Savitribai Phule Pune University

Faculty of Science & Technology

Curriculum/Syllabus

For

Honors in "Systems Engineering"

Bachelor of Engineering

(Choice Based Credit System)

Honors in Major Disciplines of Mechanical Engineering, Mechanical Engineering (Sandwich), Automobile Engineering, Electrical Engineering, Production Engineering and Production Engineering (Sandwich) - (2019 Course)

Board of Studies–Mechanical and Automobile Engineering

(With Effect from Academic Year 2021-22)

Savitribai Phule Pune University
Board of Studies - Automobile and Mechanical Engineering
Undergraduate Program - Mechanical Engineering (2019 pattern)
Honors in "Systems Engineering"

Course Code	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	TOTAL	TH	PR	TUT	TOTAL
Semester-V														
302041MJ	Foundations of systems & systems engineering	4	-	-	30	70	-	-	-	100	4	-	-	**4**
302042MJ	Foundation of Systems engineering Lab	-	2	-	-	-	50	-	-	50	-	1	-	**1**
	Total	**4**	**2**	**-**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**1**	**-**	**5**
Semester-VI														
302043MJ	Model Based Systems Engineering	4	-	-	30	70	-	-	-	100	4	-	-	4
	Total	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**-**	**100**	**4**	**-**	**-**	**4**
Semester-VII														
302044MJ	System modelling and simulation	4	-	-	30	70	-	-	-	100	4	-	-	**4**
302045MJ	System modelling and simulation Lab	-	2	-	-	-	50	-	-	50	-	1	-	**1**
	Total	**4**	**2**	**-**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**1**	**-**	**5**
Semester-VIII														
302046MJ	Systems Engineering Management	4	-	-	30	70	-	-	-	100	4	-	-	**4**
302047MJ	Seminar / Mini project / Activities (Activity based seminar)	-	-	2	-	-	50	-	-	50	-	-	2	**2**
	Total	**4**	**-**	**2**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**-**	**2**	**6**

Abbreviations: TH: Theory, **PR**: Practical, **TUT**: Tutorial, **ISE**: In-Semester Exam, **ESE**: End-Semester Exam, **TW**: Term Work, **OR**: Oral

1.Rules and Regulations for Honors / Minors Programs

R1.1 It is absolutely not mandatory to any student to opt for Honours or Minors Program. Choice is given to individual students to undertake Honors/Minors programs from the third year engineering (Fifth Semester) to fourth year engineering (Eighth Semester). Honors/Minors programs will be opted from offered programs by SPPU. Once selected he/she will not be permitted to change the Honors/Minors program in forthcoming semesters.

R1.2 The registration for Honors/Minors Programme will lead to gain additional credits to such students. The result of Honours/Minors Program will get reflected in ledgers to be maintained at University only. After the completion of the Honors/Minors program by concerned students, details of credits earned in Honors/Minors program be printed in the mark sheet of eighth semester. For those students, who will not be able to complete the Honors/Minors program, details about the additional credits earned will not get printed.

R1.3 Credits earned through registration and successful completion of the Honors/Minors Programme will **not** be considered for the calculation of SGPA or CGPA.
As per the standard practice, SGPA and CGPA calculations will be done with common base only by considering mandatory credits assigned for the Bachelor programme as per the structure approved by the Academic Council.

R1.4 Students once registered for the programme need to complete all credits assigned for the specific Honors and Minors Programme in the period of 4 years from the Semester-V. Degree with Honors/Minors will be awarded only after the completion of Honors/Minors Programme along with respective UG program degree.
Students may opt to cancel the registration for Honors/Minors within this period of 4 years. After 4 years expire automatically Bachelor's degree will be awarded to such a student provided he/she has earned the credits needed for graduation.

R1.5 Backlog Honors/Minors courses will not contribute to the decision of A.T.K.T.

2. Examination Scheme:

R2.1 Examinations for Honors/Minors Program will be organized at the University Level. Question papers will be common for all students who had opted/registered for the specific Honors/Minors Program. Evaluation of answer books for the Honors/Minors program will be done at the university level.

R2.2 Additional examination fees as per prevailing rules and regulations will be charged from those students who had registered for Honors/Minors Program to match the expenses for paper setting and the assessment of answer books at the CAP Centre.

