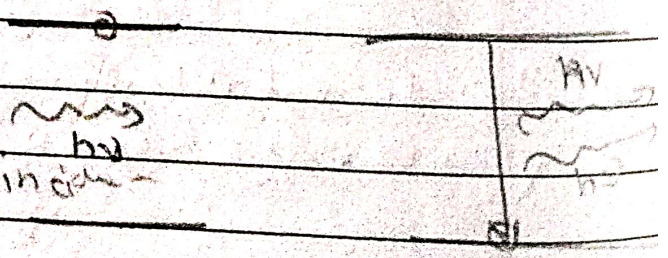
Laser

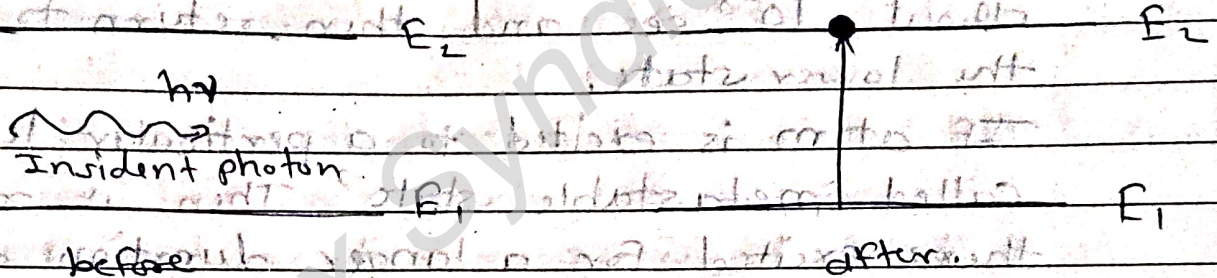
Que 1) Differentiate between spontaneous emmission and stimulated emission.

Spontaneous	stimulated.
1) When the atoms jumps from higher energy level to the lower energy level without an any external agent This process is called spontaneous emission.	1) When the atoms jumps from higher energy level to the lower energy level The Photon of energy $h\nu$ is used as external agent to force atom the process is called stimulated emission
2) spontaneous emission is natural process	2) stimulated emission is a Artificial process.
3) This is uncontroled process	3) This is a controled process.
4) This light is not coherent, diffused and not focused.	4) This light is coherent un-diffused and highly direction.
5) The light produced by electric bulb, tubes and L.E.D.	5) The light produced by He-Ne lasers, Nd-Yag laser,



2) Explain the term 1) Absorption
2) Population Inversion 3) metastable states
4) Pumping.

i) Absorption
When the atom jumps from lower energy level to the higher energy level by absorbing incident photon of energy hν this process is called Absorption



2) population Inversion.
The process in which the number of atoms in excited state are more than the ground state this process is called population Inversion
Let N_1 and N_2 be the number of atoms present in excited state (E_2) and ground state having energy E_1 and excited state of energy E_2 respectively

We know $\frac{N_2}{N_1} = e^{-(E_2 - E_1)/KT}$

Case 1 : $\frac{N_2}{N_1} < 1$

$N_2 < N_1$

this is called normal or natural state

Case - II $\frac{N_2}{N_1} > 1$

$N_2 > N_1$

This is called population inversion state.

3) Metastable state.

→ By providing external energy an atom is excited to one of its higher energy level. It stays there for a short duration of about 10^{-8} sec and then return to one of the lower state.

If atom is excited to a perticular level called 'metastable state' Then it remains there excited for a longer duration of about 10^{-3} to 10^{-2} sec before finally coming to the ground state.

4) Pumping

→ To achieving and maintaining the condition of population inversion in the active medium, The atoms have to be raised continuously to The excited state, It requires energy to be supplied to the system.

The process of raising large number of atoms from a lower energy level to higher energy level is called pumping.

3) What is active medium and active centre?

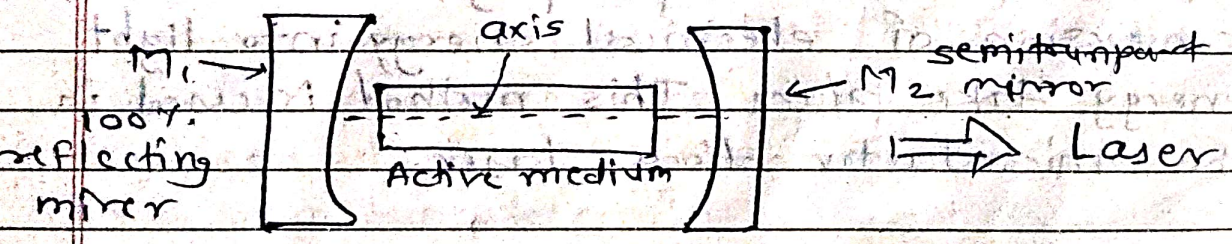
→ active medium : A medium in which population inversion takes place and as a result, light gets amplified is called an active medium.

active centre : Out of different atoms in the active medium, only a few atoms of particular kind are responsible or useful for stimulated emission and consequent light amplification. They are called Active centres.

