Exam of course MICRO 372: Advanced Mechanisms for Extreme Environments

F. Cosandier – V05 – 08.05.2025 (prior versions of this document are discarded)

Duration: **3 hours**

Date: **Thursday 26.06.2025**

Schedule: **9:15 a.m. to 12:15 p.m.**

Room: **SG1 & SG0213**

Authorized material:
- **Paper and pens**
- **Calculator** (no smartphone nor computer)
- **"Flex" form** (FLEX_FORMULAIRE.pdf from Moodle)
- A **single-sided form** is provided (approximately 10 days before the exam), personal annotations (handwritten or "iPad style") are permitted on the blank reverse side, as well as on the front side
- Additional formulas needed for the exam can be provided within the exam document

Exam format:
- Multiple choice questions (25%)
- Problems to solve, calculations (75%)
- **No open questions**

Subjects excluded from the exam:
- Homework lectures
- COMSOL Tutorials
- Yellow topics in the subjects list

Subjects included in the exam:

Green topics are considered as **general knowledge for MCQ**.
Blue topics are considered as **knowledge needed to solve problems and to answer MCQ.**
Yellow topics are **excluded**.

1. Introduction

2. Application fields and examples

3. Operating environments and associated constraints
   - Vacuum environment
   - Outgazing
   - Cryogenic environment
   - High temperature environment
   - Radiative environment
   - Dusty environment
   - Sterile environment

- o In vivo environment
- o Micro-gravity environment
- o Vibrations
- o Micro-vibrations
- o Magnetic environment

4. Advanced mechanisms design
   - o Flexure building blocks
   - o Stiffness calculation
   - o Kinematic analysis
   - o Geometric models
   - o Optimization
   - o Fatigue

5. Advanced mechanisms analysis
   - o FEA theory
   - o Meshing
   - o Constraints and loads
   - o Static and transient FEA
   - o Modal and frequency FEA
   - o Buckling FEA
   - o Multibody Dynamic Analysis
   - o Environmental vibration analysis (Miles)
   - o Topology optimization
   - o Multiphysics
   - o Numerical ordinary differential equation (ODE) resolution of dynamical system

6. Mechanisms dynamic aspects
   - o Vibrational mechanics theory
   - o Damping
   - o Lagrangian mechanics
   - o Balancing

7. System aspects
   - o Sensors
   - o Actuators

8. (Ultra-) High precision
   - o Calibration procedure
   - o Tolerances calculation
   - o Kinematic couplings

9. Manufacturing, assembly and integration of high precision mechanisms
   - o Manufacturing techniques
   - o Post-treatments
   - o Assembly

10. Characterization and testing

11. Synthesis examples
    - o Clarifications