

## SECTION - B



# EXPERIMENT

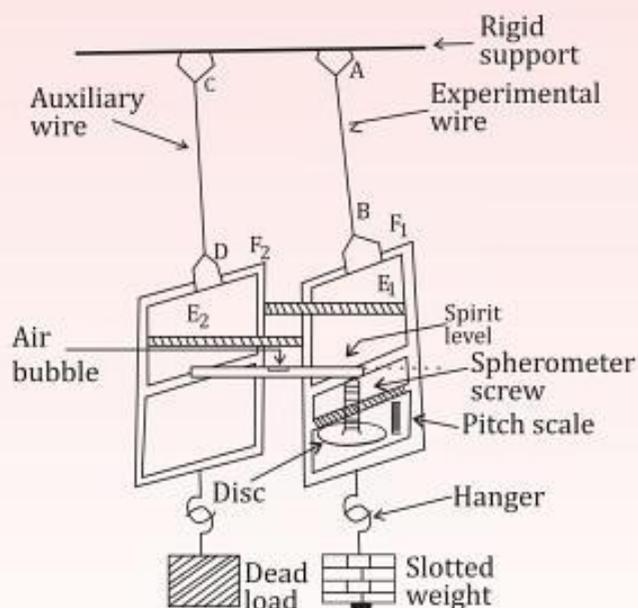
## AIM

To determine Young's modulus of elasticity of the material of a given wire.

## MATERIAL REQUIRED

Searle's apparatus, two long metallic wires, screw gauge, meter rod, slotted weights (0.5 kg each) meter scale and hanger.

## DIAGRAM



## THEORY

### SEARLE'S APPARATUS

Searle's setup includes two lengthy steel wires with identical dimensions, a meter scale, a screw gauge, eight slotted weights, each weighing a kilogram, and a hanger with a mass of 1 kg. The apparatus is constructed with two metal frames, denoted as  $F_1$  and  $F_2$ , featuring torsion heads at their upper sides and hooks at their lower sides. These frames hang from two wires, AB and CD, made of the same material and possessing equivalent length and cross-section. The upper ends of these wires are securely fastened to torsion heads mounted on the same rigid support.

A constant 1-kilogram weight is suspended from the hook of frame  $F_2$ , connected to the auxiliary wire CD, ensuring tension in the wire. Simultaneously, a hanger H with a mass of 1 kilogram is suspended from the hook of the other frame  $F_1$ . The experimental wire AB can be loaded by attaching slotted weights to the hanger.

A spirit level is positioned horizontally, with one end hinged in frame  $F_2$ . The other end of the spirit level

rests on the tip of a spherometer screw fitted in frame  $F_1$ . The spherometer screw can be vertically adjusted and a pitch scale marked in millimeters facilitates this movement. Cross bars  $E_1$  and  $E_2$  keep the two frames connected.

In the experimental procedure, kinks are eliminated from wire AB by loading and unloading it several times. All weights are then removed from the hanger, leaving wire AB taut under the hanger's weight alone. The spherometer screw is rotated until the bubble centers in the spirit level. The initial reading on the spherometer disc is recorded as the zero-load position.

Subsequently, a half-kilogram weight is added to the hanger, causing the extension of wire AB and downward movement of frame  $F_1$ . This disturbs the leveling, and the bubble is realigned by rotating the screw upwards. The recorded screw displacement represents the elongation of the wire due to the half-kilogram weight. Multiple observations are recorded by incrementally increasing the load on the hanger in half-kilogram steps. The process is then repeated in reverse order, decreasing the load until all weights are removed. The mean of these observations is calculated.

A graph is plotted with load ( $M$ ) on the X-axis and mean extension ( $l$ ) on the Y-axis, resulting in a straight line. The graph provides the mean increase in length ( $l$ ) for a load of  $M$  kilograms. The measurements of the wire's length and radius are taken and the value of  $Y$  is computed using the given relation.

$$Y = \frac{MgL}{\pi r^2 l} \text{ Nm}^{-2}$$

## PROCEDURE

1. Suspend weights from hooks of the frames so that wires A and B get stretched.
2. Suspend a dead weight  $W_1$  of about 1 kg from hook of frame A and keep A constant.
3. Measure the length of wire B from point of suspension to the point where it attaches to the frame, using a meter scale.
4. Find the least count and zero error of the screw gauge. Measure the diameter of the experimental wire using screw gauge, at about six different places in two mutually perpendicular directions at each place. Find mean diameter and hence the mean radius of the wire.
5. Find the breaking stress of material (generally steel) of wire used. Make sure that the maximum load shall not exceed the value of one-third of the breaking stress.
6. Find the pitch and least count of micrometer. Adjust its position so that the bubble in spirit level lies exactly in the centre.
7. Increase the load in the hanger of experimental wire by half a kilogram. Wait to allow expansion of experimental wire and stabilization of the wire. Raise the screw carefully to allow the bubble in spirit level come to the centre. Note the micrometer reading.
8. Repeat Step 7 by increasing the load on hanger in steps of 0.5 kg. Take seven or eight observations.
9. Now unload the weight one by one and take micrometer readings each time, in the same manner as done while increasing the loads.

