CSE 260
Discrete Structures in Computer Science

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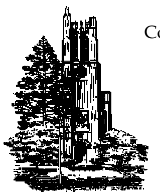

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Catalog Description

- **CSE 260: Discrete Structures in Computer Science**
- **Prerequisite:** {MTH 126 (Survey of Calculus II) or MTH 133 (Calculus II) or MTH 153H (Honors Calculus II) or LBS 119 (Calculus II) }
- **Description:** Propositional and first order logic. Equivalence, inference and method of proof. Mathematical induction, diagonalization principle. Basic counting. Set operations, relations, functions. Grammars and finite state automata. Boolean algebra. Truth tables and minimization of Boolean expressions. Applications to computer science and engineering.

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Continuous vs Discrete Mathematics

- CM
  - Math based on the real numbers
  - Use topology to study the idea of shape, closeness, etc
  - Use differential equations to study how things change
- DM
  - Distinct values
  - Use graph theory to study relations between objects
  - Use recurrence relations to study how things change

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Course Motivation & Objectives

- Motivation:
  - The role of discrete mathematics in the study of computer science is analogous to the role that calculus plays in physics or in the engineering disciplines
  - It allows us to define, describe and reason about complex systems.
- Objectives:
  - Expose you to the mathematical concepts that form the basis for much of Computer Science.
  - Train you to analyze problems; think in a logical fashion; and ***communicate your reasoning in a clear and unambiguous manner.***

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Applications of discrete mathematics

- World of computers
- Algorithm Design
- Programming Languages Design
- Compiler Design
- Software Engineering & Formal Methods
- Data Structures
- Relational Database Theory
- Complexity Theory
- Security

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Course Topics

- Propositional Logic
- Predicate Logic
- Proof Methods
- Set Theory
- Number Theory
- Recurrence Relations
- Combinatorics
- Relations and their Representations
- Languages and Grammars

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Course Outcome (ABET)

- Students will be skilled in propositional logic, including modeling English descriptions with propositions and connectives and doing truth table analysis. Students will be conversant in predicate logic.
- Students will be able to use various methods of proof, such as direct, proof by contradiction, and mathematical induction.
- Students will be conversant in the concepts of sets and their refinements as relations and functions.
- Students will be able to solve basic counting and combinatoric problems.
- Students will demonstrate how grammars and FSAs can be used to define and to recognize a language (set of strings) for Type 2 and Type 3 languages. Students will be able to design practical machines using methods FSAs.

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Course Outline, Book Sections

- Logic and proofs
  - Sections 1.1 – 1.8
- Set, Functions, sequences, …
  - Sections 2.1 – 2.5
- Algorithm,
  - Sections 3.1 – 3.3
- Number theory
  - Sections 4.1 – 4.6
- Induction, Recursion
  - Sections 5.1 – 5.4, 8.1 – 8.2

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Course Outline, Book Sections…

- Counting
  - Sections 6.1 – 6.4
- Relations
  - Sections 9.1 – 9.5
- Languages and Grammars
  - Sections 13.1 – 13.3

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Course work and grading

- Class attendance and participation (5%)
- Homework (10%)
- Daily Quizzes (25%)
- Weekly Exams (60%)
- Course Grade is based on straight scale; percentages are on total scores possible:

90 – 100%	4.0
85 – 89%	3.5
80 – 84%	3.0
75 – 79%	2.5
70 – 74%	2.0
65 – 69%	1.5
60 – 64%	1.0

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Class Procedures ...

- Class notes and other course materials and resources will be available on the course website: http://www.cse.msu.edu/~cse260/
- It is password protected (cse260, dmig4me).
- Visit this site on regular basis. It is your responsibility!

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Class Procedures …

- We expect that you attend the class regularly; attendance will be taken most likely when you are not present!
- If you know you are going to miss a class and want to make sure you do not lose any points due to a missed quiz or assignment, you must contact the instructor ahead of time unless there is an emergency.

