SE498 Systems Engineering

Fall 2019

Instructor: Prof. William R Norris
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210B Transportation Building

3:30 – 4:50 TR, 112 Transportation Bldng
Undergraduate – 3 hr CRN 70948
Graduate – 4 hr CRN 70949
Office Hours – By Appointment

Teaching Assistant

Course Description/ Overview

This course in systems engineering examines the principles and process of creating effective systems to meet application demands. The concepts, problems, and methods of systems engineering are introduced in lectures and discussions and applied in assignments and through a semester-long group project.

The focus is on systems of hardware and software components engineered to perform complex behavior. Such systems embed computing elements, integrated sensors and actuators, operate in a reliable and timely fashion, and demand rigorous engineering from conception through production. Applications of robotics and autonomous systems will be used to illustrate applications and challenges in engineering complex systems.

The course is organized as a progression through the systems engineering processes of analysis, design, implementation, and deployment with consideration of verification and validation throughout. Case studies in each phase present best practice in the field, and both successes and failures are considered. Reading assignments from the textbook and current literature tie theory to practical methods of creating complex engineered systems. Homework assignments reinforce concepts and provide direct experience of key techniques.

The course should be appropriate for graduate students in all areas and for advanced undergraduates who intend to become practicing engineers.

Prerequisites

This course is designed for senior undergraduate and graduate students with some experience in the practice of engineering—students who have built things. We intend to learn by doing, students must have some basic skills to be able to get started and sustain themselves as they learn new information and techniques from lectures and readings. Any concerns about your background should be discussed with the instructor.

Course Goals

This course will examine the analysis, design, and systems issues of complex engineered systems with particular attention to the parallel development of hardware and software.

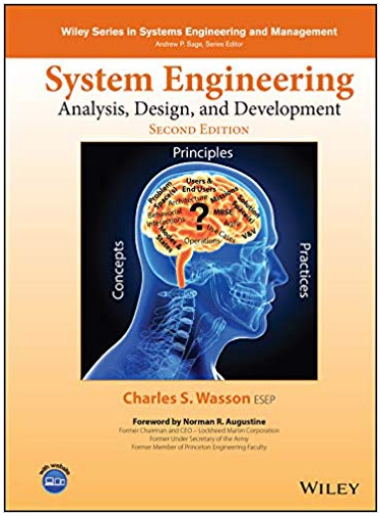
By the end of this course students will be able to:

- Examine systems from many perspectives (such as software, hardware, product, etc.)
- Identify how the assumptions and constraints of each subsystem affect other subsystems
- Contrast systems engineering with software, electrical, and mechanical engineering
- Plan and manage the systems engineering process

- Identify the critical requirements imposed by applications including temporal and quality attributes
- Identify and evaluate analysis and design methods
- Identify, capture, model, and analyze system requirements
- Formulate system concepts (concept of operation)
- Architect a system
- Identify and state temporal issues associated with system performance
- Predict and assess the impact of usability issues in system operation
- Identify and resolve critical aspects of a system by prototyping
- Document designs at appropriate levels of detail
- Validate system requirements, concept, and design
- Assess risks and failure modes
- Distinguish critical functions, diagnose problems, and apply descoping strategies
- Conduct test and evaluation plans
- Judge the complexity of production and deployment issues
- Apply the entire systems engineering process from formulation though implementation

Textbooks and References

Charles S. Wasson, System Analysis, Design, and Development: Concepts, Principles, and Practices; Wiley-Interscience, John Wiley and Sons, Inc.: Hoboken, NJ; 2006. ISBN-13 978-0-471-3933-7.



