MODEL ANSWER

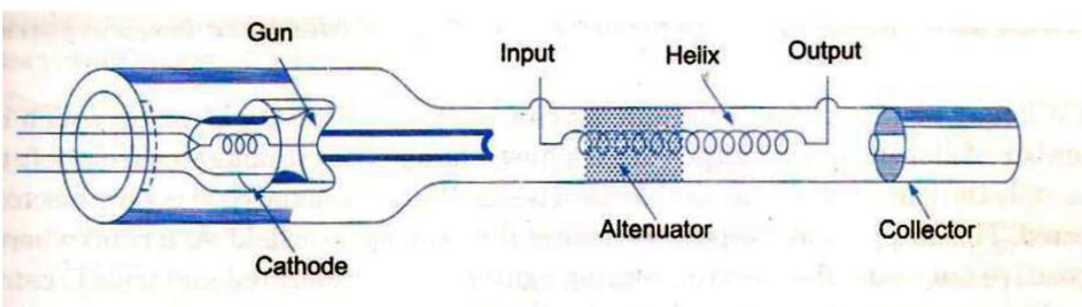
SUMMER– 17 EXAMINATION

Subject Title: Advanced communication systems Subject Code: 17656

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q.N.	Answer	Marking Scheme
Q.1	(A)	**Attempt any THREE :**	12-Total Marks
	(a)	**Define the terms w.r.t. waveguide :** (i) Cut-off frequency (ii) Phase velocity (iii) Group velocity (iv) Guided wavelength of waveguide	4M
	Ans:	**Cut-off frequency:** It is the frequency of the signal above which propagation of waves occur. $$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$ **Phase velocity:** Phase velocity is defined as the rate at which the wave changes its phase in terms of the guide wavelength. **OR** The phase velocity is the velocity with which the wave changes phase in a direction parallel to the conducting surface. Mathematically The phase velocity is given by $$v_p = \frac{v_c}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}}$$	(1M Each Definition)

		Group velocity: It is defined as the rate at which the wave propagates through the waveguide and is given by $$v_g = v_c\sqrt{1-(\frac{\lambda}{\lambda_c})^2}$$ **OR** $$v_g = v_c \sin\theta$$ The group velocity is also can be defined as the velocity of energy flow in the waveguide system. **Guided wavelength of waveguide:** It is defined as the distance travelled by the wave in order to undergo a phase shift of 2π radians along the waveguide. $$\lambda_g = \frac{\lambda}{\sqrt{1+\left(\frac{\lambda}{\lambda_c}\right)^2}}$$ where λ = wavelength of the signal λ_c = cut off wavelength	
	(b)	**Draw labeled sketch of TWT. Give two applications.**	**4M**
	Ans:	**Diagram :**  **Applications:** **(Any 2 Applications)** • Low noise RF amplifier in broadband microwave receivers. • Repeater amplifiers for long distance telephony. • Used as power output tube in communication satellites. • Continuous wave high power TWT"s are used in troposcatter links. • Airborne and ship borne pulsed high power radars, EM ground based radars.	**3M** **1M**
	(c)	**Describe the principle of Doppler effect used in Radar system.**	**4M**
	Ans:	**DOPPLER EFFECT :** When the target is moving relative to radar it will result in, an apparent shift in the carrier frequency of the received signal. This effect is called the doppler effect and it is the basic of Continuous Wave(CW) radar.	**4M**

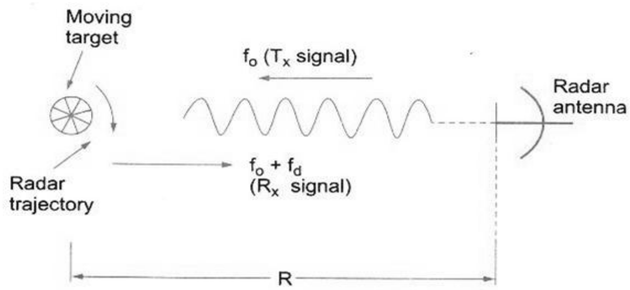


Fig. 11.39

If R is the distance of the target from radar station, the total number of wavelengths contained in the two-way path = $\frac{2R}{\lambda}$ where, λ = wavelength of the transmitted wave. (Refer Fig. 11.39).

Since one wavelength corresponds to a phase shift of 2π rads, the total phase shift

$$\phi = 2\pi \times 2\,R/\lambda \quad i.e. \quad \phi = \frac{4\pi R}{\lambda} \text{ rad} \qquad ...(11.20)$$

If the target is in motion, R (the range) and ϕ (phase) are continuously changing.

A change in ϕ with respect to time is equal to frequency. The *doppler angular frequency* (ω_d) is given by,

$$\omega_d = 2\pi f_d = \frac{d\phi}{dt} = \frac{d}{dt}\left(\frac{4\pi R}{\lambda}\right) = \frac{4\pi}{\lambda}\cdot\frac{dR}{dt} = \frac{4\pi}{\lambda}\cdot v_r \qquad ...(11.21)$$

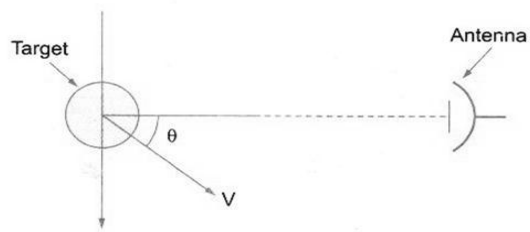
where, f_d = doppler frequency shift

v_r = relative velocity of target with respect to radar

$$\therefore \quad f_d = \frac{2v_r}{\lambda} \text{ Hz} \qquad ...(11.22)$$

The relative velocity (v_r) may be written as (as per Fig. 11.40)

$$v_r = v \cos\theta$$



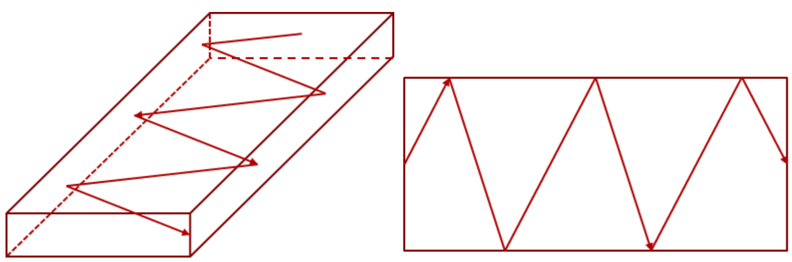
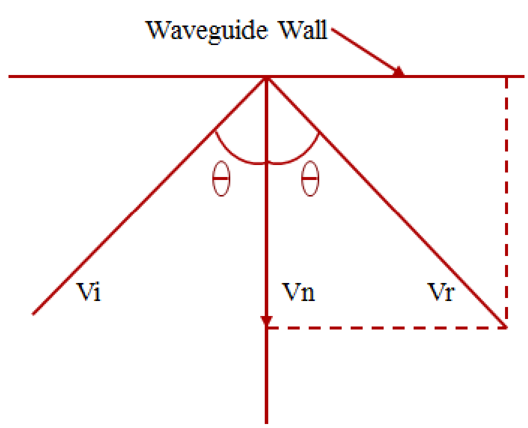
$$\therefore \quad f_d = \frac{2v\cdot\cos\theta}{\lambda}$$

where, v = speed of the target

θ = angle made by target trajectory and line joining radar and target.

On the basis of this frequency change it is possible to determine the relative velocity of target with either pulsed or CW radar.

	(d)	**Define following terms w.r.t. satellite :** **(i) Foot print**	**4M**

	(ii) Azimuth angle	
Ans:	**Definition :** **Foot print:** The footprint of a satellite is the earth area that the satellite can receive from or transmit to. This is a function of both the satellite orbit and height and the type of antenna the satellite uses. **Azimuth angle:** The angle measured clockwise from the true north to the projection of satellite (sub-satellite point) on the horizontal plane at the earth station is called as azimuth. **OR** It is also defined as the horizontal pointing angle of an antenna. It is usually measured in a clockwise direction in degree from true north.	**2M Each**
(B)	**Attempt any ONE :**	**6M**
(a)	**With neat diagram describe propagation of microwave through rectangular waveguide. In which condition it becomes dominant mode?**	**6M**
Ans:	**Diagram :**   **Explanation :** • The angle of incidence and angle of reflection of wave fronts vary in size with the frequencies of the input energy. • Arrow shows the direction of propagation. • The cut off frequency in the waveguide is the frequency that causes angles of	**2M** **(3M and 1M condition for**

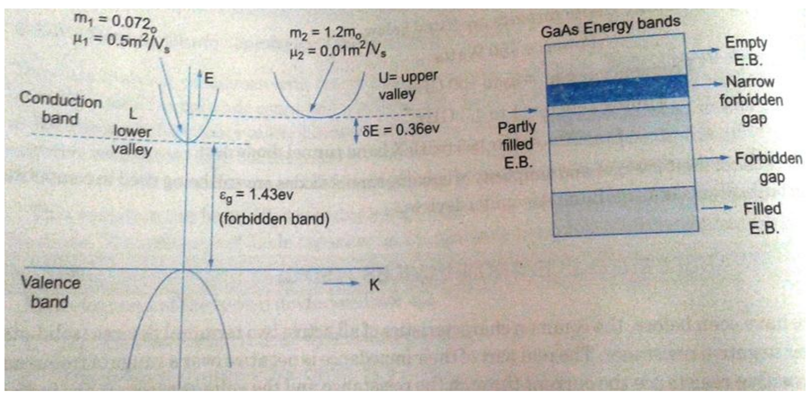
incidence and reflection to be perpendicular to the wall of guide.

- If the frequency is below the cut off frequency, the wave fronts will be reflected back and forth across the waveband and no energy will be conducted down the waveguide.
- The velocity of propagation of wave along a waveguide is less than its velocity through free space. This lower velocity is caused by zigzag path taken by wavefront in a waveguide.
- The wave propagates down the waveguide in a zigzag manner with the Electric field maximum at the center of the guide and zero at the walls.
- Due to this pattern Waves can no longer be TEM because propagation by reflection requires not only a normal component but also a component in the direction of propagation for either the electric or magnetic field, depending on the way in which waves are set up in the waveguide.
- The mode with the lowest cutoff frequency is termed the dominant mode of the guide. It is usual to choose the size of the guide such that only this one mode can exist in the frequency band of operation.

