

AL- Mustaqbal University  
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Medical physics  
Third Stage

Lec 2  
Properties Of Laser

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**Laser** can be defined as follows :

**“ Light Amplification by Stimulated Emission of Radiation ”.**

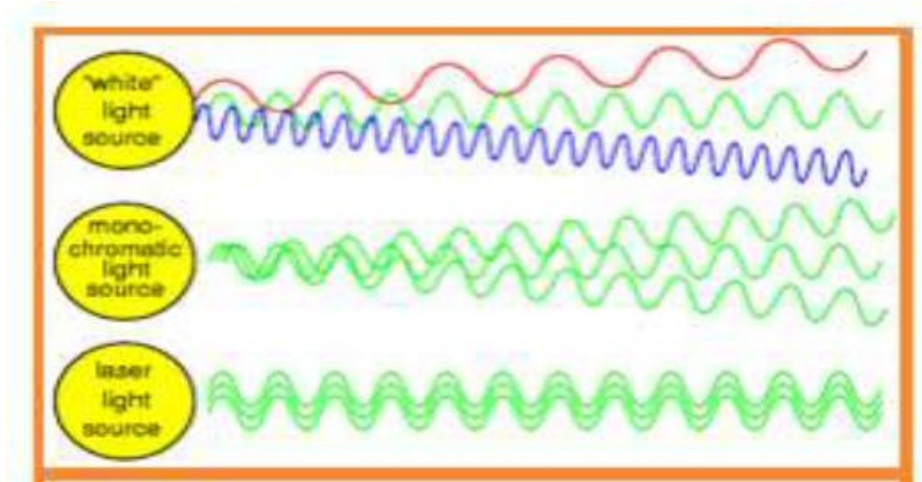
The laser light exhibits some peculiar properties compared with the conventional light which make it unique. The broad applications of lasers are made possible by their unique properties which distinguishes them from all other light sources.

A laser emits a beam of electromagnetic radiation that is always monochromatic, collimated and coherent in nature . Lasers consist of three main components: a lasing medium (solid, liquid or gas), a stimulating energy source (pump) and an optical resonator.

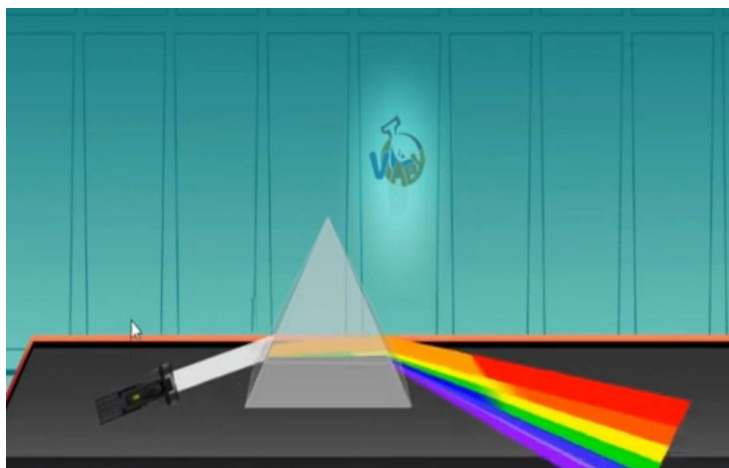
There are many uses for lasers, some of them beneficial to humanity and some dangerous, This depends on the type of laser and its intensity. It is imperative to be aware of the risks associated with laser use in terms of tissue damage (burns and eye injuries) and fire hazards. Therefore, a person must be fully familiar with the laser before working with it.

## Properties Of Laser :

1 - **Monochromatic** : Monochromatic light is a light containing a single colour or wavelength. The light emitted from a laser is monochromatic, it is of one wavelength (one color). The light emitted from ordinary light sources have different energies, frequencies, wavelengths, or colors.

