AE4ASM003 Linear Modelling Assignment 2: truss element

Due 22 September 2024, 17:00 CET

AIAS level 3 (AI Assessment level; definition: see slides lecture 1)

Please upload on Brightspace under the 'assignments' tab (on top of the page). You can upload multiple times, but only the last version you upload is retained and will be checked and graded. Grading will only start after the deadline has passed.

Please note that the deadline is enforced: solutions uploaded less than 2 hours after the deadline will get a maximum of 80%; solutions handed in more than 2 hours after the deadline will not be graded. The plagiarism check is enabled in Brightspace. Please follow the submission guidelines on page 4 of this assignment.

As a guideline, the report should be 1-3 pages (including figures from Abaqus). This is just a guideline, your final report can be longer/shorter. Make sure you have answered all the questions as stated in the assignment.

The aim is to provide you with feedback and a grade two weeks after the deadline, if grading takes longer this will be announced on Brightspace. Please refrain from asking questions about grading until two weeks after the assignment deadline or the new date announced on Brightspace.

In this exercise you are asked to write a generally applicable Python or Matlab code to solve truss structures. Your code should take as input the node locations, connectivity matrix, material elastic modulus, area of each element, force vector and boundary conditions. Your code should calculate the node displacement, reaction forces, and stress and strain in each element. The input and output is defined and is attached to this assignment. You do have to fill in the correct numbers for this case, but **do not change the form of the input file (i.e., names, format of the variables etc.), only the name of the functions file from HW2functionsExample to HW2functions_StudentNumber** . You only have to upload the code with the functions (HW2functions as empty template provided) and it must work with the input file (HW2ForStudents) provided. Please note that the current input of the code is for the example problem worked out in the lecture notes.

Hint: use as many functions as possible that you can re-use in future assignments; you should be able to re-use some of the functions from assignment 1 (for example applying boundary conditions and solving the system).

As a verification case, please use the structure shown in Figure 1 that you should build in Python/Matlab and Abaqus. The node numbers are in circles, the element numbers in squares (use this numbering in Python/Matlab; the numbering in Abaqus may be different).

This example is based on the structure supporting the wheels of the perseverance robot, circled in Figure 2. The structure connecting the wheels on one side is assumed to be a 2-dimensional structure with a few members. There is one connection point to the main body on top, the other elements have to be stiff enough to support the rover, but at the same time be flexible enough to allow the rover to ride over uneven terrain and pull itself loose. The load case is based on the middle wheel being stuck, and the other wheels being pulled in different directions trying to get loose. For this exercise you are asked to **model the complete structure using truss elements**.

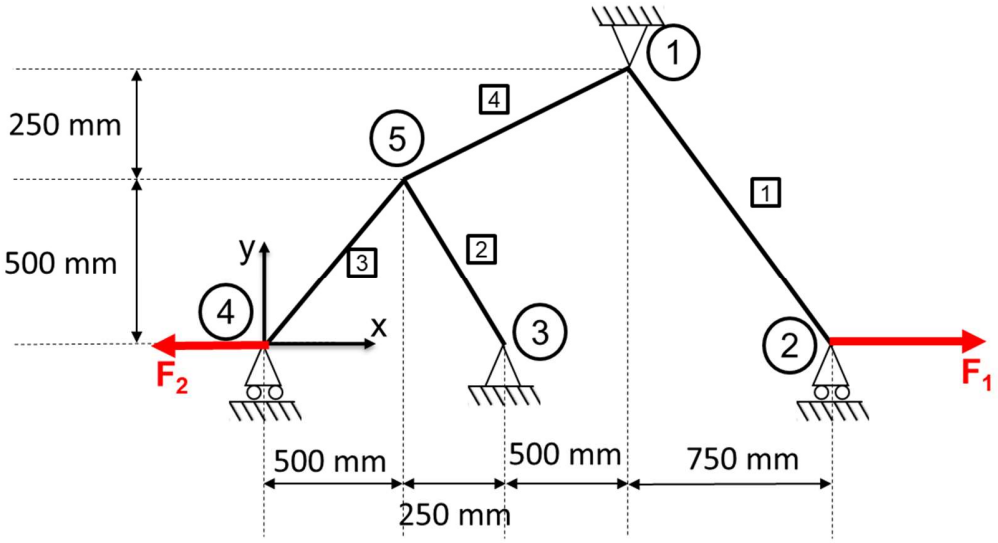

Figure 1: verification case to use for this assignment (drawing not to scale)

All truss elements are made from Aluminium (E = 70 GPa, ν = 0.3). Elements 1 and 4 have a cross section of 50 mm^2, elements 2 and 3 have a cross section of 30 mm^2. The forces are F_1 = 1.5 kN; F_2 = 0.5 kN.

