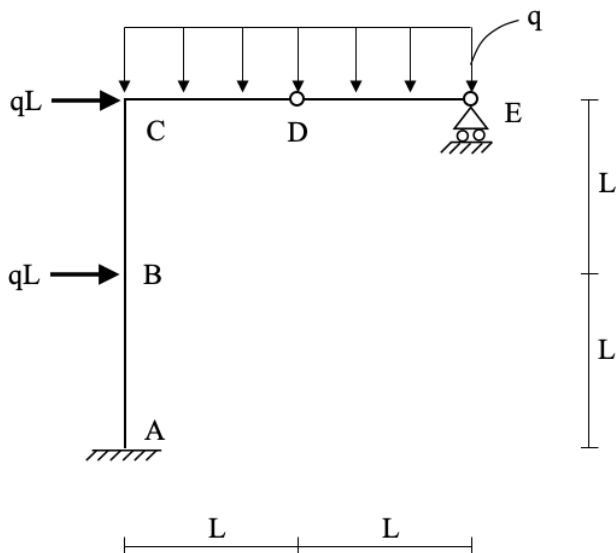


### Mechanics question 1

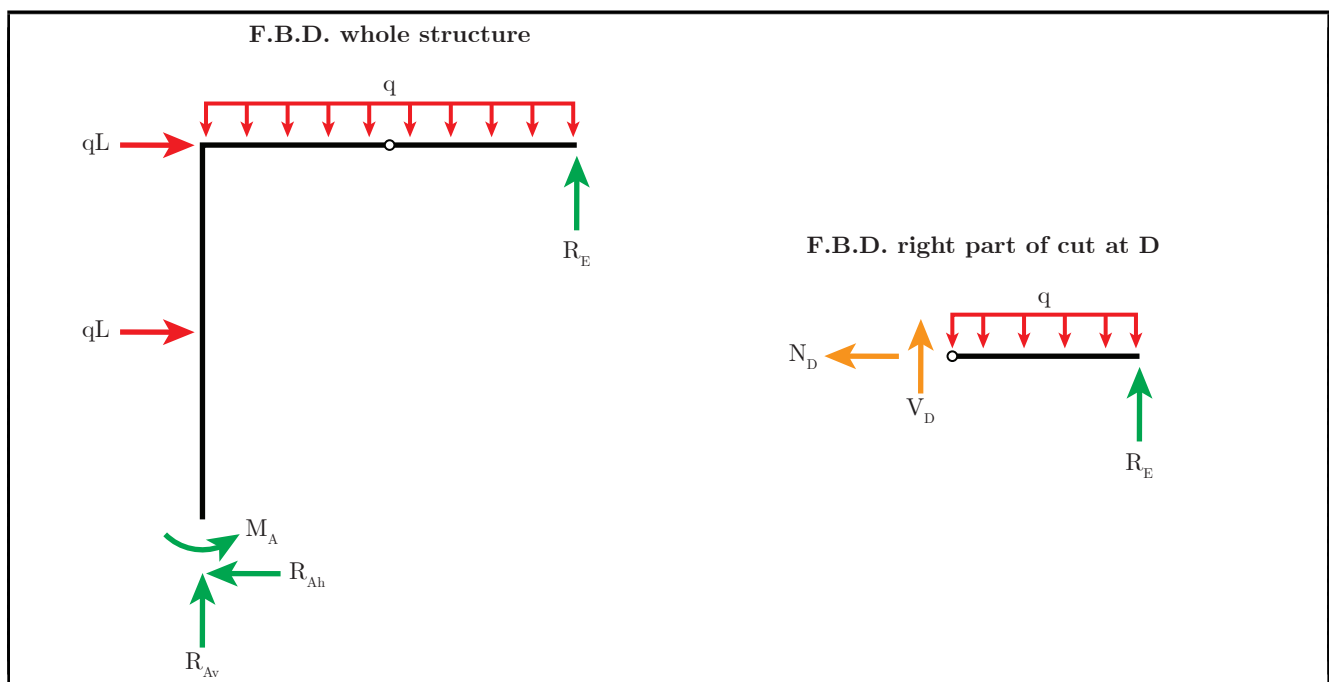
The below structure is formed of a column (AC) with height of  $2L$  and a beam (CE) with length of  $2L$ . In the middle of the beam (at point D), there is an internal hinge. The structure is supported by a fixed (clamped) support at point A and a roller at point E.

