# Homework 1 Due: Friday, September 25, 2015 @ 5:00 PM in E218

For each of the systems shown below:

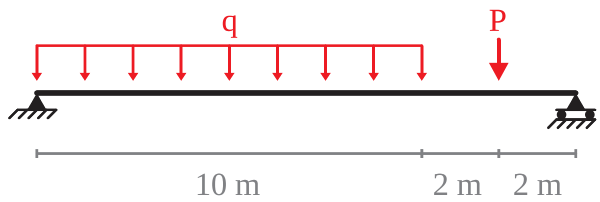
i) Find the reactions and draw the complete FBD

ii) For the beam and frame: draw the shear and moment diagrams (onto the actual structure)
For the truss: calculate axial forces and label on the FBD

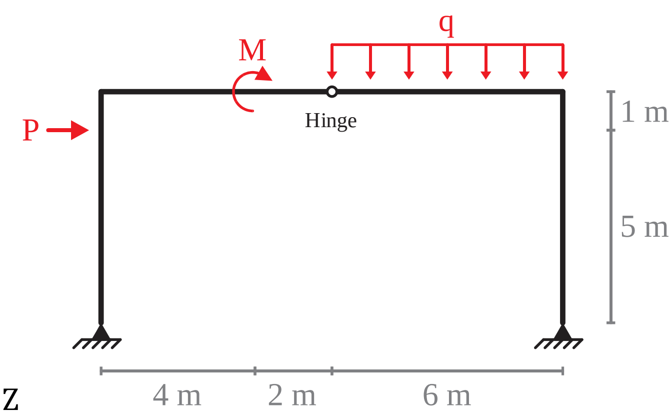
iii) Sketch the approximate deformed shape (you do not need to calculate for deflections)

Show all calculations, provide all critical values for shear and moment diagrams, use a ruler for diagrams, and use consistent sign convention. M = 5 kNm, P = 10 kN, q = 2 kN/m. **10 pts each.**

**1.** Beam:




**2.** Frame:

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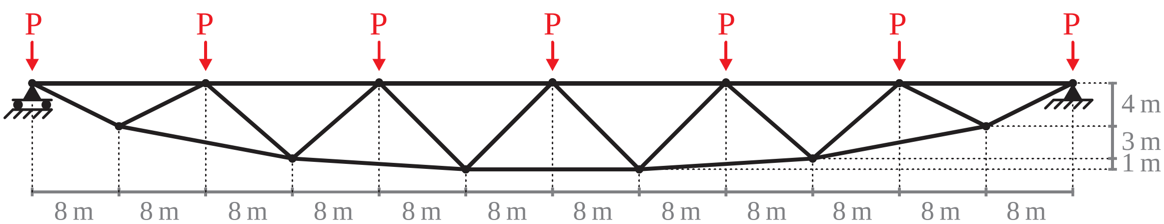
**3.** Truss:

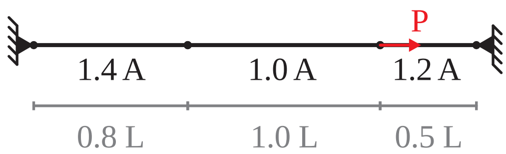


## Homework 2 Due: Friday, October 2, 2015 @ 5:00 PM in E218

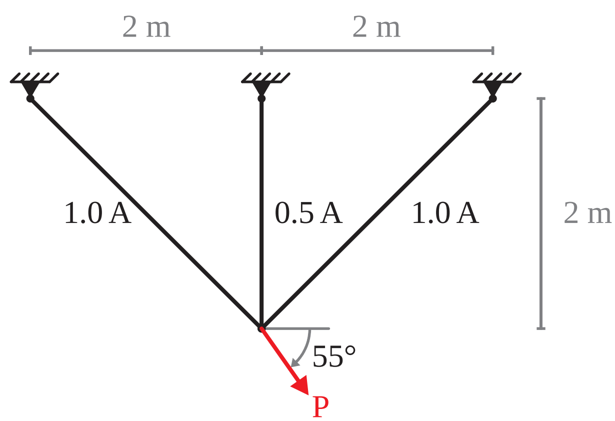
Solve each problem by hand:
i) Redraw the diagram and label your degrees of freedom
ii) Generate the element <u>and</u> global stiffness matrices
iii) Solve for the displacements, reactions, and axial forces
iv) Draw the FBD (with axial forces labeled) and sketch the deformed shape

