Introduction to Systems Engineering - I

Welcome

Welcome to the course "Introduction to Systems Engineering - I". The subject of systems engineering is very broad and it is applicable to many industries and domains. The emphasis in this course will be in the engineering domain and more specifically the safety of automated vehicles. It is hoped that you will benefit from this course and learn the fundamentals of systems engineering, typical applications, and the use of some tools. The course is designed so that you can apply the material in actual projects.

Documents on the website

The website http://www.lesoftgroup.com/courses/ has a link to the systems engineering course that includes the following documents:

- Readme-First: Short document with instructions on how to get started.
- Course Syllabus & Information: This document.
- Basic-Concepts-Systems-Engineering: This document has background information and fundamental concepts.
- Overview-Systems-Engineering: This document contains an overview of the topics of the course.
- Online-Assignment: To be completed by each student by June 15th at midnight.

Course Title: Introduction to Systems Engineering – 1

Course Length: 2 days with a prior online component, online and in-person

Time Online: 6.5 hours

Time in Class: Day 1: 6.5 hours, Day 2: 7 hours (includes labs)

Time in lab: Day 1: 2 hours, Day 2: 2 hours

Class Size: Minimum 7 / Maximum 12

Location: Genesee County *or* Company Site

Course Description:

Systems are becoming increasingly large and complex with many challenges in their design, development, and implementation. Systems engineering enables the successful completion of large and complex projects. In this course, you will be introduced to systems engineering (SE) with emphasis on model based SE (MBSE) using the SysML language. Your knowledge will be reinforced by carefully designed assignments, and lab projects involving automotive and autonomous vehicle systems.

Lab Projects Description:

Lab Project 1: Development of the structure, behavior, and requirements for ABS using SysML.

Lab Project 2: Development of the structure, behavior, and requirements for an AV obstacle detection and avoidance controller using SysML.

Course Learning Objectives:

- Articulate the concepts of system life cycle, requirements, and the various design activities
- Describe importance of verification and validation (V&V) of requirements
- Define and illustrate what is meant by model based system engineering (MBSE)
- Explain the main features of SysML as a SE language
- Develop the structure, behavior, and requirements of a specific sub-system using SysML
- Articulate the concept of a safety culture and the role of the system architec

Course Content/Syllabus:

Online Component (throughout one week):

The course begins with a one week online component to be completed prior to classroom instruction. On this week, you'll take a Pre-Assessment to get a baseline of your understanding of the course material. After detailed information on the course, you will get a thorough introduction to systems engineering and systems lifecycle. This is followed by the characterization of requirements and various design activities and an introduction to requirements verification and validation (V&V). You will spend time on generating your own ideas about how to successfully complete large and complex projects. This component will end with a comprehensive assignment to be completed before the classroom instruction.

Topics:

- Knowledge Pre-Assessment
    - Welcome, Course schedule, Course collaboration tools, Learning objectives, Course syllabus.
    - Instructor, Training and delivery methodology, Assignments, Laboratories, Grading and completion criteria.
    - Introduction to course
    - Systems life cycle
    - Introduction to Systems Engineering
    - Requirements
    - Conceptual Design
    - Preliminary and Detailed Design
    - Construction, Production, and Utilization phases
    - SE Management
    - Introduction to V&V

Graded Assignment

- Detailed set of questions on system life cycle, requirements, and V&V.

Day 1:

On day 1 we review the online content material, answer your questions, and discuss the graded assignment of the online component. After defining systems thinking you will get an in-depth coverage of model based system engineering (MBSE). You will then be exposed to SysML as an example language for MBSE. Day 1 will end with a comprehensive assignment and completing a laboratory project.

Topics:

- Defining systems thinking
- Architecture of complex systems
- Model based systems engineering (MBSE)

- SysML as an example language for MBSE
- SysML: Structure, Behavior, Requirements, and parameters
- Demo of SysML

Graded Assignment
- Read, comment, and summarize a paper on SysML.

Laboratory Project 1
- Development of the structure, behavior, and requirements for ABS using SysML.

Day 2:

On day 2 we review the day 1 material, answer your questions, and discuss the graded assignment and lab project of day 1. You will then get an overview of ISO 26262 as an example of system engineering. You will then be exposed to SE management and the roles of the system architect and the safety manager. You will then work on a graded assignment and complete lab project 2. Day 2 will end with a course summary, main takeaways, a post assessment, and a course assessment.

