16.482 / 16.561: Computer Architecture and Design
Spring 2014

Homework #2
Due **Thursday, 2/13/13**

Notes:
- While typed submissions are preferred, handwritten submissions are acceptable.
- Any handwritten solutions that are scanned and submitted electronically <u>must</u> be clearly legible and combined into a single file—<u>simply sending a picture of each scanned page is not an acceptable form of submission</u>.
- This assignment is worth a total of 100 points.

1. (20 points) Compute the result of each floating-point arithmetic arithmetic operation below, in which each of the values is encoded in single-precision IEEE floating-point format. Recall that:

- For floating-point addition, align the binary points, add the significands, then normalize the result.

- For floating-point multiplication, add the exponents (taking care to only account for the bias once), multiply the significands, normalize the result, and then determine the sign.

All arithmetic should be done in binary, and results should be re-encoded in single-precision IEEE floating-point format.

a. `0x41900000 + 0x3fe00000`
b. `0x40e00000 * 0x3e800000`
c. `0x40b00000 + 0xc0100000`
d. `0xc0800000 * 0x3f200000`

2. (80 points) Consider the following sequence of instructions:

```
add     $t1, $t2, $t3
add     $t4, $t5, $t6
lw      $t7, 0($t1)
lw      $t8, 0($t4)
sub     $t9, $t7, $t8
lw      $s0, 4($t1)
sw      $t9, 4($t4)
slt     $s1, $s0, $t9
```

Assume that each datapath stage requires the following minimum amount of time to complete:
  o Instruction fetch (IF): 40 ns
  o Instruction decode (ID): 25 ns
  o Execute / address calculation (EX): 30 ns
  o Memory access (MEM): 40 ns
  o Register write back (WB): 25 ns

a. (15 points) How long will this code take in a single-cycle datapath?

b. (15 points) If we assume ideal pipelining (i.e., no hazards and therefore no stalls), how long will the code take in a pipelined datapath?

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

d. (15 points) If we now assume a pipelined datapath **with** forwarding, how long will the code take?

e. (15 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.