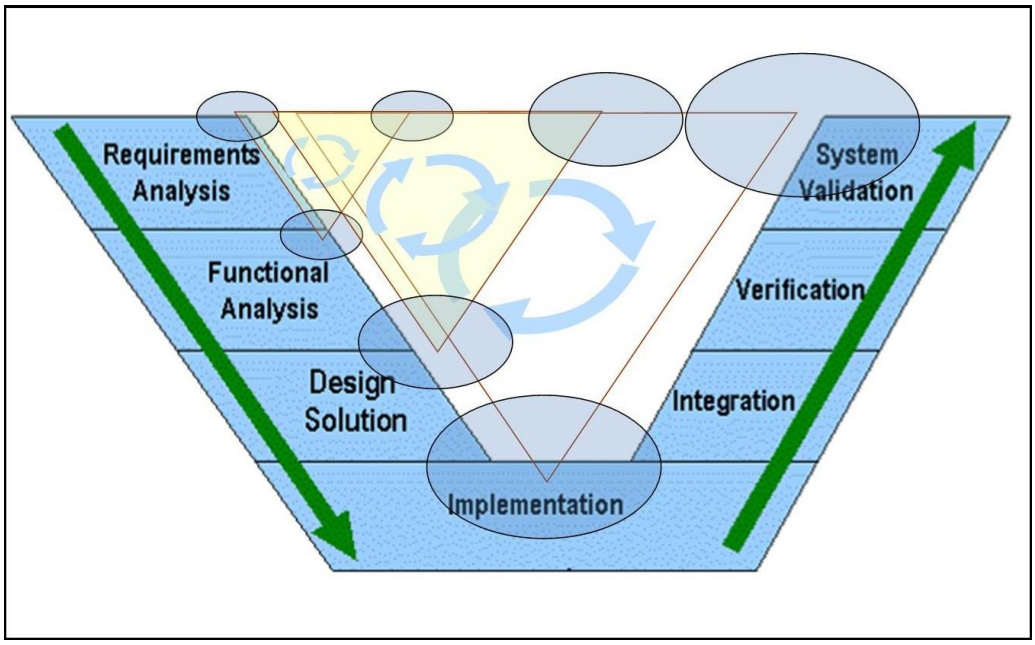
# UNIVERSITY
# OF
# SOUTHERN CALIFORNIA

# Syllabus
# Systems Engineering Theory & Practice
# SAE 541




## Jim Hines
## Summer 2017

**UNIVERSTY OF SOUTHERN CALIFORNIA**

**COURSE SYLLABUS**

**SYSTEMS ENGINEERING THEORY AND PRACTICE (SAE 541)**

**Instructor:** Jim Hines; Phone: 562-714-4326; Email: jhines@usc.edu
Office Hours: 3:30 PM Wednesday or By Appointment
**TA**: TBD ; Phone: TBD; Email: TBD
**Class:** Wednesday 04:00 PM-07:10 PM OHE 136

**Course Description:**

Systems engineering is an evolving discipline that applies an inter-disciplinary problem-solving approach across the entire technical effort whether military, industrial, commercial or civil systems and system of systems. The discipline mandated on all military and civil programs. Over the past few decades, especially due to the evolution digital computers and software, the complexity and interconnectiveness of systems for a great variety of applications has overwhelmed previous technical & management processes. This complexity has resulted in developmental failures, cost overruns, schedule slippage, stakeholder dissatisfaction and environmental disasters.

This course will acquaint the student with both the theory and practice of the systems engineering discipline and the systems engineering design approach to devise a system solution, which meet customer/stakeholder objectives optimally within available resources. The course will discuss solving open-ended problems, employing creativity, formulating of problem and need statements and requirements, examining alternative solutions, utilizing concurrent engineering design, and considering a variety of realistic constraints, such as economic (business case) factors, safety, reliability, aesthetics, ethics, social impact, production, and operations

This course is the introductory course to the Systems Architecture and Engineering master's program.

Among the topics covered in the class are:

- Perspectives of Systems, System Types and the System Architecture
- Systems, Critical, Design Thinking
- Value of Systems Engineering
- System Acquisition & Life Cycle Models
- Systems Engineering Process Standards
- General Statement of the Problem or Need
- Requirements & Functional Analysis
- Capability Documents & Specifications
- Synthesis & Architecting
- Systems Analysis **(**Trade Studies and Other Decision Methodologies) & Affordability
- Verification, Validation, and Test
- Product Realization (Program Execution) including Implementation, Integration & Transition and Interface Analysis
- Design for Specialties (Reliability, Availability, Maintainability, Safety, Human Systems Integration, Operations & Interoperability, Manufacturing and Production, Supportability, Sustainability & Logistics)
- Next Steps in Systems Engineering

**Course Objectives:**

**Scope**

Systems engineering is a scientific way to understand the underlying structure and characteristics of systems and their complexities and a problem – solving approach. This course will acquaint you with concept of systems and the role systems engineering plays in their development. It will also provide basic systems engineering framework and processes for solving problems using systems analysis methods and techniques.

