**Experiment**

**8**

# Young's Modulus

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## **Introduction**

## From bridges and buildings to miniaturize electrical circuits, the behavior of the materials involved as they are subjected to a variety of conditions is an important aspect of design. The collapse of the Nimitz Freeway as a result of the violent forces generated by the earthquake is a sad reminder of this fact. Although solids appear to be rigid, it is possible to deform them either temporarily or permanently by applying stresses. One such stress is called a tensile stress (or tension), and the effect on a solid in general is the elongation of the dimension parallel to the stress. Below a certain "elastic limit", such behavior is predictable and is quantified by a Hooke's Law type of function (review this law before beginning). The Hooke's Law constant is called "Young's modulus", and the measurement of this constant for a steel wire will be undertaken in this experiment to further your understanding of this important topic. The goal of this lab is to measure Young’s modulus for steel.

## **Theory**

Before beginning, you should study the meaning of the modulus of elasticity (Young's modulus) and understand why it is a measure of a material's rigidity. Begin by defining each of the following terms (in your own words).

1. Stress: A force experienced by an object that can cause change.

1. Strain: Measure of the degree of deformation.
2. Tension: The action-reaction pair of forces acting at each end of an object.
3. Yield Strength: The maximum amount of stress an object will have before it permanently deforms.
4. Tensile Strength: The maximum amount of stress an object will have before it fractures.

**Procedure**

1. Attach the 1kg mass hanger to the bottom of the wire and measure using a meter stick equipped with caliper jaws. This length is from the inside point of attachment at the top to the inside point of attachment at the bottom. Record your data in Table 1.
2. Examine the Young's Modulus apparatus and locate the leveling table. Check to see that the circular micrometer screw tip is positioned at the center of the anvil.
3. Carefully turn the micrometer screw until the table is level as evidenced by the spirit leveling bubble and record the circular micrometer reading. Note that one revolution of the disk (100 divisions) corresponds to 1 mm on the vertical scale. Why is this a micrometer reading?
4. Now add a 2 kg mass to the hanger and repeat step 3. Continue adding 2 kg masses (leveling and recording the micrometer reading after each 2 kg increment) until you have added 10 kg to the hanger.
5. Remove the 5-2 kg masses and the hanger from the wire and measure the thickness of the wire using the micrometer calipers.
6. Compare the value of Young’s Modulus obtained from the ratio stress/strain to the value obtain from you graph? Do they agree? If not, is this an indication that the experimenter needed to be extra careful in carrying out the experiment (or is it an artifact of the apparatus)? Explain.

**Data, Analysis, and Conclusions**

Now is your chance to demonstrate learning. Use the format that you have been using for the entire semester to complete the rest of this lab report. Note that I have already given you the procedure and apparatus part and given you the outline for the theory section. What you need to do is present your data, analyze your data, and draw any relevant conclusions. When presenting your data, make sure all relevant information is given. Certainly, a table (or tables) is (are) necessary (properly formatted tables—titles, units etc.). In the Analysis section, show all relevant calculations and a properly analyzed graph is required (minimum 4 point deduction if the results of your curve fit are not used in determining Young’s Modulus).

Your conclusion must include a discussion of results, systematic errors, and an estimate of the experimental uncertainty (expressed as a percentage). *Were you ever close to the yield strength of the wire? If so, how would this affect your results? Discuss in your conclusion.* **You don’t need to compare your measured value to the accepted value**.

**Data**

**Length of wire: L = 0.650 m**

**Diameter of wire: D = 0.00057 m**

**Table 2: Increasing the Tension on the Wire**

Circular Micrometer Reading with no Mass on Hanger: L0 = 0.00741 m

|  |  |  |  |
| --- | --- | --- | --- |
| Number of Masses | Mass (kg) | Circular Micrometer Length (m) | Change in Length (m) |
| 1 | 0.50007 | 0.00758 | 0.00017 |
| 2 | 0.95808 | 0.00772 | 0.00031 |
| 3 | 1.41606 | 0.00786 | 0.00045 |
| 4 | 1.91641 | 0.00798 | 0.00057 |
| 5 | 2.41668 | 0.00815 | 0.00074 |

**Sample Calculation for Change in Length :**

**Analysis**

**Table 3: Young’s Modulus**

|  |  |  |  |
| --- | --- | --- | --- |
| Number of Masses | Stress (N/m2) | Strain | Young’s Modulus (N/m2) |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |

**Sample Calculation for Stress:**

Stress =

**Sample Calculation for Strain:**

Strain =

**Sample Calculation for Young’s Modulus:**

**Calculation for Young’s Modulus Standard Deviation and Uncertainty:**

Average Y =

Chart, line chart

Description automatically generated

Young’s Modulus from Graph Y =

Figure 1: This is a plot of Stress vs Strain of a Copper Wire and Hanging Mass System. Most of the data does not fit on the curve fit line, but the data generally follows a linear line which means the relationship between the stress and strain on the wire is not verified by Young’s Modulus possibly caused by the yield strength of the copper wire being exceeded causing a small amount deformation.

**Conclusion:**

The experiment involves the use of a wire and hanging mass system to find Young’s Modulus of a copper wire. Calculating the average Young’s Modulus by dividing the measured stress over the measured strain is . Calculating Young’s Modulus by graphing the measured stress and strain gives a value of . Compared to the accepted value of , both of my measured values do not agree with the accepted value. The biggest source of systematic error would be not considering the weight of the hanger itself causing some measurements to be slightly off. Calculating the experimental uncertainty by multiplying the uncertainty of Y over Y times 100 is found to be 2.34%.