CIV102F Assignment # 7 – October 27, 2020

Due Wednesday November 3, 2020 at 23:59 Toronto time

General Instructions

- There are five questions on this assignment. All questions must be attempted; however, only one question will be graded.
- Submissions which are incomplete and do not contain a serious attempt to solve each question will receive a grade of 0.
- Intermediate steps must be provided to explain how you arrived at your final answer. Receiving full marks requires both the correct process and answer.
- All final answers must be reported using slide-rule precision (ie, four significant figures if the first digit is a “1”, three otherwise), and engineering notation for very large or very small quantities.
- Submissions must be prepared neatly and be formatted using the requirements discussed in the course syllabus. Marks will be deducted for poor presentation of work.

Assignment-Specific Instructions

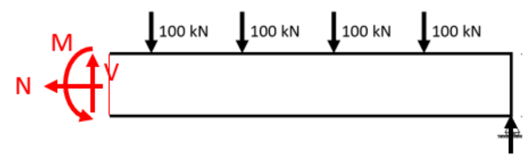
- For all bending moment diagrams and shear force diagrams, label key values (i.e. local minima/maxima)
- Final answers obtained from a truss analysis **must** be provided in a neat sketch of each structure with the member forces written in. Tension members should be indicated as (+) and compression members should be indicated as (-).

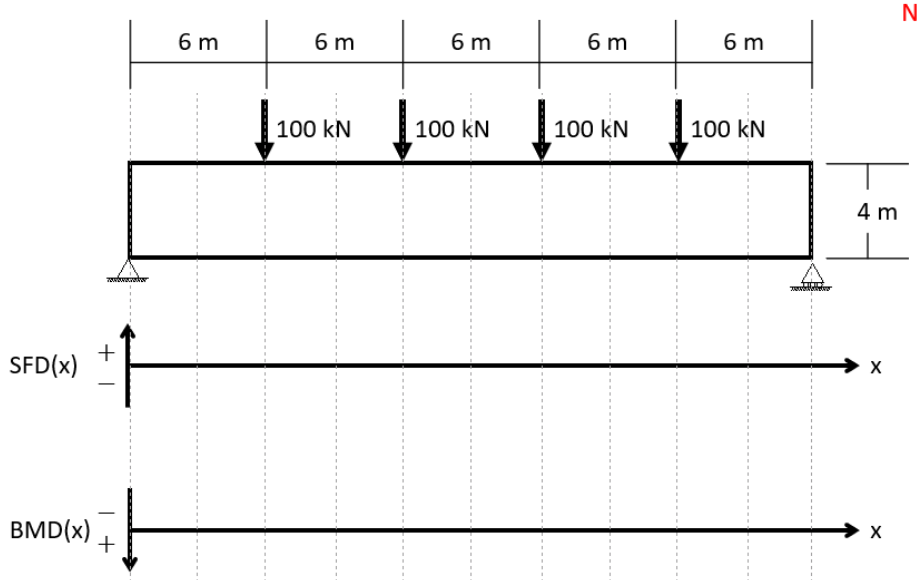
1. For the 30 m long beam shown below, calculate the reaction forces. Then:

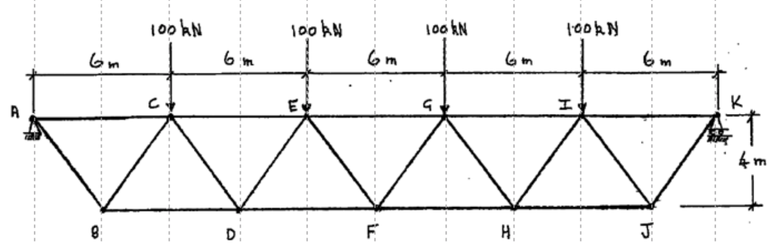
a) Consider a cut at x = 3m from the left side. Draw a partial free body diagram of the entire structure to the right side of x = 3m. At the cut surface, three unknown forces are exposed: Axial Force N (perpendicular to the cut surface), Shear Force V (parallel to the cut surface), and Bending Moment M. Use equations of equilibrium to solve for these unknown forces N, V, M at x = 3m. Plot V(x = 3m) on the shear force diagram (SFD) and M(x = 3m) on the bending moment diagram (BMD). *The sign convention for bending moments is not based on whether it is clockwise or counter clockwise but whether it causes the bottom of a member to be in tension (+) or the top of a member to be in tension (−).*

b) Consider a cut at x = 6m and similarly solve and plot the shear force V on the SFD and bending moment M on the BMD. For the SFD, consider two points as $x \to 6^-$ and $x \to 6^+$.

c) Fill out the remaining SFD and BMD with any method.







2. For the 30 m long truss shown above, calculate the reaction forces. Then:

a) Use the method of sections to calculate the vertical component of the forces in members AB, BC, and CD. Compare your results to the SFD in Q1. For the remaining vertical truss members, fill out their vertical components by reading off of the SFD in Q1.

