

**RF & MICROWAVE ENGINEERING  
(ECEN 4101)**

**Time Allotted : 3 hrs**

**Full Marks : 70**

*Figures out of the right margin indicate full marks.*

*Candidates are required to answer Group A and  
any 5 (five) from Group B to E, taking at least one from each group.*

*Candidates are required to give answer in their own words as far as practicable.*

**Group – A  
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) Identify degenerate modes in rectangular waveguides  
(a) TE<sub>21</sub> and TM<sub>11</sub> (b) TE<sub>11</sub> and TM<sub>11</sub>  
(c) TE<sub>01</sub> and TE<sub>23</sub> (d) TE<sub>11</sub> and TE<sub>34</sub>
- (ii) The cut-off frequency of a waveguide depends on  
(a) the dielectric property of the medium in the waveguide  
(b) dimensions of the waveguide  
(c) wave mode  
(d) all of the above.
- (iii) The dominant mode for rectangular waveguides is  
(a) TE<sub>11</sub> (b) TM<sub>10</sub> (c) TE<sub>10</sub> (d) TE<sub>21</sub>.
- (iv) What is the condition for S matrix to be unitary?  
(a) Matched at all port (b) Reciprocal  
(c) Lossless (d) Lossy
- (v) S- parameters are expressed as a ratio of  
(a) Voltage and current (b) Impedance at different ports  
(c) Incident and the reflected voltage waves (d) Voltage and impedance.
- (vi) If the reflection coefficient of a 2 port network is 0.25 then the return loss in the network is  
(a) 12.05 dB (b) 0.15 dB (c) 20 dB (d) 10 dB.
- (vii) In shunt stub matching, the key parameter used for matching is  
(a) Admittance of the line at a point (b) Admittance of the load  
(c) Impedance of the stub (d) Impedance of the load.
- (viii) Quality factor of a cavity resonator circuit signifies  
(a) Loss in the resonant circuit (b) Gain in the resonant circuit  
(c) Magnetic energy stored in the circuit (d) Electric energy stored in the circuit

- (ix) Available power gain of a two port network is dependent on  
(a)  $Z_L$  (b)  $Z_S$  (c)  $Z_0$  (d)  $Z_L$  and  $Z_S$ .
- (x) Number of cavity in reflex klystron  
(a) 2 (b) 4 (c) 1 (d) 3.

**Group - B**

2. (a) Derive amount of power flow through the rectangular waveguide for dominant mode. [(CO1, CO2)(Remember/LOCQ)]  
(b) A 2-cm by 3-cm waveguide is filled with a dielectric material with  $\epsilon_r = 4$ . If the waveguide operates at 20 GHz with  $TM_{11}$  mode, find:  
(i) cut-off frequency, (ii) the phase constant, (iii) the phase velocity.  
[(CO1, CO2)(Analyze/IOCQ)]  
(c) 'Microstripline supports Qusi TEM mode' - Explain the statement.  
[(CO2)(Remember/LOCQ)]
- 5 + 5 + 2 = 12**
3. (a) Design an air-filled cubical cavity to have its dominant resonant frequency at 3 GHz. [(CO2)(Create/HOCQ)]  
(b) An air-filled rectangular waveguide of dimensions  $a = 4$  cm,  $b = 2$  cm transports energy in the dominant mode at a rate of 2 mW. If the frequency of operation is 10 GHz, determine the peak value of the electric field in the waveguide.  
[(CO2)(Analyze/IOCQ)]  
(c) Define degenerate mode? [(CO2)(Remember/IOCQ)]
- 4 + 6 + 2 = 12**

**Group - C**

4. (a) Derive the S matrix for E-plane TEE. [(CO3)(Remember/LOCQ)]  
(b) A two-port network has the following s-matrix  
$$[S] = \begin{bmatrix} 0.4\angle 0^\circ & 0.8\angle -40^\circ \\ 0.8\angle 40^\circ & 0.4\angle 0^\circ \end{bmatrix}$$
  
(i) Determine whether the network is lossless and reciprocal?  
(ii) Find return loss at port 1 if the port 2 is terminated with a short circuit load.  
[(CO3)(Analyze/IOCQ)]
- 8 + 4 = 12**
5. (a) Describe the working function of an Isolator with a diagram.  
[(CO3)(Remember/LOCQ)]  
(b) Mention the advantages of stub matching over quarter wave transformer?  
[(CO3) ([Understand/IOCQ)]  
(c) Find the characteristics impedance of a quarter wave transformer matching a  $75\Omega$  source with a  $300\Omega$  load. [(CO3)(Analyze/IOCQ)]
- 7 + 2 + 3 = 12**

**Group – D**

6. (a) Explain the oscillation mechanism of a magnetron with a suitable diagram. [(CO4) (Remember/LOCQ)]  
 (b) 'PIN diode act as a switch'- Justify the statement with a diagram. [(CO4) (Understand/LOCQ)]  
 (c) Identify the Advantages of TWT over klystron as microwave power source. [(CO4)(Understand/LOCQ)]
- 7 + 3 + 2 = 12**
7. (a) Explain the working function of an IMPATT diode. [(CO4) (Remember/LOCQ)]  
 (b) Draw the equivalent circuit of a MESFET for high frequency application. [(CO4) (Understand/LOCQ)]
- 8 + 4 = 12**

**Group – E**

8. (a) Design a prototype for low pass Butterworth filter of the order N=5. The cut off frequency is 4 GHz and the input resistance  $R_0 = 20 \Omega$ . The filter parameters are given as  
 $g_0 = 0.6180, g_1 = 1.6180, g_2 = 2.000, g_3 = 1.6180, g_4 = 0.6180, g_5 = 1.000$ . [(CO5, CO6)(Create/HOCQ)]  
 (b) Convert the above low pass prototype to high pass prototype for 2GHz frequency. [(CO6) (Analyze/IOCQ)]
- 8 + 4 = 12**
9. (a) Find the normal power gain of a two port high frequency amplifier. [(CO5) (Analyze/IOCQ)]  
 (b) The S -parameter for GaAs FET at 2 GHz are given below ( $Z_0 = 50\Omega$ ).  
 $S_{11} = 0.794 \angle -50.6^\circ$   
 $S_{12} = 4.122 \angle 123.6^\circ$   
 $S_{21} = 0.125 \angle 52.4^\circ$   
 $S_{22} = 0.781 \angle -27.6^\circ$   
 Check whether this system is conditionally stable or unconditionally stable. [(CO5, CO6)(Analyze/IOCQ)]
- 8 + 4 = 12**

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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	30%	43.33%	26.67%

**Course Outcome (CO):**

After completing this course, the students will be able to:

1. Apply previous E.M. theory concepts to understand microwave engineering.
2. Identify high frequency electromagnetic wave propagation characteristics through guided media.
3. Analyze microwave passive components and circuits.

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4. Students should be able to enhance their knowledge on semiconductor and vacuum tube devices operating at high frequency.
5. Design high frequency filters and amplifiers.
6. Implement the concepts in developing different prototype microwave systems.

\*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question

<b>Department &amp; Section</b>	<b>Submission link:</b>
ECE BACKLOG	<a href="https://classroom.google.com/c/NDU1NjE4NTY1MTAw?cjc=33jsgin">https://classroom.google.com/c/NDU1NjE4NTY1MTAw?cjc=33jsgin</a>