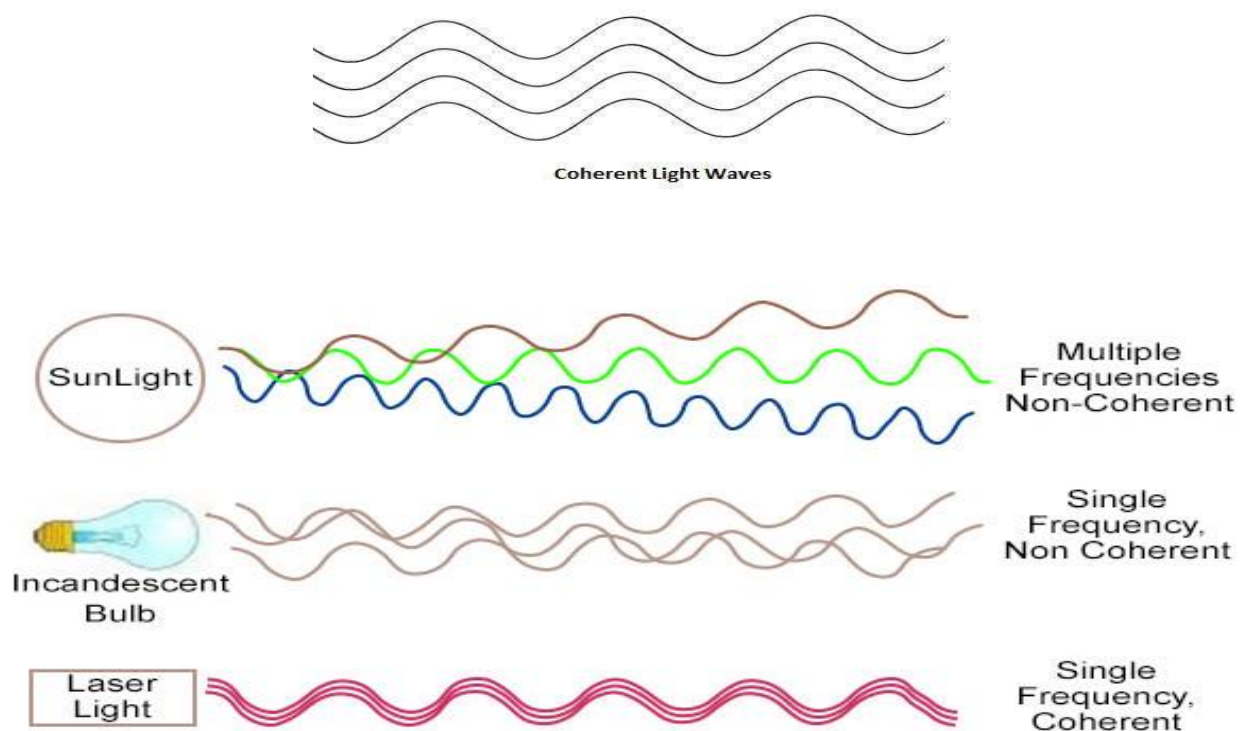


Like white light is a combination of many different wavelengths (different colors). Therefore, when white light passes through a prism, it decomposes into seven colors. But laser light has a single wavelength or colour.



**Laser** light covers a very narrow range of frequencies or wavelengths. This can be due to the stimulated characteristics of laser light. The bandwidth of the conventional monochromatic light source is **100 nm**. But the bandwidth of an ordinary light source is **1 nm** . For a highly sensitive laser source it is  **$10^{-9}$  nm** .

**2 - Coherence :** A predictable correlation of the amplitude and phase at any one point with another point is called coherence . That means if two or more waves of same frequency and in the same phase or have constant phase difference then these waves are said to be coherent in nature. In the case of conventional light, the property of coherence exhibits between a source and its virtual source whereas in the case of laser the property coherence exists between any two or more light waves. So, when two or more LASER radiations can make regular interference each other, therefor LASER radiation has a coherency.



**3 - Directionality :** The light beam coming from an ordinary light source travels in all directions, but laser light travels in a single direction. Lasers emit light that is highly directional. Laser light is emitted as a relatively narrow beam in a specific direction . Ordinary light, such as coming from the sun, a light bulb, or a candle, is emitted in many directions away from the source. Laser light is emitted as a relatively narrow beam in a specific direction For example, the light emitted from torchlight spreads 1km distance it spreads 1 km distance. But the laser light spreads a few centimeters distance even it travels lacks kilometer distance. The directivity depends on the angle of divergence. The directionality of the laser beam is expressed in terms of divergence

$$\Delta\theta = \frac{r_2 - r_1}{D_2 - D_1}$$

Where  $r_1$  and  $r_2$  are the radius of laser beam spots at distances of  $D_1$  and  $D_2$  respectively from the laser source.

