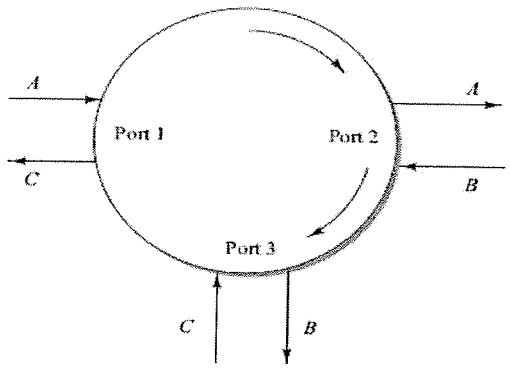
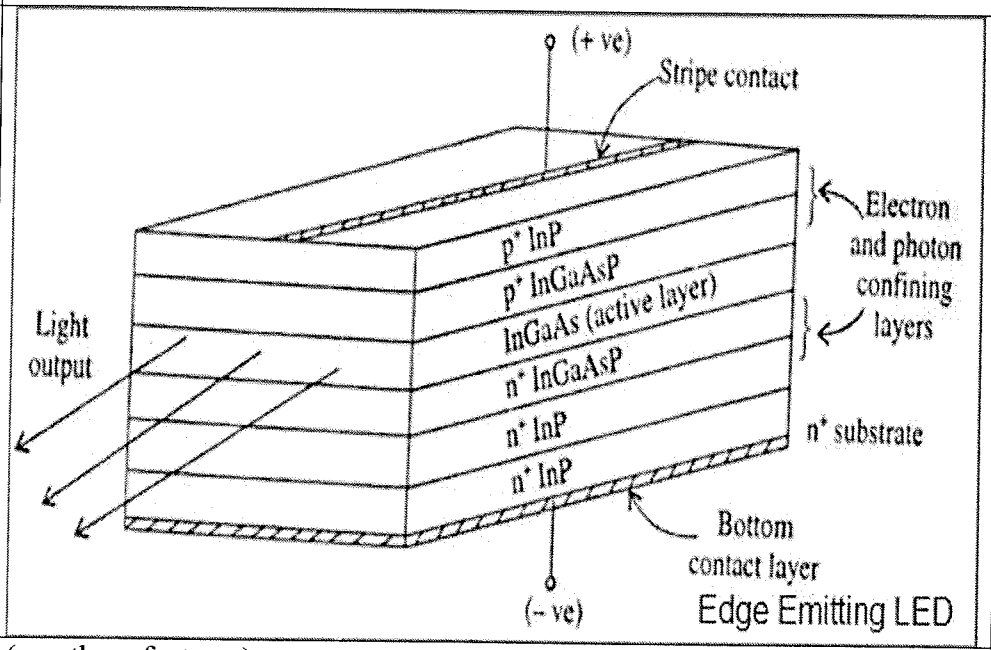
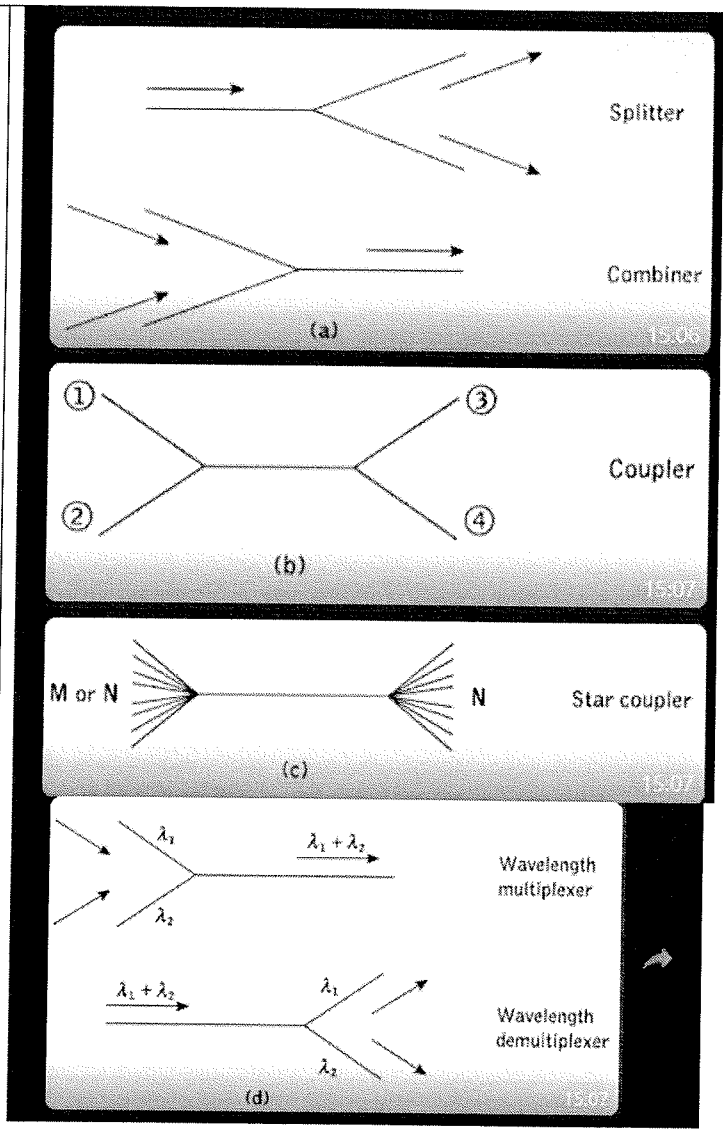
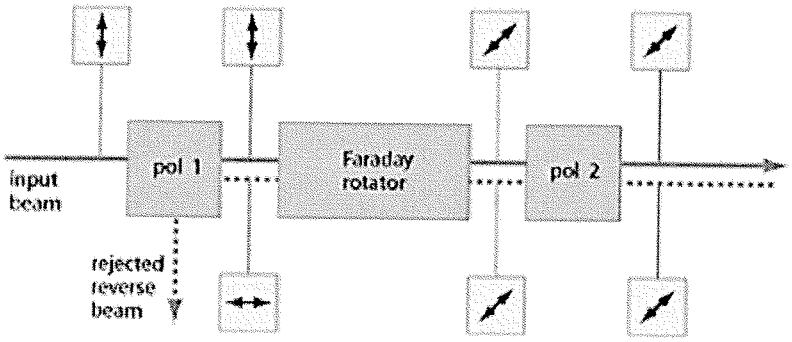
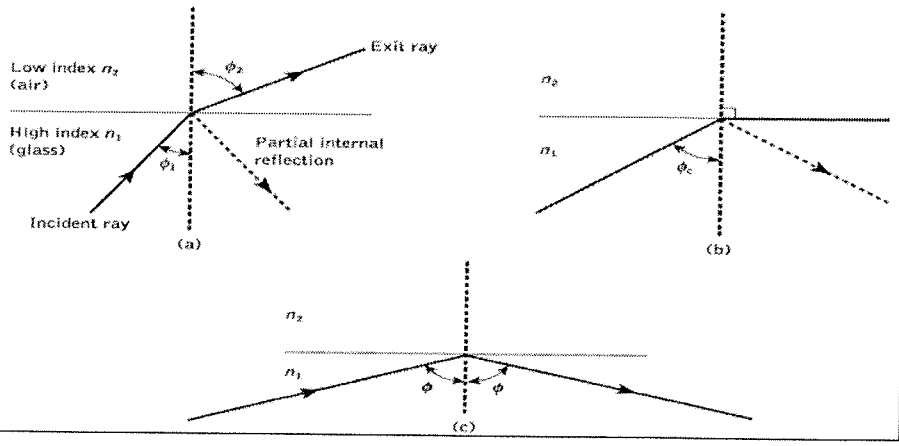
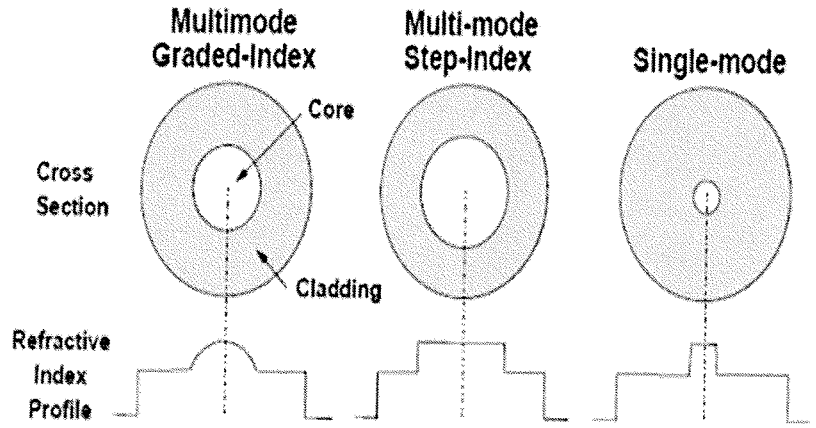
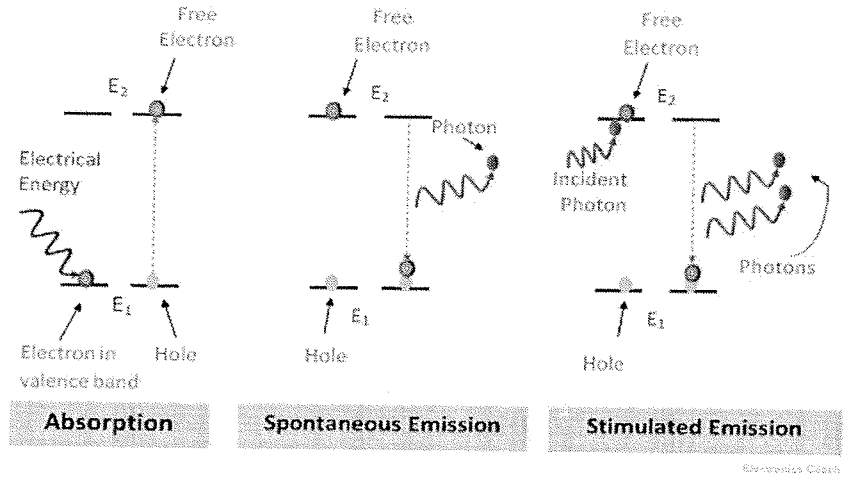
SCORING INDICATORS (SET1)

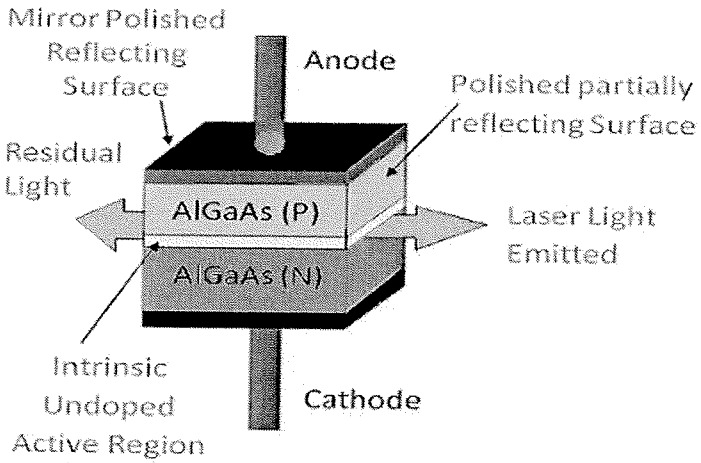
	Course Code: 5043A **Revision : 2021** **Course Title : OPTICAL COMMUNICATION AND NETWORKING** **QID : : 2109230091**	**SET 1**		
Qn. No.	**Scoring Indicator**	**Split score**	**Sub Total**	**Total Score**
	PART A			9
I.1	Multimode and single mode.	1	1	1
I.2	The ratio of velocity of light in vacuum to velocity of light in medium.	1	1	1
I.3	LEDs and LASERs	1	1	1
I.4	APD amplifies the photocurrent generated by the incident light or APD is having higher sensitivity.	1	1	1
I.5	Optical amplifiers are used to amplify optical signals while electrical amplifier amplifies electrical signals.	1	1	1
I.6	Dispersion refers to the spreading or broadening of optical pulses as they travel travel through the fiber.	1	1	1
I.7	An optical circulator is a non-reciprocal optical component that directs light sequentially through its ports in a specific, unidirectional manner. It's a three-port device commonly used in fiber-optic communication systems to route light from one port to another while minimizing signal loss. It allows light to flow from Port 1 to Port 2, then from Port 2 to Port 3, Port 3 to Port 1,but not in the reverse direction.  	1	1	1
I.8	Synchronous Digital Hierarchy.	1	1	1
I.9	A beam splitter in optical fiber communication is an optical device that divides or splits an incident optical beam into two or more separate beams,	1	1	1
	PART B			24
II 1	$n_1^2 - n_2^2 = NA^2$. n1=1.65,n2=1.55 NA=0.565	3	3	3

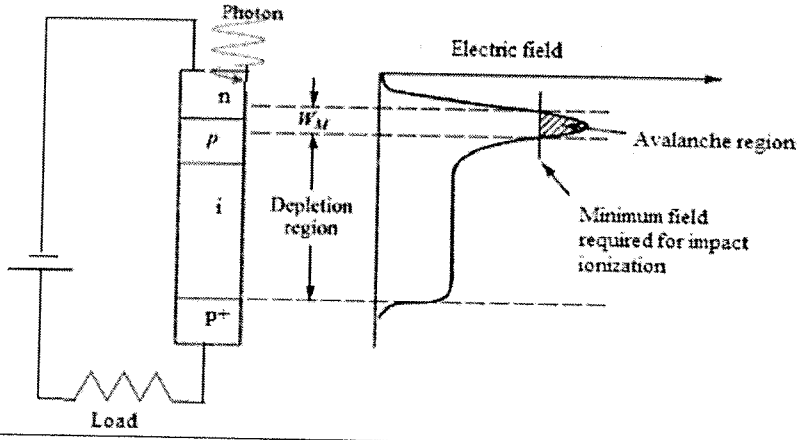
II 2	Numerical aperture (NA) is a parameter used to characterize and quantify the light-gathering and light-confining capabilities of an optical system, such as a lens or an optical fiber The numerical aperture provide critical information about how effectively an optical system can collect and focus light.	2 1	3	3
II 3	$1.0 \times \sin(30°) = 1.5 \times \sin(\theta r)$ $\theta r \approx 19.47$	3	3	3
