

UNIVERSITY OF SOUTHERN CALIFORNIA
COURSE SYLLABUS

SAE 541
SYSTEMS ENGINEERING THEORY AND PRACTICE

Class lectures: Tuesdays: 4:00–6:40 p.m. PT

Location: OHE 120 and via DEN / WebEx

Instructor: Dr. Robert Minnichelli

Phone (mobile): 310-291-8380
(urgent use only – use DEN Discussion Board for most questions,
Email for more private discussions like grading, issues, etc.)

Email: minniche@usc.edu

Office Hours: Mondays 6:00-6:30 PT, “virtual” via TBD
(details to follow, time may change based on student availability)

Course Producer: TBD

Office Hours: On request

Email: TBD

References:

Required:

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 or through the USC Library.
 - a. The electronic version is included with paid regular or student membership in INCOSE or, for USC students, with a free CAB-limited membership. Many corporations and government organizations are also CAB members. Use your USC e-mail address to join if joining for free as a USC student, or your company/organization e-mail address if joining for free that way. <https://www.incose.org/about/Membership/Join>
 - b. You can also download it for free as a PDF chapter by chapter from Wiley via the USC library, or access it directly as needed: <https://ebookcentral.proquest.com/lib/socal/detail.action?docID=4040424&pq-origsite=primo> (you need to be logged into your USC account).

- c. If you decide to buy a hard copy, please make sure it's the 4th Edition. But note that a new 5th Edition is planned to be published in the next year or so, so you might want to wait to get a hard copy.
2. Department of Defense Acquisition University, *Systems Engineering Fundamentals*, 2001. Free government PDF document online:
http://space.se.spacegrant.org/SEModules/Reference%20Docs/DAU_SE_Fundamentals.pdf
3. *NASA Systems Engineering Handbook*, NASA/SP-2016-6105 Rev2, 2017. Free government PDF, Kindle, or eBook document online:
nasa.gov/sites/default/files/atoms/files/nasa_systems_engineering_handbook_0.pdf

Recommended:

4. *Systems Engineering and Analysis*, 5th Edition, Blanchard and Fabrycky, Prentice Hall, 2011.
5. *DoD Systems Engineering Guidebook*, February 2022.
https://ac.cto.mil/wp-content/uploads/2022/02/Systems-Eng-Guidebook_Feb2022-Cleared-slp.pdf
6. FAA Systems Engineering Manual, v. 1.0.1, 2014. Free government PDF document online:
http://everyspec.com/FAA/FAA-General/FAA_SEM_V1x0_19JUN2014_52250/
7. Expanded Guidance for NASA Systems Engineering (Volumes 1 and 2), NASA/SP-2016-6105-SUPPL
<https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20170007238.pdf>
<https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20170007239.pdf>

Other references will be uploaded to DEN, a few to be assigned as required readings throughout the course.

Other Resources:

USC Distance Education Network (DEN): <http://gapp.usc.edu/den>

USC DEN Desire2Learn: <https://www.uscdcn.net/>

DEN Exams and Proctoring,

denexam@usc.edu,

(213) 821-3136

Fax: (213) 821-0851

Instructional Support Center,

denotes@usc.edu.

(213) 740-9356

Technical Support,

webclass@usc.edu

Online Services, Webcast Problems, Software

(213) 821-1321

Questions or General Technical Questions

Course Description:

Systems engineering is the engineering discipline dedicated to integrated system design and

implementation from a holistic perspective. It involves viewing the system problem space in its entirety from the initial concept throughout the lifecycle to retirement. As systems and systems-of-systems grow in complexity, the importance of an interdisciplinary approach that considers stakeholder's needs, design, cost, production, safety, quality, test, implementation and the impact of the system's use in the environment, becomes increasingly important.

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

Among the topics to be covered in the class are:

- Perspectives of Systems, System Types and System Architecture
- Systems Engineering Process, Acquisition, & Life Cycle Models
- The Value of Systems Engineering
- Systems Engineering Standards
- Systems Thinking and the Systems Approach
- Requirements & Functional Analysis
- Synthesis, Architecting, and Design
- Systems Analysis and Control
- Specialty Engineering
- Implementation, Integration, Transition, Operation, Sustainment, and Disposal
- Integration, Verification, Validation, and Test
- Model Based System Engineering
- Real World Considerations & Advanced Topics

Course Objectives:

Scope

Systems engineering is a multi-disciplined approach to transform operational needs and requirements into an integrated system design solution through the concurrent considerations of the entire enterprise and life cycle of the system under consideration. This course will acquaint you with concept of systems and the role systems engineering plays in their development. It will also provide a basic framework for problem solving and integrated enterprise thinking within the systems engineering process.

It is the intent of this course to give the student a strong foundation in the fundamentals of system engineering, and at the same time, introduce the student to innovative systems approach to problem solving and team leadership.