#### **4. Highly Intense or Brightness**

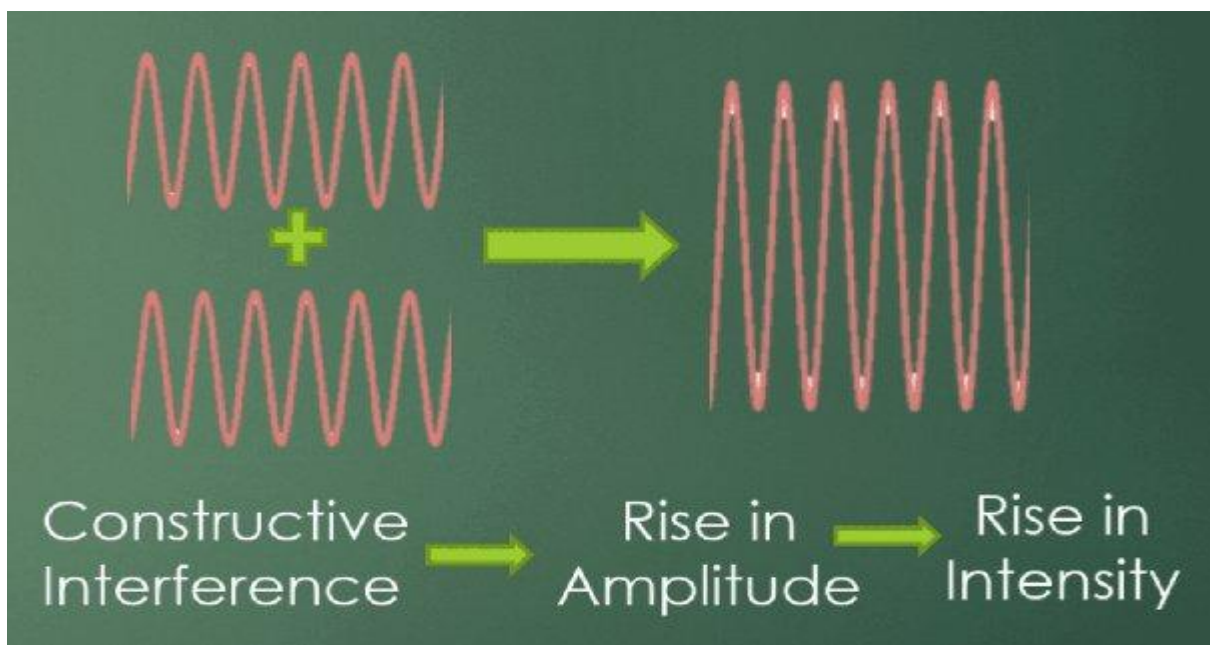
Laser light is highly intense than conventional light. We know that the intensity of a wave is the energy per unit time flowing through a specific area. Because laser light is: Monochromatic - It contains only one specific wavelength and hence one color. Coherent - The motion of all photons is coordinated.

Directional - The laser beam is very narrow, concentrated and therefore, it is a

high intensity source. A one mill watt He-Ne laser is more intense than the sun intensity. This is because of the coherence and directionality of the laser.

Suppose when two photons each of amplitude  $a$  are in phase with another, then young's principle of superposition, the resultant amplitude of two photons is  $2a$  and the intensity is  $4a^2$ . Since in laser many numbers of photons are in phase with each other, the amplitude of the resulting wave becomes  $na$  and hence the intensity of the laser is proportional to  $n^2a^2$ . So the 1mW He-Ne laser is more intense than the sun.

The intensity of light falling on a surface, depends on the intensity of the source and on how far the light spreads after leaving the source.



# **Discussion**

1.

**The word LASER stands for:**

- A) Light Amplification by Stimulated Energy of Radiation
- B) Light Absorption by Stimulated Emission of Radiation
- C) Light Amplification by Stimulated Emission of Radiation
- D) Light Absorption by Spontaneous Emission of Radiation
- E) Light Application by Stimulated Energy of Rays

**Correct Answer: C**

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2.

**Which of the following is NOT a main component of a laser?**

- A) Optical resonator
- B) Lasing medium
- C) Stimulating energy source (pump)
- D) Cooling system
- E) None of the above

**Correct Answer: D**

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3.

**Laser light is unique compared with conventional light because it is:**

- A) Diffused, broad, random
- B) Monochromatic, coherent, directional
- C) White, multi-wavelength, scattered
- D) Pulsed, weak, incoherent
- E) Infrared only

**Correct Answer: B**

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**4.**

**Which of the following is the lasing medium?**

- A) Solid only
- B) Liquid only
- C) Gas only
- D) Solid, liquid, or gas
- E) None of the above

**Correct Answer: D**

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**5.**

**Ordinary light sources emit light that is:**

- A) Monochromatic
- B) Collimated
- C) Coherent
- D) Polychromatic
- E) None of the above

**Correct Answer: D**

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**6.**

**When white light passes through a prism, it:**

- A) Becomes monochromatic
- B) Disappears
- C) Splits into multiple colors
- D) Remains unchanged
- E) Turns into laser light

**Correct Answer: C**

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7.

