

ANSWER ANY FOUR QUESTIONS.

- Please show your work as discussed in class. Points will be deducted if you do not show your work.
- You are allowed to access a binary to hex converter (calculator or online), the opcode map, and your laptop for anything other than class notes or previous test solutions.
- Please follow the Rowan University Student Code of Conduct (no discussion or collaboration with other students taking the test).

1. Answer both parts:

- a. (15 points) Convert the following RV32I instructions to machine code (binary or hex):
- SUB X10, X11, X12
 - ADDI X20, 32(X21)
 - LW X15, 16(X18)
- b. (10 points) You are given two computers with the following characteristics:

Computer A	Computer B
Cache hit rate = 0.95	Cache hit rate = 0.96
Cache miss penalty = 6 cycles	Cache miss penalty = 7 cycles
Everything else is identical.	Everything else is identical.

You are also given two programs, each with 1500 instructions. All memory operations (including cache hits) take at least 2 cycles to run. All other (non-memory) instructions take 1 cycle to run. The programs have the following characteristics:

Program A: 25% of instructions are memory instructions.

Program B: 30% of instructions are memory instructions

Which program runs faster on which computer? Show your work.

Note: Round up fractional values if needed.

2. Answer both parts:

- a. (15 pts) What are the values of all the control signals, and the values of Q4, Q5, Q8, Q9, Q12 when the following instruction is executed?

LW X10, 24(X8)

Given, Reg[X8] = 2400, mem[2424] = 72, Reg[X10] = 55.

Datapath diagram is given on the last page.

- b. (10 points) Convert the following RV32I instructions to machine code (bin or hex):

- i. BGE X22, X25, 24
- ii. XOR X19, X21, X11

3. Answer both parts:

- a. (10 pts) You are given the following program in RV32I assembly:

Program Counter (Instr. address)	Instruction
4032	ADD X10, X11, X12
4036	ADD X11, X10, X12
4040	ADDI X9, X9, -1
4044	BNE X9, X0, -12
4048	ADDI, X11, X11, 7

You are also given the following information:

Reg[X0] = 0

Reg[X10] = 5

Reg[X11] = 3

Reg[X12] = 4

Reg[X9] = 3

Show the program processing trace (sequence of instruction addresses being processed).

- b. (15 pts) What are the values of all the control signals, and the values of Q8, Q9, Q13, Q15, Q16 when the following instruction is executed?

BEQ X9, X10, 32

Given, Reg[X9] = 41, Reg[X10] = 41, PC = 3636.

Datapath diagram is given on the last page.

4. You are given the following program:

I0: LW X5, 8(X6)

I1: ADD X6, X7, X5

I2: ADD X7, X5, X8

I3: LW X4, 16(X7)

I4: ADDI X8, X4, 32

I5: SW X8, 0(X9)

- a. (5 points) Draw the data dependency graph.
- b. (20 points) Plot the pipelined execution of the above program, making sure to avoid structural and data hazards.

5. Answer both parts:

- a. (15 points) You are given the following DMEM:

Starting Address	Content
0x00000140	46
0x00000160	89
0x00000180	-68
0x000001A0	72
0x000001C0	12
0x000001E0	34
0x00000200	-64
0x00000220	44
0x00000240	37
0x00000260	19

You are also given the following RegFile:

Register	Content
X5	528
X6	400
X7	344
X10	0
X11	0

You are then given the following program:

```
LW X10, -16(X5)
LW X11, 16(X6)
ADDI X11, X11, 12
SUB X10, X11, X10
SW X10, 8(X7)
```

Explain what each instruction does, and how the register contents are updated.

b. (10 points) What are the values of all the control signals, and the values of Q8, Q9, Q4, Q0, Q1 when the following instruction is executed?

```
ADDI X9, X10, 20
Given, Reg[X10] = 14, PC=1624
Datapath diagram is given on the last page.
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