

Homework 2

(Due: October 09, 2026)

Question 1: 10 points.

The cantilevered frame structure carries vertical loads P kN, $2P$ kN, $3P$ kN and $4P$ kN at nodes D, F, H and I. Use the **method of sections** to determine the forces in members a, b and c, as a function of the problem parameters L and P .

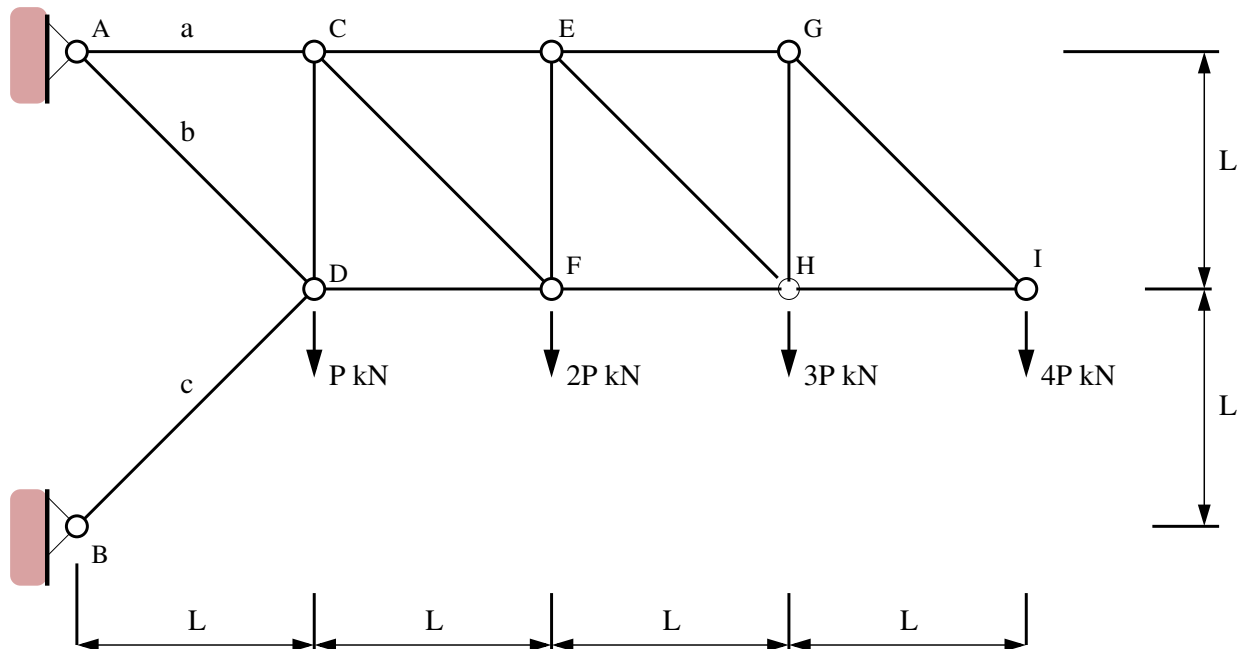


Figure 1: Cantilevered frame structure.

State if the members are in tension or compression. Show all of your working.

Question 2: 10 points.

If the maximum tensile force that any member in Figure 1 can carry is 50 kN, and the maximum compressive force is 30 kN (before buckling), what is the maximum value of loads P that can be carried.

Question 3: 10 points.

Figure 2 shows a multi-span beam. The cantilever is fully-fixed to the wall at Point A. Points B, D, E are hinges. Beam elements A-B and D-E have flexural stiffness EI . Beam elements B-C-D and E-F-G-H have flexural stiffness $2EI$. Vertical point loads $6P$ (kN) and $3P$ (kN) are applied mid-way between D and E, and at node H.

