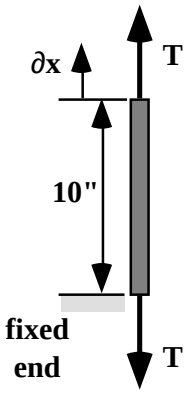
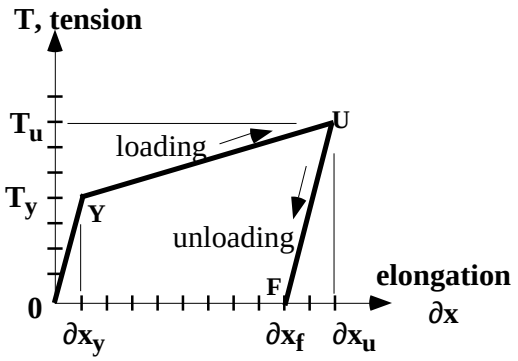
Material Properties:

A tensile testing machine is employed by engineers to determine certain mechanical properties of various materials to be used in their designs. In a particular tensile testing machine, an uniform bar of metal is being pulled by a force of "T" pounds as shown. The bar's cross-section is 0.5 inch^2 and originally it is $\mathbf{x_o = 10}$ **inches** long. Let us assume that the results of one complete cycle of tensile testing are as shown in the attached graph - it is essentially **a force-displacement graph**; the tension **"T"** begins and ends at **T = zero,** but the length of the bar changes permanently, as shown, to a length of ($\mathbf{10.0 + \partial x_f}$) inches when all loading is finally removed.

We wish to determine the work and different energies involved in this test.





Assume that:

- the "yield strength (Maximum tension before certain permanent deformation sets in)", $\mathbf{T_y = 40{,}000}$ **lbs,** at $\mathbf{\partial x_y = 0.001 x_o = 0.01}$ **inch**;
- the "ultimate strength (Maximum tension before it breaks)", $\mathbf{T_u = 60{,}000}$ **lbs,** at $\mathbf{\partial x_u = 0.010 x_o = 0.10}$ **inch**; and
- the **slope** of the line **OY** is the same as the slope of the line **UF** .

Determine:

a. the **final elongation** of the bar in inches, $\mathbf{\partial x_f}$: [Hint: Use geometry in **tension-elongation graph]**

b. the amount of **work** done **on the bar** during the "loading" portion of the test in ft-lbs; i.e., work from **O** to **U** ;

c, the amount of energy "**returned**" by the bar, in ft-lbs, when the final load is removed (the conservative portion of the work done on it);

d. the amount of energy "**absorbed**" by the bar over the full cycle of loading, in ft-lbs, from **O** to **F** (the non-conservative portion of the work done on it).