4) What is an optical resonator cavity? What role does it play in producing laser beam?

→ 1) An optical resonator generally consists of two oppositely centred concave mirrors with active material placed in between them.

2) One mirrors (M_1) is made 100% reflective while the other mirror M_2 is semitransparent with reflectivity < 100%. The plane mirror are placed normal to the optic axis of the active medium



Role - To offer high directionality to Laser beam by making it extremely narrow so that it can travel to long distance without spreading and with a sharp focus.

5) Explain different types of pumping.

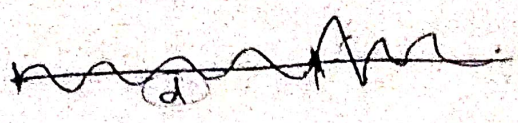
→ There are mainly four types of pumping -

1) Optical : In optical pumping, a light source such as a flash discharge tube is used. This methode is used in solid state lasers like Nd:YAG laser.

2) Electric : In electric pumping, a high voltage of about 1kV is applied across the tube containing an active medium whose ionization raises the atom level to the excited state. This method is used in the gas laser like He-Ne.

3) Chemical : In chemical pumping an organic dye dissolved in a liquid like ethly alcohol benzine, water etc. acts as a active centre. The laser using chemical pumping operate in the rang of 3000 Å to 13000 Å. The method used in liquid dye laser.

4) Direct - In direct pumping, a direct conversion of electrical energy into light energy take place. This method is used in the semiconductor diode laser.



6) Define coherence length and coherence time.

→ Coherence length - The distance over which the wave maintain constant waveform before ~~significan~~ change in phase or wave interference occurs is called coherence length.

Coherence time - The time duration over which a wave maintain its coherence or phase relationship is called coherence time. coherence time is a critical factor in quantum computing and quantum information processing.

7) Write short notes on LIDAR.

→ i) LIDAR - stands for light Detection and Ranging. It is a type of data collection that supports 3D modeling with the use of high powered lasers and other form of light energy to measure a target from afar.

ii) A LiDAR system emits rapid pulses of laser light towards the traget area. When these laser pulses strike an object or surface, they are reflected back to the LiDAR sensor.

iii) By calculating the time it takes for the pulses to trave1 to the object and back, the system determines the distance to the object. This is based on the speed of light.

iv) The system collects the data and creating a dense and detailed 3D map of the surveyed area.

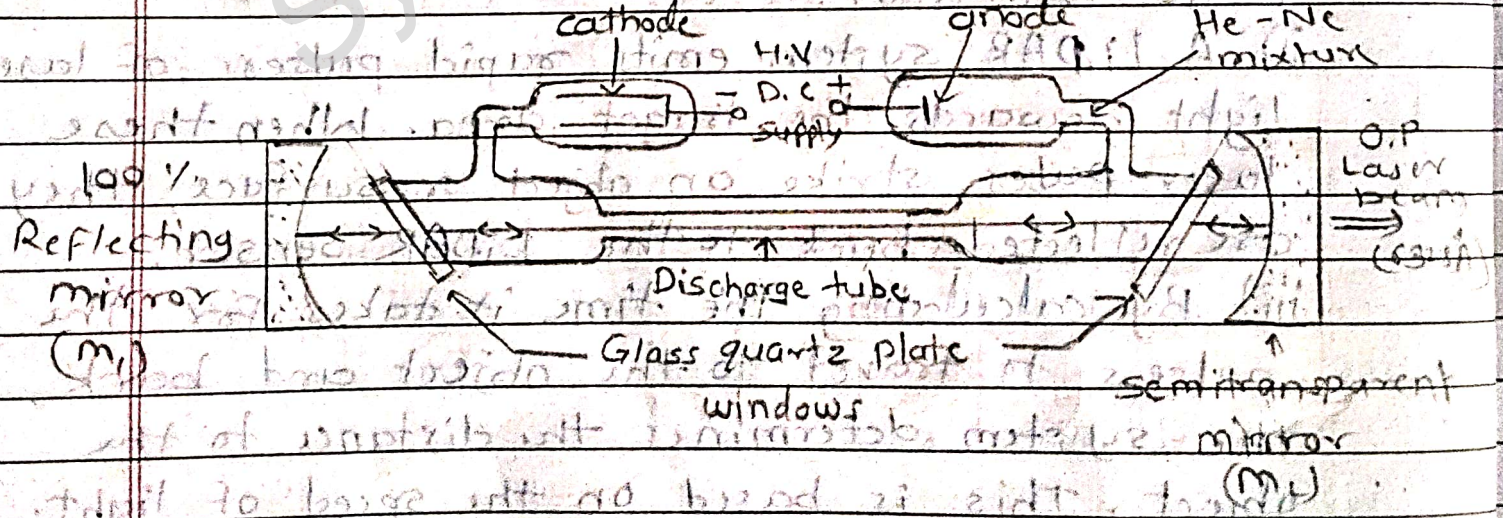
Application of LiDAR.

