

Syllabus for CECS 329, Concepts of Computer Science Theory

Instructor: Dr. Todd Ebert

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General Course Information

Academic Unit Department of Computer Engineering and Computer Science, California State University, Long Beach

Prerequisite CECS 328 with a grade of “C” or better.

Catalog Description Seminar on fundamental topics in theoretical computer science. Topics include regular languages, finite automata, context-free languages, Turing machines, computability theory, computational complexity, and NP-completeness.

Section Call Numbers 6554 (Section 1), 10341 (Section 6)

Instructor Dr. Todd Ebert (Todd.Ebert at csulb.edu)

Instructor Office Hours TuWTh 9:30 am - 10:30 am, ECS 548

Teaching Assistant Marley Schneider Email: Marley.Schneider01 at Student.CSULB.EDU

Course Meeting Times Section 1: (HC 100), Section 6: (ECS 416)

Textbook

Required Textbook M. Sipser, “Theory of Computation”, Cengage Learning, 2012, 3rd Edition, 978-1133187790

Course Topics

The course is divided into three one-unit sections, each of which spans five weeks and ends with an exam on the material from that unit.

- Unit1: Weeks 1-5. Computational Complexity Theory: Turing and Map Reducibility, Complexity Classes (P, NP, and co-NP), NP-completeness, NP-completeness proofs.
- Unit2: Weeks 6-10. Automata and Formal Language Theory: Deterministic and Nondeterministic Finite Automata, Regular Expressions, Context-Free Languages, Turing Machines.
- Unit3: Weeks 11-15. Computability Theory: Unlimited Register Machines, Encoding and Decoding of Programs, Universal Programs, Diagonalization Method, Self-Referencing Programs, Decidability and Undecidability.

Learning Outcomes

This course has eleven **core learning outcomes (LO's)** that will be assessed on each exam, as well as on four quizzes. For each outcome, your understanding is assessed via a problem that is provided on the quiz or exam. In addition to earning points (on exams only) for solving these problems, you will also receive either a Pass (P) or No Pass (NP) grade. Receiving a pass grade means that you have successfully demonstrated competency with respect to that LO. You are allowed up to three attempts to pass each LO via three exams and four quizzes.

The following are some guidelines for success towards passing each of the learning outcomes.

1. When preparing for the learning-outcome problem, carefully read its official description in the syllabus so that you know what is expected for a passing mark.
2. Each LO has a set of exercises (with solutions) to help you prepare. These exercises are located at the end of the lecture that introduces the LO.
3. Re-solve each exercise until you are able to solve it on your own without using any notes. Note that the exam and quiz problems will be similar to the exercises but *not* the same problems.
4. The problem will seem similar to one of the lecture examples or assigned exercises. Therefore, it's important to review and solve these problems.
5. During exams and quizzes you are allowed to bring pens/pencils, eraser, and a non-programmable scientific calculator **All other computing devices (cell phones, laptops, smart watches, etc.), notes, and books must be put away before starting. Failure to abide by these rules is grounds for receiving a final course grade of F without the possibility of having the grade forgiven.**

6. To help prevent cheating, when possible, please select a seat that leaves one or more empty seats between you and your nearest neighbor. **When there is sufficient evidence of exam plagiarism, all involved students are subject to receiving a final course grade of F without the possibility of having the grade forgiven.**
7. It's important to follow the directions for each problem and include all the pertinent steps of your solution.
8. During exams and quizzes, both a five and two-minute warning will be announced before solutions are to be turned in. Please have the courtesy to turn them in before the final call. A student who is still working after the final call will receive a warning and any subsequent infractions will result in a point reduction equivalent to the points earned from the highest scoring problem.
9. At the end of the semester each student will receive grade points in accordance with the following table and based on the number of different LO's passed.

Number Passed	Grade Points
1-3	0
4	0.5
5	1.0
6	1.25
7	1.5
8	2.0
9	3.0
10	3.5
11	4.0

The following are the LO's for which competency must be demonstrated.

