Faculty of Engineering & Technology
Fourth Semester B.E. (Electronics Engineering)/ET/EC
(C.B.S.) Examination
ELECTROMAGNETIC FIELD

Time—Three Hours] [Maximum Marks—80

INSTRUCTIONS TO CANDIDATES

(1) All questions carry marks as indicated.

(2) All questions are compulsory.

(3) Due credit will be given to neatness and adequate dimensions.

(4) Assume suitable data wherever necessary.

(5) Illustrate your answers wherever necessary with the help of neat sketches.

1. (A) A triangle is defined by three points A(2, –5, 1); B(–3, 2, 4) and C(0, 3, 1).

Find :

(i) $\vec{R}_{BC} \times \vec{R}_{BA}$

(ii) The area of the Triangle

(iii) A unit vector perpendicular to the plane in which triangle is located. 6

(B) Four infinite uniform sheets of charge are located as follows :

$20\ pc/m^2$ at $y = -7$; $-8\ pc/m^2$ at $y = 3$;

$6\ pc/m^2$ at $y = -1$ and $-18\ pc/m^2$ at $y = -4$

Find $\vec{E}$ at the point :

(i) $P_A(2, 6, -4)$

(ii) $P_B(0, 0, 0)$

(iii) $P_C(-1, -1.1, 5)$

(iv) $P_D(10^6, 10^6, 10^6)$ 7

OR

2. (A) Derive an expression for electric field intensity at any point due to infinitely extending line charge along z-direction. 6

(B) Find a numerical value for the divergence of $\vec{D}$ at the point indicated if :

(i) $\vec{D} = 20xy^2(z+1)\vec{a}_x + 20x^2y(z+1)\vec{a}_y + 10x^2y^2\vec{a}_z\ C/m^2$

at $P_A(0.3, 0.4, 0.5)$

(ii) $\vec{D} = 4\rho z \sin\phi\,\vec{a}_\rho + 2\rho z\cos\phi\,\vec{a}_\phi + 2\rho^2 \sin\phi\,\vec{a}_z$

at $P_B\left(1, \frac{\pi}{2}, 2\right)$. 7

3. (A) State and prove 'Ampere's Circuital Law'. 6

(B) Find vector magnetic field intensity in Cartesian co-ordinate at point P(1.5, 2, 3) caused by current filament of 24A in $\vec{a}_z$ direction on z–axis and extending from :

(i) $z = 0$ to $z = 6$

(ii) $z = 6$ to $z = \infty$

(iii) $z = -\infty$ to $z = +\infty$. 7

OR

4. (A) State and explain Stoke's theorem and hence evaluate both sides of Stoke's theorem if

$\vec{H} = 0.5y^3\vec{a}_x + 2x\vec{a}_z$ A / m for the portion of surface defined by $z = 5$, $0 \le x \le 5$, $4 \le y \le 6$m. 7

(B) Let $\vec{J} = \dfrac{400 \sin\theta}{(r^2 + 4)}\vec{a}_r$ A / m^2.

Find the total current flowing through that portion of the spherical surface $r = 0.8$ bounded by $0.1\pi < \theta < 0.3\pi$; $0 < \phi < 2\pi$. 6

5. (A) Show that time varying magnetic field satistifies the equation :

$$\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}.$$ 7

(B) Select the value of K so that each of the following pairs of fields satisfies Maxwell's equation in a region where $\sigma = 0$ and $\rho_v = 0$:

(i) $\vec{E} = (Kx - 100t)\vec{a}_y$ V/m;

$\vec{H} = (x + 20t)\vec{a}_z$ A/m;

if $\mu = 0.25$ H/m & $\varepsilon = 0.01$ F/m

(ii) $\vec{D} = 5x\vec{a}_x - 2y\vec{a}_y + kz\vec{a}_z$ $\mu c/m^2$

$\vec{B} = 2\vec{a}_y$ mT

if $\mu = \mu_o$ and $\varepsilon = \varepsilon_o$. 7

OR

6. (A) Write short notes on conduction current and displacement current densities. Derive continuity equation for time varying fields. 7

(B) In a region where $\sigma = 0$, $\varepsilon = 2.5\ \varepsilon_o$, $\mu = 10\mu_o$, determine whether following pair of field satisfy Maxwell's equation :

$\vec{E} = 100\sin(6\times10^7 t)\sin z\,\vec{a}_y$

$\vec{H} = -0.1328\cos(6\times10^7 t)\cos z\,\vec{a}_x$ 7

7. (A) Show that the characteristic wave impedance of a uniform plane wave in any medium is given by :

$$\eta = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\varepsilon}}.$$ 6

(B) The electric field intensity associated with a plane EM wave travelling in perfectly dielectric medium is given by :

$E_x(z, t) = 10\cos(3\pi \times 10^8 t - 2\pi z)$ V/m

Contd.

Compute :

(i) Frequency

(ii) Wavelength

(iii) Velocity of propagation

(iv) Magnetic field intensity $\vec{H}$

if $\mu = \mu_o$. 7

OR

8. (A) Write a short note on Brewster's angle. Derive an expression for Brewster's angle θ_B. 7

(B) A plane wave of 200 MHz, travelling in free space impinges normally on a large block of a material having $\varepsilon_r = 4,\ \mu_r = 9, \sigma = 0$. Determine η_1, η_2, β_1, β_2, Γ_R and Γ_T. 6

9. (A) Show that rectangular waveguide acts as a high pass filter. Also derive an expression for cut-off frequency. 7

(B) What is Wave impedance ? Derive the expression for wave impedance for TE wave in rectangular waveguide. 7

OR

10. (A) Prove that the geometric mean of phase velocity and group velocity is equal to to velocity of light. 8

(B) What will be the cut-off wavelength for dominant mode in rectangular waveguide whose breadth is 10 cm. For 2.5 GHz signal, calculate guide wavelength, group and phase velocities and cut-off frequency. 6

11. (A) Explain the concept of 'Retarded magnetic vector potential'. 6

(B) Explain the following terms related to an antenna :

(i) Antenna efficiency

(ii) Antenna Beamwidth

(iii) Radiation intensity

(iv) Front to back ratio. 7

OR

12 Show that the radiation resistance of a current element is given by :

$$R_{rad} = 80\pi^2\left(\frac{dl}{\lambda}\right)^2$$

where, R_{rad} = Radiation resistance

dl = Length of current element. 13