

Final practice

CS105: Great Insights in Computer Science
Michael L. Littman, Fall 2007

Rules

20 questions,
10 pts each

- Keep at least one empty seat between you and everyone else.
- Please write your answers directly on the pages.
- You may use your notes, your book, a calculator.
- You may **not** discuss the test with anyone else, including online sources (no cell phone, computer).
- You may ask clarification questions during the exam.

1. Exponentially Right?

Which of these sentences use the term “exponentially” correctly?

- a. Once I got my cell phone, I was **exponentially** better at knowing what time it was.
- b. The number of transistors on a chip has increased **exponentially** over the past twenty years.
- c. Home prices in the northeast have been rising **exponentially**.
- d. My new mac is **exponentially** more powerful than my previous one.
- e. Now that I have kids, my life is exponentially more complex.

2. Random Questions

Consider the word “valuable”. If we repeatedly pick a random letter from the word...

- a. How many times, on average, do we pick before we get the letter “b”?
- b. How many times, on average, do we pick before getting one of the letters in the word “vat”?
- c. How many times, on average, do we pick before choosing a vowel?

3. Huffman Coding

Find a Huffman code for “lolfootball”. How many bits does it take to write this string in your code?

4. Song Growth

How many syllables do you sing in n verses of the following three songs? Choose from $O(n)$, $O(n \lg n)$, $O(n^2)$, and $O(n^2 \lg n)$.

Verses are numbered.

- a.
- b.
- c.

4a. Animal Dept. Store

1. A kitty and a cat with mittens brand new got into an elevator (top floor). Then there were two: 1, 2!

Then there were two: 1, 2!

2. **Two** little animals feeling carefree. A bull came from market. Then there were three: 1, 2, 3!

3. **Three** little animals waiting to arrive. In came a mule and a mare. And then there were five: 1, 2, 3, 4, 5!

4. **Five** little animals acting sedate. The Doggy family joined them. And then there were eight: 1, 2, 3, 4, 5, 6, 7, 8!

5. **Eight** little animals standing in a line. Shep the sheep sauntered in. And then there were nine: 1, 2, 3, 4, 5, 6, 7, 8, 9!

6. **Nine** little animals waiting yet again. Mr. Hog got on. And then there were ten: 1, 2, 3, 4, 5, 6, 7, 8, 9, one oh!

...

(From Sesame Street. Assume for your analysis that between one and three animals get on per floor.)

4b. There's A Hole

1. **There's a hole** at the bottom of the sea. There's a hole at the bottom of the sea. There's a hole, there's a hole, there's a hole at the bottom of the sea.

2. **There's a log** in the hole at the bottom of the sea. There's a log in the hole at the bottom of the sea. There's a log, there's a log, there's a log in the hole at the bottom of the sea.

3. **There's a bump** on the log in the hole at the bottom of the sea. There's a bump on the log in the hole at the bottom of the sea. There's a bump, there's a bump, there's a bump on the log in the hole at the bottom of the sea.

4. **There's a frog** on the bump on the log in the hole at the bottom of the sea. There's a frog on the bump on the log in the hole at the bottom of the sea. There's a frog, there's a frog, there's a frog on the bump on the log in the hole at the bottom of the sea.

5. **There's a leg** on the frog on the bump on the log in the hole at the bottom of the sea. There's a leg on the frog on the bump on the log in the hole at the bottom of the sea. There's a leg, there's a leg, there's a leg on the frog on the bump on the log in the hole at the bottom of the sea.

...

4c. Ants Go Marching

1 The ants go marching one by one, hurrah, hurrah
The ants go marching one by one, hurrah, hurrah
The ants go marching one by one,
The little one stops to suck his thumb
And they all go marching down to the ground
To get out of the rain, BOOM! BOOM! BOOM!

2 The ants go marching two by two, hurrah, hurrah
The ants go marching two by two, hurrah, hurrah
The ants go marching two by two,
The little one stops to tie his shoe
And they all go marching down to the ground
To get out of the rain, BOOM! BOOM! BOOM!

3 The ants go marching three by three, hurrah, hurrah
The ants go marching three by three, hurrah, hurrah
The ants go marching three by three,
The little one stops to climb a tree
And they all go marching down to the ground
To get out of the rain, BOOM! BOOM! BOOM!

4 The ants go marching four by four, hurrah, hurrah
The ants go marching four by four, hurrah, hurrah
The ants go marching four by four,
The little one stops to shut the door
And they all go marching down to the ground
To get out of the rain, BOOM! BOOM! BOOM!

5 The ants go marching five by five, hurrah, hurrah
The ants go marching five by five, hurrah, hurrah
The ants go marching five by five,
The little one stops to take a dive
And they all go marching down to the ground
To get out of the rain, BOOM! BOOM! BOOM!