The structure is subjected to a vertical distributed load ( $q$ ) between points C and E. Also two horizontal concentrated forces equal to  $qL$  are applied at points B and C.

The absolute values of the reaction forces in the supports are given as follows:  $R_{Ev} = qL/2$ ,  $R_{Av} = 3qL/2$ ,  $R_{Ah} = 2qL$ , and  $M_A = 4qL^2$ .



- 2p **1a** Draw the Free Body Diagrams (FBD) of the parts of the structure needed to find the reaction forces in the box below. Include ALL internal forces.



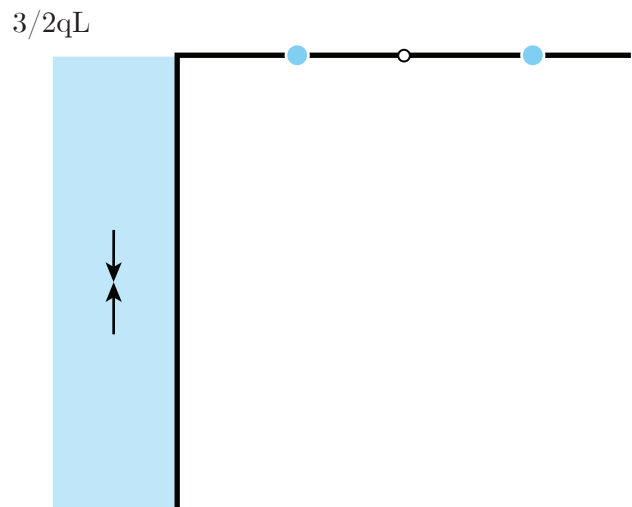
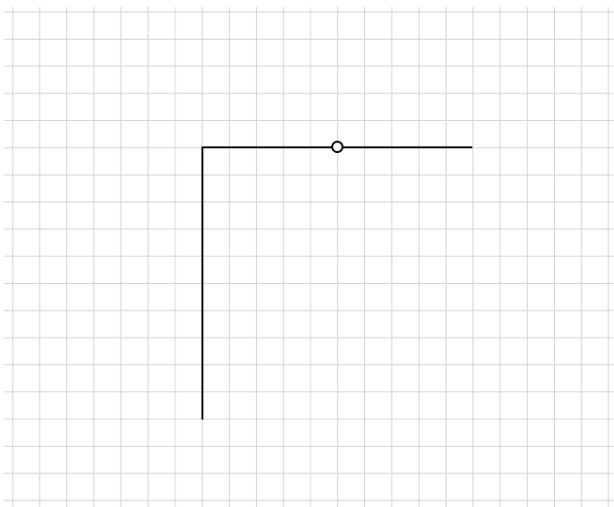
- 4p **1b** Formulate in the table the equilibrium equations and the solutions resulting in finding the reaction forces/moments and their directions.  
 In first column, indicate which part of the structure you apply the equilibrium equation (e.g. left part, whole structure, etc.).  
 In the second column, indicate the equilibrium condition used (e.g.  $\sum F_x = 0$ ,  $\sum M = 0$ , etc.)  
 In the third column, write the actual equation with the values from the structure.  
 In the fourth column, indicate the resulting value of the reaction force/moment with an arrow showing the correct direction.

Part of Structure	Equilibrium condition	Equilibrium equation	Reaction Force/moment
right part of D	$\sum M_D = 0 :$	$R_E \cdot L - q \cdot L \cdot \frac{L}{2} = 0$	$R_E = \frac{1}{2}qL$
whole	$\sum F_h = 0 :$	$qL + qL - R_{Ah} = 0$	$R_{Ah} = 2qL$
whole	$\sum F_v = 0 :$	$q \cdot 2L - R_{Av} - R_E = 0$	$R_{Av} = \frac{3}{2}qL$
whole	$\sum M_A = 0 :$	$M_A + R_E \cdot 2L = qL^2 + 2qL^2 + 2qL^2$	$M_A = 4qL^2$

- 5p **1c** In the following three parts (1c, 1d, and 1e) draw the internal force diagrams (**Normal force**, **shear force**, and **bending moment**) in the space provided.
- + in each box, indicate the **scale** you use for your drawing.
  - + indicate either **deformation signs**, or **+/- signs** (as per convention), or **both** on all diagrams.
  - + indicate **extreme** values and values of **jump** in the diagrams
  - + if the value of a diagram is **zero** over a part of the structure, then clearly indicate this.

