The University of Alabama in Huntsville
Electrical & Computer Engineering Department
CPE 431 01
Test I Solution
October 2, 2001

Name: ________________________________

1. (10 points) Use the following code fragment:

```
loop: lw    $1, 0($2)
      addi  $1, $1, 4
      sw    $1, 0($2)
      addi  $2, $2, 4
      bne   $2, $3, loop
```

Assume that the initial value of $2 is $3 – 196 and that this code fragment is run on a machine with a 250-MHz clock that requires the following number of cycles for each instruction:

Instruction	Cycles
addi	1
add, bne	2
lw, sw	3

In the worst case, how many seconds will it take to execute this code?

Answer: First, we determine the number of times the loop executes. It starts with $2 = 3 – 196, increments $2 4 each time, and ends when $2 = $3.

$2 = $3 – 192

.

.

.

$2 = $3 – 4

$2 = $3

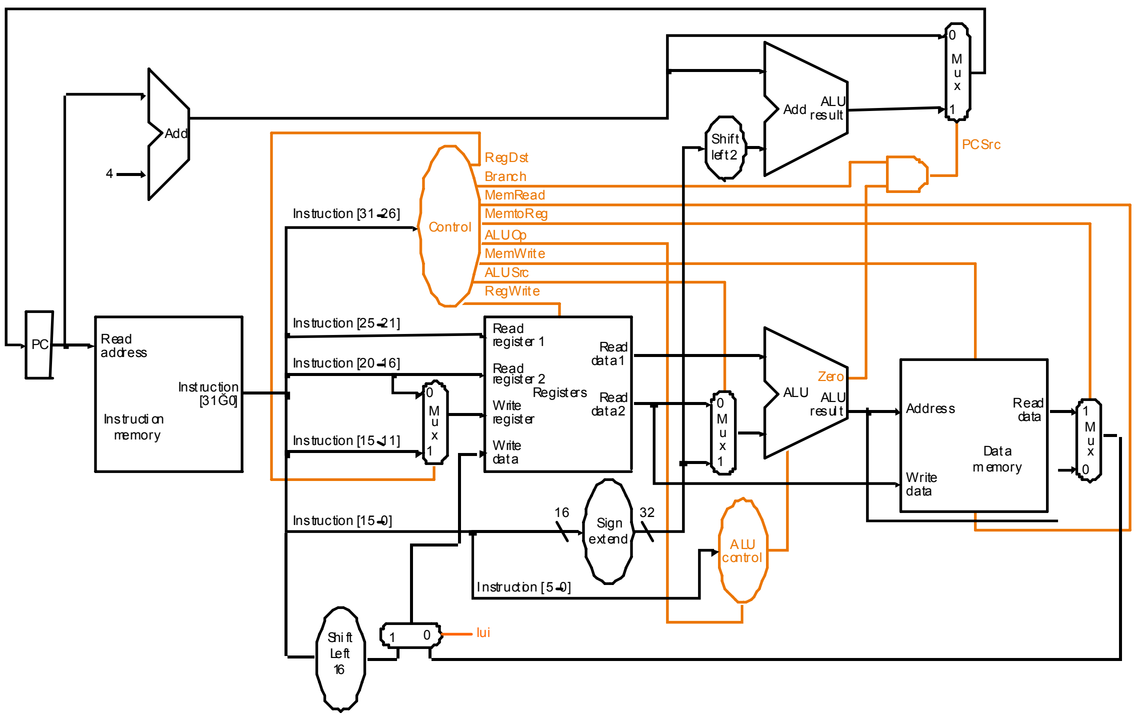
The loop executes (192 – 0)/4 + 1 times or 48 + 1 = 49 times. Then, we need to know how long each iteration takes. Lw takes 3 cycles, addi 1, sw 3, addi 1 and bne 2 for a total of 3 + 1 + 3 + 1 + 2 = 10 cycles.

49 iterations * 10 cycles/iteration * 4 ns * cycle = 1960 ns

2. (1 point) A ________compiler or assembler_____________ is a program that translates a symbolic version of an instruction into the binary version.

3. (1 point) A ____die_____________ is a rectangular component that results from dicing a wafer.

4. (10 points) Add the instruction `lui` (load upper immediate) to the single-cycle datapath shown in the figure below. Add any necessary datapaths and control signals and show the necessary additions to the table of control signals given.