Also perform an analysis using SAP2000:
v) Provide labeled images of your input geometry (with loads shown) and the deformed shape
vi) Compare (tabulate and discuss) your hand calculations with your SAP2000 analysis

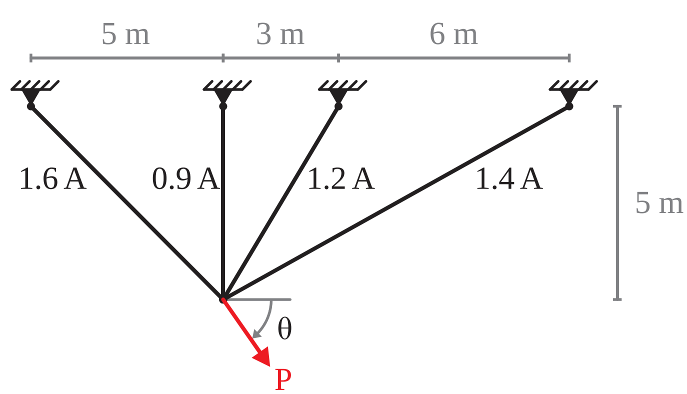
**1.** 1D truss: P = 60 kN, E = 200 000 MPa, A = 1000 mm$^2$, L = 3 m. **15 pts**




**2.** 2D truss: P = 100 kN, E = 200 000 MPa, A = 1000 mm$^2$. **20 pts**




**3.** 2D truss: Find the magnitude (P) and direction (θ) required to obtain a displacement at the bottom node of {u, v} = {3 mm, -2 mm}. E = 200 000 MPa, A = 10 000 mm$^2$. Hint: how many unknown displacements are there? **20 pts**



## Homework 3 Due: Friday, October 9, 2015 @ 5:00 PM in E218

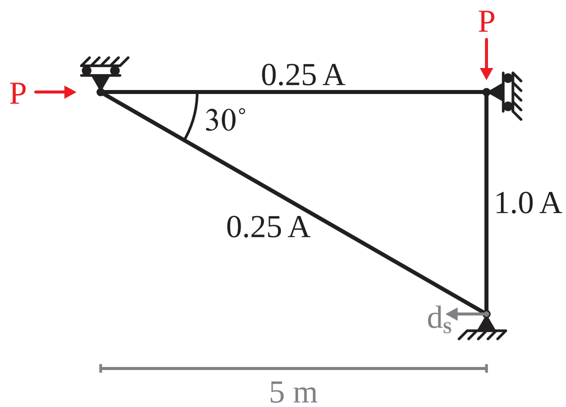
Solve **Questions 1 and 2** by hand:

i) Redraw the diagram and label your nodes and degrees of freedom
ii) Generate the element stiffness matrices, but not the global stiffness matrix
iii) Solve for the displacements, reactions, and axial forces without the global stiffness matrix
iv) Draw the FBD (with axial forces labeled) and sketch the deformed shape

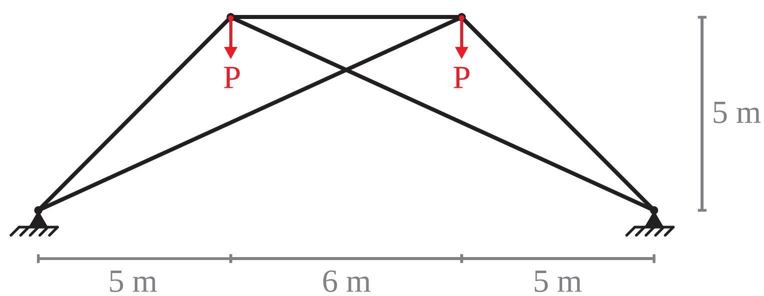
Also perform an analysis with your MATLAB program for **Questions 1, 2, and 3**:

v) Provide labeled images of your input geometry (with loads shown) and the deformed shape
vi) Compare (tabulate and discuss) your hand calculations with your MATLAB analysis
vii) Provide a short description of your codes changes and attach a printout only of the parts of the code that you changed

