Final Clicker Question!

Q: When would you prefer we hold the Final Exam review session?
Final Clicker Question!

Q: When would you prefer we hold the Final Exam review session?

[A] Monday, May 16th  
[B] Tuesday, May 17th  
[C] Wednesday, May 18th
Final Clicker Question!

Q: When would you prefer we hold the Final Exam review session?


[C] Wednesday, May 18th

Hint: Final Exam is Thursday May 19th at 2pm

Q: When would you prefer we hold the Final Exam review session?
Logistics

- CS8 will be back next Spring!
- Critical Review at the end of class today.
- Course survey available on the writing assignment.
- Final Exam: can bring a one-sided notecard! (same as midterm)
- No office hours Friday
- Today: reflect on the big parts of each unit.
Reflection!

- Today: reflect on the big parts of each unit.
- You can ask questions along the way!

(1) Main Idea

(2) Exam Prep

“The old man the boat”
Units

- Unit 0: Bits
- Unit 1: Logic
- Unit 2: Programming
- Unit 3: Algorithms
- Unit 4: Databases
- Unit 5: Machine Learning
- Unit 6: Comp. Viz + NLP
- Unit 7: Theory
- Unit Naught: Codes, Compression
- Unit 8: Recursion
- Unit 9: Cryptography
- Unit 10: Applications
Units

› Unit 0: Bits
› Unit 1: Logic
› Unit 2: Programming
› Unit 3: Algorithms
› Unit 4: Databases
› Unit 5: Machine Learning
› Unit 6: Comp. Viz + NLP
› Unit 7: Theory
› Unit Naught: Codes, Compression
› Unit 8: Recursion
› Unit 9: Cryptography
› Unit 10: Applications

One Vote: Click during your favorite unit
Unit 0: Bits

vote now if bits was your favorite unit
Unit 0: Bits

Everything can be represented as numbers!

Main Idea
Unit 0: Bits

Everything can be represented as numbers!

Humans use base ten but we could use something else (like base two)

Main Idea
Unit 0: Bits

- Converting base two to base ten and vice versa.
- Binary Addition, Subtraction.
- Representing text, video, images with numbers.
Unit 1: Logic

vote now!
Unit 1: Logic

(1) There is a notion of correct reasoning (Logic)
(2) Computers automate this reasoning process
(1) There is a notion of correct reasoning (Logic)
(2) Computers automate this reasoning process
Unit 1: Logic

(1) There is a notion of correct reasoning (Logic)
(2) Computers automate this reasoning process
Unit 1: Logic

- Physical representation of bits, gates
- Logical functions: AND, OR, NOT
- Truth Tables
- Composite logic functions
- Logical Rules

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Unit 2: Programming

vote now!
Unit 2: Programming

Lets us delegate our ideas to a computer

Idea!
Unit 2: Programming

- Loops
- Conditions
- Making your own blocks
- Lists
- Variables
- “Hand simulating” code
Unit 3: Algorithms

vote now!
Unit 3: Algorithms

- **Definition:** An *algorithm* is a recipe for solving a problem.

- Computer science is (loosely) the study of algorithms.
Unit 3: Algorithms

- Problem Specification: defines a problem via \textit{Input} and \textit{Output}

- Problems: Searching, Sorting, Satisfiability, Halting

- Search Solutions: Random Search, Linear Search, Binary Search

- Sort Solutions: Random Sort, Selection Sort

- Properties of Algorithms: Correct, Growth Rate
Unit 4: Databases

vote now!
Unit 4: Databases

- A database is a collection of data!

- Critical to:
  - Banking
  - Information Retrieval
  - Commerce
  - Government
  - Artificial Intelligence

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</table>
Unit 4: Databases

- Interacting with a database using SQL, queries
- Logic and Aggregating functions in SQL
- Repeated Database
- Dictionary (just a key-value ~ 2 column database)
Unit 5: Machine Learning

vote now!
Unit 5: Machine Learning

Learning can be represented as an algorithm!
Unit 5: Machine Learning

Learning can be represented as an algorithm!