Instruction	RegDst	ALUSrc	Memto Reg	Reg Write	Mem Read	Mem Write	Branch	ALUOp1	ALUOp0	lui
R-format	1	0	0	1	0	0	0	1	0	0
lw	0	1	1	1	1	0	0	0	0	0
sw	d	1	d	0	0	1	0	0	0	0
beq	d	0	d	0	0	0	1	0	1	0
lui	0	d	d	1	0	0	0	d	d	1

d-don't care

5. (1 point) A __________instruction____________ is an individual command to a computer.

6. (1 point) The ____yield______ is the percentage of good dies from a total number of dies on a wafer.

7. (1 point) An ___________ALU_______________ is a component of the processor that performs arithmetic operations.

8. (15 points) Consider two different implementations, M1 and M2, of the same instruction set, There are four classes of instructions (A, B, C, and D) in the instruction set. M1 has a clock rate of 400 MHz, and M2 has a clock rate of 200 MHz. The average number of cycles for each instruction class on M1 and M2 is given in the following table:

Class	CPI on M1	CPI on M2	C1 usage	C2 usage	Third-party usage	Fourth-party usage
A	3	2	20%	30%	30%	15%
B	5	3	25%	25%	30%	45%
C	7	4	30%	25%	30%	35%
D	8	5	25%	20%	10%	5%

The table also contains a summary of how four different compilers use the instruction set. C1 is a compiler produced by the makers of M1, C2 is a compiler produced by the maker of M2, and the other compilers are competing third- and fourth-party products. Assume that each compiler uses the same number of instructions for a given program but that the instruction mix is as described in the table.

Which compiler produces the best performance on M1?

$CPI_{M1,C1} = 3*0.2 + 5*0.25 + 7*0.3 + 8*0.25 = 0.6 + 1.25 + 2.1 + 2 = 5.95$

$CPI_{M1,C2} = 3*0.3 + 5*0.25 + 7*0.25 + 8*0.2 = 0.9 + 1.25 + 1.75 + 1.6 = 5.5$

$CPI_{M1,Third} = 3*0.3 + 5*0.3 +7*0.3 + 8*0.1 = 0.9 + 1.5 + 2.1 + 0.8 = 5.3$

$CPI_{M1,Fourth} = 3*0.15 + 5*0.45 + 7*0.35 + 8*0.05 = 0.45 + 2.25 + 2.45 + 0.4 = 5.55$

Since these are all running on the same machine, the clock cycle is the same and the determining factor is the CPI alone. Therefore, the 3rd party compiler produces the best performance on M1.

9. (5 points) For the following C code, write an equivalent assembly language program in the accumulator style (assume all variables are initially in memory):

a = b – c;

```
load c
neg
add b
store a
```

10. (15 points) When designing memory systems, it becomes useful to know the frequency of memory reads versus writes and also accesses for instructions versus data. Using the following average instruction-mix information, find

(1) (5 points) the percentage of all memory accesses for instructions
(2) (5 points) the percentage of data accesses that are writes
(3) (5 points) the percentage of all memory accesses that are reads.

Instruction	Percentage
`lw`	29
`sw`	15
`add`	18
`sub`	3
`lui`	7
`beq, bne`	6
`jump`	3
`and, or`	16
`mult`	3

44 % of the instructions have data accesses
15 % of the instructions are writes
29 % of the instructions have reads plus all of the instruction fetches are reads

(1) 1.0/1.44 = 69.4 %
(2) 0.15/0.44 = 34.1 %
(3) 1.29/1.44 = 89.6 %

11. (5 points) What number does the two's complement binary number represent:

$1111\ 1110\ 0000\ 1100_2$?

