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KATHMANDU UNIVERSITY
End Semester Examination
August/September, 2017

AUG 2 7 2017

Level : B. E. | Course : EEEG 309
Year : III | Semester : II

Exam Roll No. : | Time: 30 min | F. M. : 10

Registration No.: | Date :

SECTION "A"
[20 Q × 0.5 = 10 marks]

1. Which of the following is NOT a scalar field?
   a. Light intensity in a living room
   b. Displacement of a mosquito in space
   c. Temperature distribution in a classroom
   d. Atmospheric pressure in given city

2. For a cylindrical co-ordinate system with coordinates represented as (ρ, ϕ, z), which is the correct range for variables?
   a. $-\infty \leq \rho \leq \infty, \quad 0° \leq \phi \leq 360°, \quad -\infty \leq z \leq \infty$
   b. $-\infty \leq \rho \leq \infty, \quad 0° \leq \phi \leq 180°, \quad -\infty \leq z \leq \infty$
   c. $0 \leq \rho \leq \infty, \quad 0° \leq \phi \leq 360°, \quad 0 \leq z \leq \infty$
   d. $0 \leq \rho \leq \infty, \quad 0° \leq \phi \leq 360°, \quad -\infty \leq z \leq \infty$

3. Two point charges Q_1 and Q_2 of 1 nC and 2nC are located 1 m apart. Which of the following is FALSE?
   a. If the distance between charges is increased, force on Q_1 increases linearly.
   b. The charge Q_1 experiences repulsive force.
   c. The charge Q_2 also experiences force of equal magnitude.
   d. The force on Q_1 is directed along the line joining Q_1 and Q_2.

4. For a infinite sheet of charge with surface charge density ρ_s, the electric field intensity at any point in space is given by_________
   a. $\frac{\rho_s}{2\pi\varepsilon_0\rho} a_\rho$
   b. $\frac{\rho_s}{4\pi\varepsilon_0 r^2} a_r$
   c. $\frac{\rho_s}{2\varepsilon_0} a_N$
   d. None of above

5. The boundary condition for electrostatic field at conductor – free space boundary states that____
   a. Field intensity at the conductor boundary is always tangential to the boundary
   b. Tangential component of field intensity is continuous.
   c. Field intensity at the conductor boundary is always normal to the boundary
   d. The tangential component of field intensity is equal to surface charge density.

6. If $\vec{E}$ and $\vec{D}$ represent the electric field intensity and electric flux density, in a material with relative permittivity ε_r, they are related as.....
   a. $\vec{D} = \varepsilon_r \vec{E}$
   b. $\vec{D} = \varepsilon_r \varepsilon_0 \vec{E}$
   c. $\vec{E} = \varepsilon_r \varepsilon_0 \vec{D}$
   d. $\vec{D} = \frac{\varepsilon_r}{\varepsilon_0} \vec{E}$

7. Which of the following is NOT true about transmission lines?
   a. They are considered as lumped elements
   b. They are considered as distributed elements
   c. Their length are large compared to the wavelength
   d. Their primary parameters are expressed as per unit length

8. For a uniform plane wave travelling in lossless dielectrics,________________
a. attenuation constant is zero and velocity is equal to speed of light
b. intrinsic impedance is real and phase velocity is constant
c. attenuation constant is zero and velocity is function of frequency
d. attenuation constant is positive and phase velocity is constant

9. Any material can be considered a good conductor, if the loss tangent is__________
a. $\cong 1$ b. ≥ 1 c. $\ll 1$ d. $\gg 1$

10. If δ is the skin depth of a conductor, the electric field at a distance 2δ inside the surface is __________times the value at the surface:
a. 0.368 b. 0.736 c. 0.184 d. 0.135

11. For a uniform plane wave travelling in lossy dielectrics____________________
a. the wave gets attenuated as it propagates
b. the wave propagates unattenuated but the velocity decreases
c. the velocity of the wave for any frequency is constant and is equal to free space velocity
d. the wave cannot propagate at all.