- Blue dots = class one
- Purple dots = class two
- Light yellow dots = class three

Main Idea
Unit 5: Machine Learning

Learning can be represented as an algorithm!
Unit 5: Machine Learning

- Problem: Classification
  - Solution: Memorize and Guess, Nearest Neighbor

- Reinforcement Learning:
  - What can the agent learn?
  - How to provide rewards.

- Slot Machines
Unit 6: Comp. Vision & NLP

vote now!
Unit 6: Comp. Vision & NLP
Unit 6: Comp. Vision & NLP

Main Idea
Unit 6: Comp. Vision & NLP
Unit 6: Comp. Vision & NLP

Main Idea
Unit 6: Comp. Vision & NLP

1. Thought

Main Idea
Unit 6: Comp. Vision & NLP

1. Thought
2. Words

“Hey, do you want to go…”

Main Idea
Unit 6: Comp. Vision & NLP

1. Thought
2. Words

"Hey, do you want to go..."

Main Idea
Unit 6: Comp. Vision & NLP

1. Thought
2. Words
3. Coordinated nerve control

“Hey, do you want to go…”

Main Idea
1. Thought
2. Words
3. Coordinated nerve control
4. Sound

“Hey, do you want to go...”

Lungs
Larynx
Tongue, Lips

Main Idea
Unit 6: Comp. Vision & NLP

1. Thought
2. Words
3. Coordinated nerve control
4. Sound

“Hey, do you want to go…”

(Changes in air pressure)

Main Idea
Unit 6: Comp. Vision & NLP

1. Thought
2. Words
3. Coordinated nerve control
4. Sound

“Hey, do you want to go…”

(Changes in air pressure)

- Lungs
- Larynx
- Tongue, Lips

Main Idea
“Hey, do you want to go...”

1. Thought
2. Words
3. Coordinated nerve control
4. Sound
5. Back to words

Main Idea
Unit 6: Comp. Vision & NLP

1. Thought
2. Words
3. Coordinated nerve control
4. Sound
5. Back to words

"Hey, do you want to go…"

(Tongue, Lips)

(Changes in air pressure)

Larynx

Lungs

Words

Main Idea

6. Back to thought
Unit 6: Comp. Vision & NLP

Vision and Language can be understood (and implemented) computationally!

“grapes”

Main Idea
Unit 6: Comp. Vision & NLP

› Vision Features: Edges! Hierarchy!
› NLP Problem: Speech Synthesis
› Difficulties of language:
  - Phonetic ambiguity
  - Garden Path Sentences
› Dialogue Systems
Unit 7: Theory

vote now!
Unit 7: Theory

(1) We don’t yet know if SOLVE = VERIFY

(2) There are problems we can pose that are fundamentally unsolvable

Main Idea
Unit 7: Theory

**Definition:** SOLVE is the class of problems a computer can efficiently solve.
**Unit 7: Theory**

**Definition:** SOLVE is the class of problems a computer can efficiently solve.

**Definition:** VERIFY is the class of problems where a computer can efficiently verify solutions.

**Main Idea**
Unit 7: Theory

We don’t yet know if these classes are equal or not!

**Definition:** SOLVE is the class of problems a computer can efficiently solve.

**Definition:** VERIFY is the class of problems where a computer can efficiently verify solutions.
Unit 7: Theory

We don’t yet know if these classes are equal or not!

Important because we want to know if problems in VERIFY are solvable!

**Definition:** SOLVE is the class of problems a computer can efficiently solve.

**Definition:** VERIFY is the class of problems where a computer can efficiently verify solutions.

Main Idea
(2) There are problems we can pose that are fundamentally unsolvable
The Halting Problem

• **INPUT:**
  - A description of a program, input to the program.