Systems engineering consists of both technical analysis and management aspects. This course focuses on technical analysis. However, because of the links between the technical analysis and management aspects, the relationship between the two aspects is covered, wherever appropriate.

**Goals**

- Establish an understanding of basic system and systems engineering concepts and terms
- Introduce systems engineering as a problem solving process / approach and its relationship to program life cycle
  - To instill in the minds of the students that systems engineering as a way of thinking
- Understand the systems engineering technical processes and their interactions
  - Produce various systems engineering artifacts
  - Reflect the systems engineering principles in the development of artifacts.
  - Understand useful theories, models, techniques and tools
  - Address design for operational feasibility (specialty engineering) concepts
- Enable the students to work as a team to analysis a open – ended problem, synthesize a system solution and describe it in a system specification so it could be designed and built.
- Improve your "Team & Soft Skills".

**Course Highlights:**

There will be:

1) Lectures with Case Studies
2) Exercises (individual or team-based)
3) Team Presentations
4) Quizzes (Pre and Post) or Midterm & Final

These activities are to provide a valuable learning experience by demonstrating your knowledge, comprehension, application, analysis, synthesis, and evaluation of the subject material. You are expected to apply systems thinking and utilize the systems engineering process during the course.

As in the "real world" of systems, engineering involves teamwork. As a result, we will be forming teams for working on selected Exercises to solve a system problem of the team's choice. Each team is required to demonstrate that they can perform selected Exercises. Each team will be required to present results.

| Class Session | Date | Topics | Readings, INCOSE Handbook |
|---|---|---|---|
| 1 | 5/17/2017 | Course Overview, Introductions, Course Questions, Administrative Items; Systems Engineering Introduction: Definitions, System, System of Systems; | Chapter 1: Systems Engineering Scope; Chapter 2, 9.7: Systems Engineering Handbook Scope, Systems Engineering Overview; Integrated Product & Process Development |
| 2 | 5/24/2017 | Critical, System, & Design Thinking; SE Characteristics and Discipline; Value of Systems Engineering; System/Traditional Engineer/Project Management Roles. Program Life Cycle & Standards: | Chapters 3, 8: Generic Life Cycle Stages; Tailoring and Application od Systems Engineering |
| 3 | 5/31/2017 | Technical Reviews & Baselines; SE Life Cycle Development Models, Process Standards, Lessons Learned, and Tailoring; Understanding the Problem: Stakeholder, User, Business Needs | Chapters 4.1, 4.2, 4.3: Business or Mission Analysis Process; Stakeholder Needs and Requirement Definition Process; |
| 4 | 6/7/2017 | Quality Function Deployment (QFD); Requirements Analysis & Validation: Types, Writing Requirements, and Assessments | Chapter 4.3, 9.5: System Requirements Definition Process, Prototyping |
| 5 | 6/14/2017 | Requirements Validation; Capability, Specification and SOW Documents: Capabilities, Methodology, Type of Specifications, Performance, Development, Formats | Chapter 4.3: System Requirements Definition Process |
| 6 | 6/21/2017 | Functional Analysis & Allocation / Synthesis: Function, Functional Context Diagram, Operations Concept (OpsCon), Functional Flow Block Diagrams, Functional Allocation; Elements, Design Matrices, Physical Context Diagram, Hierarchy, Schematic Block Diagram, Modularity, 3 Cs Guidance | Chapter 5.7, 9.3: Measurement Process, Cross-Cutting Technical Methods – Functions Based Systems Engineering Method |
| 7 | 6/28/2017 | Architecting: States & Modes, Definitions, Heuristics, Complexity,Architectural Considerations, Architecture Description, Framework, Robust, Resilient & Agile Architectures | Chapter 4.4: Architecture Definition Process; Chapters 9.2, 9.4: Model – Based Systems Engineering; Object – Oriented Systems Engineering |
| 8 | 7/5/2017 | System Design Considerations & Interface Analysis: COTS, Open Modular Systems Approach, Interface Definition, Types, N-squared Diagram, Specification, Control Documents; Systems Analysis: Effectiveness Analysis, Affordability & Cost as an Independent Variable (CAIV) | Chapters 4.5, 9.6: Design Definition Process, Interface Management, Chapters 4.6, 5.3, 9.1, 10.1: System Analysis Process; Decision Management Process; Modeling & Simulation; Affordability |
| 9 | 7/12/2017 | Trade Studies, Utility Analyses, & AHP; Systems (Product) Realization, Integration & Evaluation: Terminology, Product Integration Goals & Practices; Challenges, | Chapters 4.7, 4.8: Implementation & Integration Processes |
| 10 | 7/19/2017 | Verification & Validation, VCRM, & Validation;Test & Evaluation/ Transition;: Types of Tests, Open Systems Testing, Test Requirement Sheet, Testability; Transition; . | Chapters 4.9, 4.10 & 4.11: Verification, Transition, & Validation Processes |
| 11 | 7/26/2017 | Design for Operational Feasibility or Specialty Engineering: Engineering Specialties, Types, Reliability, Safety & Health Hazards; Availability, Maintainability, Operation, Supportability, Sustainment & Logistics, Human Systems Integration, Interoperability, System Security & Information Assurance, Manufacturing and Production, Disposal | Chapters 10.8, 10.9: Reliability, System Safety; Chapters 10, 4.12, 4.13, 4.14: Specialty Engineering Activities, Operations, Maintenance, and Disposal Processes |
| 12 | 8/2/2017 | Risk & Opportunity: Definitions, Process, Risk Matrix, Identification, Writing Risk Statements, Analyzing, Handling, Control; Next Steps | Chapter 5.4; Risk Management Process; Application of Systems Engineering |

