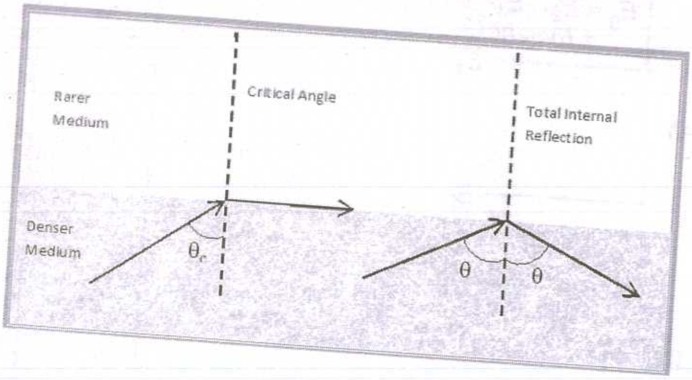
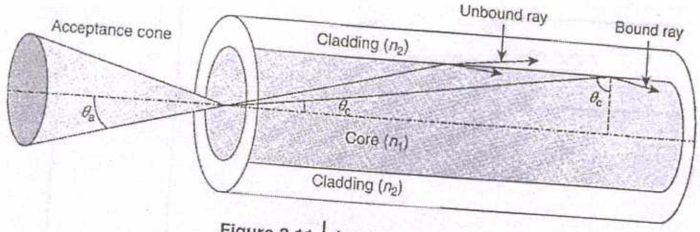
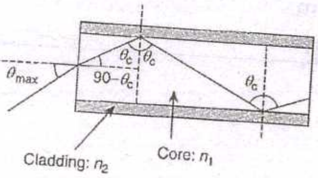
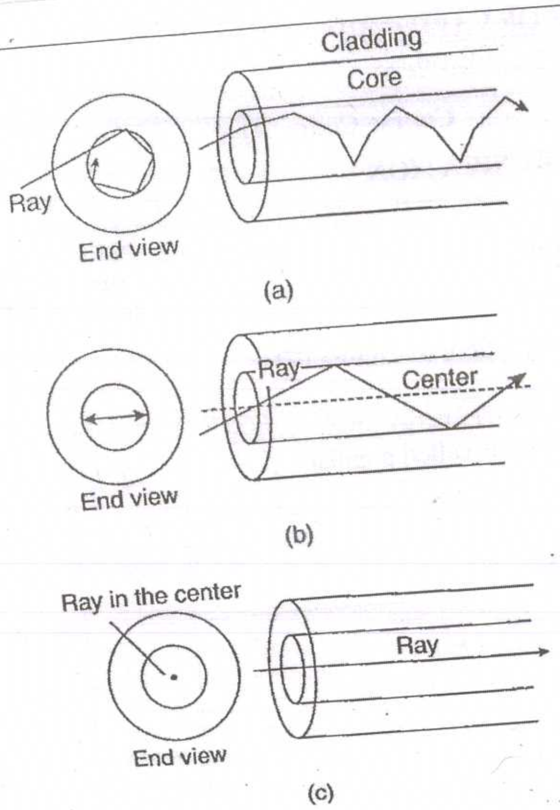
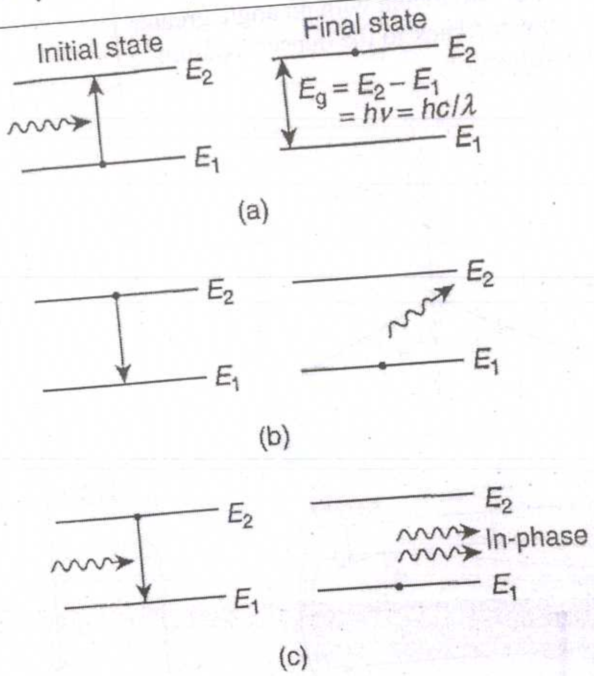
SCHEME OF VALUATION
(Scoring indicators)

