OBJECTIVES

The subject microwave engineering may be also referred to as applied electromagnetic. The importance of microwaves started way back in World War II period and later expanded its ways out to domestic (microwave oven), military, commercial, satellite and etc. This subject starts with the definition of microwave frequency range, its applications and its importance in modern era. The microwave transmission lines like waveguides (rectangular, circular), micro-strips etc. and the various microwave components like T-junctions, circulator, isolator etc. are discussed in detail to enable the student to design microwave systems and sub- systems.

.

1. Group - A (Short Answer Questions)

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
	UNIT-I **MICROWAVE TRANSMISSION LINES-1**		
1	**Name** different electromagnetic frequency spectrum region and microwave band designations for CCIR/IEEE/US military bands.	Remember	1
2	**classify** the basic advantages of microwaves	Understand	1
3	**List** the typical applications of microwaves	Remember	1
4	**How** are waveguides different from normal two wire transmission lines? Discuss the similarities and dissimilarities	Remember	1
5	**Compare** the differences between Waveguide and Co-axial cable	Understand	1
6	**Apply** the boundary conditions for TE mode along the boundary walls of the waveguide.	Apply	1
7	**Determine** the cut – off frequency of the dominant mode for an air filled rectangular WG when a/b = 2 with a = 4cm.	Evaluate	1
8	An x – Band rectangular waveguide filled with a dielectric with $\varepsilon_r = 2.25$ is	Remember	1

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
	operating at f = 9GHZ. Calculate the phase and group velocities in the waveguide. (X- Band WG the dimensions are 2.286 X 1.016cm)		
9	**What** is meant by the dominant mode of a waveguide? What is the dominant mode in rectangular wave guide?	Remember	1
10	**Examine** the TE mode field pattern in rectangular waveguide.	Analyze	1
11	**List** out the advantages of micro-strip line over rectangular wave guide.	Understand	1
12	**Define** the quality factor of a resonator.	Remember	1
13	**Determine** the group velocity and phase velocity for a dominant mode propagating through a waveguide of breadth 10cms at frequency 2.5GHz.	Evaluate	1
14	**List** few applications of a cavity resonator.	Analyze	1
15	**What** are the advantages of dominant mode propagation?	Remember	1
	UNIT-II **MICROWAVE TRANSMISSION LINES-2**		
1	**What** is the meaning of waveguide excitation? With a neat sketch show how $TE_{10}$and TE_{20} modes can be excited in a rectangular waveguide	Remember	2
2	**Distinguish** between E-plane Tee and H-Plane Tee.	Analyze	2
3	**Draw** a neat sketch explain the applications of the magic tee as mixer and duplexer	Understand	2
4	**What** are the various losses in the network? Give their expressions in terms of S-parameters.	Application	2
5	**Calculate** the coupling factor of the directional coupler when incident power is 600 mW and power in the auxiliary wave guide is 350 µW.	Remember	2
6	A matched isolator has insertion loss of 0.5 db and isolation of 25 db. Find the scattering coefficients.	Understand	2
7	**Draw** the diagram of the four port circulator using magic tees and a phase shifter	Remember	2
8	**Calculate** the attenuation of a rotary Vane attenuator if the angle of rotation is 34 degrees.	Understand	2
9	**Write** the scattering matrix for Isolator	Remember	2
10	**Write** the scattering matrix for an ideal waveguide section.	Remember	2
11	**What** are ferrites and give their properties?	Remember	2
12	**Convert** a three port circulator to an isolator	Understand	2
13	**Distinguish** between an isolator and a gyrator	Analyze	2
14	**Write** the expression for the angle that yields maximum directivity in a Bethe – hole coupler.	Remember	2
15	**Define** the S-parameters and its properties.	Remember	2

