MICRO-405

Systems engineering

Cursus	Sem.	Type
Microtechnics	MA2, MA4	Opt.
Systems Engineering minor	E	Opt.

Language of teaching	English
Credits	3
Session	Summer
Semester	Spring
Exam	During the semester
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

Pas donné en 2022-23

Summary

General introduction to systems engineering using the classical V-model approach. Topics include stakeholder analysis, requirements definition, concept selection, design definition and optimization, system integration and verification and validation.

Content

Systems engineering (SE) is a robust interdisciplinary approach to the design, creation, and operation of engineered systems, where "engineered systems" is understood as a set of processes that include people, products, services, information, processes, and natural elements.

This course is a general introduction to **systems engineering** using the classical V-model approach. Topics include stakeholder analysis, requirements definition, system architecture and concept generation, trade-space exploration and concept selection, design definition and optimization, system integration and interface management, system safety, verification and validation, and commissioning and operations. Discusses the trade-offs between performance, lifecycle cost and system operability. Readings based on systems engineering standards and research papers. Students apply the concepts of systems engineering to a cyber-electro-mechanical system.

Keywords

Systems Engineering, Stakeholder Analysis, Requirements, Concept Generation, Concept Selection, Design, Optimization, Verification, Validation, Operations, Lifecycle Properties, Model Based System Engineering

Learning Prerequisites

Required courses

None.

Recommended courses

MICRO-406 "Products design & systems engineering", in particular the sessions related to the introduction to systems engineering. Introductory videos will be available at the beginning of the course to the students who did not follow MICRO-406 course.

Learning Outcomes

By the end of the course, the student must be able to:

- Describe the most important systems engineering standards and best practices as well as newly emerging approaches
- Analyze the key steps in the systems engineering process starting with stakeholder analysis and ending with transitioning systems to operations
- Structure the important role of humans as beneficiaries, designers, operators and maintainers of aerospace and other systems
- Characterize the limitations of the way that current systems engineering is practiced in terms of dealing with complexity, lifecycle uncertainty and other factors
- Apply some of the fundamental methods and tools of systems engineering to a simple cyber-electro-mechanical system as a stepping stone to more complex and real world projects

Transversal skills

- Communicate effectively with professionals from other disciplines.
- Use a work methodology appropriate to the task.
- Use both general and domain specific IT resources and tools

Teaching methods

The class consists of five pedagogical elements that are interwoven to maximize the use of individual, group and class time. These elements are lectures, assignments, readings, exams and the design competition.
a) **Lectures:** the lectures will last 2 hours (including breaks) and will present some of the key ideas and concepts for particular steps of the systems engineering process. The lectures will roughly follow the "V" model of systems engineering. Lecture notes will be posted on moodle before the lecture.
b) **Assignments:** Small teams of students will do the assignments. Each team will turn in one deliverable per assignment with all team members that contributed clearly identified. The assignments will be scheduled such that they are more or less synchronized with the class materials. The assignment teams will have a team size of about five students and there will be a total of four (4) assignments over the course of the semester.
c) **Readings:** Weekly readings from various sources will be proposed in this class: for example from the NASA Systems Engineering Handbook and INCOSE SE Handbook, but also from journal or conference papers, as well as from other sources. Readings can be discussed during lecture. Some readings will provide support to the course and others, not mandatory, will give more in-depth perspective compared to the SE standard texts.
d) **"Exams":** There will be two personal examinations in this class. The first will be a written on-line quiz where students show their individual understanding of key SE concepts. This exam will be administered near the end of the semester once the bulk of the SE theory has been covered. The quiz will be open-book and open-internet. There will also be a 3-5 page essay due at the end of the semester, which will take the form of a personal reflection about SE fundamentals and its potential future applications.
e) **Design Project:** Students will prepare a simplified PDR-level design for a small (i.e. from fractions to several meters) cyber-electro-mechanical system throughout their assignments. The final deliverable will be a 20-minute PDR presentation given as a team.

Assessment methods

There following **mandatory assignments** are required to complete this class:

1. Group Assignments A1-A3 (total of 3): 60%
2. Group Assignment A4 simplified PDR: 20%
3. Written online quiz: 10%
4. Reflective memorandum: 10%

Supervision

Office hours	Yes
Assistants	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

[1a] NASA Systems Engineering Handbook, NASA/SP-2016-6105 Rev 2, 2016

[1b] INCOSE Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, 4th Edition, ISBN: 978-1-118-99940-0, 304 pages, July 2015

Ressources en bibliothèque

- INCOSE Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities
- NASA Systems Engineering Handbook