A	Revision : 2015 Course Title : **OPTICAL FIBRE COMMUNICATION** Course Code: 5045			
Qst. No.	**Scoring Indicator**	**Split up score**	**Sub Total**	**Total**
1	NA is the measurement of the ability of an optical fibre to capture light	2	2	2
2	The process of making the density of atoms in higher energy level greater than the density of atoms in the lower energy level is called popular inversion	2	2	2
3	Semiconductor optical amplifier (SOA) Fibre Amplifier (FA)(Raman Amplifier, EDFA)	2	2	2
4	1. High power transfer efficiency 2. Wide spectral bandwidth 3. Large dynamic range 4. Low noise figure	2	2	2
5	1. Rayleigh scattering 2. Mie scattering	2	2	2
II 1	**Total Internal Reflection** If a light ray is an incident at the interface of two media with an angle greater than the critical angle, it is completely reflected back to the denser medium. This phenomenon is called total internal reflection.   Figure 2.11 | Acceptance cone. 	3+3	6	

<table>
<tr><td>II 2</td><td>
2.10 | (a) Skew ray. (b) Meridional ray. (c) Axial ray.</td><td>2x3</td><td>6</td></tr>
<tr><td>II 3</td><td>
a. Absorption
b. Spontaneous emission
c. Stimulated emission</td><td>2x3</td><td>6</td></tr>
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<tr>
<td>II 4</td>
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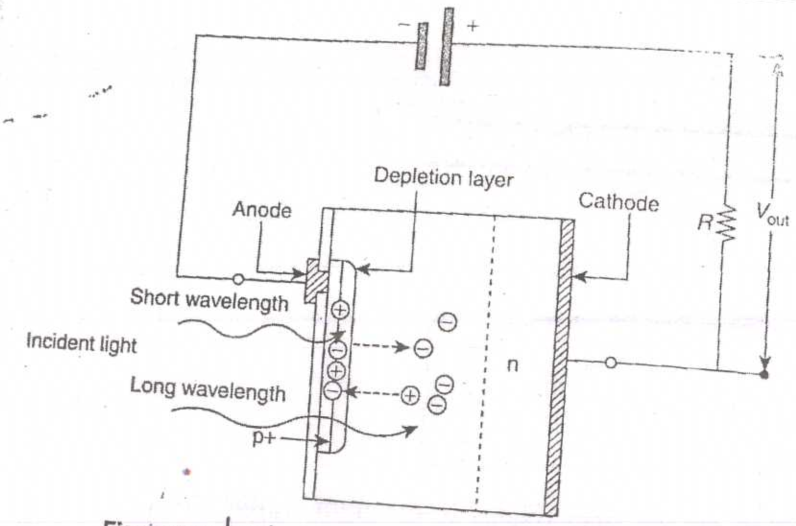

Figure 5.1 | Reverse-biased pn junction photodiode.

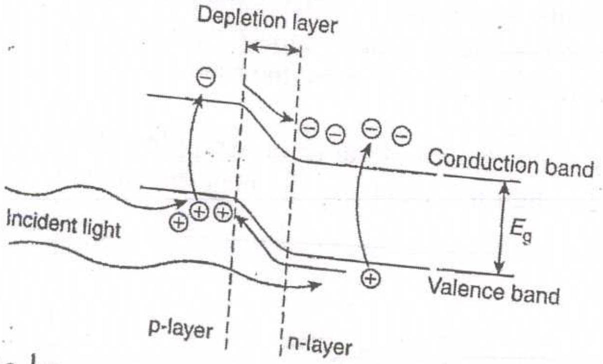

Figure 5.2 | Energy band diagram of the reverse-biased pn junction.
</td>
<td>4+2 (explanation)</td>
<td>6</td>
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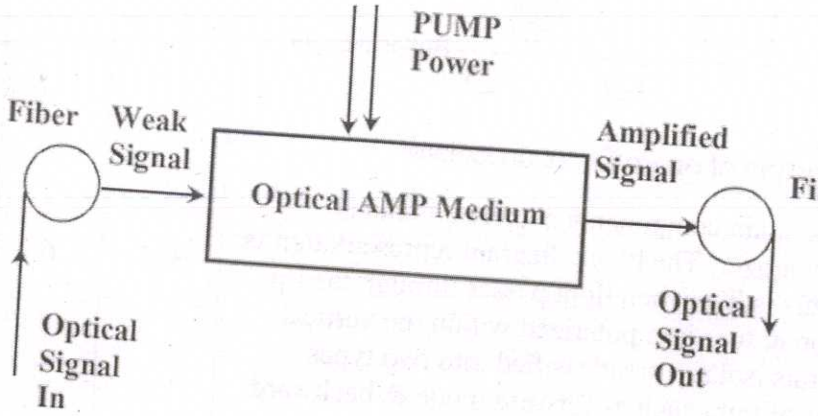
<td>II 5</td>
<td>