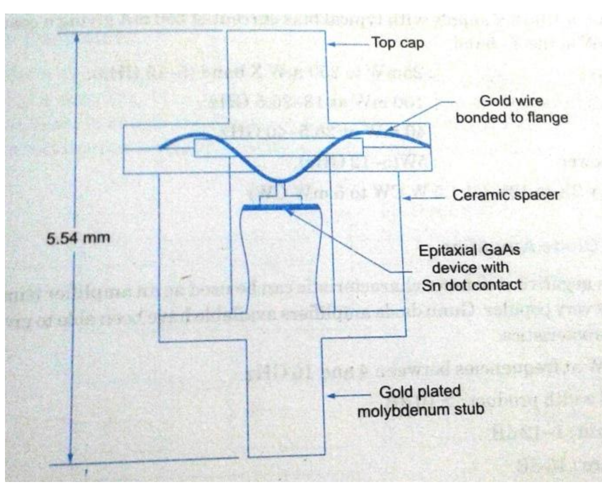
dominant mode.)

(b) With neat sketch describe the operation of GUNN diode. **6M**

Ans: **<u>Diagram :</u>** **3M**



<u>Diagram :</u>



<u>Description :</u>

- The Gunn Diode is a semiconductor device formed by sandwiching a lightly doped N type region between two heavily doped N type regions.
- When a dc bias of value equal or more than the threshold field (of about 3.3kV/cm) is applied to an n-type GaAs sample, the charge densities and electric field within the sample become non-uniform creating domains i.e. electrons in some region of the sample will be first to experience the valley transfer than the rest of the sample. **3M**
- The electric field inside the dipole domain will be greater than the fields on either side of the dipole. So the electrons in that region or domain will move to U – valley and hence will have reduced mobility.
- This creates a slight deficiency of electrons in the region immediately ahead. This region of excess and deficient electrons forms a dipole layer.
- As the dipole drifts along, more electrons in the vicinity will get transferred to the U – valley until the electric field outside the dipole region is depressed below the threshold electric field.
- This dipole continues towards the anode until it is collected. Upon collection, the field in the sample jumps immediately to its original value and the next domain formation begins as soon as the field value exceeds the threshold value and this process is repeated cyclically

Q 2 **Attempt any FOUR :** **16M**

(a) **Differentiate between waveguide and two wire transmission line.** **4M**

Ans:

(1M Each Any 4 Points)

Waveguide	**Two wire Transmission line**
A waveguide is a hollow metallic pipe design to carry microwave energy from one place to another	Transmission on line is a conductor or wire designed to carry electrical energy below microwave range from one place to another
Used for Microwave frequency above 1GHz	Used for RF up to 500 in GHz. Upto 18 GHz. For short distance.
Power handling capacity is high	Power handling capacity is low
Wave theory is considered in waveguide analysis	circuit theory considered in Transmission line
The large surface area of waveguide reduces copper losses	Two wire transmission line have large copper losses due to small surface area
Dielectric losses are less in waveguide	Dielectric losses are more in Two wire Transmission line
If the other end is also closed, then the hollow box so formed can support a signal which can bounce back and forth between	If one of the end of the waveguide is closed using a shorting plate, there will be a reflection and hence standing waves

two shorting plates resulting in resonance.	will be formed

(b)	**Describe working of reflex klystron amplifier with a neat diagram.**	**4M**
Ans:	**Diagram :**	**2M**

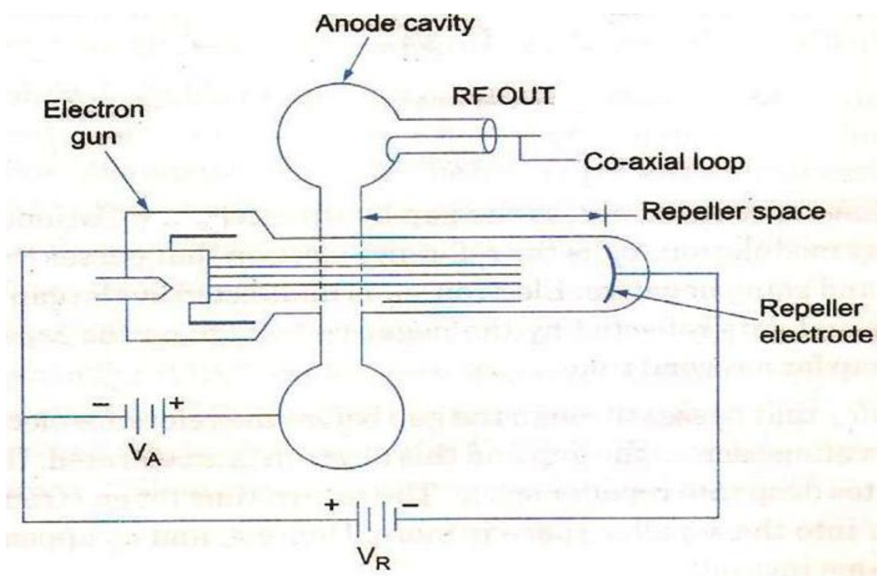
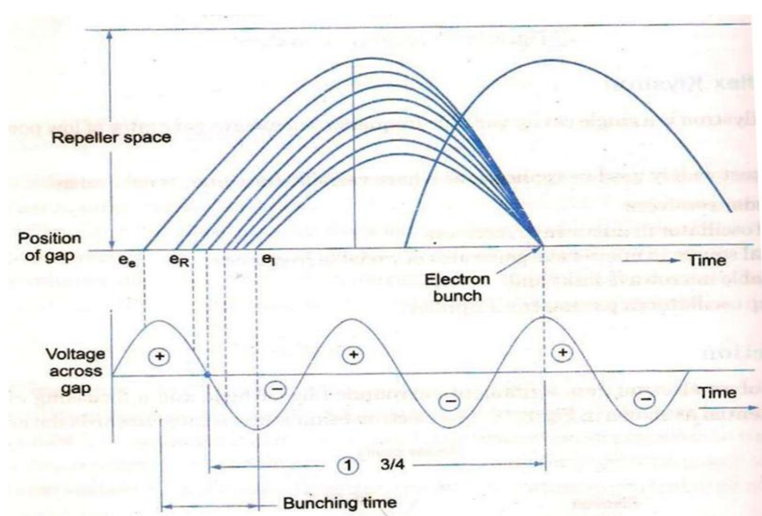


Diagram :



Working :

- The RF voltage that is produced across the gap by the cavity oscillations act on the electron beam to cause velocity modulation. er is the reference electron taken as the one that passes the gap on its way to the repeller at the time when the gap voltage is zero and going negative. This electron is unaffected, overshoots the gap and is ultimately returned to it having penetrated some distance into the repeller space. **2M**

- The early electron ee that passes the gap before the reference electron, experiences a positive voltage at the gap. This electron is accelerated and moves with greater velocity and penetrates deep into repeller space. This electron will take slightly greater time than the reference electron to return to the gap.
- The late electron el that passes through the gap later than reference electron experiences negative voltage at the gap. This electron is retarded and shortens its stay in the repeller space and will return earlier to the gap as compared to the reference electron. So, the late electron will be able to catch up with ee and eR electrons forming the bunch.
- Bunches occur once per cycle centered on the reference electron. These bunch transfer maximum energy to the gap to get sustained oscillations.

(c) Write RADAR range equation and state the factor affecting maximum range of RADAR. **4M**

Ans: **RADAR RANGE EQUATION:** **1M**

Equation :

$$R_{max} = [(P_t G^2 \sigma \lambda^2)/(4\pi)^3 S_{min}]^{1/4}$$

The factors influencing maximum range are as follows : **(3M for Factors)**

1. **Transmitted power (Pt):** if the radar range is to be doubled we have to increase a transmitted power by 16 times.
2. **Frequency(f) :** increase in frequency increase the range
3. **Target cross sectional area(€):** Radar cross sectional area of the target is not a controllable factor.
4. **Minimum received signal (S_{min}):** A decrease in minimum receivable power will have the same effect has raising the transmuting power.

(d) List uplink and downlink frequency for different bands used in satellite communication. **4M**

Ans: **(2M Uplink frequency, 2M downlink frequency)**

Band	Uplink (GHz)	Downlink (GHz)
UHF – Military	0.292 – 0.312	0.25 – 0.27
C – Commercial	5.925 – 6.425	3.7 – 4.2
X – Military	7.9 – 8.4	7.25 – 7.75
Ku - Commercial	14 – 14.5	11.7 – 12.2
Ka – Commercial	27.5 – 30	17.7 – 21.2
Ka – Military	43.5 – 45.5	20.2 – 21.2

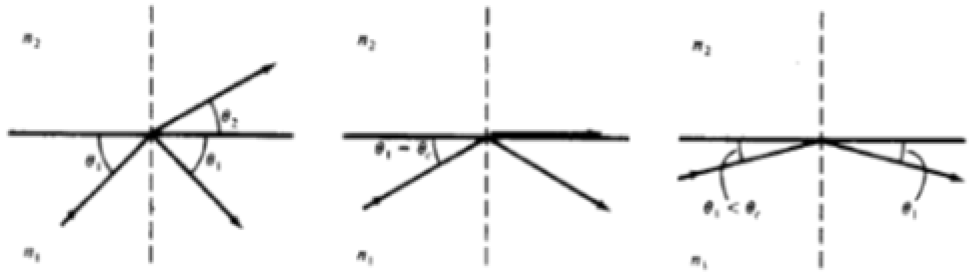
(e) Define the following with respect to optical fiber communication : **4M**

(i) Critical angle

(ii) Snell's law

With suitable diagrams.

