COS 109 Midterm Exam, Fall 2023 Due 5:00 PM, Friday, October 13

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). You may not use the Internet.

Procedure

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

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 13, 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.

10/06/2023 3:16:19 PM

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) Unix systems distinguish upper case letters from lower case letters in filenames: lab3.html, Lab3.html and LAB3.HTML are different names (as you might have learned while trying to upload your labs). How many different ways are there to write the filename **`lab3.html`** in mixtures of upper and lower case letters?

(b) The first character of the Unicode code chart for the Gothic alphabet has code **`10330`** and the last character has code **`1034F`**. How many characters are there in the Gothic code chart?

(c) In the following list of 24-bit RGB colors, expressed in hexadecimal, which one has the smallest amount of blue? (The character **`0`** is a zero.)

`ACCEDE` **`BA0BAB`** **`B0BBED`** **`C0FFEE`** **`DEC0DE`** **`D00DAD`** **`EFFACE`** **`FACADE`**

(d) The speeds of supercomputers are measured in floating-point operations per second, or "flops". Which one of these would be the most representative speed for the fastest of today's supercomputers?

1 Mflop **1 Gflop** **1 Tflop** **1 Pflop** **1 Eflop** **1 Zflop** **1 Yflop**

(e) Modern computers can efficiently process integers of several sizes, usually 1, 2, 4, and 8 bytes long. Which of these is the least number of bytes that could be used for storing a binary number that represents the population of California?

1 byte **2 bytes** **4 bytes** **8 bytes** **something bigger** **no way to tell**

(f) Archie reports a headline from *The Guardian*: "WhatsApp increases group chat size limit to 256 people. It's not clear why WhatsApp settled on such an oddly specific number." In no more than half a dozen words, explain the likely reason for this specific number.

(g) "Daily active users for [Facebook] Threads on Android dropped from 49 million on July 7 to 23.6 million on July 14, and then to 12.1 million on July 21", says a web analytics company. If this decline had continued at the same exponential rate, how many weeks would it have been before the number of users was below 1 million?

(h) What is the decimal value of the binary number **`111001.11`**?

(i) Suppose that a secretive spy agency stores the name, address, phone number and social security number for every person in the USA. *Very roughly*, how many gigabytes would be required to hold all this information, without compression? State your assumptions clearly.

(j) Computer pioneer Grace Hopper (1906-1992) said, "The instruction code should use symbols which are easily learned and identified with the operations by already existing mental associations: 'a' for add, etc. Replacing a sequence of binary numbers with a single letter to represent an operation [simplifies] the coding process and makes it much more intuitive for users." What kind or level of programming language is Hopper describing? One or two words is enough.

2. (15 points) Machines

Here is a program in the Toy assembly language, with reminders about what the instructions do.

```
Foo   GET           get a number from keyboard into accumulator
      IFZERO Bar    if accumulator is zero, go to Bar
      IFPOS  Prn    if accumulator is positive, go to Prn
      STORE  N      load accumulator value into location N
      LOAD   0      load 0 into accumulator
      SUB    N      subtract value in location N from accumulator
Prn   PRINT         print value in accumulator
      GOTO   Foo    go to instruction labeled Foo
Bar   STOP
N     0   reserve a memory location called N, set its initial value to 0
```

(a) If this program is given the sequence of inputs **3 –1 4 1 –5 9 2 –6 –5 0** ***exactly*** what does it print?

(b) It is possible to simulate the Toy instruction **`GOTO Foo`** with a sequence of two other Toy instructions, in several ways. Show one such sequence.

(c) Imagine that Alan Turing and John von Neumann are having an argument. Turing says "I can simulate *any* of your computers on my Turing machine." Von Neumann replies "So what? I can simulate your silly Turing machine on *all* of my computers." Who is right?

neither one **only Turing** **only von Neumann** **both**

(d) In his 1946 paper, John von Neumann said "We are therefore forced to recognize the possibility of constructing a hierarchy of _____, each of which has greater capacity than the preceding but which is less quickly accessible." Which of the following is the proper word to fill in the blank

accumulators **controls** **instructions** **memories** **orders** **organs** **processors**

(e) Von Neumann also said "It is convenient to group the binary digits into tetrads, groups of 4 binary digits." What synonym or alternative terminology might be used today instead of tetrads?

