

KATHMANDU UNIVERSITY
End Semester Examination [C]
May/June, 2019

Marks Scored:

Level : B. E.
Year : IV
Exam Roll No. :

Time: 30 mins.

Course : ETEG 402
Semester: I
F. M. : 10

Registration No.:

Date 05 JUN 2019

SECTION "A"
[20Q. \times 0.5 = 10 marks]

Choose the most appropriate answer from the given options and **encircle** the letter of your choice.

1. The differential surfaces in cylindrical coordinate system are.....
a. $\rho d\rho d\phi, \rho d\phi dz$ and $\rho d\rho dz$ b. $\rho d\rho d\phi, \rho d\phi dz$ and $d\rho dz$
c. $d\rho d\phi, d\phi dz$ and $d\rho dz$ d. $\rho d\rho d\phi, d\phi dz$ and $\rho d\rho dz$
2. Electric field intensity at any point in space due to a monopole is that due to a dipole?
a. Half b. Double c. Equal d. None of above
3. The physical length of a half wave dipole operating at 100 MHz is?
a. 50 m b. 3 m c. 1.5 m d. 15 m
4. For a dipole aligned along z-axis, the electric field at any point in space has only
a. ϕ component b. r component
c. ϕ and r components d. θ and r components
5. The radiation resistance of very short dipole of length $\lambda/50$ is.....
a. $0.032\pi^2 \Omega$ b. $0.032\pi \Omega$ c. $0.016 \pi \Omega$ d. $0.016 \pi^2 \Omega$
6. Average radiation intensity of a antenna that radiates total power of 100 watts is:
a. 25 b. 31.83 c. 1256.6 d. 7.957
7. In general, the size of antennawith increase in operating frequency.
a. may increase or decrease b. increases
c. remains same d. decreases
8. An antenna 'A' has a gain of 5 dB with respect to an isotropic radiator. Considering that the gain of a half wave dipole is 2.15 dB with respect to isotropic radiator, what is the gain of antenna 'A' with respect to half wave dipole?
a. 7.15 dB b. 2.85 dB c. 2.32 dB d. 10.75 dB
9. Which of the following is a impedance matching technique used for dipoles?
a. Alpha match b. Beta match c. Gamma match d. Zeta match
10. Yagi Uda antenna is an example ofarray.
a. end fire b. broad side c. Scanning d. Hansen Woodyard
11. Which of the following is an example of a frequency independent antenna?
a. Log periodic dipole array b. Yagi Uda dipole array
c. Biconical antenna d. V antenna

12. Which of the following is NOT an example of a standing wave antenna?
 a. Half wave dipole antenna b. Quarter wave monopole antenna
 c. Helical antenna d. Loop antenna
13. Radiation pattern of a disc antenna is similar to that of.....
 a. parabolic reflector antenna b. dipole antenna
 c. horn antenna d. V antenna
14. The antenna most frequently used in BTS of a cellular mobile network is.....
 a. parabolic reflector b. half wave dipoles
 c. helical d. beverage antenna
15. Which of the ionospheric layer generally has the highest electron density?
 a. D layer b. E layer c. F₁ layer d. F₂ layer
16. If the maximum electron density of an ionospheric layer is 2×10^5 , the critical frequency of that layer is.....
 a. 4 MHz b. 40 KHz c. 4 KHz d. 400 Hz
17. If f represents the frequency in Hertz and N represents the electron density, the refractive index of a ionospheric layer is given by
 a. $\sqrt{1 - \frac{81N}{f^2}}$ b. $\sqrt{1 + \frac{81N}{f^2}}$ c. $\sqrt{\frac{1+81N}{f^2}}$ d. $\sqrt{\frac{1-81N}{f^2}}$
18. In Yagi Uda antenna array, the lengths of directors arethan that of reflectors?
 a. shorter b. longer c. equal to d. may be shorter or longer
19. A practical half wave dipole isin length.
 a. 0.5λ b. 0.47λ to 0.48λ c. 0.52λ to 0.53λ d. 0.25λ
20. The radiation resistance of a quarter wave monopole is.....
 a. 73Ω b. 377Ω c. 292Ω d. 36.5Ω

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Level : B. E.
Year : IV
Time : 2 hrs. 30 mins.

SECTION "B"
[5Q × 8 = 40 marks]

Attempt *ANY FIVE* questions. Candidates are instructed to be specific while writing answers. Assume suitable values for any missing parameters.

1. a. Maxwell's equations provide a fundamental understanding to electromagnetic fields and waves. State Maxwell's equations for both static and time varying fields. [2]
- b. A 2 A source operating at 300 MHz feeds a Hertzian dipole of length 5 mm situated at the origin. Assuming far field conditions, find electric field intensity at a point in space defined in spherical coordinate system as (10, 30°, 90°). [2]
- c. Starting from the expressions of electric and magnetic field intensities provided below, derive the expression for the total power radiated by the Hertzian dipole and hence its radiation resistance. Assume suitable reference co-ordinate system. [4]

$$H_{\phi} = \frac{I_0 dl \sin\theta}{4\pi} \left[-\frac{\omega \sin\alpha t'}{rv} + \frac{\cos\alpha t'}{r^2} \right] \quad E_r = \frac{2I_0 dl \cos\theta}{4\pi\epsilon} \left[\frac{\cos\alpha t'}{r^2 v} + \frac{\sin\alpha t'}{\omega r^3} \right]$$

$$E_{\theta} = \frac{I_0 dl \sin\theta}{4\pi\epsilon} \left(-\frac{\omega \sin\alpha t'}{rv^2} - \frac{(-\cos\alpha t')}{r^2 v} + \frac{\sin\alpha t'}{\omega r^3} \right)$$

