Strength of Materials

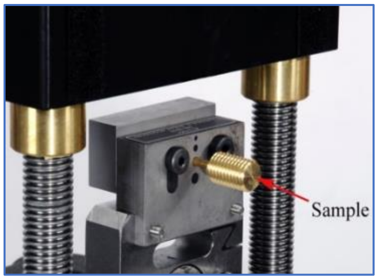
Equipment

Qty	Description	Part Number
1	Materials Testing Apparatus	ME-8236
1	Materials Shear Accessory	ME-8239
1	Aluminum Tensile Sample	ME-8231
1	Brass Tensile Sample	ME-8232
1	Annealed Steel Sample	ME-8233
1	Steel Tensile Sample	ME-8243
1	Calipers	SE-8710

Introduction

This lab investigates two ways in which a member can fail: In Tension and in Shear. The strength of a material is often expressed in terms of the maximum stress needed to cause failure. A standard tensile test is performed using the Tensile Samples, and the Tensile Strength (maximum axial stress) is measured. A shear test is then performed (on the same sample), and the Shear Strength (maximum shear stress) is measured. Four metal samples are measured, and the shear/tensile strength ratio is calculated for each.

Tested materials include 1018 steel, annealed 1018 steel, 360 brass, and 2024-T3 aluminum.



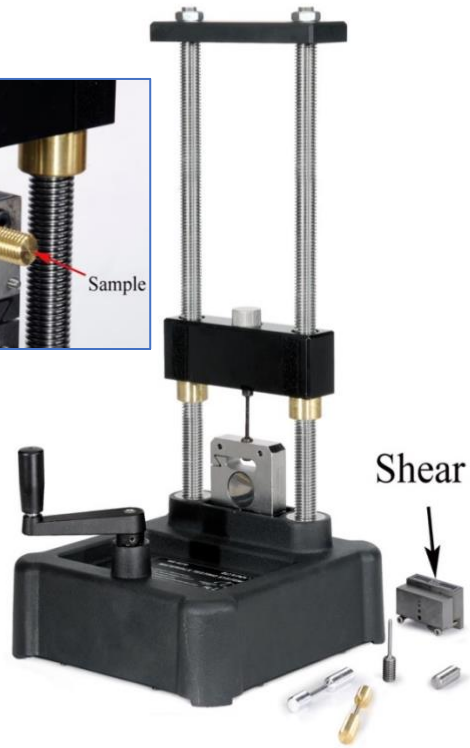


Figure 1: Shear and Tensile Testing

Four different metal Tensile Samples are broken under tension, and the Tensile Strength for each material is measured. A shear test is then performed (see inset to Figure 1) on the broken sample using the Shear Accessory, and the Shear Strength for each material is measured.

Note: A Compliance Calibration is NOT needed for this experiment.

Procedure: Tensile Test

1. Connect the Materials Testing Machine to a computer using a USB interface. In the PASCO Capstone calculator, create the following calculations, add your values for the constant as you determine its value:

Stress=10^{-6} *([Force (N)])/(π*(Dia/2)²)	with units of MPa
Dia=	with units of m
Ratio=[Shear (MPa)]/[Tensile (MPa)]	unitless

2. In PASCO Capstone, create a graph of Force vs. Position. Also create a Digits display and select Force.

3. Use calipers (or a micrometer) to measure the diameter of the machined portion of the tensile sample. Edit the value for diameter in line #2 of the calculator.

4. Install the first test sample. The end with the shorter threads should be screwed directly into the load cell. Secure the top with the knurled cap nut.

5. Your data will look better if you use the normal procedure to "seat" the test sample. A Compliance Calibration on position is NOT needed for this experiment: Only the force data is used.

6. Click on Record, and turn the crank clockwise, stretching the sample.

7. Continue cranking until the sample beaks, then click on Stop.

8. Open the Data Summary to rename your run.

9. Repeat the above procedure for your other samples.

10. Note: In this lab, both tension and compression are used. To make the data positive for this graph, use a QuickCalc on both axes to change the sign. In the second half of the lab, the data is already positive, and the sign change is not needed.

11. In PASCO Capstone, create a graph of Stress vs. Position. Use QuickCalc to make the data positive.

12. Confirm that the equation for Stress in the calculator is correct. What are the units?

13. In PASCO Capstone, create a table with user-entered data set called Tensile Strength that has units of MPa.

14. For each sample measure the Tensile Strength (maximum Stress). Use the Coordinates Tool or the Statistics feature in the graph tool palette.

