

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 1000000 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 5×10^8 cycles is generally used.

The fatigue strength at 1000 cycles is computed to be around 90% of the ultimate tensile strength ($0.9 S_{ut}$). If the component is loaded axially, then the fatigue strength at 1000 cycles is $0.75 S_{ut}$.

Alternating Stress

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

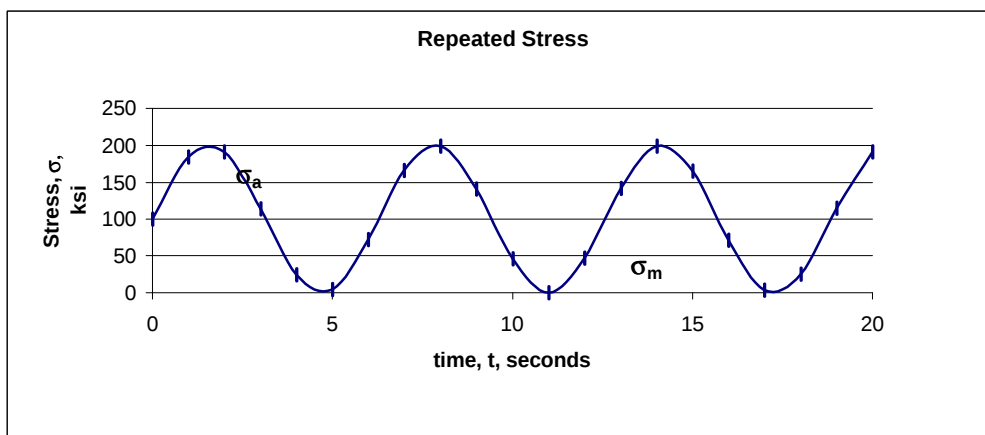
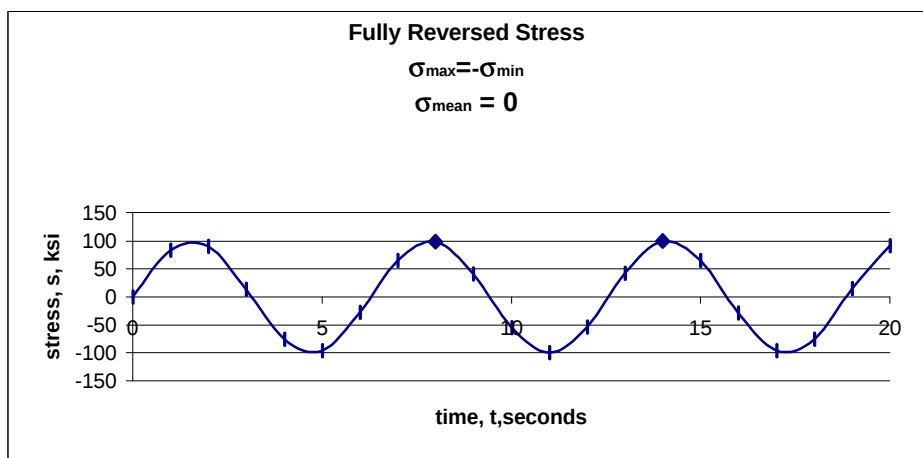
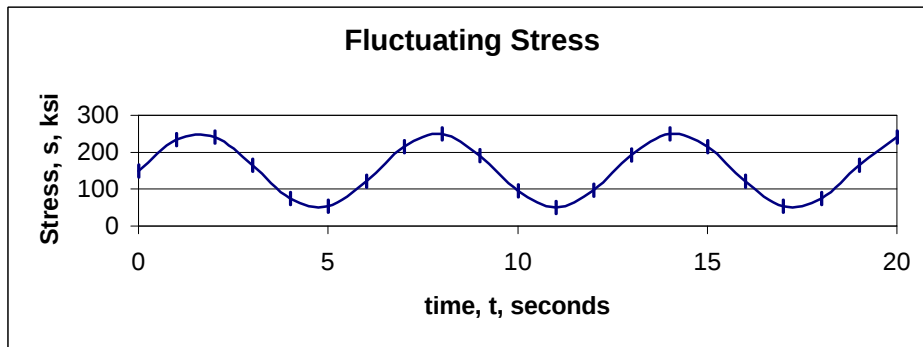
Mean Stress

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

Stress Range

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

Review the following plots and find: the **alternating stress**, the **mean stress**, and the stress range:



Given the following information, find a formula for fatigue strength.

1. The data S_f vs. N plots to a straight line on log-log paper
2. 15 209 psi is the fatigue strength at $2E7$ cycles
3. 40 500 psi is the fatigue strength at $1E3$ cycles