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
16	**Define** the following in directional couplers: i. Coupling ii. Directivity iii. Isolation iv. Insertion loss	Understand	2
	UNIT-III **WAVEGUIDE COMPONENTS AND APPLICATIONS-I**		
1	**State** the limitations of conventional tubes at microwave frequencies	Remember	3
2	**State** the characteristics and applications of the two-cavity klystron amplifier	Analysis	3
3	**Explain** velocity modulation process in two-cavity klystron	Understand	3
4	**Why** multi-cavity klystrons are preferred? What are their disadvantages?	Analysis	3
5	**What** is the need for slow wave structure?	Analysis	3
6	**How** is tuning achieved in reflex klystron oscillators? Mention the tuning range of such a device	Remember	3
7	**How** are oscillations avoided in travelling wave tube?	Remember	3
8	**What** are the high frequency effects in conventional tubes?	Remember	3
9	**Define** velocity modulation	Remember	3
10	**What** is the need of slow wave structure in TWTA?	Remember	3
11	**Distinguish** between O – type tubes and M – type tubes.	Analyze	3
12	**What** are the applications of Reflex klystron?	Remember	3
13	**Determine** the dc velocity of the electron when the applied anode voltage is 1000 volts.	Evaluate	3
14	**Draw** the Applegate diagram for a Reflex klystron operating in 1 ¾ mode.	Remember	3
15	**Compare** TWTA and Klystron amplifier	Understand	3
16	**Name** different methods of generating microwave power.	Remember	3
17	**Mention** the condition for obtaining the power output in reflex klystron.	Remember	3
	UNIT-IV **WAVEGUIDE COMPONENTS AND APPLICATIONS-II**		
1	**State** and prove the S - matrix properties of a lossless junction.	Understand	4
2	**What** is scattering matrix? Explain the significance of S - matrix.	Remember	4
3	**Write** short notes on “Properties of S - matrix”.	Understand	4
4	**Explain** the characteristics of ferrite materials.	Understand	4

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
5	**Derive** S - matrix for series Tee using the properties of S parameters.	Remember	4
6	**What** are Ferrites? Derive the scattering matrix of an isolator.	Understand	4
7	**Formulate** the S-Matrix of an ideal 3dB directional coupler.	Create	4
8	**Write** short notes on "Ferrite Devices".	Understand	4
9	**What** are ferrites? What property do they have different from ordinary conductors and insulators?	Remember	4
10	**What** is Faraday rotation? Explain how a three port circulator operates.	Remember	4
	UNIT-V **MICROWAVE TUBES-I**		
1	**State** the limitations of conventional tubes at microwave frequencies	Remember	5
2	**Explain** the principle of operation of two cavity Klystron with neat diagrams.	Remember	5
3	**Compare** "Drift space bunching" and "Reflector bunching" with the help of Applegate diagrams.	Understand	5
4	**Derive** an expression for the power output and efficiency of a two cavity Klystron.	Understand	5
5	**Discuss** various losses that occur at UH frequencies and suggest the remedies.	Remember	5
6	**What** are the performance characteristics of a klystron amplifier?	Remember	5
7	**List** the performance characteristics of and applications of of a typical reflex klystron.	Analyze	5
8	**Differentiate** between klystrons and TWT.	Understand	5
9	**State** the characteristics and applications of the two-cavity klystron amplifier	Analysis	5
10	**Why** multi-cavity klystrons are preferred? What are their disadvantages?	Remember	5
11	**How** is tuning achieved in reflex klystron oscillators? Mention the tuning range of such a device	Remember	5
12	**How** are oscillations avoided in travelling wave tube?	Remember	5
13	**Differentiate** between O – type tubes and M – type tubes.	Analysis	5
14	**Apply** the condition for obtaining the power output in reflex klystron.	Apply	5
	UNIT-VI **HELIX TWTs**		
1	**What** is strapping in magnetron? How is the same effect obtained without strapping	Remember	6
2	**What** is the difference between travelling wave tube and magnetron?	Remember	6
3	**Explain** the terms frequency pulling and frequency pushing with reference to a magnetron	Understand	6