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Class Procedures …

- When attending the class, we ask you to observe a few simple rules which are meant to create a better learning environment.
  - Come to class on time since we will start lectures right away.
  - Once class begins, we expect students to pay attention and not read the newspaper or talk, etc. Set your cell phones on vibrate.
  - No laptops, unless you are using devices like MS Surface to take notes
  - If you have a question, do not hesitate to ask.
    - Others are likely to have the same question.
    - Do not be afraid to ask questions and slow down the pace of the class. If we feel there are too many questions and that we must move on, we will say so, but that should not be taken to mean that the question was "dumb" or inappropriate.

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Class Procedures …

- Textbook: Discrete Mathematics and it's Applications by Kenneth H. Rosen, Seventh Edition, McGraw Hill.
- Students are required to get a copy of this textbook. You will have regular reading assignments from this textbook. The textbook website also has a lot of exercises. You may want to check that out.

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Class Procedures …

- Instructor: Dr. Abdol-Hossein Esfahanian
- Email: esfahanian@cse.msu.edu
- Url: http://www.cse.msu.edu/~esfahani/
- Office: 3115EB
- Tel: 353-4389
- Office Hours: Wed 1:00pm – 2:00pm, or by appointment, or whenever you can find me.

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Class Procedures …

- Course TAs:
  - Husain Khalifeh [khalife8@msu.edu]
  - Saptarshi (Tito) Mitra [mitrasap@msu.edu]
  - Office hours: M - TH 1:00 – 3:00pm,
- TAs Office:
  - 3203 EB (Bone Lab)
- We will also use piazza for announcements/discussions/Q&A
  - https://piazza.com/class/int82ke3tv01h7

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Academic Honesty

- Article 2.3.3 of the Academic Freedom Report states that "The student shares with the faculty the responsibility for maintaining the integrity of scholarship, grades, and professional standards." In addition, the College of Engineering adheres to the policies on academic honesty as specified in General Student Regulations 1.0, Protection of Scholarship and Grades; the all-University Policy on Integrity of Scholarship and Grades; and Ordinance 17.00, Examinations. (See Spartan Life: Student Handbook and Resource Guide and/or the MSU Web site: www.msu.edu.) Therefore, unless authorized by your instructor, you are expected to complete all course assignments, including homework, quizzes and exams, without assistance from any source. You are expected to develop original work for this course; therefore, you may not submit course work you completed for another courses to satisfy the requirements for this course. Also, you are not authorized to use sites such as the http://www.allmsu.com to complete any course work in CSE 260. Students who violate MSU rules may receive a penalty grade, including--but not limited to--a failing grade on the assignment or in the course. Contact your instructor if you are unsure about the appropriateness of your course work.

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Academic Integrity

- Academic Integrity is very important in this class and in this university. It is important that students do their work on their own without help from anyone except the instructor or the teaching assistant. Students are permitted to discuss the homework problems with each other. However, the work they turn in must be completely their own. Obviously, no cooperation is permitted during examinations. Students violating this will be dealt with according to the university policy.

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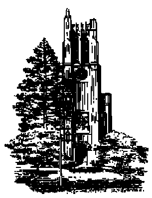
Monday May 16, 2016
Lecture 01

Propositional Logic



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Notables

- Read Chapter 1
- Schedule for this week:

Week	M	T	W	R	Topic	Section
1	5-16				Intro & propositional logic	1.1
		5-17			More on propositional logic	1.2
			5-18		Propositional Equivalences	1.3
				5-19	Predicates and Quantifiers	1.4, 1.5
2	5-23					
		5-24				
			5-25			
				5-26		

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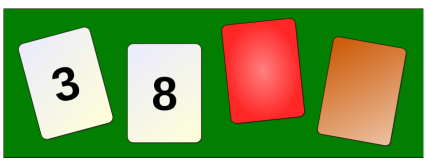
Consider the following puzzle



Each card has a number on one side, and a patch of color on the other. Which card(s) must be turned over to determine the *truth value* of the *proposition* that:
if a card shows an even number on one face, then its opposite face is red?

