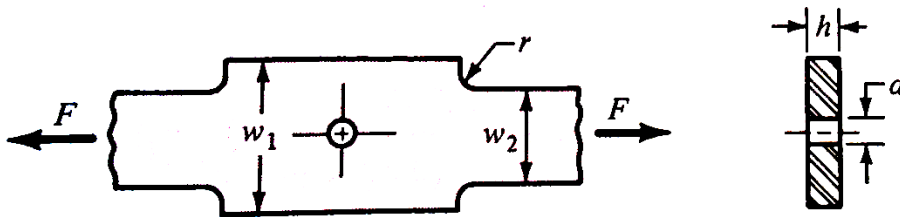


//Fatigue of a Notched Part-Solidworks Fatigue Analysis//

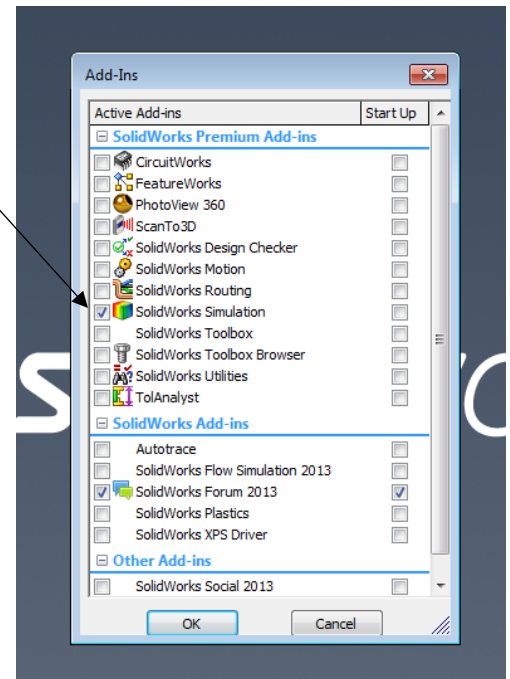
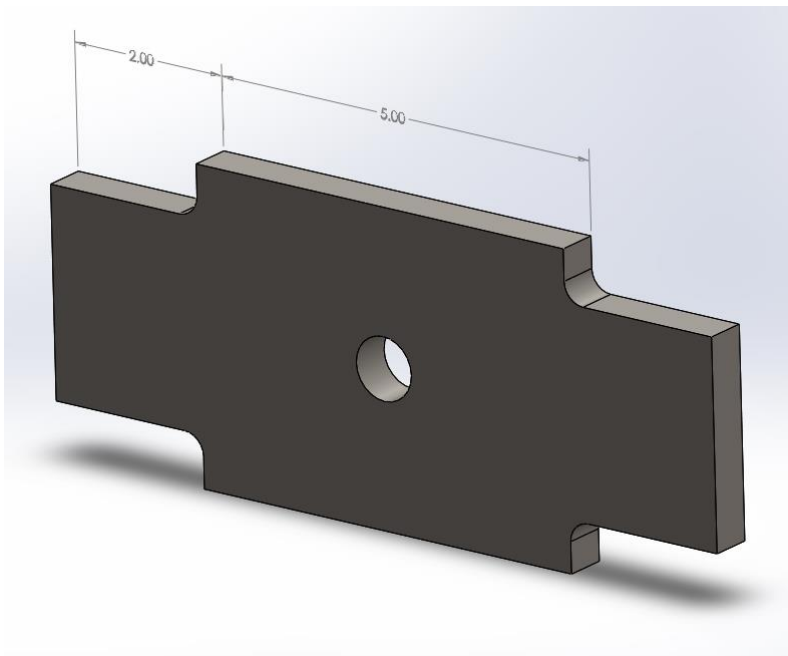
**7-26** The figure shows the free-body diagram of a connecting-link portion having stress concentration at three places. The dimensions are:  $r = 0.25$  in,  $d = 0.75$  in,  $h = 0.50$  in,  $w_1 = 3.75$  in, and  $w_2 = 2.5$  in. The forces  $F$  fluctuate between a tension of 4 kip and a compression of 16 kip. Neglect column action and find the least factor of safety. Material is 1018 CD steel.