3. (55 points, 5 each) Miscellaneous

(a) A recent biography of John von Neumann says that a particular computation produces a number "less than a trillionth of a trillionth of a billionth of 1 joule-second, far too small to be noticed in everyday life but large enough to be significant at the atomic scale."

(i) What power of ten is "a trillionth of a trillionth of a billionth"?

(ii) What power of two is nearest to this power of ten?

(b) Last month I did some experiments with a new algorithm. The measured running times were 15.0 milliseconds to process 4 items, 30.1 msec for 5 items, 59.9 msec for 6 items, and 120.2 msec for 7 items.

(i) Given these times, what is the likely running time for 10 items?

(ii) Which of these is the most likely description of how the algorithm's running time grows in proportion to the number of items?

logarithmic **linear** **n log n** **quadratic** **cubic** **exponential** **none of these**

(c) The hexadecimal value **FF00FF** can be interpreted as an RGB color, but it is really just a 24-bit integer. Suppose that we add 1 to this integer value, that is, compute **FF00FF + 1**.

(i) What is the resulting value in hexadecimal?

(ii) If the resulting value is interpreted as an standard 24-bit RGB color, which of these colors is it closest to?

red **green** **blue** **yellow** **cyan** **magenta** **black** **white**

(d) Suppose that Princeton wants to encode certain information about current Princeton undergrads *in as few bits as possible*. The information for each person is: birthday (like October 13), age (assume everyone is between 17 and 24 inclusive), class year (2024 through 2027), and donor potential on a scale of 1 through 4. What is the *minimum* number of bits needed per person, and why?

(e) Suppose that we fill Friend 008 with old vacuum tubes like the ones that were passed around in class. Ignoring chairs, desks, people, and everything else, ***very roughly*** how many vacuum tubes would the room hold? You must base your answer on sound estimates and quantitative reasoning. Be brief but clear about your assumptions and computations.

(f) The *NY Time*s said (4/7/23) that "Eleanor Catton's Booker Prize-winning novel *The Luminaries* imposes a precise numerical rule on its chapters, each of which is half the length of the [previous one]." The book has 12 chapters. I do not believe this story, but assuming that it is true and that the final chapter is only one quarter of a page long …

(i) Approximately how many pages are in the first chapter?

(ii) Approximately how many pages are in the whole book?

(g) 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.

(h) In 2008 there were about 25 COS majors per year. Today, 15 years later, there are about 200. Assume that this represents a smooth exponential growth that will continue into the future.

(i) Very roughly, what is the percentage rate of increase of the number of COS majors each year?

(ii) If this trend continues (let's hope not!), and if Princeton remains at its current size, in about how many years will all students be COS majors?

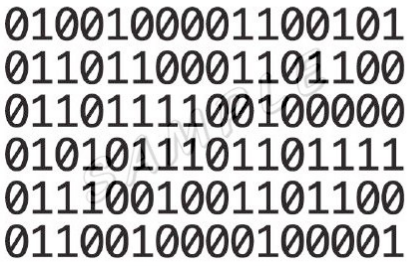
(i) Many years ago, Pat Programmer wrote a C program for a computer that now no longer exists. She still has both the C source code and the compiled code for the ancient computer. She wants to work on the program again, but will have to run it on her brand new laptop. For each of the following, circle the most appropriate answer.

She could run the original compiled code, unchanged, on her laptop	**likely**	**unlikely**
She could compile the C program and run that compiled code on the laptop	**likely**	**unlikely**
She could write a simulator in C for the old computer, and run it on the laptop	**likely**	**unlikely**
She could run the original compiled code on this simulator on the laptop	**likely**	**unlikely**
The simulated computer could run faster than the old physical computer it simulates	**likely**	**unlikely**

(j) Random quickies:

An assembler has to be written in assembly language	**true**	**false**
The Turing Award goes to mathematicians for contributions to theoretical computer science	**true**	**false**
Leibnitz advised Babbage to use binary arithmetic for his mechanical computing devices	**true**	**false**
A prox card is powered by a tiny embedded battery	**true**	**false**
The binary representation of ☹, whose hex representation is `1F641`, fits in 2 bytes	**true**	**false**

(k) The picture on the left is a close-up of a seriously geeky t-shirt from Thinkgeek.com. ***Exactly*** what does it 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