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Logic

- Logic is the underpinning of all reasoned argument. The Greeks recognized its role in mathematics and philosophy, and studied it extensively.
- Aristotle, in his Organon, wrote the first systematic treatise on logic. His work in particular had a heavy influence on philosophy, science and religion through the Middle Ages.
- But Aristotle's logic was logic expressed in ordinary language, so was still subject to the ambiguities of natural languages.
- Philosophers began to want to express logic more formally and symbolically, in the way that mathematics is written (Leibniz, in the 17th century, was probably the first to envision and call for such a formalism).
- It was with the publication in 1847 of G. Boole's The Mathematical Analysis of Logic and A. DeMorgan's Formal Logic that symbolic logic came into being, and logic became recognized as part of mathematics. This also marked the recognition that mathematics is not just about numbers (arithmetic) and shapes (geometry), but encompasses any subject that can be expressed symbolically with precise rules of manipulation of those symbols.

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Logic…

- Since Boole and DeMorgan, logic and mathematics have been inextricably intertwined.
- Logic is part of mathematics, but at the same time it is the language of mathematics.
- In the late 19th and early 20th century it was believed that all of mathematics could be reduced to symbolic logic and made purely formal. This belief, though still held in modified form today, was shaken by K. Gödel in the 1930's, when he showed that there would always remain truths that could not be derived in any such formal system.
- The study of symbolic logic is usually broken into several parts. The first and most fundamental is the propositional logic, and on top of this is the predicate logic, which is the language of mathematics.

Source:
http://people.hofstra.edu/faculty/Stefan_Waner/RealWorld/logic/logicintro.html

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Propositions: Foundation of logic

- Definition: A *proposition* is an *unambiguous declarative statement* that is either *true* or *false*
- Truth Values
  - True
  - False

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Which are propositions? Their truth values?

- 2 + 2 = 4
  - It is a proposition. Its truth value is True
- 1 = 0
  - It is a proposition. Its truth value is False
- It will rain tomorrow
  - It is a proposition. We'll know its truth value tomorrow!
- Go Green
  - Not a proposition
- The number 5.
  - Not a proposition

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Examples of non-propositions

- Exclamations
  - *Come here*
- Questions
  - *Are you bored already?*
- Ambiguous statement:
  - *I saw a man on a hill with a telescope.*
- Sentences containing indexical expressions, like, I, he, there, now, …
  - *I am handsome.*
- Self-referential statements
  - *This sentence is false.*

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Notation

- We shall use the letters p, q, r, s and so on to stand for propositions.
- We might decide that p should stand for the proposition "Lansing is the capital of Michigan." We write:
  p: "Lansing is the capital of Michigan"
- Read it as
  - p is the proposition "Lansing is the capital of Michigan."

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New Propositions

- New propositions can be formed from existing propositions using *logical operators*:
  - Negation
  - Conjunction
  - Disjunction
  - Exclusive OR
  - Conditional/Implication
  - Biconditional

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Negation

- Definition: Let p be a proposition. The negation of p, denoted $\neg p$, is the proposition

  'It is not the case that p.'
- Example
  - p: "Lansing is the capital of Michigan"
  - $\neg p$: "It is not the case that Lansing is the capital of Michigan"

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Truth Table

- Displays relationships between the truth values of propositions
- Truth table of $\neg p$

p	$\neg p$
T	F
F	T

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Conjunction

- Definition: Let p and q be propositions. The conjunction of p and q, denoted $p \wedge q$, is the proposition that is:
  - true when both p and q are true, and
  - false otherwise
- Example:
  - Let p: "the butler did it" and let q: "the cook did it." What does $p \wedge q$ say?
  - Solution: "Both the butler and the cook did it."

Truth Table for $p \wedge q$

p	q	$p \wedge q$
T	T	T
T	F	F
F	T	F
F	F	F

Example

- Consider the following proposition r
  - r : "Sky is blue and the grass is green"
- What is the truth value of r ?