Dr. D. Y. Patil Institute of Technology Pimpri, Pune

Department of Electronics and Telecommunication Engineering

TUTORIALS

ElectromagneticField Theory

(304182)

Third Year

Dr. D. Y. Patil Institute of Technology, Pimpri, Pune-18

Department of Electronics & Telecommunication Engineering

Academic Year—2023-24

Subject-- Electromagnetic Field Theory—304182 (TE)

Tutorial 1

(Vector analysis, Electric field Intensity(E): Due to Q, ρL, ρS)

1) Find the spherical and Cylindrical equivalent of the vector B = y $\vec{a}_x$ + (x + z) $\vec{a}_y$ located at P(-2,6,3) .
2) From above question , evaluate vector B at point P in Cartesian , Cylindrical and Spherical System
3) A sheet of Charge ρ_s = 2 nC/m2 is present at the plane x=3 in free space, and a line charge ρ_l = 20 nC/m is located at x= 1, z=4.
   (i)Find the magnitude of the electric field intensity at the origin.
   (ii)Find the direction of E at P(4, 5, 6) .
   (iii)What is the force per meter length on the line charge.
4) Derive expression for electric field intensity ($\bar{E}$) at the general point P due to uniform charge distribution along an infinite line charge with uniform line charge density ρ_L ?
5) State divergence theorem with its physical significance.
6) Find the gradient of $t = x^2y + e^z$ at the point p(1,5,-2)

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Tutorial 2

(Gauss's Law, Electric flux Density(D) & Electrical Potential (V) :Due to Q, ρL, ρS)

1) Find the potential between a(-7,2,1) and b(4,1,2). Given $E = (-6y/x^2)i + (6/x)j + 5k$.
2) Evaluate Gauss law for $D = 5r^2/4\ i$ in spherical coordinates with $r = 4m$ and $\theta = \pi/2$.
3) A charge of 2 X 10-7 C is acted upon by a force of 0.1N. Determine the distance to the other charge of 4.5 X 10-7 C, both the charges are in vacuum.
4) Find the flux density of line charge of radius (cylinder is the Gaussian surface) 2m and charge density is 3.14 units?
5) A point charge 0.4nC is located at (2, 3, 3). Find the potential differences between (2, 3, 3)m and (-2, 3, 3)m due to the charge.

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Tutorial 3

(Magnetic field Intensity (H)- Biot-Savart: Due to I dL, K dS, J dV, and Ampere's circuital law)

1. Calculate the convection current when electron density of 200 units is travelling at a speed of 12m/s.

2. Find the magnetic flux density when a point from a finite current length element of current 0.5A and radius 100nm.

3. Find the charge density when the electric flux density is given by $2x\ i + 3y\ j + 4z\ k$.

4. Derive H due to Straight Conductor of Finite Length

5. Using Ampere's circuital law, find out H in the region $0<r<0.5m$ in cylindrical coordinate.

   The current density $J = 4.5\ e^{-2r}\ a_z\ A/m^2$ and $J = 0$ elesewhere.

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Tutorial 4

(Electrostatic Boundary Conditions: dielectric-dielectric, conductor –dielectric.)

1.

Two perfect dielectrics have relative permittivity $\varepsilon_{r1} = 2, \varepsilon_{r2} = 8$. the planar interface between them is defined by $x - y + 2z = 5$.The origin is in region 1.If $\overline{E_1}$=100$\hat{a}_x$ +200 $\hat{a}_y$ -50$\hat{a}_z$ V/m. Find $\overline{E_2}$.

2.

The xy plane serves as the interface between two different media. Medium 1 (Z<0) is filled with a material whose μ_r=6. Medium2 (Z>0) is filled with a material whose μ_r=4. If the interface carries current $(1/\mu_o)\ \hat{a}_y$ mA/m and $\overline{B_2} = 5\ \hat{a}_x + 8\hat{a}_z$ Wb/m^2, find $\overline{H_1}$ and $\overline{B_1}$.

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Tutorial 5

(Poisson's and Laplace's Equation: Capacitance, Energy density.)

1.What is Laplace equation? Derive the equation for parallel plate capacitor using Laplace's equation?

2. Derive the expression for the energy stored per unit volume in an electric field in terms of E & D.

3.

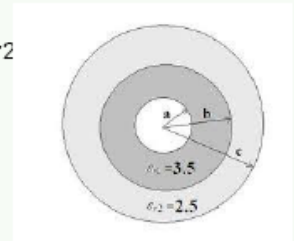
. Using Laplace's equation derive an expression for capacitance of Spherical Capacitor with radius of inner sphere 'a' and radius of outer sphere 'b'.

4.