II 4	An optical modulator is a component in optical communication systems that facilitates the modulation (variation) of an optical signal to encode information onto the light wave for transmission. The modulation process involves altering certain properties of the optical signal, such as amplitude, phase, frequency, or polarization, in response to the data to be transmitted. Types of optical modulator. Electro optic modulator. Electro absorption modulator. Acousto-optic modulators. Magneto optic modulator.	exp2 + fig1	3	3
II 5		3	3	3
II 6	(any three features) Increased Transmission Capacity Efficient Utilization of Fiber Bandwidth. Enhanced Flexibility and Scalability Transmission of more signals. Wavelength routing	3	3	3
II 7	A broadcast network is a type of network topology in which all nodes (devices like computers, printers, etc.) share a single communication channel or link. A select network is a type of network topology where devices are connected to a central switching node (like a network switch). In this topology, each device has a dedicated point-to-point connection to the switch.	3	3	3

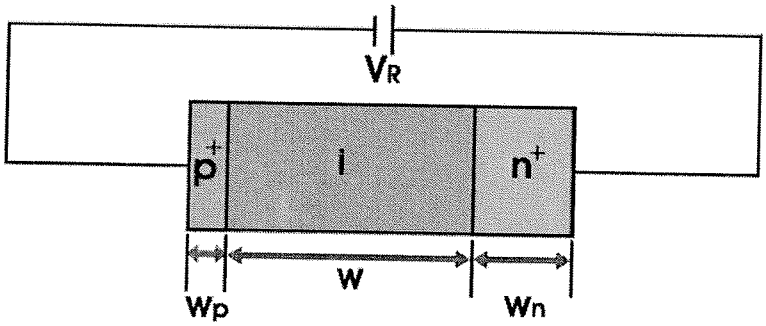
II 8		3	3	3
II 9	Optical modulation is the process of changing the characteristics of a light signal, such as its intensity, phase, or polarization. Examples of optical modulation devices: Electro-optic modulator (EOM): An EOM uses an electric field to change the refractive index of a material, which in turn changes the phase of the light signal passing through the material. Acousto-optic modulator (AOM): An AOM uses a sound wave to change the refractive index of a material, which in turn changes the direction of the light signal passing through the material. Magneto-optic modulator (MOM): An MOM uses a magnetic field to change	3	3	3

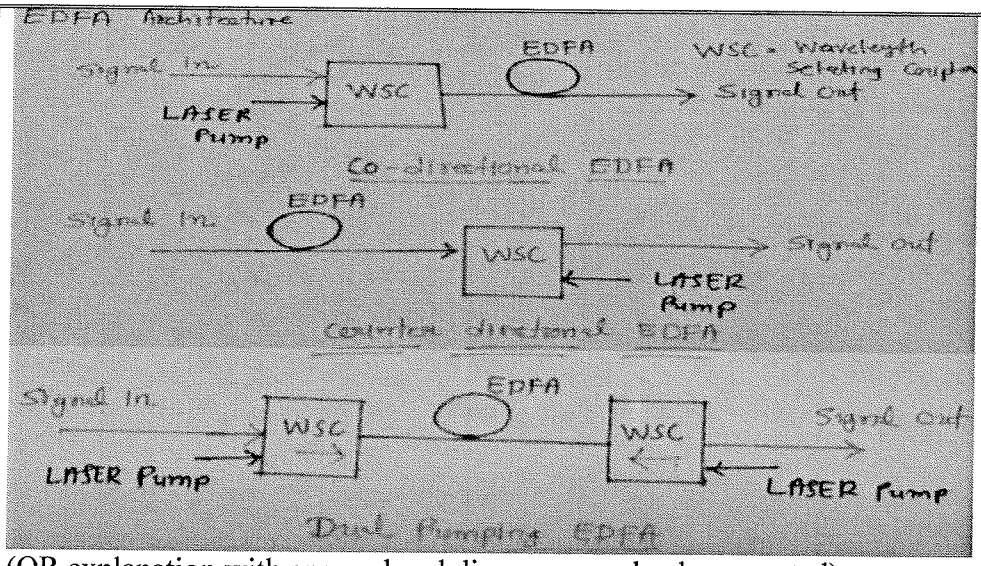
II 10	An optical isolator is a device that only allows unidirectional transmission of the optical signal.An isolator uses the properties of polarized light. In the forward direction an input polarizer converts unpolarized light into vertically polarized light.This polarized light passes through a Faraday rotator, which rotates a plane of light polarization 45 deg.An output polarizer (analyzer) allows 45deg polarized light to pass and the light passes through the unit with minimum loss.  	exp2 + fig1 1	3	3
