

EXPERIMENT 11: YOUNG'S MODULUS

When a stress is applied to a material, it will deform. In this experiment we calculate Young's modulus, the constant of proportionality between tension strain and stress in a wire. The stress will be produced by placing kilogram weights on a hanger suspended from a steel wire. We will use a micrometer screw to determine elongation, from which we calculate the amount of strain.

BACKGROUND

The equations of stress and strain are presented in section 12-7 of your textbook. Young's modulus refers to tension/compression stress; for the case of a wire, the stress will always be tension. (You cannot push with a wire, which would give compression stress.) Young's modulus is found by the ratio of stress to strain. Because the numbers are small, it is usual to use a graph and take the slope in order to get a better value of the ratio.

PROCEDURE A

1. Place the Young's Modulus Apparatus at a convenient level, either on the floor or on the table, directly over one of the legs of the table. If there is no weight on the hanger, place a 1-kg mass on the hanger. (Note that some hangers have a built in 1-kg mass; in this case, do not add another initial 1-kg mass.) Now use the position of the hanger to level the apparatus. If it is level, the hanger will be centered. Check this by looking at the two supporting side columns. The hanger should be equidistant between the columns. For the perpendicular direction, hold 2 rulers or half-meter sticks against the two columns. Again the hanger should be centered. If necessary, adjust the level by turning one or more of the three base thumbscrews.
2. With the apparatus leveled, look at the micrometer screw mechanism on the platform one-third of the way up the apparatus. Make sure the point of the screw is centered on the round dime-sized disc under it. Then turn the dial attached to the screw so that the bubble in the spirit level is centered between the two lines. Read the number on the circumference of the dial against the vertical scale, and read also the digits on the vertical scale. Call this reading L_0 and record it in the Data Table in column two.
3. Now add one kilogram at a time (although you may need to take one off and add two in some cases, since there are a mixture of one and two kilogram weights available). Each time wait about one-half minute and then readjust the micrometer screw and record the reading as before with the i th reading corresponding to the i th kilogram added. Continue this until you have added 9 kg after the first (which may be part of the hanger).
4. At this point, measure the length of the wire, from top chuck (support of wire) to bottom chuck, by using a two-meter stick and caliper jaws (metal pointers which slide onto the meter stick). Also use a micrometer to measure the diameter of the steel wire. Record both measurements in the Data Table.

5. Now record the same micrometer screw reading (L_9) on the bottom line of the third column of the Data Table, and remove one kilogram at a time, recording the micrometer screw reading each time, moving up the Data Table, back to L_0 .

PROCEDURE B

6. The remainder of this experiment is calculations and graphing. Fill in the remainder of the Data Table, either by hand, or by using an Excel spreadsheet and entering formulas into the spreadsheet for calculations and graph, as explained in experiment 2 directions.
7. In the fourth column of the Data Table, enter the average value of L_i , the average of the two readings taken with the same kilogram load, one recorded adding kilograms and one recorded removing kilograms.
8. In the fifth column of the Data Table, calculate $\Delta L_i = L_i - L_0$, so, for example, $\Delta L_5 = L_5 - L_0$.
9. In the next two columns of the Data Table, write the force and the stress ($= Mg$ and $Mg/(\pi r^2)$, respectively) for each case.
10. In the eighth column enter the strain, $\Delta L_i/L$.
11. Now you are ready to graph stress vs strain. If you graph this quantity correctly, the slope of this graph is the value of Young's modulus. You may either do the graph by hand, or use the Excel program and print the graph on the printer.
12. Compare the value of Young's modulus from your graph with the value for steel in your textbook. Calculate a percent error and report it in your conclusion.

QUESTIONS

1. If you replaced the wire in your apparatus with one twice as thick, which of the following would change when you add the first kilogram, and how: ΔL , F , stress, strain, and value of Young's modulus (if you completed the whole experiment with the new wire)? Give quantitative answers to the changes, for example, the new value would be twice as large as the old.
2. Does it make any significant difference whether you measure the diameter and the length of the wire at the beginning (with only 1kg), or when there are 10 kg total loaded on the hook? Explain.

	Micrometer screw reading reading		Li ()	ΔL ()	F()	Stress()	$\Delta L / L$
	()	()					
L0				X	X	X	X
L1							
L2							
L3							
L4							
L5							
L6							
L7							
L8							
L9							

L

Wire diameter _____