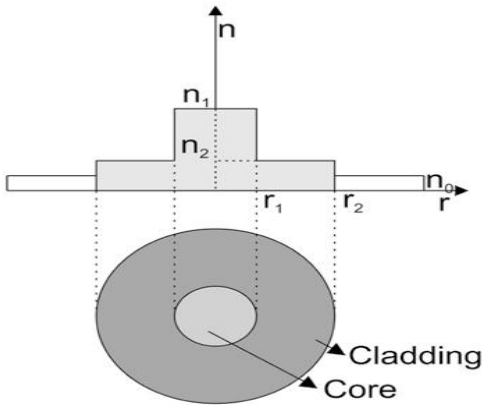
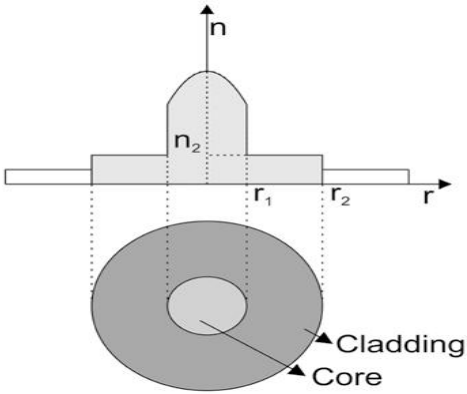


**APPLIED PHYSICS-II (2ND SEMESTER DIPLOMA ENGG STUDENTS
FROM SUMMER 2025 ONWARDS**

Unit-7 (Modern Physics)

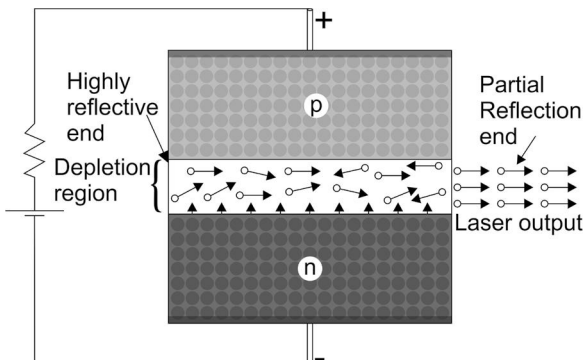
2 MARKS QUESTIONS & SOLUTIONS

Q. No.	Question	Taxonomy Level	Marking Scheme
Q 1.	Distinguish between ordinary light and Laser light.	L2	2
Ans.	<p>Ordinary Light Ordinary light is the mixture of different wave lengths. It is less intense, spreads out in all directions, incoherent and polychromatic. Example: Sun light, light bulb.</p> <p>Laser Light: Laser Light is a single wavelength. It is highly intense, highly directional, coherent and monochromatic. Example: He- Ne Laser, semiconductor Laser.</p>		<p align="center">1</p> <p align="center">1</p>
Q2.	Define population inversion.	L1	2
Ans.	<p>Population Inversion creates a situation in which the number of atoms in higher energy state is more than that in the lower energy state. Usually at thermal equilibrium, the number of atoms N_2 i.e., the population of atoms at higher energy state is much lesser than the population of the atoms N_1 at lower energy state that is $N_1 > N_2$. The Phenomenon of making $N_2 > N_1$ is known as Population Inversion.</p>		
Q3.	Write the full form and definition of LASER.	L1	2
Ans.	<p>LASER stands for Light Amplification by Stimulated Emission of Radiation. Laser is a device which emits a coherent, monochromatic beam of light through a process called stimulated emission.</p>		<p align="center">1</p> <p align="center">1</p>
Q 4.	Write four applications of laser.	L1	2
Ans.	<ul style="list-style-type: none"> • Bar code readers • Computer printers • Holography • Fibre optic communications 		<p align="center">0.5</p> <p align="center">0.5</p> <p align="center">0.5</p> <p align="center">0.5</p>
Q5.	Define optical feedback.	L2	2
Ans.	<p>Light radiation of desired wave length has to be amplified, that brings the atoms from metastable state (due to population inversion) to ground state (in three level) or lower excited state (in four level). In lasers, the mechanism used to amplify light radiation is known as optical feedback.</p>		2
Q6.	Write two advantages of optical fiber communication system over other communication system.	L1	2
Ans.	<ul style="list-style-type: none"> • Faster signal propagation • More information carrying capacity 		<p align="center">1</p> <p align="center">1</p>
Q7.	Define numerical aperture and explain how it can be increased.	L2	2

<p>Ans.</p>	<p>Numerical aperture (NA) is defined as the sine of the maximum acceptance angle. Mathematically</p> $NA = \sin\alpha = \sqrt{n_1^2 - n_2^2}$ <p>Where α is the maximum acceptance angle n_1 is the refractive index of core of optical fiber n_2 the refractive index of cladding of optical fiber r. NA can be increased either by increasing the refractive index of the core or by decreasing the refractive index of the cladding.</p>		<p>1</p> <p>1</p>
<p>Q8.</p>	<p>Draw refractive index profiles in step index fiber and graded index fiber.</p>	<p>L3</p>	<p>2</p>
<p>Ans.</p>	<p>Refractive index profile of step index Fiber is as given below</p>  <p>Refractive index profile of graded index fiber is as given below</p> 		<p>1</p> <p>1</p>
<p>Q9.</p>	<p>Describe pulse dispersion? Why is it high in step index fiber and low in graded index fiber?</p>	<p>L2</p>	<p>2</p>
<p>Ans.</p>	<p>Pulse dispersion is the spreading out of light pulses as they pass through the optical fiber.</p>		<p>1</p>