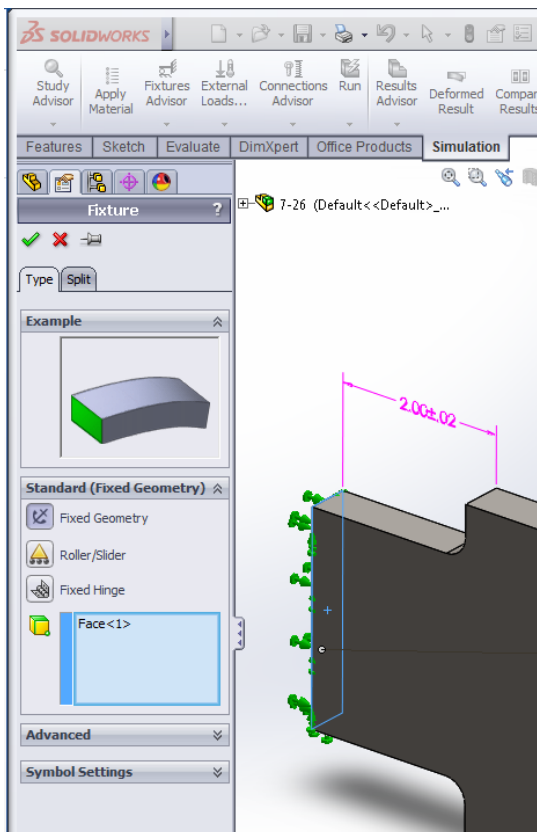
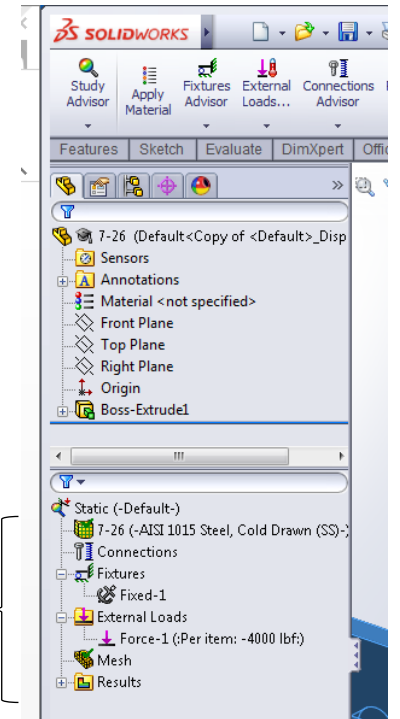
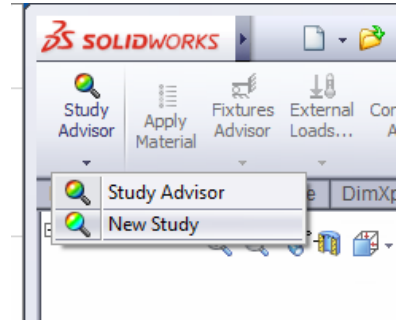
7-26

The two missing dimensions you need for the model are shown below.

- 1) Start Solidworks
  - a. Under Tools-Add Ins... Check the check box "Solidworks Simulation"
- 2) Model the Part from Shigley's Mechanical Engineering Design Problem 7-26 it should look something like this...

