Name: _________________________________________________
Circle Section: A (9am), B (10am), C (11am), D (12pm), E (1pm), F (2pm), G (3pm)

**Hardware Homework #8 (5.5 points)**
Due to Gradescope by 11:45 PM on Thursday, February 20th
You need to submit a pdf to Gradescope; failure to mark which pages your questions are on will result in a 10% deduction on your grade

**Homework Goal:** Understand memory hierarchy and access

1. Practice your vocab from these chapters! (1 point)
   Memory is divided into fixed-size units called _________________, each of which has a standard size of ___________________________________________________.
   Cache stores ________________________ from a slower device to be accessed faster, while registers store _______________________ that are being used during processing.

2. Zybooks mentions four different types of computers in Chapter 3. For each one, give a possible use case where that type of computer would be better than the others. (0.5 points)

3. Sort the following memory types from slowest (left) to fastest (right), then by cost from cheapest (left) to most expensive (right). Then, discuss the relationship between cost and speed. (0.5 points)
   Hard Drive, Cache, RAM, Solid State Drive
4. Suppose it takes 4 ns to access Cache Memory from the CPU and 43 ns to access RAM from the CPU. Assume the Cache Hit Ratio is 85%. Compute the average access time in ns. Give your answer to two decimal points. (1 point)

5. What is something that can be done to increase the cache hit rate? (0.5 points)

6. For the two different types of locality that we discussed, give an example of a programming construct where each occurs. (0.5 points)
   a. Temporal Locality
   b. Spatial Locality

7. What do MAR and MDR stand for, and what is each used for? (0.5 points)
8. Consider the following structure of the instruction register. (1 point)

<table>
<thead>
<tr>
<th>Op code</th>
<th>Address-1</th>
<th>Address-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 bits</td>
<td>14 bits</td>
<td>14 bits</td>
</tr>
</tbody>
</table>

a. What is the maximum number of distinct operations that can be recognized and executed by the processor on this machine?

b. What is the maximum memory size on this machine?

c. How many bytes are required for each operation?