## OBSERVATIONS

Length of experimental wire,  $l =$  \_\_\_\_\_ cm = \_\_\_\_\_ m

### For Radius of Wire

Pitch of screw gauge = \_\_\_\_\_ mm.

Least count of screw gauge = \_\_\_\_\_ mm

Zero error of screw gauge = \_\_\_\_\_ mm.

Mean diameter = \_\_\_\_\_.



Mean corrected diameter = \_\_\_\_\_.

Mean radius = \_\_\_\_\_.

S. No.	Reading in one direction			Reading in perpendicular direction			Mean Diameter $d = \frac{d_1 + d_2}{2}$
	M.S.R. (S)	Circular scale (C)	$d_1 = S + (C \times L.C.)$	M.S.R. (S)	Circular scale (C)	$d_2 = S + (C \times L.C.)$	
1.							
2.							

### Measurement of extension in wire

Pitch of micrometer screw = \_\_\_\_ mm.

Least count of micrometer = \_\_\_\_ mm.

S. No.	Weight in hanger m (kg wt)	Micrometer reading			Extension for 2 kg wt. l (cm)	Mean extension ( $\Delta l$ )
		Loading	Unloading	Mean		
1.	0.5					
2.	1.0					
3.	1.5					
4.	2.0					
5.	2.5					
6.	3.0					
7.	3.5					
8.	4.0					

Mean extension, 'l' = 2 kg wt  $\times$  9.8 cm = \_\_\_\_\_ m

### CALCULATIONS

$$Y = \frac{mg l}{\pi r^2 l} = \text{_____ N/m}^2$$

Graph is plotted between load 'F' and extension 'l' produced in the wire.

$$\text{Slope of graph, } \frac{\Delta l}{\Delta w} = \text{_____}$$

$$\text{Therefore, } Y = \frac{1}{\text{Slope}} \times \frac{1}{\pi r^2}$$

### RESULT

For given materials of wire,

Calculated, Young's modulus = \_\_\_\_\_ N/m<sup>2</sup>

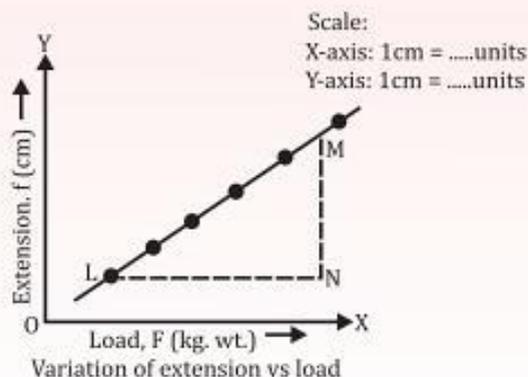
Value of Y from the table of constants = \_\_\_\_\_ N/m<sup>2</sup>

Percentage error = \_\_\_\_\_

Since load versus extension graph is a straight line, it also proves that stress is directly proportional to strain, which is Hooke's law.

### PRECAUTIONS

1. Kinks of wire should be removed before starting the experiment.



2. The diameter of the wire should be carefully determined.
3. Wire should not be loaded beyond its elastic limit.
4. To avoid the backlash error, the micrometer screw should be rotated in one direction only.
5. Zero correction in measuring devices should be done carefully.

### SOURCES OF ERROR

1. The experimental wire may be of non-uniform cross section.
2. Slotted weights may not be standard weights.
3. Backlash error arises in micrometer screw.

## VIVA VOCE

### Q1. Define elasticity.

**Ans.** Elasticity is defined as the property of a body by virtue of which it tends to regain its original configuration on applying some deforming force.

### Q2. Give examples of almost perfectly elastic substances. When do we say a body is elastic?

**Ans.** Ivory and quartz are examples of almost perfectly elastic substances. A body is said to be 100% elastic if it regains its original configuration on removal of deforming force.

### Q3. Define stress.

**Ans.** The internal restoring force per unit area of a body if it is deformed due to application of external force.

### Q4. Define plasticity.

**Ans.** The plasticity of a body is defined as its tendency to maintain its changed configuration once a deforming force is applied.

### Q5. State S.I. unit of (a) stress and (b) strain.

**Ans.** (a)  $\text{N/m}^2$   
(b) Strain has no unit.

### Q6. Distinguish between compressive stress and tensile stress.

**Ans.** When the deforming force passes a body, stress is called compressive stress. When the deforming force tends to produce a pull/tension, then the stress is called tensile stress.

### Q7. Name the three types of strain.

**Ans.** Longitudinal strain, Volumetric strain and Shearing strain.

### Q8. State Hooke's Law.

**Ans.** When a deforming force acts on a body, then stress is directly proportional to strain produced in the body.

### Q9. What do you mean by yield point?

**Ans.** The point on stress strain curve which corresponds to the elastic limit is called yield point.

### Q10. Why do we prefer to use long wires in Searle's apparatus?

**Ans.** In long wire, the elongation for a given load is more. This helps to take accurate measurements.