A parallel plate capacitor with area 0.30 sq m and separation 5.5mm contains three dielectrics with interfaces normal to $\bar{E}$ as follows ε_{r1}=3, ε_{r2}=4, ε_{r3}=6,d_1=1mm, d_1=2mm, d_1=2.5mm.

5.

Derive the capacitance of 10mm long cylindrical capacitors shown if a= 1mm, b=2mm,c=3mm, ε_{r1}=2.5, ε_{r2}



6. Derive Poisson's equation $\nabla^2 v=-\rho v/\mathcal{E}$ from Gauss's law. Explain its physical significance?

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Tutorial 6

(Magnetic Boundary Conditions, Inductance, Force, Torque, Energy density.)

1. Derive an expression of energy density in electric fields?

2. Derive the expression for electric field and potential due to an electric dipole?

3. Calculate the distance between two charges of 4C forming a dipole, with a dipole moment of 6 units.

4. A small current loop L, with magnetic moment $5a_z$;, A/m^2 is located at the origin while another small loop current *L2* with magnetic moment 3ay A • m2 is located at (4, -3, 10). Determine the torque on L2. (Sadiku)

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Tutorial 7

(Faradays Law, Maxwell's Equations.)

1. State and explain Maxwell's equation for static and harmonically varying fields.

2. The electric and magnetic field in free space are given by

$$E = \frac{50}{\rho}\cos(10^6 t + \beta z)\, a_{\phi} \quad V/m$$

$$H = \frac{H0}{\rho}\cos(10^6 t + \beta z)\, a_{\rho} \quad A/m$$

Determine the constants H0 and β such that the fields satisfy maxwells equations.

3. In the material for which σ = 6 s/m, εr =2.5 . The electric field intensity E = 250 sin (1010 t) V/m. Find the conduction and displacement current densities and the frequency at which both have equal magnitudes.

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Tutorial 8

(Poynting Theorem, Retarded Magnetic Potential.)

1. Write a note on Retarded Magnetic Vector Potential.
2. Define pointing vector. State its significance. Derive the expression for pointing vector P.
3. If the electric field strength of a radio broadcast signal at a TV receiver is given by E = 5.0 cos(wt -βy) az, V/m, determine the displacement current density. If the same field exists in a medium whose conductivity is given by 2.0 x 103(mho)/cm, find the conduction current density.

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Tutorial 9
(Transmission line: Primary & Secondary Constants V & I)

1. A transmission line has characteristic impedance of 50 ohm . find the reflection coefficient if line is terminated with 50 ohm, 0 ohm, 75 + j 75 ohm..

2. Explain the phenomenon of reflection on transmission line and reflection coefficient.

3. Explain what do you understand by standing waves and standing wave voltage ratio and hence derive for input impedance of line in terms of characteristics impedance.

4. The open and short circuit impedences of a certain open wire transmission line of 40 km length at 796 Hz are , Zoc=328 < -29.2 degree Ω and ZSC=1548 < -6.8 degree Ω. Calculate the value of Zo, α, β, R, L,G and C.

5. A transmission line operating on 100 Mhz has Zo= 60 ohm, attenuation const 0.02 Np/m and phase velocity is 0.6 where c is speed of light in vaccum. Find the line parameters R, L, G, and C.

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Tutorial 10

(Reflection Coefficient, SWR, etc using Smith Chart.)

1. What do you mean by distortion less line? Derive the expression for characteristic impedance and Propagation constant for distortion less line.

2. Explain standing waves and standing wave voltage ratio and hence derive the expression for input impedance and propagation constant.

3. A transmission line with Characteristic impedance of $692 < -12° \ \Omega$ is terminated in 200 Ω resistor. Determine the reflection coefficient and VSWR and input impedance.

4. A lossless transmission line with characteristic impedance 50 ohm is 30 m long and operates at 2 Mhz . The line is terminated with a load of (60+j 40). If phase velocity is 0.6 c where c is speed of light then find using Smith Chart.
   (1)Reflection Coeff. (2)The standing wave ratio. (3)The input Impedance.

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Tutorial 11

(Uniform Plane Waves: Wave parameters, Incidence/Reflection /transmission of UPW.)

1 Derive the relationship between depth (δ)of penetration and conductivity(σ) for a plane wave incident on a good conductor..

2 What is polarization of wave? Explain the polarization of three types of wave with the relevant diagram

3 Derive the fundamental equation for free space propagation and explain its parameter.

4 A metal sheet of Aluminium has conductivity(σ) = 38.2M mho meter and μr = 1 . Calculate the skin depth δ, the propagation constant , and velocity of propagation at frequency of 1.6 M.Hz