# 16.482 / 16.561: Computer Architecture and Design

Summer 2015

Homework #5

Due **Friday, June 12**

**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.

1. Dynamic scheduling (30 points) Given the loop below:

```
            DADDI     R3, R0, #4
outer:      DADDI     R2, R1, #32
inner:      L.D       F0, 0(R1)
            MULT.D    F6, F0, F6
            S.D       F6, 8(R1)
            DADDI     R1, R1, #16
            BNE       R2, R1, inner
            DADDI     R3, R3, #-2
            BNEZ      R3, outer
```

Assume the following latencies:

- 1 cycle for DADDI, BNE, and BNEZ
- 3 cycles (1 EX, 2 MEM) for L.D and S.D
- 4 cycles for MULT.D

How long would this nested loop take without speculation? Remember, without speculation, you cannot fetch past a branch until the outcome of the branch is known.

2. Speculation (30 points) How many cycles will the sequence in Question 1 take if we do allow speculation and assume every branch prediction—including the predicted target from the BTB—is correct?

3. Speculation & branch prediction (40 points) Now, assume the processor has a 2-bit BHT to predict branch outcomes. On a mispredicted branch, the correct instructions are fetched starting with the cycle after the misprediction is recognized (EX). Assume that all BHT entries are initially equal to 00, and that the two branches in this example use separate BHT entries. Also, assume the BTB correctly predicts all targets for taken branches. How long will the loop in Question 1 now take?