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
4	**What** is strapping in magnetron? How is the same effect obtained without strapping	Remember	6
5	**What** is the difference between travelling wave tube and magnetron?	Remember	6
6	**Explain** the terms frequency pulling and frequency pushing with reference to a magnetron.	Understand	6
7	**Discuss** various operating mode of Gunn diodes	Remember	6
8	**What** are the limitations of LSA modes of Gunn diodes?	Remember	6
9	**Explain** the negative resistance property of a Gunn diode with the help of two valley model along with the emphasis of drift velocity.	Remember	6
10	**Explain** GUNN effect.	Understand	6
11	**Explain** transferred electron effect.	Understand	6
12	**List** the devices under Avalanche transit-time. Compare this with TED.	Analyze	6
	UNIT-VII **MICROWAVE SOLID STATE DEVICES**		
1	**Describe** the principle of operation of IMPATT diode.	Understand	7
2	**Explain** the physical structure and construction of IMPATT diodes.	Remember	7
3	**Draw** the graph between negative resistances versus transit angle and explain its Shape.	Analysis	7
4	**Write** short notes on “LSA mode in GUNN diode”.	Analysis	7
5	**Explain** GUNN effect. Mention the type materials suitable for fabricating GUNN diodes.	Remember	7
6	**Explain** gunn effect using the two valley theory.	Understand	7
7	**Differentiate** between transferred electron devices and transistors.	Remember	7
8	**Compare** IMPATT and TRAPATT diodes.	Remember	7
9	**Derive** the criterion for classifying the modes of operation for Gunn effect diodes.	Understand	7
10	**Describe** the principle of operation of TRAPATT diode.	Remember	7
11	**Describe** the principle of operation of BARITT diode.	Remember	7
12	**What** are the limitations of LSA modes of Gunn diodes?	Remember	7
13	**With** the help of two valley model along with the emphasis of drift velocity, explain the negative resistance property of a Gunn diode	Remember	7
14	**Explain** resonant modes in magnetron.	Understand	7
	UNIT-VIII **MICROWAVE MEASUREMENTS**		
1	Under what conditions double minimum method of VSWR is preferred?	Remember	8

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
2	**How** insertion loss can be measured?	Remember	8
3	**Explain** in brief about errors in microwave power measurement?	Understand	8
4	**Define** the method for measuring VSWR <10	Remember	8
5	**What** is the Principle for microwave frequency measurement?	Remember	8
6	**What** are the various techniques that can be used for measuring microwave frequencies?	Remember	8
7	**State** the various methods for measuring attenuation?	Understand	8
8	**Define** i) Voltage standing wave ratio ii) Reflection coefficient	Remember	8
9	In a microwave measurement it is observed that λ_0=3 cm and λ_C=4 cm. Find λ_G.	Remember	8
10	**Draw** the microwave setup using slotted line to measure VSWR.	Understand	8
11	**Define** the following: i. Insertion loss ii. Reflection loss iii. Return loss iv. Attenuation loss	Analysis	8

2. Group - II (Long Answer Questions)

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
	UNIT-I **MICROWAVE TRANSMISSION LINES-1**		
1	**Formulate** the expressions for cut off frequency, phase constant, group velocity, Phase velocity and wave impedance in A rectangular wave guide.	Create	1
2	A rectangular wave guide is filled by dielectric material of ε_r= 9 and has dimensions of 7 × 3.5 cm. It operates in the dominant TE mode. i. Determine the cut off frequency. ii .Find the phase velocity in the guide at a frequency of 2 GHz. iii. Find the guided wave length at 2GHz.	Understand	1
3	**Determine** the characteristic wave impedance of a rectangular wave guide with dimension of 3 × 2 cm operates in the TM11 mode at 10 GHz.	Understand	1
4	A rectangular guide of inner dimensions 2.5 cm × 1.2 cm is to propagate energy in TE10 mode. Calculate the cut off frequency. If the frequency of signal is 1.2 times this cut off frequency, compute the guide wave length, phase velocity and wave impedance. Derive the relations used.	Remember	1
5	**Prove** that for any wave guide. $\frac{1}{\lambda^2} = \frac{1}{\lambda g^2} + \frac{1}{\lambda c^2}$	Evaluate	1
6	**Derive** the expression for guide wave length of TE_{mn} mode in rectangular wave guide.	Understand	1

