**INTRODUCTION TO FIELD, WAVES AND ANTENNAS**

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**Q1 (1) What is Electromagnetism? Explain in brief along with Gravitational force analogue**

# Define electromagnetism…

Electromagnetism force is one of the four fundamental forces in nature .nuclear weak interaction and gravitational .Gravitational is the weakest at 0¯41 that of the nuclear force EM force exists between charged particles it is the dominate force in microscopic system that of the nuclear forces.

# Gravitational force analogue..

Force acts at a distance concept of field

Each mass m1 induces a gravitational field around it so that if another mass m2 introduced to some point, it will experience force equal to eq: 1

The field does not physically eminate from the object but its influences exists ar every point in space the field is defined as:

= -$R\frac{GMI}{R2}$ (N/kg)

Where R is a unit vectors that point radially away from m1 (-R point towards m1)

**Q1 (2) Explain in brief the branches of Electromagnetism along with the table?**

|  |  |  |
| --- | --- | --- |
| Branches | Condation | Field Quantities(units) |
| Electrostatics | Stationary charges (ₐq/ₐt=0) | Elec. Field intensity E(V/m)Elec. Flux density D (C/m)D=e |
| Magnetostatics | Steady currents (ₐI/ₐt=0) | Magnetic flux density B(T)Mag . field intensity H(A/m)B=ᶣH  |
| Dynamics  | Time varying current (ₐI/ₐTǂ0) | E,D,B and HE,D couple to (B,H) |

**Q1 (3) Explain in detail the sinusoidal wave in lossless medium with mathematical expressions**

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**Q1 (4) Proof the Euler’s Formula? Where does it come from?**

# Euler formula

e=cosᴓ+jsinᴓ

Where does this come from ?

On way to see this is using Taylor series even if u don’t prove it u can convince your self that these series hold. Take the taylor series representation for sin and cos :

$$cos^{∅}=1+\frac{∅2}{2!}+\frac{∅^{4}}{4!}+\frac{∅^{6}}{6!}+\frac{∅8}{8!}.\\_$$

 Sin$∅=1+\frac{∅3}{3!}+\frac{∅5}{5!}+\frac{∅^{7}}{7!}+\frac{∅9}{9!}…\\_$

 What does the exponential function?

$$e^{x}=1+z \frac{z2}{2!}+\frac{z^{3}}{3!}+\frac{z4}{4!}+\frac{z6}{6!}+\frac{z7}{7!}…,$$

What about if we take z to be j$∅$?

$$e^{z}=1+z+\frac{z2}{2!}+\frac{z3}{3!}+\frac{z^{4}}{4!}+\frac{z5}{5!}+\frac{z6}{6!}+\frac{z7}{7!}…$$

$$e^{j∅}=1+j∅\frac{z2}{2!}+\frac{z^{3}}{3!}+\frac{z6}{4!}+\frac{z5}{5!}+\frac{z6}{6!}+\frac{z7}{7!}$$

 cos$∅=1+\frac{∅2}{2!}+\frac{∅4}{4!}+\frac{∅^{6}}{6!}+\frac{∅8}{8!}…$

 j sin$∅=j∅-\frac{j∅3}{3!}+\frac{j∅^{5}}{5!}+\frac{j∅7}{7!}+\frac{j∅9}{9!}…$

so we have : ej$∅$=cos$ ∅$+j sin$ ∅$

**Q1 (5) Explain in detail the sinusoidal wave in a lossy medium with mathematical expressions**

# Sinusoidal wave in lossy medium…

So far wave amplitude did not change with distance lossless case

If it changes (decreases )loss case (loss medium).

**Attenuation constant** $∝$characterizes how lossy the medium is

$∝$is measuredin Np/m

Fall –off given by an exponential function exp (\_ax)so that full wave is given by

Example of such function given

**Q2) a: An airline is a transmission line in which air separates the two conductors, which renders** $G^{'}=0 because σ=0.$ **In addition, assume that the conductors are made of a material with high conductivity so that** $R^{'}≃ 0. $ **For an air line with a characteristic impedance of 50** $Ω$ **and a phase constant of 20 rad/m at 700 MHz Find the line inductance** $L^{'}$ **and the capacitance** $C^{'}$**. Following quantities are given as: (**5 marks)

$$Ζ\_{0}=50Ω, β=20 rad/m, f=700MHz $$

An air line is a transmission line in which air separates the two conditions which riders G=0 because $σ=0 $in assume that the conductors are made that of a material characteristic impendence of 50 and a phase constant of 20 rad/m at 700 MHz fine the line inductors L’ and the line capacitance C’

