Determination of Young’s modulus

Apparatus:
Laser mount, Laser, Knife Edges, Slotted weights, Material Bar, Meter Scale, Screw gauge, Vernier Caliper.

Purpose of Experiment:
To determine the Young’s Modulus of the material of the bar subjected to non-uniform bending by measuring the depression at the center using optical lever.

Introduction:
Young's modulus, also known as the elastic modulus, is a measure of the stiffness of a solid material. It is a mechanical property of linear elastic solid materials. It defines the relationship between stress (force per unit area) and strain (proportional deformation) in a material.

$$Y = \frac{Stress}{Strain} = \frac{F/A}{\Delta L/L}$$

A solid material will deform when a load is applied to it. If it returns to its original shape after the load is removed, this is called elastic deformation. In the range where the ratio between load and deformation remains constant, the stress-strain curve is linear.

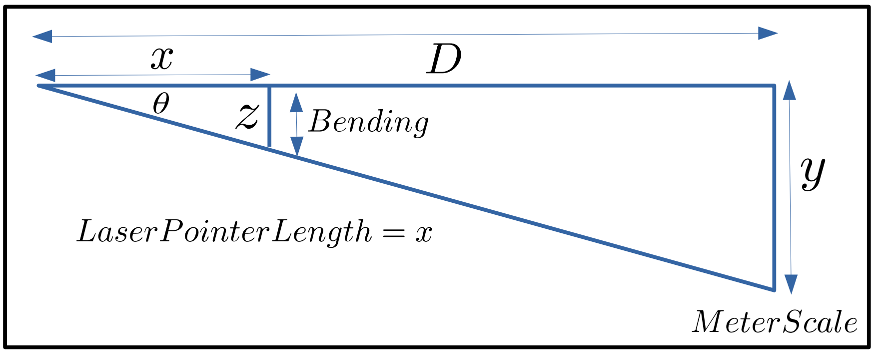
In this experiment we are using three different kind of plates whose Young’s Modulus we need to measure. In order to do so we are hanging some weights at the center of the plates placed on knife edges, by noting the depression we are estimating how much strain we have applied for a given stress.

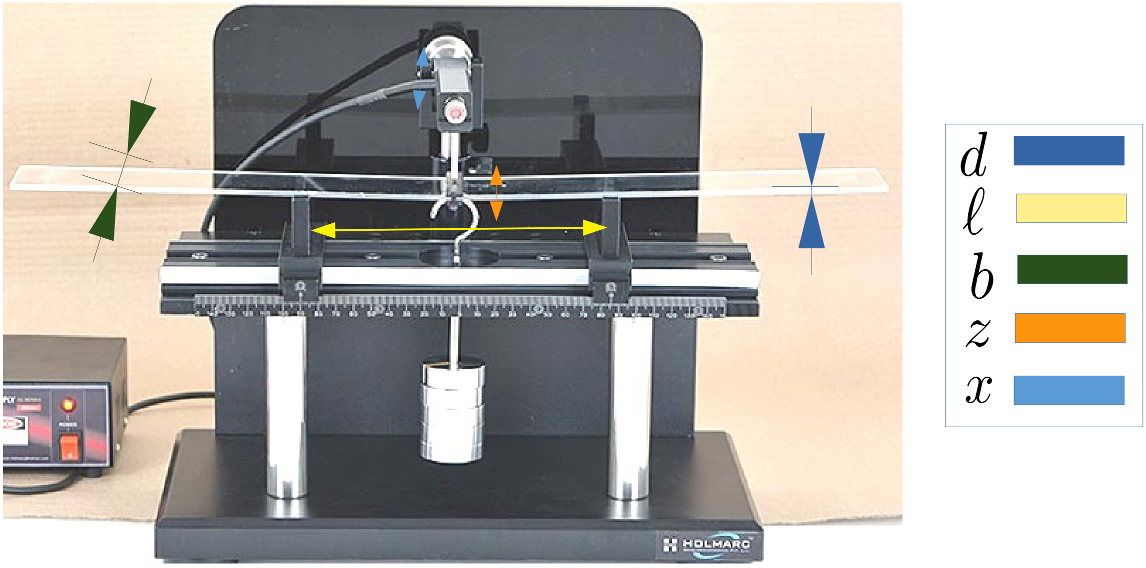
In non uniform bending, the beam (meter scale) is supported symmetrically on two knife edges and loaded at its center. The maximum depression is produced at its center. Since the load is applied only at a point of the beam, this bending is not uniform through out the beam and the bending of the beam is called non-uniform bending.