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
7	**What** are TEM, TE, TM and HE modes? Sketch the field patterns for dominant modes in a rectangular wave guides.	Remember	1
8	A rectangular wave guide has a = 4 cm, b = 3 cm as its sectional dimensions. Find all the modes which will propagate at 500 MHz	Analyze	1
9	**Distinguish** between the properties of TEM mode of propagation and that of TE and TM type of propagation.	Analyze	1
10	**Derive** the expression for the attenuation of TE10 mode of a rectangular waveguide with finite conductivity.	Understand	1
	UNIT-II **MICROWAVE TRANSMISSION LINES-2**		
1	An air filled rectangular cavity with brass walls has σ = 1.54 × 107 (s/m) and the following dimensions a= 4 cm, b = 3 cm and d = 5 cm. Determine: i. The dominant mode and its resonant frequency for this cavity. ii. Find the Q and the time average stored electric and magnetic energies at resonant frequency, assuming H0 to be 0.1 A/m.	Understand	2
2	**Prove** that a cavity resonator is nothing but an LC circuit.	Understand	2
3	**Derive** an expression for Q of a cavity supporting TE101 mode. What is the resonant frequency of the cavity if each side of the guide is 3 cm?	Understand	2
4	**Derive** the expression for attenuation constant for dielectric loss.	Remember	2
5	**Determine** an expression for the attenuation factor of a micro strip line.	Understand	2
6	**Derive** an expression for Q of a cavity supporting TE101 mode. What is the resonant frequency of the cavity if each side of the guide is 3 cm?	Understand	2
7	An air filled circular wave guide of 2 cm inside radius is operated in the TE01 mode. i. Compute the cut off frequency ii. If the guide is to be filled with a dielectric material of _r = 2.25, to what value must its radius be changed in order to maintain the cut off frequency at its original values.	Understand	2
8	**Discuss** the power transmission in circular wave guides.	Understand	2
9	**Derive** the expression for attenuation constant for dielectric loss.	Remember	2
10	**Write** short notes on “Rectangular resonant Cavity”	Understand	2
11	**Write** short notes on “Cavity resonators and its applications”.	Understand	2
12	**What** is a cavity resonator? Discuss the applications of cavity resonators.	Remember	2
13	**Derive** the expression for the resonant frequency of a rectangular cavity resonator.	Understand	2
14	A rectangular cavity of width ‘a’ height ‘b’ and length ‘d’ is to resonance with TE101 mode. Show that the frequency of resonance If frequency = 10GHz, a= 2 cm., and b = 1cm, find ‘d’	Understand	2

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
15	**Discuss** how wave equations are useful in understanding the propagation of EM waves in wave guides.	Create	2
	UNIT-III **WAVEGUIDE COMPONENTS AND APPLICATIONS-I**		
1	**Explain** the operation of a directional coupler with the help of a sketch, showing the field lines at the junction.	Understand	3
2	A 20 dB coupler has a directivity of 30 dB. Calculate the value of isolation.	Understand	3
3	**Derive** the expression for the coupling and directivity of a two hole directional coupler.	Remember	3
4	There are two identical directional couplers connected back to back to sample incident and reflected powers. The outputs of the couplers are 12 mw and 0.12 mw respectively. What is the VSWR in the guide?	Analysis	3
5	**Sketch** a 4 port hybrid junction and justify that it is a basically a 3 dB directional coupler.	Understand	3
6	**Write** short notes on: (a) Wave guide Irises (b) Rat? Race hybrid (c) Dielectric phase shifters	Understand	3
7	**Show** that a symmetrical magic Tee is a 3dB directional coupler.	Understand	3
8	**Write** short notes on the following. (a) Directional coupler. (b) Wave guide windows. (c) Flap attenuator.	Understand	3
9	**Explain** the working of two hole directional coupler with a neat diagram.	Understand	3
10	**Explain** about E plane Tee junction with a neat sketch. Why it is called a series Tee?	Understand	3
11	**Derive** the expressions for coupling factor and directivity of a two hole directional coupler.	Apply	3
12	**What** are the different types of matching elements normally used in wave guide system? Distinguish between magic Tee and rat race hybrid.	Remember	3
13	**Draw** the H-plane Tee junction and explain its properties.	understand	3
	UNIT-IV **WAVEGUIDE COMPONENTS AND APPLICATIONS-II**		
1	**What** are the properties of ferrite material for applications at microwave frequencies? Explain the principle of ferrite phase shifter.	Understand	4
2	**Explain** Faraday rotation with a neat diagram? Explain the working of ferrite isolator.	Understand	4
3	Give the scattering matrix of 3 port circulator. The scattering variables measured at a port area = 5 + j2 and b = 2 + j2The normalizing impedance Z0 = 50 ohms. Calculate the voltage and current.	Understand	4
4	**Explain** the principle of operation of an isolator? What is the significance of using isolator in microwave circuits?	Understand	4
5	**Why** are S - parameters used at microwave frequencies explain? Give the properties of S -parameters.	Remember	4