Goals

1. Establish an understanding of basic system and systems engineering concepts and terms
2. Introduce systems engineering as a problem-solving process / approach, project decision support, and its relationship to program life cycle
3. Instill in the minds of the students that systems engineering is holistic thinking
4. Understand the systems engineering technical processes and their interactions
 - a. Understand how the technical processes are both distinct and integrated
 - b. Produce various systems engineering artifacts
 - c. Reflect the systems engineering principles in the development of artifacts
 - d. Understand useful theories, models, techniques and tools
 - e. Address design for operational feasibility (specialty engineering) concepts
5. Enable the students to develop their systems thinking and leadership skills by developing a class project
6. Improve the student's "team and soft skills"

Course Highlights:

1. Lectures
2. Homework assignments (individual and team-based)
3. Team projects
4. Midterm exam / Final exam

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

Course Grading:

USC Grading Policies shall be followed. The course activity breakdown is as follows:

Homework Assignments	20%
Midterm and Final exam	40%
Team Project	40%

All assignments will be submitted through DEN Desire2Learn 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, homework is due at 10:00 am PT on the day of the lecture following the week that it is assigned. Please consult the teaching assistant or instructor before the day the homework is due if there are special circumstances that prevent you from submitting homework on time.

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:
<https://policy.usc.edu/scampus/>

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.

Classroom Courtesies:

Standard classroom courtesies are expected from students attending the lectures on campus. Cell phone use and conversations among students are not allowed. These practices are distracting to the on-going lecture. These courtesies also extend to DEN students who should mute their phones during lecture when not speaking to the class.

Planned Course Schedule (subject to change):

Mtg #	Topic	Reading and Homework Assigned
Week 1 Aug 23	Course Overview // Introduction to Systems Engineering Concepts // Value of Systems Engineering	INCOSE SEH, Ch. 1&2 DoD SE Fundamentals, Ch. 1&2 NASA SEH, Ch. 1&2 HW #1 (incl. "book report" topic)
Week 2 Aug 30	Systems Engineering Processes Overview & Life Cycles // "Book Report" selection due	INCOSE SEH, Ch. 3 DoD SE Fundamentals, Ch. 3 NASA SEH, Ch. 3 HW #2 (incl. one artifact from team mtg)
Week 3 Sept 6	Mission & Business Analysis // Stakeholders, Needs, Scope, and CONOPS // Proposed project topic due	INCOSE SEH, Ch. 4.1-4.2 DoD SE Fundamentals, Ch. 4.1 NASA SEH, Ch. 4.1 HW #3
Week 4 Sept 13	Requirements Analysis and Development //	INCOSE SEH, Ch. 4.3 DoD SE Fundamentals, Ch. 4 NASA SEH, Ch. 4.2, 6.2, App. C HW #4
Week 5 Sept 20	Functional Analysis and Allocation	INCOSE SEH, Ch. 9.3 DoD SE Fundamentals, Ch. 5 NASA SEH, Ch. 4.3 NASA ExpGuidance v2 App. F HW #5 (plus "book report")
Week 6 Sept 27	Architecture Definition // Design Definition // "Book Report" due	INCOSE SEH, Ch. 4.4-4.5 DoD SE Fundamentals, Ch. 6 NASA SEH, Ch. 4.4 NASA ExpGuidance v2 7.2-7.3 HW #6

Mtg #	Topic	Reading and Homework Assigned
Week 7 Oct 4	Systems Analysis and Control	INCOSE SEH, Ch. 4.6, Ch. 5.2-5.7, 9.1 DoD SE Fundamentals, Ch. 10, 12-15 NASA SEH, Ch. 6.3-6.7, App. L HW #7
Week 8 Oct 11	Team presentations // Action Item Prep	HW #8 – incl. draft AIs and feedback
Week 9 Oct 18	Midterm Exam – NO LECTURE (Open Book, online)	
Week 10 Oct 25	Implementation, Integration, & Transition, Interface Analysis // Draft AI's due 10/25	INCOSE SEH, Ch. 4.7, 4.8, 4.10, 5.8, 7.5, 9.6-9.7 NASA SEH, Ch. 5.1-5.2, 5.5, App H HW #10
Week 11 Nov 1	Verification, Validation, Quality, Test // Feedback on Draft AIs to originators 11/1	INCOSE SEH, Ch. 4.9, 4.11 DoD SE Fundamentals, Ch. 7 NASA SEH, Ch. 5.3-5.4, App. D, E, I HW #11
Week 12 Nov 8	Decision Analysis and Value Functions // Cost analysis // Final AIs Due from originators 11/9	INCOSE SEH, Ch. 5.3, 10.1 NASA SEH, Ch. 6.8 NASA ExpGuidance v1 6.1.2.2 MBSE paper reading assignment HW #12
Week 13 Nov 15	Model-Based Systems Eng. // AI “Dispositions” Due (w any project updates) 11/15	INCOSE SEH, Ch. 9.1 (review), 9.2 HW #13
Week 14 Nov 22	Specialty Engineering, Security	INCOSE SEH, Ch. 10
Week 15 Nov 29	Operation, Maintenance, Disposal // Review & Final Exam focus areas	INCOSE SEH, Ch. 4.12-4.14
(no class) Dec 6	(USC “Study Days”: Dec 3-6)	
FINAL: Tuesday Dec. 13	Final Exam: (closed book, timed, very focused)	Nominally 4:30-6:30 p.m. PT (University exam schedule) https://classes.usc.edu/term-20223/finals/