Ans: **Critical angle:**

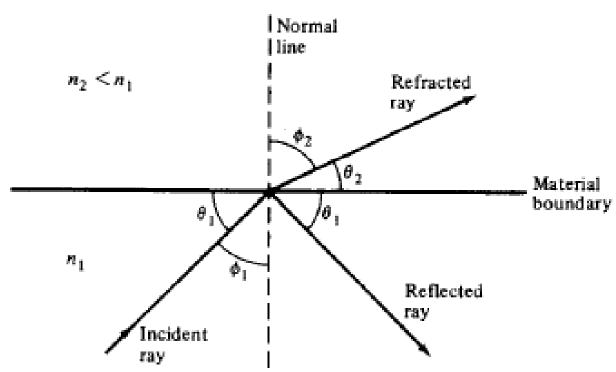


- Above figure shows a glass surface in air. A light ray gets bent towards the glass surface as it leaves the glass in accordance to Snell's law.
- If the angle of incidence θ_1 is decreased, a point is reached where the light ray in air is parallel to the glass surface. This angle is known as the **critical angle of incidence θ_c**.
- **$\sin \theta_c = n_2/n_1$**

(2M each Definition)

Snell's law:

1. How a light ray reacts when it meets the interface of two transmissive materials that have different indices of refraction can be explained with Snell's law.
2. A refractive index model for Snell's law is shown in figure below.

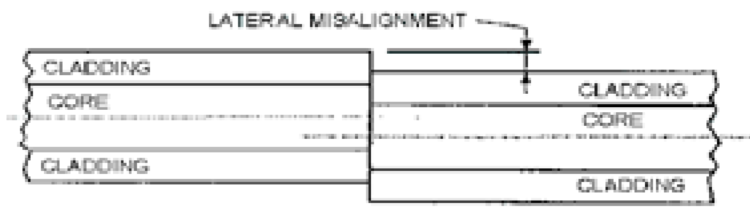
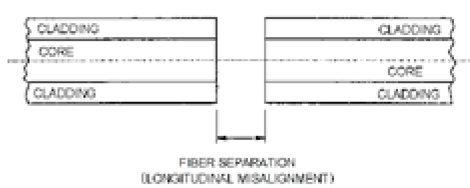
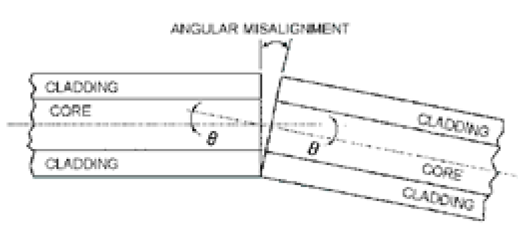


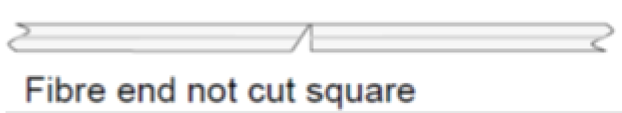
3. At the interface of medium 1 and medium 2, the incident ray may be refracted toward the normal or away from it, depending on whether η_1 is greater than or less than η_2. Hence angle of refraction can be greater or smaller than the angle of incidence, depending on the refractive indices of the two materials.
4. The relationship at the interface is known as Snell's law and is given by

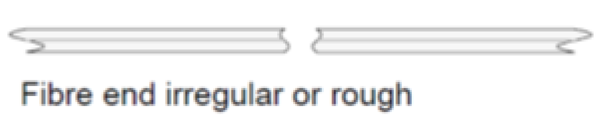
$$\eta_1 \sin \emptyset_1 = \eta_2 \sin \emptyset_2$$

or equivalently, $\eta_1 \cos \theta_1 = \eta_2 \cos \theta_2$
where the angles are defined in the figure above.

(f)	**Describe coupling losses occur in optical fiber communication with neat diagrams.**	**4M**

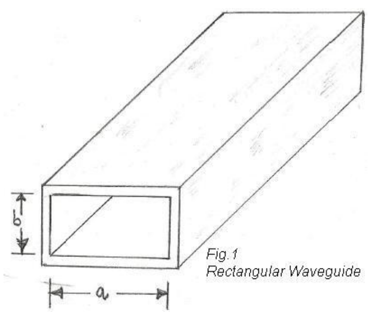
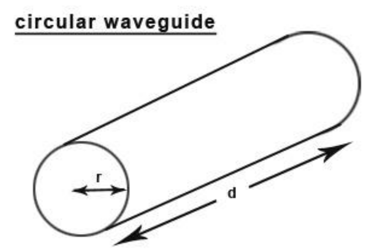
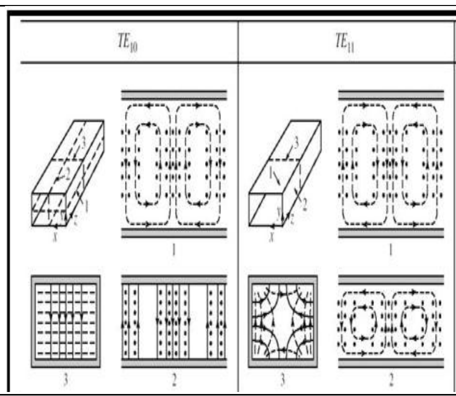
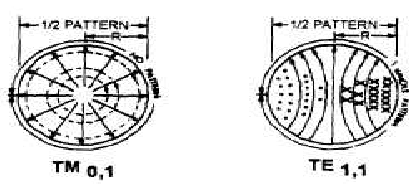
	Ans:	**Coupling Losses/Connector losses:** • In fiber cables, coupling losses can occur at any of the following three types of optical junctions- light source to fiber connection, fiber to fiber connections and fiber to photo detector connections. Junction losses are most often caused by one of the following alignment problems: **Lateral Misalignment:** • The lateral or axial displacement between two pieces of adjoining fiber cables is as shown in the figure. The amount of loss can be from a couple of tenth of a decibel to several decibels. This loss is generally negligible if the fiber axes are aligned to within 5% of the smaller fiber diameter.  **Gap Misalignment:** • This is sometimes called as end separation as shown in figure. When splices are made in OF's, the fibers should actually touch. The farther apart the fibers are, the greater the loss of light. If two fibers are joined with the connector, the ends should not touch. This is because two ends rubbing against each other in the connector could cause damage to either or both fibers.  **Angular Misalignment:** • This is shown in figure and is sometimes called angular displacement. If the angular displacement is less than 2°, the loss will be less than 0.5dB.  	**1M each problems.**

<table>
<tr><td></td><td></td><td><u>Imperfect Surface finish:</u>
This is shown in figure. The ends of the two adjoining fibers should be highly polished and should fit together squarely. If the fiber ends are less than 3° off from the perpendicular, the losses will be less than 0.5dB.




</td><td></td></tr>
<tr><td>Q. 3</td><td></td><td>Attempt any FOUR :</td><td>16M</td></tr>
<tr><td></td><td>(a)</td><td>Compare rectangular waveguide and circular on the basis of :
(i) Definition
(ii) Construction
(iii) Application
(iv) Field pattern</td><td>4M</td></tr>
</table>

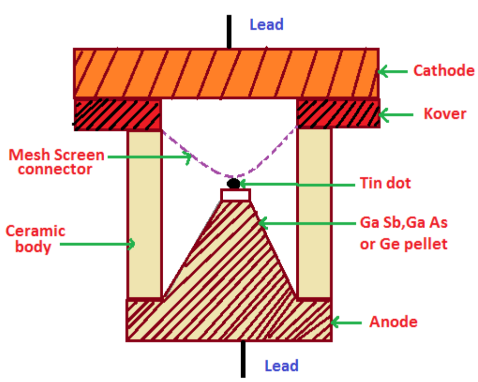
Ans:

Parameter	Rectangular waveguide	Circular waveguide
Definition	It is a hallow metallic tube of rectangular cross section to carry microwave signal from one point to another.	It is a hallow metallic tube of circular cross section to carry microwave signal from one point to another.
Construction	A hallow metallic tube is made up of brass or copper.The inner walls are coated with gold. 	A hallow metallic tube is made up of brass or copper.The inner walls are coated with gold. 
Application	Almost in all microwave applications rectangular waveguides are used due to their small size.	In Rotational coupling
Field pattern		

(1M each parameter)

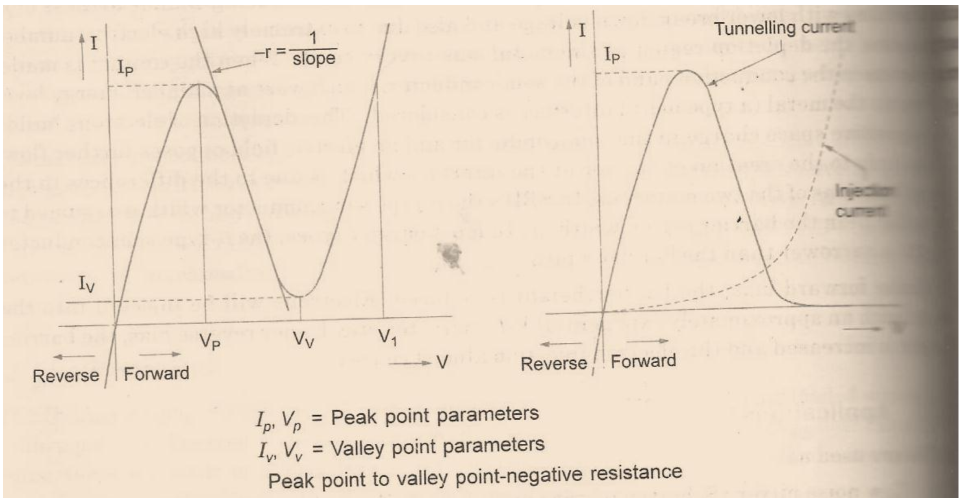
(b) Sketch the construction of Tunnel diode and write its operation. **4M**