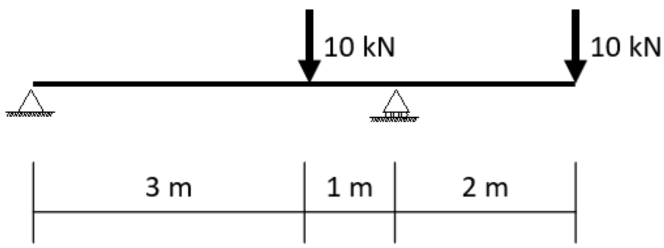
b) Use the method of sections at a cut at x = 3m and calculate the force in member AC. Repeat at x = 6m for member BD and x = 9m for member CE. Compare your member forces with the BMD at x = 3, 6, 9 in Q1. For the remaining horizontal truss members, fill out their member forces by reading off of the BDM in Q1 and dividing by the distance between the top and bottom members. Confirm that the truss has been solved correctly.

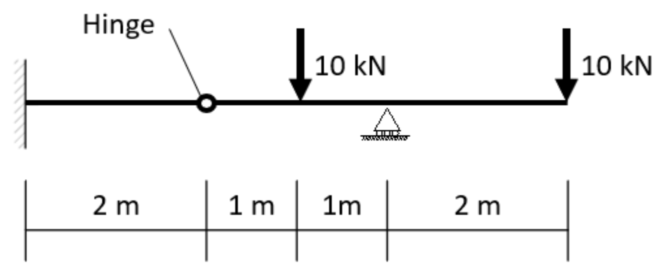
c) If The top chord members are made from HSS 203x203x6.4, the bottom chord members are made from HSS 152x152x4.8 and the diagonal webs are made from HSS 127x127x8.0, what is the factor of safety of this bridge? *$E = 200000$ MPa and $\sigma_{yield} = 350$ MPa.*

d) Calculate the midspan deflection at point F due to the 100 kN loads. What is the natural frequency of the bridge? *(The same procedure in part a) and/or b) can be used to solve the dummy system)*

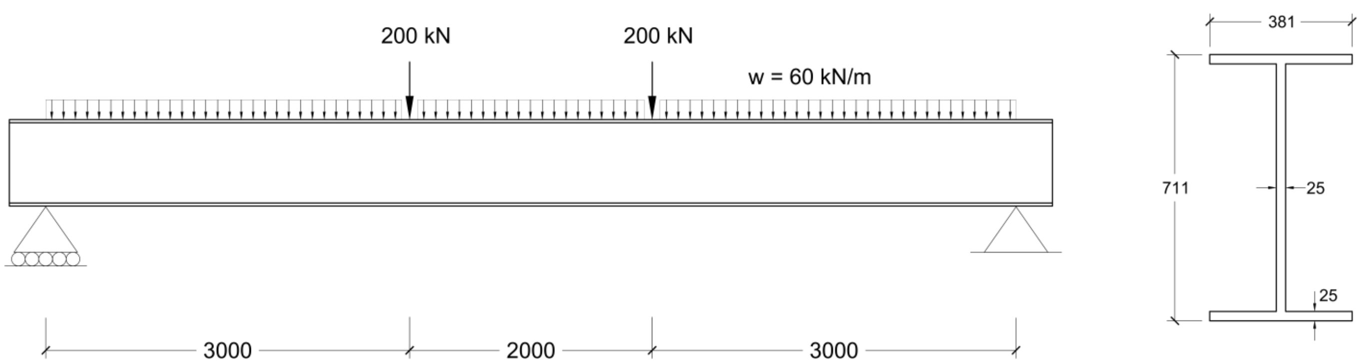
e) Suppose that the 100 kN loads begin to oscillate, so that the bridge is now loaded by four 100 ± 25 kN loads which vibrate at a frequency of 2.75 hz. Calculate the maximum displacement of the bridge due to dynamic effects. Are any members likely to buckle or yield? When performing your calculations, assume a damping value of 0.03 (3%).

3. For the following structures, calculate the reaction forces and draw the SFD and BMD.





4. Shown below is a steel I-beam subjected to two concentrated point loads of 200 kN each, as well as a distributed load of 60 kN/m. Draw the shear force and bending moment diagrams and calculate the maximum tensile and compressive stresses in the beam. Indicate where on the beam these maximum stresses occur. Neglect the self-weight of the beam. All dimensions are in mm. The second moment of area for this section is $2{,}840 \times 10^6$ mm^4.



5. The wooden beam shown below is subjected to a high uniform load of 90 kN/m. It has a square cross section with dimensions 356 × 356 and is made of spruce. Calculate the factor of safety against failure for this member. When doing your factor of safety calculations, assume that failure is defined as when the flexural stress in the member equals to σ_{ult}. All dimensions are given in mm.