Weekly Homework (20% of course grade):

- Will be assigned weekly to work the following week.
- Will be due the next Tuesday at 10:00 a.m. PT
- Late homework received before class at 4:00 p.m. PT will be accepted and graded with a 10% penalty. [Rationale: Motivate an early input to provide a brief opportunity for me to review submissions prior to lecture and comment, but with small penalty.]
- Late homework received after the class starts (where the answers may be discussed) will be accepted for one more week and graded with a 50% penalty. [Rationale: Once we discuss the answers, it’s obviously easier to provide the responses, but there

is still learning value in terms of working it out and writing it down.]

Book Report: (Optional, Extra Credit)

If you choose to participate, then select one book from the list below that you haven't read before signing up for this class:

- Donella Meadows, "Thinking in Systems: A Primer", 2008. 240 pages.
- Hammond and Keeney, "Smart Choices: A Practical Guide to Making Better Decisions", 2015. 256 pages.
- Janine Benyus, "Biomimicry: Innovation Inspired by Nature", 1997/2002. 308 pages. (introductory 20-minute video: treemedia.com/biomimicry)
- de Weck, Roos, and Magee, "Engineering Systems: Meeting Human Needs in a Complex Technological World", 2011. 183 pages.
- Peter Bernstein, "Against the Gods: The Remarkable Story of Risk", 1998. 400 pages.

None of these teach systems engineering processes the way we study them in this class. They are all somewhat peripheral, but definitely related, to the core topics in this class. And they are all relatively easy reading (although they all take work to put into practice).

Identify your selected book at Week 2 as part of homework #1. Submit your "book report" (about 2 pages) in Week 6 along with homework #5. Your report should provide a brief summary of the whole book and also address the question: *How do the concepts in this book relate to the stakeholder needs and requirements development process?* The report should also refer to and integrate into the theme at least 3 concepts or quotes from different parts of the book.

This should be an enjoyable assignment that lets you explore a peripheral topic of interest while integrating it into your "systems thinking" approach. If you don't think it will be enjoyable, you shouldn't do it – it's optional with a relatively small grade impact.

Team Project initial products (20% of course grade):

During weeks 2 – 8, we'll divide into teams of 4-6 students (or "groups" in Desire2Learn) to conduct team projects. Each team will develop a specification for a new capability of some sort that goes beyond currently available capabilities and present that spec in a 15-minute presentation in the style of an abbreviated requirements review.

The various teams will work on different versions of a similar project, to be defined at the first lecture.

During the week 8 class, each team will make a 15-minute presentation of their results to the class. Each team submits one "specification" and one "presentation" prior to the week 8 class, and may update these the following day (any significant but simple

feedback from the presentation can be incorporated in this next-day update). Format of submissions will be discussed in class in advance.

As part of HW#8 (due week 10), each student rates each teammate:

- Exceeded expectations and sort of “carried the team”; maybe “dominated”
- “Pulled his or her weight”; contributed substantially and consistently to ideas and discussions (I hope most people will be in this category)
- Participated somewhat, minor contributions, but not really significant; this is also how you should rate someone if you really don’t know if they contributed or not
- Completely slacked off; just didn’t contribute at all, maybe didn’t even show up

Grading: The grade of everyone on the team will be dominated by the graded quality of the products and presentation. There may be small individual adjustments up and down due to teammate ratings on individual participation. I will not indicate if any adjustments were made in the grade provided to the student.

Individual Student Feedback to Projects – Assessment and “Action Items” (10% of course grade):

Individuals will provide “action item” feedback or clarification requests to the other teams’ projects in a formal design review “action item” format. We will discuss the use and intent of this process in class.

Update to Projects incorporating provided feedback (10% of course grade):

Teams will disposition the action items that they receive, determining if each needs to be addressed, and if so, if it is a future action for the team (beyond the scope of this review and this class project) or should result in an update to the design review products (specification and presentation). Any updates will be incorporated and submitted as a “final” set of products.

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call

studenthealth.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call

suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press “0” after hours – 24/7 on call

studenthealth.usc.edu/sexual-assault

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086 | Title IX – (213) 821-8298

equity.usc.edu, titleix.usc.edu

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298

usc-advocate.symplicity.com/care_report

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776

dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.