



ECE544 Fault-Tolerant Computing and Reliability Engineering

Fall 2022

Electrical and Computer Engineering Department
University of Massachusetts Dartmouth

- Instructor:** Prof. Liudong Xing, SENG 213C, Phone: (508)999-8883, Email: lxing@umassd.edu
- Time & Place:** Monday & Wednesday, 3:30pm ~ 4:45pm @ SENG 212 (**Face-to-face Modality**)
- Office Hours:** Mon./Wed. 2:00pm ~ 3:00pm (**In-person**); Tue. 1:00pm ~ 3:00pm (**Virtual**) by joining the following Zoom meeting room or other time by appointment via email.
<https://umassd.zoom.us/j/96832974567?pwd=NnRva1l6Ti9zUEEx4bW52WGIJPUTBIUT09>
- Feedback:** Send Prof. Xing anonymous feedback using *Yahoo* account: ID: [feedback02747](#) PWD: [feedback4xing](#)
- Catalog Description:** Techniques for designing and analyzing dependable computer-based systems. Topics addressed include: fault, error, and failure cause-and-effect relationships; fault tolerance techniques, including hardware redundancy, software redundancy, information redundancy, and time redundancy; fault coverage; time-to-failure models and distributions; reliability modeling & evaluation techniques, including fault trees, cut-sets, reliability block diagrams, binary decision diagrams, and Markov models. In addition, availability modeling, safety modeling, and trade-off analysis are presented. A research project & investigation of current topics is also included.
- Course Objectives:** This course is intended to introduce the students to modern techniques for designing and analyzing fault-tolerant and dependable computer-based systems. The course attempts to provide the students a clear understanding of why systems fail and how they can be designed to tolerate failures and operate reliably and safely. The course presents various techniques for fault tolerance and various techniques for modeling and evaluating system reliability, and availability. The students investigate the design of existing systems to acquire an understanding of how the theory presented in this course is used in practice. Lastly, a research project that will prepare the students to perform research in fault-tolerant computing, hardware and software reliability engineering is required.
- Learning Outcomes:** Upon successfully completing this course, the student will be able to
- Demonstrate knowledge of modern techniques for designing and analyzing fault-tolerant and dependable computer-based systems
 - Achieve a clear understanding of why systems fail and how they can be designed to tolerate failures and operate reliably and safely
 - Develop a suitable mathematical representation of the system failure behavior
 - Analyze the reliability performance of computer-based systems using appropriate models and techniques.
 - Evaluate design alternatives and compare two or more systems in terms of the system reliability
- Credits:** 3-credit hour (**meeting the MS CPE math course requirement**)
- Prerequisites:**
- Probability (MTH 331 or ECE 384 or equivalent)
 - Differential equations (MTH212 or equivalent)
- Course Website:** <https://xingteaching.sites.umassd.edu/>: all important class information including lecture, homework assignments, projects, exams, and major deadlines will be posted to this site. The website also includes a frequently asked questions (FAQ) section for homework, exams, and projects. Check the website frequently since new announcements and information about the class will be added regularly.
- Resources:**
- **Lecture notes** prepared by Prof. Xing, available from the class website
 - **Book chapters & research papers**
 - **There is no required textbook**
 - **Recommended references**
M. Rausand & A. Hoyland, "System Reliability Theory: Models, Statistical Methods, and Applications" (2nd Ed.), Wiley, 2003
B. W. Johnson, "Design and Analysis of Fault Tolerant Digital Systems", Addison-Wesley, 1989

L. Xing and S. V. Amari, "Binary Decision Diagrams and Extensions for System Reliability Analysis", Wiley-Scrivener, MA, ISBN: 978-1-118-54937-7, July 2015
K. S. Trivedi, "Probability and Statistics with Reliability, Queuing and Computer Science Applications" (2nd Ed.), Wiley, 2002
M. Modarres, M. Kaminskiy, and V. Krivtsov, "Reliability Engineering and Risk Analysis" (2nd Ed.), CRC Press, 2009, ISBN 978-0-8493-9247-4
Martin L. Shooman, "Reliability of Computer Systems and Networks: Fault Tolerance, Analysis, and Design", John & Sons Wiley, 2002, ISBN 0-471-29342-3.