1) Creating highly accurate topographic maps for various applications, including flood risk assessment, forestry and urban planning
2) measuring coastal erosion, mapping underwater topography, and assessing changes in coastal environments.
3) providing real time 3D maps of the environment for navigation and obstacle avoidance.
4) Environmental Monitoring, Assessing forest structure, measuring biomass,

Ex 8*

1) Describe the construction and working of a He-Ne gas laser with proper energy level diagram, what are its merits and demerits?

→ Construction:-



Construction

Laser

Filled

cathode	Electric field	anode
	electrons ⊖ →	
	← ⊕ ions	
	He-Ne mixture	

i) He-Ne laser device consists of a narrow discharge tube filled with He and Ne gases in the ratio 10:1 under a pressure of 1mm of mercury.

ii) Two flat glass quartz plates windows are sealed at the ends of the tube.

iii) Two concave mirror m_1 and m_2 are fixed at the ends of the tube as shown in fig so that 1% of the laser beam can be trapped.

Working :- When high voltage D.C power supply about 1kV is switch 'ON', the electric field ionize the atom form He-Ne mixture.

2) Due to the electric field the electrons get accelerated toward anode and cathode. The helium atom are more readily excitable than neon atoms because they are more lighter

3) The electron excite Helium by collisions to the higher energy level E_2 and E_3 which is metastable. As the current increses more and more helium atom excited.

4) This excited helium atom return to the ground state by transferring energy to the neon atom through colligion.

5) The K.E. of the helium atoms provide the additional energy for exciting the neon atoms to E_6 and E_4 level. this is the main pumping mechanism in the He-Ne system. The population of Ne atom increases and therefore population inversion take place at E_6

6) Neon atoms are the active centres and the role of helium is to excite the neon atoms and cause the population inversion.