</td>
<td>4+2(explanation)</td>
<td>6</td>
<td></td>
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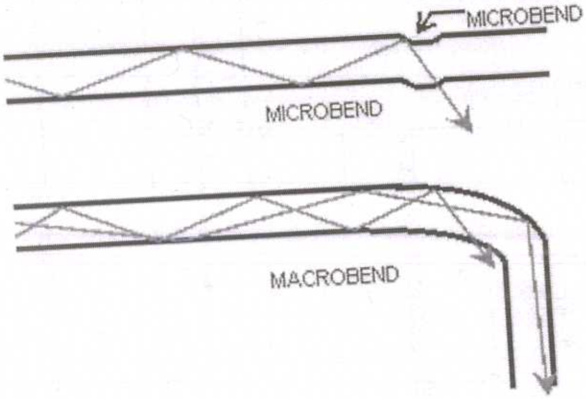
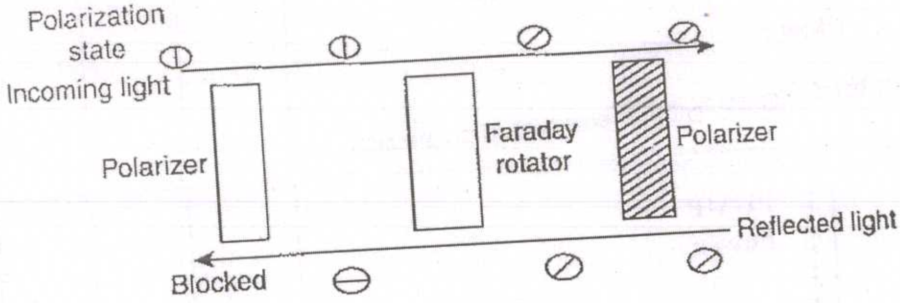
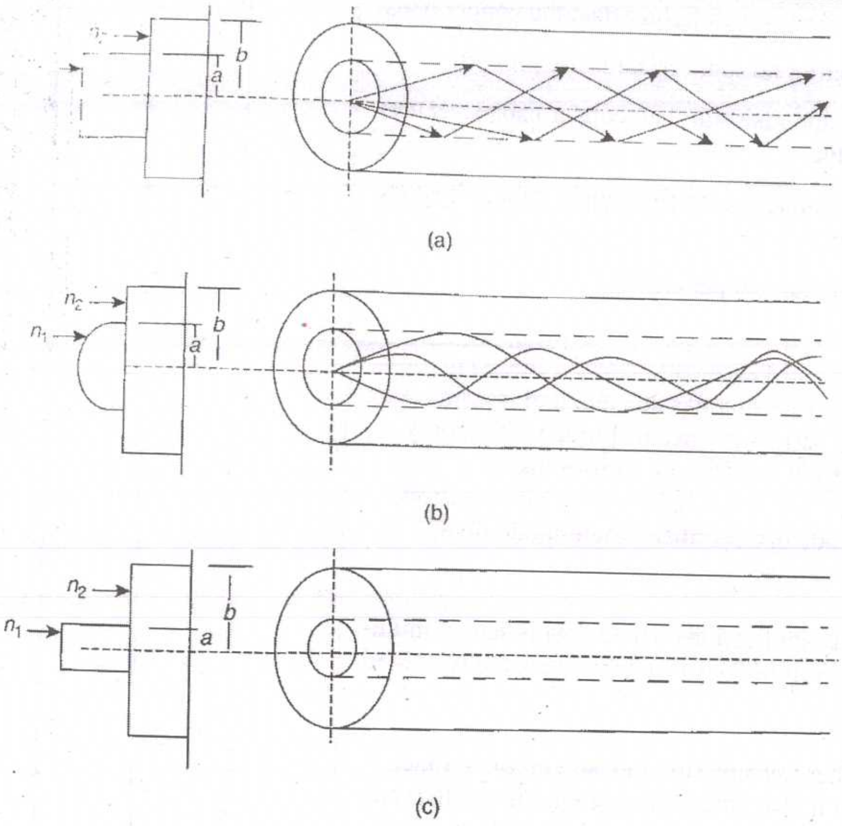
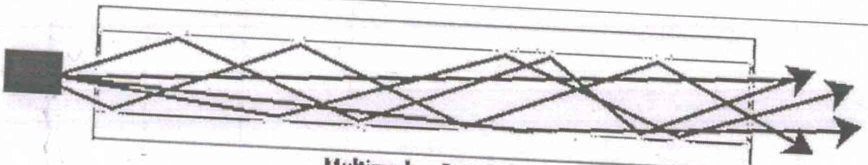
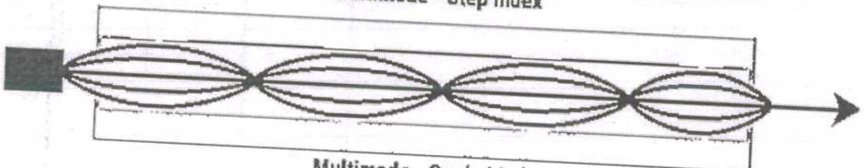
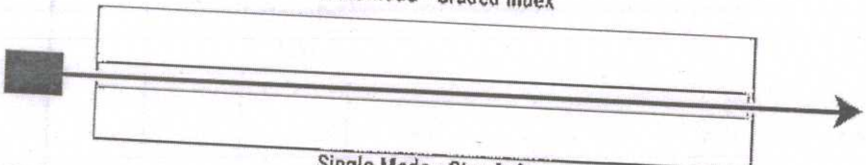
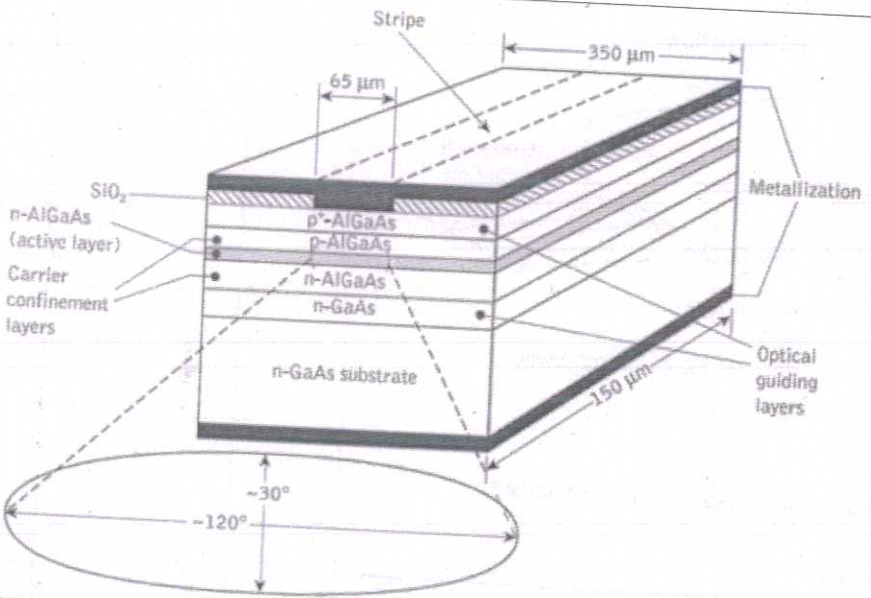
II 6	 Microbending attenuation of an optical fiber relates to the light signal loss associated with lateral stresses along the length of the fiber. The loss is due to the coupling from the fiber's guided fundamental mode to lossy, higher-order radiation modes. Mode coupling occurs when fibers suffer small random bends along the fiber axes. This random bending is usually caused by external mechanical stresses against the cable material that compress the fiber. Macrobending is the attenuation associated with bending or wrapping the fiber. Light can "leak out" of a fiber when it is bent. As the bend becomes tighter, more light escapes	2+2+2	6
II 7	 **Figure 6.13** | Principle of operation of an isolator. An optical isolator includes three main components namely a Faraday rotator, i/p polarizer, & an o/p polarizer. The block diagram representation is shown below. The working of this is like when light passes through the i/p polarizer in the forward direction & turn into polarized within the vertical plane. The operation modes of this isolator are classified into two types based on the different directions of light such as forward mode & backward mode. In forward mode, the light enters into the input polarizer then becomes linearly polarized. Once the light beam arrives at the Faraday rotator, then the rod of the Faraday rotator will turn with 45°. Therefore, finally, the light leaves from the o/p polarizer at 45°. Similarly in backward mode, initially the light enters into the o/p polarizer with a 45°. When it transmits throughout the Faraday rotator, rotates continuously for another 45° in a similar path. After that, the 90° polarization light turns into vertical toward the i/p polarizer & cannot depart the isolator. Thus, the light beam will be either absorbed or reflected.	3+3	6