- Topic Outline:** A tentative topic outline that is subject to changes based on class performance & exceptional cases:
- Concepts of fault-tolerant and dependable systems
 - Fault, error, and failure
 - Hardware redundancy techniques: passive, active, and hybrid techniques
 - Information redundancy techniques: error detecting and correcting codes
 - Time redundancy techniques
 - Software redundancy techniques: distributed recovery block, N-version programming, and N self-checking programming
 - Time-to-failure models & distributions
 - System reliability modeling and evaluation techniques: fault trees, reliability block diagrams, cut/path sets, binary decision diagrams, and Markov models
 - Sensitivity analysis
 - Network reliability analysis
 - Availability modeling and analysis
- Project:** A research project on a topic relevant to fault-tolerant computing and reliability engineering is required (see Project Description for more details)
- Grading Policy:** The final grade will be calculated as a weighted average:
- Homework: 8%
 - Project: 20%
 - Midterm (tentative date: Oct. 17, Mon.): 30%
 - Final (3pm ~ 6pm, Dec. 15, Thu.): 42%
- See final exam schedule at <http://www.umassd.edu/registrar/finalexams/>
- There will be in-class extra-credit problems: participation in these problems would help your grade (although non-participation would not hurt your grade). There is **no make-up** for missed extra-credit problems!
- The letter grades will be assigned using the following approximate scale:
(A+, A) [100-90] (A-, B+, B) [90-80] (B-, C+, C) [80-70] (C-, D+, D) [70-60] (D-) [60-57] (F) [<57]
- https://catalog.umassd.edu/content.php?catoid=62&navoid=5015#Grades_and_Grading_System
- Incomplete Grade Policy:** The incomplete policy is that at least 70% of the course must be already completed and an exceptional circumstance (i.e. medical issue) must exist. If you feel you require an incomplete for an exceptional reason, you need to email me and state your reasons for incomplete in writing. We will then decide on a course of action.
- Late Assignments Policy:** Assignments are always due at the beginning of class on the due date. **Unless you have a legitimate reason and inform the instructor in advance**, late assignments are subject to the following penalty: assignments one day late subtract 10%; two days late loses 25%; three days late loses 50%. After three days the assignments will be considered a ZERO.
- Exam Policy:** It is your responsibility to take exams at the scheduled times and to make alternative arrangements **in advance** if you have a **legitimate** reason for not being able to take an exam at the scheduled time.
- Attendance Policy:** Students are expected to regularly attend classes and all other scheduled activities related to the course in person. The instructor reserves the right to record attendance from time to time (not regularly). Students who miss a lecture must self-study the missed material and make arrangement with the instructor about any questions of the missed lecture when necessary.

Please follow the health and safety protocols (<https://www.umassd.edu/covid/>) when you come to the campus.

Special Needs: Please feel free to contact the instructor if you have any special needs. Particularly, if you or a family member become sick that affects your submission of an assignment or participation in an exam, please feel free to email me to request an extension to complete the assignment without late penalty or alternative arrangements for the exam.

Communication Plan: Please check the class website frequently; the *Recent Posts* section will be used as a primary means of notification of new assignments, deadlines, any class related announcements and information.

Other than questions asking and answering during the specified office hours, you may also email me (lxing@umassd.edu) with your questions. You can expect a reply from me via email within 24 hours during the workweek. If the question a student asked is of a nature that even one other student in the course could benefit from the answer, the question and the answer will be posted in the FAQ section of the course website.

In Case of Difficulty: If you feel yourself slipping behind, feel free to come and see the instructor for advice. If you do decide the class is not happening for you at this semester, the last day to Add/Drop is **Monday, Sept. 12, 2022**, and the last day to withdraw is **Monday, Nov. 14, 2022**. However, before you withdraw, discuss your decision with the instructor and your academic advisor.

Academic Integrity: Unless specifically stated otherwise, all homework assignments and exams in this class are to be completed without help from anyone other than the instructor. Any collaboration with others or use of work completed by others for previous offerings of this class is considered to be unauthorized aid. Furthermore, you should explicitly acknowledge any sources of ideas used that are not your own; this includes other people, books, web pages, etc. **Academic dishonesty will be "rewarded" with a grade of "F"**. For more details on academic integrity, refer to Student Handbook:

<https://www.umassd.edu/studentaffairs/studenthandbook/academic-regulations-and-procedures/>

Academic Support Services: Academic Resource Center (www.umassd.edu/arc/), Writing&Multiliteracy Center (www.umassd.edu/wmc/), Engineering Student Support & Services (ES³, <https://www.umassd.edu/engineering/support/>), STEM Learning Lab (<https://www.umassd.edu/arc/stem-learning-lab/>), Center for Access & Success (www.umassd.edu/dss/)

Title IX Information: The purpose of a university is to disseminate information, as well as to explore a universe of ideas, to encourage diverse perspectives and robust expression, and to foster the development of critical and analytical thinking skills. In many classes, including this one, students and faculty examine and analyze challenging and controversial topics.

If a topic covered in this class triggers post-traumatic stress or other emotional distress, please discuss the matter with the professor or seek out confidential resources available from the Counseling Center, <http://www.umassd.edu/counselling/>, 508-999-8648 or - 8650, or the Victim Advocate in the Center for Women, Gender and Sexuality, <http://www.umassd.edu/sexualviolence/>, 508-910-4584. In an emergency contact the Department of Public Safety at 508-999-9191 24 hrs./day.