

MSE160 – Molecules and Materials  
Problem Set #10- Due April 9<sup>th</sup> 2020

1. A fatigue test was conducted in which the mean stress was 70 MPa and the stress amplitude was 210 MPa.
  - a. Compute the maximum and minimum stress levels
  - b. Compute the stress ratio
  - c. Compute the magnitude of the stress range
  
2. Three identical fatigue specimens are fabricated from a nonferrous alloy. Each is subjected to one of the maximum-minimum stress cycles listed below; the frequency is the same for all three tests. Rank the fatigue lifetimes of these three specimens from the longest to shortest

<i>Specimen</i>	<i>Maximum Stress (MPa)</i>	<i>Minimum Stress (MPa)</i>
<i>A</i>	+450	-150
<i>B</i>	+300	-300
<i>C</i>	+500	-200

3. Using the fatigue data below, create an S-N plot. Determine the fatigue strength at  $5 \times 10^5$  cycles and determine the fatigue life for 200MPa.

Stress Amplitude (MPa)	Cycles to Failure
310	$2 \times 10^5$
223	$1 \times 10^6$
191	$3 \times 10^6$
168	$1 \times 10^7$
153	$3 \times 10^7$
143	$1 \times 10^8$
134	$3 \times 10^8$
127	$1 \times 10^9$

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4. One of my labmates wants to be Waluigi for Halloween. For his costume, he will need a tennis racket. The racket shaft is what you will design, which we can assume to be a beam with a circular cross section. The consideration for this design is for the racket shaft to be as light as possible, while preventing the failure of the beam via cracking near the end closest to your hand. The necessary information for this question is provided below, with an equation for the full failure due to cracking as well as the necessary moments of area. In the equations below, C is a constant and can be assumed to be 1. The moment used in this equation is equal to  $Z_p = \frac{\pi}{3} r^3$

$$F_f = \frac{C Z_p \sigma_f}{L}$$

- a. Derive a materials performance index for this question, showing all your work as has been shown in the tutorial this week.
- b. Given the list of materials below, rank them from best to worst for this application.

Material	Density (g/cm <sup>3</sup> )	Failure stress (MPa)
Steel Alloy 4340	7.85	1760
Aluminum Alloy 7075T	2.80	572
Magnesium alloy ZA91D	1.81	197.5
Nylon 6,6	1.14	85.25
HDPE	0.96	26.55
Bamboo	0.65	122
Eastern White Pine	0.40	59.3