in air with

$$\hat{\vec{E}} = 8\, Cos\, (\omega t - 4x - 3z)\, \widehat{a_y}\ V/m$$

is incident on a dielectric slab ($z \geq 0$) with parameters $\varepsilon r = 2.5$, $\mu r = 1$ and $\sigma = 0$. Find

i) The polarization of the wave

ii) The angle of incidence

iii) The reflected **E** field

iv) The transmitted **H** field

Assume a 50-MHz uniform plane wave having electric field 10V/m. The medium is lossless with ε_r=1 and μ_r =1. The wave propagates in the x,y plane at a 30° angle to the x axis and is linearly polarized along z. Deduce the phasor expression for the electric field.