2018

(6th Semester)

PHYSICS

ELEVENTH PAPER

(Electromagnetic Theory)

(Revised)

Full Marks : 55

Time : 2½ hours

(PART : A—OBJECTIVE)

(*Marks* : 20)

The figures in the margin indicate full marks for the questions

SECTION—A

(*Marks* : 5)

Tick (✓) the correct answer in the brackets provided : 1×5=5

1. The energy density of a monochromatic plane wave travelling in vacuum is ($_0$ permittivity of free space, E = electric field)

(a) $_0E^2$ ( ) *(b)* $2\ _0E^2$ ( )

(c) $4\ _0E^2$ ( ) *(d)* $8\ _0E^2$ ( )

2. The speed of an electromagnetic wave in a dielectric medium where $_0$ and $4\ _0$ is (c = speed of light in vacuum)

(a) $\frac{c}{4}$ ( ) *(b)* $\frac{c}{2}$ ( )

(c) c ( ) *(d)* $2c$ ( )

3. An electric field $\vec{E}$ in terms of scalar V and vector potential $\vec{A}$ is

(a) $^{\rightarrow}V\ \frac{\vec{A}}{t}$ ( ) *(b)* $^{\rightarrow}V\ \frac{\vec{A}}{t}$ ( )

(c) $^{\rightarrow}\vec{A}\ \frac{V}{t}$ ( ) *(d)* $^{\rightarrow}\vec{A}\ \frac{V}{t}$ ( )

4. Slew rate of an op-amp is a parameter that defines

(a) how rapidly the output changes with the change in input frequency ( )

(b) how rapidly the output changes with the change in operating voltage ( )

(c) the rate at which mathematical operation is performed ( )

(d) the rate of change of output resistance ( )

5. The decimal equivalent of $(1001)_2$ is

(a) 7 ( ) *(b)* 8 ( )

(c) 9 ( ) *(d)* 10 ( )

SECTION—B

(*Marks* : 15)

Answer the following questions : 3×5=15

1. The electric field of an electromagnetic wave in vacuum is given by

$$\vec{E}_x \quad 0, \ \vec{E}_y \quad 30\cos 2 \quad 10^8 t \quad \frac{2}{3} x \ , \ \vec{E}_z \quad 0$$

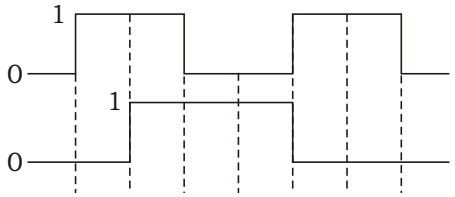
where $\vec{E}$ is in volts per meter, t is in seconds and x is in meters. Determine the wavelength, direction of propagation of the wave and direction of the magnetic field.

2. State and explain Brewster's law in electromagnetic waves.

3. Magnetic vector potential is given by $\vec{A} \quad x^2\hat{i} \quad 2xy\hat{j}$. Obtain the magnetic field at (1, 2, 0).

4. What is output offset voltage of op-amp? Explain how it can be adjusted.

5. Draw the output waveform for the given input waveforms to a two-input NAND gate :



(PART : B—DESCRIPTIVE)

(*Marks* : 35)

The figures in the margin indicate full marks for the questions

1. Derive the Poynting theorem and obtain the expression for Poynting vector. 7

OR

(a) Derive Maxwell's equation $\overrightarrow{\quad} \vec{D}$, where $\vec{D}$ is electric displacement and is the charge density. 3

(b) Using Maxwell's equations, discuss the boundary conditions for magnetic field vector at the interface between different media. 4

2. *(a)* Deduce the laws of refraction for plane waves at the boundary of two dielectrics from electromagnetic theory. 5

(b) A uniform plane wave whose electric field is given by $E_I \quad 100\cos(\ t \quad 6\ x)\hat{z}\,\mathrm{Vm}^{\ 1}$ is incident from a region having $_1 \quad 4\ _0$, $_1 \quad _0$ normal to the plane surface of a material having $_2 \quad 9\ _0$, $_2 \quad 4\ _0$. Obtain the expression for the reflected electric field. 2

OR

(a) Obtain the expression for skin depth when electromagnetic wave is incident on a conducting surface from air medium. 5

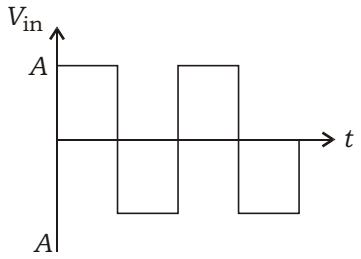
(b) A 2 MHz electromagnetic wave propagates in a non-magnetic medium having a relative permittivity of $2\ _0$ and a conductivity of 100 S/m. Determine if the material is a good conductor or not. Calculate the skin depth. [$_0 \quad 8\ 85 \quad 10^{\ 12}\ \mathrm{Fm}^{\ 1}$] 2

3. What do you mean by gauge transformations? Show that Lorentz condition leads to two decoupled differential equations in electric field and magnetic field. 2+5=7

OR

What are the scalar and vector potentials in electromagnetic waves? Derive the Poisson's equation using vector potential with the current density. 7

4. *(a)* Draw the circuit diagram of a basic differentiator using op-amp. Derive the expression for its output voltage. Draw the output waveform for the square wave given below : 5



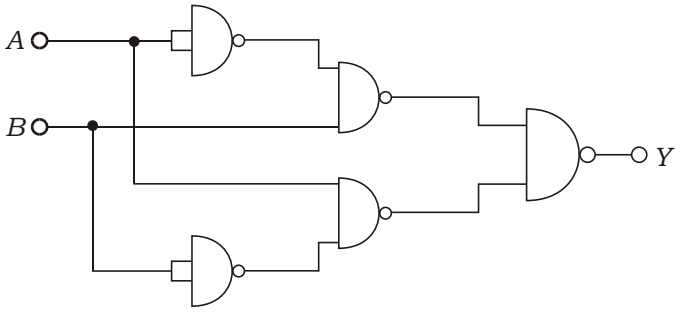
(b) Write at least four characteristics of ideal op-amp. 2

OR

(a) With the help of appropriate circuit diagram, explain the use of op-amp as unity follower. Give at least one application of unity follower circuit. 3½

(b) Explain CMRR of an op-amp. Give reason why high CMRR is suitable. 3½

5. *(a)* Write the Boolean equation for the digital circuit shown below and give its truth table : 3



(b) Simplify the Boolean expression $Z \quad \overline{(\overline{A} \quad C)\ (B \quad \overline{D})}$ and realize its using NAND gates. 2+2=4

OR

(a) Write the truth table and draw the digital circuit of half adder. 4

(b) Using 2's complement, perform binary subtraction of the following : 3

(i) $(110011)_2$ $(100111)_2$

(ii) $(101\ 1101)_2$ $(101\ 0111)_2$

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