	PART C			42
III	The ratio of velocity of light in vacuum to velocity of light in another medium is called the refractive index of the medium. Whenever a ray of light is incident on the boundary separating two different media, part of ray is reflected into the first medium and the remainder is refracted as it enters the second medium. The degree of refraction or bending depends upon relative refractive indices of the two mediums. When we increase the incident angle with respect to normal, at some incident angle, the dielectric of surface and φ2 becomes 90 and such incident angle is called critical angle. As the angle of incidence is beyond the critical angle, then the light rays gets reflected with in the denser medium rather than causing refraction. • This is called total internal reflection.  	Exp 4 + fig3	7	7

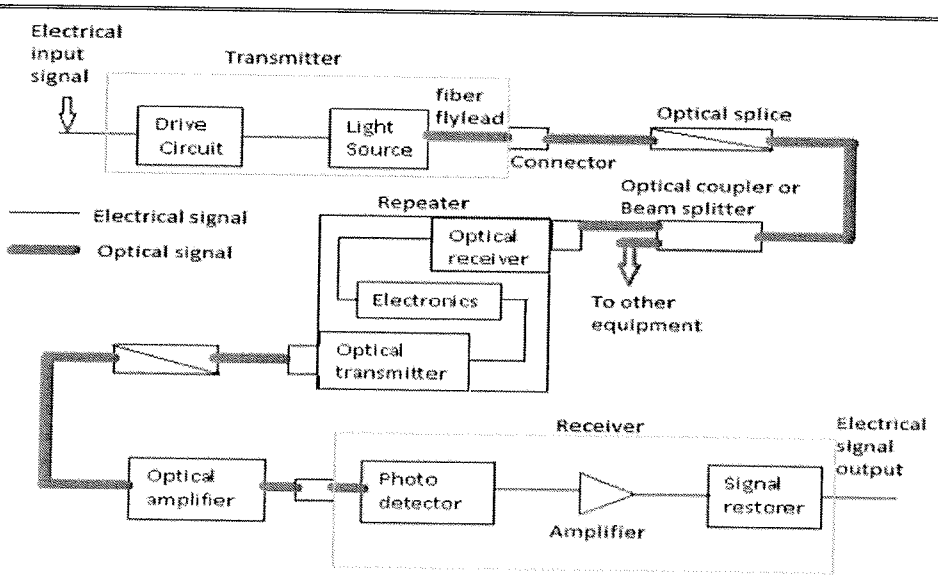
IV	Step index fiber In step index fiber the refractive index of the core is uniform through out and at the core cladding interface there is a sudden decrease in the refractive index, and remains constant throughout the cladding part of the optical fiber. Graded index fiber • If the refractive index of the core is made to vary as a function of the radial distance from the center of the fiber, then it is called graded index fiber. In this the refractive decreases from core to cladding and remains constant with respect to the radial distance.  	Exp2 Exp2 Fig 1.5+1.5	7	7
V	There are basically three phenomena by which an atom can emit light energy and that are **Absorption, Spontaneous Emission & Stimulated emission.**  **Absorption** In absorption, the electrons at lower energy levels jump to higher energy level i.e. from valence band to conduction band when the electrons are provided with an external source of energy. **Spontaneous Emission** If the electrons in higher energy level are unstable then they will tend to move to the lower energy level in order to achieve stability. But if they will move from higher energy