12. If a uniform plane wave strikes a perfect conductor at normal incidence, the reflection coefficient is equal to________
a. 0 b. 1 c. -1 d. ∞

13. The reflection coefficient for a uniform plane wave striking a medium boundary at normal incidence is -0.5. What is the value of SWR?
a. 0.33 b. 3 c. 1.5 d. 0.5

14. For a EM wave, given is $H = 0.5\, e^{-0.1x} \sin(10^6 t - 2x)\overrightarrow{a_z}$ A/m. Which of following statement is not correct?
a. $\beta = -2\, rad/m$
b. $\alpha = 0.1\, Np/m$
c. $\omega = 10^6\, rad/s$
d. The propagation direction is $\overrightarrow{a_x}$

15. Which of following is NOT true of EM waves in general?
a. It is a function of time and space
b. It may be a function of time only
c. It may be sinusoidal or cosinusoidal
d. Its velocity may vary

16. Which of the following is a criteria used to identify distortionless transmission lines?
a. $\frac{R}{L} = \frac{G}{C}$
b. $\frac{R}{G} = \frac{L}{C}$
c. $R \ll \omega L$ and $G \ll \omega C$
d. $R = G = 0$

17. The matched load condition in a transmission line is achieved when ____________
a. $Z_L = 0$ b. $Z_L = Z_0^*$. c. $Z_L = Z_0$ d. $Z_L = Z_{in}$

18. Radiation resistance of a half wave dipole is_________
a. 36.5 Ω b. 200 Ω c. 73 Ω d. 50 Ω

19. The antenna that radiates equally in all directions is called________________
a. an isotropic antenna
b. omnidirectional antenna
c. dipole antenna
d. monopole antenna

20. A rectangular metallic waveguide supports______________________
a. TE modes only
b. TEM modes only
c. All TE, TM and TEM modes
d. TE and TM modes only but not TEM mode

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SECTION "B"
[5Q × 8 = 40 marks]

Attempt *ANY FIVE* questions. Use constants and relations provided if needed. Assume suitable values for missing parameters if any.

1. a. A field is expressed in spherical coordinates by $\vec{E} = \frac{25}{r^2}\overrightarrow{a_r}$. Find the expression of $\vec{E}$ in Cartesian coordinates at P (-3, 4, -5). Find $|\vec{E}|$ and also the angle that $\vec{E}$ makes with the vector field $\vec{B} = 2\overrightarrow{a_x} - 2\overrightarrow{a_y} + \overrightarrow{a_z}$. [3]

   b. Define and explain the curl of a vector field. Also state Stokes's theorem as related to the curl of a vector field. [2]

   c. Starting from the Maxwell's equation for time varying fields, obtain the wave equation for the uniform plane EM wave in free space. Also state and discuss about the solution of the wave equation for electric and magnetic fields in instantaneous time and phasor forms. [3]

2. a. A uniform plane wave with electric field $\vec{E} = E_x\overrightarrow{a_x}$ propagates in a lossless dielectric medium in positive z direction. Assume that the electric field follows sinusoidal variation with a frequency of 100 MHz and has a maximum value of 10^{-4} V/m at $t = 0, z = 0$. If the medium has properties as given by $\mu_r = 1, \varepsilon_r = 4, \sigma = 0$, find the following: [3]
      i) Propagation constant k, attenuation constant α, phase constant β, intrinsic impedance of the medium, the phase velocity of the wave.
      ii) The instantaneous time and phasor expressions for electric field $\vec{E}$ and magnetic field $\overrightarrow{H}$.
      iii) Locations along z axis where the field is zero at time $t = 10^{-8}s$.

   b. A uniform plane wave travelling in medium 1 $(intrinsic\ impedance\ \eta_1)$strikes medium $2(intrinsic\ impedance\ \eta_2)$ at normal incidence. Derive the expressions for reflection coefficient and the transmission coefficients. Also explain the consequences for the total field in medium 1 if medium 2 is a perfect conductor. [3]

   c. Determine the electric field intensity $\vec{E}$at point $P(-0.2,\ 0, -2.3)$ due to a point charge of $5\ nC$ located at $Q(0.2, 0.1, -2.5)$. What is the vector force experienced by the charge if a charge of $-10\ nC$ is placed at P? [2]

3. a. Sea water may be considered as a conductor due to its salt content. Consider that sea water at certain location has conductivity $\sigma = 4\frac{S}{m}$, and relative permittivity $\varepsilon_r' = 81$. Use $\varepsilon_0 = 8.85 \times 10^{-12} F/m$ [3]
      i) If the frequency of a uniform plane wave is 1 MHz, find the loss tangent, skin depth, wavelength and phase velocity of the wave travelling in the sea water.
      ii) What is the skin depth and wavelength if frequency is 10 Hz?
      iii) How will the analysis differ if the frequency is 10 GHz?