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
6	**What** is a Gyrator? Describe how isolators can be realized by using Gyrators and Hybrids. Give the S matrix for an ideal Gyrators.	Remember	4
7	A Three port circulator has an insertion loss of 1dB, isolation 30 dB and VSWR = 1.5. Find the S - matrix.	Understand	4
8	**Derive** the S - matrix for 4 port directional coupler when the coupling factor is 3dB.	Analyze	4
9	**What** is Faraday rotation? Explain the working of a ferrite circulator with neat sketches. How can it be used as an isolator?	Remember	4
10	**Describe** any one microwave component which make use of Faraday rotation principle, with neat sketches.	Understand	4
11	**Explain** the principle of operation of an isolator. What is the significance of using isolator in microwave circuits?	Understand	4
12	**Explain** the characteristics of a 3 port circulator listing its S- matrix. How can this be used as an Isolator?	Understand	4
	UNIT-V **MICROWAVE TUBES-I**		
1	A reflex klystron operates at the peak mode of n = 2 with Beam voltage V0 = 300V Beam current I0 = 20mA Signal Voltage V1 = 40V. Determine: i. Input power in watts. ii. Output power in watts. iii. The efficiency.	Understand	5
2	**Derive** the relation between accelerating voltage V0 , repeller voltage VR & repeller space L.	Understand	5
3	A reflex klystron operates with Vb = 400V, Rsh = 20k, f = 9GHZ, L = 10−3m. n = 2. Find the repeller voltage & electronic efficiency.	Understand	5
4	**Derive** the expression for output power & Efficiency of a 2 cavity klystron.	Understand	5
5	**Explain** in detail bunching process & obtain expression for bunching parameter in a two cavity klystron amplifier.	Understand	5
6	**What** are the limitations of conventional tubes at microwave frequencies? Explain how these limitations can be overcome.	Understand	5
7	A reflex klystron having an accelerated field of 300v oscillates at a frequency of 10GHZ with a retarding field of 500v. If its cavity is returned to 9GHZ. What must be the new value of retarding field fro oscillations in the same mode to take place?	Analysis	5
8	**Give** the analysis of reflex klystron & derive the expression for repeller voltage Vr in terms of l,n & Va.	Understand	5
9	**Name** different methods of generating microwave power. Describe the necessary theory & Working of reflex klystron.	Understand	5
10	**Explain** in detail bunching process & obtain expression for bunching parameter in a two cavity klystron amplifier.	Understand	5
11	**Explain** the principle of operation of a reflex Klystron oscillator and derive an expression for the bunching parameter.	Understand	5
12	**Explain** the construction & working of two cavity klystron amplifier.	Remember	5
13	By means of applegate diagram explain the operation of a reflex klystron.	Understand	5