level to lower energy levels they release the energy which will be the energy difference between these two levels. The energy released will be in the form of light and thus photons will be emitted. This process is called spontaneous emission. **Stimulated Emission** In stimulated emission, the photons strike electrons at higher energy level and these photons are supplied from an external light energy source. When	Fig 3 Exp4	7	7

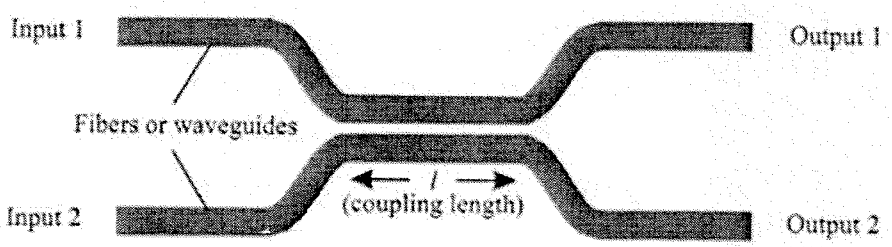
	these photons strike the electrons, electrons gain energy and they recombine with holes and release an extra photon. Thus, one incident photon stimulates another photon to release. Thus, this process is called stimulated emission			
V1	**Construction of Laser diode** The Laser diode is made up of two layers of Semiconductors i.e. P-type and N-type. The layers of semiconductors are made up of GaAs doped with materials like selenium, aluminium or silicon. The construction is same as that of LED except the channels used in Laser are narrow to produce a single beam of light And one more difference in a Laser diode is that an intrinsic layer of GaAs (undoped) is also present. This layer is called active layer. The active layer is enclosed by layers of lower refractive index. This act as optical reflectors. These layers along with active layer form a waveguide so that light can travel only in a single path in a single and fixed direction. The beam of light is produced in this section. The metal contacts are provided to facilitate biasing  **Construction of Laser Diode**	Exp4 + Fig3	7	7
V11	APD, internally multiplied the primary signal photo current before it enters the i/p circuit of the following amplifier. This increases receiver sensitivity, for carrier multiplication to take place. The photo generated carriers must transverse a region, where a very high electric field is present. In this high field region, a photo generated electron or hole can gain enough energy, so that it ionizes bound electrons in the valance band This carrier multiplication mechanism is known as impact ionization. The newly created carriers are also accelerated by the high electric field. Thus gaining enough energy to cause further impact ionization. This phenomenon is the avalanche effect. The π (i) layer is basically an intrinsic material with P – doping.	Exp4+ fig3	7	7