According to the theory of non-uniform bending, for a bar of thickness d and breadth b, supported by two knife edges ℓ distance apart, the depression z at the midpoint due to load M is given by,

$$z = \frac{Mg\ell^3}{4Ybd^3} \implies Y = \frac{Mg\ell^3}{4zbd^3}$$

$$\tan\theta = \frac{z}{x} = \frac{y}{D} \implies z = \frac{xy}{D}$$





Setup and Procedure:

1. The bar is symmetrically placed on two knife edges.
2. A weight hanger is suspended at the center of the bar.
3. Optical lever is placed with its front leg at the center of the bar from where the weight hanger is suspended.
4. A vertical scale is arranged at a distance of about one meter from the laser module.
5. Laser is focused on to the vertical scale.
6. The bar is loaded and unloaded a number of times to measure its depression with loading and unloading of the mass.
7. With the weight hanger of mass W_0 alone to the bar, note the scale reading corresponding to the laser spot.
8. Add the mass M in steps and scale readings are noted.
9. The experiment is repeated by unloading the masses in steps and the mean value of the scale reading for each mass is noted.
10. Repeat the experiment for 2 given plates and compare their respective Young's modulus.

Dimensions of the plates:

Material	Thickness d (cm)	Breadth b (cm)
Acrylic	0.6	5
Brass	0.2	5

Determination of Young's modulus

Observations:

Plate 1:

Thickness d = ____ cm, Breadth b = ____ cm

Length between Laser pointer leg and its pivot x = _______ cm

Distance between scale and optical lever D = __________ cm

Young's modulus need to be calculated using following expression,

$$Y = \frac{Mg\ell^3}{4bd^3x}\frac{D}{y}$$

Trail No.	Dist. between knife edges , l (cm)	Mass Suspended M (grams)	Scale Reading (cm)			Mean shift (cm)		Young's Modulus
			Loading	Unloading	Mean	For 4M (α)	For M ($\alpha/4$)	Y
1.		W_0 $W_0 + M$ $W_0 + 2M$ $W_0 + 3M$ $W_0 + 4M$ $W_0 + 5M$ $W_0 + 6M$ $W_0 + 7M$	X_{0L} X_{1L} X_{2L} X_{3L} X_{4L} X_{5L} X_{6L} X_{7L}	X_{1U} X_{2U} X_{3U} X_{4U} X_{5U} X_{6U} X_{7U}	$y_1 = 0.5\ (X_{4L} - X_{0L}) + 0.5\ (X_{5U} - X_{1U})$ $y_2 = 0.5\ (X_{5L} - X_{1L}) + 0.5\ (X_{6U} - X_{2U})$ $y_3 = 0.5\ (X_{6L} - X_{2L}) + 0.5\ (X_{7U} - X_{3U})$ $y_4 = 0.5\ (X_{7L} - X_{3L}) + 0.5\ (X_{7L} - X_{4U})$	$0.25y_1+$ $0.25y_2+$ $0.25y_3+$ $0.25y_4$	$y =$	
2.		W_0 $W_0 + M$ $W_0 + 2M$ $W_0 + 3M$ $W_0 + 4M$ $W_0 + 5M$ $W_0 + 6M$ $W_0 + 7M$	X_{0L} X_{1L} X_{2L} X_{3L} X_{4L} X_{5L} X_{6L} X_{7L}	X_{1U} X_{2U} X_{3U} X_{4U} X_{5U} X_{6U} X_{7U}	$y_1 = 0.5\ (X_{4L} - X_{0L}) + 0.5\ (X_{5U} - X_{1U})$ $y_2 = 0.5\ (X_{5L} - X_{1L}) + 0.5\ (X_{6U} - X_{2U})$ $y_3 = 0.5\ (X_{6L} - X_{2L}) + 0.5\ (X_{7U} - X_{3U})$ $y_4 = 0.5\ (X_{7L} - X_{3L}) + 0.5\ (X_{7L} - X_{4U})$	$0.25y_1+$ $0.25y_2+$ $0.25y_3+$ $0.25y_4$	$y =$	

Average Value of Young's modulus Y = _________ Appropriate Units

Repeat the experiment for 2 plates.

Result:

The Young's Modulus of two different materials is measured using non-uniform bending technique and is found to be,

1. For Acrylic =
2. For Brass =