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
	Show that the theoretical efficiency of reflex klystron is 27.78%.		
	UNIT-VI **HELIX TWTs**		
1	**Compare** & contrast TWT & Klystron amplifier.	Understand	6
2	**Explain** the construction & working of TWT.	Understand	6
3	**Give** the different types & explain the characteristics of slow wave structure.	Understand	6
4	**What** are the slow wave structures? Explain how a helical TWT achieves amplification.	Understand	6
5	**Draw** a neat sketch of traveling wave tube and explain its principle of operation with bunching diagrams.	Understand	6
6	**Draw** the sketches of different types of magnetron anodes.	Understand	6
7	**Write** short notes on “8 cavity magnetron”	Understand	6
8	**Discuss** types of magnetrons and list the important applications.	Understand	6
9	**How** is bunching achieved in a cavity magnetron? Explain the phase focusing effect.	Understand	6
10	**Explain** Hatree conditions. Derive the voltage under this condition for linear magnetron.	Understand	6
	UNIT-VII **MICROWAVE SOLID STATE DEVICES**		
1	**Explain** Gunn effect using the two valley theory.	Understand	7
2	**Derive** the criterion for classifying the modes of operation for Gunn effect diodes.	Understand	7
3	An n-type GaAs Gunn diode has following parameters Electron drift velocity: Vd = 2.5 × 105m/s Negative Electron mobility: µn= 0.015 m2/ v s Relative dielectric constant: _r = 13.1 Determine the criterion for classifying the modes of operation.	Understand	7
4	**Derive** the equation for power output & efficiency of IMPATT diode.	Remember	7
5	**Determine** the conductivity of n-type Ga As Gunn diode if Electron density n = 1018 cm−3 Electron density at lower valley nl = 1010 cm−3 Electron density at upper valley nu = 108 cm−3 Temperature T = 300oK.	Understand	7
6	A Ku-band IMPATT diode has a pulse operating voltage of 100v and a pulse operating current of 0.9 A. The efficiency is about 10%. Calculate i. The output power ii. The duty cycle if the pulse width is 0.01ns and frequency is 16 GHz.	Understand	7
7	**What** are cross field devices? How does a magnetron sustain its oscillations using this cross field? Assume π-mode for explaining the same.	Understand	7
8	**Explain** how oscillations are sustained in the Cavity Magnetron, with suitable sketches.	Understand	7

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
9	**Explain** fully the Gunn effect, whereby negative resistance, and therefore oscillations are obtainable under certain conditions from bulk gallium arsenide and similar semiconductors.	Remember	7
10	**Describe** the principle of operation of IMPATT diode.	Understand	7
11	**Explain** the physical structure and construction of IMPATT diodes.	Remember	7
12	**Draw** the graph between negative resistances versus transit angle and explain its Shape.	Analysis	7
13	**Write** short notes on "LSA mode in GUNN diode".	Analysis	7
14	**Compare** IMPATT and TRAPATT diodes.	Remember	7
15	**Derive** the criterion for classifying the modes of operation for Gunn effect diodes.	Understand	7
16	**Describe** the principle of operation of TRAPATT diode.	Remember	7
17	**Describe** the principle of operation of BARITT diode.	Remember	7
18	**What** are the limitations of LSA modes of Gunn diodes?	Remember	7
19	**With** the help of two valley model along with the emphasis of drift velocity, explain the negative resistance property of a Gunn diode	Remember	7
	UNIT-VIII **MICROWAVE MEASUREMENTS**		
1	A slotted line is used to measure the frequency and it was found that the distance between the nulls is 1.85 cm. Given the guide dimension as 3cm X 1.5 cm. Calculate the frequency.	Understand	8
2	**Calculate** the standing wave ratio of a transmission system operating at 8 GHz .The distance between twice minimum power points is 0.9 mm on a slotted line whose velocity factor is unity.	Understand	8
3	**Calculate** the VSWR of a transmission system operating at 10 GHz. Assume TE_{10} wave transmission inside a waveguide of dimensions a = 4 cm, b = 2.5 cm. The distance measured between twice minimum power points = 1 mm on the slotted line.	Understand	8
4	**Explain** the following methods for microwave frequency measurement i) Slotted line method ii) Resonant cavity method	Remember	8
5	**Explain** Slotted line method for impedance measurement.	Understand	8
6	**Explain** the following techniques for microwave power measurement i)Thermocouple detector ii)Bolometer mount technique	Understand	8
7	In a microwave power measurement set up, the microwave pulse had an average power of 250W and a duration of 5micro seconds. If the time interval between pulses were measured as 2m/sec. Determine the values of the peak power?	Understand	8
8	Double minimum method is used to determine the VSWR values on a waveguide. If the separation between the two adjacent nulls is 3.5cm and that between twice minimum power point is 2.5mm. Determine the values of VSWR?	Remember	8

