Second Semester Final Examination

- Attempt all questions.
- The Exam consists of **4** questions in **2** pages.
- Maximum grade is **60 Marks**.

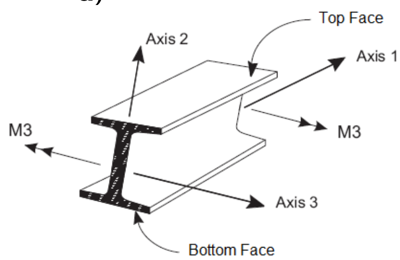
Question (1): (10 Marks)

(a) Choose the correct answer (**Put a, b, c or d in front of the statement number in your answer paper**).

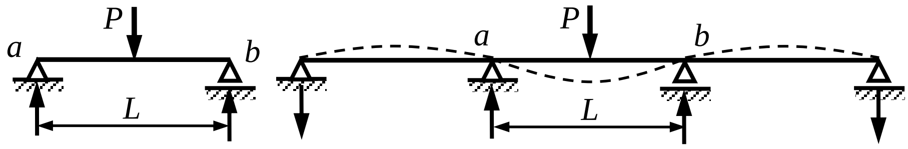
1. The hinged support has restraints in Joint Local Directions as:

a) b) c) d)

2. If the direction of the moment M3 is as shown in the figure,
   a) The top face will be subject to compression.
   b) The top face will be subject to tension.
   c) The top and bottom faces will be subject to compression.
   d) The top and bottom faces will be subject to tension.



3. **Result verification:** If a load P is applied to the mid-span of the shown simple and continuous beams, you expect from the program results that:



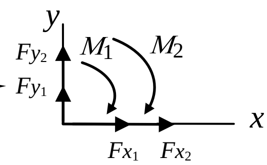
   a) There is no relation between the deflections under P in the shown simple and continuous beams.
   b) The deflection under P in the simple beam will be equal to that in continuous beam.
   c) The deflection under P in the simple beam will be smaller than that in continuous beam.
   d) The deflection under P in the simple beam will be larger than that in continuous beam.

4. One of the assumptions that the stiffness method is based on to analyze plane frames is
   a) Members (beams and columns) are straight with variable properties between joints.
   b) Members will behave in non-linear and plastic manner.
   c) Axial forces in members are very much less than the respective Euler buckling loads.
   d) Applied loads may act out of the structure plane.

5. After drawing the frame lines, the order of the input data is
   a) **Editing Supports** then **Assigning Frame Sections**.
   b) **Assigning Frame Sections** then **Editing Supports.**
   c) The order is not important.
   d) The order is very important.

(b) **TRUE or FALSE** (**Put ✓ or ✗ in front of the statement number in your answer paper**)

1. Stiffness is the property of an element which is defined as displacement per unit force.
2. For plane frame element 1-2 (connecting joints 1 and 2), the positive sign of forces (forces and moments) is as shown in the figure.



3. The frame element is also called beam-column element.
4. Homogeneous means that the material properties are independent of the coordinates.
5. For intermediate hinge, only the compatibility of the displacement is satisfied while the compatibility is not satisfied for the rotation.

Please turn over

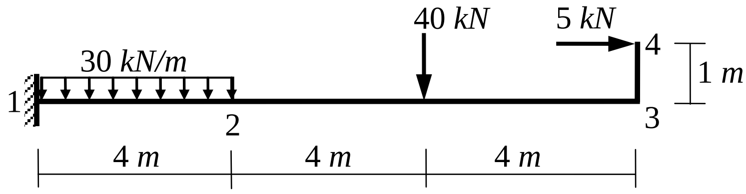
Question (2): (10 Marks)

The matrix equilibrium equation of the shown structure is:

$$\{F\} = [K]\{\Delta\} + \{F^f\}$$

Write

- The nodal forces vector $\{F\}$
- The nodal displacements vector $\{\Delta\}$
- The fixed end solution $\{F^f\}$



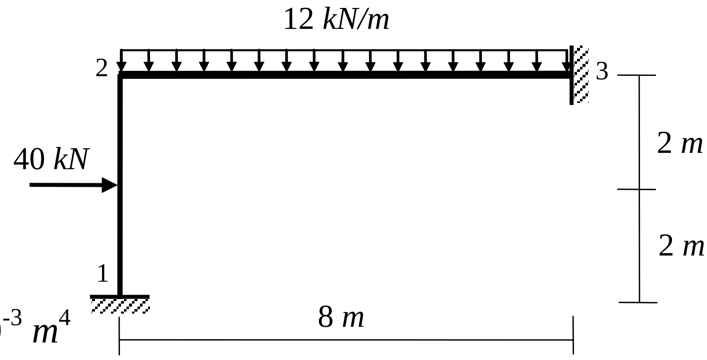
Question (3): (20 Marks)

For the shown frame, using the stiffness method:

Neglect axial deformation

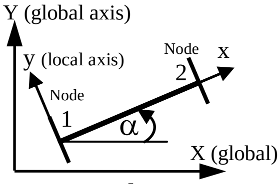
(a) Determine the displacements at the nodes due to the given load.

