**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: Stress is the force applied per unit area of a material. Stress is defined as the ratio of the force applied to an object or material to the area over which the force is distributed. The equation for Strain is:

Stress = F/A

1. Strain: Strain is the measure of deformation that occurs in a material when subjected to stress. Strain is defined as the ratio of the change in length of an object to its original length. The equation for strain is:

Strain = ΔL / L

1. Tension: Tension is present in many physical systems, including ropes, cables, springs, and other elastic materials. Tension is the pulling force by an object by another object that is connected by a string, cable, or other connector.
2. Yield Strength: Yield strength is the amount of stress an object can undertake before it begins to demonstrate permanent damage to its structure. This is especially useful when designing structures. When designing structures, these buildings need to be able to withstand a certain amount of stress to make them viable for use.
3. Tensile Strength: Tensile strength is the amount of stress required to pull something apart along it’s length. Tensile strength is typically measured using a tensile test, in which a sample of the material is pulled apart until it breaks.

**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**.

\*To prevent data spillage, the information will be reported on the following pages.

# *Table 1 - Data*

# Diameter of Wire: .6500cm

# Incrementing Tension to The Wire:

|  |  |  |  |
| --- | --- | --- | --- |
| Number of Hanging Masses: | Mass on Hanger:  (kg) | Circular Micrometer Length (m): | L Total Change in Length(m): |
| 0 | 0 | 0.00730 | 0 |
| 1 | 0.50007 | 0.00758 | 0.00028 |
| 2 | 0.95808 | 0.00772 | 0.00042 |
| 3 | 1.41606 | 0.00786 | 0.00056 |
| 4 | 1.91641 | 0.00798 | 0.00068 |
| 5 | 2.41668 | 0.00815 | 0.00085 |

# Sample Calculations:

# Table 2- Analysis/Results

|  |  |  |  |
| --- | --- | --- | --- |
| Number of Hanging Masses: | Stress | Strain | Youngs Modulus |
| 1 |  | 0.00043 |  |
| 2 |  | 0.00064 |  |
| 3 |  | 0.00086 |  |
| 4 |  | 0.0010 |  |
| 5 |  | 0.0013 |  |

# Stress Sample Calculation:

0.000430769

# Sample Calculation For Youngs Modulus:

# Average Youngs Modulus

# Calculating for Youngs Modulus with Uncertainty:

# Average Youngs Modulus is

# Stress vs. Strain of Hanging Mass System Graph

A screen shot of a graph

Description automatically generated with medium confidence

## Fig Caption: This graph measures stress against strain in an attempt to find the slope of the function which should be equal to the values we calculated for in the sample calculation portion of the lab. Furthermore, both results should be within the uncertainty range of the true value of youngs modulus for steel.

# Results:

|  |  |
| --- | --- |
| **Average Young’s Modulus**  **Y**  **(N/m2)** | **Young’s Modulus**  **From Graph**  **Y**  **(N/m2)** |
| (7.32 ± 0.5) ×1010 | (9.98 ± 0.2) ×1010 |

# Conclusion:

The purpose of this lab was to confirm the existence of Youngs Modulus for a certain type of metal. Here we can define Youngs Modulus as ). In a simplified way of defining, its properties, the higher the rate of Youngs Modulus the more stiff it is and the higher the structural integrity of the element being considered.

In this experiment, we were tasked with adding mass to a hanging apparatus that is held up by a taut metal string. As the string begins to take more mass it will deform. The rate at which it deforms, the force applied, the area of the string, and the length of the string can be used to calculate for Youngs Modulus.

During this experiment, we encountered systematic errors as our values for Youngs Modulus did not coincide with the actual values our sources indicated to be true. Our values found 7.32 to be our Youngs Modulus average with our graph arguing against those values with The experimental uncertainty of Youngs Modulus is .2 is The systematic errors present could be due to the ancient apparatus that we suspect could be experiencing friction within its internal components. These internal components can be described as the modulus that is reporting the change in length. We may find that the yield strength has been exceeded and the wire has deformed, we may find that the system collet was not fastened properly. In addition, the