III a	 .19 The refractive index profiles and light propagation in (a) multimode step- (b) multimode graded-index, and (c) single-mode step-index fibers.	10	10	15
III b	Functional Advantages The functional advantages of optical fibers are – • The transmission bandwidth of the fiber optic cables is higher than the metal cables. • The amount of data transmission is higher in fiber optic cables. • The power loss is very low and hence helpful in long-distance transmissions. • Fiber optic cables provide high security and cannot be tapped. • Fiber optic cables are the most secure way for data transmission. • Fiber optic cables are immune to electromagnetic interference. • These are not affected by electrical noise. Physical Advantages The physical advantages of fiber optic cables are – • The capacity of these cables is much higher than copper wire cables. • Though the capacity is higher, the size of the cable doesn't increase like it does in copper wire cabling system. • The space occupied by these cables is much less.	5 (Any five)	5	

	• The weight of these FOC cables is much lighter than the copper ones. • Since these cables are di-electric, no spark hazards are present. • These cables are more corrosion resistant than copper cables, as they are bent easily and are flexible. • The raw material for the manufacture of fiber optic cables is glass, which is cheaper than copper. • Fiber optic cables last longer than copper cables.			
IV a	**Single Mode** cable is a single stand (most applications use 2 fibers) of glass fiber with a diameter of 8.3 to 10 microns that has one mode of transmission. Single Mode Fiber with a relatively narrow diameter, through which only one mode will propagate typically 1310 or 1550nm. Carries higher bandwidth than multimode fiber, but requires a light source with a narrow spectral width. Synonyms mono-mode optical fiber, single-mode fiber, single-mode optical waveguide, uni-mode fiber. Single Modem fiber is used in many applications where data is sent at multi-frequency (WDM Wave-Division-Multiplexing) so only one cable is needed - (single-mode on one single fiber) Single-mode fiber gives you a higher transmission rate and up to 50 times more distance than multimode, but it also costs more. Single-mode fiber has a much smaller core than multimode. The small core and single light-wave virtually eliminate any distortion that could result from overlapping light pulses, providing the least signal attenuation and the highest transmission speeds of any fiber cable type. Single-mode optical fiber is an optical fiber in which only the lowest order bound mode can propagate at the wavelength of interest typically 1300 to 1320nm. **Multi-Mode cable** has a little bit bigger diameter, with a common diameters in the 50-to-100 micron range for the light carry component (in the US the most common size is 62.5um). Most applications in which Multi-mode fiber is used, 2 fibers are used (WDM is not normally used on multi-mode fiber). POF is a newer plastic-based cable which promises performance similar to glass cable on very short runs, but at a lower cost. Multimode fiber gives you high bandwidth at high speeds (10 to 100MBS - Gigabit to 275m to 2km) over medium distances. Light waves are dispersed into numerous paths, or modes, as they travel through the cable's core typically 850 or 1300nm. Typical multimode fiber core diameters are 50, 62.5, and 100 micrometers. However, in long cable runs (greater than 3000 feet [914.4 meters), multiple paths of light can cause signal distortion at the receiving end, resulting in an unclear and incomplete data transmission so designers now call for single mode fiber in new applications using Gigabit and beyond.	3+3+4	10	15

	 Multimode - Step Index  Multimode - Graded Index  Single Mode - Step Index			
IV b	1. Two materials with slightly different refractive index for making of core and cladding are required. 2. These materials should be transparent to light in the operating wavelength range of around 800-1600 3. These materials should have low attenuation 4. These materials should have low intrinsic and scattering losses 5. The materials must allow the making of long thin and flexible fibres	5	5	
V a		5+3 (explanation)	8	15

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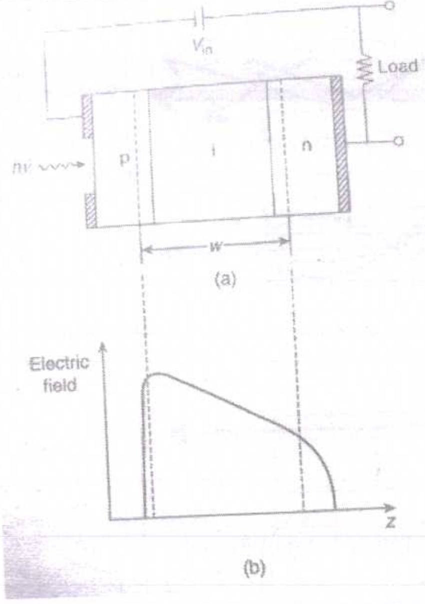
<tr><td>V b</td><td>