• **OUTPUT:**
  - True if the program will halt when run on that input.
  - False if the program does not halt with that input.
The Halting Problem

- Suppose we have a correct algorithm for this problem:
The Halting Problem

- Suppose we have a correct algorithm for this problem:
  - Linear Search
  - Dictionary
  - “Snow”
The Halting Problem

- Suppose we have a correct algorithm for this problem:

  Halt Genie

  “Halts”
The Halting Problem

- Suppose we have a correct algorithm for this problem:

- Random Search
- Dictionary
- “Flaboygle”
The Halting Problem

- Suppose we have a correct algorithm for this problem:

  Halt Genie

  “Runs forever”
The Halting Problem

Now consider the wily Gremlin:

A program
The Halting Problem

Now consider the wily Gremlin:

A program

A program

Gremlin

Halt Genie

“Halts”

“Loops”
The Halting Problem

Now consider the wily Gremlin:

A program $\rightarrow$ Gremlin $\rightarrow$ A program $\rightarrow$ Halt Genie $\rightarrow$ “Loops” $\rightarrow$ “Halts” $\rightarrow$ Stop running $\rightarrow$ Loop forever
The Halting Problem

Now consider the wily Gremlin:

Gremlin

Halt Genie

"Halts"

"Loops"

Stop running

Loop forever
The Halting Problem

Now consider the wily Gremlin:

Gremlin

Gremlin

Halt Genie

“Halts”

“Loops”

Stop running

Loop forever

stop

forever

65
The Halting Problem

Now consider the wily Gremlin:

- **Gremlin**
- **Halt Genie**
  - "Halts"
  - Loop forever

Stop running

"Loops"

Stop all
The Halting Problem

If a Halt Genie exists (i.e. a correct algorithm for the Halting Problem), then we get a contradiction!
The Halting Problem

If a Halt Genie exists (i.e. a correct algorithm for the Halting Problem), then we get a contradiction!

Therefore, no correct algorithm can exist for this problem.
Unit 7: Theory

‣ SOLVE and VERIFY.

‣ How to pose a verification specification (e.g. Sudoku)

‣ All problems in SOLVE are in VERIFY. (and why!)

‣ Halting Problem is unsolvable.
Unit Naught: Codes, Compression

vote now!
Unit Naught: Codes, Compression

Encode information in a particular way, to make the information:

1. Safe from error
2. Compressed

Everything else, black

1K

0.3K

Main Idea
Unit Naught: Codes, Compression

- Error Codes:
  - Repetition Code
  - Checksum

- Compression:
  - Run length encoding ("aaaa" —> 4a)
  - Kolmogorov Complexity
Unit 8: Recursion

vote now!
Unit 8: Recursion

**Definition:** a process, program, or object is said to be *recursive* if it involves repeated self-reference

*Recursion is everywhere, in math, in computation, in art, and in nature*
Unit 8: Recursion

Q: How do these two bubbles relate?

Things that can be computed, period.

Computations that can be represented recursively

factorial

length of word

Main Idea
Q: How do these two bubbles relate?

A: They’re identical...
Unit 8: Recursion

- In general, *recursive entities can be described as:*
  - A simple step
  - A recursive step

- Recursion can be *infinite*

- For recursion to be *finite*, we need a **base case**.

- Be ready to write or analyze an algorithm recursively (factorial, length of a list, max, drawing a spiral, etc.)
Unit 9: Cryptography

vote now!
Unit 9: Cryptography

(1) We can use algorithms to simulate a lock and key

(2) We can use algorithms to simulate randomness

Main Idea
Unit 9: Cryptography

- Classical methods (Caesar, etc.)
- Breaking classical methods
- Problem set up (Alice, Bob, Eve)
- Definition of One Way Function
- Diffie-Helman Key Exchange
- Definition of Pseudorandomness
Applications

vote now!
Applications

Main Idea
Applications

None! Technical material from Comp Bio and Graphics will not appear on the final.
Your TAs!
Computer Science

- It’s not about the computer
Computer Science

- It’s not about the computer

- It’s about the ideas you can explore, the worlds you can create, and the problems you can solve.
Computer Science

- It’s not about the computer.
- It’s about the ideas you can explore, the worlds you can create, and the problems you can solve.
- I hope you enjoyed your first byte!¹

¹Thanks to Michael Littman for this!