Take 2s complement

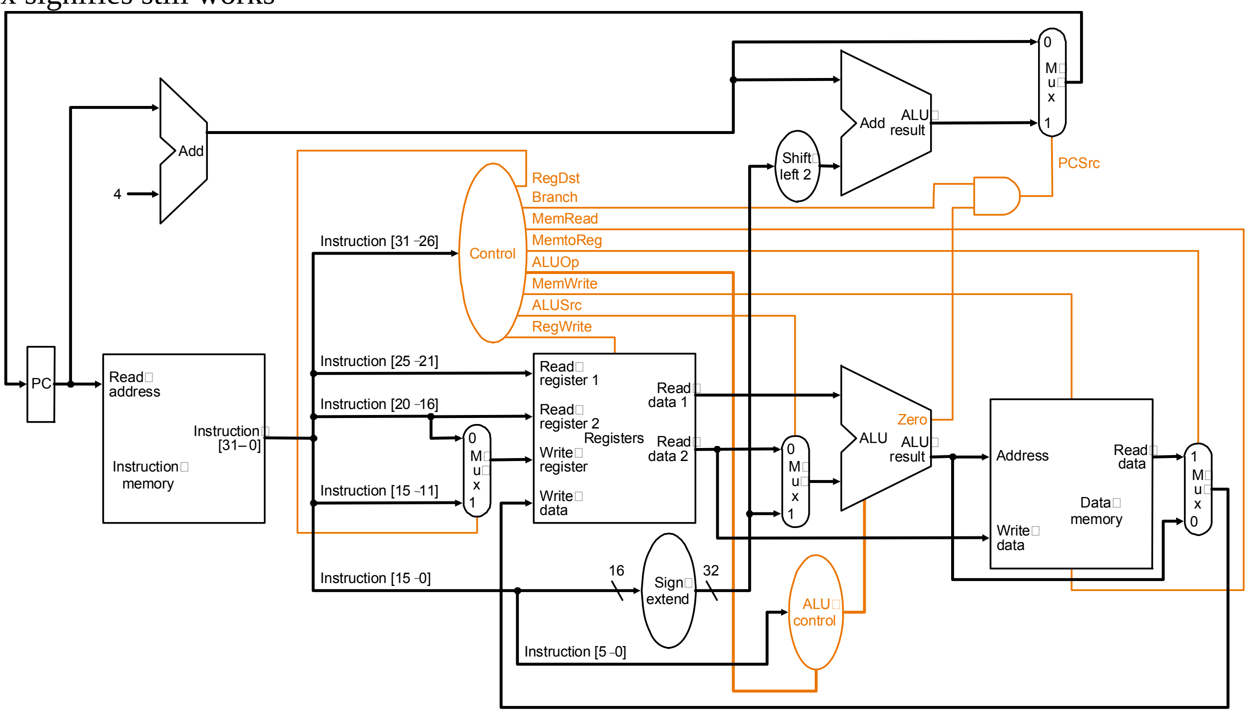
$0000\ 0001\ 1111\ 0100_2$

That's –(256 +15*16 + 4) = -(256 + 240 + 4) = -500

12. (20 points) a. (5 points) Describe the effect that a single stuck-at-0 fault (i.e., regardless of what it should be, the signal is always 0) would have on the multiplexors in the single-cycle datapath shown. b. (15 points) Which instructions, if any would still work? Consider each of the following faults separately: RegDst = 0, ALUSrc = 0, MemtoReg = 0, Zero = 0.

	RegDst = 0	ALUSrc = 0	MemtoReg = 0	RegWrite= 0
R-type		x	x	
lw	x			
sw	x		x	x
beq	x	x	x	x

x signifies still works



a. For RegDst stuck-at-0, the register written will always be specified by the rs instruction field.
b. For ALUSrc stuck-at-0, the A input to the ALU will always come from Read data 2.
c. For MEMtoReg stuck-at-0, the ALU result will always be selected.
d. For RegWrite stuck-at-0, the register file will never be written.

12. (15 points) The table below shows the number of floating-point operations executed in two different programs and the runtime for those programs on three different machines:

Program	Floating-point operations	Execution time in seconds		
		Computer A	Computer B	Computer C
1	10,000,000	1	10	20
2	100,000,000	1000	100	20

One user has told you that the two programs above constitute the bulk of his workload, but he does not run them equally. The user wants to determine how the three machines compare when the workload consists of different mixes of these programs. Suppose the total number of FLOPS executed in the workload is equally divided among the two programs. Find which machine is fastest for this workload and by how much.

ET = IC * CPI * CC

For the two programs to have the same number of FLOPS, program 1 is run 10 times for every run of program 2. So, the weights for the programs are 10/11 and 1/11, respectively.

ET_A = 10/11*1 + 1/11*1000 = 91.8
ET_B = 10/11*10 + 1/11*100 = 18.2
ET_C = 10/11*20 + 1/11*20 = 20

So, machine B is fastest for this workload.

$$\frac{P_B}{P_A} = \frac{ET_A}{ET_B} = \frac{91.8}{18.2} = 5.0$$
$$\frac{P_B}{P_C} = \frac{ET_C}{ET_B} = \frac{20}{18.2} = 1.1$$