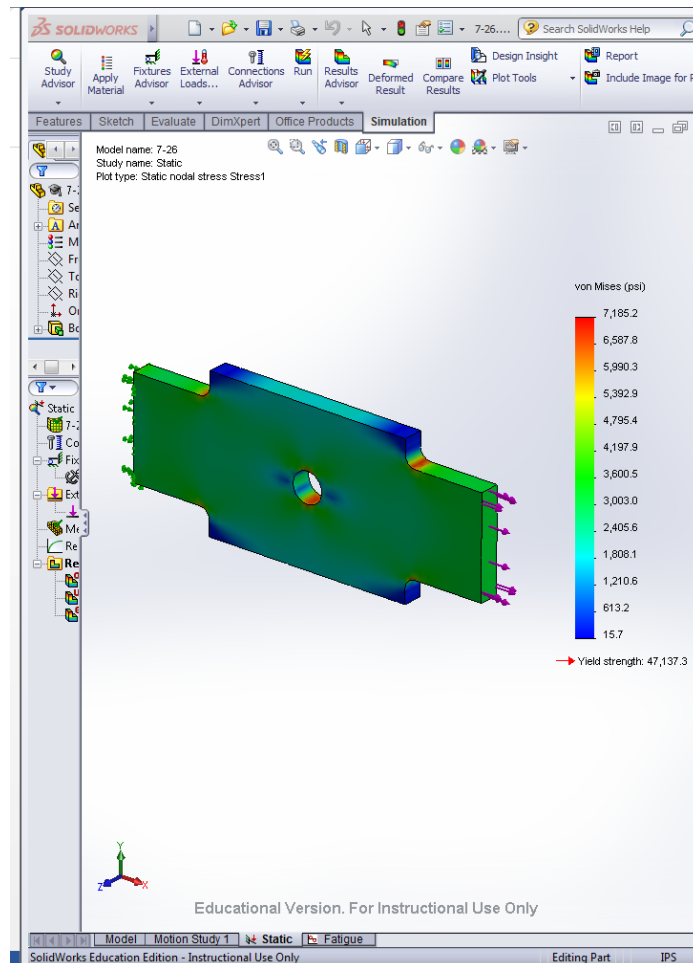


- 3) To study fatigue in Solidworks one must first create a “Static Study” then run a “Fatigue Study”
  - a. To start the “Static Study” Select the Simulation Tab that appeared when you completed Step 1.
  - b. Select the Study Advisor drop down and select “New Study”
  - c. The “Static Study” should be automatically Selected  
Rename the Study and click the green check.
  - d. On the left you will have in addition to your Design Tree you will now have a Simulation Tree
  - e. In the Simulation Tree we have many options, lets go through each...
    - i. The first will have your Part name you need right click this icon and select “Apply/Edit Material” Solidworks doesn’t have 1018 CD Steel but the 1015 Cold Drawn has similar properties.
    - ii. The second is Connections, since we have no welds, bolts or bearings we will leave this option alone.
    - iii. The third is Fixtures, since this part is being pulled at 4kips and compressed at 16kips we need to fix one of the sides and we will pull/push on the other. Set one side as a “Fixed Geometry” as seen below and click the green check.



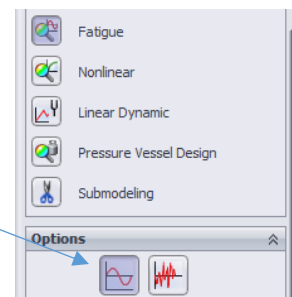
Simulation Tree

- iv. Next we need to add loads, Solidworks Selects the Minimum Load first from the Static Study and Calculates the larger load from the R values you will see later.
- v. Set a Load by right clicking the “External Loads” and selecting “Force” set the load to on the opposite face from the “Fixed Geometry” to 4000 lbf. To get my force in tension I needed to select the “Reversed Direction” check box.
- vi. Next it is time to “Mesh” the part. This allows Solidworks to solve each small node of the part and sum them to model the stresses. Right click the “Mesh” icon and select “Create Mesh”. Use the slider to adjust the size of the mesh. A little finer than default mesh works well. Once you have meshed select “Run.” You should get a Result like this.



#### 4) Fatigue Analysis

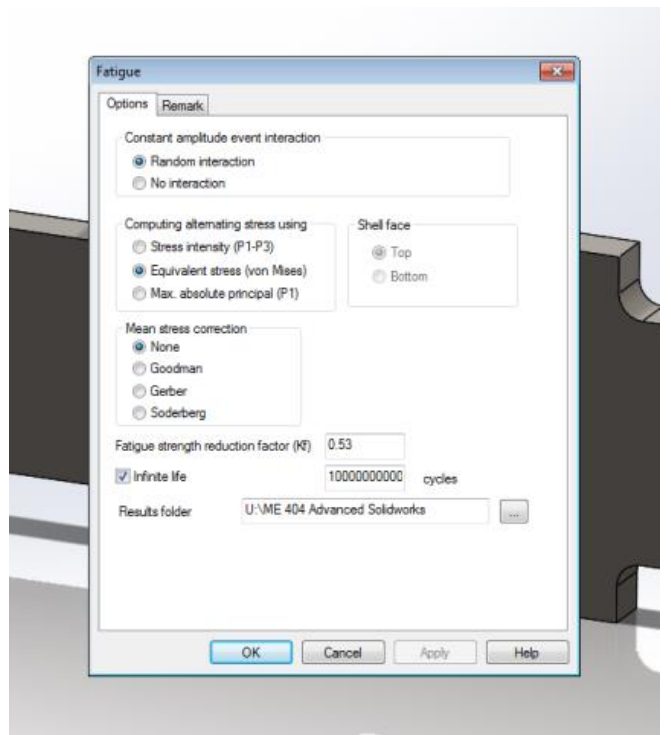
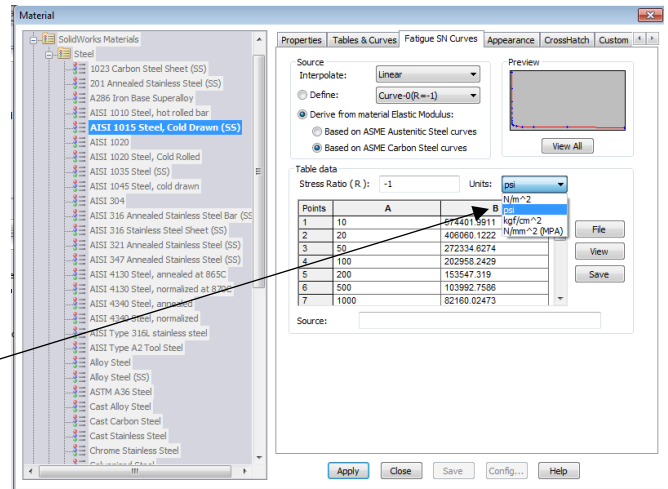
- a. As with the Static Study select the Study Advisor in the top left and Select “New Study”
- b. Select the “Fatigue” Icon and make sure at the bottom of the column the constant amplitude loading is selected click the green check.



