PURDUE UNIVERSITY | Elmore Family School of Electrical and Computer Engineering

Engineering Faculty Document No. EFD 45-22
January 31, 2022

Memorandum

To: The College of Engineering Faculty

From: The Elmore Family School of Electrical and Computer Engineering

Re: Course modifications to ECE 36900 Discrete Math for Computer Engineering

The faculty of the Elmore Family School of Electrical and Computer Engineering has approved the changes to the following undergraduate course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM

ECE 36900 Discrete Math for Computer Engineering, Sem. 1, 2, Class 3, Lab 0, Cr. 3.
Prerequisites: ECE 27000

This course introduces discrete mathematical structures and finite-state machines. Students will learn how to use logical and mathematical formalisms to formulate and solve problems in computer engineering. Topics include formal logic, proof techniques, recurrence relations, sets, combinatorics, relations, functions, algebraic structures, and finite-state machines.

No learning outcomes listed in catalog; however, these are on the current syllabus:

Learning Outcomes: i) an ability to define, reason about, and operate on sets using basic set operations and recursive definition. [1,7]; ii) an ability to represent and verify entailment arguments in predicate logic, both syntactically and semantically. [1,3,7]; iii) an ability to argue carefully using a variety of informal proof techniques, including mathematical induction. [1,3,7]; iv) an ability to count in a wide range of settings including permutations, combinations, countable infinities, and recurrence equations. [1,7]; v) an ability to define and reason about functions and binary relations and work with their useful properties. [1]; vi) an ability to define finite-state automata and regular expressions for languages, and relate these formalisms using non-determinism. [1,7]; vii) an ability to formulate algorithmic problems as decision problems and reason about their decidability and scalable solvability. [1,7]

ELMORE FAMILY SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING
Materials Sciences and Electrical Engineering Building, Room 140
501 Northwestern Avenue, West Lafayette, IN 47907
Office: 765-494-3390

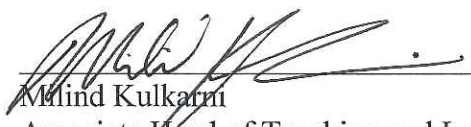
TO:

ECE 20869 Discrete Math for Computer Engineering, Sem. 1, 2, Class 3, Lab 0, Cr. 3.
Prerequisites: ECE 20875 or 26400 (may be taken concurrently)

This course introduces discrete mathematical structures, with a focus on developing problem-solving skills and abstract reasoning. Students will attain substantial experience formulating and reasoning about a wide range of discrete mathematics problems. Topics generally include sets, sequences, relations, mappings, recursive definition, formal logic syntax and semantics, mathematical induction, recursion and loop invariants, counting and combinatorics, countability, asymptotic complexity, finite-state automata, regular expressions, and non-determinism.

Learning Outcomes: i) an ability to define, reason about, and operate on sets using basic set operations and Recursive definition. [1,7]; ii) an ability to represent and verify entailment arguments in predicate logic, both syntactically and semantically. [1,3,7]; iii) an ability to argue carefully using a variety of informal proof techniques, including mathematical induction. [1,3,7]; iv) an ability to count in a wide range of settings including permutations, combinations, countable infinities, and recurrence equations. [1,7]; v) an ability to define and reason about functions and binary relations and work with their useful properties. [1]; vi) an ability to define finite-state automata and regular expressions for languages, and relate these formalisms using non-determinism. [1,7]; vii) an ability to formulate algorithmic problems as decision problems and reason about their decidability and scalable solvability. [1,7]

Reason: Currently students tend to take this course in one of their last two semesters, but they would benefit greatly from exposure of this material earlier in their program. Though this course is not a pre-requisite for any other ECE course, moving it to a 200-level sophomore course will increase the flexibility for students to take courses in their junior and senior year that rely on this course's content for a more in-depth understanding with computer systems. In addition, the material from ECE 27000 is minimal and is now covered at the start of the course, thus eliminating the need for it as a pre-requisite.



Milind Kulkarni
Associate Head of Teaching and Learning
Professor of Electrical and Computer Engineering

ECE 20869 - Discrete Mathematics for Computer Engineering

Lecture Hours: 3

Credits: 3

Normally Offered: Each Fall, Spring

Co-requisites: ECE 20875 or ECE 264 or equivalent programming experience

Catalog Description:

This course introduces discrete mathematical structures, with a focus on developing problem-solving skills and abstract reasoning. Students will attain substantial experience formulating and reasoning about a wide range of discrete mathematics problems. Topics generally include sets, sequences, relations, mappings, recursive definition, formal logic syntax and semantics, mathematical induction, recursion and loop invariants, counting and combinatorics, countability, asymptotic complexity, finite-state automata, regular expressions, and non-determinism.