Ans: **<u>Diagram :</u>** **2M**

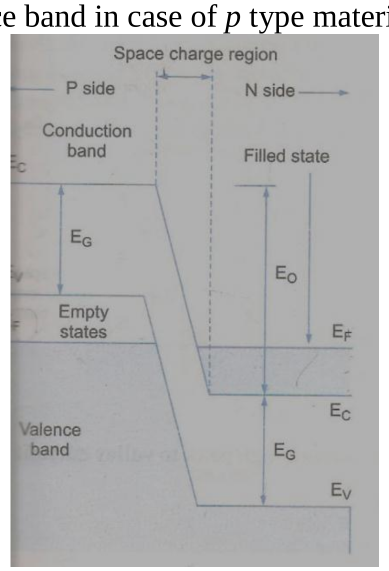


Explanation :

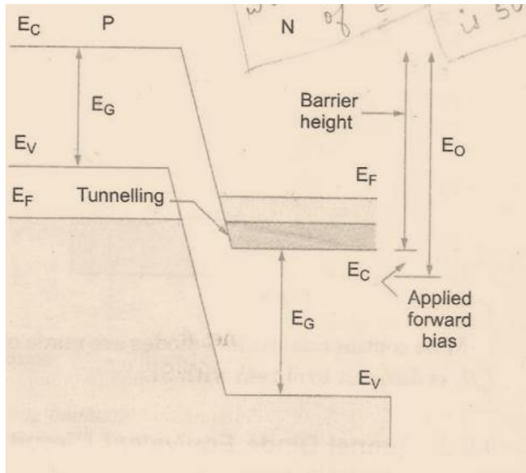
1. Tunnel diode is a specially made p-n junction device which exhibits negative resistance over part of the forward bias characteristic. It has an extremely heavy doping on both sides of the junction and an abrupt transition from the p-side to the n-side. The tunneling effect is a majority carrier effect and is consequently very fast. **2M**
2. The tunnel effect controls the current at very low values of forward bias where the normal or the injection current is very small as shown in figure below.



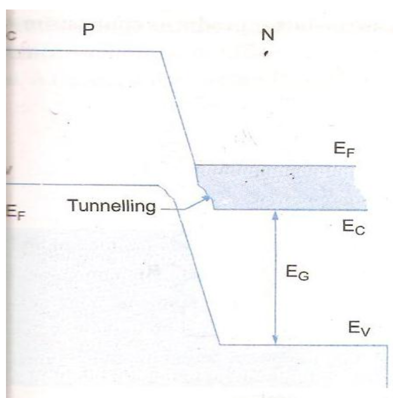
1. An electron on one side of the barrier will have a certain probability of leaking through the barrier if barrier is very thin. If both *p* and *n* type materials of a junction are heavily doped, the depletion region becomes very narrow; as narrow as the order of 100Å.
2. Another effect of heavy doping is to widen the donor level in *n* material and the acceptor level in the *p* material respectively.
3. The Fermi level also moves up into the conduction band in case of *n* material and moves down in the valence band in case of *p* type material.



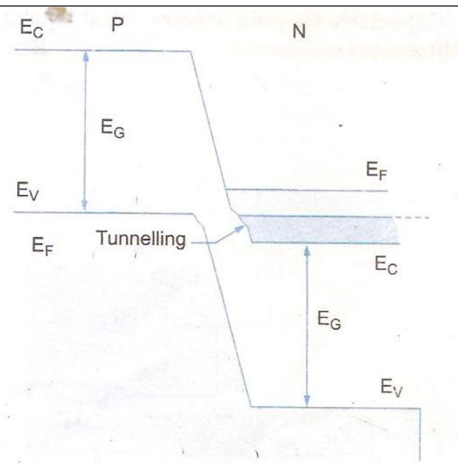
4. Under unbiased condition, there is just the same probability of electrons going from states in the conduction band on the *n* side to the states in the valence band on the *p* side, as in the opposite direction. Net tunneling on the thin barrier is then zero.
5. As forward bias is applied the energy levels on the *n* side are raised relative to those on *p* side and consequently the electrons in the conduction band on the *n* side see empty states just across the barrier and tunneling takes place.



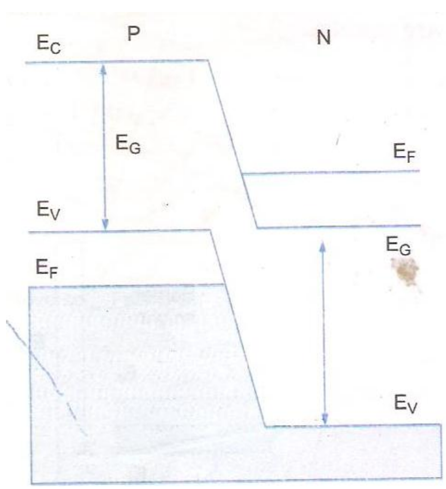
6. This tunneling current will read a maximum value I_p at a forward bias V_p of the order of 0.1V as shown in figure below.

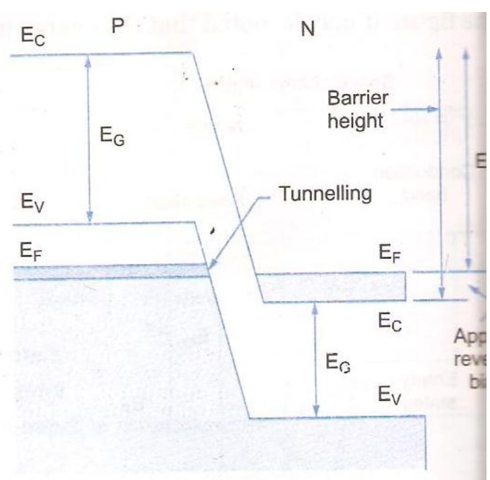


7. As the forward bias is further increased, the energy levels on *n* side are raised so high that only part of the electrons in the conduction band sees available energy levels across the barrier as shown in figure below. Thus the tunneling current is reduced as the bias increases. This phenomenon, the suppression of tunneling, is responsible for the negative resistance part of the diode characteristic.



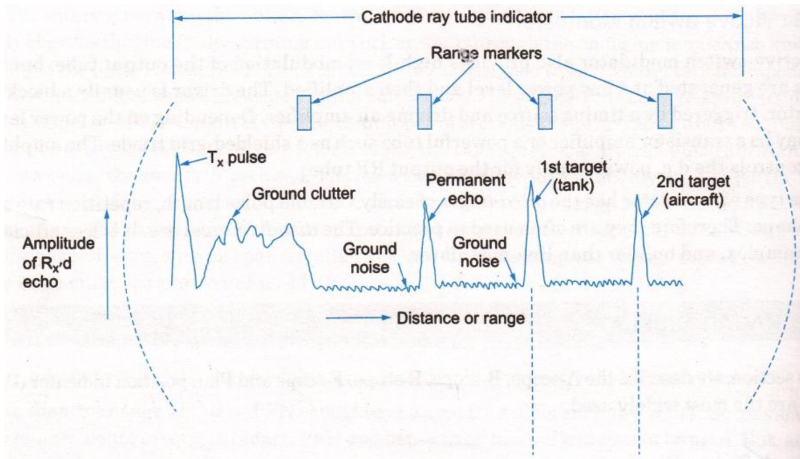
8. If a reverse bias voltage is applied, the height of the barrier is increased above the open circuit value E_0 as shown in fig.(f). It is observed that there are some energy states in the valence band of the *p* side which lie at the same level as allowed empty states in the conduction band of the *n* side. Hence these electrons will tunnel through from the *p* side to the *n* side, giving rise to reverse diode current. As reverse bias increases, diode current will increase. Hence the tunnel diode acts as a good conductor when reverse biased.





(c)	**Explain A-scope Display Method with diagram, used in Radar System.**	**4M**
Ans:		

Diagram : **2M**



Explanation : **2M**

- This is the most popular type of the deflection modulation type display system which indicates the range of the target.
- The A-scope display, shown in figure, presents only the range to the target and the relative strength of the echo.
- The A-scope normally uses an electrostatic-deflection crt. The sweep is produced by applying a sawtooth voltage to the horizontal deflection plates. The electrical length (time duration) of the sawtooth voltage determines the total amount of range displayed on the CRT screen.
- The ranges of individual targets on an A-scope are usually determined by using a movable range gate or step that is superimposed on the sweep.
- In addition to this there are various signals displayed on the screen corresponding to:
  - **Ground clutter** i.e. echoes from various fixed objects near the transmitter & from the ground.
  - **Grass noise** i.e. an almost constant amplitude & continuous receiver noise.
  - **Actual targets.** These signals are usually large.

(d)	**State four advantages of geo-stationary satellite.**	**4M**

Ans: ***Note: Any other relevant advantages can be considered.***

Advantages Of Geostationary Satellites: **(1M each advantage)**

1. This satellite remains almost stationary in respect to a given earth station. Consequently expensive tracking equipment is not required at earth stations.
2. High altitude geosynchronous satellites can cover a much larger area of the earth than their LEO satellite counterpart.
3. There is no need to switch from one satellite to another as they orbit overhead. Consequently there are no breaks in transmission because of switching times.
4. The effects of Doppler shift are negligible.