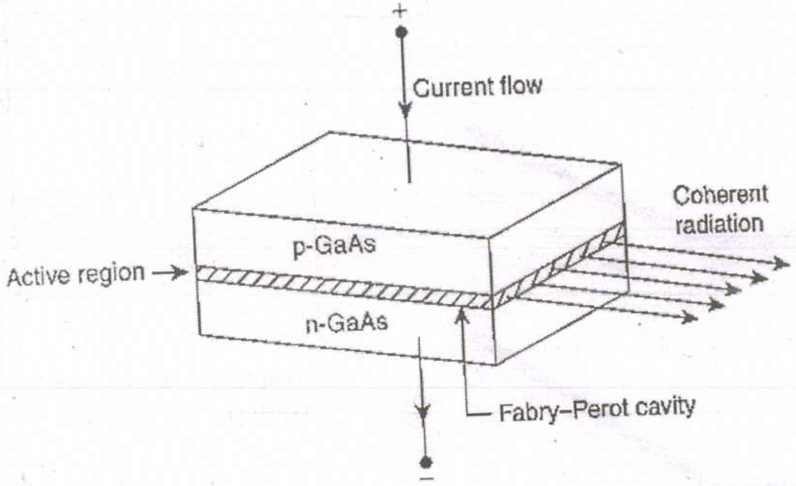
a. Structure of PIN photodiode in reverse bias condition
b. Electric field variation</td><td>4+3(explanation)</td><td>7</td><td></td></tr>
<tr><td>VI a</td><td>

Figure 4.30 | Semiconductor laser diode structure.

