Digital Design and Computer Architecture
E85

K. Wang and J. Spjut   **Final**   **Fall 2012**

This is an open book, open notes take-home exam. You are allowed at most **5 hours** to take the exam. This exam is due back to Prof. J. Spjut's office no later than 5:00p.m. on Friday, 12/17/2012.

You may not discuss the exam with anybody else except Prof. Wang or Prof. Spjut and you may not consult any references outside of the book and your notes or use a computer until you have turned in the exam. Remember that the Harvey Mudd College Honor Code applies.

The number of points for questions on each page is shown below. The entire exam is worth 100 points. All work and answers should be written directly on this examination booklet. Use the backs of pages if necessary. Write neatly; illegible answers will be marked wrong. **Show your work** for partial credit. If you need to separate the pages, be sure to write your name on the top of each page and staple the test before handing it in.

Name: _____

Do Not Write Below This Point

Page 2:   _____/9
Page 3:   _____/6
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1. Perform the following numerical conversions. Show your work.

   a) [3] Convert the decimal number -150_{10} to 8-bit two's complement. Show your result in binary.

   Answer:_____

   b) [3] Convert the two's complement number 0x7F02 shown in hex to decimal.

   Answer:_____

   c) [3] Express the base 10 number -8.078125 in 12-bit fixed-point sign/magnitude format. Use the same number of bits for the integer and fractional part. Show your result in binary.

   Answer:_____

d) [3] Express the base 10 number -8.078125 in 12-bit fixed-point two's complement format. Use the same number of bits for the integer and fractional part. Show your result in binary.

Answer:_____

e) [3] Express the IEEE floating point number 0xC1980000 in decimal.

Answer:_____

2. [8] Given a MIPS with no bypass hardware or register forwarding, add the minimal number of nops to the following program to eliminate all hazards.

```
add $t2, $t1, $t3


lw $t5, 4($t1)


sub $t0, $t2, $t4


add $t3, $t2, $t1


or $t0, $t0, $t3


andi $t5, $t5, 42
```

3. The extraterrestrial life project team has just discovered aliens living on the bottom of Mono Lake. They need to construct a circuit to classify the aliens by potential planet of origin based on measured features available from the NASA probe: greenness, brownness, sliminess, and ugliness. Careful consultation with xenobiologists leads to the following conclusions:

- If the alien is green and slimy or ugly, brown, and slimy, it might be from Mars.
- If the critter is ugly, brown and slimy, or green and neither ugly nor slimy, it might be from Venus.
- If the beastie is brown and neither ugly nor slimy or is green and slimy, it might be from Jupiter.

Note that this is an inexact science; for example, a life form which is mottled green and brown and is slimy but not ugly might be from either Mars or Jupiter.

Part C is on its own page!!!!

a) [5] Program a 4x4x3 PLA to identify the alien. You may use dot notation.

b) [5] Program a 16x3 ROM to identify the alien. You may use dot notation.

c) [5] Implement your design in SystemVerilog.

4. You would like to add the `lh` instruction to your multicycle MIPS processor. Recall that

        lh $t0, 42($t1)

loads the least significant half word (16 bits) of $t0 from the address 42 bytes beyond the base address in $t1.

Suppose you are constrained to use the same memory system that you used in Labs 9 and 10. Recall that this memory system uses a 32-bit wide RAM.

a) [8] Mark up the datapath on the next page with your changes. Do not change the number of bits in existing control signals. Use as few new control signals as possible. Unreadable, incomplete, or messy answers will receive no credit.