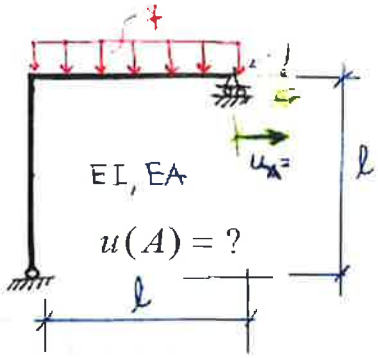
CIV-E1020 - Mechanics of Beam and Frame Structures

duration: 3h (given formulary on the verso of this paper)

Examination: 25.10.2016 (1st period: 12.09.2016-21.10.2016)

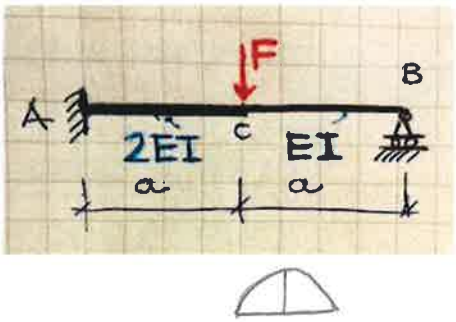


1. **Virtual force principle:** *a*) write mathematically *the dummy unit-load principle* for determining the horizontal displacement at roller support A of the plane frame accounting for both bending and stretching **[1p]**.
   b) Assuming linear-elastic material and **using the answer of question 1)** determine this horizontal displacement and show explicitly the contributions form bending and stretching **[4 p]**.

1X: **[Extra, 1p] - Strain energy of a frame:** write mathematically the expression of strain energy of a linear elastic frame accounting for bending, stretching and shearing *a*) in terms of internal forces **[0.5 p]** and *b*) in terms of corresponding generalized deformations **[0.5 p]**. (No need to account for 2nd order effects). /extra means that you can freely choose not to answer without losing points. However, right answer will count/

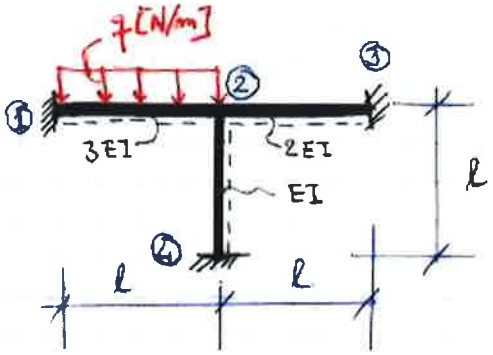
2X: **[Extra, 1p] – Principle of virtual work:** write mathematically the *virtual displacement principle* (the theorem) accounting only for bending of a simply supported beam (vapaasti tuettun kaksitukisen palkin taivutsu) with transversally distributed load. Only a complete right answer (the full proposition) will lead to the full extra-point.

2. **Structural analysis using the *General Force Method***



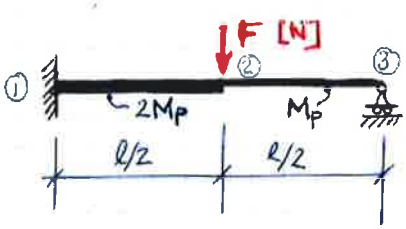
What is the degree of statical indeterminacy? (Redundancy degree).
Solve the reaction at the roller support *B*? **[3p]**
Determine the bending moment *M* and draw accurately the diagram (the graph). **[2p]**
Assume a linear-elastic material. Account only for bending when computing the flexibility coefficients (the Mohr's integrals).
Extra: determine the vertical deflection at *C*. **[1p extra]**

3. **Structural analysis using the *Slope-Deflection Method*** (displacement method)



What is the degree of kinematical indeterminacy? (Number of independent degrees of freedom).
Determine the rotation at node 2 **[4p]**
Solve the *bending moment* at support 3 **[1p]**
Assume a linear-elastic material and neglect the stretching effects on displacements and rotations.

4. **Structural analysis - Plastic limit load**



Use the kinematic method and
a) determine the plastic limit load and the failure mechanism. **[4p]**
b) check that the bending moment corresponding to the failure mechanism fulfils the yield condition (draw the bending moment at failure) **[1p]**.
The material is elastic-perfectly plastic and the full plastic bending moment capacity is as shown in the figure and, notice that it changes in the two parts 1-2 and 2-3.