Supplementary Information:

This is a required mathematics course for the BSCmpE. It counts as a Complementary Elective for the BSEE.

Required Text(s):

1. *Mathematical Structures for Computer Science*, 7th Edition, Judith L. Gersting, W. H. Freeman, 2014, ISBN No. 978-1429215107

Recommended Text(s): None.

Learning Outcomes: A student who successfully fulfills the course requirements will have demonstrated:

- an ability to define, reason about, and operate on sets using basic set operations and recursive definition. [1,7]
- an ability to represent and verify entailment arguments in predicate logic, both syntactically and semantically. [1,3,7]
- an ability to argue carefully using a variety of informal proof techniques, including mathematical induction. [1,3,7]

- an ability to count in a wide range of settings including permutations, combinations, countable infinities, and recurrence equations.[1,7]
- an ability to define and reason about functions and binary relations and work with their useful properties. [1]
- an ability to define finite-state automata and regular expressions for languages, and relate these formalisms using non-determinism. [1,7]
- an ability to formulate algorithmic problems as decision problems and reason about their decidability and scalable solvability. [1,7]

Lecture Outline:

Weeks	Topic
2	Sets and recursive definition
3	Boolean and predicate logics: syntax, semantics, entailment, proof
2	Informal proof: direct and indirect proof, case analysis and proof by contradiction, mathematical induction, loop invariants
3	Counting: countability/uncountability, permutation and combinations, pigeonhole principle, binomial theorem, inclusion/exclusion, recurrence equations
1	Relations and functions: equivalence relations, partial orders, injection/surjection/bijection, inverse and composition
4	Decision problems: undecidability, finite-state automata, regular expressions and Kleene's theorem, asymptotic complexity, P and NP

PURDUE UNIVERSITY

Course Information

ECE 20869 – Discrete Mathematics for Computer Engineering

Course credit hours: 3
Course web page:
Brightspace page (syllabus, lecture notes): https://purdue.brightspace.com/d2l/home/460451
Gradescope page (assignments): https://www.gradescope.com/courses/344545
Piazza page (announcements, discussions): https://piazza.com/purdue/spring2022/ece36900
Course calendar: https://tinyurl.com/ys3ev24n

Prerequisites:
ECE 20865 or ECE 26400 [may be taken concurrently]

Information About the Instructor(s)

Instructors

Milind Kulkarni
Office: EE 324A
Email Address: milind@purdue.edu
Office hours, times and location:
Wednesdays 2–3:20pm, Thursdays 1:30–2:50pm, in person (walk ins welcome)
By appointment, in person and virtual

Graduate Teaching Assistants

Asha Shekar
Email Address: shekara@purdue.edu
Sanghyun Cho
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Yipei Wang
Email Address: wang4865@purdue.edu
Josh Majors
Email Address: jmajors@purdue.edu

Undergraduate Teaching Assistants

There are several UTAs who will be helping with this course, by holding office hours, responding to Piazza posts, and grading assignments: Jonathan Eppele, Jason Lei, Qingyang Wang, Ahmed Rmadi

Lab Hours

Lab hours are held in the following classrooms (sorry that they're not always in the same place—it's the best we could do). Pay attention to the office hours logistics post on Piazza—that is where we post any updates regarding office hours schedules.

- Monday 1–5pm, ME 3006
- Tuesday 2–5pm, REC 307
- Wednesday 4–7pm, REC 112
- Thursday 3–7pm, GRIS 102
- Friday 2–6pm, ME 1009

What is this course About?

This course teaches you how to think mathematically, formally, and precisely. Understanding how to reason about computers and computation means being able to precisely specify the world of *discrete structures*: things that don't just deal with real numbers and continuous functions. As computer engineers, you have repeatedly encountered situations where a computer does only, and exactly, what you tell it to: no more, no less. This course helps you understand the method behind the madness of why computation works the way it does, and how to think systematically and carefully about what you are telling a computer to do.

Course Description

This course introduces discrete mathematical structures, with a focus on developing problem-solving skills and abstract reasoning. Students will attain substantial experience formulating and reasoning about a wide range of discrete mathematics problems. Topics generally include sets, sequences, relations, mappings, recursive definition, formal logic syntax and semantics, mathematical induction, recursion and loop invariants, counting and combinatorics, countability, asymptotic complexity, finite-state automata, regular expressions, and non-determinism.

Learning Outcomes

A student who successfully fulfills the course requirements will have demonstrated:

1. an ability to define, reason about, and operate on sets using basic set operations and recursive definition.
2. an ability to represent and verify entailment arguments in predicate logic, both syntactically and semantically.
3. an ability to argue carefully using a variety of informal proof techniques, including mathematical induction.
4. an ability to count in a wide range of settings including permutations, combinations, countable infinities, and recurrence equations.
5. an ability to define and reason about functions and binary relations and work with their useful properties.
6. an ability to define finite-state automata and regular expressions for languages, and relate these formalisms using non-determinism.
7. an ability to formulate algorithmic problems as decision problems and reason about their decidability and scalable solvability.