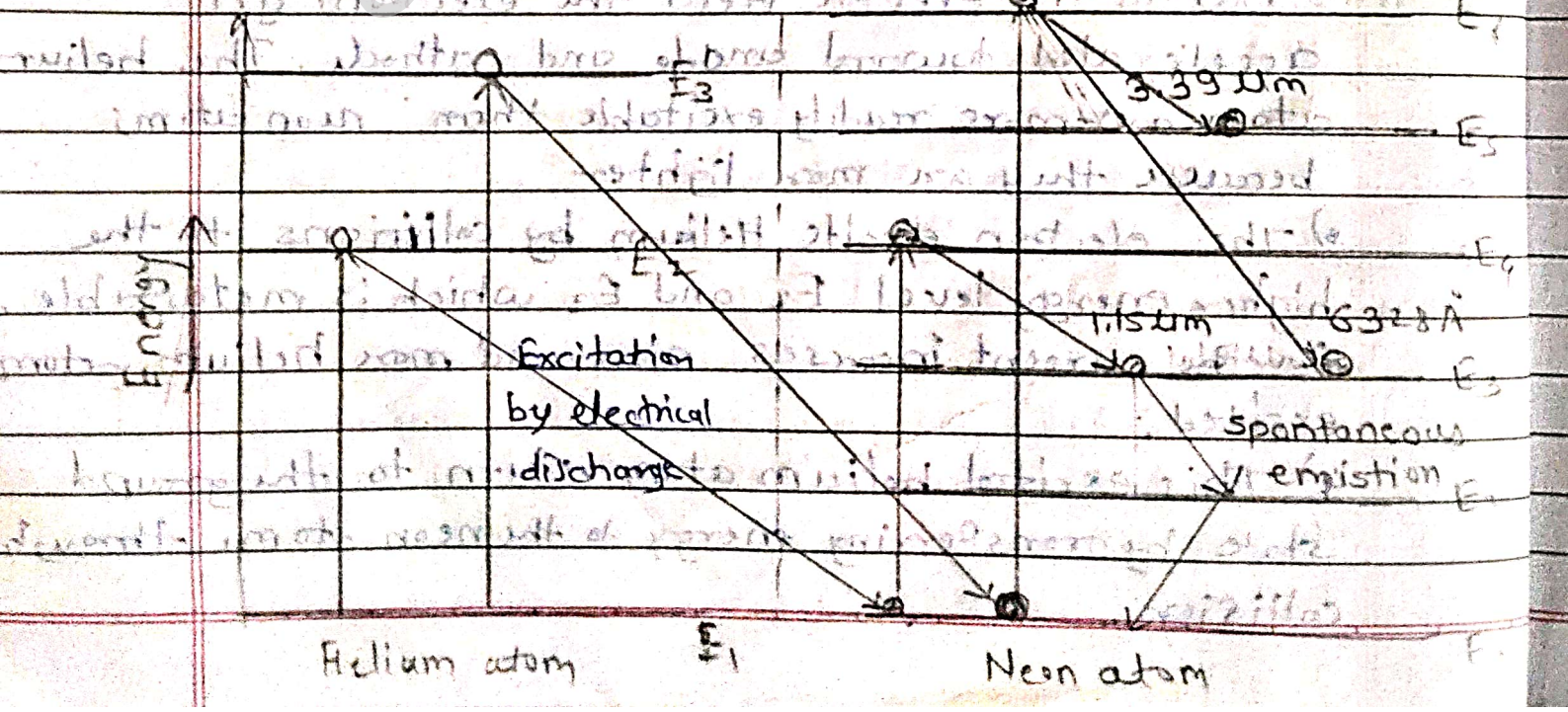
7) Three transitions are :

1) E_6 to E_5 It gives a laser of radiation of wavelength 33912 Å which is not visible

2) E_6 to E_3 It gives a laser of wavelength 6328 Å which Red light and visible

3) E_4 to E_3 It gives a laser of wavelength 11529 Å which is not visible.

8) As the discharge current is continuous the laser emission is also continuous. Therefore He-Ne lasers is called continuous wave laser.



Merits of He-Ne laser

1) Its output is continuous from 0.8 mW to 22.5 mW at 6328 Å.
2) It give highly monochromatic red colour.
3) It is highly stable.
4) The He and Ne gases are found in the most pure form therefore the laser operation is accurate and reliable.
5) It requires less pumping power.

Demerits of He-Ne laser

1) because of three available wavelength of laser output, to obtain one perticular wavelength, The other two wavelengths require supperession which is achieved by several techniques and devices, which required proper design and this cause higher cost.
2) He-Ne laser requires high voltage about 1000 V which is costly and needs more safety precaustion.

Application of He-Ne laser

1) Holography.
2) communication equipments.
3) Research activity
4) Weapons
5) Barcode scanner
6) Laboratory demonstrations of optics
7) In interferometers,

Explain applications of laser in brief.

→ 1) Laser cutting - Laser cutting involves using a high powered laser beam to melt, burn or vaporize metal, producing precise cuts. because of narrow width of the cut it produces less material waste. It has wide range of cutting including steel, aluminium, brass

2) Laser welding - Laser welding uses a concentrated laser beam to join metal pieces by melting their edges and fusing them together. It is faster than traditional welding methods

3) Laser drilling - A focused laser beam drills precise holes of various size and depth in metal sheets. This Technique is particularly benficial for creating small holes with minimal mechanical stress on material.

4) Laser marking - Laser beam can be used to permanently mark, engrave, or etch text, logos, or other information onto metal surfaces. This is non-contact and clean process suitable for marking various types of metals like stainless steel, titanium, aluminium.

5) Laser surface Treatment - Laser surface treatment involves using a laser to modify the properties of a metal surface, such as hardness, wear resistance, and corrosion resistance. Techniques include laser hardening, laser cladding and laser texturing.

5) Laser trimming and Ablation.

Laser trimming is a precise material removal process used to adjust the electrical properties of components, typically resistors and capacitors, to achieve specific values. It is widely used in the electronics industry to fine-tune circuit components for accurate performance.

① Laser cutting - high powered laser
② Laser welding - concentrated laser
③ Laser drilling - focused laser beam
④ Laser marking
⑤ Laser surface treatment
⑥ Laser trimming