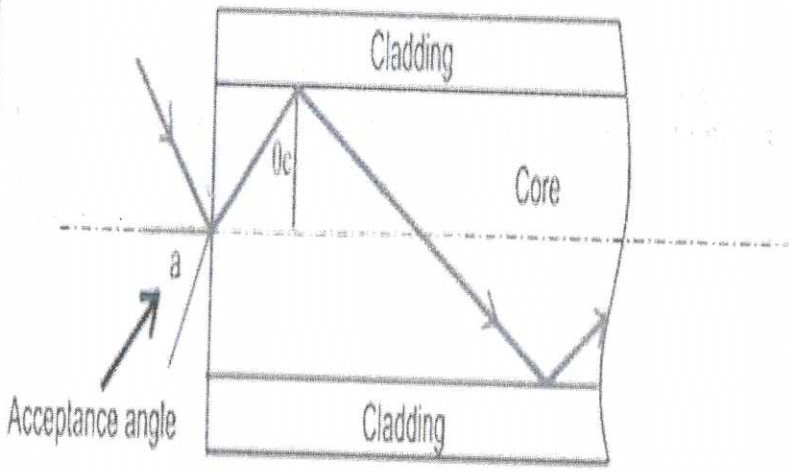
SCHEME OF EVALUATION

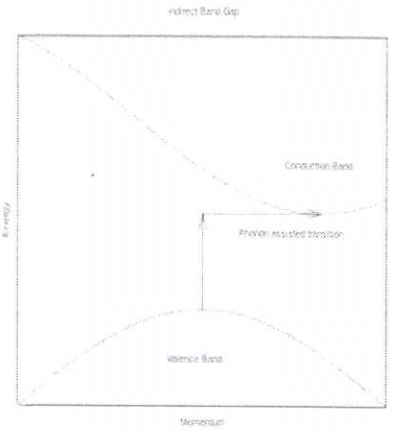
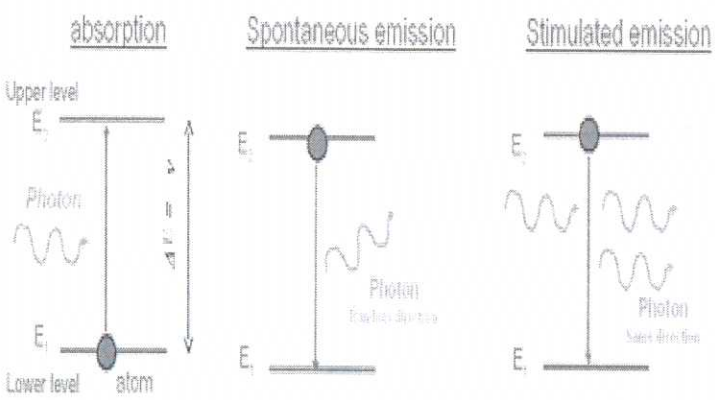
(SCORING INDICATORS)

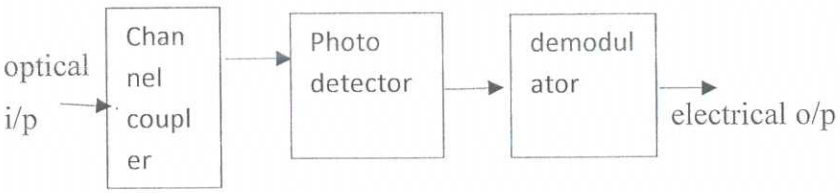
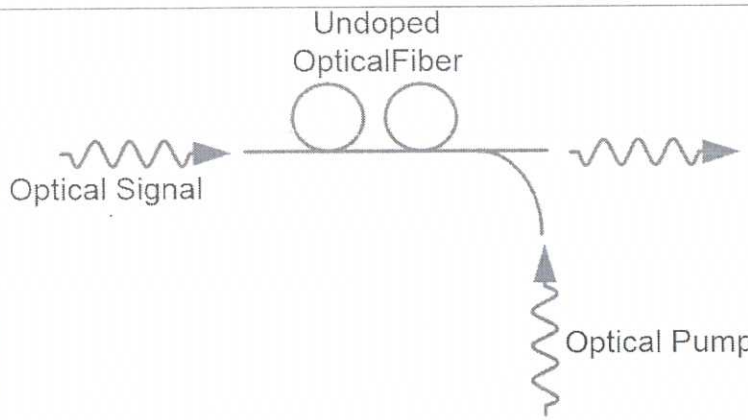
Revision: 15