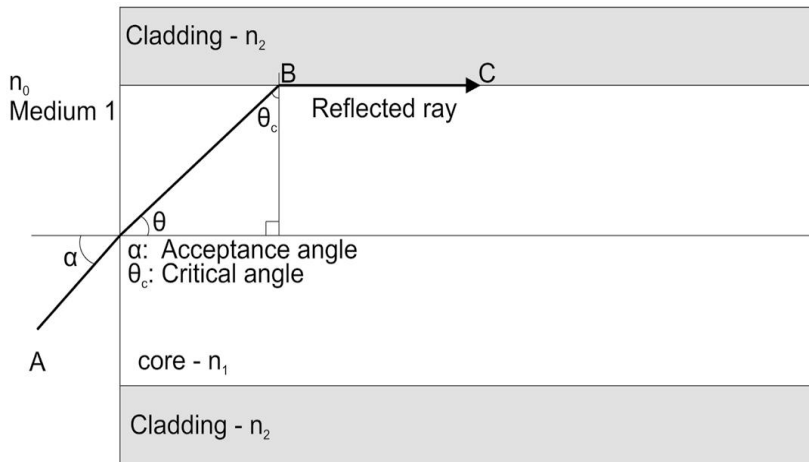
	The abrupt change in refractive index at the core-cladding boundary in step index optical fiber, leading to high pulse dispersion. Whereas, gradually change in refractive index in graded index fiber, causes low pulse dispersion		1
Q 10.	Write two applications of optical fiber.	L2	2
Ans.	i. Medical applications: Example- endoscope are used by doctors ii. Sensors: Example-Fiber optic sensors are used as transducers for measurement of strain and temperature.		1 1
Q 11.	Define nanomaterials and 1 nanometer is equal to how much meter.	L1	2
Ans.	Nanomaterials are materials having dimensions in Nano Scale (10^{-9} m) or at least one dimension in Nano scale. 1 nanometer= 10^{-9} meter		1 1
Q 12.	Define Nanoscience and Nanotechnology.	L2	
Ans.	Nanoscience is the study of materials and phenomena at nanoscale. Nanotechnology can be defined as synthesis (fabrication), characterization (determine size and properties) and finding applications of nonmaterial.		1 1
Q 13.	Give two principal factors that causes the properties of Nano Materials to differ significantly from other materials.	L2	
Ans.	Increased relative surface area: the surface to volume ration increases when we take particle in smaller dimensions. Quantum confinement effect. The electrons in nanomaterial are restricted to move in a region of nanometer size and this is known as quantum confinement		1 1
Q 14.	Write the name of two instruments use for characterization of nanomatreials	L1	
Ans.	SEM: Scanning Electron Microscopy STM: Scanning Tunneling Microscopy		1 1
Q15.	Write two examples of nanometer size devices.	L1	
Ans.	SET (Single Electron Transistor): It is a switching device that uses controlled electron tunneling to amplify current. Quantum well and quantum dot lasers: These are semiconductor lasers that use quantum dots and quantum well as the active laser medium in the light emitting region.		1 1

(5 MARKS QUESTIONS & SOLUTIONS)

Q. No.	Question	Taxonomy Level	Marking Scheme												
Q 1.	Distinguish between spontaneous emission and stimulated emission	L3	5												
Ans.	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">Stimulated Emission</th> <th style="width: 50%;">Spontaneous emission</th> </tr> </thead> <tbody> <tr> <td>a) An atom in the excited state is induced to return to the ground state, thereby resulting in emission of two photons of same frequency and energy is called Stimulated emission.</td> <td>a) The atom in the excited state returns to the ground state, thereby emitting a photon, without any external inducement is called Spontaneous emission.</td> </tr> <tr> <td>b) The emitted photons move in the same direction and is highly directional.</td> <td>b) The emitted photons move in all directions and are random</td> </tr> <tr> <td>c) The radiation is highly intense, monochromatic and coherent.</td> <td>c) The radiation is less intense and is incoherent.</td> </tr> <tr> <td>d) The photons are in phase, there is a constant phase difference</td> <td>d) The photons are not in phase (i.e.) there is no phase relationship between them.</td> </tr> <tr> <td>e) Ex: Light from Ruby laser and He-Ne Laser</td> <td>e) Ex: Light from sodium and mercury vapour lamp.</td> </tr> </tbody> </table>	Stimulated Emission	Spontaneous emission	a) An atom in the excited state is induced to return to the ground state, thereby resulting in emission of two photons of same frequency and energy is called Stimulated emission.	a) The atom in the excited state returns to the ground state, thereby emitting a photon, without any external inducement is called Spontaneous emission.	b) The emitted photons move in the same direction and is highly directional.	b) The emitted photons move in all directions and are random	c) The radiation is highly intense, monochromatic and coherent.	c) The radiation is less intense and is incoherent.	d) The photons are in phase, there is a constant phase difference	d) The photons are not in phase (i.e.) there is no phase relationship between them.	e) Ex: Light from Ruby laser and He-Ne Laser	e) Ex: Light from sodium and mercury vapour lamp.		<p align="center">1</p> <p align="center">1</p> <p align="center">1</p> <p align="center">1</p> <p align="center">1</p>
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Q2.	Write construction and working of semiconductor laser with diagram.	L2	5												
Ans.	 <p>Construction:</p> <ul style="list-style-type: none"> • Active medium is a p-n junction diode made from a single crystal of Gallium Arsenide (GaAs). • Forward biasing is used as pumping source in semiconductor laser. 		<p align="center">1</p> <p align="center">2</p>												