6 The ants go marching six by six, hurrah, hurrah
The ants go marching six by six, hurrah, hurrah
The ants go marching six by six,
The little one stops to pick up sticks
And they all go marching down to the ground
To get out of the rain, BOOM! BOOM! BOOM!

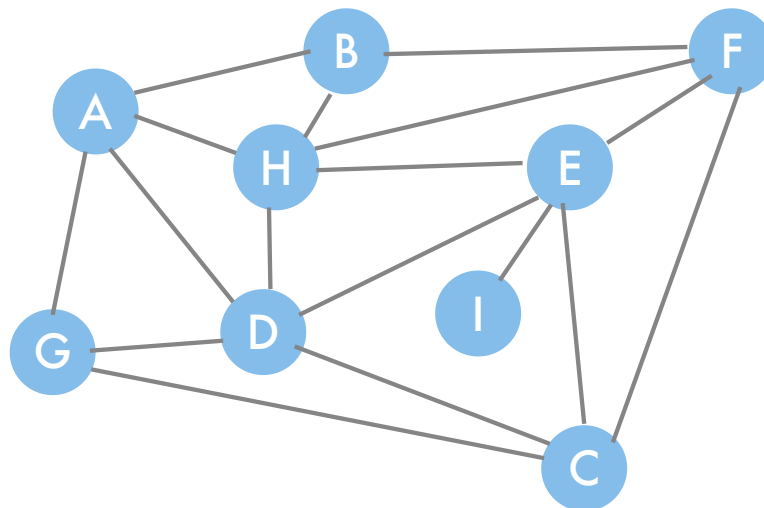
7 The ants go marching seven by seven, hurrah, hurrah
The ants go marching seven by seven, hurrah, hurrah
The ants go marching seven by seven,
The little one stops to pray to heaven
And they all go marching down to the ground
To get out of the rain, BOOM! BOOM! BOOM!

8 The ants go marching eight by eight, hurrah, hurrah
The ants go marching eight by eight, hurrah, hurrah
The ants go marching eight by eight,
The little one stops to shut the gate
And they all go marching down to the ground
To get out of the rain, BOOM! BOOM! BOOM!

5. Pathology

A. What's the shortest path from G to F?

B. What's a longest (cycle-free) path from G to C?



6. Mystery Routines

The scratch-like scripts below work on the 1 through n elements of list L and set the variable *answer* to zero (False) or one (True). Match each script to the question it answers.

A. Does the number -1 appear in the list?

B. Are all elements in the list ten or larger?

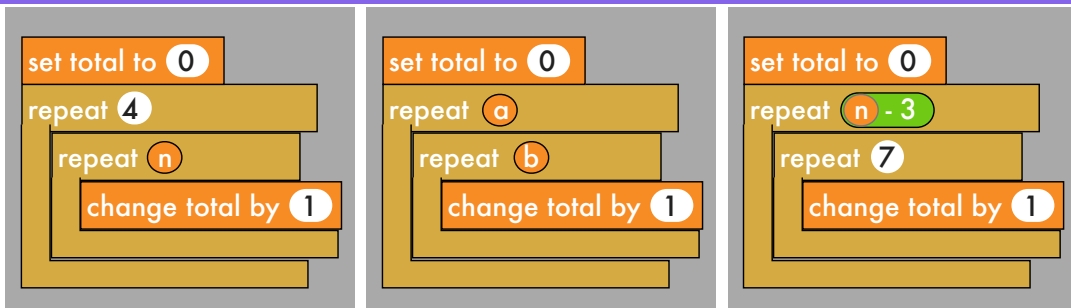
C. Is there an element in the list whose position matches the number (like the number 5 in the 5th position)?

The Scripts

The image shows three Scratch-like scripts, each starting with 'when I receive mystery1', 'when I receive mystery2', and 'when I receive mystery3'. Each script follows a similar structure: a 'repeat until' loop with condition ' $n < 1$ ', an 'if' statement, and a 'change n by -1' block. The 'if' statements are: ' $L[n] < 10$ ', ' $L[n] = -1$ ', and ' $L[n] = n$ '. The 'set answer to' blocks are: 0, 1, and 0. The 'stop script' blocks are at the end of each script.

| Script | Repeat Until Condition | If Condition | Set Answer To |
|----------|------------------------|--------------|---------------|
| mystery1 | $n < 1$ | $L[n] < 10$ | 0 |
| mystery2 | $n < 1$ | $L[n] = -1$ | 1 |
| mystery3 | $n < 1$ | $L[n] = n$ | 1 |

7. Loopin'



What value will *total* have at the end of each script?

8. Algorithm Growth

You have a list of integers of length n . How fast can you answer the following questions if the list is unsorted? Sorted? Your choices are $O(1)$, $O(\log n)$, $O(n)$, $O(n^2)$.