Learning Resources, Technology, & Texts

Notes and Books

The course material for this course will be in the form of lecture notes and lecture recordings. We will also be using the following textbook. We will draw some homework problems from the book, and the book will also be useful as a reference.

Mathematical Structures for Computer Science , 7th Edition , Judith L. Gersting , W. H. Freeman , 2014 , ISBN No. 978-1429215107

Instructors' Email Availability and Policies

We ask that all course-related questions be posted to the Piazza discussion board – your questions may be useful to other students.

If you have a question of a personal nature that you do not want to post on Piazza, then you may email the instructors. We will endeavor to respond to your emails within 24 hours (not counting weekends, when responses may be delayed).

Assignments and Points

The achievement of course objectives will be assessed through a combination of tests (2 midterms and a final) and 15 problem sets.

Grades will be assigned as follows:

Problem sets: 60% (5% per assignment)
Exams: 50% (15% per midterm, 20% for the final)
Participation Points: 10%

The observant will notice that there are a total of 120 points available in the course, though the grade scale is out of 100. This gives students ample opportunity to make up for missed points on exams or homeworks.

Problem Sets

There will be 12 problem sets, due weekly (except for Week 1, and the two weeks with midterms). Problem sets will typically be posted on Saturday and due by Friday at midnight. Problem sets are to be submitted via **Gradescope**. We will accept problem sets up to 3 days late (i.e., up to the Monday after they are due), with a 10% penalty per day late, though we cannot guarantee that late submissions will receive a grade at the same time as on-time submissions.

Exams

There will be two midterms and a final. We currently plan to hold *in-person evening exams*. (Depending on the Covid situation at the time of the exam, we may switch to online exams.) We will cancel two regular class sessions to account for evening exams.

All exams are open book and open notes.

Topics and exact dates are tentative. The final exam is cumulative, but will focus on material after Midterm 2. Think of it as a midterm plus a bit of review.

a. Midterm 1 — Boolean logic; predicate logic; formal and informal proof; sets

- Wedensday, 2/23, 6:30pm–7:30pm, CL50 224 & WALC 1055

b. Midterm 2 — binary relations; induction; recursion; loop invariants; counting and combinatorics
   - Wednesday, 4/6, 6:30pm–7:30pm, BHEE 129 & WALC 1055

c. Final exam — recurrence relations; regular languages and finite automata; decision procedures and undecidability
   - TBD

Participation Points

There are a maximum of 10 bonus participation points available in the class. 1 points is available by filling out the course evaluation. The remaining 9 points are available through:

a) Participation on Piazza (up to 4 points). These bonus points are awarded by looking at questions, answers, and helpful responses.
b) Attendance quizzes (up to 5 points). You can get up to 5 points by participating in attendance quizzes given periodically in class. These quizzes will be to test your knowledge and for me to get a sense of where the class is in understanding. You will *only be assessed on participation, not whether you get the right answer*. Attendance quizzes are given every week there is a homework due. Each attendance quiz is worth 0.5 points, so you can miss 2 attendance quizzes and still get the full 5 points.

Please note that attendance is *not* required in class. If you miss attendance for a week, you will be able to make up your attendance quiz for that week by completing an additional question on the problem set (that question will be graded). Moreover, all participation points are bonuses.

Grading Scale

The maximum grade cutoffs for this course are given below. Grades *will not be rounded*: a 90.99 is an A-, and a 91.01 is an A. Thresholds may be lowered globally for the entire class at the instructors' discretion.

Note that to receive an A or A+ in the class, students must also achieve at least a B standard (79 or better) in both the exam component of the class and the problem set component of the class

Letter grade	Minimum range
A+	97
A	91
A-	88
B+	85
B	79
B-	76
C+	73
C	67
C-	64
D+	61
D	55
D-	40
F	0

Course Logistics

Course Discussion

This term we will be using Piazza for class discussion. If you have questions about the course material, I encourage you to post them on Piazza. It's a shared discussion forum, where your question can be answered by myself, the TA or your fellow students! Piazza will be the primary method for disseminating course announcements, so *you must have a Piazza account*. Please use your Purdue email address on Piazza; otherwise we will not be able to assign bonus points.

Group work policy

You may work on problem sets with your fellow students. While you can work together to formulate solution strategies, you *must* write up and submit your answers on your own.

If you work with other students on a problem set, you *must* acknowledge who you have worked with in your solution writeup.

Copying material from another student, or failing to acknowledge collaboration, will be considered an integrity policy violation.