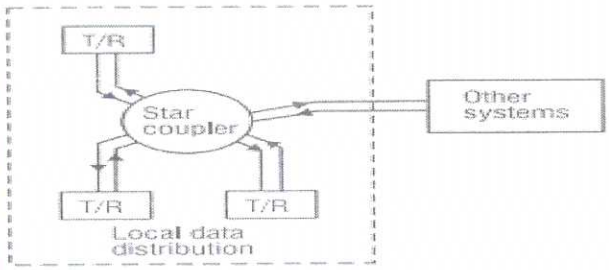
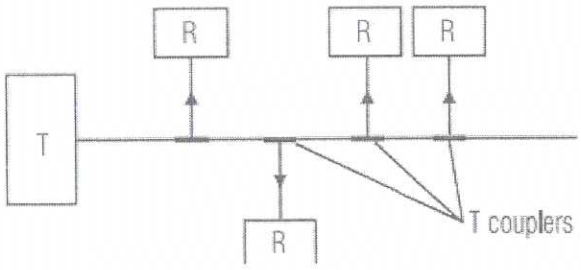
Course code: 5045

Course Title: Optical Fibre Communication

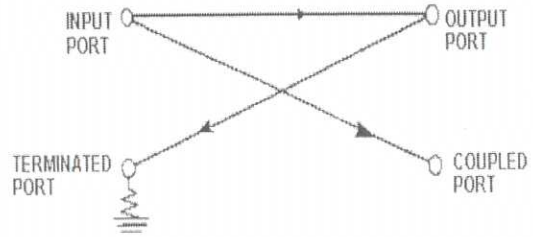
Qst No:	Scoring indicator	Split up score	Sub total	Total
I	**PART A** 1. Dispersion is a phenomenon related to the variation in velocity of different frequencies (wavelengths) or different modes 2. Excitation and recombination, Photon extraction 3. Avalanche photo diode is a photo diode that internally amplifies the photocurrent by avalanche process 4. Optical transceiver is combination of transmitter and receiver that uses fibre optical technology to send and receive data 5. Splices are permanent fibre joints whereas connectors are temporary fibre joints	1+1=2marks 2marks 2marks 2marks 2marks	2*5=10	10 marks
1)	**PART B** The light propagates through fiber by total internal reflection. Light rays are reflected and guided down the length of an optical fiber. Only light enters the fibre at or less than acceptance angle will be totally internally reflected at the core cladding interface  	Fig =3marks Expln=3marks	3+3=6	6marks

2	 In direct band gap the momentum of electrons and holes is the same in both the conduction band & valence band. So on electron hole recombination the band gap energy is emitted as light. In indirect band gap the max and min energies of valence & conduction bands occur at different values of crystal momentums. So electron hole recombination occurs when electron loses momentum corresponding to max energy level of valence band. This conversion of momentum requires the emission or absorption of photon.	Fig =3marks Expln=3marks	3+3=6	6marks
3	 The three different mechanisms are shown in Figure 1. Absorption: The process of absorbing energy from photons is called absorption of radiation. An atom in a lower level E1 absorbs a photon of frequency hν and moves to an upper level E2. 2. Spontaneous emission: The process by which excited electrons emit photons while falling to the ground level or lower energy level is called spontaneous emission. An atom in an upper level can decay spontaneously to the lower level and emit a photon of frequency hν if the transition between E2 and E1 is radiative. This photon has a random direction and phase.	Fig:3marks expln:3marks	3+3=6	6marks

	3. Stimulated emission: The process by which electrons in the excited state are stimulated to emit photons while falling to the ground state or lower energy state is called stimulated emission An incident photon causes an upper level atom to decay, emitting a "stimulated" photon whose properties are identical to those of the incident photon.			
4	 The function of the optical receiver is to detect the incoming optical power and extract it from the signal (either analog or digital) that is being transmitted. The coupler focuses the received optical signal into photo detector. The photodetector(APD /PIN) converts it into electrical pulses. The demodulator demodulated the received signal back to original information	Fig: =3marks Expln =3marks	3+3=6	6marks
5	 **RFA amplifier** uses a technique called Raman amplification which is a method that uses pump lasers to donate energy to the signal for amplification. The laser signal energy and the photons of the transmitted signal are coupled, thereby increasing the signal strength. Uses Raman scattering, which is the process in which light is scattered by molecules from lower wavelength to higher wavelength	Fig =3marks Expln=3marks	3+3=6	6marks
6	**Absorption of light energy due to heating of ion impurities results in dimming of light at the end of the fiber.** **Two types:**	Defn=2marks	2+2+2=6	6marks

