CIV102F Assignment # 6 – October 18-20, 2022
Due October 25-27, (before assigned tutorial), 2022

General Instructions

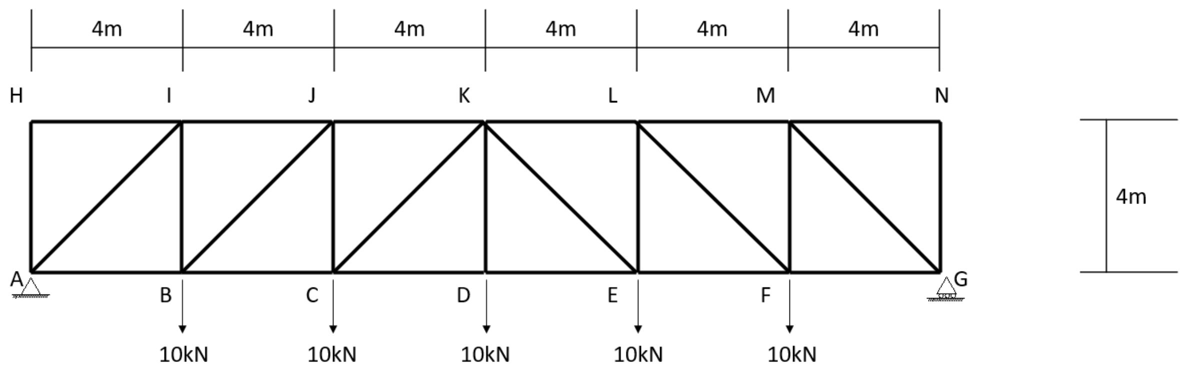
- There are three questions on this assignment. All questions must be attempted; however, only one question will be graded.
- Submissions which are incomplete and do not contain a serious attempt to solve each question will receive a grade of 0.
- Intermediate steps must be provided to explain how you 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

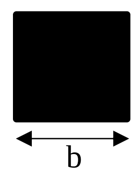
- Final answers obtained from a truss analysis **must** be provided in a neat sketch of each structure with the member forces written in. Tension members should be indicated as (+) and compression members should be indicated as (-).

1. a) Solve the forces in each member of the truss below. Show these magnitudes on a truss diagram and clearly indicate tension (+) and compression (-) forces.
Hint: Some members have 0 member forces and can be found via inspection. The truss is symmetrical. The method of joints shown in the Practice Exercises posted on Quercus can drastically improve your analysis speed.

b) Choose the lightest square HSS for all truss members. Use a factor of safety of 3.0 for buckling and 2.0 for yielding. Assume $E=200{,}000$ MPa, $\sigma_{yield}=350$ MPa.
Hint: Member JK may have the largest compression force but may not be the most likely to buckle



c) If you are allowed to use square solid steel cross-sections, choose the minimum width, b, for all truss members. For solid square cross-sections with a width of b, $A = b^2$, $I = b^4/12$, $r = \sqrt{I/A}$. Comment on the total weight of structural steel used in part b) hollow sections compared to part c) solid sections.
Hint: You do not need to actually calculate the total weight since the total length of truss members used in both parts is the same.



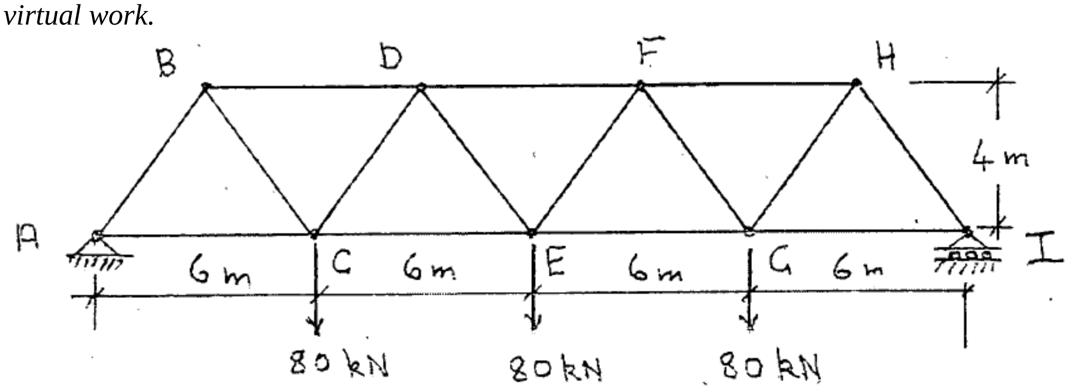
2. a) Calculate the vertical displacement of joint E due to the application of the 80 kN loads. The top three members of the truss are HSS 178x178x4.8, the four bottom members are HSS 127x51x4.8 and the eight diagonal members are HSS 127x127x4.8. $E = 200000$ MPa and $\sigma_{yield} = 350$ MPa.