References:

Students may choose to join the International Council on Systems Engineering for the Student Fee of $38.00, and thus gain access to the 4th Edition of the INCOSE Systems Engineering Handbook; the Primer on Metrics; the Systems Engineering Body of Knowledge (SeBoK); and, all of the proceedings from the last 21 years of international symposia on systems engineering. These benefits are good for an entire calendar year. [http://www.incose.org/]

Students may choose to download a free copy of the Defense Acquisition University manual on systems engineering, Systems Engineering Fundamentals, Defense Acquisition University Press, January 2001. [http://www.dtic.mil/dtic/tr/fulltext/u2/a606327.pdf]

Expectations

To succeed in this class, you will need to:

- Read the chapter before coming to class, and formulate questions
- Participate in the class
- Make sure you understand the homework problems and solutions
- Seek out help when you have trouble

Obtaining help: The main two ways to obtain help are online at Piazza or in person at office hours. You can also speak with your professor briefly after lecture. Please do not send email directly to TAs or professors for routine help or absences. In cases of emergencies related to exams (e.g., illness) you should email your professor at the earliest possible opportunity.

Online Resources/ Forum

Email

Email communication should be addressed to both the instructor and TA (If there is one. All relevant email will start with the subject line: SE 498: [SUBJECT]. The TA (If there is one), will respond to emails as soon as possible and will check emails at least once per day.

Compass

We will use Illinois Compass as the central site for course resources. This includes announcements, online homework questions, a discussion board, and grades.
https://compass2g.illinois.edu/

Piazza

This class uses Piazza for all communication between the instructor, TAs, and students. Please visit https://piazza.com/illinois/fall2018/se498 to register. The Piazza link will take you to the current class page at any time. Official class announcements will be sent via Piazza, so you must register with an email address that you regularly check. If you desire, you can post anonymously on Piazza or make a private post just to the instructors (this should be done rather than emailing the professor directly). TAs are scheduled to be checking Piazza three times per day during the week. Note that Piazza should be used to communicate with your instructors, rather than email.

Media Use in Class

Please turn off your phone-ringer before class.

Activities and Grading

There are two sections for this class. The 4-credit graduate students will be assigned extra problems/extra homework. 3-credit undergraduate students may attempt these problems for EXTRA CREDIT. The grade break-down:

Undergraduate (3 credit hours)	***Graduate (4 credit hours)***
Participation 5%	Participation 5%
Assignments 20 %	Assignments 10 %
Weekly Quizzes 20 %	Project 15 %
Two Examinations 30 % (15 %each)	Weekly Quizzes 20 %
Final Examination 25 %	Two Examinations 25 % (12.5 %each)
	Final Examination 25 %

Participation

Participation in class and group work is essential to success in any project and in this class. The quality and quantity of contributions to the class activities and discussion will contribute 5% to each student's final grade.

Assignments

Assignments will be given during this course for completion individually. These assignments will apply lecture and reading material and require specific skills and knowledge. There will be 5 assignments that will be posted on the course website. They are on due dates that will be shown in Compass. Homework must be turned physically in class AND electronically to Compass.

IMPORTANT: Students are responsible of ensuring that their work is correctly and successfully submitted electronically and should notify the instructor of any problems in this matter at least 30 minutes before the homework deadline. Students are encouraged to submit their homework assignments at least 40 minutes before the deadline.

Weekly Quizzes

The 10-minute quizzes will consist of questions designed to test your comprehension of the concepts we will cover during the lecture. They will be given on the last day of class on every week where there is no exam. The lowest quiz grade will be dropped at the end of the semester.

Two Non-Cumulative Examinations and Cumulative Final

There are two in-class non-cumulative exams and a cumulative final that will be held on the dates listed in the schedule. If you are unable to sit for an exam for legitimate reasons (e.g. family emergencies, serious illness, attending a conference, etc.), please let the instructor and TA know in advance so that we can accommodate you. Not showing up w/o prior notice will result in 0 (zero) grade for the exam in question.

Project

In addition to the homework and exams, 4-credit students will have to do an independent case study project. The topic of the project must be discussed with and approved by the instructor by September 28. Additional guidance will be announced on COMPASS and in class. All 4-credit students are expected to present their final project during class time on December 7th and 10th. 3-credit students MUST attend these presentations.

Final Grade

The final grade will be related to the total number of grade points you have earned during the course. Grades will be posted in Illinois Compass so that you can monitor your progress. Attendance of lectures and active participation are a plus. A total points-to-grade scale will be based on gaps in the total final score of the class students.