(b) Draw the bending moment diagram.



Given Data:

$E = 2.1\times10^{7}\ kN/m^2 \quad A = 0.15\ m^2 \quad I = 3.125\times10^{-3}\ m^4$



Frame element

$$[K_e] = \begin{bmatrix}
\left(\frac{EA}{L}\lambda^2 + \frac{12EI}{L^3}\mu^2\right) & \left(\frac{EA}{L}\mu\lambda - \frac{12EI}{L^3}\mu\lambda\right) & -\frac{6EI}{L^2}\mu & \left(-\frac{EA}{L}\lambda^2 - \frac{12EI}{L^3}\mu^2\right) & \left(-\frac{EA}{L}\mu\lambda + \frac{12EI}{L^3}\mu\lambda\right) & -\frac{6EI}{L^2}\mu \\
\left(\frac{EA}{L}\mu\lambda - \frac{12EI}{L^3}\mu\lambda\right) & \left(\frac{EA}{L}\mu^2 + \frac{12EI}{L^3}\lambda^2\right) & \frac{6EI}{L^2}\lambda & \left(-\frac{EA}{L}\mu\lambda + \frac{12EI}{L^3}\mu\lambda\right) & \left(-\frac{EA}{L}\mu^2 - \frac{12EI}{L^3}\lambda^2\right) & \frac{6EI}{L^2}\lambda \\
-\frac{6EI}{L^2}\mu & \frac{6EI}{L^2}\lambda & \frac{4EI}{L} & \frac{6EI}{L^2}\mu & -\frac{6EI}{L^2}\lambda & \frac{2EI}{L} \\
\left(-\frac{EA}{L}\lambda^2 - \frac{12EI}{L^3}\mu^2\right) & \left(-\frac{EA}{L}\mu\lambda + \frac{12EI}{L^3}\mu\lambda\right) & \frac{6EI}{L^2}\mu & \left(\frac{EA}{L}\lambda^2 + \frac{12EI}{L^3}\mu^2\right) & \left(\frac{EA}{L}\mu\lambda - \frac{12EI}{L^3}\mu\lambda\right) & \frac{6EI}{L^2}\mu \\
\left(-\frac{EA}{L}\mu\lambda + \frac{12EI}{L^3}\mu\lambda\right) & \left(-\frac{EA}{L}\mu^2 - \frac{12EI}{L^3}\lambda^2\right) & -\frac{6EI}{L^2}\lambda & \left(\frac{EA}{L}\mu\lambda - \frac{12EI}{L^3}\mu\lambda\right) & \left(\frac{EA}{L}\mu^2 + \frac{12EI}{L^3}\lambda^2\right) & -\frac{6EI}{L^2}\lambda \\
-\frac{6EI}{L^2}\mu & \frac{6EI}{L^2}\lambda & \frac{2EI}{L} & \frac{6EI}{L^2}\mu & -\frac{6EI}{L^2}\lambda & \frac{4EI}{L}
\end{bmatrix}$$

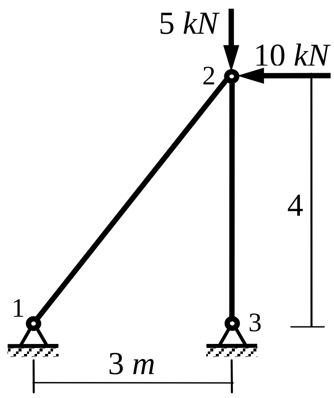
Where, $\lambda = \cos\alpha$ and $\mu = \sin\alpha$

Question (4): (20 Marks)

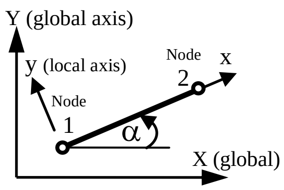
For the shown truss, using the stiffness method:

(a) Determine the displacements at the nodes due to the given load.

(b) Determine the reactions at the supports.



Given Data: $E = 2.0\times10^{7}\ kN/m^2 \quad A = 2.0\times10^{-4}\ m^2$



Truss (Bar) element

$$[K_e] = \begin{bmatrix}
\frac{EA}{L}\lambda^2 & \frac{EA}{L}\mu\lambda & -\frac{EA}{L}\lambda^2 & -\frac{EA}{L}\mu\lambda \\
\frac{EA}{L}\mu\lambda & \frac{EA}{L}\mu^2 & -\frac{EA}{L}\mu\lambda & -\frac{EA}{L}\mu^2 \\
-\frac{EA}{L}\lambda^2 & -\frac{EA}{L}\mu\lambda & \frac{EA}{L}\lambda^2 & \frac{EA}{L}\mu\lambda \\
-\frac{EA}{L}\mu\lambda & -\frac{EA}{L}\mu^2 & \frac{EA}{L}\mu\lambda & \frac{EA}{L}\mu^2
\end{bmatrix}$$

Where, $\lambda = \cos\alpha$ and $\mu = \sin\alpha$

With my best wishes

Dr. M. Abdel-Kader