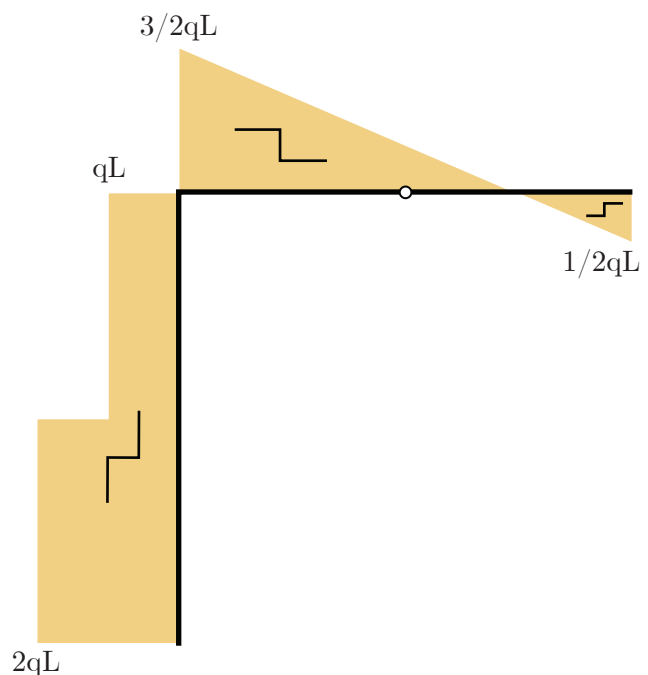
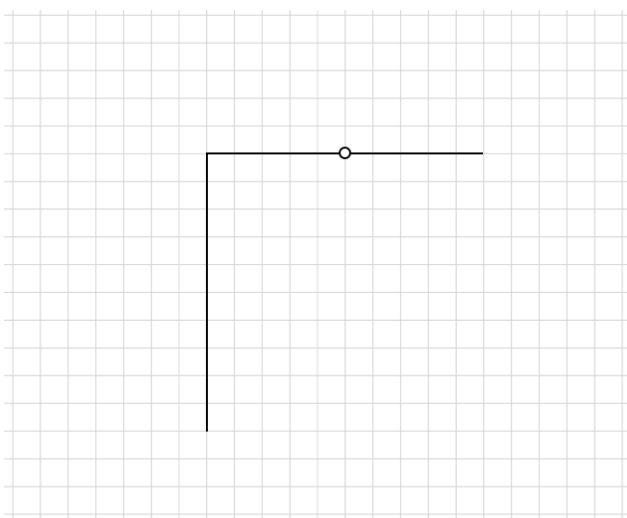
(First draw the diagrams in scrap paper and draw the final versions in the space provided below. If you make a mistake and want to re-draw, just do so in the space to the right of the grid-paper).

Normal force diagram (5 points)



