

EXPERIMENT No. –

Experiment Title: - Angular Divergence of LASER Beam

Aim: - To determine the **angular divergence of laser beam** for a given laser source.

Practical Significance: -

The angular divergence of a laser beam is significant because it indicates how quickly the beam spreads as it travels away from the source. A smaller angular divergence means that the laser beam maintains a tighter focus over longer distances, which is crucial for applications requiring precision, such as in laser cutting, medical surgeries, and optical communication. Additionally, understanding beam divergence helps in the design of optical systems to efficiently collimate or focus laser light.

Relevant program outcomes: The most relevant Program Outcomes are-

Program Outcome (PO)	Relevance to the Experiment
PO1: Engineering Knowledge	Applies the principles of laser physics, optics, diffraction, and wave propagation to determine the angular divergence of a laser beam
PO2: Problem Analysis	Identifies experimental variables, analyses beam divergence data, and calculates the divergence angle using appropriate mathematical relationships.
PO4: Investigation of Complex Problems	Conducts experimental measurements, records observations, analyses results, and interprets the characteristics of the laser beam using scientific methods.
PO5: Modern Tool Usage	Uses modern laboratory equipment such as a laser source, optical bench, measuring scale, and screen to perform accurate measurements and analysis.
PO9: Individual and Team Work	Performs the experiment individually or collaboratively while maintaining coordination and responsibility during laboratory work.
PO10: Communication	Develops the ability to prepare clear laboratory records, present calculations, interpret results, and explain observations effectively.
PO12: Life-long Learning	Encourages continuous learning of laser technology and optical measurement techniques used in research, communication systems, medical devices, and industrial applications.

Relevant Course outcomes:

Students will be able to describe the different types of lasers, its principle, properties of laser beam.

Practical learning outcomes:

Use Laser Source (He-Ne Laser)

1. To determine the **angular divergence** of a laser beam.
2. To understand the directional nature of laser light.
3. To study how beam diameter changes with distance.
4. To verify the relationship between beam spread and propagation distance.
5. To gain practical experience in handling laser equipment safely.

Practical Skills Developed:

1. Experimental Skills: -

- Understand the theory and objective of the experiment.
- Perform the experiment using the correct procedure.
- Set up and align the apparatus properly.
- Check the working condition and suitability of instruments.
- Determine the least count and recognize measurement limitations.
- Handle laboratory equipment safely and carefully.

2. Observational Skills: -

- Record observations in the correct sequence.
- Take accurate and systematic measurements.
- Improve accuracy by repeating observations and minimizing errors.

3. Drawing Skills: -

- Draw a neat and labelled schematic diagram of the experimental setup.

4. Reporting Skills: -

- Present observations systematically in tabular form with proper units.
- Perform necessary calculations and estimate errors.
- Interpret the results, draw valid conclusions, and identify the limitations and scope for further study.

Relevant affective domain related outcomes:

- 1. Receiving:** -Demonstrates awareness of the objectives of the experiment, laboratory safety rules, and the importance of laser safety precautions.
- 2. Responding:** - Actively participates in performing the experiment by following the prescribed procedure and laboratory instructions with interest.
- 3. Valuing:** - Appreciates the importance of precision, accuracy, and systematic observation in determining the angular divergence of a laser beam.
- 4. Organization:** - Integrates safe laboratory practices, proper instrument handling, and systematic data recording into the experimental work.
- 5. Characterization (Internalization):** - Consistently demonstrates responsibility, discipline, ethical laboratory practices, and a scientific attitude while handling laser equipment and interpreting experimental results.

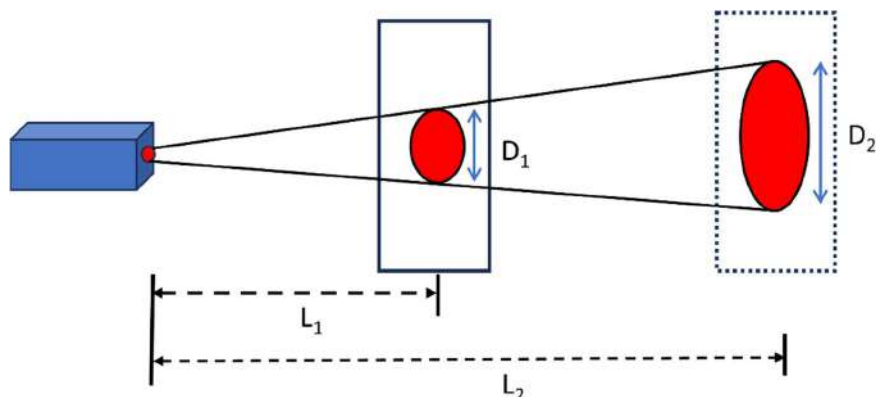
Theoretical Background: -

A laser produces light that is highly directional and travels almost parallel to its propagation direction. However, no practical laser beam remains perfectly parallel. As the beam propagates through space, its diameter gradually increases. This gradual increase is called the **Angular Divergence of the Laser Beam**. The divergence occurs because of diffraction and the finite diameter of the laser cavity.

Laser beam divergence is one important parameter to know for laser manufacturers and users alike who need to take control of their laser spot size. From laser welding applications to wafer dicing or eye surgery, knowing your beam divergence is a must for building a functional setup and directing the energy precisely where it is needed for a given process.

The angular divergence of a laser beam is determined by how much the beam expands as it travels away from the laser aperture. It is measured as the angular spread of the beam, often visualized as a cone with the tip at the laser source.