Help from outside sources (i.e., not other students currently taking the course, or the course staff) is not allowed. If you are not sure whether a resource is acceptable, please feel free to contact the course staff.

Assignment Submission

Unless otherwise specified, all project steps are due at 11:59pm on the due date.

Late submission policy

Except for medical and family emergencies (accompanied by verification), there will be *no extensions* granted for assignment submissions. Late submissions will be scaled according to lateness, docking 10% from your score per day late, up to a maximum of 30% (three days late). Submissions more than three days late will not be graded.

Course Schedule

The rough schedule of the class is given below. The schedule may be tweaked based on class progress.

Week	Topic
Week 1	Boolean algebra. Propositional logic
Week 2	Models and entailment. Inference rules and formal proof
Week 3	Sets. Predicate logic
Week 4	Predicate logic (cont.). Proofs in predicate logic
Week 5	Informal proof
Week 6	Binary relations
Week 7	Induction. **Midterm 1**
Week 8	Counting.
Week 9	Countability, uncountability, combinatorics
Week 10	**Spring break**
Week 11	Recursion and loop invariants
Week 12	Recurrence relations

Week 13	Regular languages and finite automata. **Midterm 2**
Week 14	Non-determinism. Beyond regular languages.
Week 15	Decisions problems and undecidability. P & NP
Week 16	Slack

* Schedule and assignments subject to change. Any changes will be posted in the learning management system.

Attendance Policy

Attendance in this class is *highly* encouraged. Students are responsible for all the content covered in class. Course material will be posted on Brightspace *after* their associated lectures, but may be up to one week delayed.

We note that in our experience, students who attend class regularly outperform students who attend class less frequently.

Academic Guidance in the Event a Student is Quarantined/Isolated

If you must miss class at any point in time during the semester, please reach out to the instructor of your section via email so that we can communicate about how you can maintain your academic progress. If you find yourself too sick to progress in the course, notify your adviser and notify us via email. We will make arrangements based on your particular situation. Please note that, according to Details for Students on Normal Operations for Fall 2021 announced on the Protect Purdue website, "individuals who test positive for COVID-19 are not guaranteed remote access to all course activities, materials, and assignments."

Classroom Guidance Regarding Protect Purdue

Any student who has substantial reason to believe that another person is threatening the safety of others by not complying with Protect Purdue protocols is encouraged to report the behavior to and discuss the next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights and the Violent Behavior Policy under University Resources in Brightspace.

Academic Integrity

Punishments for academic dishonesty are severe, including receiving an F in the course or being expelled from the University. By departmental rules, all instances of cheating will be reported to the Dean. On the first instance of cheating, students will receive a 0 on the assignment; the second instance of cheating will result in a failure of the course.

Accessibility

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let us know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247. More details are available on our course Brightspace under Accessibility Information.

If you need special accommodations for midterms and exams, please remember to submit your requests to DRC ASAP.

Nondiscrimination Statement

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. Link to Purdue's nondiscrimination policy statement.

Diversity and Inclusion

We strive for equity, providing equal access and opportunity, and working to maximize student potential. This requires both instructor and students to identify and remove barriers that may prevent someone from full access or full participation. You can help by:

- Contacting us, anonymously if needed, if you see a potential barrier for someone or yourself in participating fully in the class. This might be a physical barrier such as access to technology or a personal situation.
- Suggesting ways in which members of our class can support each other. Virtual study groups and discussion boards are examples, but we encourage you to be creative in your ideas.
- Getting to know each other as contributing members of our learning community. Everyone, with all ranges of skills and backgrounds, has something to contribute, we cannot have our best classroom experience without your participation. There are many opportunities built into this course for this type of engagement. It is important we do it together.

Mental Health Statement

- **If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack.** Sign in and find information and tools at your fingertips, available to you at any time.
- **If you need support and information about options and resources**, please see the Office of the Dean of Students for drop-in hours (M-F, 8 am- 5 pm).
- **If you're struggling and need mental health services**: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

If you find yourself under stress and are worried about completing the objectives of this course, please contact the instructors, your advisor, or the Office of the Dean of Students so we can work with you on options.

Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it related to COVID-19, students may submit requests for emergency assistance from the Critical Needs Fund

Course Evaluation

During the last two weeks of the course, you will be provided with an opportunity to evaluate this course and your instructor. Purdue uses an online course evaluation system. You will receive an official email from evaluation administrators with a link to the online evaluation site. You will have up to two weeks to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. I strongly urge you to participate in the evaluation system.

Students who provide proof of completion of their course evaluation will receive a bonus point.

Emergency Preparation

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website, Piazza, and Brightspace. You are expected to read your @purdue.edu email on a frequent basis.

Disclaimer

This syllabus is subject to change. Changes in any aspect of the course will be communicated via Piazza and Brightspace.