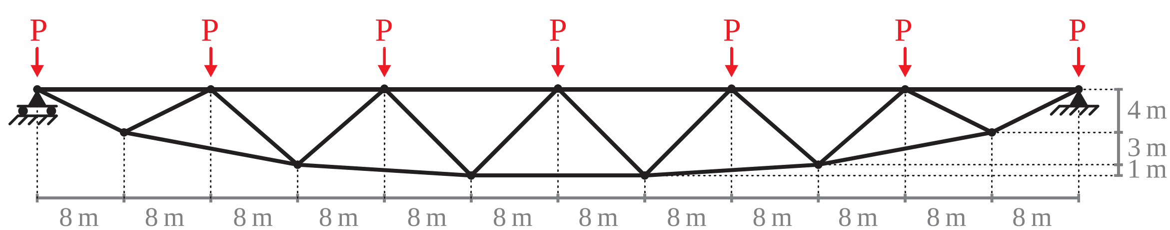
**1.** Truss: $d_S$ = 1 mm to the left. P = 100 kN, E = 200 000 MPa, A = 2000 mm$^2$. **15 pts**




**2.** Truss: P = 10 kN, E = 120 000 MPa, A = 1500 mm$^2$. You will need to use symmetry. **15 pts**




**3.** Truss: Use hand calculations from HW1 for relevant comparisons. P = 10 kN, E = 200,000 MPa, A = 1200 mm$^2$. **10 pts**



# Homework 4 Due: Friday, October 16, 2015 @ 5:00 PM in E218

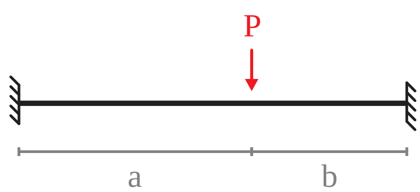
Solve **Questions 1 and 2** by hand:

i) Redraw the diagram and label your nodes and degrees of freedom
ii) Generate the element stiffness matrices and the global stiffness matrix
iii) Solve for the displacements, reactions, and internal moments and shears
iv) Draw the Free Body, moment, and shear diagrams, and sketch the deformed shape

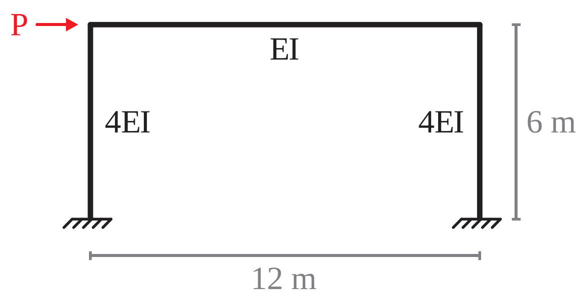
Code in the beam element into MATLAB and perform an analysis for **Questions 2 and 3**:

v) Provide labeled images of your input geometry (with loads shown) and the deformed shape
vi) Compare (tabulate and discuss) your hand calculations with your MATLAB analysis
vii) Provide a short description of your codes changes and attach a printout only of the parts of the code that you changed