(e)	**Differentiate between satellite communication and fiber optic communication. (any four points)**	**4M**

Ans: ***Any Other relevant point can be considered.*** **1M Each**

Parameter	Satellite communication	Optical fiber

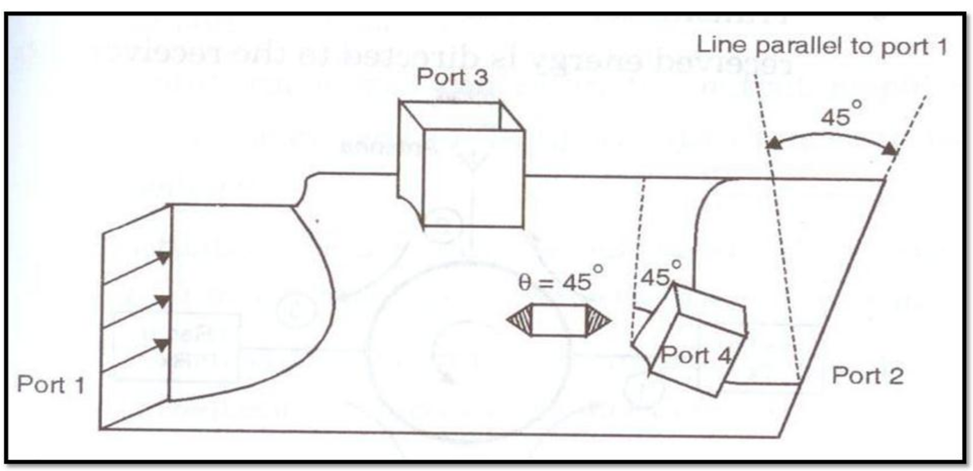
		communication
Frequency range	1GHz to 100GHz	10^{14}Hz to 10^{15}Hz
Electromagnetic interference	Not Immune to EM interference	Immune to EM interference
Application	i) It provide information regarding weather, make forecast about rains and cyclones. ii) It provides communication, remote sensing etc. iii) Used in mobile communication.	i) TV studio to transmitter interconnection illuminating microwave radio link ii) Secure communication system at military basis. iii)Data acquisition of control signal communication in industrial presses control system
Limitation	i) Launching and positioning of satellite is costlier, elaborated and need high technology. ii) Repel is nearly impossible after launching the satellite.	i) Difficulty in termination of fiber optics cable. ii) Fragility

Q. 4	(A)	**Attempt any THREE :**	**12M**
	(a)	**Sketch the construction of circulator and isolators. State two applications of each**	**4M**

Ans: ***Note: Any other Applications can be considered.***

Circulator:

Diagram :

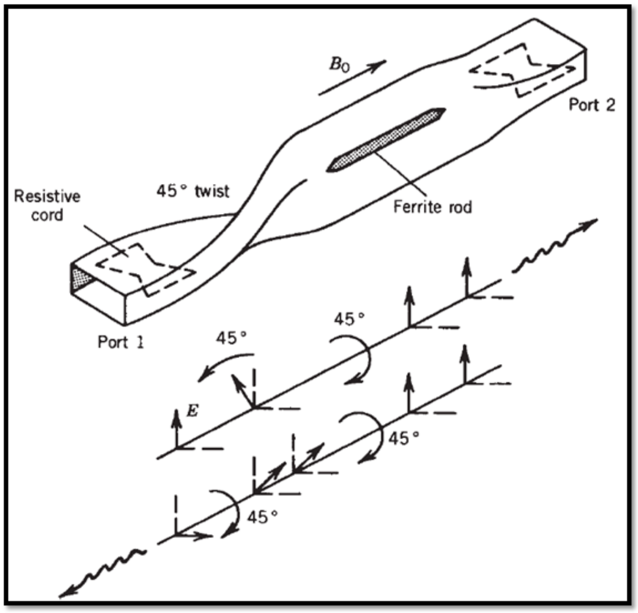
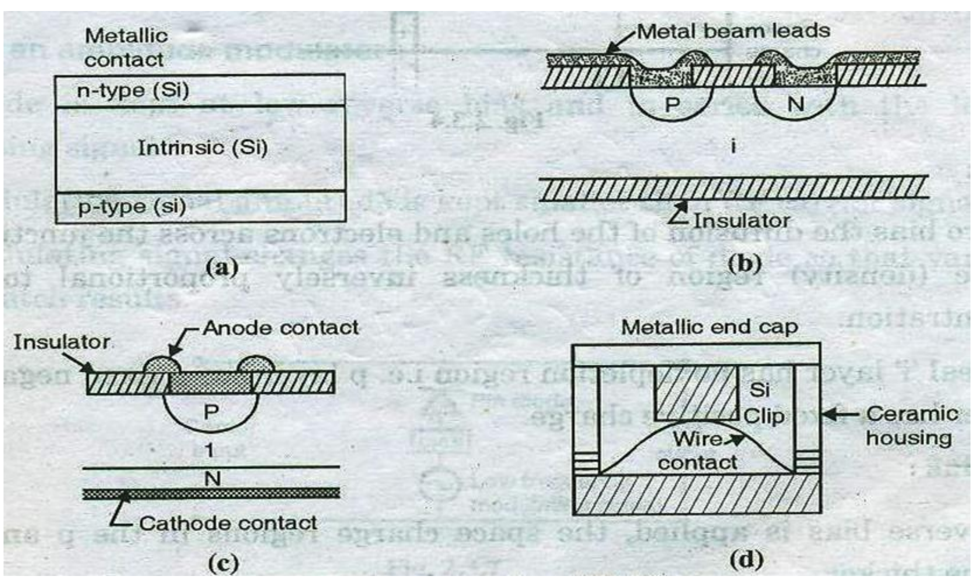


1M

Application:

i. Circulators are used in duplexers in radars.

ii. Another common use of circulators is as coupling elements is reflection amplifier,

		such as parametric amplifiers. **Isolator:** **Diagram :**  **Application:** i. Isolators are most widely used to protect high power RF sources. ii. Isolators are often used between the transmitter and the antenna is several communication systems and radar systems. They are also used on the output of signal generators.	1M 1M 1M
	(b)	**Draw the construction of PIN diode. Describe working principle.**	4M
	Ans:	**Diagram :** 	2M

Explanation:

Operation:

Zero bias:

- At zero bias the diffusion of the holes and electrons across the junction causes space charge region of thickness inversely proportional to the impurity concentration.
- An ideal 'i' layer has no depletion region i.e. p layer has a fixed negative charge and n layer has a fixed positive charge.

Reverse bias:

- As reverse bias is applied the space charge regions in the p and n layers will become thicker.
- The reverse resistance will be very high and almost constant.

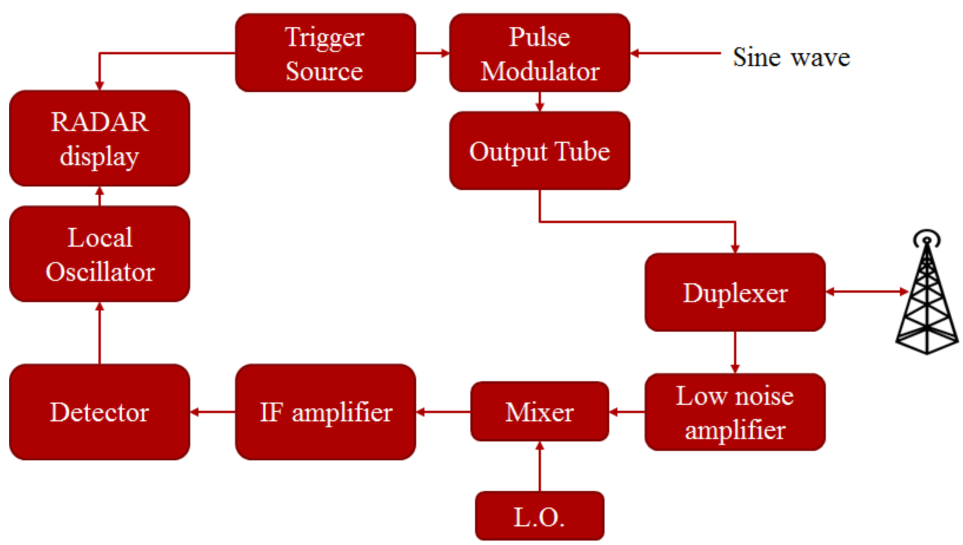
Forward bias:

- With forward bias carrier will be injected into the I layer and p and n space charge regions will become thinner.
- So the electrons and holes are injected into the i layer from p and n layers respectively. This increases the carrier concentration in the I layer above equilibrium. Thus resistivity decreases as increase in forward bias. Therefore low resistance is offered in the forward direction

2M

(c)	**Give the operation of pulsed radar to detect the object.**	**4M**

Ans: **Diagram :** **2M**



Explanation :

The Block diagram of high power Pulsed RADAR set is shown in fig. Above.

Trigger Source: It Provides pulses for the modulator.

Pulse Modulator: This Modulator provides rectangular voltage pulses which act as the supply voltage to the output tube, thus switching ON & OFF as required.

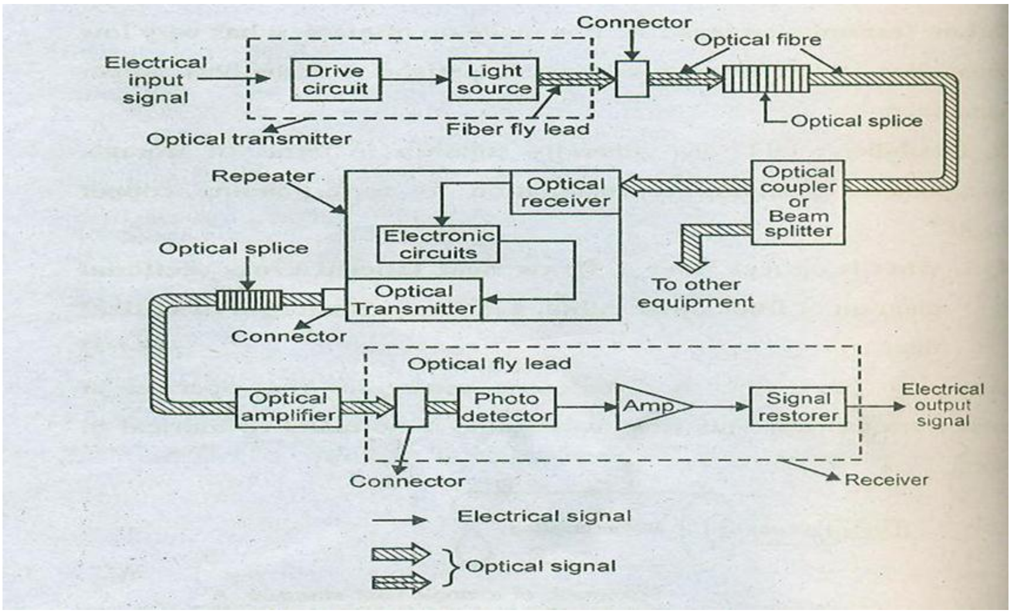
Output tube: It may be an oscillator tube such as a magnetron oscillator or an amplifier such as klystron, TWT or crossed field amplifier. If an amplifier is used, a source of microwave is also required.

