Code : 100308

B.Tech 3rd Semester Exam., 2020
(New Course)

ELECTROMAGNETIC FIELD THEORY

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

(v) Symbols and notations carry their usual meanings.

1. Choose the correct answer of any *seven* of the following : 2×7=14

(a) In free space, the Poisson equation becomes

(i) Maxwell equation

(ii) Ampere equation

(iii) Laplace equation

(iv) steady-state equation

(b) Poisson equation can be derived from which of the following equations?

(i) Point form of Gauss law

(ii) Integral form of Gauss law

(iii) Point form of Ampere law

(iv) Integral form of Ampere law

(c) Depth of penetration in free space is

(i) α

(ii) $\frac{1}{\alpha}$

(iii) 0

(iv) ∞

(d) Poynting vector gives the

(i) rate of energy flow

(ii) direction of polarization

(iii) intensity of electric field

(iv) intensity of magnetic field

(e) Using volume integral, which quantity can be calculated?

(i) Area of cube

(ii) Area of cuboid

(iii) Volume of cube

(iv) Distance of vector

(f) Electric flux density in electric field is referred to as

(i) number of flux lines

(ii) ratio of flux lines crossing a surface and the surface area

(iii) direction of flux at a point

(iv) flux lines per unit area

(g) Which of the following correctly states Gauss law?

(i) Electric flux is equal to charge

(ii) Electric flux per unit volume is equal to charge

(iii) Electric field is equal to charge density

(iv) Electric flux per unit volume is equal to volume charge density

(h) Find the power reflected in a transmission line, when the reflection coefficient and input power are 0·45 and 18 V respectively.

(i) 3·645

(ii) 6·453

(iii) 4·563

(iv) 5·463

(i) In a waveguide, which of the following conditions is true always?

(i) Phase velocity = c

(ii) Group velocity = c

(iii) Phase velocity > c

(iv) Phase velocity < c

(j) The phase and group velocities do not depend on which of the following?

(i) Frequency

(ii) Wavelength

(iii) Phase constant

(iv) Attenuation constant

2. Attempt any *two* parts of the following : 7×2=14

(a) A rectangular waveguide with dimensions of 3 cm × 2 cm operates at 10 GHz. Find—

(i) cut-off frequency (f_c);

(ii) cut-off wavelength (λ_c);

(iii) guided wavelength (λ_g);

(iv) phase constant (β_g).

(b) What do you mean by transmission line? Derive an expression for transmission line equations.

(c) Determine the expression for average power of Poynting vector.

3. Attempt any *two* parts of the following : 7×2=14

(a) (i) Define quality factor. Give its relation with attenuation factor.

(ii) Define reflection coefficient and ASWR. Also write their interrelation.

(b) (i) Compare wave impedance and characteristic impedance.

(ii) Define tangent loss.

(c) Derive the field components when wave is propagating inside a rectangular waveguide with TM mode of propagation.

4. Attempt any *two* parts of the following : 7×2=14

(a) Derive an expression for input impedance when transmission line is terminated with any load impedance.

(b) What is equipotential surface? Explain Poynting vector and average Poynting vector.

(c) State and prove Ampere's work law as $\nabla \times \vec{H} = J$.

5. Attempt any *two* parts of the following : 7×2=14

(a) Derive the Gauss divergence theorem and Stokes' theorem along with their significances.

(b) Explain the wave between parallel planes. Derive the expression for the attenuation in parallel plane guide.

(c) Derive the expressions for the reflection and refraction of the waves by the perfect dielectric.

6. Attempt any *two* parts of the following : 7×2=14

(a) Find the reflection and transmission coefficient for the interface between air and freshwater ($\varepsilon = 81\varepsilon_0$, $\sigma \cong 0$) in the case of perpendicular incidence.

(b) Derive the relationship between the following :

(i) Standing-wave ratio and magnitude of reflection coefficient

(ii) Standing-wave ratio and the reflection coefficient

(c) (i) Write the condition for a line to be distortionless.

(ii) Define the term 'phase velocity'.

7. Attempt any *two* parts of the following : 7×2=14

(a) What is polarization of wave? Discuss the properties of S- and P-polarized light. Explain why P-polarized light is also called as TM-polarized light.

(b) Explain the term 'standing-wave ratio' related to transmission line. What will be the values of input impedances when output impedances are *(i)* open-circuited and *(ii)* short-circuited?

(c) Explain why TEM wave does not propagate in waveguide.

8. Attempt any *two* parts of the following : 7×2=14

(a) A transmission line has a characteristic impedance of 100 ohms and is terminated in a load impedance of $200 + j180$ ohms. Find the voltage reflection coefficient.

(b) What is the penetration depth in current penetration in copper at a frequency of 10^4 MHz, if the resistivity is $1 \cdot 7 \times 10^{-6}$ Ω cm?

(c) What are the satisfactory conditions for low-loss transmission lines?

9. Attempt any *two* parts of the following : 7×2=14

(a) A uniform plane wave propagating in a medium has $E = 2e^{-\alpha z} \sin(10^8 t - \beta z) a_y$. If the medium is characterized by $\varepsilon_r = 1$, $\mu_r = 20$ and $\sigma = 3$ mhos/m, then find α, β and $\vec{H}$.

(b) In a non-magnetic medium

$$E = 4 \sin(2\pi \times 10^7 - 0 \cdot 8x) a_z \text{ V/m}$$

Find—

(i) the time-average power carried by the wave;

(ii) the total power crossing 100 cm^2 of plane $2x + y = 5$.

(c) What is the boundary condition for metal dielectric interface?

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