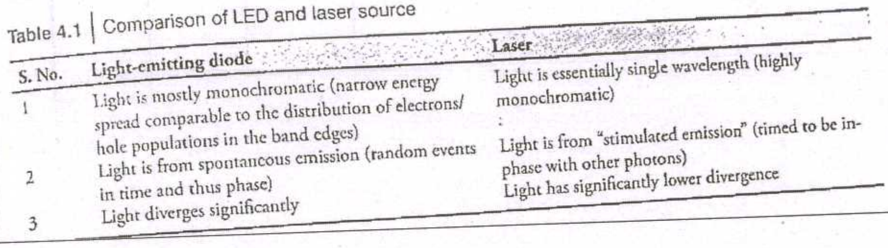
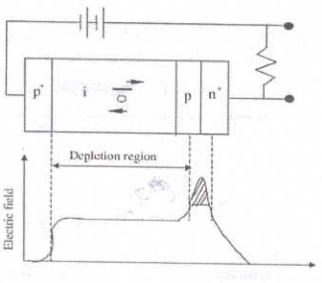
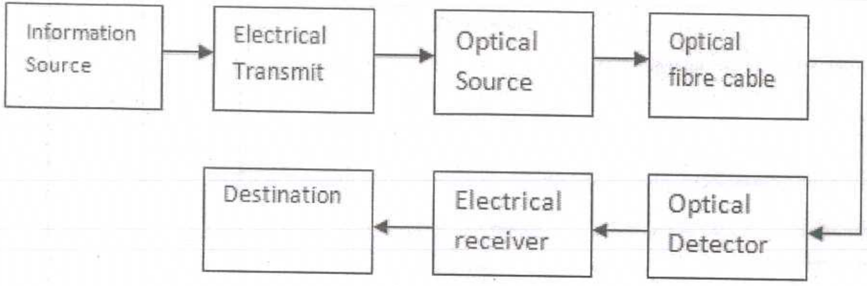
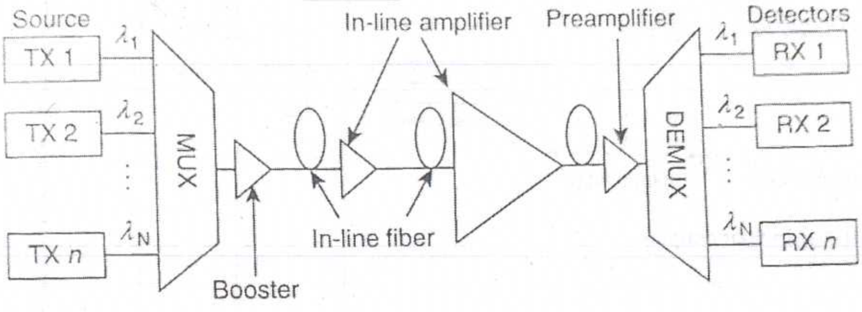
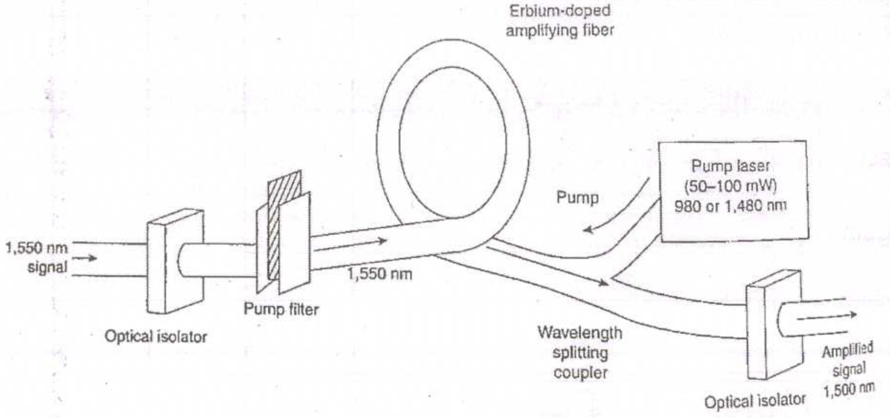
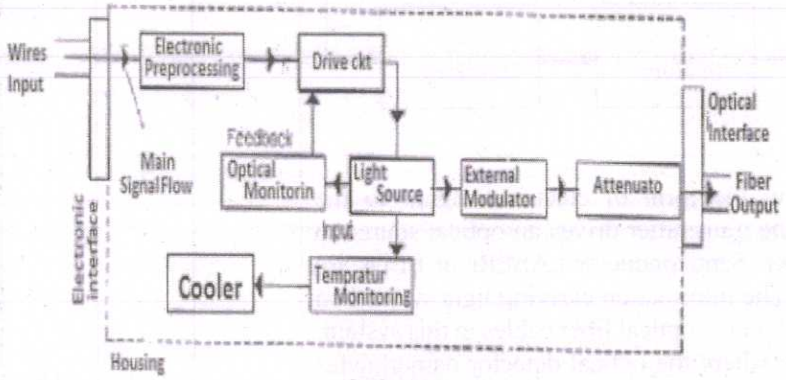
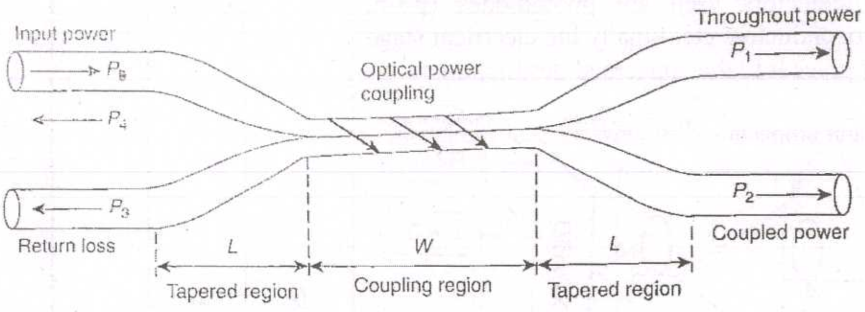
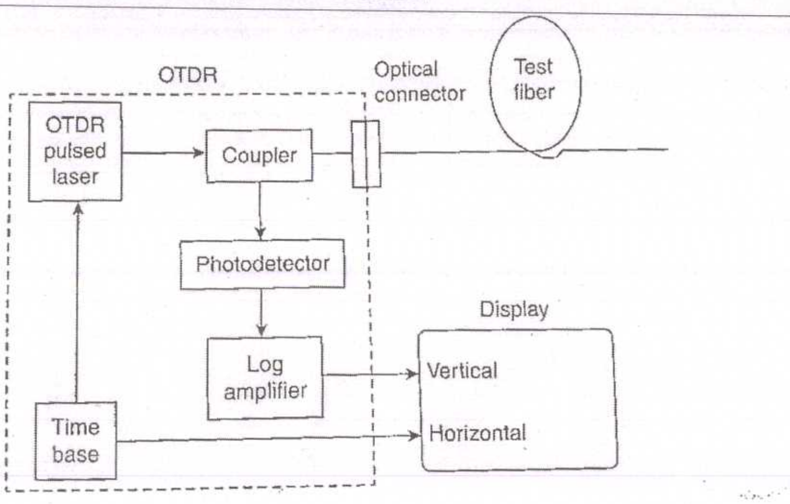
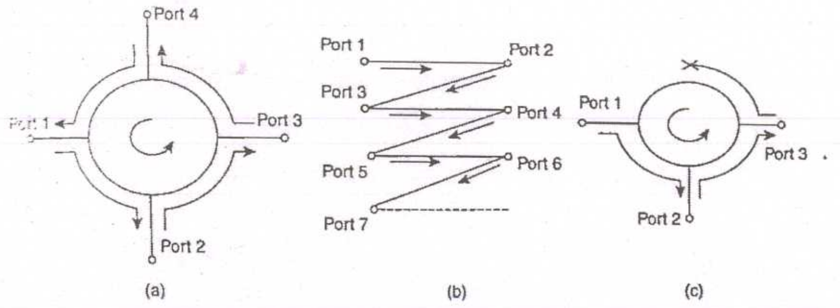