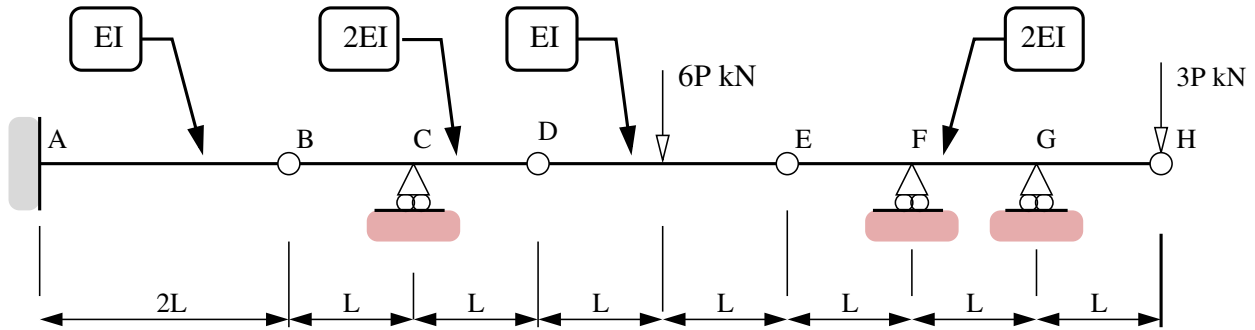


Figure 2: Three-span beam.

Draw and label the distributions of bending moment and curvature throughout the beam as a function of P and L . Qualitatively sketch the deflected shape of the beam.

Question 4: 20 points.

In the design of large frame structures, engineers are often required to compute the maximum and minimum member forces and support reactions due to a variety of loading conditions.

Figure 3 shows a thirteen bar pin-jointed truss that carries a variety of horizontal loads, P kN, and vertical loads Q kN. The symbols $F_1, F_2, \dots, F_{13}$ represent the axial forces in truss members 1 through 13, and R_{ax}, R_{ay} , and R_{by} are the horizontal and vertical support reactions at joints A and B.

Write down the equations of equilibrium for joints A through H and put the equations in matrix form. Now suppose that the frame supports a variety of payloads:

$$\begin{bmatrix} P_1 \\ Q_1 \end{bmatrix} = \begin{bmatrix} 250 \\ 0 \end{bmatrix}, \quad \begin{bmatrix} P_2 \\ Q_2 \end{bmatrix} = \begin{bmatrix} 200 \\ 200 \end{bmatrix}, \quad \begin{bmatrix} P_3 \\ Q_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 500 \end{bmatrix} \text{ kN.} \quad (1)$$

Develop a Python program that will solve the matrix equations for each of the external load conditions, and compute and print the minimum and maximum support reactions at nodes A and B, and axial forces in each of the truss members.

Getting Started with Python. Download and unpack the file `python-code.zip`. Make sure that your

