Last name: First name:

Notes:
- If you perceive any ambiguity in any of the questions, state your assumptions clearly.
- Questions vary in difficulty; it is strongly recommended that you do not spend too much time on any one question.
- This exam is open book/notes but no electronic devices.

1. [5 points] Circle the correct answer among the choices given. If you circle more than one answer, you will lose the grade of the corresponding question.

(A) Which language of the following is hardware independent?
   a. High Level language    
   b. Assembly language     
   c. Machine language      
   d. They are all hardware independent

(B) If we want to design a computer system, what is the correct order?
   a. develop the ISA first, then the hardware
   b. develop the hardware, then the ISA
   c. develop the high level language first, then the ISA, then the hardware
   d. the order is not important

(C) For the data path given in question 4, which of the following statements is not a valid microinstruction?
   a. MDR->MAR    
   b. PC->MDR    
   c. MDR->M[MAR]
   d. MAR->ALU    
   e. M[MAR]->MDR

(D) If we want to add an extra instruction to the instruction set of a processor, which of the following MUST be updated?
   a. control unit  
   b. datapath     
   c. the memory system   
   d. all of them

(E) The main difference between MIPS ISA and x86 ISA is:
   a. MIPS ISA is more complicated    
   b. MIPS ISA is less complicated
   c. x86 uses way more registers    
   d. x86 has less instructions
2. [3 points] Suppose you wish to express -64 as 2’s complement number.
   a. What is the minimum number of bits we will need?

   b. With this number of bits you mentioned above, what is the largest positive number you can represent, assuming signed numbers of course? (Please give answer both in decimal and binary)

   c. With that same number of bits you used in the above two questions, what is the largest unsigned number you can represent? (Please give answer both in decimal and binary).

3. [4 points] What is the IEEE 754 presentation of the decimal number: -35?
4. [4 points] For the following datapath:

a. Write the microinstructions needed to do fetch phase (optimize as much as you can)

b. Write the microinstructions required to implement: \( sw \ Rd, 5(Rt) \) (That is, store the content of register Rd in memory location \([5 + \text{content of } Rf]\)).
5. Suppose we want to design a logic circuit that accepts three binary inputs a, b, and c. There is one output for that circuit. The output, f, is set to 1 if the number of 1s in the input is even (example: if a = 1, b=1, and c = 0 then f is 1), otherwise it is set to 0. Assume f = 1 when all inputs are 0.

a. [1 point] Draw the truth table for that circuit.

b. [1 point] Draw the logic circuit using gates.

c. [2 points] Try to design the same circuit using one decoder and any number of OR gates.