# EE116C/CS151B Homework 3 Solution

Problem 1

4.7 In this exercise we examine in detail how an instruction is executed in a single-cycle data path. Problems in this exercise refer to a clock cycle in which the processor fetches the following instruction word:

10101100011000100000000000010100.

Assume that data memory is all zeros and that the processor's registers have the following values at the beginning of the cycle in which the above instruction word is fetched:

R0	R1	R2	R3	R4	R5	R6	R8	R12	R31
0	-1	2	-3	-4	10	6	8	2	-16
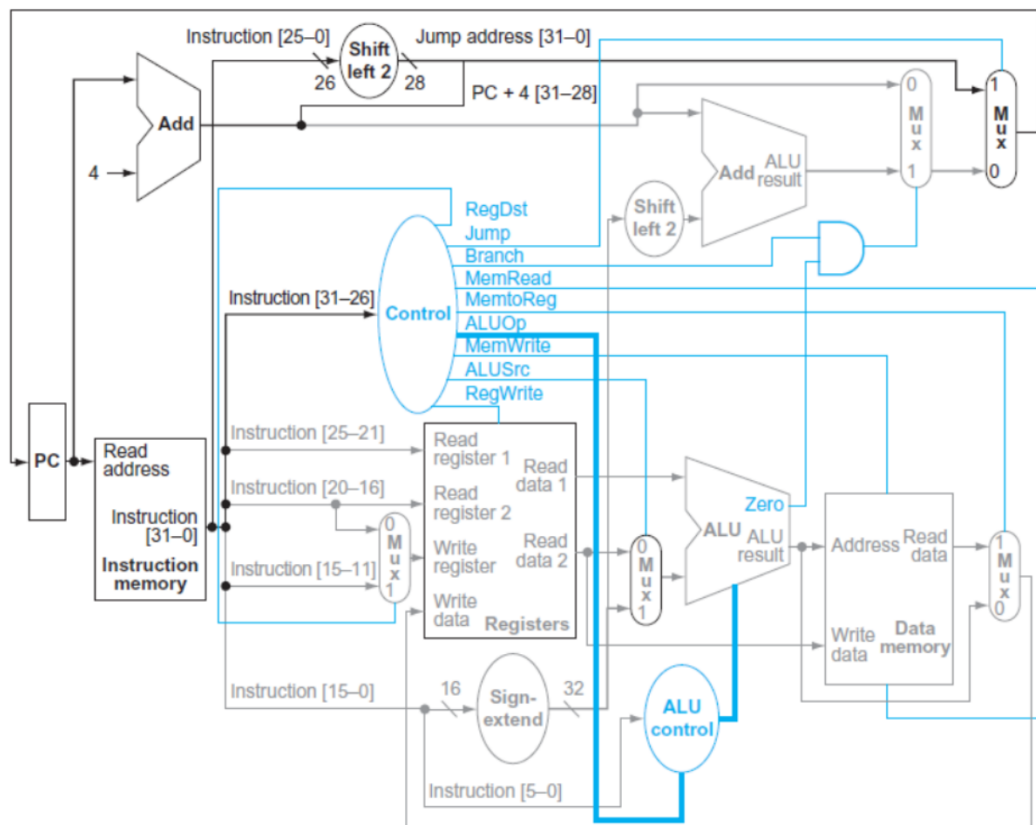
1. What are the outputs of the sign-extend and the jump "Shift left 2" unit for this instruction word?

Opcode = $(101011)_2$ = 43
Thus this is a Load/Store function.
Rs = $(00011)_2$ = 3
Rt = $(00010)_2$ = 2
Address = $(0000000000010100)_2$ = 20

Thus, the instruction can be translated as sw $s2, 20($s3).

Thus, the input of the sign-extend is 0000000000010100, the output of the sign-extend is $(00000000000000000000000000010100)_2$.
The output of the shift left 2 is $[29..0](00011000100000000000001010000)_2|[31-28](PC+4)$.

