Fatigue:

Fatigue is **progressive failure** that occurs due to dynamic and fluctuating stresses.

Fatigue failures **can occur at stress levels far below the ultimate or yield strengths** of a material.

Fatigue accounts for **90%** of all metallic failures!

Fatigue occurs suddenly and without warning.

The mechanism of fatigue begins with **crack initiation**--which almost always occurs at a stress riser (hole, keyway, corrosion, radius, etc.) The stresses are very high at the tip of the crack and this increased level of stress causes the **crack to propagate**.

The crack propagates with each stress cycle until the material finally **fails**.

To determine the fatigue strength of a material, a highly polished test specimen is subjected to pure bending. The specimen is subjected to reversed stresses until the material fails. The stress level at failure and the number of cycles to failure determine the materials **fatigue strength**.

The data would look something like this

Stress Amplitude (ksi)	**Cycles to Failure**
36.0	1 E5
34.2	3 E5
32.5	1 E6
30.9	3 E6
29.1	1 E7
28.0	3 E7
28.0	1 E8
28.0	3 E8

Plots are produced from collection of this data called S-N plots. For ferrous metals, S-N plots are characterized by a knee. The "knee of the plot " generally occurs around 1 000 000 cycles and is called the **endurance limit**. The endurance limit is the level of alternating stress that can be taken by the metal indefinitely without failure. **Nonferrous**

metals typically do not exhibit an endurance limit. When an endurance limit is not available, the fatigue strength at 5 E8 cycles is generally used.

The fatigue strength at 1000 cycles is computed to be around 90% of the ultimate tensile strength (0.9 S_{ut})

For steels, the uncorrected fatigue strength, S_f:

if S_{ut} < 200 ksi	S_f = 0.5 * Sut
if $S_{ut} \geq$ 200 ksi	S_f = 100 ksi

For aluminum, the uncorrected fatigue strength, S_f

If S_{ut} < 48 ksi	S_f = 0.4 * Sut
If $S_{ut} \geq$ 48 ksi	S_f = 19 ksi

Alternating Stress

$$s_a = \frac{s_{max} - s_{min}}{2}$$

Mean Stress

$$s_m = \frac{s_{max} + s_{min}}{2}$$

Stress Range

$$\Delta s = s_{max} - s_{min}$$

In class Exercises:

Given the following data, calculate the **mean stress**, σ_m, the **alternating stress**, σ_a, and the **stress range**, $\Delta\sigma$.

s_{max}	s_{min}	s_m	s_a	Ds
1000	0			
1000	-1000			
1500	500			
1500	-500			
500	-1000			
2500	-1200			
0	1500			

Given the following data, determine the equation of fatigue strength, S_f (the S-N line).

Material	S_{ut}
Steel	90 000
Steel	250 000
Steel	120 000
Steel	150 000
Aluminum	25 000
Aluminum	70 000
Aluminum	35 000