CIV102F Assignment # 5 – October 13, 2021

Due Wednesday October 20, 2021 at 23:59 Toronto time

General Instructions

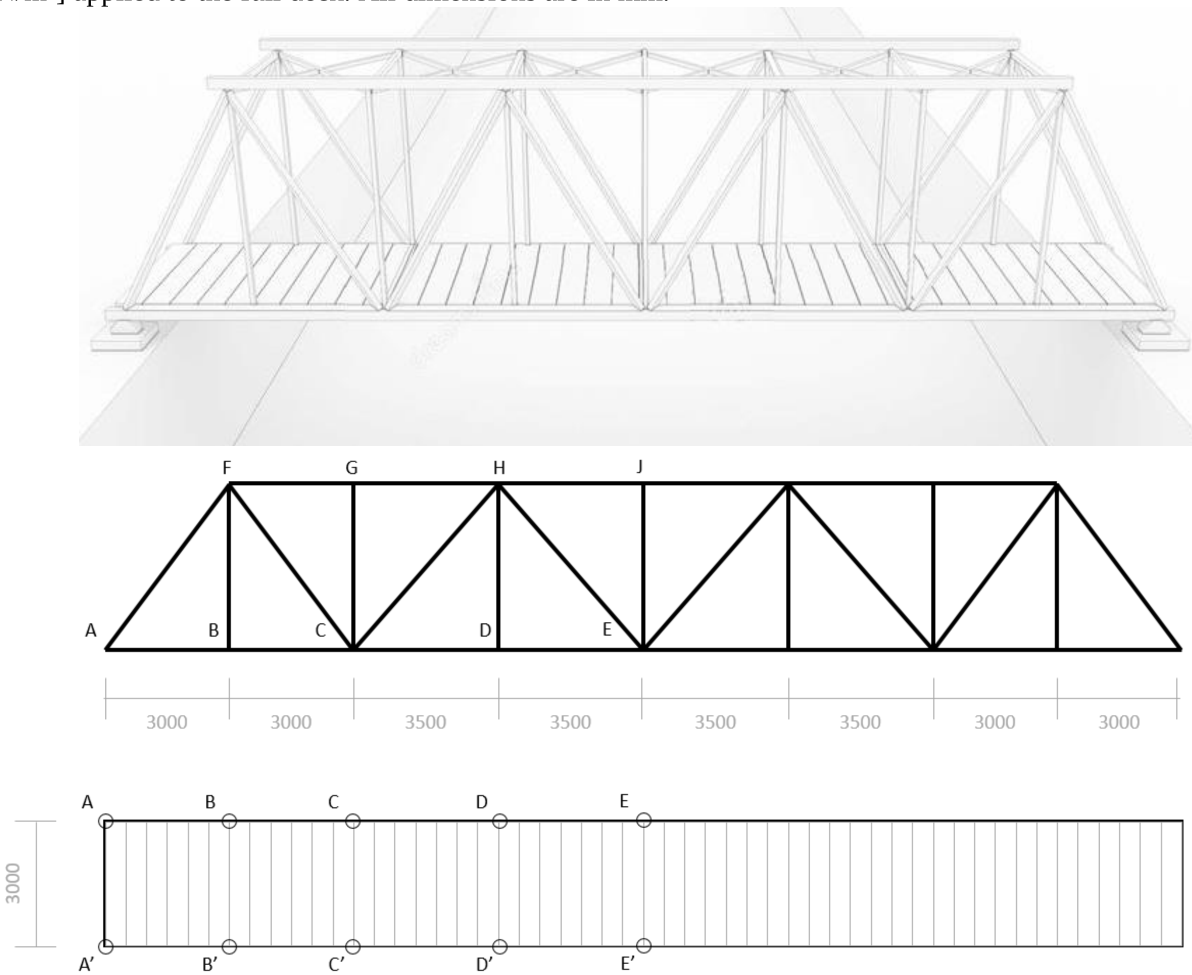
- There are five questions on this assignment. All questions must be attempted; however, only one question will be graded.
- Submissions which are incomplete and do not contain a serious attempt to solve each question will receive a grade of 0.
- Intermediate steps must be provided to explain how you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