**The bandwidth of conventional monochromatic light is about:**

- A) 1 nm
- B) 10 nm
- C) 100 nm
- D)  $10^{-9}$  nm
- E) 1000 nm

**Correct Answer: C**

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8.

**The bandwidth of a highly sensitive laser source can be as small as:**

- A) 100 nm
- B) 1 nm
- C)  $10^{-9}$  nm
- D)  $10^{-3}$  nm
- E) 1000 nm

**Correct Answer: C**

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9.

**The property of waves having the same frequency and constant phase difference is called:**

- A) Monochromaticity
- B) Intensity
- C) Coherence
- D) Diffraction
- E) Reflection

**Correct Answer: C**

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**10.**

**In ordinary light, coherence exists between:**

- A) Any two light waves
- B) Source and its virtual source
- C) Source and detector
- D) Sunlight and candlelight
- E) None of the above

**Correct Answer: B**

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**11.**

**In lasers, coherence exists between:**

- A) Only the source and its virtual source
- B) Any two or more light waves
- C) Two different light bulbs
- D) Sound and light waves
- E) Heat radiation and visible light

**Correct Answer: B**

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**12.**

**Which property allows laser beams to interfere regularly with each other?**

- A) Intensity
- B) Diffraction
- C) Coherence
- D) Refraction
- E) Scattering

**Correct Answer: C**

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**13.**

**Laser light is highly:**

- A) Divergent
- B) Directional
- C) Random
- D) Incoherent
- E) None of the above

**Correct Answer: B**

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**14.**

**The divergence of a laser beam depends on:**

- A) The power supply
- B) The pump medium
- C) The angle of divergence
- D) Temperature of the source
- E) Type of lens used

**Correct Answer: C**

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**15.**

**Torchlight spreads about \_\_\_\_\_ after traveling 1 km:**

- A) A few centimeters
- B) A few meters
- C) 1 km
- D) Infinite distance
- E) It does not spread

**Correct Answer: C**

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**16.**

**Laser light, after traveling kilometers, spreads only:**

- A) A few centimeters
- B) A few meters
- C) Several kilometers
- D) Not at all
- E) Same as torchlight

**Correct Answer: A**

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**17.**

**Which property makes laser light more intense than sunlight?**

- A) Directionality and coherence
- B) High temperature of laser
- C) Colorfulness
- D) Divergence
- E) Short wavelength

**Correct Answer: A**

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**18.**

**The intensity of a wave is proportional to:**

- A) Amplitude (a)
- B)  $a^2$
- C)  $n^2 a^2$
- D) Frequency only
- E) None of the above

**Correct Answer: C**

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**19.**

**A 1 mW He-Ne laser is more intense than the sun because:**

- A) It is hotter
- B) It is coherent and directional
- C) It is polychromatic
- D) It is very small
- E) It emits infrared only

**Correct Answer: B**

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**20.**

**Laser intensity increases significantly because of:**

- A) Random photon emission
- B) Out-of-phase photon superposition
- C) In-phase photon superposition
- D) Absorption of light
- E) Heat radiation

**Correct Answer: C**

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**21.**

**The energy source used to excite the lasing medium is called:**

- A) Stimulator
- B) Pump
- C) Resonator
- D) Amplifier
- E) Absorber

**Correct Answer: B**

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**22.**

**Which part of the laser reflects light back and forth to amplify it?**

- A) Pump
- B) Cooling system
- C) Optical resonator
- D) Fiber cable
- E) Lens system

**Correct Answer: C**

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**23.**

**Which of the following is a potential danger of lasers?**

- A) Eye injury
- B) Skin burns
- C) Fire hazards
- D) All of the above
- E) None of the above

**Correct Answer: D**

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**24.**

**Before working with lasers, a person must be:**

- A) Familiar with its principles and risks
- B) Wearing any glasses
- C) Working in the dark
- D) Using white light
- E) None of the above

**Correct Answer: A**

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**25. Which of the following is a beneficial application of lasers?**

- A) Medicine
- B) Communication
- C) Industry
- D) Research
- E) All of the above

**Correct Answer: E**