2. What are the values of the ALU control unit's inputs for this instruction?

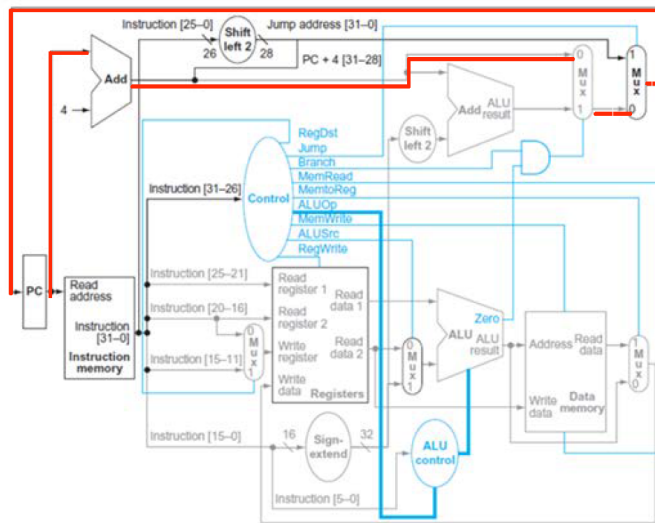ALU control unit's input is 010100;
ALUop is 00;
Input1 of ALU is $(00011)_2$;
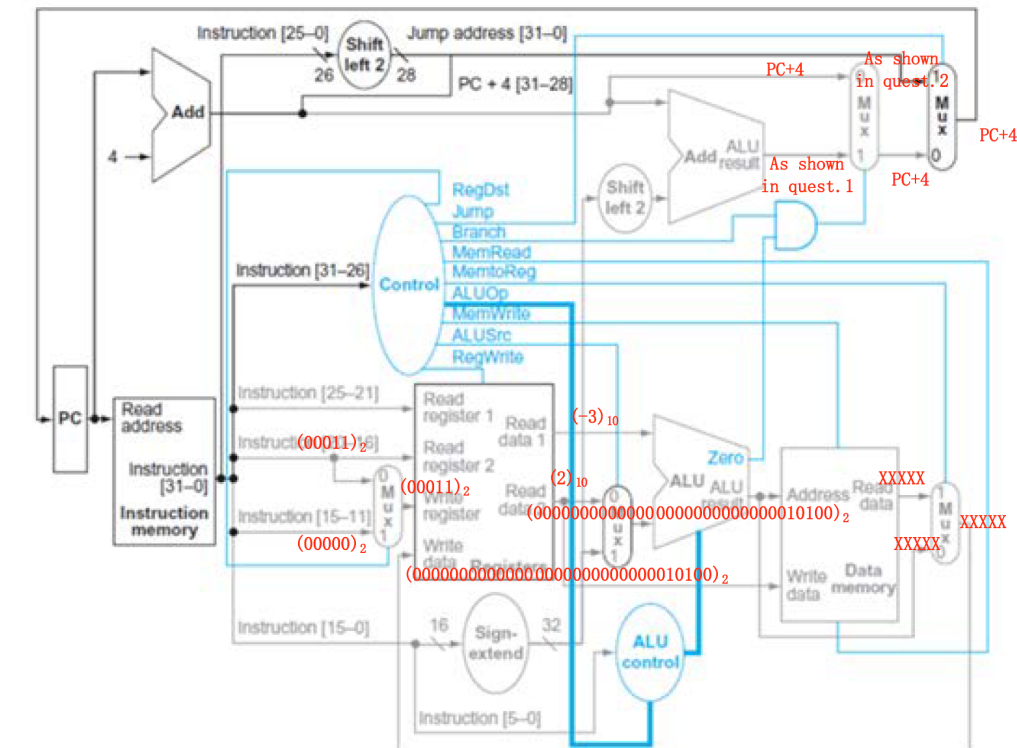Input2 of ALU is $(00000000000000000000000000010100)_2$.

3. What is the new PC address after this instruction is executed? Highlight the path through which this value is determined.

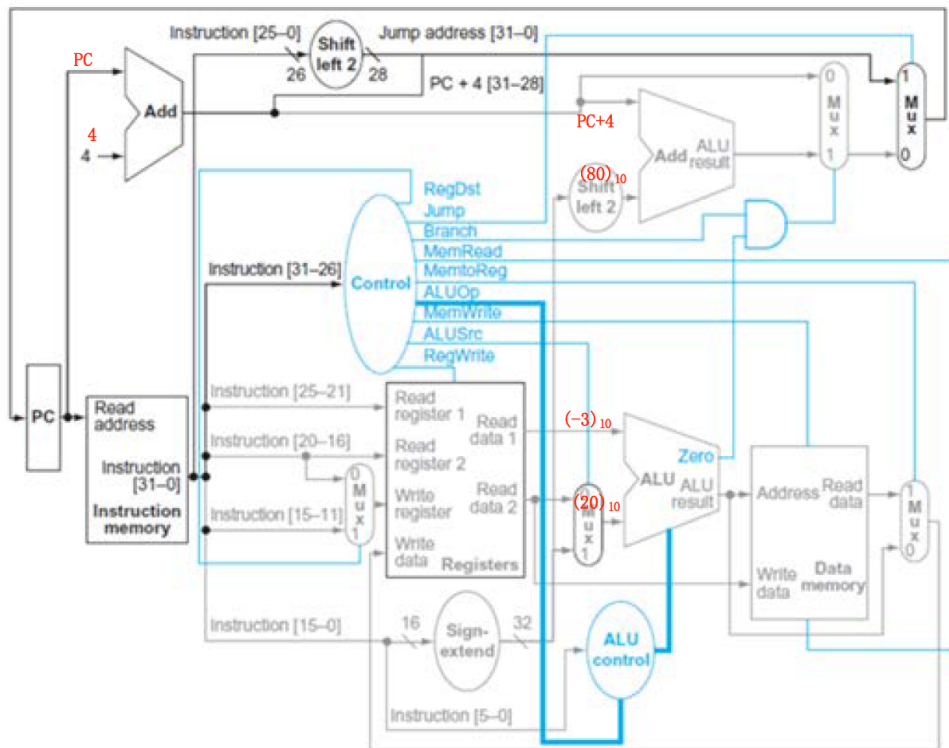The new PC is PC+4.
The path is shown below:

4. For each Mux, show the values of its data output during the execution of this instruction and these register values.

5. For the ALU and the two add units, what are their data input values?

The data inputs are shown below:

6. What are the values of all inputs for the "Registers" unit?

Instruction [25–0]   Shift   Jump address [31–0]
26   left 2   28
PC + 4 [31–28]

Add

4

RegDst
Jump
Branch
MemRead
MemtoReg
ALUOp
MemWrite
ALUSrc
RegWrite

Instruction [31–26]   Control

0
Mux
1

Add ALU result

Shift left 2

1
Mux
0

0
Mux
1

PC

Read address

Instruction [31–0]

Instruction memory

Instruction [25–21]   (00011)₂   0

Instruction [20–16]   (00010)₂

(00010)₂

Instruction [15–11]

XXXXX

Instruction [15–0]

0
Mux
1

Read register 1   Read data 1

Read register 2

Write register   Read data 2

Write data   Registers

16   Sign-extend   32

Zero
ALU   ALU result

0
Mux
1

Address   Read data

Write data   Data memory

1
Mux
0

ALU control

Instruction [5–0]