Ans

An optical fiber consists of a solid cylindrical glass rod called core and another coaxial cylindrical structure surrounding the core known as cladding. The light wave propagates through optical fiber by multiple successive total internal reflections.



As shown in the above figure, a light ray is passing from any specific medium to the optical fiber through its core. Further it continues towards cladding and gets reflected at the core-cladding interface.

Let, n_0 : refractive index of the medium 1, n_1 : refractive index of the core
 n_2 : refractive index of the cladding

Applying Snell's law at medium 1 –core interface

$$\begin{aligned} n_0 \sin \alpha &= n_1 \sin \theta \\ \Rightarrow n_0 \sin \alpha &= n_1 \sin \left(\frac{\pi}{2} - \theta_c \right) \\ \Rightarrow n_0 \sin \alpha &= n_1 \cos \theta_c \quad (\because \theta = \frac{\pi}{2} - \theta_c) \dots \dots \dots (1) \end{aligned}$$

Applying Snell's law at core cladding interface

$$\begin{aligned} n_1 \sin \theta_c &= n_2 \sin \left(\frac{\pi}{2} \right) \\ \Rightarrow n_1 \sin \theta_c &= n_2 \\ \Rightarrow \sin \theta_c &= \frac{n_2}{n_1} \end{aligned}$$

$$\therefore \cos \theta_c = \sqrt{1 - \sin^2 \theta_c} = \sqrt{1 - \frac{n_2^2}{n_1^2}} = \frac{\sqrt{n_1^2 - n_2^2}}{n_1} \dots \dots \dots (2)$$

Substituting equation (2) in equation (1), we get

$$\begin{aligned} n_0 \sin \alpha &= n_1 \times \frac{\sqrt{n_1^2 - n_2^2}}{n_1} = \sqrt{n_1^2 - n_2^2} \\ \Rightarrow \sin \alpha &= \frac{\sqrt{n_1^2 - n_2^2}}{n_0} \end{aligned}$$

For an optical fiber in air $n_0 = 1$,

$$\sin \alpha = \sqrt{n_1^2 - n_2^2}$$

Here, $\sin \alpha$ is called as the **numerical aperture** of the optical fiber

$$\therefore \text{Numerical Aperature (NA)} = \sin \alpha = \sqrt{n_1^2 - n_2^2}$$

	This is the require relationship between NA and refractive indices. More the value of NA, better is the fiber.																
Q5.	Distinguish between Single mode fiber and Multimode fiber	L3	5														
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Q6.	Write two approaches for synthesis of nanomaterials and name of the instruments for nanomaterial characterization.	L1	5														
Ans	<p>There are two approaches for synthesis of nanomaterials:</p> <p>Top down: Approach to the nanoscale dimension starting with the bulk scale materials by physical breaking of the source material through high energy processes. Example: Ball milling, Mechanical attrition.</p> <p>Bottom up: Approach to the nanoscale dimension starting with the atomic scale materials by chemical method and other synthesis processes. Example: chemical precipitation, Chemical vapour deposition.</p> <p>Instruments used for Nanomaterial characterization are STM (Scanning Tunneling Microscopy), SEM (Scanning Electron Microscopy), AFM (Atomic Force Microscopy)</p>		2 2 1														
Q7.	Mention some application of nanotechnology based devices.	L1	5														
Ans	<p>Devices using nanomaterials:</p> <p>Sensors- Sensors based on nanotechnology can detect very minute amounts of chemical vapours.</p> <p>Solar Cells- Nano-structured materials can be used to absorb more light and improve the efficiency of solar cells, generating more electricity from the same amount of sunlight.</p> <p>High Performance batteries-Nanostructured materials can be used to creat batteries with significantly increased storage capacity and faster charging time.</p> <p>Medical diagnostics - Nano-sized probes can be used to detect diseases at the cellular level, enabling early diagnosis and improved treatment options.</p>		1 1 1 1														

	Electronics: Nano-wires with excellent conductivity can be used to create smaller, faster electronic components like transistors, leading to more powerful and compact devices.		1
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