S. No	QUESTION	Blooms Taxonomy Level	Course Outcome
9	**Draw** a neat diagram of microwave test bench and explain about each block along with its features.	Understand	8
10	**Explain** the measurement of microwave power using bolometer method.	Remember	8
11	**Explain** the power ratio method of measurement of attenuation.	Understand	8
12	**Explain** the method of measurement of high VSWR.	Understand	8
13	**Explain** the RF substitution method of measurement of attenuation.	Understand	8
14	**Explain** the measurement of Q of a cavity resonator.	Understand	8
15	**Explain** the frequency measurement techniques.	Understand	8
16	**Explain** the measurement of unknown impedance using Smith Chart.	Understand	8
17	**Explain** the measurement procedure to measure guide-wavelength.	Understand	8
18	In the X-Band lab microwave test bench measurement, it is found that the distance between two successive minima is 2.5 cm. Calculate the frequency of the microwave source. Assume inside dimensions of X-Band waveguide to be 2.286 Cm x 1.016 Cm.	Understand	8
19	**Explain** the general method of measuring Q of a cavity.	Understand	8
20	**Name** five types of test equipment used to make microwave measurements.		8
21	**Draw** the block diagram setup to measure attenuation. Write the steps involved in measuring attenuation.	Understand	8
22	**Explain** the measurement of low VSWR (S<20). What are the possible sources of error in these measurements?	Understand	8
23	**What** are the different techniques employed in measuring impedance? Explain any one method.	Remember	8
24	**Explain** the measurement of frequency using wave meter method.	Understand	8
25	**Explain** the high power measurements using calorimetric method.	Understand	8

3. Group - III (Analytical Questions)

S. No	QUESTIONS	Blooms Taxonomy Level	Program Outcome
	UNIT-I **MICROWAVE TRANSMISSION LINES-I**		
1	Can a waveguide have more than one cut-off frequency? On what factors does the cut-off frequency of a wave guide depend?	Understand	1
2	**When** the dominant mode is propagated through a waveguide at a frequency of 9GHz, the guide wavelength is found to be 4cms. Find the breadth of the waveguide.	Remember	1

S. No	QUESTIONS	Blooms Taxonomy Level	Program Outcome
	UNIT-II **MICROWAVE TRANSMISSION LINES-II**		
1	**Prove** that it is impossible to construct a perfectly matched, loss less, reciprocal three port junction.	Remember	1
2	A wave length termination having VSWR of 1.1 is used to dissipate 100 W of power. Find received power	Remember	1
3	An attenuator of 20dB is fed with 100w input. Find the output power of the attenuator.	Understand	1
	UNIT-III **WAVEGUIDE COMPONENTS AND APPLICATIONS-I**		
1	**Formulate** the expression for optimum drift space distance $L_{optimum}$ in a Two Cavity Klystron Amplifier.	Create	3
2	A reflex klystron operates at 8 GHz with dc beam voltage 300 V, repeller space=1mm for 1 mode. Calculate P_{RFmax}	Remember	3
3	**Determine** the gain parameter C for a TWTA with Beam current 30mA, characteristic impedance 10Ω, and Beam voltage 3KV.	Evaluate	3
	UNIT-VI **HELIX TWTs**		
1	A Gunn device operates in the transit time mode of 20 GHz.If it is fabricated from gallium arsenide, find length of device. Consider that $V_S=10^7$ cm/s	Understand	6
2	An IMPATT diode has a drift length of 2µm. Determine the operating frequency of the IMPATT diode if the drift velocity for Si is 10^7 cms/sec	Remember	6
3	**Determine** the hull cutoff voltage for a given anode voltage of 26kv. Assume radii of cathode and anode cylinders as 5cm and 10cm respectively.	Evaluate	6
	UNIT-VIII **MICROWAVE MEASUREMENTS**		
1	In a microwave measurement it is observed that λ_0=3 cm and λ_C=4 cm. Find λ_G.	Remember	8
2	The peak power is 1KW. The duty cycle is 10^{-3}. Find the average power.	Remember	8
3	Convert -30 dBm and 0 dBW into absolute power.	Understand	8
4	The reflection coefficient of a given microwave component is 0.5. Find its VSWR.	Remember	8
5	**Find** the Q of a cavity resonator, if its resonating frequency and bandwidth are 9 GHz and 1MHz respectively	Understand	8
6	The input power given to an attenuator is 1000 W. The output power produced by the attenuator is 1W. Calculate the value of the attenuator.	Remember	8