**Group Name(s)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Failure: Creep, Fatigue, and Fracture**

**Activity I : Conceptualizing Creep & Fatigue**

1. a) What is creep? Give an explanation that a 2nd year engineering student who has not taken this class yet would understand. (Note: There are several necessary factors for creep to occur. These should be part of your explanation as well as an explanation of the underlying atomic/grain size causes.)

b) Why is it dependent on temperature?

b) Does it occur if the applied stress is less than the yield stress?

1. What is fatigue? Give an explanation that a 2nd year engineering student who has not taken this class yet would understand. (Again note that underlying mechanisms and necessary factors should be part of this explanation.)
2. Pick 2 of the following engineering systems: bridge, airplane, bike, artificial joint, or make up a specific case. Describe specific examples of components/parts of these systems where creep and/or fatigue will be an issue, why they are issues, and options that you might have to improve the life time of the components.

System 1: System 2:

Component Component

Issues Issues

Improvements Improvements

**Activity II: Graphical Understanding of Creep & Fatigue**

1. One of the lines in the plot below represents the creep rate (hr-1) for a metal at 500oC and the other the creep rate at 400oC. However, the labels have been lost. First identify which curve corresponds to which temperature. If the temperature is 500oC and you apply a stress of 60 MPa to your piece of metal, indicate the value of the creep rate on the graph. Then give its numerical value.



100 MPa

80 MPa

60 MPa

40 MPa

20 MPa

10 MPa

Stress [MPa]

**10-6**

**10-7**

**10-8**

**10-9**

Creep rate [hr-1]

1. You are told that your piece of metal has a yield strength of 100MPa and a length 150 cm. What will be the new length of your piece after 10 hrs of applying 60 MPa of stress to it at 500oC?
2. A 2 mm diameter rod of an aluminum alloy (2014-T6) is loaded in tension and compression. The number of cycles to failure for various forces is given in the table. Fill in the table and complete the graph.

Stress Amplitude (MPa)

|  |  |  |  |
| --- | --- | --- | --- |
| Tension and Compression Force (N) | Cycles to Failure | Stress Amplitude (Mpa) | Log10 (Cycles) : (10x) = Cycles |
| 1200 | 10000 |  |  |
| 1000 | 15000 |  |  |
| 800 | 100000 |  |  |
| 600 | 630000 |  |  |
| 400 | 6300000 |  |  |



Number of Cycles to Failure

1. You are supposed to make a 50 cm long rod of 2014-T6 aluminum which must last up to at least 3\*105 cycles of loading at 1200N of tension and compression force. What is the smallest diameter rod you should use?

**Activity III: Failure**

1. Which type of "failure" would be more acceptable from a safety standpoint, yielding or fracture? Explain your reasoning.
2. A very large sheet of a titanium alloy is loaded in tension and has a crack emanating from one edge as shown. (Assume that the crack is much smaller than the sheet.) The alloy has yield strength 830 MPa and fracture toughness 55 MPa√m. How long can the edge crack be to ensure that the component will yield before it fractures?
3. If the crack is 0.1 mm longer than calculated in Question 8, what will happen? At what stress will failure occur?

**Activity IV: Reflection (If your group has time, this can be a helpful learning tool.)**

1. As a group discuss how creep and fatigue are different and similar. Take notes on some of your ideas.