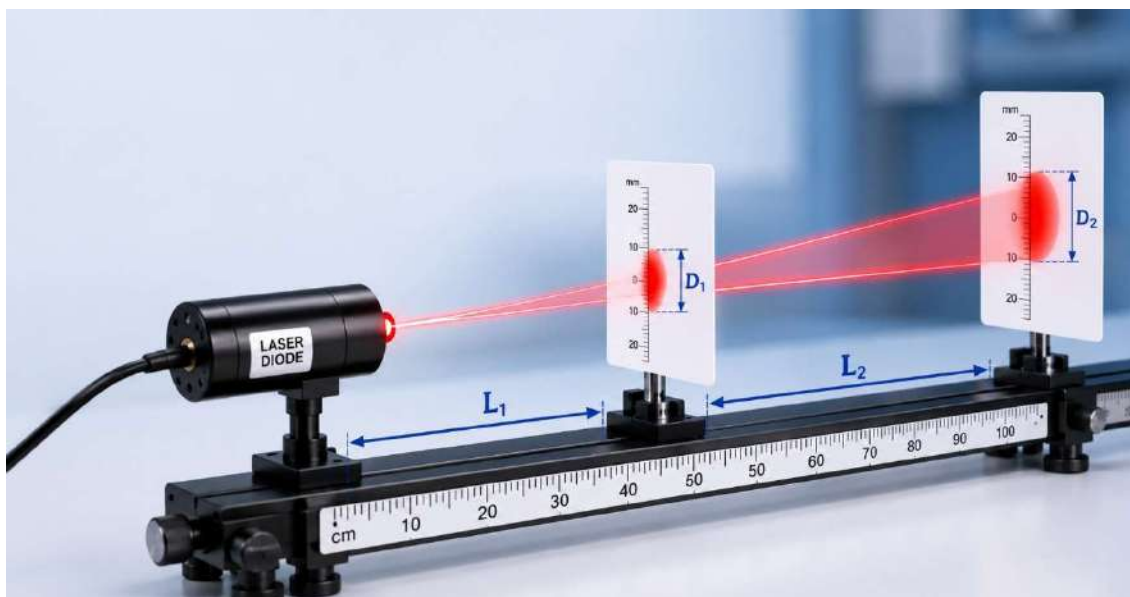
If the initial diameter of the laser beam at the exit aperture is D_1 at a distance L_1 , and the diameter grows to D_2 at a further distance L_2 , the angular divergence (θ) can be calculated using simple trigonometry.



The formula to calculate the **laser beam divergence experiment** angle is given by:

$$\theta = \frac{D_2 - D_1}{L_2 - L_1}$$

Experimental set-up: -



Resources required: -

S. No.	Name of equipment	Specifications/Purpose	Quantity	Remark
1	He-Ne or Diode Laser	Light source	1	
2	Optical Bench	Supports equipment	1	
3	Screen	Displays laser spot mounted on a movable stand	1	
4	Meter Scale	Distance measurement	1	
5	Vernier Scale/Ruler	Spot diameter measurement	1	
6	Graph Sheet	Observation and plotting	1	

Precautions: -

1. Never look directly into the laser beam.
2. Keep the laser properly aligned.
3. Measure beam diameter carefully.
4. Avoid vibrations during measurements.

5. Perform the experiment in a dark room.
6. Keep the screen perpendicular to the beam.
7. Record multiple observations.

Procedure: -

1. Place the laser source securely on one end of the optical bench.
2. Align the laser source horizontally.
3. Set up the screen covered with a sheet of graph paper.
4. Keep the screen close to the laser.
5. Measure distance L_1 of the screen from the laser exit aperture.
6. Switch on the laser source. **Note:** *Never look directly into the laser beam.*
7. Observe the circular spot formed on the graph paper.
8. Carefully mark the boundaries of the main central spot on the graph paper
9. Measure the diameter of the spot along both the horizontal and vertical axes to find the average diameter D_1 .
10. Move the screen further away to a new distance L_2 .
11. Mark the boundaries of the expanded laser spot at this new position and record its diameter D_2 .
12. Repeat the process for at least five different distances to ensure statistical accuracy.
13. Calculate the angular divergence for each set of readings using the formula and find the mean value.

Observations Table: -

Wavelength of Laser used -

Laser Type-

S. No.	Distance b/w source and screen(at 1 st position) (L_1) cm	Diameter of the beam spot (at 1 st position of screen)			Distance b/w source and screen (at 2 nd position) (L_2) cm	Diameter of the beam spot (at 2 nd position of screen)			$\theta = \frac{D_2 - D_1}{L_2 - L_1}$ (in rad)
		Horizontal diameter (a)	Vertical diameter (b)	$D_1 = (a + b) / 2$ cm		Horizontal diameter (c)	Vertical diameter (d)	$D_2 = (c + d) / 2$ cm	
1									
2									
3									

Calculations:

Mean of the Angular divergence calculated

$$\theta = \frac{\theta_1 + \theta_2 + \dots + \theta_n}{n}$$

Results:

The angular divergence of the given laser beam is approximately rad.

Conclusion and recommendations:

Conclusion: -

The experiment to determine the angular divergence of a laser beam demonstrates one of the most important characteristics of laser light—its high directionality. By measuring the beam diameter at different distances, students can calculate the divergence angle and appreciate why lasers are preferred over conventional light sources in scientific, industrial, and communication applications.

Recommendations: -

- Align the laser source properly before taking observations.
- Perform the experiment in a dimly lit room for clear visibility.
- Take multiple readings and use the average value for better accuracy.
- Avoid parallax error while measuring the beam diameter.
- Handle the laser carefully and never look directly into the beam.
- Keep the apparatus stable and record observations systematically.