	Intrinsic Absorption: ▪ Caused by the interaction with one or more components of the glass ▪ Occurs when photon interacts with an electron in the valence band & excites it to a higher energy level near the UV region. **Extrinsic Absorption:** ▪ Also called impurity absorption. ▪ Results from the presence of transition metal ions like iron, chromium, cobalt, copper & from OH ions i.e. from water.	2marks 2marks		
7.	A fiber optic coupler is a device used to connect a single (or multiple) fiber to many other separate fibers. **Star couplers** - The star coupler is used in applications that require multiple ports (input and/or output). The star coupler will distribute optical power equally from one or more input ports to two or more output ports.  **T –couplers** – a passive optical coupler having 3 ports/fibers. ie: two isolated i/p's combined into one o/p or one i/p into two isolated o/p's  **Directional Couplers** are passive, matched and lossless devices. By construction, these devices in which two transmission lines are positioned such that energy propagating on one line can	Defn:2marks Expln Any two: 2*2=4	2+4=6	6marks

couple over to the other.



III. a)

PART C

UNIT I

a) Single mode step index fiber.

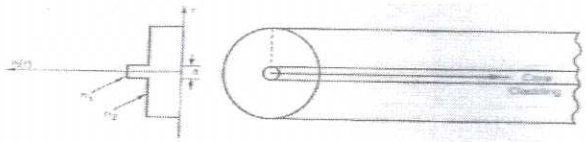


Fig 1.5+Expln: 1.5marks=3

Single mode fiber will permit only one mode to propagate and does not suffer from mode delay differences. The core fiber of a single mode fiber is very narrow compared to the wavelength of light being used. Therefore, only a single path exists through the cable core through which light can travel

Multimode step index fiber.

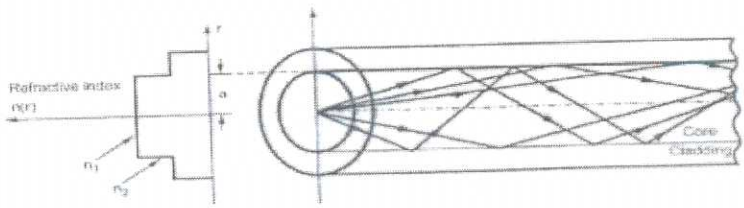


Fig 1.5+Expln: 1.5marks=3

There is many paths that a light ray may follow during propagation. Since the core index of refraction is higher than the cladding index of refraction, the light enters at less than critical angle is guided along the fiber. Light rays passing through the fiber are continuously reflected off the glass cladding towards the center of the core at different angles and lengths

Multimode Graded Index Fiber

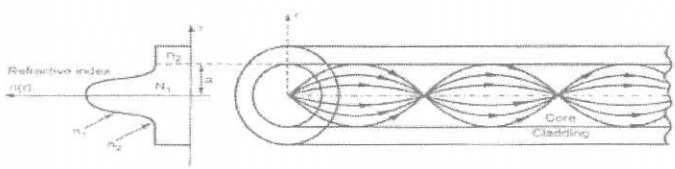
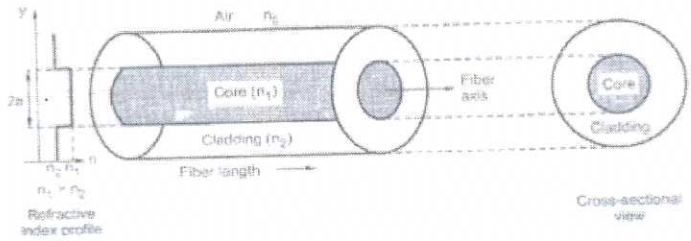
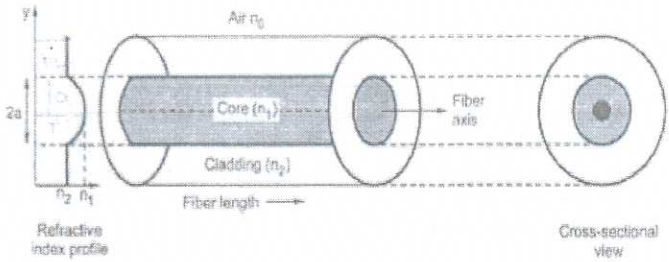