2. a. With suitable figures to illustrate the definition, define following antenna types:
i) Isotropic antennas, ii) Omni directional antennas iii) Directive antennas [3]
- b. Are the terms '*antenna bandwidth*' and '*antenna beamwidth*' same? If not, explain what do you understand by each of them? [2]
- c. An antenna with a radiation resistance of 48 Ω, a loss resistance of 2Ω and a reactance of 50 Ω is connected to a generator with open circuit voltage of 10 v and internal impedance of 50 Ω - j 50 Ω via matched lossless transmission. Draw the equivalent circuit of the system. Determine the power supplied by the generator. Also determine the power radiated by the antenna and power lost by the antenna. [3]
3. a. Directive properties of antenna arrays are conveniently expressed in terms of array factors. Derive the array factor for the antenna array of two vertical infinitesimal dipoles aligned along z-axis and separated by a distance d. [3]
- b. With relevant derivation, prove that the directivity of a half wave dipole is 2.15 dB. [2]
- c. The input impedance of a 0.47 λ folded dipole operating at 10 MHz is $Z_{in} = 306 + j75.3$. To resonate the element, it is proposed to place a lumped element in shunt (parallel) at the input terminals where the impedance is measured. (a. What kind of an element (capacitor or inductor) should be used to accomplish the requirement? (b. What is the value of the element (in farads or henries)? [3]

4. a. What do you understand by end fire and broad side arrays? Derive the condition for a uniform linear array of N elements to be an end fire and broadside antenna. [3]
- b. How do travelling wave antennas differ from standing wave antennas? Explain in terms of construction and radiation patterns. Also introduce long wire antennas. [3]
- c. Introduce equiangular planar spiral antennas. [2]
5. a. Two lossless polarization matched antennas are aligned for maximum radiation between them, and are separated by a distance of 50λ . The antennas are matched to their transmission lines and have directivities of 20 dB. Assuming that the power at the input terminals of the transmitting antenna is 10 w, find the power at the terminals of the receiving antenna. [3]
- b. Explain the construction and operation principle of log periodic dipole arrays. [3]
- c. Derive the Friis transmission equation for antennas. [2]
6. a. Design a five turn helical antenna which at 400 MHz operates in the normal mode. The spacing between turns is $\frac{\lambda}{50}$. It is desired that the antenna possesses circular polarization. Determine the circumference of the helix, length of the single turn, overall length of the helix, pitch angle. [3]
- b. Explain the phenomena of ionospheric reflection and hence the principle of sky wave propagation. [2]
- c. Obtain the expression for reflection coefficient for plane earth reflection of vertically polarized electromagnetic waves. [3]

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Note: Some useful relationships:

Definition of curl for spherical coordinate system:

$$\nabla \times \mathbf{H} = \frac{1}{r \sin \theta} \left(\frac{\partial(H_\phi \sin \theta)}{\partial \theta} - \frac{\partial H_\theta}{\partial \phi} \right) \mathbf{a}_r + \frac{1}{r} \left(\frac{1}{\sin \theta} \frac{\partial H_r}{\partial \phi} - \frac{\partial(r H_\phi)}{\partial r} \right) \mathbf{a}_\theta + \frac{1}{r} \left(\frac{\partial(r H_\theta)}{\partial r} - \frac{\partial H_r}{\partial \theta} \right) \mathbf{a}_\phi \quad (\text{spherical})$$

For far fields in Hertzian dipoles,

$$H_\phi = j \frac{\beta I_0 dl \sin \theta e^{-j\beta r}}{4\pi r} \quad E_\theta = j\eta \frac{\beta I_0 dl \sin \theta e^{-j\beta r}}{4\pi r}$$

For Half wave dipoles:

$$P_{rad} = 1.218 \frac{\eta I_m^2}{4\pi} \quad E = j \frac{60 I_m e^{-j\beta r} \cos\left(\frac{\pi}{2} \cos \theta\right)}{r \sin \theta}$$

For a finite length dipole,

$$R_{rad} = \frac{\eta}{2\pi} \left[\begin{aligned} & C + \ln(2\beta H) - C_i(2\beta H) + \frac{1}{2} \sin(2\beta H) \{S_i(4\beta H) - 2S_i(2\beta H)\} \\ & + \frac{1}{2} \cos(2\beta H) \{C + \ln(\beta H) + C_i(4\beta H) - 2C_i(2\beta H)\} \end{aligned} \right] \quad C=0.5772$$

For helical antennas is normal mode,

$$AR = \frac{|E_\theta|}{|E_\phi|} = \frac{2\lambda S}{C^2} \quad \text{For circular polarization, AR should be equal to 1.}$$

$$L_0 = \sqrt{S^2 + (C)^2} \quad \alpha = \tan^{-1} \frac{S}{C} = \tan^{-1} \frac{S}{\pi D}$$

For horn antennas:

$$A = \frac{a_1}{\lambda} \sqrt{\frac{50}{\rho_h/\lambda}} \quad D_H = \frac{b}{\lambda} \frac{G_h}{\sqrt{\frac{50}{\rho_h/\lambda}}} \quad B = \frac{b_1}{\lambda} \sqrt{\frac{50}{\rho_e/\lambda}} \quad G_h = \frac{32}{\lambda} A \quad G_e = \frac{32}{\lambda} B \quad D_E = \frac{a}{\lambda} \frac{G_e}{\sqrt{\frac{50}{\rho_e/\lambda}}}$$

$$D = \frac{\lambda^2 \pi}{32 a b} D_E D_H$$

