COS 109 Midterm Exam, Fall 2019 Due 5:00 PM, Friday, October 25

DO NOT OPEN THIS EXAM UNTIL YOU ARE READY TO TAKE IT

PRINT your name here _____

Do not discuss the exam with, or accept help from, anyone. You must write and sign this statement:

"*This examination represents my own work in accordance with University regulations.*"

Rules

This examination is open-book and open-note:

- you may use the textbook, course notes, your own notes, corrected problem sets and solutions, old exams and answer sheets from the course web page, lab instructions, etc.
- you may use a calculator.
- you may not use anything else; specifically, you may not use a computer, phone or tablet (except that you can use the calculator program on one of these, and you can use your computer to view course notes if you did not print them).

Procedure

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This is a 90-minute exam that you must complete in a single 90-minute period any time before it is due. Set aside a comfortable time when you will be awake, where you will not be disturbed, and where you have all your course material at hand. Then open the exam and do it.

After 90 minutes, close it and turn it in as soon as possible. Make sure that all pages are firmly attached.

There are a total of 90 points for the questions; use the point values for each question to allocate your time appropriately (one point per minute).

Write your answers directly on these pages; if you need more space, attach extra pages (stapled) and make sure your name is on any extra pages you submit. Please write neatly -- we can't grade it if we can't read it. It's quite all right to be brief as long as you're clear. We have tried to leave plenty of room for answers; if you are writing or computing a lot, you may be off on the wrong track.

Good luck.

Submission

Due by 5:00 PM, Friday, Oct 25, in the box outside Room 311 of the Computer Science building.

Please do not discuss the exam with anyone until after the submission deadline has passed.

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DO NOT OPEN THIS EXAM UNTIL YOU ARE READY TO TAKE IT

1. (20 points, 2 each) Short Answers. Circle the right answer or write it in the space provided.

(a) Eventually the USA will run out of 9-digit social security numbers. If social security numbers used hexadecimal digits instead of decimal, how many hexadecimal social security numbers could there be? Express your answer as some approximate number multiplied by the closest power of 10, like 1.2 * 10^34.

(b) A while back, the NY Times described a device "the size of a grain of rice" that could be implanted in people as a "subdermal barcode" to help identify them. Which one of the many gadgets and devices we have talked about in class uses the most similar technology?

(c) In September, a court in _____ decided that the "right to be forgotten" did not apply to Google searches made from outside of the court's jurisdiction. What jurisdiction belongs in the blank?

(d) The speeds of supercomputers are measured in floating-point operations per second, or "flops." Princeton's web page on 10/7/19 described a new campus supercomputer, Traverse, whose speed of 1.4 PFlops puts it in the top 500 in the world. Approximately how does Traverse's speed compare to the fastest computer on the list? Traverse is…

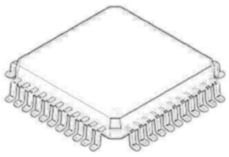
1/1000 times as fast **1/100 times as fast** **1/10 times as fast** **about the same** **10 times faster**

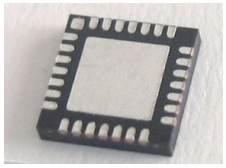
(e) If **n** and **m** are integers, how many 1 bits (i.e., bits that have the value 1) are there in the binary representation of the number $\mathbf{2^n / 2^m}$?

(f) If on my laptop I start a big program that I haven't used before, it takes about 10 seconds before it's ready to use. If I then quit the program and 15 seconds later restart it, the startup is much faster. ***Very briefly*** explain why.

(g) As integrated circuit chips get more complicated, they usually need more pins to connect to external circuitry. If pins are arranged around the periphery of a square chip at a fixed spacing as shown in the pictures, which of these expressions best describes how the number of pins varies in proportion to the width **w** of the chip?

log w **√w** **w** **w log w** **w^2** **2^w**





(h) Suppose we organize an enormous singles tennis tournament with everyone in the world participating. The winner of each match advances to the next round; the loser of each round is eliminated. (An odd person out gets a bye to the next round.) About how many rounds would it take to determine the ultimate winner?

(i) Sports teams often perform a post-game ritual in which each member of one team shakes hands with each member of the other team. If there are **N** players on each team, how many handshakes are there??

(j) If I want to store the contents of all of the RAM on the laptops of the 47 students in COS 109 on a single disk, which of these is the smallest that would be sufficient?

1 GB **1 TB** **1 PB** **1 EB** **1 ZB** **1 YB** **none of these**

2. (15 points) Playing with Toys

Here is a short program in assembly language for the toy computer used in class, with reminders about what the instructions do:

```
Foo  GET          get a number from keyboard into accumulator
     IFZERO Bar   if accumulator is zero, go to location Bar
     IFPOS  Foo   if accumulator is >= zero, go to location Foo
     LOAD   Sum   load accumulator with value in location Sum
     ADD    1     add 1 to accumulator
     STORE  Sum   store accumulator in location Sum
     GOTO   Foo   go to location Foo
Bar  LOAD   Sum
     PRINT
     STOP
Sum  0   reserve a memory location called Sum, set its initial value to 0
```

(a) If you run this program and give it the sequence of inputs **6 5 –3 2 1 –4 7 0** ***exactly*** what does it print?