V111	The PIN diode is a type of photo detector, used to convert optical signal into an electrical signal. The PIN diode comprises of three regions, namely P-region, I-region and N-region. Both the P and N regions are heavily doped. The PIN photodiode consists of p and n regions separated by a lightly -N-doped intrinsic region. In normal operation, a sufficiently large reverse bias voltage is applied across the device so that the intrinsic region is fully depletedofcarriers. When an incident photon has an energy greater than or equal to the band gap energy of the semiconductor material, the photon can give up its energy and excite an electron from the valance band to the conduction band. This process generates free electron hole pairs which are known as photo carriers. These carriers are generated in the depletion region, where most of the incident light is absorbed. The high electric field present in the depletion region causes the carrier to separate and collected across the reverse biased junction. This give rise to a current flow in an external circuit with one electron flowing for every carrier pair generated. This current flow is known as the photo current.  	Exp4+ fig3	7	7
IX	Basis of EDFA It is used to boost intensity of optical signals It has a fibre whose core is heavily doped with Erbium ions It works based on the concept of stimulated emission It operate in C band (1530 – 1560) nm and L band (1570 – 1610)nm LASER pump energy at 980nm or 1480nm. High energy and weak signal are mixed by wavelength selective coupler. Er3+ ions absorbs energy by LASER pumping , get excited to higher levels. Then stimulated absorption and stimulated emission will amplify weak signal	Exp4+ fig3	7	7

	 (OR explanation with energy band diagram can also be accepted)			