A. What is the second biggest number in the list?

Unsorted: _____ Sorted: _____

B. Are there two numbers in the list that add up to 1000?

Unsorted: _____ Sorted: _____

C. How many times does 74 appear in the list?

Unsorted: _____ Sorted: _____

D. Is the product of the numbers divisible by 7?

Unsorted: _____ Sorted: _____

9. Efficient List Algorithms

608, 230, 163, 632, 355, 884, 150, 407, 676, 441, 863, 288, 915,
807, 273, 356, 341, 647, 209, 769, 180, 343, 523, 543, 748, 708,
461, 106, 675, 914, 379, 953, 929, 181, 141, 974, 655, 324, 826,
364, 292, 863, 928, 804, 867, 126, 945, 406, 514, 156, 998

A. Is the product of these numbers divisible by 5?

B. Is the median of these 51 numbers bigger than 500?

10. Look It Up

Ask.com needs a way to create an index so they can quickly determine how many web pages contain any given word. They realize that they can solve their problem by sorting a list of all n words.

A. Using the solution of one problem (sorting) to solve another (indexing) is an example of what?

B. If they use selection sort to do their sorting, what is the running time?

12. 3-input Gate

Write a logical expression with A, B, C, and, or, not, as needed.

D =

| A | B | C | D |
|-------|-------|-------|--------------|
| False | False | False | False |
| False | False | True | False |
| False | True | False | True |
| False | True | True | True |
| True | False | False | False |
| True | False | True | False |
| True | True | False | False |
| True | True | True | True |

13. WIN @ NIM

In mini-nim, players take turns removing one or two objects from a pile. The goal is to be the one to remove the last object.

A. It's your turn. There are 15 objects. How many should you take to win?

B. It's your turn. There are 7 objects. How many should you take to win?

14. Subroutines

when Sprite1 clicked
set kids to 2
repeat until kids < 1
broadcast verse and wait
change kids by -1

when I receive verse
say There were for 1 sec
say kids for 1 sec
say on the bed for 1 sec

What will the sprite say when clicked?

15. Halt or Not

(A) when I receive p1
set n to ?
repeat until n < 12
play sound pop and wait
change n by -1

(B) when I receive p3
set n to ?
repeat until n > 20
play sound pop and wait
change n by 5

(C) when I receive p2
set n to ?
repeat until n > 41
play sound pop and wait
change n by -3

(D) when I receive p4
set n to ?
repeat until n = 6
play sound pop and wait
change n by 2

For what values of “?” does each of these scratch scripts halt?

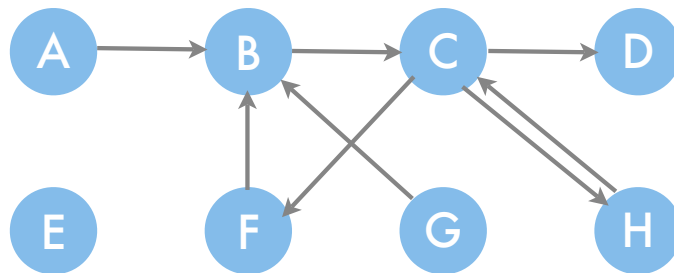
16. Logical Question



green pants

If a stands for “has green pants” and b stands for “has open eyes”, give a logical expression that will split the group in half.

17. Graph Terms



A. List the nodes reachable from A.

B. List the source(s).

18. 10-exactly-one

A k -exactly-one gate outputs True if exactly one of its k input bits are True. It can be made with one AND gate, one k -at-most-one gate, and one k -or gate.

A k -at-most-one gate outputs True if no more than one of its k input bits are True. It can be made with $k(k-1)/2$ AND gates, one NOT gate, and one k -or gate.

A k -or gate outputs True if at least one of its k input bits are True. It is made of $k-1$ OR gates.

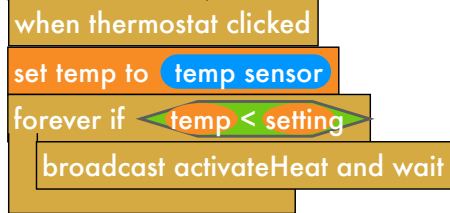
How many AND gates are there in a 10-exactly-one gate?

19. Find The Bug

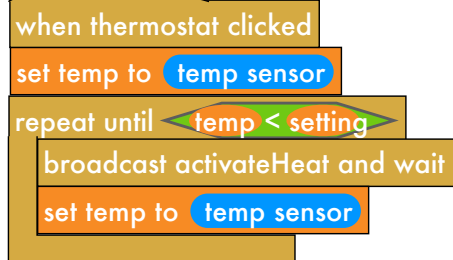
The number of described U.S. species of beetles is 23,700. If I'm thinking of one of them, how many guesses would it take for you to figure out which, using only yes/no questions?

20. The Heat Is On

(a)



(b)



Each program has a bug.
Choose one description for
each script.

- A. Turns on the heat when it's hot.
- B. Turns on the heat at most once.

C. Leaves the heat always on or always off.

- D. Turns off the heat at most once.
- E. Never turns on the heat, no matter what.