Answer1

a. $CPI = 1 \times 50\% + 2 \times 20\% + 8 \times 20\% + 20 \times 10\% = 4.5$

b. $MIPS = 50 \div 4.5 = 11.1 \quad Time = \frac{4.5 \times 400000}{50 \times 10^6} = 3.6 \times 10^{-2} s$

c. easy to implement,
the cycle time is associated to the longest instruction,
signal asynchrony.

d. $CPU_A\ instr\ count = 25 \times 2 + 75 \times 1 = 125$
$CPU_B\ instr\ count = 25 \times 2 + 50 \times 1 = 100$

Case 1

$CPU_A\ rate = 1.5m \qquad CPU_B\ rate = m$

$CPU_A\ time = \frac{125}{1.5m} \qquad CPU_B\ time = \frac{100}{m}$

$CPU_A is\ faster$

Case 2

$CPU_A\ rate = 1.2m \qquad CPU_B\ rate = m$

$CPU_A\ time = \frac{125}{1.2m} \qquad CPU_B\ time = \frac{100}{m}$

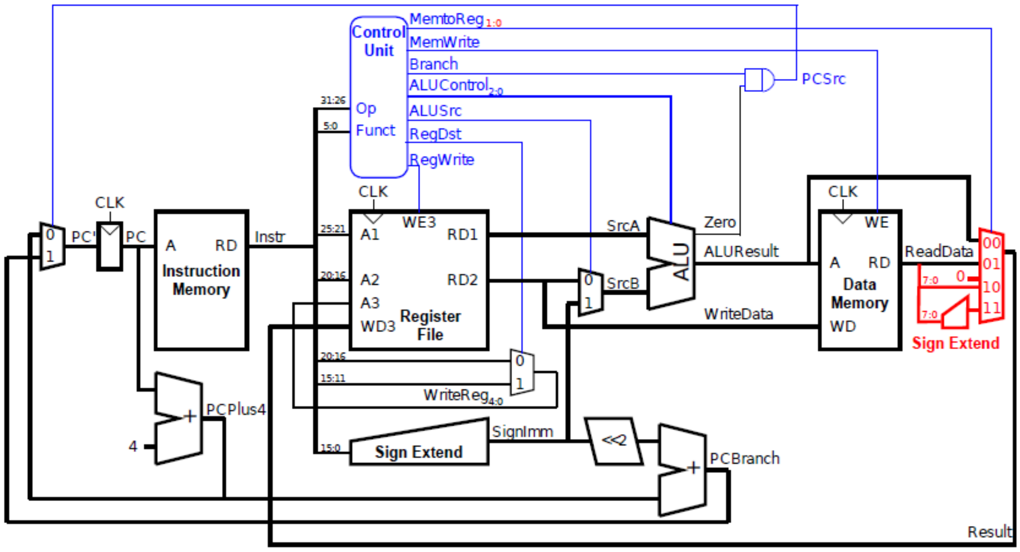
$CPU_B is\ faster$

Answer2

a. No, because the value in r5 register hasn't been written back, thus leading to ***data hazard***.
b. Yes, because there are ***two multiply units*** thus avoiding structure hazard.
c. It will cause ***data hazard***, ***control hazard***.
d. Using hardware implemented with algorithm like ***scoreboard*** and ***tomasulo***.
Using ***stall*** and ***forwarding*** to avoid hazards.

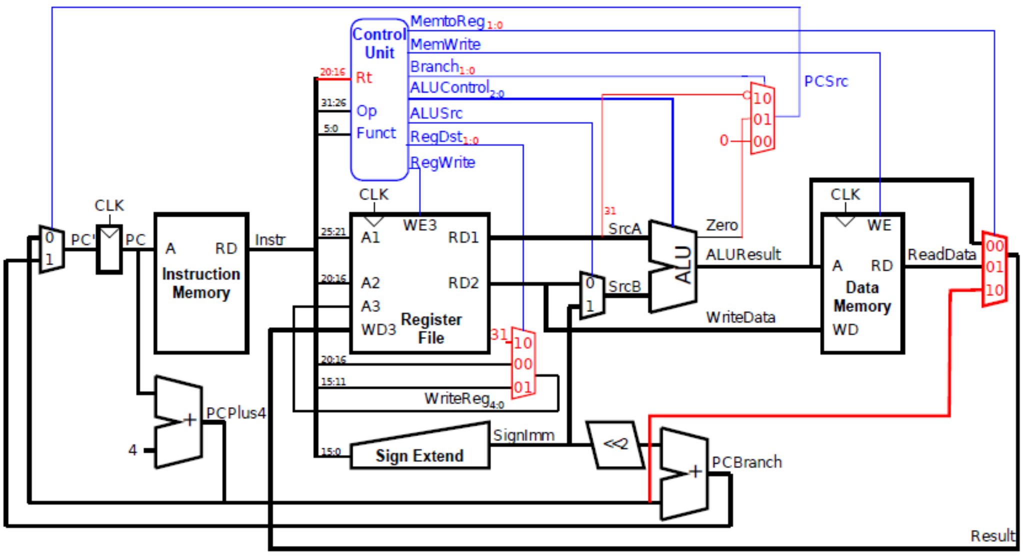
Answer3

a.



Inst.	OP	RegWrite	RegDst	ALUSrc	Branch	MemWrite	MemToReg	ALUOp
R-type	000000	1	1	0	0	0	00	1-
lw	100011	1	0	1	0	0	01	00
sw	101011	0	-	1	0	1	--	00
beq	000100	0	-	0	1	0	--	01
lb	100000	1	-	1	0	0	11	00
lbu	100100	1	-	1	0	0	10	00

b.



Inst.	OP	Rt	RegWrite	RegDst	ALUSrc	Branch	MemWrite	MemToReg	ALUOp
R-type	000000	-	1	01	0	00	0	00	1-
lw	100011	-	1	00	1	00	0	01	00
sw	101011	-	0	--	1	00	1	--	00
beq	000100	-	0	--	0	01	0	--	01
bgezal	000001	10000	1	10	-	10	00	10	--

Answer4

a

1) ***7***
2) ***8***
3) No. The predicted PC can't be calculated until the fetch stage is finished for the jmp instruction.

b

[1]

icode:ifun←"M" _"1" [PC]
rA:rB←"M" _"1" [PC+1]
valC←"M" _"4" [PC+2]
valP←PC+6

[2]

valA←R[rA]
valB←R[rB]

[3]

valM←"M" _"4" [valE]
"M" _"4" [valE]←valA

[4]

R[rA]←valM

c

[1]**M** [2]**E** [3]**E** [4]**--**
[5]**done** [6]**E** [7]**W** [8]**M**
[9]**11** [10]**--** [11]**0x44F**
[12]**W** [13]**D** [14]**M**
[15]**6** [16]**0x44F**

d

18

F	F								1
D	D	F	F						2
E	E	D	D	F	F				3
E	E	D	E	D	F	F			4
M	M	E	E	D	D	F	F		5
W	W	E	M	E	D	D	F	F	6
		E	W	E	D	D	F	F	7
		M		M	D	E	D	F	8
		W		M	D	E	E	D	9
				M	D	E	E	D	10
				W	E	M	M	D	11
					E	W	W	D	12
					M			E	13
					W			E	14
								M	15
								M	16
								M	17
								W	18