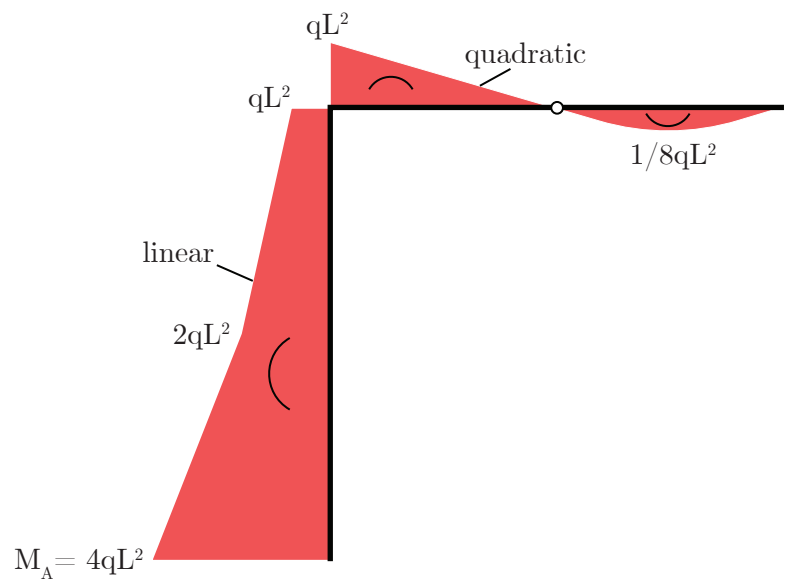
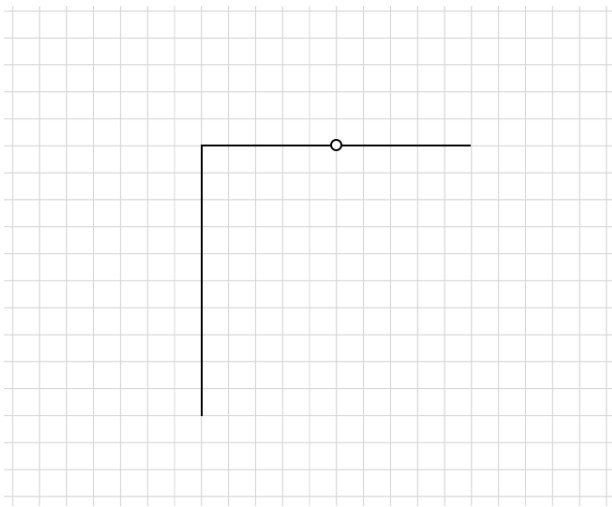
- 5p **1d** Shear force diagram

Shear force diagram (5 points)



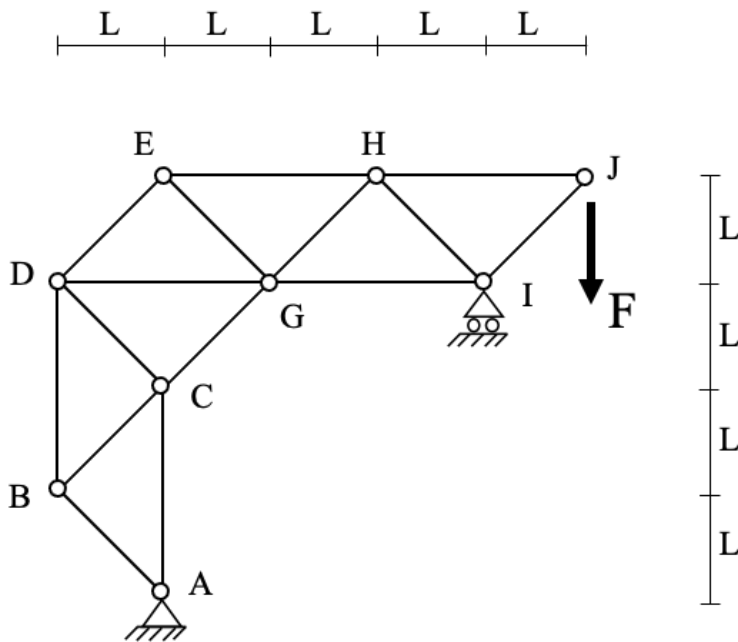
5p **1e** Bending moment diagram

Bending moment diagram (5 points)