- LO1. The ability to understand the concept of Turing reducibility as a general algorithm strategy and how it is specifically used for the 2SAT decision problem. Part 1: the ability to demonstrate the steps of the Improved 2SAT Algorithm. Part 2: the ability to answer a short-answer question about using a Reachability-oracle for the sake of solving an instance of 2SAT. **References.** Turing Reducibility
- LO2. The ability to provide the definition of what it means to be a mapping reduction f from some problem A to another problem B , demonstrate one of the following reductions for some instance $x \in A$, and verify that the solution to $x \in A$ is the same as the solution to $f(x) \in B$.
 - (a) Even $\leq_m$ Odd See Exercise 1 of the Mapping Reducibility lecture for the kind of problem to expect.
 - (b) Max Independent Set $\leq_m$ Max Clique
 - (c) Set Partition $\leq_m^p$ Subset Sum
 - (d) Hamilton Path $\leq_m^p$ LPath
 - (e) Subset Sum $\leq_m^p$ Set Partition

(f) $\text{Vertex Cover} \leq_m^p \text{Half Vertex Cover}$

(g) $\text{Clique} \leq_m^p \text{Half Clique}$

- LO3. An understanding of the complexity classes P, NP, and co-NP.
- LO4. The ability to demonstrate and/or answer questions about the following polynomial-time mapping reductions that establishes the NP-completeness of some decision problem: 3SAT to Clique, 3SAT to Subset Sum, SAT to 3SAT, 3SAT to DHP, DHP to UHP, and Hamilton Cycle to Traveling Salesperson.
- LO5. The ability to design and draw the state diagram of a DFA that accepts a given regular language. The ability to provide the computation of the DFA on one or more input words.
- LO6. The ability to i) provide the state diagram of an NFA that accepts a given language and only uses a prescribed number of states, ii) provide the δ -transition table for an NFA N that is defined via a state diagram, and iii) convert the table to an equivalent DFA M (i.e. M and N accept the same language).
- LO7. Given the description of a regular language L , the ability to provide a regular expression E for which $L = L(E)$. Also, given a regular expression that represents some language L , the ability to provide an NFA that accepts L and makes use of the methods for unioning, concatenating, and starring existing NFA's.
- LO8. Given the description of a context-free language L , the ability to provide a context-free grammar G for which $L = L(G)$. Also, given a context free grammar G and a word $w \in L(G)$, the ability to derive w using the rules of G .
- LO9. An understanding of the deterministic Turing machine model of computation, including the ability to design a Turing machine for the purpose of solving some problem, and, given a Turing machine M , the ability to demonstrate a computation with respect to M and some input. Finally, the ability to establish that a function is URM computable by writing a URM program for computing the function.
- LO10. The ability to encode and decode a URM program and to demonstrate how a universal program P_U , on inputs x and y , simulates a single step (i.e. moving from one configuration encoding to the next) of the computation $P_x(y)$.
- LO11. Three parts: i) the ability to describe the role of each of the three program parts (A, B, and C) that comprise a self-referencing program, ii) Given a description of some program property A , the ability to determine if some specific program has that property, iii) Furthermore, the ability to prove that A is undecidable by writing a self-referential program P that makes use of a) the **self** programming concept and b) the assumption that $d_A(x)$ is total computable in order to have P behave in a way that is contradictory to whether or not P has property A . This includes the the ability to perform a case-by-case analysis that establishes that P 's behavior contradicts $d_A(\gamma(P)) = d_A(\text{self})$.

Reading Assignments

A reading assignment will be provided on most weeks of the semester. Reading the textbook will offer a somewhat alternative and more comprehensive viewpoint of the subject matter. Please check the “Reading Assignments” link at the course website for the current and past assignments. The reading assignment topics pertain to those topics that will be covered in the class meetings for the following week.

Class Meetings

Our class meetings will be devoted to working through the course lecture notes. These notes have several examples. Some have provided solutions while the solutions to others will be demonstrated in class. The notes also contain all the needed definitions, formulas, theorems, exercises, and exercise solutions. Each Wednesday (except for exam days) I will devote the final 15 minutes of class to addressing any issues with the weekly homework and exercises. Although class attendance is not mandatory, at the end of the semester I look to improve the final grades of students who meet the following criteria: i) final course GPA is close to the borderline between two grades, ii) consistent class attendance, and iii) sustained improvement during the semester.

Weekly Exercises

Associated with each learning outcome presented in lecture will be a set of assigned practice exercises, as well as some additional exercises that pertain to a related peripheral learning outcome or represents a more advanced exercise that may form the basis for an advanced exam problem.

Homework

Homework will be assigned most weeks and consist of one or two problems that expand on ideas that were covered during a previous week. These problems are meant to either highlight interesting applications of the subject or represent a more advanced problem that requires more time complete than a typical exercise.

The following are some rules and guidelines for solving the HW problems and submitting their solutions.

1. Problems will be made available at least one week before they are due.

2. Solutions should be submitted by uploading a single PDF file to the appropriate Canvas drop box.
3. Please make sure to write your full name at the top of each page.
4. Solutions should be presented in the same order that they appear on the problem sheet.
5. All solutions should be handwritten (including the use of an electronic writing tablet) **Typed solutions will not be graded.**
6. Plagiarizing the work of others shall not be tolerated. When plagiarism is first detected, the students involved will receive a warning. Detecting plagiarism a second time will result in a final homework grade of F. It is OK for students to collaborate on homework, but it's not OK for students to copy one another or copy from a source on the web. Each student has the responsibility to present each solution in a unique way.

