COS 109 Midterm Exam, Fall 2014 Due 5:00 PM, Friday, October 24

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 24, 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.

10/24/2014 8:01:11 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. 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 chart for characters in the N’Ko script has code \texttt{07C0} and the last character has code \texttt{07FA}. How many characters are there in the chart?

(c) In the following list of RGB colors, expressed in hexadecimal, which one has the least amount of green? (The character \texttt{0} is a zero.)

\begin{verbatim}
ACCEDE BEADED B0BBED COFFEE DECODE EFFACE FAÇADE
\end{verbatim}

(d) If you move around on a Google map by moving the mouse while holding the button down, the display reveals new map information in the direction you are moving, while old information disappears in the other direction. What basic computing technique is Google using to make this display work responsively almost all the time? A word or two is sufficient.

(e) Which one of these three-letter acronyms would be most likely to occur in the description of this year’s Nobel Prize in Physics?

\begin{verbatim}
CPU FAT GHz RAM RGB ROM TLA USB
\end{verbatim}
(f) While cleaning up the mess in my office, I found a shiny thing that was about 8 inches in diameter, very thin and light, and covered with a repeated pattern on one side. Sadly, it was quite brittle and when I dropped it on the floor, it broke into several pieces. What was it?

(g) Suppose that a group at a (very boring) party is simulating the Towers of Hanoi algorithm with half a dozen disks, and it takes them 10 minutes to perform the moves. If they decide to play again with a dozen disks, approximately how long will it take them?

(h) What is the decimal value of the binary number $101.01$?

(i) Suppose that the NSA (just hypothetically) stores the name, address, phone number and social security number or equivalent for every person in the world. Very roughly, how much money would they have to spend on disk drives to hold all this information?

(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 should be enough.
2. (15 points) Machines

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

<table>
<thead>
<tr>
<th>Line</th>
<th>Instruction</th>
<th>Reminder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foo</td>
<td>GET</td>
<td>get a number from keyboard into accumulator</td>
</tr>
<tr>
<td>IFZERO Bar</td>
<td>if accumulator is zero, go to Bar</td>
<td></td>
</tr>
<tr>
<td>LOAD Sum</td>
<td>load accumulator with value in location Sum</td>
<td></td>
</tr>
<tr>
<td>ADD 1</td>
<td>add 1 to accumulator</td>
<td></td>
</tr>
<tr>
<td>STORE Sum</td>
<td>store accumulator in location Sum</td>
<td></td>
</tr>
<tr>
<td>GOTO Foo</td>
<td>go to instruction labeled Foo</td>
<td></td>
</tr>
<tr>
<td>Bar</td>
<td>LOAD Sum</td>
<td></td>
</tr>
<tr>
<td>PRINT</td>
<td>print contents of accumulator</td>
<td></td>
</tr>
<tr>
<td>STOP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum 0</td>
<td>reserve a memory location called Sum, set its initial value to 0</td>
<td></td>
</tr>
</tbody>
</table>

(a) If this program is given the sequence of inputs 3 -1 4 1 -5 9 2 -7 0 exactly what does it print?

(b) The line “Sum 0” could be moved to one other place in this program and the program would behave identically. Where is that place?

(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 “Words coding the orders are encoded in the memory just like numbers.” Our Toy machine has 10 “orders.” If they are encoded in the memory just like numbers in as few bits as possible, how many additional instructions could be added to the Toy’s repertoire before another bit would be needed for the encoding?
3. (55 points, 5 each) Miscellaneous

(a) A *NY Times* story on 8/5/08 about horse-doping drugs referred to a non-existent unit of mass called a “petragram”. Presumably they meant picograms; a petagram would be a lot of drugs.

(i) How many picograms are there in a petagram?

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

(b) I opened up a quite old laptop and found a device that was in a sealed metal box about 2-3/4 inches wide, 4 inches deep, and almost half an inch high, with a circuit board attached to one of the 2.75x4 sides, and a connector with nearly 50 pins on one end. It was labeled “1 GB.”

(i) What kind of device is this likely to be?

(ii) Would it make a noise in normal operation? Yes or no.

(iii) If this were a brand new laptop, what might appear instead of “1 GB” (very roughly)?

(c) The hexadecimal value **FF0100** can be interpreted as an RGB color, but it is really just a 24-bit integer. Suppose that we subtract 1 from this integer value, that is, compute **FF0100 − 1**.

(i) What is the resulting value in hexadecimal?

(ii) If the resulting value is interpreted as RGB, which of these colors is it closest to?

- red
- green
- blue
- yellow
- cyan
- magenta
- black
- white
(d) A car odometer with 6 decimal digits rolls over to zero after 999,999 miles. Suppose that the odometer in a car works in binary, not decimal.

(i) If the odometer is 12 binary digits long, what binary value does it show just before it rolls over to zero?

(ii) What is that value expressed in decimal?

(iii) What is that value expressed in hexadecimal.

(e) The ancient core memory that I passed around in class has four 64 by 64 arrays of ferrite cores.

(i) How many bytes does the core memory hold?

<table>
<thead>
<tr>
<th>64</th>
<th>128</th>
<th>256</th>
<th>512</th>
<th>1K</th>
<th>2K</th>
<th>4K</th>
<th>8K</th>
<th>16K</th>
<th>32K</th>
</tr>
</thead>
</table>

(ii) Each 64x64 square measures about 2 inches by 2 inches. By contrast, a 1 GB SD memory card is about 1 inch by 1 inch. Ignoring wiring, power, the mechanical frame, etc., approximately what would be the area of a 1 GB memory if it were made of cores?

(f) Suppose that you want to encode certain information about Princeton undergrads in as few bits as possible. The information for each person is gender, birthday (like October 24), age (let’s assume everyone is between 17 and 24 inclusive), and class year (2015 through 2018). What is the minimum number of bits you need per person, and why?
(g) Experience shows that enrollment in MOOCs (massive open online courses) drops off rapidly; a typical course loses half its remaining students every week. Suppose a MOOC starts with one million online students.

(i) What percentage of the remaining students drop the course every day?

(ii) How many students will be left by the end of a 12-week semester?

(h) 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

(i) A PU id is a 9-digit number that occupies 9 bytes when stored as ASCII characters.

(i) How many bytes would a PU id occupy if it was stored in binary instead?

(ii) Suppose that in this binary representation, one additional bit was used to encode the gender of the person. If the additional bit were the rightmost (least significant) bit, how could you immediately determine a person’s gender by examining only the decimal value of the PU id?
(j) I want to count the number of directories and the number of files in a file system, by going systematically through the hierarchy. Assume there are $D$ directories and $F$ ordinary files. For each of the following, how many directories do I have to read and how many files do I have to read …

to compute $D$? __________ directories, __________ files

to compute $F$? __________ directories, __________ files

to list the files in order of size? __________ directories, __________ files

to compute the number of files that are guaranteed to be Microsoft Word documents? __________ directories, __________ files

Each file wastes some number of bytes because its last block is not completely filled. How many directories and how many files do I have to read to compute the total amount of such unused space?

___________ directories, __________ files

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

0100100001100101
0110110001101100
0110111100100000
0101011101101111
0111001001101100
0110010000100001