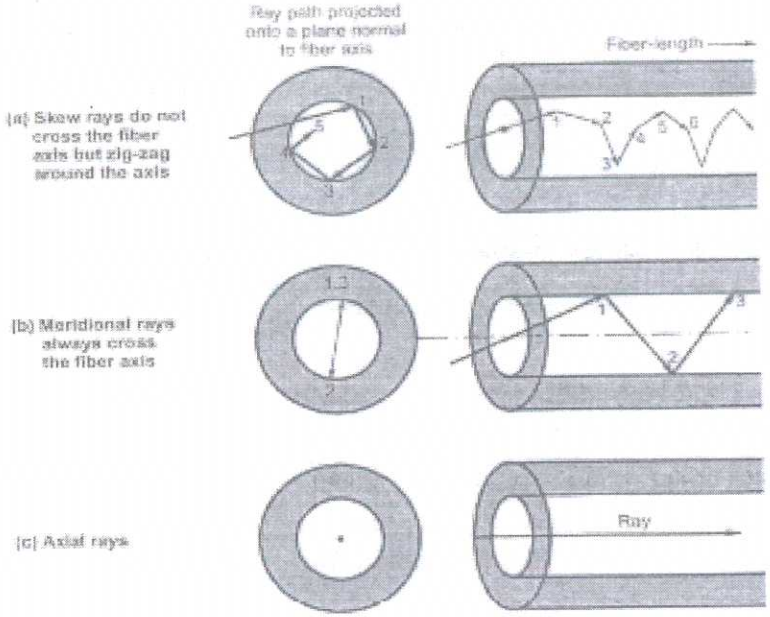
Fig 1.5+Expln: 1.5marks=3

3+3+3=9

9marks

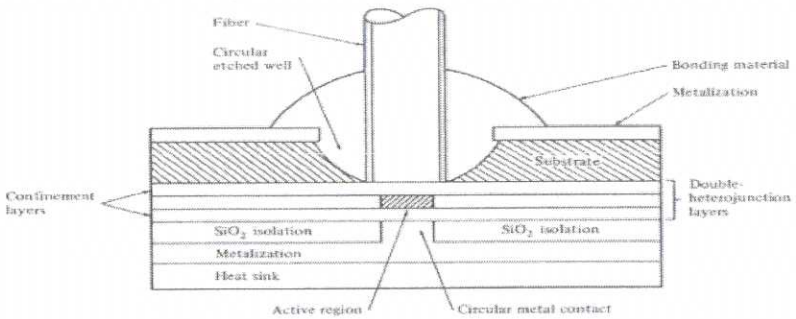
	The light ray is propagated throughrefraction. The light ray enters the fiber at many different angles,as the light propagates across the core toward the center it is intersecting a less dense to more dense medium. Therefore the light rays are being constantly being refracted and ray is bending continuously			
III b)	1).bandwidth – greater b.w than metallic cables 2).low power loss 3) Interference- immune to electromagnetic interference 4)flexibility- bends easily 5)security 6) Safety 7) Low cost 8) Less weight (any 6 =6marks)	1*6=6		6marks
IV a)	1)Step index fiber.  The step index fiber is a cylindrical waveguide core with central or inner core has a uniform refractive index of n1 and the core is surrounded by outer cladding with uniform refractive index of n2. The cladding refractive index (n2) is less than the core refractive index (n1). But there is an abrupt change in the refractive index at the core cladding interface. 2) Graded index fiber.  In the graded index (GRIN) fiber the refractive index is not uniform within the core, it is highest at the center and decreases smoothly and continuously with distance towards the cladding. The refractive index profile across the core takes the parabolic nature	Fig:2marks +Expln:1mark Fig:2marks +Expln:1mark	3+3=6	6mark
IV b)	**skew rays** does not pass through the center ,it reflects off from the core cladding boundaries and again bounces around the outside of the core. It takes helical path.**Meridional ray** enters the core and passes through its axis. When the core surface is	Expln:3marks Fig:2*3=6	3+6=9	9marks

parallel, it will always be reflected to pass through the enter.
Axial ray travels along the axis of the fiber and stays at the axis all the time.