(b) Which of these expressions best describes how the running time of this program depends on **N**, the input number?

log N **N** **N log N** **N^2** **2^N** **independent of N**

(c) The line "**`Sum 0`**" could be moved to one other place in this program and the program would behave identically. Where is that place?

(d) There are 10 instructions in the Toy computer's repertoire. How many bits are needed to encode an instruction?

(e) Von Neumann's paper describes a computer with 21 instructions. If the Toy computer is modified to include any new instructions from von Neumann's design, could the modified Toy perform fundamentally new computations that it could not have done before? Why do you say so? **Be brief**; we're looking for the idea, not an essay.

3. (55 points, 5 each) Miscellaneous

(a) Here are five hexadecimal numbers corresponding to the traditional colors Princeton orange, Harvard crimson, Yale blue, Dartmouth green and Podunk gray. Write the proper school name beside each color.

00693E

0F4D92

706E71

C90016

E77500

(b) An article in the *NY Times* some years ago said that the number of regular wired telephone lines in the USA shrank by a factor of two in the previous 12 years, leaving only 65 million wired lines when the story was written.

(i) What is the yearly percentage rate of decline, assuming that it has been a uniform exponential decline?

(ii) Assuming (improbably) that this rate of exponential decline continues smoothly, how many years from now will there be only a million wired lines?

(c) Suppose that Thomas Sweet has a special on ice cream cones: they will double the diameter of the scoop for only 4 times the price. Is this a good value for an ice-cream lover, a bad value, or not special at all. Explain your answer by quantitative reasoning.

(d) A specific byte in the RAM of a computer contains the hexadecimal value **`0F`**. Clearly mark each of the following that this single byte could possibly represent.

The letter F in ASCII	**could represent**	**could not represent**
Part of an instruction in the Safari browser	**could represent**	**could not represent**
An emoji in Unicode	**could represent**	**could not represent**
The integer value 15	**could represent**	**could not represent**
Part of Allegri's *Miserere* in MP3 format	**could represent**	**could not represent**

(e) According to news stories in October 2019, cameras operated by Los Angeles County police capture and store 3 million license plate pictures every week. The data includes the plate number and the time, date and place where it was recorded. Estimate how much disk space one year's worth of these records will occupy. Explain your reasoning carefully but concisely so we can see how you got your answer.

(f) Some binary arithmetic:

(i) Add these two binary numbers:

```
11010.101101
  101.010011
------------
```

(ii) Suppose you are adding two **n**-bit binary numbers by hand. Which of these expressions best describes how the amount of work you have to do depends on **n**, the length of each number?

log n **n** **n log n** **n^2** **2^n** **doesn't depend on n**

(g) Joe College has 100 files on his computer whose names end in **`.docx`**.

(i) How many times does Joe have to run Word to compute the total number of bytes in all of the **`.docx`** files?

(ii) How many files does he have to read to determine whether they really are Word files?

(h) Quickies:

Alan Turing's estate endowed the ACM Turing Award	**true**	**false**
John von Neumann is buried in his native Hungary	**true**	**false**
Bill Gates got his start by writing a Basic interpreter for Windows	**true**	**false**
Oracle v Google is about Java APIs	**true**	**false**
A prox card is powered by a tiny embedded battery	**true**	**false**

(i) How does your phone produce a vibration for vibrate mode? Describe briefly but precisely the mechanism by which a vibration is probably produced. 10-15 words should be more than enough.

(j) The professor in a class with **N** students normally returns problem sets that he has laboriously sorted by student name. For each of the following, give a single expression in **N** (e.g., 2^N) that tells how the work is proportional to or depends on the size of the class in the worst case.

– If the professor uses an efficient algorithm, how much work does he have to do to sort the problem sets?

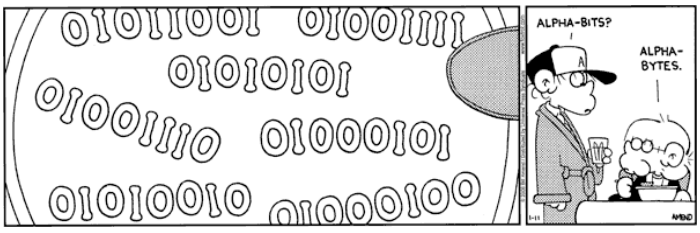
– How many problem sets does the first student have to look at to find her problem set in the sorted pile, if she uses an efficient algorithm?

– How many problem sets in total must be looked at by all the members of the class when the pile is sorted, if each in turn uses an efficient algorithm to find his or her own problem set?

– If the professor fails to sort the problem sets, how many problem sets does the first student now have to look at to find her problem set in the unsorted pile?

– How many problem sets in total must be looked at by all members of the class when the pile is unsorted?

(k) ***Exactly*** what do the alphabytes in Jason's cereal bowl say? Write your answer clearly and ***unambiguously***.



	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR	SO	SI
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2	SPC	!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	DEL