FINAL EXAM – MN44

- **Exam duration: 2 hours.**
- **Each answer must be both correct and well-presented (clear and concise).**
- **Each party will be written on a different copy.**

PART 1 (D. CHAMORET AND S. ROTH)

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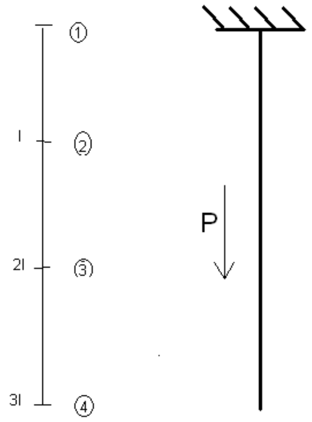
A. QUESTIONS

1. What "simulation driven design" could mean for a product design?
2. Finite Element analysis.
    a. Why finite element analysis is widely accepted in engineering. List a various applications of finite element analysis in engineering.
    b. Explain pre-processing and post-processing in a FEM Code.
    c. Explain classical errors inherent in FEM Formulation
3. When differences are observed between an experimental data and a finite element analysis, what could be the cause of discrepancies? What solution can you find to solve this problem?
4. Constitutive laws.
    d. Is the Hooke law sufficient, if you want to study the rupture of a material? Explain your answer.
    e. Name another well-known constitutive law usually used for steel material.

B. EXERCISE

We study a beam under a constant pressure, as illustrated on the following figure.



The length of the beam is equal to L, discretized into 3 elements linked by nodes 1, 2, 3, 4. The length of each element is l (l = length). The equilibrium equation of the system and the boundary conditions are the following ones:

$$\begin{cases} \dfrac{d}{dx}\left(E.A.\dfrac{du}{dx}\right)+p=0 \\ u(0)=0 \\ u(L)=u_L \end{cases}$$

1. Solve this equation, and give analytical results of the displacement as a function of the position.

Elementary matrix and equation of an element, for linear approximation is the following equation:

$$\frac{E.A}{l}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}.\begin{bmatrix} u_i \\ u_j \end{bmatrix}=\frac{p.l}{2}\begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

2. Write this equation for each elements (for each node i and j) and assembly the final matrix in order to obtain the global equation : K.U=F
3. Use the boundary conditions to solve the global equation, and find $u_i, \forall i$
4. Compare your results with the analytical solution.

PART 2 (N. LEBAAL)

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1) What is the result in case the temperature changes in structure and is not properly considered in design?
2) What are the different physical parameters that can define the *thermomechanical reference state* for the structure?
3) What can be the result if the member is completely blocked against axial elongation in the following cases?
   a) the temperature variation is positive $\Delta T>0$
   b) the temperature variation is negative $\Delta T<0$

PART 3 (GE- OLIVIER CHAPUIS)

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Target is to model transient behavior of a wall made by two slice of distinct material. On one side, the wall is in contact with a source of constant temperature. On the other side the wall exchanges energy by convection with a fluid at a constant temperature. Slices are parallel to the heat flow direction. **For the project, we focus on thermal physics only.**

You are supposed to follow the 11 steps to provide the system of equation representing the thermal behavior of the wall.