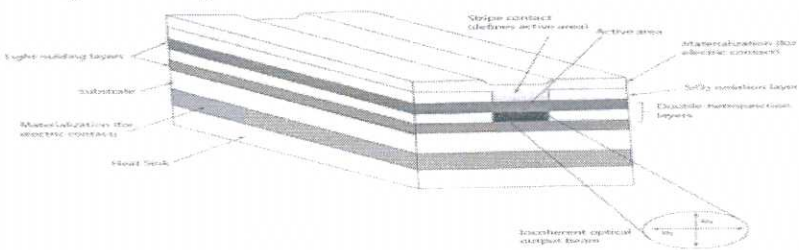
UNIT II

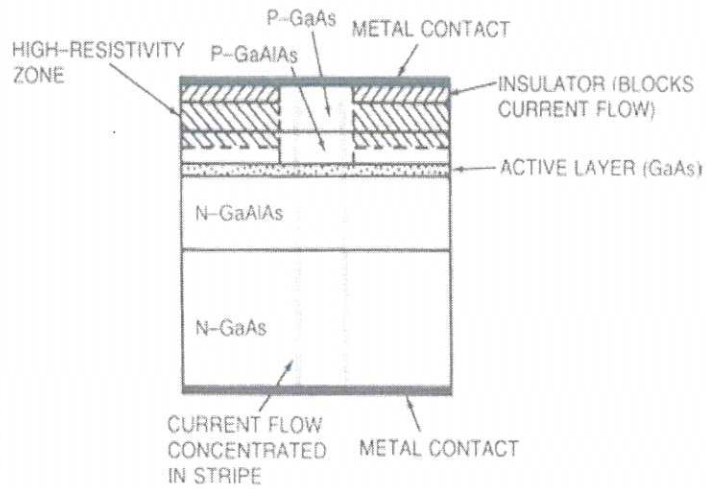
V. a) 1. Surface Emitting LED (SLED):- — Fig:2marks; Exoln:1.5marks — 2+1.5=3.5 + 2+1.5=3.5 — 7marks

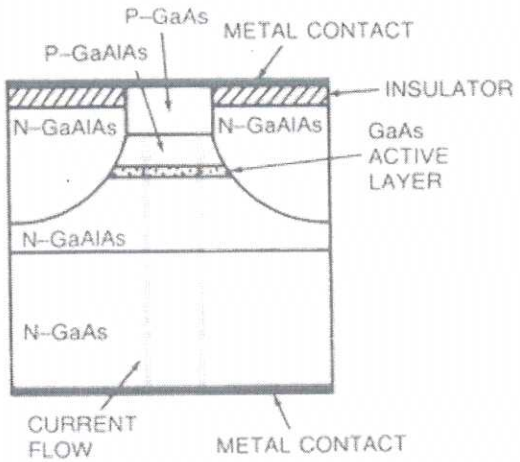


In SLEDs, the size of the primary active region is limited to a small circular area .The primary active region is below the surface of the semiconductor substrate perpendicular to the axis of the fiber.A well is etched into the substrate to allow direct coupling of the emitted light to the optical fiber. The etched well allows the optical fiber to come into close contact with the emitting surface.

2. Edge-emitting LED:- — Fig:2marks; Expln:1.5marks



	In the case of edge emitter, the light is more directional. In this case the double hetero structure is surrounded by a semiconductor having a larger band gap than that of the active layer. This makes the process of recombination to be confined to the active layer. The surrounding layer acts as a dielectric waveguide. The light coming out of the waveguide is coupled to the optical fiber by a lens system.			
V. b)	 Gain guided laser: A laser diode in which the beam is confined to the region of the active layer, which lies beneath the contact stripe. Insulating regions at the top of the laser chip block current from flowing to either side in a complex double-heterojunction laser. The only path for the current is through a narrow stripe at the middle, which runs the length of the chip between the two cavity mirrors. Thus, recombination of current carriers and a population inversion occur only in the narrow stripe through which the current flows, so only that one has gain. Because there is no gain at the sides, those regions do not emit light, even though no physical boundary separates the stripe from the rest of the active layer Index guided lasers: Index guided lasers add high level of confinement by surrounding the stripe in the active layer with a material of lower refractive index. A \The o/p beam is contained in the active layer	Fig:2marks Expln:2maeks Fig:2marks Expln:2maeks	4*2=8marks	8marks