The following quantities are given

Z=50 $β$=20 rad/m

F=700MHz =7$×$10HZ

With R =G=0

$β$=Jm$\sqrt{\left(jwL^{'}\right)}\left(jwC\right)$

=jm (jw$\sqrt{L'C')}$=$ω\sqrt{L'C'}$

Z0=$\frac{\sqrt{jwL'}}{jwC'}$=$\frac{\sqrt{L^{'}}}{C'}$

# The ratio of $β$ to z0 is

$\frac{β}{wZ0}$=wC’

Or

C’=$\frac{β}{wZ0}$

$$\frac{20}{2π×7×10×50}$$

=9.09$×$10-11(F/M)=90.9(Pf/m)

**Q2 b: A 50**$Ω$ **microstrip line uses a 0.5mm – thick sapphire substrate with** $ε\_{r}=9. $**What is the width of its copper strip?**

A 50 micro strip line uses a 0.5mm thick sapphire substrate with $ε$ =9 What is the width of its copper strip?

Since z0= 50> 44-18 =32 we should use

P= $\frac{\sqrt{ε+1}}{2}×\frac{Z0}{60}$+($\frac{εr-1)}{εr+1}$(0.2+$ \frac{0.12}{εr}$)

=$\frac{\sqrt{9+1}}{2}×\frac{50}{60}$+ ($\frac{9-1}{9+1}$)(0.23+$\frac{0.12}{9}$)

=2.06

X=$\frac{w}{h}$

=$\frac{8eP}{\begin{array}{c}e2p-2\\\end{array}}$

=$\frac{8e2.06}{\begin{array}{c}e4.12\_{2}\\\end{array}}$

=1.056

# Hence

W=sh

=1.056$×$0.5mm

=0.53mm

To cheak our calculations we will use s=1.056 tocalculate Z0 to verify that the value we obtained is indeed equal or close to 50 with $ε$ =9

X=0.55

Y=0.99

Z0=49.93ans

**Q3) a) Transform the vector (x + z)ay to cylindrical**. (5 marks)

 

$\left⌈\begin{array}{c}Ap\\A∅\\Az\\\end{array}\right⌉$=$\begin{matrix}cos∅&sin∅&0\\-sin∅&cos∅&0\\0&0&1\end{matrix}$

Ap =0\*cos$∅$+(x+z) sin$∅$+0

Ap = (x+z) sin$∅$

Ap= (pcos$∅$+z)cos$∅$

A$∅$ =0\* (-sin$∅$)+(x+z)cos$∅$+0

A$∅$ =(pcosp$∅$+z)cos$∅$

Az=0

**b)** Explain the difference between the two points with the help of figures and transform A to spherical and find the value of A at points (3, -4,0) given below. (2+3 marks)

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# Ans…

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Ax | Ay | Az | Ap | A$∅$ | Az | Ar | A$∅$ | A$∅$ |
| Ax | 1 | 0 | 0 | Cos$∅$ | -sin$∅$ | 0 | sin$∅cos∅$ | Cos$∅$cos$∅$ | -sin$∅$ |
| Ay | 0 | 1 | 0 | Sin $∅$ | cos$∅$ | 0 | sin$∅sin∅$ | Cos$∅$sin$∅$ | cos$∅$ |
| Ax | cos$∅$ | 0 | 1 | 0 | 0 | 1 | Cos$∅$ | Cos $∅$ | 0 |
| Ap | -sin$∅$ | sin$∅$ | 0 | 1 | 0 | 0 | Sin$∅$ | Sin$∅$ | 0 |
| A$∅$ | 0 | cos$∅$ | 0 | 0 | 1 | 0 | 0 | o | 1 |
| Ax | sin$∅$cos$∅$ | 0 | 1 | 0 | 0 | 1 | Cos$∅$ | Cos$∅$ | 0 |
| Ar | cos$∅cos∅$ | Sin$∅$cos$∅$ | cos$∅$ | sin$∅$ | 0 | cos$∅$ | 1 | 1 | 0 |

**Ar= p cos**$∅$**sin**$∅$**+pz2 sin**$∅$ **az**

=(rsin$∅$)cos$∅$sin$∅$+(rsin$∅$)(r cos$∅$)2 $sin∅$cos$∅$

=r sin$∅$ cos$∅$+r3sin$∅$cos$∅$sin$∅$

A$∅$=rsin$∅$ cos$∅$-r sin$∅$2

A$∅=0$

 $⟹$A=A,a+A,a+

(x,y,z,)=(3,-4,0)$⇒$(r,$∅$)=(5,$\frac{π}{2},-53.13)$