Kuwait University	Course 125 Phys. Lab. I.
Physics Department	Experiment 4: Elasticity: Young's modulus

Elasticity: Young's modulus

Objectives

- To calculate the load required for unit depression
- To study elasticity of solids and to determine their Young's modulus

Equipment to be used:

- Wood, steel or aluminium beam (1 m long, rectangular or square cross section)
- Two rigid knife-edge supports
- Hooks, mass pieces
- Vernier calliper
- Micrometer screw guage
- Travelling microscope

References

R. A. Serway, Physics for Scientists and Engineers,
Sections 8.6 , 12.4 , 13.2.

D.Halliday, R. Resnick and J.Walker, Fundamentals of Physics, Sections 8.7 , 13.6 , 16.3.

Theory

Hook's law states that when an elastic body is subjected to a **Stress** (force per unit area of the cross-section of the body), a corresponding **Strain** (change of length per unit length of the body) is produced and that the ratio between the strees and strain is constant as long as the elastic limit of that object is not exceeded.

$$Stress \;\propto\; Strain \;\Longrightarrow\; Stress \;=\; Y\;\; Strain \tag{1}$$

Now from the definitions of stress and strain we can write equation (1) in a different format using the fact that stress is $(\frac{F}{A})$ and strain is $(\frac{\Delta L}{L_o})$ therefor :

$$\frac{F}{A} \;=\; Y\,\frac{\Delta L}{L_o} \tag{2}$$

where F is the tensile force applied to a body with a constant cross-sectional area A and length L_o, ΔL is the elongation or the increment of length and Y is the elastic constant or the *Young modulus* of the body. The value of this modulus depends on the nature of the material the body is made of and it is defined as the ratio between the force per unit Cross-sectional area and the elongation per unit length.

In this experiment you will determine Young's modulus by the *Bending of a Beam Method*, see Figure 1. The beam is supported by two rigid knife-edge supports. It is loaded in the central point by variable weight forces $(M + m)\ g$ due to different masses (fixed by a hook). The bending of the beam is observed by a *travelling microscope* that is used for measuring the depression S of the beam. The depression S of the middle point of the beam from the horizontal position is related to Young's modulus by the equation:

$$Y = (M + m)\,\frac{gL^3}{4bd^3S} \tag{3}$$

where (L) is the distance between the supports, (M) is the mass of the load, (m) is the mass of the hook, (g) is the acceleration due to gravity, (S) is the depression of the middle point of the beam, (b) is the width of the beam, and (d) is the depth of the beam.

Procedure

1. Measure the width b of the beam using the Vernier Caliper. Repeat the measurement a sufficient number of times and record your data in (Table 1).

2. Measure the depth d of the beam using the Micrometer screw guage. Repeat the measurement a sufficient number of times and record your data in (Table 1).

3. Setup the equipment and measure the length L of the beam between the two supports.

4. Focus the cross wires of the microscope on a needle point fixed vertically to the beam midway between the supports.

5. Record the microscope reading R_o without load in (Table 2).

6. Fix mass pieces with a hook in equal steps and **record** the corresponding readings of the microscope R. Calculate the depression S.

7. Plot a graph of the depression S versus total mass $(M + m)$. Get the slope of this straight line and **calculate** Young's modulus using equation (3).

Kuwait University	Course 125 Phys. Lab. 1	Student's Name:
Physics Department	Experiment 4: Elasticity	Student's Number:
Date:		Group:

Laboratory Assignment

1. Get Young's modulus from Table 12.1 in the textbook by Serway for the materials in use (wood, steel, aluminium).

2. Answer the following questions:

a) What is the Maximum load that can be applied to a Wooden beam of length L=1 m so that the travelling microscope reads a depression of 50 mm?. Assume that the beam has square cross section of side length 1 cm.

b)How will your result in part (a) be modified if the beam is made of steal?

3. What is the definition of stress, strain and elastic limit?

Kuwait University	Course 125 Phys. Lab. I	Student's Name:
Physics Department	Experiment 4: Elasticity	Student's Number:
Date:		Group:

Worksheet for experiment 4

Table 1 (Young's Modulus)

	1st meas	2nd meas	3rd meas	4th meas	5th meas
width(b)					
depth(d)					

average width(b) =.....

average depth(d) =.....

L of beam between two supports = ...

	Loaded mass $(M+m)$	Microscopic reading (R)	Depression $(S = R_o - R)$
1.	0		
2.			
3.			
4.			
5.			
6.			
7.			

Young's Modulus (Y) from the graph = ...

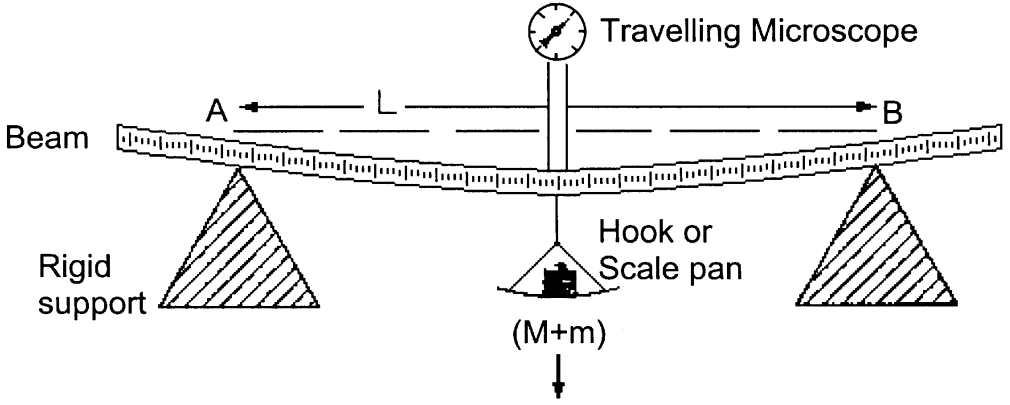

Figure 4.1 Determining Young's Modulus by *Bending of Beam* method