Tasks

1. Complete the code given in the assignment: change the input values to the values of the problem shown in Figure 1 to verify your code and program all functions. **Do not change the names or shape of the variables in the input file or the output printed.** You do not have to upload your input file, hence your input file needs to have the same data structure as the one provided. No need to describe the methodology in the report, just the code is sufficient.
   Instead of coding such that you can vary the input, you can also hard-code the verification case (hence fixed loading, fixed boundary conditions and fixed connectivity matrix) or work it out by hand, in which case you can get a maximum of 7/10 for this assignment.
2. In the report, mention what you believe is the most important assumption (**only one**!) you make while solving this problem and explain why you think this is the most important assumption and what effect it has on the solution.
3. In the report, show the verification you did using Abaqus.
4. In the report, answer the following question: how would you change your code if member 2 was not a truss member, but a rope with the same E-modulus and cross sectional area? You only have to explain how your code would change, no need to change the code itself.

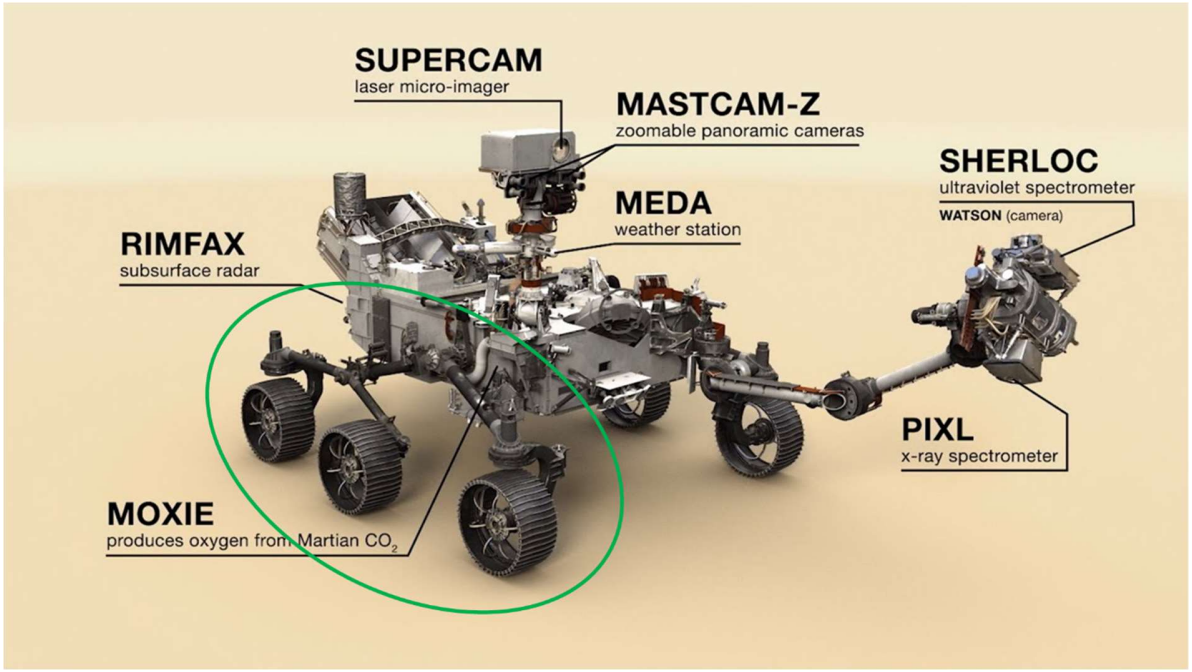

Figure 2: schematic of the perseverance rover, with the modelled part highlighted (adapted from a screenshot at 1:27 of https://www.youtube.com/watch?v=5qqsMjy8Rx0&ab_channel=NASAJetPropulsionLaboratory)

Submission and naming:

- submit your own Python/Matlab code and the report in pdf format using the following naming convention:
    - LMex2_StudentNumber.pdf
    - HW2functions_StudentNumber.py or HW2functions_StudentNumber.m
    - change StudentNumber by your student number in the naming convention
- Upload each individual file, no external links to the files, no zip folders.
- Make sure you add all files and click 'submit' (only last submission is visible for grading, so if you hit submit for each file only 1 file will be visible for grading; if you want to make a change to a file, you have to upload all files again).
- Only the functionality of the code will be graded, not whether 'good coding practises' have been used.
- Your submission should look like this right before submitting (check all files have been uploaded and are visible). Do not forget to click 'submit':