**Grading:** USC Grading Policies followed.

| | | Activity Weighting Factor | |
|---|---|---|---|
| Quizzes | 10 post quizzes | 50% | 150 points |
| | (10 pre-quizzes; 10 post-quizzes, 15 points total per quiz for right answers.) | | |
| Exercises | 10 exercises / 3 team presentations/ peer evaluation | 50% | 150 points |
| | (100 points,10 points/ 10 exercises; 28 points, | | |
| | 7 points/ 4 team presentations, 22 points/ peer evaluation) | | |
| | Total | 100% | 300 points |

All assignments submitted through DEN for this class, unless otherwise noted by the instructor or teaching assistant. Please use Microsoft Word or PowerPoint or PDF documents for your submitted assignments.

Unless otherwise noted by the instructor or teaching assistant, exercises and quizzes are due at 9:00 PM PT on the day before the lecture (Tuesday) following the week assigned. Please consult with the Teaching assistant or Instructor before the day the exercises & quizzes are due if there are any reason that prevent you from submitting exercises or quizzes on time.

| Exercises/ Quizzes | Session(s) | Exercises Due | Pre-Test Quiz | Post Test Quiz | Topics |
|---|---|---|---|---|---|
| 1 | 1,2 | 6/7/2017 | 5/24/2017 | 6/14/2017 | Systems Engineering Introduction, Program Life Cycle |
| 2 | 3 | 6/7/2017 | 6/7/2017 | 6/14/2017 | Problem / Need Understanding |
| 3 | 4,5 | 6/14/2017 | 6/7/2017 | 6/21/2017 | Rgmt Analysis & Documentation |
| 4 | 6 | 6/21/2017 | 6/14/2017 | 6/28/2017 | Functional Analysis & Synthesis |
| 5 | 7 | 6/28/2017 | 6/21/2017 | 7/5/2017 | Architecting |
| 6 | 8 | 7/5/2017 | 6/28/2017 | 7/12/2017 | Design & Interfaces |
| 7 | 9 | 7/12/2017 | 7/5/2017 | 7/19/2017 | Trade Studies |
| 8 | 10 | 7/19/2017 | 7/12/2017 | 7/26/2017 | Realization/ Integration/ V&V/ Test |
| 9 | 11 | 7/26/2017 | 7/19/2017 | 8/2/2017 | Specialty Engineering |
| 10 | 12 | 8/2/2017 | 7/26/2017 | 8/8/2017 | Risk |

**University of Southern California**
**Systems Engineering Theory and Practice (SAE 541)**

**Assignments & Exercises**

1. Assignment 1: Session 1: Course Overview: Assignment - Student Profile & Course Agreement, Due 5/24/2017

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***Be sure to turn in your Student Profiles before next class.***

| Student Name | Phone/FAX | E-mail |
|---|---|---|
| | | |

| Company & Location | Systems Engineering Experience | Industry Experience | Number of SAE and ISE Courses Taken |
|---|---|---|---|
| | | | |

| Objective in Taking Course | Learning Style http://vark-learn.com/the-vark-questionnaire/ Personality http://www.humanmetrics.com/cgi-win/JTypes2.asp | Other Comments |
|---|---|---|
| | | |
| | | |