15. Record your values in the table.

16. Is the Tensile Strength a property of the specific sample, or of the ***material*** being tested?

Setup: Shear Test

Note: When testing the samples under tension, they usually break in two uneven lengths. You will want to use the longer of the two pieces to test in shear. However, if your sample broke in the middle of the machined part, both pieces may be too short to use. A minimum of about 20 mm is needed to reach through the shear. If needed, break another sample before installing the Shear Accessory. You can also force the sample to break at a specific point by making a small notch with a file.

1. Check the diameter of the sample to see if it has changed.

2. The Materials Shear Accessory consists of two hardened metal blocks, held together permanently by the two black screws (see Fig. 3). The stationary block (with the label) fastens directly to the load cell using the two silver cap screws as shown in Figure 2.

3. The movable block slides vertically to provide the shearing action. Lift this block to the top of its travel as shown in Figure 3 and insert the sample into the appropriately sized hole from the ***BACK*** of the Shear as shown. If you insert the sample from the front, it can get in the way as you turn the crank!

   Note: When the rod is properly inserted, the front (movable) shear block will be higher than the back. When the cross-head is lowered, it should press on the front block that is free to move, NOT the back block that is fastened to the load-cell.

4. Turn the crank counter-clockwise, moving the cross-head downward until it is almost touching the front shear block. The shearing force is applied by the cross-head, which is in direct contact with the front block. Note that the knurled cap nut is not needed for this part of the experiment.

5. Make sure the plastic Safety Shield is in place on the front of the tester.

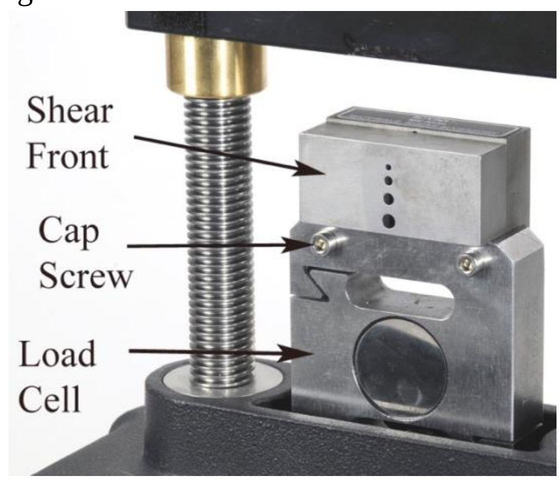


Figure 2: Front view of Shear Accessory

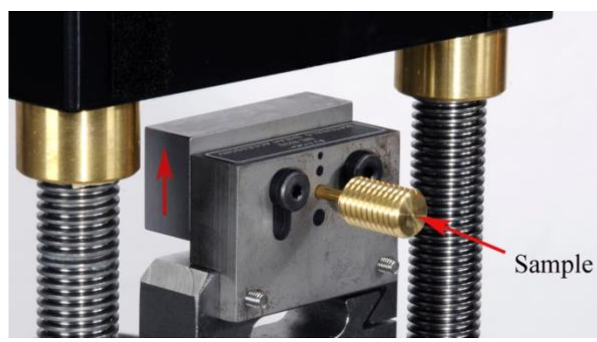


Figure 3: Back view of Shear Accessory

Procedure: Shear Test

Note: Your data will look better if you use the normal procedure to "seat" the test sample. A Compliance Calibration on position is NOT needed for this experiment: Only the force data is used.

1. Turn the crank counter-clockwise, moving the cross-head downward until it is just touching the front shear block.

2. Click on Record and turn the crank counter-clockwise.

3. Continue cranking until the rod shears, then click on Stop.

4. Repeat the procedure for the other samples.

5. Open the Data Summary and re-name your runs to show the material used.

6. In PASCO Capstone, add a user-entered data set called Shear Strength that has units of MPa to the table.

7. Measure the Shear Strength (max stress) for each of your materials, and record in the table.

8. How do your values for Tensile Strength and Shear Strength compare to those listed in reference data tables for the materials?

Analysis: Tensile and Shear Strength

1. Confirm that the Shear Strength / Tensile Strength ratio is being calculated correctly for your data.
2. There is much written on the theoretical relationship between the Shear Strength and Tensile Strength for a material. For example, the von Mises criterion predicts this ratio to be $1/\sqrt{3} \approx 0.6$. Compare your values to that predicted by theory.

Analysis: For Further Study

1. This lab focused on the ultimate breaking strength of the material, but a similar lab can be done looking at the ***yield*** strengths.

2. When investigating strength of materials, a common property often measured is the Young's Modulus. This can be measured directly from a stress/strain graph of the sample in tension, but you would need to perform a Compliance Calibration on position.

3. You can also measure the Young's Modulus of the test sample by performing a Three Point Bend Test. You should do this test first (before the Tensile and Shear tests) and be very careful not to go past the elastic limit of the material.