NOTE: the exam will also have true/false, fill in the blank, and multiple choice questions. You would be wise to study all the terminology we have learned in the class thus far; a set of definitions can be found at https://quizlet.com/csci101/folders/csci-101-spring-2018/sets. For each FULL page completed (and brought to class on Feb 26th), 1 point extra credit will be earned.

1. Identify which type of instruction each one of the following steps belongs to:
   a) Display contents of register to screen.
   b) $x > 0$
   c) Take the cube root of $x$.
   d) while ($x \neq 0$), where $x = 0$

2. Assume your computer uses 8-bit 2’s complement signed numbers. Find the sum of the two binary numbers below; give the result in binary and in (signed) decimal, and discuss your answer

   \[
   \begin{array}{cccccccc}
   0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 \\
   + & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 \\
   \end{array}
   \]

   \[
   \begin{array}{cccccccc}
   1 & 0 & 1 & 0 & 0 & 1 & 1 & 0 \\
   + & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\
   \end{array}
   \]

3. If our machine stores a number in 4 bits. What is the smallest and largest number we can represent
   a. in unsigned binary
   b. in sign/magnitude
   c. in 2’s compliment

4. Assume your computer stores fractional numbers using 16 bits, 5 bits for the exponent (bias = 15) and 10 bits for the mantissa. How would your computer store the decimal number -17.25?
5. Given the following 8-bit binary number: 1000 1001. What is its decimal representation in each of the following notations?
   a. Unsigned binary notation

   b. Sign/magnitude notation

   c. Two’s complement

6. Create a truth table for the optimized circuit shown below.

   ![](image)

7. Give a Boolean expression in the format of your choice (using only AND, OR, and NOT) that produces the truth table from problem #6.

8. Using the sum-of-products algorithm discussed in class, give a circuit made only of AND, OR, and NOT gates that produces the truth table below. Do NOT optimize your circuit. You should show each step of the algorithm in your answer.

   ![](image)
9. If the average access time for RAM is 40 nsec and the average access time for cache memory is 5 nsec, what is the overall average access time if our cache hit rate is 75%?

Would it be better for a system designer to decrease RAM access time to 30 nsec, or increase the hit rate to 85%? Justify your response.

10. What color is the following RGB pixel? 00000000 11111111 11111111

11. Assuming the standard memory cell size of 1 byte, how big can our memory be if our computer uses 16 bit address?

32 bit address?

12. Complete the table below.

<table>
<thead>
<tr>
<th>Decimal</th>
<th>Binary</th>
<th>Octal</th>
<th>Hex</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0000 0010</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>0001 1010</td>
<td></td>
<td>52</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25</td>
</tr>
</tbody>
</table>
13. Suppose Simon designed a machine language with an opcode field of 4 bits. How many different instruction types can Simon’s language contain?

Caleb designed a system with 6 bits opcode. How many instructions does his language support?

14. List and describe the parts of a machine language instruction?

15. Using the op codes described in the table below. Write a program in assembly to compute the computation \( z = \frac{x+y}{\sqrt{x-y}} \). The address of x, y, and z are M[5], M[6], and M[7]. Also, assume M[4] is available for any intermediate answer. Then convert your assembly program into machine language. Use 2 bit op codes and 3 bit address.

<table>
<thead>
<tr>
<th>Code</th>
<th>Assembly</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>add</td>
<td>Addition</td>
</tr>
<tr>
<td>1</td>
<td>sub</td>
<td>Subtraction</td>
</tr>
<tr>
<td>2</td>
<td>div</td>
<td>Division</td>
</tr>
<tr>
<td>3</td>
<td>sqrt</td>
<td>Square root</td>
</tr>
</tbody>
</table>

16. Suppose Jo’s digital camera has a storage capacity of 256MB. How many photographs could be stored in her camera if each picture is 1024 by 1024 pixels, and it each pixel requires three bytes of storage (RGB)?