Assignment 2: Session 1: Initiate Team Formation, Due May 31. 2017

Exercise 1: Session 2: Systems Engineering: Exercise #1: F-22 Program Integrated Product Development Teams Case Study; Due June 7, 2017 (Team Assignment)

Exercise 2: Session 3: Understanding the Problem / Need: Exercise #2: Problem/ Need Statement, Stakeholders' Needs Analysis; Due June 7, 2017 (Team Assignment)

Exercise 3: Sessions 4 & 5: Capability, Specification, SOW Documents: Exercise #3: QFD & Writing requirements, QFD, Pairwise Comparison, Pareto, & MOE Requirements, Due June 14, 2017 (Team Assignment); Team adjustments, if required

Exercise 4: Session 6: Logical Analysis: Exercise #4: Functional Analysis: Functional Context Diagram, OpsCon, Functional Flow Block Diagrams, Timeline, Data Flow Diagram, Performance Requirements, Due June 21, 2017 (Team Assignment)

Exercise 5: Session 6 & 7: Exercise #5: Architecting / Synthesis: Functional – Physical Matrix, Requirements Allocation Sheet (RAS), Physical Hierarchy, Schematic Block Diagram (SBD), Due June 28, 2017 (Team Assignment)

Exercise 6: Session 8: Systems Design Considerations & Interface Analysis: Systems Analysis: Exercise #6: States & Modes, N-Squared Diagram, Key Interfaces, & Timeline; Due July 5, 2017 (Team Assignment)

Exercise 7: Session 9: Systems (Product) Realization, Integration & Evaluation: Exercise #7: Trade Tree, Trade Study & Utility Curves, Trade Matrix, Due July 12, 2017 (Team Assignment)

Exercise 8: Session 10 & 11: Verification & Validation, Transition, Specialty Engineering: Exercise #8, Integration Strategy & Requirements, Verification Strategy & VCRM, TRS, Failure Modes & Effects Analysis; Criticality List, Specialty requirements & impacts, Due July 19, 2017 (Team Assignment)

Exercise 9: Session 12: Risk & Opportunity & Systems Engineering Next Steps: Exercise #9: Failure Modes & Effects Analysis; Criticality List, Specialty requirements & impacts, Due July 26, 2017 (Team Assignment)

Exercise #10, Risk Analysis: Risk Watch List, Risk Statement, Risk or Opportunity Matrix, Mitigation Waterfall, Due August 2, 2017 (Team Assignment)

## TEAM EXERCISES

## INSTRUCTIONS & REQUIREMENTS

**How to Select a Team Project**: First, examine possible system problems to be solved / or a need to be satisfied based upon a discussion between your team members and your instructor.

The more critical items to consider in selecting the topical area for your project are:

1. You are interested in the problem to be solved or satisfy a need. Reminder you will use the problem or need throughout the course.
2. There should be enough substance in the topic and organizational relevance to justify the time and effort.
3. Existing systems are not recommended. The topics can be based on a new or modification of an existing system. Information and software systems are also not recommended.
4. Proprietary systems not permitted.
5. Solutions should be avoid when choosing a project.

**Selection of Team Members:**

The information you provided in the STUDENT PROFILES is used for creating the Project Teams. Several criteria will be used,

Including

- Diversity in level of systems engineering experience and of academic study
- Geography
- Similarity of interest or industry in which team members are employed

*Note: Optionally the students may wish to organize their own teams with minimum instructor intervention*.

**References**:

1. International Council of Systems Engineering, *Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities*, 4th Edition, 2015. Hardcopy from Wiley, or online from INCOSE.org (electronic version is free with student membership or for USC students; instructions for USC student download is provided in D2L SAE 541
2. ISO/IEC/IEEE 26702, Systems Engineering - Application and management of the systems engineering process (replaces IEEE 1220™.
3. Defense Acquisition University, Systems Engineering Fundamentals, 2001. http://ocw.mit.edu/courses/aeronautics-and-astronautics/16-885j-aircraft-systems-engineering-fall-2005/readings/sefguide_01_01.pdf
4. Defense Acquisition University Guidebook, Chapter 4, Systems Engineering https://acc.dau.mil/CommunityBrowser.aspx?id=332951&lang=en-US
5. NASA Systems Engineering Handbook, NASA/SP-2007-6105 Rev1, December 2007 http://www.ap233.org/ap233-public-information/reference/20080008301_2008008500.pdf
6. Guide to the Systems Engineering Body of Knowledge (SEBoK) v 1.6 http://sebokwiki.org/wiki/Guide_to_the_Systems_Engineering_Body_of_Knowledge_(SEBoK) http://sebokwiki.org/wiki/Download_SEBoK_PDF
7. Systems Engineering for Intelligent Transportation Systems, 2007 http://ops.fhwa.dot.gov/publications/seitsguide/seguide.pdf
8. FAA Systems Engineering Manual , Version 1.1, 2015 https://sep.faa.gov/policy_and_guidance/main