Topics:
- Example of SE: Automotive safety standard ISO 26262
- SE Management
- Roles of system architect, safety manager

Graded Assignment
- Read, comment, and summarize a paper on MBSE.

Laboratory Project 2
- Development of the structure, behavior, and requirements for an AV obstacle detection and avoidance controller using SysML.
- Course Summary and Wrap-up
- Course Takeaways

Knowledge Post-Assessment
- Course Assessment

Course Tool:
The open source SysML tool Modelio will be used for the demos and laboratory projects. Students should download, install, and get familiarized with the tool (version 3.7.1)from:

https://www.modelio.org/downloads/download-modelio.html

After installation go to Help then click on Welcome for an introduction to the tool.
You also need to install the SysML Architect module. To do this, click on “configuration” then “modules” and choose the SysML Architect module to be installed.

Training and delivery methodology:
The methodology includes an online component to be completed in about 6.5 hours (including a

pre-assessment quiz and an assignment) and face-to-face meetings for days 1 and 2. Each day will include a slide presentation, interactive discussions (involving course material and assignments), demonstrations, performing laboratory projects, and assessments (only on the last day).

NOTE: Laboratory projects will be performed in groups of two students per group. Thus attempt to form your groups prior to day 1 (if possible). It is suggested that one member of the group be responsible for installing the Modelio tool on a laptop. Students in the same group will receive the same grade for the laboratory projects. To obtain credit, each group will provide a quick demo to the Instructor and optionally Email the model to the Instructor. There is no need to write a project report for the lab project.

Grading and completion criteria:
A final performance score will be computed for each student

Post-Assessment Quiz (the same as the pre-assessment quiz)	15%
On-line assignment	15%
Day 1 assignment	15%
Submission/demo of day 1 laboratory project	20%
Day 2 assignment	15%
Submission/demo of day 2 laboratory project	20%
TOTAL	100%

Expectations from the Student

- Complete the online component on time.
- Attend the face-to-face sessions for days 1 & 2
- Complete all quizzes, assignments, and lab projects.
- Actively participate in the discussions for days 1 & 2
- Collaborate with team members for the laboratory projects
- Have an open mind and a good learning attitude.

Expectations from the Instructor

- Present the material in a clear and understandable fashion
- Answer questions and address concerns of the students
- Give timely feedback on quizzes, assignments, and projects
- Be a facilitator and coach for learning
- Engage students in class discussions that are conductive to learning

About The Instructor:

Dr. Juan R. Pimentel is a retired Professor of Computer Engineering at Kettering University in Flint, Michigan. He is an expert in the Internet of Things (IoT), Industrial Internet, systems engineering, safety-critical systems, self-driving vehicles, and the safety of autonomous vehicles and is a recognized international expert in the areas of industrial communications, real-time and

dependable systems, and autonomous vehicle safety. He has written books on industrial networking, multimedia systems, and safety-critical automotive systems. Dr. Pimentel has also performed extensive international consulting and conducted professional training courses in North and South America, Europe, Asia, and the Middle East. He is an expert witness on patent infringement cases involving automotive systems, industrial communications, and IoT.

Dr. Pimentel has performed research at institutions around the world such as the Franuhofer Institute, Germany; INRIA, France; University of Padova, Italy; Universidad Policteсnica de Madrid and Universidad Carlos III de Madrid, Spain; Universidad de los Andes, Colombia; and UTEC, Peru. In 2007 he received the "Distinguished Researcher Award" from Kettering University for contributions in the area of industrial communication systems and automotive systems. He has written over 86 peer reviewed papers at international conferences and Journals, primarily the IEEE and SAE.

As a 1980 graduate of the University of Virginia, additional accomplishments include the co-development of the application layer for Profibus (with Siemens), and the development of FlexCAN, a CAN-based dependable architecture for safety-critical applications. In the last few years he has been involved with various projects dealing with self-driving vehicles including design, simulation, testing, functional safety, and developing online training materials. He is a faculty advisor to the Kettering University team participating in the AutoDrive autonomous vehicle competition organized by SAE International and General Motors. One of his latest projects involve the development of techniques and methodologies to design self-driving vehicles with a sufficient level of safety.