Table 4.1 | Comparison of LED and laser source

<table>
<tr><th>S. No.</th><th>Light-emitting diode</th><th>Laser</th></tr>
<tr><td>1</td><td>Light is mostly monochromatic (narrow energy spread comparable to the distribution of electrons/hole populations in the band edges)</td><td>Light is essentially single wavelength (highly monochromatic)</td></tr>
<tr><td>2</td><td>Light is from spontaneous emission (random events in time and thus phase)</td><td>Light is from "stimulated emission" (timed to be in-phase with other photons)</td></tr>
<tr><td>3</td><td>Light diverges significantly</td><td>Light has significantly lower divergence</td></tr>
</table></td><td>5+3</td><td>8</td><td>15</td></tr>
</table>

VI b	**Avalanche Photodiodes** • High gain due to avalanche multiplication effect • Increased noise • Silicon has high gain but low noise • Si-InGaAs APD often used(diagram on right)  	7	7	
VII a	 The source provides information in the form of electrical signal to the transmitter. The electrical stage of the transmitter drives an optical source to produce modulated light wave carrier. Semiconductor LASERs or LEDs are usually used as optical source here. The information carrying light wave then passes through the transmission medium i.e. optical fiber cables in this system. Now it reaches to the receiver stage where the optical detector demodulates the optical carrier and gives an electrical output signal to the electrical stage. The common types of optical detectors used are photodiodes (p-i-n, avalanche), phototransistors, photoconductors etc. Finally the electrical stage gets the real information back and gives it to the concerned destination.	6+3	9	15
VII b	 **Figure 6.8** | Typical WDM system.	6	6	

VIII a	 **Figure 7.21** An erbium-doped fiber amplifier.	6+3 (working)	9	15
VIII b	 Optical transmitter	6	6	
XI a	 **Figure 6.12** Fused-fiber coupler.	6+3 (working)	9	15
XI b	**Intramodal Dispersion** Intramodal, or chromatic, dispersion depends primarily on fiber materials. There are two types of intramodal dispersion. The first type is material dispersion. The second type is waveguide dispersion. Intramodal dispersion occurs because different colors of light travel through different materials and different waveguide structures at different speeds. **Intermodal Dispersion** Intermodal or modal dispersion causes the input light pulse to spread. The input light pulse is made up of a group of modes. As the modes propagate along the fiber, light energy distributed among the modes is delayed by different amounts. The pulse spreads because each mode propagates along the fiber at different speeds. Since modes travel in different directions, some modes travel longer	3+3	6	

	distances. The modes of a light pulse that enter the fiber at one time exit the fiber a different times. This condition causes the light pulse to spread. As the length of the fiber increases, modal dispersion increases.			
X a	 **Figure 8.3** | Experimental setup for fiber attenuation measurement using OTDR.	9	9	15
X b	**Fiber splicing** is the process of permanently joining two fibers together. Unlike **fiber** connectors, which are designed for easy reconfiguration on cross-connect or patch panels. There are two types of **fiber splicing** – mechanical **splicing** and fusion **splicing**. **Circulator**  (a) (b) (c) Figure 6.15 | Optical circulator connections: (a) Strict-sense circulator with four ports. (b) Non-strict-sense circulator in ladder topology. (c) Non-strict-sense three-port circulator.	6	6	