Exams and Quizzes

There will be two midterm exams, four quizzes, and a final exam.

Midterm 1 four problems worth 25 points each and pertaining to LO's 1-4, and additional problems worth a total of 50 points.

Quiz 1 three problems pertaining to LO's 4, 5, and 6

Midterm 2 four problems worth 25 points each and pertaining to LO's 5-8, additional problems worth a total of 50 points, and four problems worth 0 points each and pertaining to LO's 1-4.

Quiz 2 two problems pertaining to LO's 7 and 8

Quiz 3 two problems pertaining to LO's 9 and 10

Quiz 4 two problems pertaining to LO's 9 and 10

Final Exam four problems worth 25 points each and pertaining to LO's 9-11, additional problems worth a total of 75 points, and eight problems worth 0 points and pertaining to LO's 1-8

The purpose of the quizzes is to provide each student with at least three opportunities to pass each of the learning outcomes. Furthermore, not passing an LO problem on some quiz does *not affect* a student's overall grade. However, it does place more pressure on the student to pass the LO on a future assessment, whether it be another quiz or an exam. To provide more incentive to perform well on quizzes, if the *first* assessment of an LO occurs on a quiz and a student (fully) passes the corresponding LO assessment problem, then an additional 0.1 shall be added to the student's final course GPA. The opportunity to avail the extra credit occurs on Quizzes 1 and 3 (LO's 4, 5, 6, 9, and 10). In addition, any student who has *already passed* any of LO's 2-4 may attempt the corresponding makeup problem on the final exam and will have an additional 0.1 added to their GPA for each problem (fully) passed.

Final Grade Determination

At the end of the semester, grades will be assigned based on the six categories shown in the table below.

Categories	Percentage Weight
Learning Outcomes	30%
Midterm 1	20%
Midterm 2	20%
Final	20%
Homework	10%

Exam and Quiz Dates TuTh Section

Midterm 1 September 25th

Quiz 1 October 16th

Midterm 2 October 30th

Quiz 2 November 6th

Quiz 3 November 20th

Quiz 4 December 4th

Final Exam Thursday December 12th, 8:00-10:00 am

Exam and Quiz Dates Friday Section

Midterm 1 September 26th

Quiz 1 October 17th

Midterm 2 October 31st

Quiz 2 November 7th

Quiz 3 November 21st

Quiz 4 December 5th

Final Exam Friday December 12th, 10:15-12:15 pm

Exam and Quiz Makeups

Exam and Quiz Makeups will only be permitted in case of a documented accident, emergency, or illness. Acceptable documentation includes a doctor's notes, police report, photographs, etc.. Documentation must be provided in advance before taking the makeup assessment.

Registration Deadlines

September 8th Last day to add or drop classes without approval

September 15th Deadline to add a course

November 19th Withdrawal deadline

Study Suggestions

About 80% percent of your success in this course will depend on your ability to demonstrate competency in each the course learning outcomes. Here are some suggestions that should help you accelerate towards competency. The following steps should be applied to each learning outcome.

1. Prepare to solve the assigned exercises by reviewing the part of the lecture notes that pertains to the outcome, including definitions, results, general discussion, and examples.
2. Perform a first pass of solving the exercises with the help of the lecture notes. For each exercise, give yourself up to 20-30 minutes to solve it with the help of reviewing the solution(s) to the pertinent lecture example(s). If after that time you still cannot solve it, then review the exercise's solution and make sure you understand it. If not, then seek help from other students or the instructor.
3. Based on your understanding and skill that were attained from the previous step, develop 3×5 note cards that cover all the essential definitions, results, and steps that are needed to solve the different kinds of problems that are related to the learning outcome. These note cards should be general so that they apply to all future problems that pertain to the outcome.
4. Perform a daily review of the note cards with the goal of memorization, together with re-solving a few of the assigned exercises to see if your performance has improved. Continue to do this until you feel comfortable with your level of understanding and performance.
5. Repeat the previous step, but now focus on solving new exercises (without the help of your notecards) taken from assessments given in previous semesters.

Steps 1-3 should occur within 24 hours after lecture, while step 4 should be ongoing until you feel comfortable with your understanding and performance. Finally, step 5 should occur soon before the next class assessment of the outcome.

The above steps should comprise about 80% of your studying for the subject outside of attending class. The other 20% should involve completing homework assignments, solving the assigned additional problems which can help prepare you for the additional problems on each exam, and reading the course textbook.