X.	Absorption losses in optical fibers occur when the fiber material absorbs a portion of the light energy as it travels through the fiber. The absorbed energy is converted into heat, resulting in a reduction of the optical signal strength. This loss is typically caused by impurities or defects within the fiber material. Intrinsic Absorption Loss: Intrinsic absorption losses are inherent to the material itself and are caused by fundamental pronperties of the material at the atomic and molecular level. These losses occur due to the interaction of light with the intrinsic components of the material Extrinsic absorption losses are caused by impurities, defects, or foreign substances introduced into the material intentionally or unintentionally. These impurities or extrinsic factors can introduce additional absorption mechanisms that contribute to signal loss. Fiber bend losses occur when an optical fiber is bent, causing some of the light to escape from the core and be absorbed or scattered in the cladding or surrounding materials. **Microscopic Bending Loss:** Microscopic bending loss refers to localized and minute variations in the fiber's geometry, leading to signal attenuation at a smaller scale or radius of curvature, typically in the range of micrometers to millimeters. Microscopic bending loss refers to localized and minute variations in the fiber's geometry, leading to signal attenuation at a smaller scale or radius of curvature, typically in the range of micrometers to millimeters. **Microscopic Bending Loss:** Microscopic bending loss refers to localized and minute variations in the fiber's geometry, leading to signal attenuation at a smaller scale or radius of curvature, typically in the range of micrometers to millimeters.	Exp 3.5 + 3.5	7	7

X1	 Itconsists of three main elements: Transmitter: An electric signal is applied to the optical transmitter. The optical transmitter consists of driver circuit, light source and fiber flylead. • Driver circuit drives the light source. • Light source converts electrical signal to optical signal. • Fiber flylead is used to connect optical signal to optical fiber. Transmission channel: It consists of a cable that provides mechanical and environmental protection to the optical fibers contained inside. Optical splice is used to permanently join two individual optical fibers. Optical connector is for temporary non-fixed joints between two individual optical