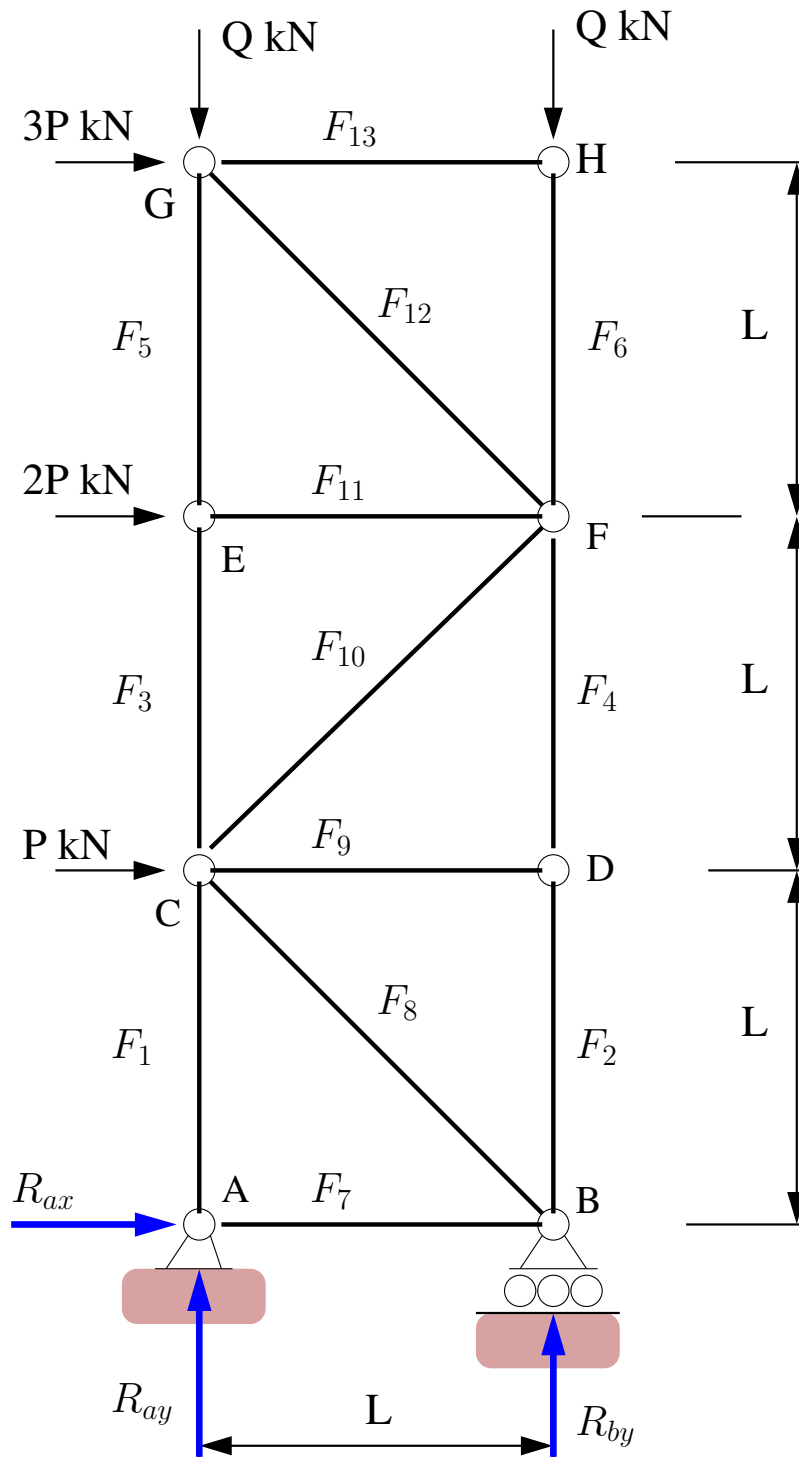


Figure 3: Front elevation of pin-jointed tower.

laptop has version 3.X of Python installed. The test program `TestTrussAnalysis01.py` demonstrates the solution procedure (in a simplified way) for analysis of a three-bar truss. Details are covered in the lecture slides. Similarly, `TestTrussAnalysis02.py` demonstrates the solution procedure for analysis of a nine-bar truss. The function `PrintMatrix()` is designed to handle the printing of large matrices by dividing the output into blocks of six columns.

Hint. The truss structure has 8 nodes, 13 member forces and 3 reactions. The structure is statically determinate and there will be 16 equations of equilibrium to consider. Practically speaking, there's a reasonable chance of making at least one mistake when you write out the equations. The first line of defense in finding errors is to use the linear algebra functions `rank()` and `det()` to make sure your matrix `A` is not singular. A second good idea is to test your problem formulation on the simplest load patterns possible:

$$\begin{bmatrix} P_1 \\ Q_1 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}, \quad \begin{bmatrix} P_2 \\ Q_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, \quad \begin{bmatrix} P_3 \\ Q_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix} kN. \quad (2)$$

Checking that python code calculations are consistent with the equations of equilibrium is an easy computation. Once you are confident that everything works correctly, plug in the numbers for equations 1.