### Mechanics question 3

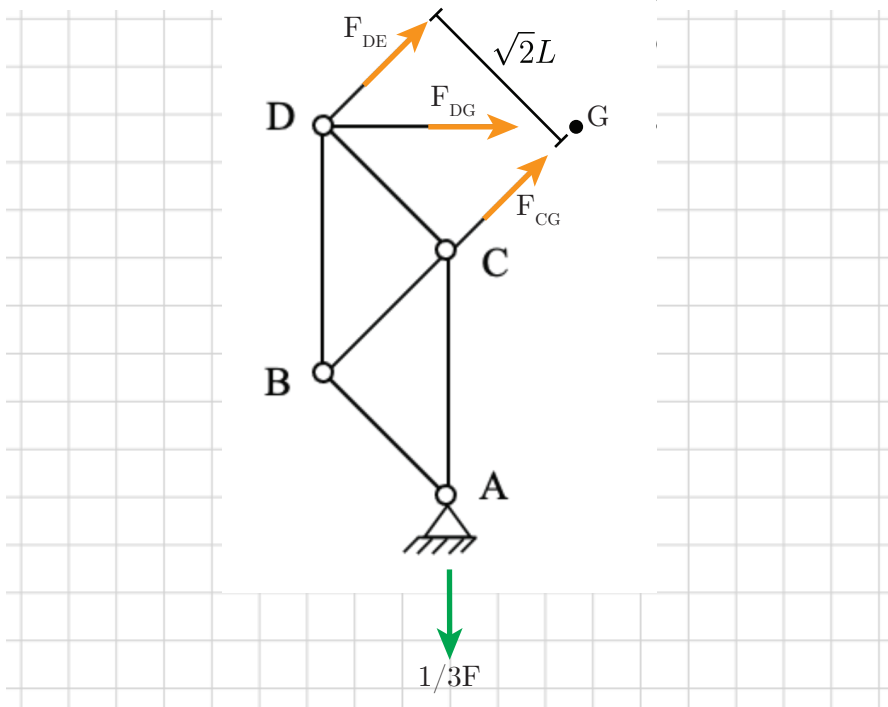
The mechanical scheme of a truss structure is given below. All members are connected in the nodes by an internal hinge. The structure is supported by a hinge at point A and a roller at point I.



- 1.5p **3a** Write equilibrium equations and find the support reaction forces in the table below  
 + Indicate in the drawing above, the reaction forces and their directions  
 + in the third column, clearly indicate the value and direction of each reaction force

Equilibrium condition	Equilibrium equation	Reaction force + Direction
$\sum F_h = 0 :$	$R_{Ah} = 0$	$R_{Ah} = 0$
$\sum M_A = 0 :$	$R_{Iv} \cdot 3L - F \cdot 4L = 0$	$R_{Iv} = \frac{4}{3}F$
$\sum F_v = 0 :$	$F - R_{Av} - R_{Iv} = 0$	$R_{Av} = -\frac{1}{3}F$

- 4p **3b** Using the **Method of Sections**, determine a section from which the force in members DE, DG, and CG can be calculated analytically (i.e. with the help of equilibrium equations). Draw (in the box below) the Free Body Diagram of the part of the structure used to find the forces asked above. Clearly show the internal forces.



Provide in the table below the **equilibrium condition** for this section, the corresponding **equilibrium equation** and the **value of the force** in the three members asked above, also indicating the **nature of the force** i.e. tension (+), compression (-), or zero (0).

Equilibrium condition	Equilibrium equation	Force (value & nature)
$\sum M_G = 0 :$	$\frac{1}{3}F \cdot L - F_{DE} \cdot \sqrt{2}L = 0$	$F_{DE} = \frac{1}{3\sqrt{2}}F$
$\sum M_D = 0 :$	$-\frac{1}{3}F \cdot L + F_{CG} \cdot \sqrt{2}L = 0$	$F_{CG} = \frac{1}{3\sqrt{2}}F$
$\sum M_C = 0 :$	$-F_{DG} \cdot L - F_{DE} \cdot \sqrt{2}L = 0$	$F_{DG} = -\frac{1}{3}F$

- 9p **3c** Provide the **values** of the other member **forces** in the table below, also indicating the **nature** of the force i.e. tension (+), compression (-), or zero (0).

**You can use a combination of every method** to calculate the values of the forces: "Method of Sections", or "Method of joints", or the methods used to find "zero-force" members.

In the table below, only provide your final answers.

Member	Nature of the force (-/0/+)	Value of the force (-/0/+)	member	Nature of the force (-/0/+)	Value of the force (-/0/+)
AB		0	EH		$\frac{1}{3}F$
AC		$\frac{1}{3}F$	HG		$\frac{2}{3\sqrt{2}}F$
BC		0	GI		$-\frac{2}{3}F$
BD		0	HI		$-\frac{2}{3\sqrt{2}}F$
DC		$\frac{1}{3\sqrt{2}}F$	HJ		$F$
EG		$-\frac{1}{3\sqrt{2}}F$	IJ		$-\sqrt{2}F$