16.482 / 16.561: Computer Architecture and Design

Spring 2015

Homework #3

Due **Thursday, 2/12/15**

Notes:

- While typed submissions are preferred, handwritten submissions are acceptable.
- Any electronic submission must be in a single file. Archive files will not be accepted.
- Electronic submissions should be e-mailed to Dr. Geiger at Michael_Geiger@uml.edu.
- This assignment is worth a total of 100 points.

Consider the following sequence of instructions:

```
loop:     add  $t0, $t1, $t2
          lw   $t3, 10($t0)
          lw   $t4, 14($t0)
          sub  $t5, $t4, $t3
          sw   $t5, 18($t0)
          addi $t2, $t2, 4
          slti $t6, $t2, 200
          bne  $t6, $zero, loop
```

Assume each datapath stage requires the following amount of time to complete:

- Instruction fetch (IF): 30 ns
- Instruction decode (ID): 20 ns
- Execute / address calculation (EX): 25 ns
- Memory access (MEM): 30 ns
- Register write back (WB): 20 ns

1. (20 points) How long will a single iteration of this loop take in a single-cycle datapath?

2. (20 points) If we assume ideal pipelining (i.e., no hazards and therefore no stalls), how long will one loop iteration take in a pipelined datapath?

3. (20 points) If we now assume a more realistic pipelined datapath **without** forwarding, how long will one iteration take? Show a revised code sequence that includes all necessary no-ops to support your answer.

4. (20 points) If we now assume a pipelined datapath **with** forwarding, how long will one iteration take?

5. (20 points) Calculate the speedup for each of the pipelined datapaths over the single-cycle case. In other words, determine how much faster each of the pipelined cases are than the single-cycle case.