Instructions:

- Minimum number of Experiments/Assignments in PR/Tutorial shall be carried out **as mentioned in the syllabi** of respective courses.
- Assessment of tutorial work has to be carried out similar to term-work. The Grade cum marks for Tutorial and Term-work shall be awarded on the basis of **continuous evaluation.**

302031MJ: Foundations of systems & systems engineering					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**4 Hrs./Week**	**Theory**	**4**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Awareness of product design and development, problem solving skills.

Course Objectives:

Students are expected to,

1. Obtain the fundamental knowledge of systems and systems engineering
2. Study systems engineering processes and practices.
3. Understand Hierarchy of Complex Systems
4. Understand basic system development process through the system life cycle
5. Outline the nature of systems philosophy and its relationship to the engineering of systems throughout the lifecycle.

Course Outcomes:

On completion of the course the learner will be able to;

CO1. DESCRIBE the methods, Processes and practices of systems engineering.

CO2. APPLY systems engineering practices and methods to the relevant examples.

CO3. RECOGNIZE important systems engineering and systems thinking strategies and PRACTICES in examples and cases.

CO4. DEVELOP requirements, architectures, and perform traceability studies of systems.

Course Content

Unit 1	**Introduction to Systems Engineering**

History / Background, Industrial revolution, Discover Systems Engineering, Systems Engineering definition INCOSE, V-Cycle. Cyber physical systems – Advantages, Necessity and its challenges:

a) Security: Control of interfaces, emergent vulnerabilities.
b) Data: Privacy, data capture, analysis, access issues, data adequacy and accuracy.
c) Regulations and Standards: Policy, Standards.
d) Life cycle Sustainment.

Unit 2	**Systems Thinking**

Real life applications in the context of Systems Engineering, Concept of emergent property, Properties of systems, Systems classification, principles of systems thinking.

Unit 3	Systems Science

Overview of systems science, philosophy and systems theories. Open system definitions. System Life cycle process, Systems Engineering Concepts: System, System of Systems, System of Interest, Enabling System, System Interfaces, Functions, Requirements. Systems ideas to complex problems, system complexity, emergence, viability, resilience. Exploration and evaluation of key systems, Systems Science case studies.

Unit 4	Systems Architecture and Design

Introduction to systems architecture, Architecture Frameworks, System modelling languages, Types of Architecture, Architectural Views, Architecture Development and Traceability, Architecture Validation and its need, Feasibility study, Architecture Trade-offs.

Unit 5	Introduction to Model Based Systems Engineering (MBSE)

Introduction, evolution of MBSE, Modelling with MBSE, the system modelling language - SysML, basic structure of SysML, Interpret a simple SysML model, Difference between MBSE and traditional systems engineering, modelling, simulation and Trade-off analysis.

Unit 6	Systems Modelling

Concepts of simulation modelling in the SE lifecycle, The basis of quantitative modelling, The role of modelling in decision making. Introduction to Modelling Paradigms, Discrete event simulation, System dynamics modelling.

Text Book:

1. Jon Holt, "Systems Engineering Demystified", Packt, Birmingham - Mumbai, 2021.
2. Reinhard Haberfellner, Olivier de Weck Ernst Fricke, Siegfried Vössner, "Systems Engineering Fundamentals and Applications", Springer Nature, Switzerland AG, 2019.

Reference Books:

1. NASA Systems Engineering Handbook, NASA/SP-2007–6105 Rev 1. Military Bookshop.
2. INCOSE,. Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities. 4th ed. Wiley, 2015. p. 304. ISBN: 9781118999400.
3. ISO/IEC/IEEE 15288:2015, Systems and Software Engineering—System Life Cycle Processes.

302032MJ: Foundation of Systems engineering Lab					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**Term Work**	**50 Marks**

Prerequisites: Basic awareness of geometric modelling and simulation tools.

Course Objectives: Students are expected to study, Functions to describe the system's activities, interactions, and operations.

Course Outcomes:

On completion of the course the learner will be able to;

CO1. ANALYSE the role of simulation modelling in the successful realization of systems.

CO2. IDENTIFY the necessary requirements and need of the systems.

CO3. DEVELOP and ANALYZE simple models using systems engineering approach.

