**Honor Statement:**

An essential feature of the University of Tennessee, Knoxville, is a commitment to maintaining an atmosphere of intellectual integrity and academic honesty. As a student of the university, I pledge that I will neither knowingly give nor receive any inappropriate assistance in academic work, thus affirming my own personal commitment to honor and integrity.

**Project Expectations:**

I have personally written all the code, compiled all the graphs, computed all the handwork, and written all the text in this project. I have accurately cited when I used information obtained anywhere except lecture notes, office hours, and Norton’s Design Textbook.

Name: (Printed)

Signature:

Date:

Use this template to complete your project. Include any diagrams generated using Matlab. Show all work. Upon completion of this project:

1. Upload this report as a .docx document.
2. Upload the Excel answer sheet provided. **Make sure your answers are in the specified units and match the report.**
3. Upload your matlab code as a .m file.

Design a Bike Arm of length [L] inches so that it will not fail under static conditions. See Figures 1-3 for details.

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Figure Bicycle Pedal Assembly with Bike Arm

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Figure Isometric view of Bike Arm

Graphical user interface, application, Teams

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Figure Front and Side views of Bike Arm with Coordinates Defined

Three scenarios are being considered. In all three scenarios, a person weighing [F] lbs is stepping on the pedal at a distance [a] inches from the centerline of the Bike Arm. The variables [L], [F], and [a] are unique for each student and are assigned in Canvas. Figures 4-6 illustrate the three scenarios.

Diagram

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Figure Horizontal Position

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Figure 45-degree Position

Diagram

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Figure Vertical Position

Choose a material and thickness (t) for the Bike Arm so that the maximum Von Mises stress is below the yield stress of the material.

Assumptions:

1. The Bike Arm can be modeled as a Cantilevered Beam that begins at x = 0.
2. Use the coordinate system defined by Figure 3.
3. The Pedal interacts as a concentrated force at the center of the pedal hole (1/2 an inch from the end of the Bike Arm)
4. The force F is the weight of a person standing on the pedal. Consider it a concentrated force acting at location a.
5. Neglect the change in area of the Bike Arm where the Pedal mounts.
6. The material must be either Aluminum or Carbon Steel and must come from Table A-2 or A-9 in Norton’s Textbook.
7. Assume the calculation is static. This means that the acceleration of the Bicycle Assembly is 0.

Use this document as a template for writing a report with your findings. The report should include:

* Answers you reported to the Excel Answer Sheet
* Any hand calculations
* Any Matlab code
* All necessary graphs

Be aware that all students should be writing their own code. If your code shares more than 20% of the content of another student’s code or my example code, it will be considered a case of academic dishonesty. If you use any code that you got from another source, make sure you cite where the code originated from.

The following sections will guide you through the project. Text that is blue should be recorded in the Excel Answer Sheet. **Make sure your answers are in the specified units.**

# Chosen Parameters:

It will be necessary to assign a thickness and material before you can calculate the stresses. This is likely to be an iterative process. In this section, create a table that shows the iterations you made. You should have at least two iterations. Be sure that you only include your final iteration in the Excel sheet.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 | Iteration 6 |
| Material |  |  |  |  |  |  |
| Condition |  |  |  |  |  |  |
| (kpsi) |  |  |  |  |  |  |
| (kpsi) |  |  |  |  |  |  |
| Thickness (in) |  |  |  |  |  |  |

SAE Designation

Condition = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

kpsi

kpsi

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_inch

# Reaction Forces and Moments

Create a Free Body Diagram for each of the three scenarios. It is helpful to create the FBDs in terms of variables so that they will apply to any iteration. It is often helpful to do the first iteration by hand, then code it in Matlab to make sure that the code is correct. For that reason, it is ok to submit handwork for an iteration, but the final values recorded in the tables should be of the final iteration. Calculate the reaction loads that occur at x = 0.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Horizontal | 45 degrees | Down |
|  | 0 |  |  |
|  |  |  | 0 |
|  | 0 | 0 | 0 |
|  |  |  | 0 |
|  | 0 |  |  |
|  |  |  | 0 |

# Individual Loading Diagrams

In this section, write the singularity function and graph the loading function for all loads on the Bike Arm. For each of the three scenarios, record the maximum value and x location of the load. At that x location, record the maximum stress, and y location and z location for the maximum stress. If there are a range of locations that have the same stress, only include the first location on the Excel Answer sheet. Note that the three scenarios do not necessarily have to have the maximum stress located at the same location.

## Maximum Axial Load (about the x axis):

|  |  |  |  |
| --- | --- | --- | --- |
|  | Horizontal | 45 degrees | Down |
|  |  |  |  |
|  |  |  |  |
| Max Stress (kpsi) |  |  |  |
|  |  |  |  |
|  |  |  |  |

## Maximum Shear Load in the y direction:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Horizontal | 45 degrees | Down |
|  |  |  |  |
|  |  |  |  |
| Max Stress (kpsi) |  |  |  |
|  |  |  |  |
|  |  |  |  |

## Maximum Moment about the x axis (Torque):

|  |  |  |  |
| --- | --- | --- | --- |
|  | Horizontal | 45 degrees | Down |
|  |  |  |  |
|  |  |  |  |
| Max Stress (kpsi) |  |  |  |
|  |  |  |  |
|  |  |  |  |

## Maximum Moment about the y axis:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Horizontal | 45 degrees | Down |
|  |  |  |  |
|  |  |  |  |
| Max Stress (kpsi) |  |  |  |
|  |  |  |  |
|  |  |  |  |

## Maximum Moment about the z axis:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Horizontal | 45 degrees | Down |
|  |  |  |  |
|  |  |  |  |
| Max Stress (kpsi) |  |  |  |
|  |  |  |  |
|  |  |  |  |

# Superimposed Stress diagram:

We now need to check the total stress at every point along the beam. There are several methods for doing this. If we were working the problem by hand, it is best to find the locations on the x-axis that have the highest loads. We would then find the points in each of those cross sections that have the highest stresses and calculate effect of all the loads on the stress at those locations.

Since we are using Matlab, we can check the stress for a point on the cross section throughout the whole beam. Displayed graphically, we can quickly see the highest stress for each location of the cross section. Consider nine possible points on the cross section as described by Figure 7.

Diagram

Description automatically generated

Figure Cross Section of Bike Arm with Points Defined

At any x location, we can find an applied stress (the stress cube) for each of the nine points. In order to compare stresses of different types, we will use the von Mises Stress. This combines the three principal stresses calculated from an applied stress into a single value.

Since this can be done at any x location, write a script that graphs the von Mises stress of at least two cross sectional points across all x for each scenario. Note that not all nine points on the cross section need to be considered. Looking at the loads, you should be able to deduce which locations are likely to have the greatest stress.

The maximum stress on the beam should be clearly seen for each of the three scenarios.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Horizontal | 45 degrees | Down |
| Max von Mises Stress (kpsi) |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

# Conclusions

If the maximum stress is above the material yield strength, change the material or the thickness of the beam in order to reduce the stress. In this section, state what you learned and whether this is a satisfactory solution. What other items should be considered before approving this design?

Maximum von Mises stress on the Bike Arm = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ kpsi