VI. a)

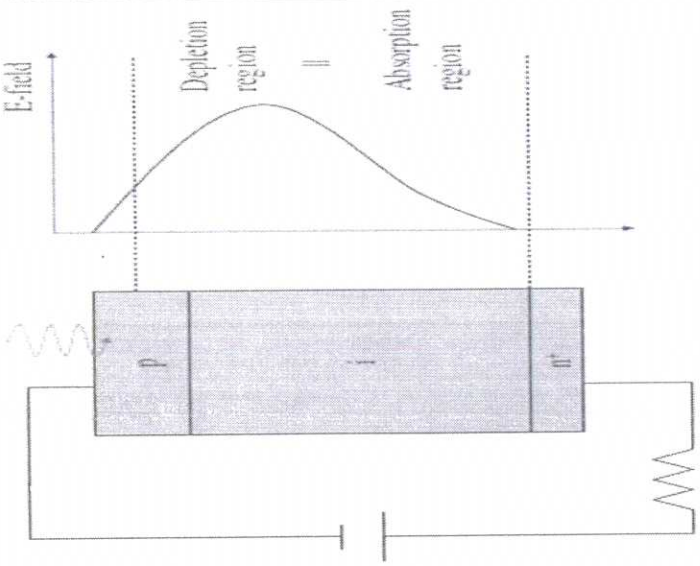


Fig3+2=5marks

Expln:2+2=4marks

5+4=9

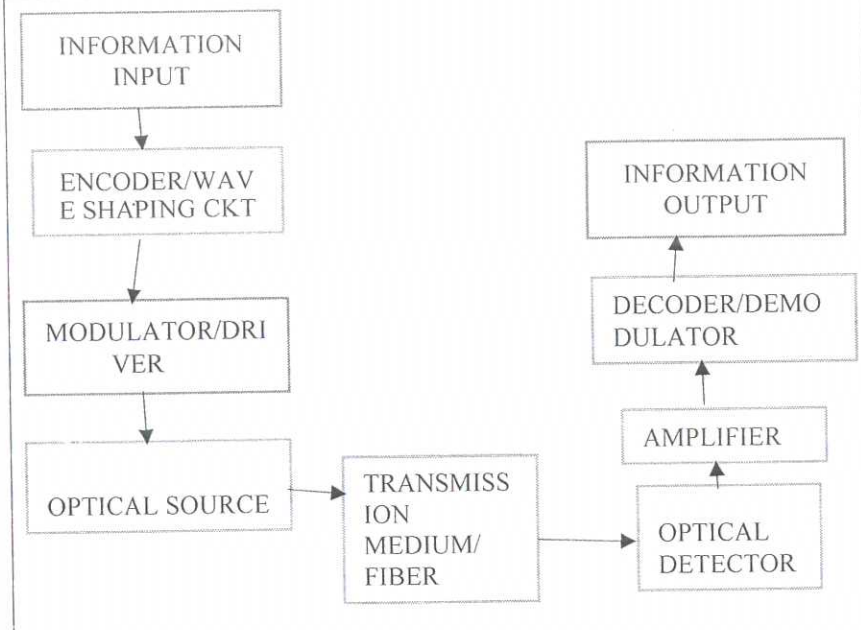
9marks

In PIN diode an intrinsic layer of high resistivity is sandwiched between the P and N-region, hence the name PIN diode. The high resistive layer of the intrinsic region provides the large electric field between the P and N-region. The electric field induces because of the movement of the holes and the electrons. The direction of the electric field is from n-region to p-region.

The working principle of a photodiode is, when a photon strikes the diode, it makes a couple of an electron-hole. If the absorption arises in the depletion region junction, then the carriers are removed from the junction by the inbuilt electric field of the depletion region because the width of depletion region is higher compared to P and N regions, and it is lightly doped n-material. Therefore, holes in the region move toward the anode, and

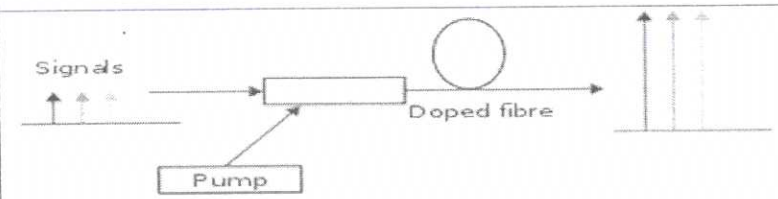
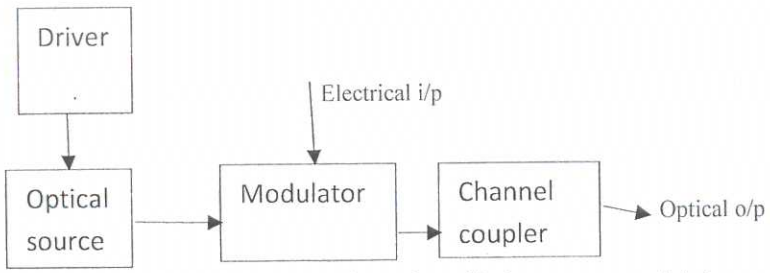
	electrons move toward the cathode, and a photocurrent will be generated.			
VI. .b		Any 6=1*6=6marks	6marks	6marks

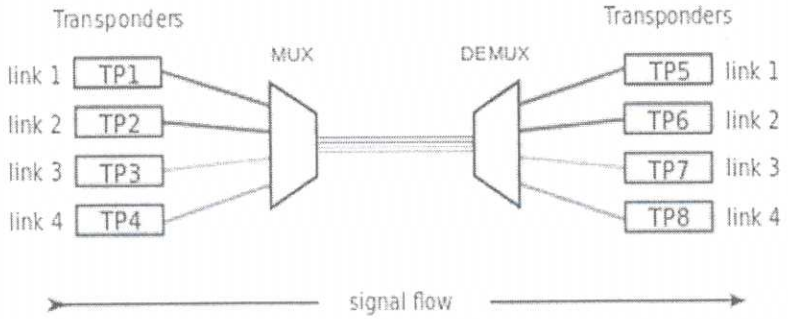
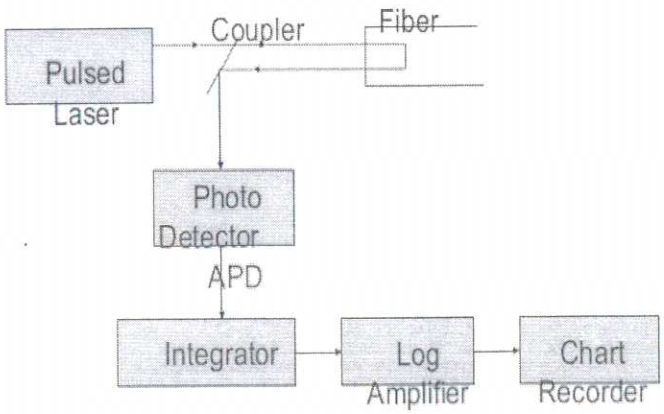
PIN	APD
Less gain	Self multipying mechanism so high gain
PIN diode does not have high electric field region	APD has high intensity field region
Photocurrent generated is less	Photocurrent generated is more
Less noise levels	Higher
Response time is less	Response time is high
Less costly	costly