fibers. Optical coupler or splitter provides signal to other devices. Repeater converts the optical signal into electrical signal using optical receiver and passes it to electronic circuit where it is reshaped and amplified as it gets attenuated and distorted with increasing distance because of scattering, absorption and dispersion in waveguides, and this signal is then again converted into optical signal by the optical transmitter. Receiver: Optical signal is applied to the optical receiver. It consists of photo detector, amplifier and signal restorer. Photo detector converts the optical signal to electrical signal. Signal restorers and amplifiers are used to improve signal to noise ratio of the signal as there are chances of noise to be introduced in the signal due to the use of photo detectors.	Exp4+ fig3	7	7

X11	**Principle of DWDM** ❖ The DWDM. Divides the light travelling through optical cable into different wavelengths. ❖ DWDM takes input optical signal and divides it into different wavelengths. ❖ All these wavelengths are transmitted through the same optical cable. ❖ DWDM selects the wavelength in certain band. It is around 1550nm and it is called as operating window of DWDM. ❖ Thus DWDM increases the capabilities of existing optical networks without extra cabling. ❖ Thus, using DWDM the different signals can travel in parallel as if they travel in dedicated lanes, where each lane is independent. **Categories of WDM** Based upon the wavelength, WDM can be divided into two categories – **Course WDM (CWDM)** : CWDM generally operates with 8 channels where the spacing between the channels is 20 nm (nanometers) apart. It consumes less energy than DWDM and is less expensive. However, the capacity of the links, as well as the distance supported, is lesser. **Dense WDM (DWDM)** : In DWDM, the number of multiplexed channels much larger than CWDM. It is either 40 at 100GHz spacing or 80 with 50GHz spacing. Due to this, they can transmit the huge quantity of data through a single fiber link. DWDM is generally applied in core networks of telecommunications and cable networks. It is also used in cloud data centers for their IaaS services	Exp4+ types 3	7	7