- Final answers **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 (-)

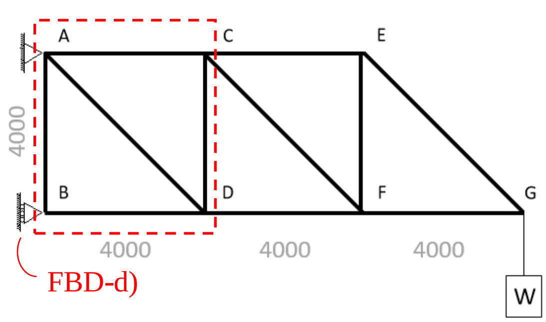
Truss Analysis: Applied Joint Loads

1. The figure below shows a truss bridge from a 3D view, an elevation view (side view), and a plan view (floor/ceiling view). Calculate the applied joint loads at joints A to E if the bridge was carrying a uniformly distributed load of w = 9.2 kPa [kN/m^2] applied to the full deck. All dimensions are in mm.



Truss Analysis: Method of Joints and Method of Sections

2. The truss structure shown below is holding a weight W = 141.4 kN. Perform the following consecutive tasks:



a) Draw a free body diagram (FBD) of the entire structure where the only forces acting on the free body are:

- the force of the weight
- the reactions forces of the pin support at joint A
- the reaction force of the roller support at joint B

Then, solve for the reaction forces using ΣFx=0, ΣFy=0, ΣM=0

b) Draw a FBD of joint B where the only forces acting are:

- The reaction force of the roller at joint B
- The unknown member forces in members AB and BD

Then, solve for the forces in AB and BD using ΣFx=0, ΣFy=0

c) Draw a FBD of joint A and solve for the forces in member AD and AC similarly to part b)

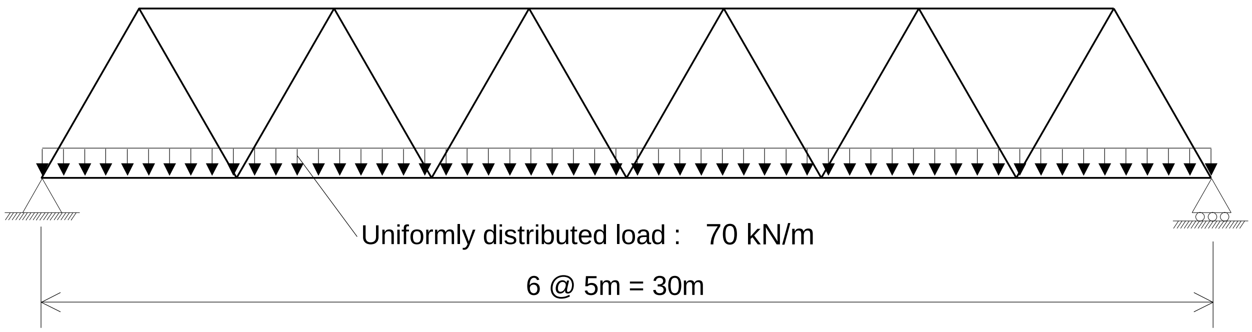
d) Draw the FBD (FBD-d shown in diagram) where the only forces acting on the free body are:

- The reaction forces at joints A and B
- The unknown member forces in member CE, CF, and DF

