Structures - Experiment 3A
1.101 Sophomore Design - Fall 2006
The Tension Test.

Our objective is to measure the Elastic Modulus of steel.

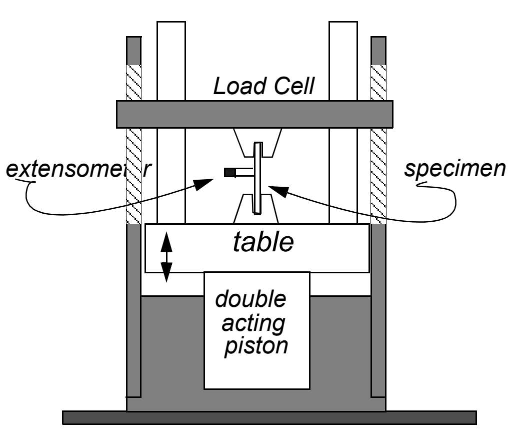
You will subject a steel rod speciman to a tension test using an Instron testing machine designed specifically for that purpose. An "extensometer" will be used to obtain a measure of strain and a "load cell" used to obtain a measure of stress.

You will use the pages that follow in reporting your results. This then is your report.

2.1 Tension Test of a steel rod.

The INSTRON machine is built specifically to subject structural elements to tension or compression. The schematic at the right indicates how it works.

A double acting piston drives the table up, or down, when pressurized hydraulically. The test specimen is fixed relative to the top bar and the shaded cross bar by the grips; the shaded cross bar is fixed in space. Hence, the specimen is subject to a tensile load as the table moves downward.



INSTRON Machine

Test Sequence - Overview[1]

Measure and record the diameter of the test specimen.

Fix the specimen in the grips of the machine.

Attach the extensometer, recording the gage length (below)

Set up the Instron for "ramp" increase of load, setting the actuator control for a table motion of 0.2in / min.

Do "automatic calibration" to set full scale values for load and displacement and output voltages. Record load and displacement factors. (below)

Ensure the Data Acquisition System is set to record.

Load specimen to rupture. **Wear safety glasses.**

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[1] Steve Rudolph will set up and run the test machine. You are responsible only for the first step.

Parameters for determining tensile stress.

The load is sensed by a load cell at the top bar. It puts out a voltage proportional to the load. For our purposes, all you need know is the scaling factor for converting the voltage to tensile force. This is obtained from a "full scale" setting, the "automatic calibration" of the load cell. At full scale, the signal output is_____ *Volts*; the *corresponding load is* ____*KN* or ___________ Kips[1].

The load factor is then:

Load factor = _____________ KN/volt

Knowing the cross-sectional area of the test specimen, we can, knowing the load, compute the tensile stress in the bar. We record that the diameter of the specimen as:

Diameter =_____________ mm

So the cross sectional area is

Area = _____________ mm^2

The bar, made of ___________steel, has a (ask)

yield stress of ______ Mpa and an ultimate stress of ________ MPa

For our specimen then, we expect large deformations at a load of

Expected yield ~ __________________ KN

This suggests that our output voltage will range from zero to above

Anticipated load voltage at yield = _____________ volts.

Our goal is to graph how the tensile stress varies with the tensile strain. We need, then to go one step further and construct the factor for tensile stress in terms of voltage. Dividing the force by the area we obtain[2]:

Stress factor =_____________ MPa/volt

To compute the corresponding values of the strain, we need to measure the change in length of the specimen. The strain is then the ratio of the change in length to the original length.

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[1] 1 Kip is 1000 pounds.

[2] 1 psi = 6.895 x 10^3 Pascals. 1 lb. = 4.448 N

Parameters for determining tensile strain.

An extensometer will be used to measure the change in length between two points located on the surface of the cylindrical specimen. The two knife edges, which are held in place against the specimen by simple elastic bands, are initially spaced a preset distance apart. This "gage length" is

Gage Length = ____________ mm

The gage factor is determined from "full scale" conditions. The extensonmeter we will use can accomodate a full scale displacement of +/- ____ mm. Full scale output voltage is _______volts. Hence, the scale factor for displacement is

Displacement factor = __________mm/volt

The strain factor is then, dividing by the gage length

Strain factor = ____________ mm/mm/volt

Data Collection and Analysis

Data will be recorded via the computer (equipped with analogue to digital conversion hardware). An ASCI text file will be produced in three column format. The first dozen or so readings will show negative values for the displacement and load as the speciman "takes up the load".

