University of Al-Mustaqbal
College of Science
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# Laser in medicine

## Practical Experiences

**Third Stage**

## Study of the Properties of a Semiconductor Laser

**Lec 4**

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## Experiment: Study of the Properties of a Semiconductor Laser

## Objective:

To study the properties of a semiconductor laser, including its threshold current, output power, wavelength, and beam divergence.

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## Experiment Tools:

1. **Semiconductor laser diode** (e.g., GaAs laser diode)
2. **Laser power meter**
3. **Digital oscilloscope**
4. **Current source with precise control**
5. **Spectrometer** or **monochromator**
6. **Optical bench** with mounts and holders
7. **Lens system** for collimating the laser beam
8. **Screen** for beam profile observation
9. **Micrometer** or **ruler**
10. **Thermal controller** (optional, to maintain temperature stability)

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## Work Steps:

### 1. Setting Up the Laser Diode:

- Mount the laser diode on the optical bench with proper alignment.
- Connect the diode to the current source, ensuring appropriate safety measures (e.g., using safety goggles designed for the laser wavelength).

### 2. Measuring Threshold Current:

- Gradually increase the current from the source while monitoring the output power with the laser power meter.

- Note the current at which the laser starts emitting coherent light, called the **threshold current**.

**3. Output Power vs. Current (L-I Curve):**

- Continue increasing the current in small increments beyond the threshold.
- Record the corresponding laser output power at each current value.
- Plot the **L-I curve** to study the linearity above the threshold.

**4. Determining Wavelength:**

- Use a spectrometer to measure the laser's wavelength.
- Observe the spectral lines and determine the peak wavelength of emission.

**5. Measuring Beam Divergence:**

- Place a screen at a known distance from the laser.
- Collimate the beam using the lens system and measure the spot size on the screen.
- Repeat at different distances to calculate the divergence angle using the formula: $\theta = \tan^{-1}(\Delta d L)$ where $\Delta d$ is the change in beam diameter and $L$ is the distance.

**6. Observing Temperature Dependence (Optional):**

- Vary the temperature of the laser diode using a thermal controller.
- Record changes in threshold current and wavelength, if any.

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**Conclusion:**

- **Threshold Current:** The current required for coherent laser emission was identified as the threshold current.

- **L-I Curve:** Above the threshold, the laser output power increased linearly with current, demonstrating efficient operation.
- **Wavelength:** The laser emitted at a specific wavelength characteristic of the semiconductor material used.
- **Beam Divergence:** The divergence angle was calculated, indicating the spatial coherence of the beam.
- **Temperature Dependence:** If conducted, variations in threshold current and wavelength due to temperature were observed, highlighting the sensitivity of semiconductor lasers to thermal effects.

This experiment provides insights into the operational characteristics and practical applications of semiconductor lasers, such as in communication systems and optical devices.

# Discussion

1. **What is the primary objective of this experiment?**
   A. To determine the thermal efficiency of a laser diode
   B. To study the properties of a semiconductor laser
   C. To build a laser diode system from scratch
   D. To test the durability of a laser diode
   E. To study beam absorption in semiconductors

2. **Which component is used to measure the output power of the laser?**
   A. Spectrometer
   B. Laser power meter
   C. Digital oscilloscope
   D. Current source
   E. Screen

3. **What safety measure is recommended while working with the laser diode?**
   A. safety goggles
   B. thermal shield

C. Operating in complete darkness

D. gloves

E. Screen

**4. Which tool is used to determine the laser's wavelength?**

A. Monochromator or spectrometer
B. Laser power meter
C. Screen with ruler
D. Lens system
E. Thermal controller

**5. How is beam divergence calculated?**

A. $\theta = \tan^{-1}(\Delta d/A)$

B. $\theta = \tan^{-1}(\Delta d/L)$

C. $\theta = \tan^{-1}\Delta d$

D. $\theta = \sin^{-1}(\Delta d/L)$

E. $\theta = \tan(d/L)$

6. **Which tool is optional to maintain temperature stability :**

A. Screen
B. Lens system
C. power meter
D. Thermal controller
E. Ruler

7. **Which tool is used to measure the laser's output power?**

A. Digital oscilloscope

B. Laser power meter

C. Spectrometer

D. Optical bench

E. Micrometer

8. **Which laser diode is mentioned in the experiment?**

A. GaN laser diode
B. InGaN laser diode
C. GaAs laser diode
D. AlGaAs laser diode
E. ZnSe laser diode

**9. Which tool is used in Semiconductor Laser experiment ?**

A. Digital oscilloscope
B. Glass can
C. Water
D. Caliper
E. Paper sheet

**10. Which tool is NOT used in Semiconductor Laser experiment?**

A. Optical bench
B. Lens system
C. Screen
D. Caliper
E. None of the above.