CO4. CREATE SysML diagrams using object oriented systems engineering approach.

Guidelines for Laboratory Conduction

The learner shall complete the following activity as a Term Work. Perform any of the Four labs Practical from the following list. Any suitable commercial or the open source software shall be preferred for conduction of the practical.

Term Work

1. Demonstration of Project Management and Project Life Cycle Software Platform/Tools
2. Demonstration of Model Based System Engineering Software Platform/Tools
3. Identification of needs and necessary requirement analysis using suitable software Platform / Tools exposure e.g. case study like robotics, EV systems or its components, cyber-electro-mechanical system, battery operated system, aviation system, etc.
4. Create / develop SysML diagrams for the case study considered in practical number 3 using suitable MBSE system engineering software / tools.
   (*It should capture System Requirements, functional requirements, logical components and then identification of physical components which represent the CAD model.*)
5. Creating CAD models, models related to above identified requirements like manufacturing, service & quality for those sub-components.
6. Design and develop a simple mechanism or system using System Engineering approach e.g. robotic arm, braking system, four bar mechanism, etc.

302033MJ: Model Based Systems Engineering					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**4 Hrs./Week**	**Theory**	**4**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Foundations of Systems Engineering, Geometric Modelling and Simulation Software

Course Objectives:

Students are expected to,

1. Create awareness of systems, subsystems and systems modelling.
2. Develop and understand structural and behavioural aspects of general diagramming concepts.
3. Perform a functional analysis.
4. Construct systems engineering requirements.

Course Outcomes:

On completion of the course the learner will be able to;

1. UNDERSTAND fundamentals of systems and subsystems.
2. DIFFERENTIATE between traditional document-based and model based systems engineering.
3. ANALYZE three pillars of MBSE: languages, methods, and tools.
4. APPLY Model Based Systems Engineering (MBSE) approach to Engineering problems.
5. CREATE models and diagrams using modelling language.

Unit 1	**Fundamentals of MBSE**

Introduction, Need of model based engineering, The MBSE Framework, Systems, subsystems and levels, Modelling in MBSE, abstracting the system, visualizing the model, defining system approach.

Unit 2	**Pillars of MBSE**

System Engineering processes in MBSE, Modelling methods, Modelling tools and Modelling language.

Unit 3	**Systems Modelling Language - SysML**

Introduction, The general diagram concept, The SysML diagrams & its structure, Diagram vs Model, the structural aspect and the behavioural aspect, The relationships between behavioural diagrams and structural level

Unit 4	**Modelling Methods & Tools**

Methodology in MBSE, Introduction to Object Oriented Systems Engineering methods (OOSEM), OOSEM methodologies, Difference between Modelling tools & diagramming tools, SysML formats (*XML, REQIF, UXF*)

Unit 5	Introduction to process modelling
Systems engineering process, General framework, Vee-model, Iterative model.	
Unit 6	**Requirement modelling with MBSE**
Introduction, The Requirements modelling Framework, Approach to Context-based Requirements Engineering (ACRE), Requirement and assumption validation.	

Books and other resources

Text Books:

1) Jon Holt and Simon Perry, "*SysML for Systems Engineering, A model-based approach*", 3rd Edition, The Institution of Engineering and Technology, 2019
2) Sanford Friedenthal and Christopher Oster, "Architecting spacecraft with SysML", Createspace Independent Publishers, 2017
3) Lenny Delligatti "SysML Distilled: A Brief Guide to the Systems Modelling Language", Addison-Wesley; 1st edition, 21 November 2013.

Reference Books:

1) Jose L. Fernandez and Carlos Hernandez, "*Practical Model-Based Systems Engineering*", Artech House, 2019
2) "*NASA Systems Engineering Handbook*", National Aeronautics and Space Administration NASA Headquarters Washington, D.C. 20546 December 2016.
3) "*INCOSE Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities*", Wiley, 2015.
4) Tim Weilkiens, "*Systems Engineering with SysML/UML - Modelling, Analysis, Design*", Morgan Kaufmann OMG Press, 2008

Weblinks:

1) http://sysml-models.com/spacecraft/models.html
2) https://www.sebokwiki.org/wiki/Life_Cycle_Models