XIII.	Directional couplers are essential components in optical fiber communication systems, facilitating the splitting and combining of optical signals within the fiber optic network. Directional couplers are essential components in optical fiber communication systems, facilitating the splitting and combining of optical signals within the fiber optic network.  Use in Optical Fiber Communication Signal Splitting: Optical Signal Combining: Signal Monitoring	Exp3 + Fig1 App3	7	7
XIV	Synchronous Optical Networking (SONET) and Synchronous Digital Hierarchy (SDH) are standardized protocols for high-speed communication over optical networks. SONET is a standard primarily used in North America. It defines a set of standards for optical telecommunications transport. SONET uses synchronous framing, dividing the optical signal into fixed-length frames, typically 125 microseconds. Each frame consists of several bytes, and synchronization is maintained through a high-level clocking	Exp 3.5 + 3.5	7	7

	scheme.SONET defines multiple levels of optical carriers each with a specific data rate. SONET supports various network topologies, including point-to-point, ring, and mesh, providing flexibility and redundancy options for network design. SDH (Synchronous Digital Hierarchy): SDH is a similar standard to SONET but is widely used in Europe and other parts of the world. It has the same basic principles as SONET but differs slightly in terminology and specific implementation. Key points about SDH include. SDH, like SONET, employs synchronous framing and divides the signal into fixed-length frames. It uses the synchronous transport module (STM) as the basic unit. SDH is an international standard developed by the International Telecommunication Union (ITU) to ensure global compatibility and interoperability. SDH has evolved to incorporate the Optical Transport Network (OTN) standard, which adds further functionalities like enhanced error correction, forward error correction (FEC), and the ability to carry data formats other than traditional telecom data. SDH supports various network topologies similar to SONET, offering versatility in network design and redundancy options			