

## CS 14 Spring 2005 — Mid-term #2

This is a closed-book, closed-note exam. Answer all of the questions **clearly, completely, and concisely**. You have 50 minutes, so be sure to budget your time. All work should be written in your blue book.

1. (10 points) Subtract 10 from 4 using *twos complement* binary representation. Show your work, and show that your answer is, indeed,  $-6$ .
  
2. (15 points) Consider building a 32-bit adder from 8 4-bit fast-carrying adders.
  - (a) If you *ripple-carry* between the 4-bit adders, what is the critical path length?
  - (b) If you *fast-carry* (a.k.a. *carry-lookahead*) between the 4-bit adders, what is the critical path length? Assume that you can only fast-carry in groups of at most 4.
  
3. (25 points) Consider adding support for the `jal` instruction to our datapaths and controls.
  - (a) Modify the attached single-cycle datapath and control diagram so that it can support this instruction.
  - (b) Decompose this instruction into a sequence of steps that could be carried out by a multicycle processor. Be sure to indicate clearly the inputs into and operations performed by each component at each step.

4. (25 points) Assume modifying the MIPS ISA such that `blt`, `ble`, `bgt`, and `bge` are all real instructions (instead of pseudoinstructions).
- (a) Show how to add an output line to the ALU that will be asserted if and only if  $A > B$ . Like the *zero* output line, its value will be meaningful only when the subtraction operation is selected. Draw only the components necessary for producing this new output line, and be sure to take overflow into account.
  - (b) Given an ALU that emits both a *zero* and an  $A > B$  line, show how to control the PC register's input value for all branching instructions—the four above **and** `beq/bne`.
5. (25 points) Consider adding a `swap` instruction to the MIPS ISA. For example...
- ```
swap $t0, $s1
```
- ... will, in a single instruction, swap the contents of registers `$t0` and `$s1`.
- (a) Can this instruction be supported with a single-cycle datapath and control? Justify your answer.
  - (b) Decompose this instruction into a sequence of steps on our multicycle datapath. Clearly indicate the inputs into and operations performed by each component. If any changes need to be made to the multicycle datapath, show them on the attached diagram.