**Administrative:**

DEN Instructional Support Center dentsc@usc.edu, dennotes@usc.edu, (213) 740-9356

DEN Exams and Proctoring,
https://gapp.usc.edu/graduate-programs/den/technical-support/homework-and-exams
(213) 821-3136 or denexam@usc.edu

Technical Support, Online Services, Webcast Problems, Software Questions or General Technical Questions
(213) 821-1321 or webclass@usc.edu

USC DEN Desire2Learn: https://www.uscden.net/

BlueJeans conferencing tool available for DEN@Viterbi Faculty and Students http://uscviterbi.bluejeans.com

**Other Considerations**

**Academic Integrity Statement** - "The School of Engineering adheres to the University's policies and procedures governing academic integrity as described in USC Campus. Students are expected to be aware of and to observe the academic integrity standards described in USC Campus, and to expect those standards to be enforced in this course. scampus.usc.edu

**Students with Disabilities:**
Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be

obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. - 5:00 p.m., Monday through Friday. The phone number for DSP is (213)740-0776."

**Quizzes:**

Quizzes will be given online and will consist of multiple choice questions. If a student has a recognized disability with respect to course work, he or she should follow the procedure on disabilities in the previous paragraph.

**Classroom Courtesies:**

For students attending the lectures on campus, standard classroom courtesies are expected. Cell phone use and conversations among students are not discouraged. These practices are distracting to the on-going lecture. These courtesies are also extend to DEN students who should mute their phones during lecture.

**Plagiarism:**

University policies on plagiarism will be in effect. For the exercises, material shall not be directly copied/ extracted from web sites or other sources, including internal company documents. Quotations within quotation marks are expected and references cited.

***Sources***: *Students must properly reference all sources*. If a student directly quotes text from a source, they must properly designate quoted material "in quotation marks" *or in italics*, and give a citation for each quotation via a footnote or a numbered reference. Please do not use in-text (author-date) notation for citations. The amount of quoted text relative to the total text in your paper should be kept to a minimum-- if excessive; this will detract from the paper's grade.

Please cite references used in class exercises even lecture notes. Should use APA and CSE reference formats. Check Research and Documentation Online (DianaHacker.com) for more information. Examples:

1. Book - Mai J, Paxinos G, Assheuer J. Atlas of the human brain. 2nd ed. Burlington (MA): Elsevier; 2004.
2. Journal - Gulbins E, Lang F. Pathogens, host-cell invasion and disease. Am Sci. 2001; 89(5): 406-413.
3. Magazine - Stevens MH. Heavenly harbingers. Smithsonian. 2001 Nov:20, 22.
4. Lecture - Hines, J. SAE 541 Class Note Lecture# , slides ##

Indicate reliability of source, i.e. Wikipedia http://en.wikipedia.org/wiki/Electric_car. Provide more than just link to website. Example:

Graphic Newcastle Engineering Design Centre:
http://www.edc.ncl.ac.uk/assets/graphics/cost.png, July 2005

**Limits**: The SAE Program cannot accept a request to limit access to abstracts or research papers. Although the plan is not to disseminate student's work without their permission, The SAE Program cannot guarantee that other people (including non-US citizens) will not view or handle your submitted materials. Thus, student must not use classified, proprietary or company limited-

distribution materials in their coursework. If a student's employer requires review and approval for their submitted materials (e.g. Public Affairs Office or Export Compliance Review) then the student must obtain such approval within the deadlines listed in this syllabus. As the approval practices in many companies may be time consuming, the best practice is not to use company material at all."

**Help Wanted:**

We encourage asking for help. Do not assume. Our phone numbers and e-mail addresses listed at the top of this syllabus. However, we encourage the use of the discussion board since others may have same inquiry about course materials, etc.

Also, e-mail us. The usual turnaround time for discussion board or emails is less than 24 hours. If you do not hear from us within that timeframe, please send us a reminder. Always include the TA in any email sent to the instructor.