Grade ranges:

98 + -- A+	77-78 -- C+
92-97 -- A	72-76 -- C
89-91 -- A-	69-71 -- C-
87-88 -- B+	61-68 -- D
82-86 -- B	60- -- F
79-81 – B	

Course Policies

Read and abide by the Code of Policies and Regulations Applying to All Students at http://www.admin.uiuc.edu/policy/code/index.html. Please be aware that this syllabus may change during the semester. Changes to the syllabus will be announced in class and on Compass.

Academic Integrity

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: http://studentcode.illinois.edu/. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any

misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Schedule (Tentative)

Month	Date	Chapter and Topic	Page
August	27	1 Systems, Engineering, and Systems Engineering	1
	29	2 The Evolving State of SE Practice-Challenges and Opportunities	17
	31	PART I SYSTEM ENGINEERING AND ANALYSIS CONCEPTS	49
		3 System Attributes, Properties, and Characteristics	51
September	2	**Labor Day**	
	3	4 User Enterprise Roles, Missions, and System Applications	76
	5	5 User Needs, Mission Analysis, Use Cases, and Scenarios	99
	10	6 System Concepts Formulation and Development	129
	12	7 System Command and Control (C2) - Phases, Modes, and States of Operation	147
	17	8 System Levels of Abstraction, Semantics, and Elements	174
	19	9 Architectural Frameworks of the SOI and Its Operating Environment	198
	24	10 Modeling Mission System and Enabling System Operations	219
	26	11 Analytical Problem-Solving and Solution Development Synthesis	245
October	1	Exam 1	
	3	PART II SYSTEM ENGINEERING AND DEVELOPMENT PRACTICES	255
		12 Introduction to System Development Strategies	257
	8	13 System Verification and Validation (V&V) Strategy	270
	10	14 The Wasson Systems Engineering Process	293
	15	15 System Development Process Models	313
	17	16 System Configuration Identification and Component Selection Strategy	344
	22	17 System Documentation Strategy	365
	24	18 Technical Reviews Strategy	376
		19 System Specification Concepts	397
	29	20 Specification Development Approaches	415
		21 Requirements Derivation, Allocation, Flow Down, and Traceability	429
	31	22 Requirements Statement Development	446
		23 Specification Analysis	465
November	5	24 User-Centered System Design (UCSD)	480
		25 Engineering Standards of Units, Coordinate Systems, and Conventions	518
	7	26 System and Entity Architecture Development	542
		27 System Interface Definition, Analysis, Design, and Control	575
	12	28 System Integration, Test, and Evaluation (SITE)	599
		29 System Deployment, OM&S, Retirement, and Disposal	623
	14	PART III ANALYTICAL DECISION SUPPORT PRACTICES	649
		30 Introduction to Analytical Decision Support	651
	19	31 System Performance Analysis, Budgets, and Safety Margins	666
		32 Trade Study Analysis of Alternatives (AoA)	682
	21	Exam 2	
	25,26,27	**Thanksgiving Holiday**	
December	3	33 System Modeling and Simulation (M&S)	703
	5	34 System Reliability, Maintainability, and Availability (RMA)	721
	7	***Project Presentations***	
	10		
	TBD	***Final Exam***	

Students with Disabilities

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the DRES as soon as possible. To ensure that disability-

related concerns are properly addressed from the beginning, students with disabilities who require assistance to participate in this class should contact Disability Resources and Educational Services (DRES) and see the instructor as soon as possible. If you need accommodations for any sort of disability, please speak to me after class, or make an appointment to see me, or see me during my office hours. DRES provides students with academic accommodations, access, and support services. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TDD), or email a message to disability@uiuc.edu. http://www.disability.illinois.edu/.

Emergency Response Recommendations

Emergency response recommendations can be found at the following website: http://police.illinois.edu/emergency-preparedness/. I encourage you to review this website and the campus building floor plans website within the first 10 days of class. http://police.illinois.edu/emergency-preparedness/building-emergency-action-plans/.