The pulse modulated sine wave carrier then travels via duplexer to the antenna where it is radiated into space.

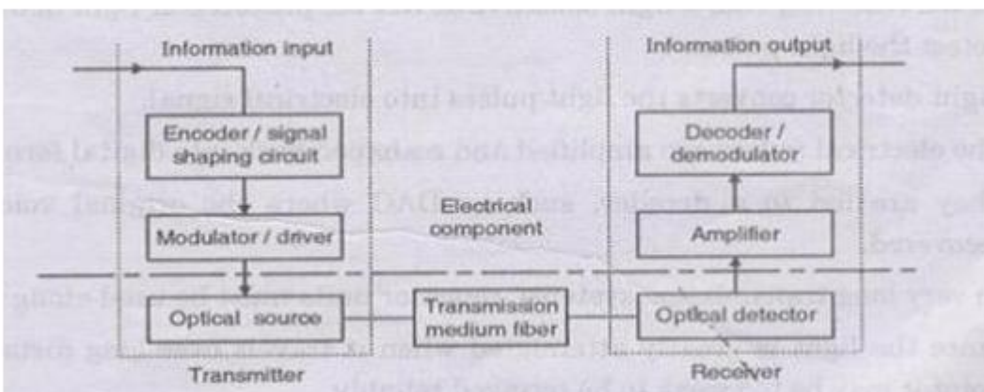
A single antenna is generally used for both transmission & reception. Usually parabolic **2M**

		reflectors with center feed arrangements is used. **Duplexer:** The duplexer channelize the returned echo signal to the receiver and not to the transmitter. The duplexer consists of gas-discharge tubes, one known as TR tube and other as ATR. The TR tube protects the receiver during transmission and the ATR helps in directing the received echo signals to the receiver. **Receiver:** The receiver is usually of superheterodyne type whose function is to detect the desired echo signals in the presence of noise, interference & Clutter. The receiver in Pulsed RADAR consists of the RF amplifier, mixer, local oscillator, IF amplifier, Detector, Video Amplifier & RADAR display. **Low Noise RF amplifier:** It is the first stage of the receiver. It is a low noise transmitter amplifier or parametric amplifier or TWT amplifier. **Mixer & Local Oscillator:** These converts RF signal output from RF amplifier to comparatively lower frequency levels (IF). Thus, in a mixer stage, the Carrier frequency is reduced. **IF amplifier:** This amplifier consists of a cascade of tuned amplifier & Provides the main receiver gain. It should be designed as a matched filter to get maximum peak signal to mean noise power ratio at the output. **Detector:** The Detector is often is a schottky-barrier diode which extracts the pulse modulation from the IF amplifier output. The detector output is the amplified by the video amplifier to a level where it can be properly displayed usually on CRT directly or via computer processing and enhancing. Sync pulses are applied by the trigger source to the display devices or the display indicator.	
	(d)	**Describe the function of Altitude Control Subsystem in Satellite for keeping satellite in its orbit.**	**4M**
	Ans:	• The attitude of a satellite refers to its orientation in space. Attitude control of a satellite refers to the maintenance of the satellite stability at its assigned position. Attitude control is necessary to keep the antenna pointed towards the desired region on the surface of the earth. It is also used to help solar cells so that they face the sun. • A satellite maintains the desired orientation and orbital position through its attitude control subsystem. The attitude control subsystem must continue to perform all functions reliably throughout its lifetime because the loss of satellite attitude renders a spacecraft useless. • Satellites once placed in its orbit experience a number of forces due to gravitational fields of the earth and the moon, solar radiation pressure, magnetic field interaction and meteorite impacts. • Attitude control must not be confused with station keeping, which is the term used for maintaining a satellite in its correct orbital position. • The two commonly employed stabilizing techniques for the satellite attitude are: a) Spin Stabilization b) 3 – axis or Body Stabilization	**4M**
	(B)	**Attempt any ONE :**	**6M**
	(a)	**Draw block diagram of Optical Fiber Communication System. Describe the function of different sensors used in optical communication system.**	**6M**
	Ans:		

		Diagram:	**4M**



OR

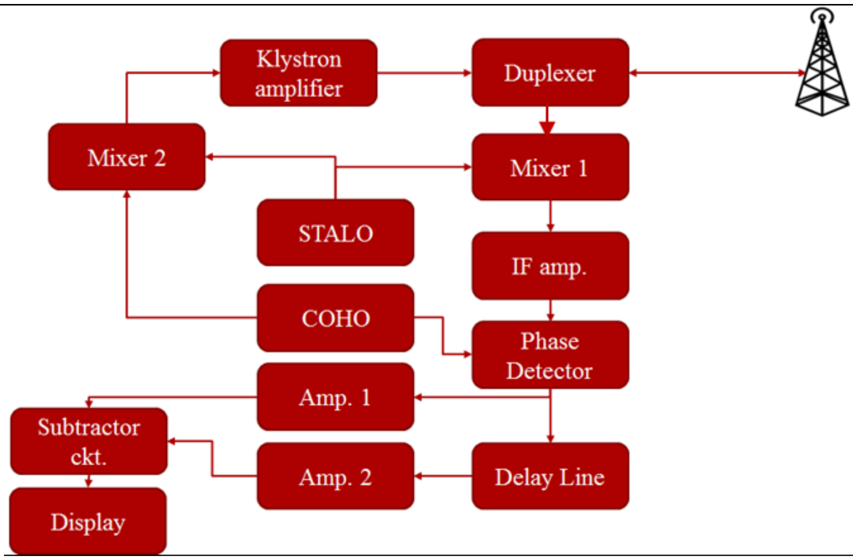


2M Sensors used.

In FOC two types of sensors are used.-

1. Light source at the transmitter end which converts electrical current into optical signal. Light sources which are used are LED and LASER.
2. light detector at the receiver end which converts optical energy electrical signal. The light detectors which are used as PIN photodiode and avalanche photo diode.

	(b)	**Draw the block diagram of MTI radar and describe its working with waveforms.**	**6M**
	Ans:	**Diagram :**	



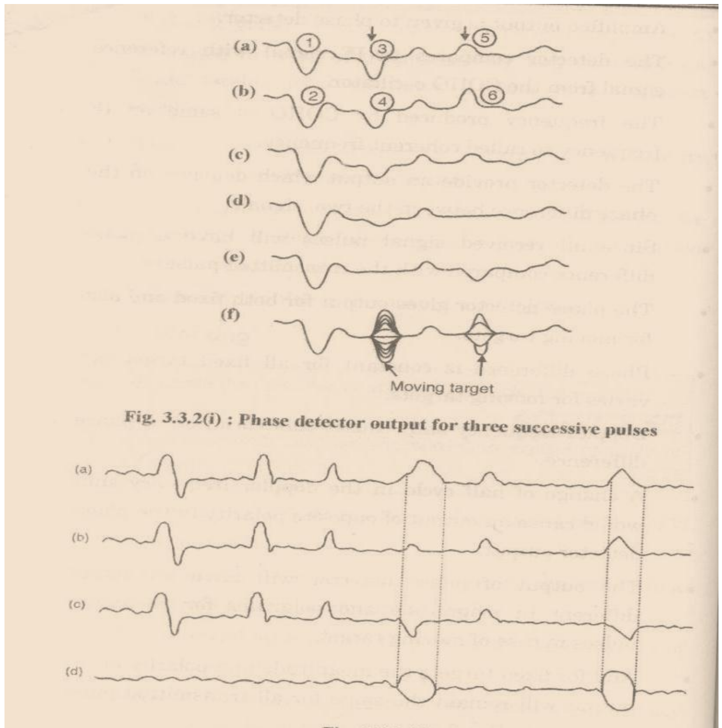
2M

3M

Explanation :

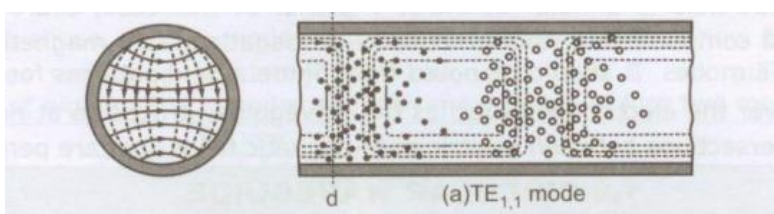
- The echo pulse from the target is received by MTI radar antenna. If echo is due to moving target, the echo pulse undergoes a Doppler frequency.
- The received echo pulses then pass through mixer 1 of the receiver. Mixer 1 heterodynes the received signal of frequency (Fo+Fc) with the output of the stalo at Fo. Mixer 1 produces a difference frequency Fc at its output.
- This difference frequency signal is amplified by an IF amplifier. Amplifies output is given to phase detector. The detector compares to IF amplifier with reference signal from the COHO oscillator.
- The frequency produced by COHO is same as IF frequency so called coherent frequency. The detector provides an output which depends upon the phase difference between the two signals.
- Since all received signal pulses will have a phase difference compared with the transmitted pulse. The phase detector gives output for both fixed and also moving targets. Phase difference is constant for all fixed targets but varies for moving targets.
- Doppler frequency shift causes this variation in the phase difference. A change of half cycle in Doppler shift would cause an output of opposite polarity in the phase detector output.
- The output of phase detector will have an output different in magnitude and polarity from Successive pulse in case of moving targets. And for fixed target magnitude and polarity of output will remain the same as shown in figure.