b) What is the natural frequency of the truss bridge?

c) Suppose that the 80 kN loads begin to oscillate at a frequency of 2.75 Hz. Calculate the dynamic amplification factor, *DAF*, if the damping ratio, $\beta = 0.03$ (3%).

d) If the loads oscillate with an amplitude of 20 kN (i.e., each point load = 80 ± 20 kN), calculate the maximum value of each point load after being amplified by dynamic (resonance) effects. Under this loading, are any truss members likely to buckle or yield? *Hint: The max value of each point load will be higher than 80 + 20kN. You do not need to re-analyze the truss member forces.*

e) Calculate the maximum displacement of the bridge at joint E due to dynamic effects. *Hint: You do not need to reapply the method of virtual work.*



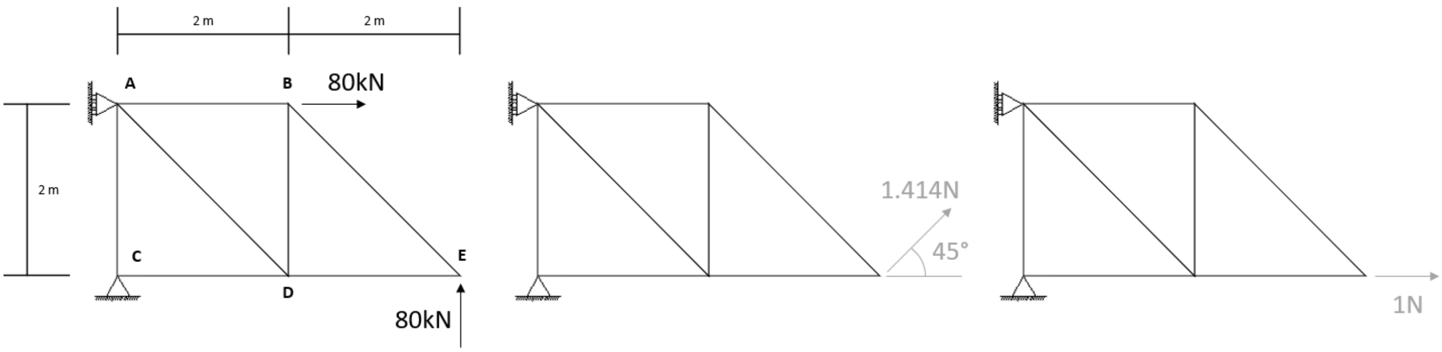
3. For the following truss structure, all members have a cross-sectional area of 1000 mm^2 and a Young's modulus E = 200,000 MPa.
a) Calculate the distance joint E moves in the direction 45º from the horizontal (Δ_{E45}) using the method of virtual work. Set up a dummy system with a dummy force vector that points 45º from the horizontal as shown below.
b) Calculate the horizontal displacement of joint E (Δ_{Ex}) using two different methods:

i) Take the x-component of Δ_{E45}.

ii) Set up a dummy system with a horizontal dummy force vector at joint E and use the method of virtual work.

Which method produces the correct answer to question b)? Explain the differences between the two quantities calculated with the use of a diagram, no calculations required.
Hints:

- *Δ_{Ey} can be found to be 10.12 mm upward (using again the method of virtual work). The displacement vector of joint E, Δ_E =* $\begin{bmatrix} \Delta_{Ex} \\ \Delta_{Ey} \end{bmatrix}$
- *Think about vector projections from ESC103. The vector* $\begin{bmatrix} 1 \\ 1 \end{bmatrix}$ *has an angle of 45º*



Real system

Dummy system for **a)** *(dummy forces can have any magnitude)*

Dummy system for **b) ii)**