Then, solve for the forces in member CE, CF, and DF using ΣFx=0, ΣFy=0, ΣM=0

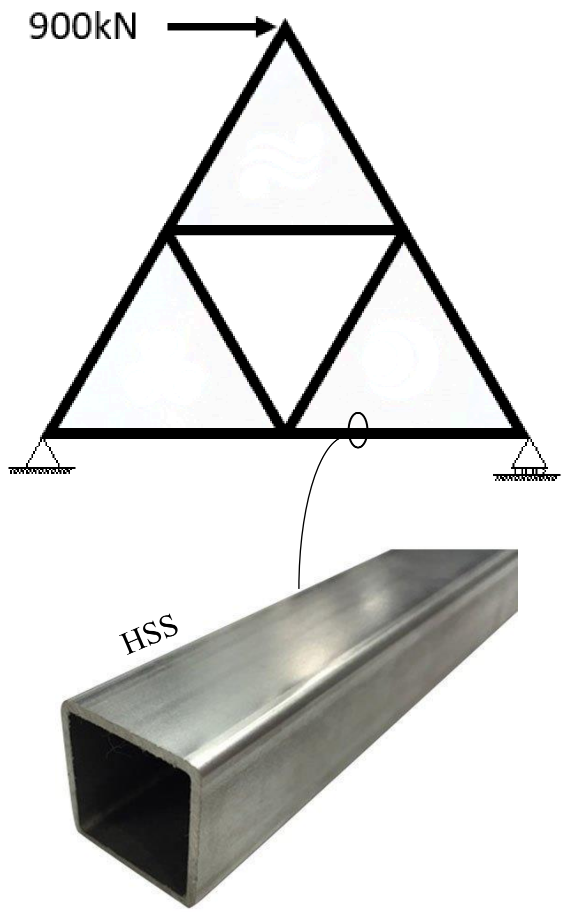
Truss Analysis

3. Calculate the applied joint loads acting on all bottom joints from the uniformly distributed load and solve for the forces in all members of the Warren truss below. All members have the same length. Truss must be solved using method of joints or method of sections. Sample calculations are only required for the first two joints or sections. Present your final member forces on a truss diagram. Denote tension forces with (+) and compression with (−).



Truss Design

4. In the truss structure shown below, all members have the length 4000 mm, σ_{yield} = 350 MPa, E = 200,000 MPa.



a) Solve for member forces in all 9 members and identify the member with the largest tensile force and the largest compressive force.

b) Multiply the largest force from part a) by the $FOS_{yielding}$ = 2 and calculate the *required cross-sectional area* (A) such that yielding will not occur. Provide your answer for the *required cross-sectional area* (A) in mm^2.

c) Multiply the largest compressive force from part a) by the $FOS_{buckling}$ = 3 and calculate the *required second moment of area* (I) such that buckling will not occur. Recall that the force required to cause a member in compression to buckle is:

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

Provide your answer for the *required second moment of area* (I) in 10^6 mm^4.

d) For the longest member in the structure, calculate the *required radius of gyration* (r) such that the minimum slenderness ratio is less than 200. Recall that the slenderness ratio is the ratio between the length the member and radius of gyration (L/r). Provide your answer for the *required radius of gyration* (r) in mm.

e) Using Appendix B from the course notes, pick the lightest square hollow structural section (HSS) designation such that the chosen HSS has a higher area (A), second moment of area (I), and radius of gyration (r), than those required in parts a), b), and c).

(E.g. HSS 305×305×9.5 has an area A = 11 000 mm^2, a second moment of area I = 158 × 10^6 mm^4, and a radius of gyration r = 120 mm. This choice will likely satisfy all three requirements from parts b), c), d), but it is also likely not the lightest choice since it weighs 86.5 kg/m.)

Truss Design

5. Consider the truss bridge shown below. The truss members identified as I, II and III have the largest member forces and will hence govern how much load the bridge can carry. All members are made of steel which have σ_{yield} = 350 MPa, E = 200,000 MPa, A = 2000 mm^2 and I = 5.6×10^6 mm^4. All dimensions provided are in mm.

- **a)** Solve for the forces in I, II and III using the method of joints (I) and method of sections (II and III) in terms of P.
- **b)** Calculate the value of P which would cause the bridge to fail. Failure may occur if the member stress exceeds the yield strength (in both tension or compression), or if a member in compression buckles. Factors of safety are ignored when the exact failure is to be determined.