Time	Displacement	Load	Extensometer
(sec)	(volts)	(volts)	(volts)

Process your raw data as we did the first class of the semester, using a spread sheet. You will be able to download the text data file from our Stellar site almost immediately.

Results

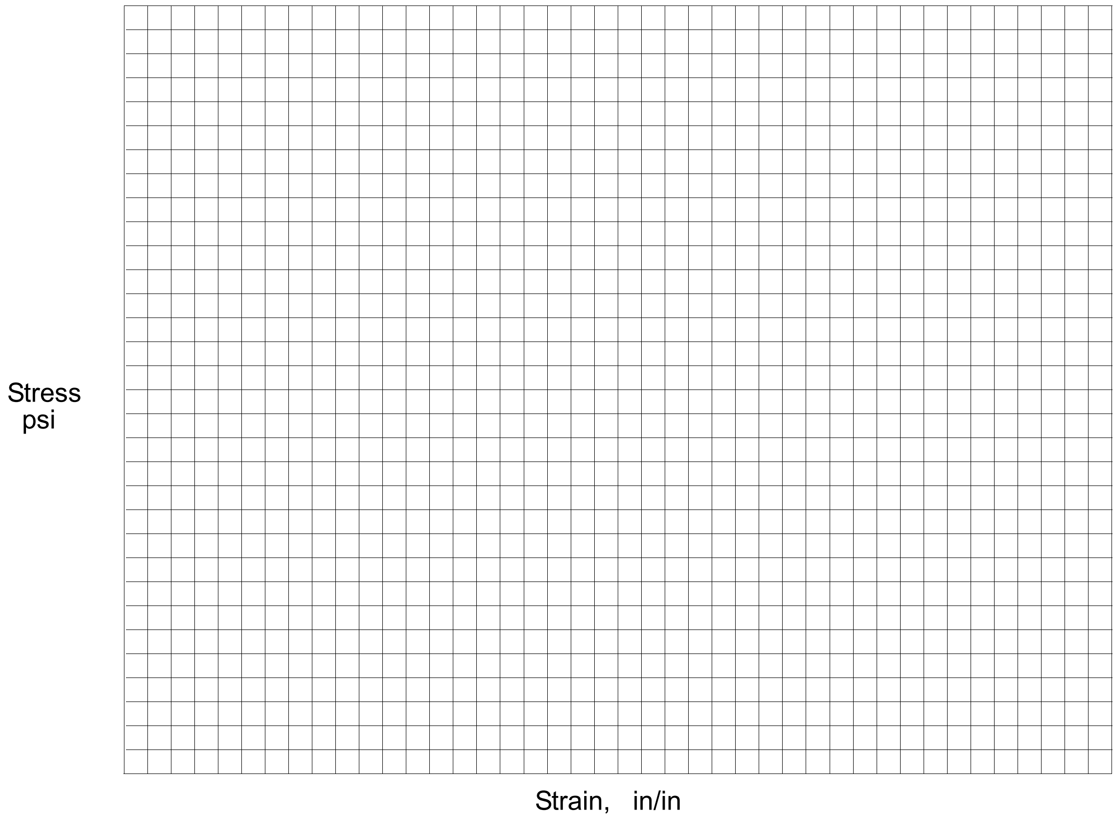
Once we have a plot, we determine the slope in the elastic range. This slope, if taken directly from the graph, will have the units of volts/volts. We follow the trail back through all the scale factors to compute the slope as a ratio of tensile stress to tensile strain. We obtain in this way the following experimentally determined value for *E, the elastic, or Young's modulus*:

E, the elastic, or Young's modulus = ___________+/- ? psi or ____________+/-? Pascals

$$E_{book\ value} = 30 \times 10^{6}\ psi = 207 x 10^{9}\ Pa$$

Import the graph from your spread sheet or simply, physically cut and paste it into this document on the next page.

A graph of the stress-strain curve, ranging up to four times the strain at yield is shown below.



Stress versus strain - Uniaxial Tension Test
Steel Bar Date:

The slope is indicated on the graph.

It differs from the “book value” by ~ ____________ %

Reasons for this discrepancy include:

[*Here attempt to explain this discrepancy and deviations from linearity.*]