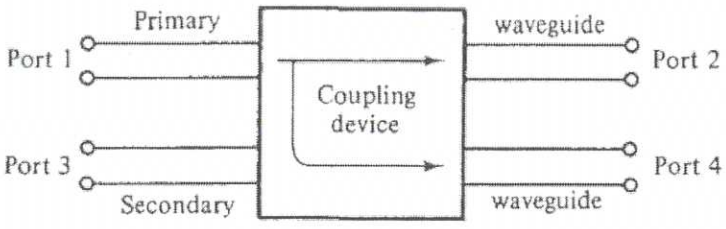
	UNIT - III			
VII. a)		Fig:5marks Expln:4marks	5+4=9marks	9marks

Transmitter section :
The main parts of the transmitter section are a source (LED or a LASER), efficient coupling means to couple the output power to the fiber, a modulation circuit and a level controller for LASERs. High coupling losses result from direct coupling of the source to optical fibers.

Drive circuitry :
These are the circuits used in the transmitters to switch a current in the range of ten to several hundred miliamperes required for

	proper functioning of optical source. For LEDs there are drive circuits like common emitter saturating switch, low impedance, emitter coupled, transconductance drive circuits etc. On the other hand for LASERs, shunt drive circuits, bias control drive circuits, ECL compatible LASER drive etc are noticeable. Receiver section : It includes Photodetector, low noise amplifier, voltage amplifier and a decision making circuit to get the exact information signal back. The two most common photodetectors are **p**-i-n diodes and avalanche photodiodes.			
VII. b)	 Optical amplifier is a device that amplifies an optical signal, without the need to convert it to an electrical signal. The signal to be amplified and a pump laser are multiplexed to the doped fibre, and the signal is amplified through interaction with the doping ions	Fig:3marks Expln:3marks	3+3=6	6marks
VIII. a)	 The main part of the transmitter is a light source which converts an information signal from its electrical form into light eg: light-emitting diodes (LEDs) or laser diodes (LDS). Both are miniature semiconductor devices that effectively convert electrical signals into light. They need power-supply connections and modulation circuitry. (Explain each block)	Fig:4marks Expln:4marks	5+3=8	8marks

VIII . b)	In fiber communication wavelength-division multiplexing (WDM) is a technology which multiplexers number of optical carriers onto a single optical fiber using different wavelengths. This technique enables bidirectional communications over one strand of fiber, as well as multiplication of capacity. WDM is applied onto optical carrier. A WDM system uses a multiplexer at the transmitter join the several signals together, and a demultiplexer at the receiver to split them apart **wavelength-division multiplexing (WDM)**  	Fig:4marks Expln:3marks	4+3=7	7marks
	UNIT - IV			
IX a)	Principle: • OTDR emits high power pulse that hits the fiber and bounces back • The back comes signal is measured, factoring time and distance the trouble spots are recognized for repair  	prin:2marks Fig:4marks	2+4+3=9	9marks

	▪ A light pulsed is launched into the fiber in forward direction from an injection laser using a coupler or beam splitter. ▪ Beam splitter or coupler makes possible to couple the optical excitation power impulse into the tested fiber and to deviate the backscattered power to the optical receiver. ▪ The backscattered light is detected using an Avalanche Photodiode receiver. ▪ Output of photodiode receiver drives an integrator. ▪ Integrator improves SNR by giving an arithmetic average over a number of measurements taken at one point. ▪ This signal is fed to Logarithmic amplifier and average measurements for successive points within the fiber are plotted as a Chart Recorder. ▪ Overall link length can be determined from the time difference between reflection from the fiber input and output end faces.	Expln:3marks		
IX b)	A Directional coupler is a 4-port waveguide junction. It consists of primary waveguide 1-2 and a secondary waveguide 3-4. When all ports are terminated in their characteristic impedance, there is free transmission of power between port1 to port 2 without reflection. There is no transmission between port 1 and port 3 and vice versa  	Expln:3marks Fig:3marks	3+3=6	6marks
X. a)	An optical isolator is a passive mafneto optic device that only allows light to travel in one direction. Isolators are used to protect source from backward reflections.Isolators function based on Faradays effect. Forward Mode	Defn:2marks	2+2+1.5+2+1.5=9	9marks