   b. What do you understand by VSWR in relation to a transmission line? Obtain its relation with the reflection coefficient of a terminated transmission line. Show that VSWR of an open circuit finite lossless transmission line is ∞. [3]

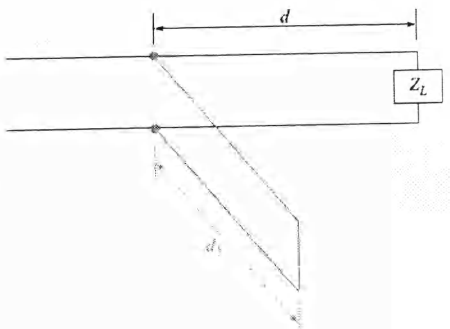
   c. Stub matching are popular methods for matching load impedance to the transmission line. Explain how short circuit single stub methods works. [2]

4. a. Following characteristics have been measured on a lossy transmission line at frequency 100 MHz. [3]
$Z_0 = 50\ \Omega,\ \alpha = 1.15 \times 10^{-3} Np/m$ and $\beta = 0.8\pi\ rad/m$
Find the primary parameters $R, G, L\ and\ C$ of the line.

b. A finite length terminated transmission line may be represented by an equivalent circuit using its input impedance. Define the term 'input impedance' and obtain the input impedance of a lossless transmission line in following conditions: [3]
i) Open circuit termination
ii) Half wave with arbitrary termination
iii) Quarter wave with arbitrary termination

c. State Maxwell's equation for static and time varying fields in differential and integral forms. [2]

5. a. In the figure shown, the terminating load on the 50Ω line is 250Ω. Find the shortest distance d and the shortest length d_1 of the short-circuited stub line that will provide a perfect match on the main line. Use Smith chart and express all answers in wavelengths. [3]



b. How does a general waveguide differs from a transmission line? Derive the expression for the cutoff frequency of the wave guide for TE and TM modes m to be possible. [3]

c. Define the terms, directive gain, directivity and power gain as related to the antenna. [2]

6. a. A parallel plate waveguide is known to have a cutoff wavelength for the $m = 1$ TE and TM modes of $\lambda_{c1} = 4.1\ mm$. The guide is operated at wavelength $\lambda = 1.0\ mm$. How many modes of the TE and TM waves propagate through the guide? [2]

b. What do you understand by radiation pattern of an antenna? Explain. With the sketch of a typical pattern, define various terms associated with a radiation pattern. [4]

c. A linear radiating element has a length of 5m. The frequency of the signal fed to it is 30 KHz. What is the radiation resistance of the radiator? Also find the power radiated by the element if it carries the effective current of 0.25 ampere. [2]

Some useful constants and relations:

$\varepsilon_0 = 8.85 \times 10^{-12} F/m$

$\mu_0 = 4\pi \times 10^{-7} H/m$

Relation between spherical and Cartesian coordinates:

$$r = \sqrt{x^2 + y^2 + z^2}$$

$$\theta = \cos^{-1} \frac{z}{\sqrt{x^2 + y^2 + z^2}}$$

$$\phi = \tan^{-1} \frac{y}{x}$$

	$\mathbf{a}_r$	$\mathbf{a}_\theta$	$\mathbf{a}_\phi$
$\mathbf{a}_x \cdot$	$\sin\theta\cos\phi$	$\cos\theta\cos\phi$	$-\sin\phi$
$\mathbf{a}_y \cdot$	$\sin\theta\sin\phi$	$\cos\theta\sin\phi$	$\cos\phi$
$\mathbf{a}_z \cdot$	$\cos\theta$	$-\sin\theta$	0

For a transmission line:

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} \qquad \sqrt{(R + j\omega L)(G + j\omega C)} = \sqrt{ZY} = \alpha + j\beta$$

For parallel plate waveguides:

$$\omega_{cm} = \frac{m\pi c}{nd} \qquad \beta_m = \frac{n\omega}{c}\sqrt{1 - \left(\frac{\omega_{cm}}{\omega}\right)^2} \qquad \lambda_{cm} = \frac{2\pi c}{\omega_{cm}} = \frac{2nd}{m}$$

For linear antennas, current distribution is:

constant for $l \leq \frac{\lambda}{50}$

linear for $\frac{\lambda}{50} \leq l \leq \frac{\lambda}{10}$

The Complete Smith Chart

Black Magic Design