Waveform



1M

Q.5		**Attempt any FOUR :**	**16M**
4	**(a)**	**Draw field pattern of circular waveguide.**	**4M**
	Ans:	Field Pattern of circular waveguide:	
		Diagram :	**4 M**



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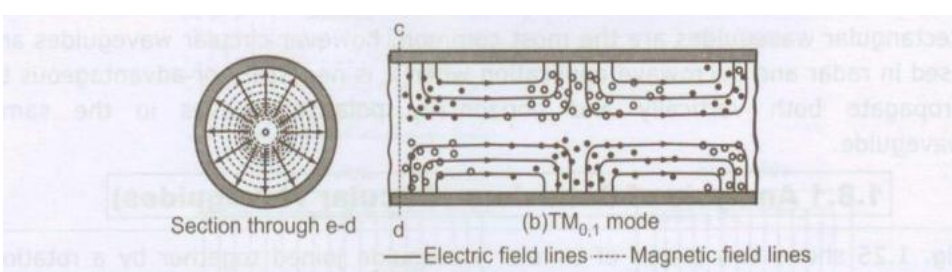
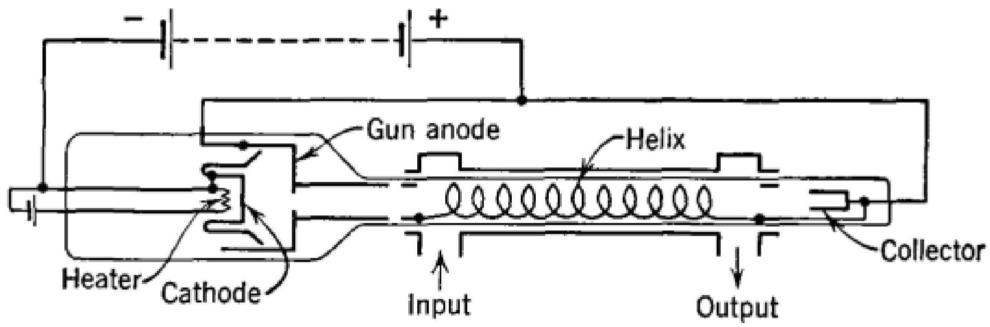
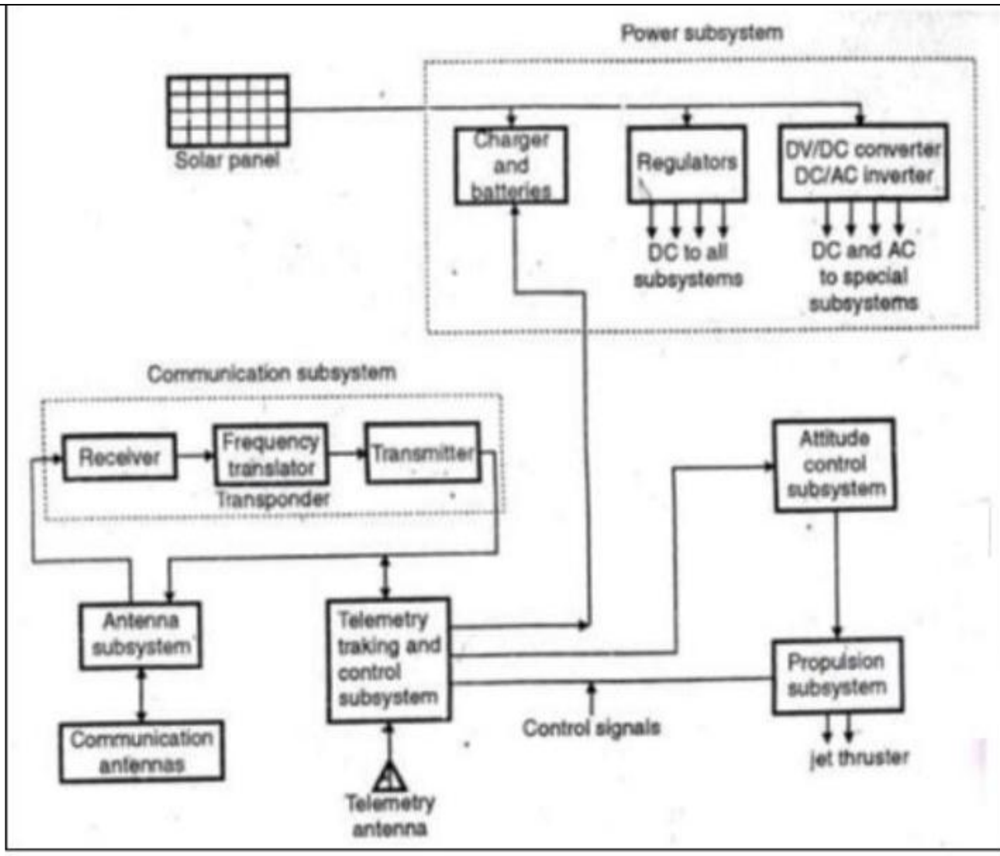


	(b)	**Draw TWT and give its two applications.**	**4M**
	Ans:		**2M**

		Diagram :  **Application:** • TWTAs are commonly used as amplifiers in satellite transponders, where the input signal is very weak and the output needs to be high power. • A TWTA whose output drives an antenna is a type of transmitter. TWTA transmitters are used extensively in radar, particularly in airborne fire-control radar systems, and in electronic warfare and self-protection systems. In such applications, a control grid is typically introduced between the TWT's electron gun and slow-wave structure to allow pulsed operation. The circuit that drives the control grid is usually referred to as a grid modulator. • Another major use of TWTAs is for the electromagnetic compatibility (EMC) testing industry for immunity testing of electronic devices.	**2M**
	(c)	**State four limitations of LED as a source to optical fiber.**	**4M**
	Ans:	**Following are the limitations:** • Coupling losses are high for LED • Radiant output power for a LED is less so it can be used for short distances. • LED's supports less bit rates (few hundred of mbps) as switching speed is slow. • LED has wide spectral width hence chromatic dispersion loss is present.	**Any four point 1 M each point.**
	(d)	**Draw block diagram of satellite subsystem and describe function of each sections.**	**4M**
	Ans:	**Diagram :**	**2M**



Telemetry, Tracking and Command (TT&C) Subsystem:

- These systems are partly on the satellite and partly at the control earth station. They support the functions of
the spacecraft management. The main functions of a TTC system are
- To monitor the performance of all satellite subsystems and transmit the monitored data to the satellite control
center via a separate Telemetry link.
- To support the determination of orbital parameters.
- To provide a source to earth station for tracking.
- To receive commands from the control center for performing various functions of the satellite.
- Typical functions include:
- To correct the position and attitude of the satellite.
- To control the antenna pointing and communication system configuration to suit current traffic requirements**.**

To operate switches on the spacecraft.

2M

Telemetry:

- It collects data from all sensors on the satellite and send to the controlling earth station.
- The sighting device is used to maintain space craft altitudes are also monitored by telemetry.
- At a controlling earth station using computer telemetry data can be monitored and decode.
- And status of any system on satellite can be determined and can be controlled from

earth station

Tracking:

• By using velocity and acceleration sensors, on spacecraft the orbital position of satellite can be detect from earth station.
• For accurate and precise result number of earth stations can be used

OR

Propulsion sub-system:

- Propulsion sub-system is the reaction control sub-system carried by the satellite in the geostationary orbit so as to generate forces on it whenever needed.
- It moves satellite to its assigned position in orbit, to maintain in that position (station keeping) and to maintain the direction of spin axis and attitude control.
- Usually propulsion subsystem has three units. i) Low thrust (10-3 to 20N) actuators (Reaction control system, RCS) ii) High thrust (400 to 50,000 N) motor (Apogee kick motor: AKM or Apogee Boost Motor (ABM) which provides velocity increment) to inject satellite into geostationary orbit from transfer orbit apogee. iii) Perigee kick motor (PKM) which provides velocity increments required to inject the satellite into the transfer orbit.
- Low thrust actuators (RCS) are of much importance as these are responsible for keeping the satellite in orbit with its perfect attitude till its life end. They are either chemical or electrical thrusters.

OR

Antenna Sub-system:

• Antenna on board serves as an interface between the earth on the ground and various satellite subsystems

OR

Power Subsystem:

- This system provides the necessary DC power to the satellite. All communication satellites derive their electrical power from solar cells. There is also a battery backup facility used during launch and eclipses.
- The batteries are of sealed Nickel Cadmium type and have good reliability and long life.

OR

Communication Subsystems :

• It is a major component of the communication satellite, and the remainder of the spacecraft is there solely to support it.

It consists of:

i. Microwave antennas and

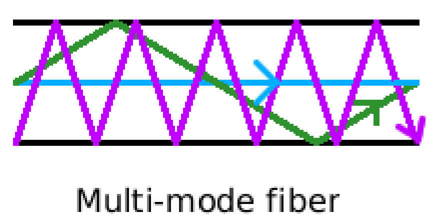
		ii. As set of receiver and transmitter units referred to as Transponders • The antenna system is used to receive signals from and transmit signals to the ground stations in the coverage area. • The antenna used range from dipole type antennas where Omni directional characteristics are required to the highly directional antennas (the paraboloidal reflector being the most common) required for telecommunication purposes and TV relay and broadcast. • The transponders amplify and retransmit the incoming signals. **Attitude and Orbit Control System (ACOS) :** • This subsystem provides stabilization of the satellite and controls its orbit. It fires jet thrusters to perform attitude adjustments and station keeping man oeuvres that keep the satellite in its original orbital position with correct orientation.	
	(e)	**A silica optical fiber with a core diameter large enough to be considered by ray theory analysis has a core reflective index of 1.50 and a cladding refractive index of 1.47. Calculate (i) Critical angle, (ii) NA of fiber, (iii) Acceptance angle in air for fiber.**	**4M**
	Ans:	Given : $n_1 = 1.5$ $n_2 = 1.47$ To Find : 1. critical angle 2. Numerical Aperature (N.A) 3. Acceptance Angle Solution : $\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1.47}{1.5}\right)$ $\theta_c = 78.52^\circ$ Critical angle $\theta_c = 78.52^\circ$ $N.A = \sqrt{n_1^2 - n_2^2}$ $= \sqrt{1.5^2 - 1.47^2}$ $= 0.2984$ Numerical Aperature = 0.2984 $N.A = \sin\theta_0$ $0.2984 = \sin\theta_0$ $\theta_a = 17.36^\circ$ Acceptance Angle = 17.36°	**(1M given ,find 1M for each answer)**

	(f)	**Differentiate between single mode and multimode fiber.**	**4M**
	Ans:	(see comparison below)	**(One point 1M. Any four point consider.)**

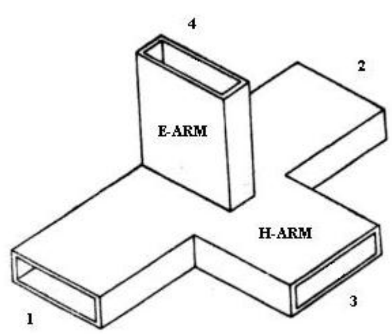
Single mode fiber	Multi mode fiber
Core radius is small.	Core radius is large.
Supports one mode of propagation.	Supports hundreds of modes.
Optical source- LASER.	Optical source- LED.
The launching of optical power into fiber is difficult as the core radius is small.	The launching of optical power into fiber is easier as the core radius is large.
Supports larger bandwidth.	Supports lesser bandwidth.
Intermodal dispersion is absent.	These fiber suffer from Intermodal dispersion.
Used for long distance communication.	Used for short distance communication.