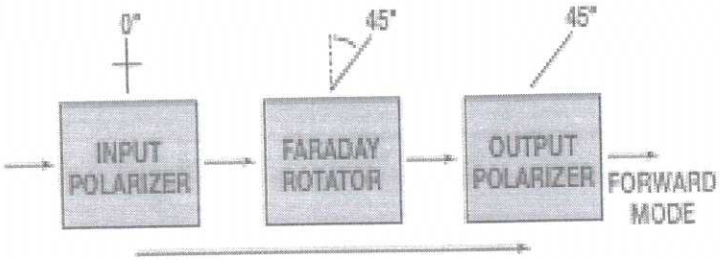
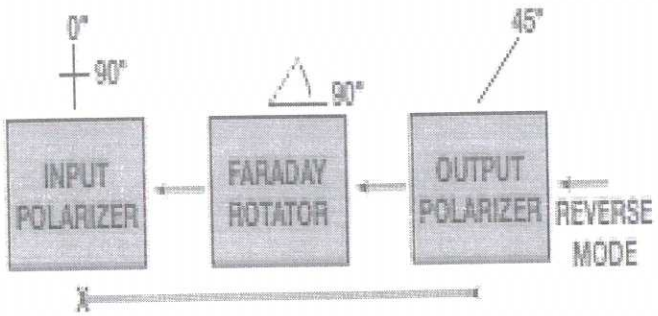


Fig:2marks

Laser light, whether or not polarized, enters the input polarizer and becomes linearly polarized, say in the vertical plane (0°). It then enters the Faraday rotator rod, which rotates the plane of polarization (POP) by 45°, in the clockwise sense. Finally, the light exits through the output polarizer whose axis is at 45°. Therefore, the light leaves the isolator with a POP of 45°.

1.5marks

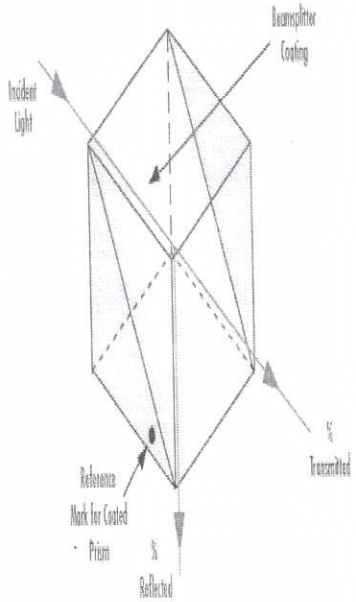
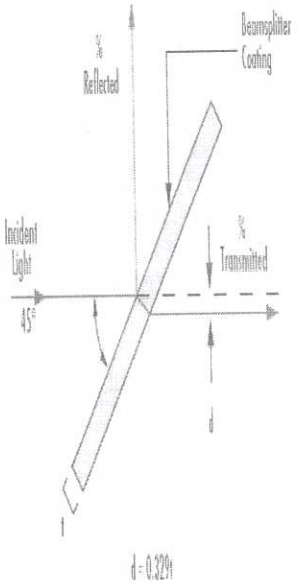
Reverse Mode



2marks

Light traveling backwards through the isolator will first enter the output polarizer, which polarizes the light at 45° with respect to the input polarizer. It then passes through the Faraday rotator rod, and the POP is rotated another 45° in the positive direction. This results in a net rotation of 90° with respect to the input polarizer, and thus, the POP is now perpendicular to the transmission axis of the input polarizer. Hence, the light will either be reflected or absorbed.

1.5marks

X. b)	Cube Beamsplitters  Plate Beamsplitters  Beam splitters are optical components used to split incident light at a designated ratio into two separate beams. Additionally, beam splitters can be used in reverse to combine two different beams into a single one. Beam splitters are often classified according to their construction: cube or plate Cube beam splitters are constructed using two typically right angle prisms The hypotenuse surface of one prism is coated, and the two prisms are cemented together so that they form a cubic shape. Plate beam splitters consist of a thin, flat glass plate that has been coated on the first surface of the substrate & an anti-reflection coating on the second surface	Any one fig:3marks Expln:3marks	3+3=6	6marks