

Score: _____

Name: _____

ECE 3055 Quiz IV, Wednesday, June 19

The program below is executed on the 5 stage pipelined MIPS described in chapter 6. Answer the following questions about this program.

```

loop:  sw      $2,100($0)
       sub     $2,$5,$2
       lw      $7,200($2)
       and     $8,$3,$4
       andi    $5,$7,8
       beq     $5,$8,then
       add     $5,$5,$8
then:  or      $8,$3,$8
       sw      $5,100($6)
       beq     $8,$0,loop
    
```

Assume the control unit **does not have** any hazard detection, forwarding, a new branch compare circuit, or automatic branch flushing. That register file will not write and then read a new register value in one clock cycle. Rewrite the code sequence by adding the minimum number of NOP instructions (do not reorder or change instructions) to eliminate all potential data and branch hazards – do not change the order of the instructions. Assume other non-NOP instructions follow the last branch in the original code sequence above.

Total number of NOPs required 16

```

sw
sub
nop
nop
nop
lw
and
nop
nop
andi
nop
nop
nop
    
```

```

beq
nop
nop
nop
add
or
nop
nop
sw
beq
nop
nop
nop
    
```

1 pt. pen
 nop cluster
 -1 For missing Nops
 extra nops or
 nops in wrong
 place (each occurrence)

Assume the control unit is improved by adding the hazard and forwarding unit as outlined in the text, adding a branch compare unit to the decode stage, and the register file writes then reads a new value in a single clock cycle. Determine the number of clock cycles required to complete the first loop execution (i.e. executes code in loop and branches back to top of loop and is just ready to fetch sw again) of the original code sequence. Assume the inner branch is taken.

If there were no hazards or branch flushing, the original program would require 9 clock cycles for execution. (*do not include the time to initially fill the pipeline*).

But the program stalls and/or flushes the pipeline 2+ clock cycles so a total of 11 clock cycles is required for execution (*do not include the time to initially fill the pipeline*).