Diagram :

Diagram :



Q.6		**Attempt any FOUR :**	**16M**
	(a)	**Describe function of hybrid Tee with neat diagram. (E-H plane or Magic Tee)**	**4M**
	Ans :	**Diagram :**	**2M**

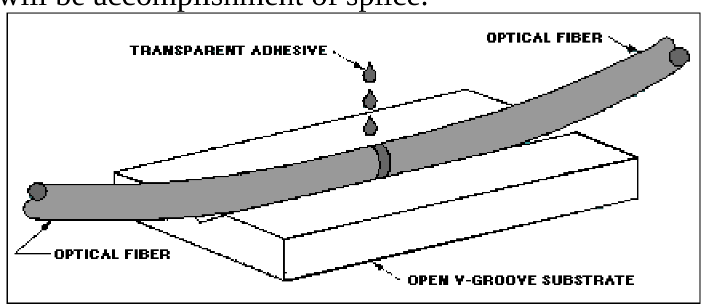


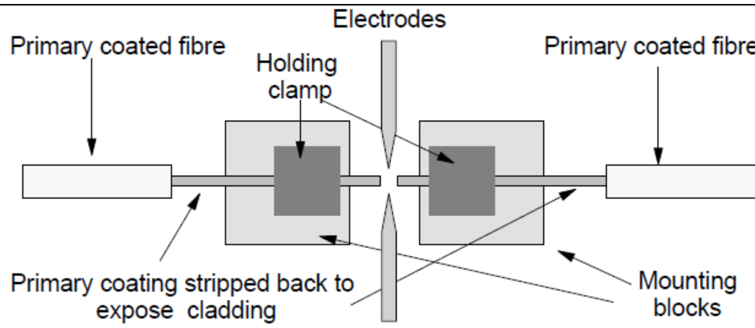
Explanation:

Magic tee (or magic T or hybrid tee) : **2M**

- is a hybrid or 3 dB coupler used in microwave systems. It is an alternative to the rat-

		race coupler. • In contrast to the rat-race, the three-dimensional structure of the magic tee makes it less readily constructed in planar technologies such as microstrip or stripline. • The magic tee is a combination of E and H plane tees. Arm 3 forms an H-plane tee with arms 1 and 2. Arm 4 forms an E-plane tee with arms 1 and 2. Arms 1 and 2 are sometimes called the *side* or *collinear* arms. Port 3 is called the H-plane port, and is also called the Σ port, sum port or the P-port (for "parallel"). Port 4 is the E-plane port, and is also called the Δ port, difference port, or S-port (for "series"). • There is no one single established convention regarding the numbering of the ports. • To function correctly, the magic tee must incorporate an internal matching structure. This structure typically consists of a post inside the H-plane tee and an inductive iris inside the E-plane limb, though many alternative structures have been proposed. Dependence on the matching structure means that the magic tee will only work over a limited frequency band.	
	(b)	**List the different losses occur in optical fiber. Describe any one loss with diagram.**	**4M**
	Ans:	**<u>Losses occur in optical fiber:</u>** • Absorption Scattering • Radiative losses (bending losses) 1.Microbending losses. 2. Macro bending losses. • Rayleigh-type Scattering • Material (Chromatic) dispersion • Waveguide dispersion • Dispersion loss • 1. **<u>Radiative losses:</u>** also called bending losses, occur when the fibre is curved. There are two types of radiative losses: Micro bending losses. Macro bending losses. **<u>OR</u>** **<u>Scattering loss:-</u>** Basically, scattering losses are caused by the interaction of light with density fluctuations within a fiber. Density changes are produced when optical fibers are manufactured. ¬ Linear Scattering Losses: Linear scattering occurs when optical energy is transferred from the dominant mode of operation to adjacent modes. It is proportional to the input optical power injected into the dominant mode. o Linear scattering is divided into two categories: Mie scattering and Rayleigh scattering. ¬ Non- Linear Scattering Losses: o Scattering loss in a fiber also occurs due to fiber non-linearity's i.e. if the optical power at the output of the fiber does not change proportionately with the power change at the input of the fiber, the optical fiber is said to be operating in the non-linear mode. Non-Linear scattering is divided into two categories: Stimulated Raman Scattering and Stimulated Brillouin Scattering. **<u>OR</u>** **<u>Dispersion loss:</u>**	**Different Types -1 M And Explanation any one loss 3 M.**

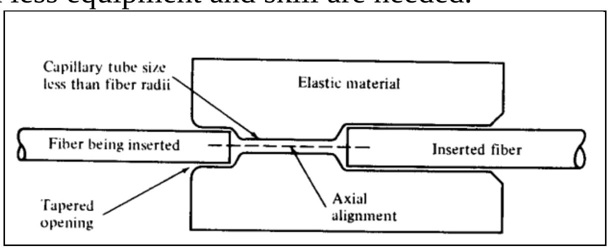
		Dispersion is a measure of the temporal spreading that occurs when a light pulse propagates through an optical fiber. Dispersion is sometimes referred to as delay distortion in the sense that the propagation time delay causes the pulse to broaden. ***Note:Any other relevant loss explanation***	
	(c)	**List different types of splicing techniques. Describe any one method.**	**4 M**
	Ans:	**<u>List Different Types:-</u>** • Fusion Splice • V-groove Splice • Elastic tube splice **<u>Explanation :</u>** **<u>Fusion Splice</u>:** • It is accomplished by applying localized heating i.e by a flame or an electrical arc at interference between two butted, pre aligned fiber ends. • This technique involves heating of two prepared fiber ends to their fusing point by applying sufficient axial pressure between the two optical fibers. For heating most widely source is electric arc. Following are steps for fusion process • PERFUSION: It is a technique, which involves the rounding of the fiber ends with a low energy discharge before pressing the fibers together. • By moving movable block, with proper pressure two fibers are pressed together. • Then there will be accomplishment of splice.  **<u>OR</u>** **<u>V-groove Splice</u>**: • In this technique V-grooves are used to secure the fibers to be joined. This method utilizes a V-groove into which the two prepared fiber ends are pressed. • The V-groove splice ends through insertion in the groove. The splice is made permanent by securing the fibers in the V-grooves with epoxy resin.	**(List Different Types-1M)** **(Explanation on Any One-3M)**



OR

Elastic tube splice:

- The elastic tube splice shown cross sectionally in the figure below is a unique device that automatically performs lateral, longitudinal and angular alignment. .
- It splices multimode fibers with losses in the same range as commercial fusion splices, but much less equipment and skill are needed.



- The splice mechanism is basically a tube made of elastic material. The central hole diameter is slightly smaller than that of the fiber to be spliced and is tapered on each end for easy fiber insertion.
- When the fiber is inserted, it expands the hole diameter so that the elastic material exerts a symmetrical force on the fiber.
- This symmetry feature allows an accurate and automatic alignment of the axes of the two joined fibers.
- A wide range of diameters can be inserted into the elastic tube. Thus the fibers to be spliced do not have to be equal in diameter, since each fiber moves into position independently relative to the tube axis.

	(d)	**Describe the function of telemetry and tracking in satellite communication system.**	**4M**
	Ans:	**Telemetry, Tracking and Command (TT&C) Subsystem:**	**4M**

• These systems are partly on the satellite and partly at the control earth station. They support the functions of
the spacecraft management. The main functions of a TTC system are
• To monitor the performance of all satellite subsystems and transmit the monitored data to the satellite control
center via a separate Telemetry link.
• To support the determination of orbital parameters.
• To provide a source to earth station for tracking.
• To receive commands from the control center for performing various functions of the satellite.
• Typical functions include:
• To correct the position and attitude of the satellite.
• To control the antenna pointing and communication system configuration to suit current traffic requirements.

To operate switches on the spacecraft.

Telemetry:

- It collects data from all sensors on the satellite and send to the controlling earth station. **2M**
- The sighting device is used to maintain space craft altitudes are also monitored by telemetry.
- At a controlling earth station using computer telemetry data can be monitored and decode.
- And status of any system on satellite can be determined and can be controlled from earth station

Tracking:

- By using velocity and acceleration sensors, on spacecraft the orbital position of satellite can be detect from earth station. **2M**

(e) Distinguish between LED and LASER. (4 points) **4 M**

Ans: **Diagram :** **Any 4 points,1 M**

Ans: (Note: any other relevant point can be considered)

Parameter	LED	LASER
Principle of operation	Spontaneous emission	Stimulated emission
Output Beam	Non-coherent	Coherent
Data rate	Low(max. 400Mbps)	High(several Gbps)
Coupling efficiency	Very low	High
Spectral width	20 to 100nm	1 to 5nm
Transmission distance	Smaller	Greater
Compatible with	Multimode SI/GI fiber	Single mode fiber
Circuit complexity	Simple	Complex