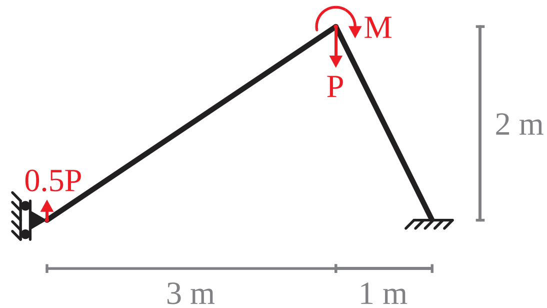
**1.** Beam: Solve in variable form. E, I are constant. Hint: $a^3 + 3a^2b + 3ab^2 + b^3 = (a + b)^3$. **10 pts**




**2.** Frame: Ignore axial deformations. P = 12 kN, E = 30 000 MPa, I = 2 x $10^9$ $mm^4$. **20 pts**




**3.** Frame: You do not need to provide a comparison with any hand calculations, but you still need to provide a table of results. Also, draw the Free Body, moment and shear diagrams by hand. P = 200 kN, M = 100 kNm, E = 100 000 MPa, A = 5000 $mm^2$, I = 200 x $10^6$ $mm^4$. **10 pts**



## Homework 5 Due: Friday, October 23, 2015 @ 5:00 PM in E218

For all questions:

i) Find the Equivalent Nodal Forces by hand (be sure to include diagrams)

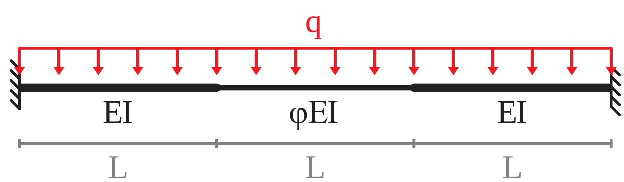
Solve **Questions 1 and 2** by hand:

ii) Redraw the diagram and label your nodes and degrees of freedom
iii) Generate the element stiffness matrices, but not the global stiffness matrix
iv) Solve for displacements, reactions, and internal forces without the global stiffness matrix
v) Draw the FBD, moment and shear diagrams, and sketch the deformed shape

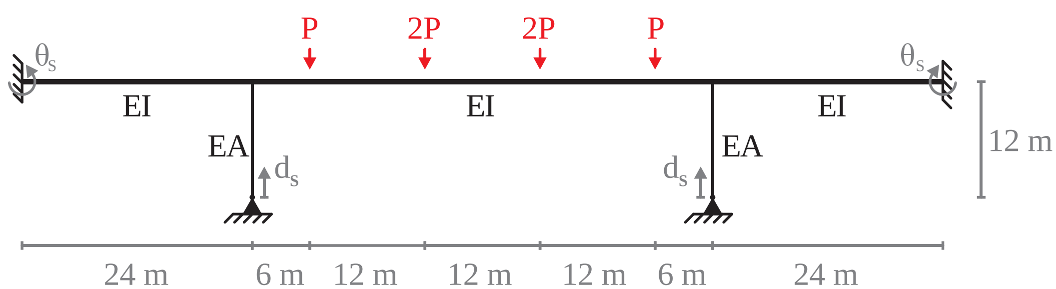
Code in the hinge element into MATLAB and perform an analysis for **Questions 2 and 3**:

vi) Provide labeled images of your input geometry with loading and the deformed shape
vii) Compare (tabulate and discuss) your hand calculations with your software analysis
viii) Provide a short description of your codes changes and attach a printout only of the parts of the code that you changed

**1.** Beam: Find φ that makes the moments zero at a distance L from either support. **15 pts**




**2.** Beam/Truss Hybrid: The horizontal beam is supported by two truss elements. P = 60 kN, $\theta_S = 1 \times 10^{-4}$ rad, $d_s = 2$ mm, E = 50 000 MPa, I = $1.2 \times 10^{12}$ mm$^4$, A = 90 000 mm$^2$. **25 pts**




**3.** Frame: Tabulate displacements, reactions, internal forces, and draw shear, moment, and free body diagrams. Use hand calculations from HW1 for relevant comparisons. M = 5 kNm, P = 10 kN, q = 2 kN/m, E = 200 000 MPa, I = $60 \times 10^9$ mm$^4$, A = 120 000 mm$^2$. **10 pts**