- c. You now have a new Simulation Tree but for Fatigue we will work down the tree like before.
- d. Right click “Loading” and select “Add an Event”. Make sure the Static Study we did earlier shows up. You have two different options to mess with. The first is the number of cycles the part will undergo. For us, we will be calculating infinite life which we will define later. The second is the loading ratio. We don’t have “Fully Reversed Loading (LR=-1)” so select “Loading Ratio” from the drop down menu. Our Loading Ratio can be calculated by the following.

$$R = \frac{S_{min}}{S_{max}} = \frac{\frac{F_{min}}{A}}{\frac{F_{max}}{A}} = \frac{F_{min}}{F_{max}} = \frac{4000lb_f}{-16000lb_f} = -.25$$

- e. The icon with your part name now appears. Right click your part icon, in the simulation tree, and select “Apply/Edit Fatigue Data” in this we be assigning an S-N (Stress vs Life) curve to our material.
- f. Unless you carry S-N curve data around Solidworks makes it easy and allows us to derive it from the Elastic Modulus. Select the option to derive from Elastic Modulus. Then select the ASME Carbon Steel curves. Make sure you select “psi” for the units. Click “Apply” then Close.
- g. Next right click the “Results Options” and select “Define/Edit” the default selection is the “Whole model” this works for our application. Click the Green Check
- h. Lastly under the Study Advisor Drop Down select “Study Properties.” We have many things to play with in here but for this problem and the fatigue you do in Odom’s class we will only use a few. The first box “Constant Amplitude Event Interactions” Will remain “Random Interactions”
- i. The next box “Computing Alternating Stress Using” Select the Equivalent Stress (von Mises) which we are familiar with.
- j. Next is the “Mean Stress Correction” this comes into play in Bob’s ME461 Fatigue



and Fracture class but for this problem we will select “None”

- k. The Next step is important. The (Kf) value needs to be assigned. This is the Fatigue Strength Reduction Factor. **NOTE: THIS IS NOT THE Kf FROM THE SHIGLEY BOOK!** This is the “Ke” from the Shigley book Solidworks will bark at you if you try to put a value larger than one in.
- l. Using the charts in the Shigley Book I came up with a  $K_e = K_f(\text{Solidworks}) = .53$
- m. Select the infinite life check box and select OK.
- n. Run the study. Be patient Solidworks runs the Static Study first then the Fatigue.
- o. Right Click the “Results” in the Simulation Tree select “Define Fatigue Plot” select the “Load Factor” this is just another name for the Safety Factor.
- p. Right click the Load factor plot and select “Show” repeat and select the “Probe” tool. Select the bottom of the fillet. Select a couple points I get around 1.8 as the safety factor which is consistent with the answer in the back of the book of 1.8 at the fillet.

***Due to the fact we choose a slightly different material and that Solidworks probably uses other fatigue models other than just the S-N, Solidworks gets a minimum safety factor at the hole instead of at the fillet. We see that our approach is still an accurate way to model but shows the differences between model types and methods.***

