

1. PC: address of sw

IF/ID: address of sw

32'b instruction = 1111110010100010010111000100011 (0xfe512e23)

ID/EX: address of sw

content of X2

content of X5

32'b immediate = 11111111111111111111111111111111 (0xffffffff)

Instruction[30,14-12] = 1010

Instruction[11-7] = 11100

Control: WB: RegWrite = 0, MemtoReg = 1

M: Branch = 0, MemRead = 0, MemWrite = 1

EX: ALUSrc = 1, ALUDp = 00

EX/MEM: Sum: address of sw + immediate 11111111111111111111111111111111 (0xffffffff)

Zero: unknown

ALU result: content of X2-4

content of X5

Instruction[11-7] = 11100

Control: WB: RegWrite = 0 MemtoReg = 1

M: Branch = 0, MemRead = 0, MemWrite = 1

MEM/WB: D-Mem[content of X2-4]

ALU result: content of X2-4

Instruction[11-7] = 11100

Control: WB: RegWrite = 0 MemtoReg = 1

2. (1) 300 ps

(2) 1500 ps

(3) IF/MEM, 300 ps

(4) $t = 300 \times (5 + 1 \times (1000 - 1)) = 301200 \text{ ps}$

$$CPZ = \frac{1004}{1000} = 1.004$$

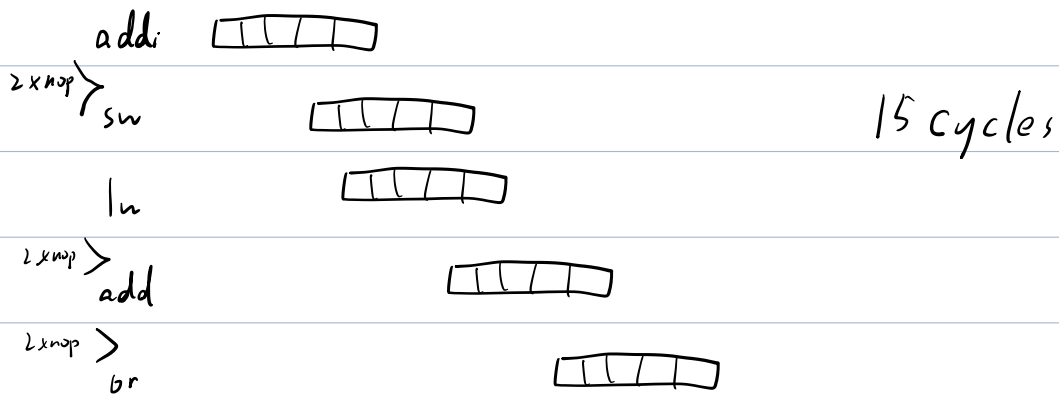
3. (1) data dependencies between

x11, L1 & L2

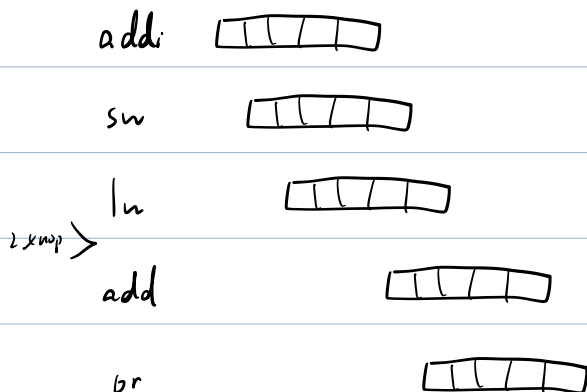
x11, L1 & L3

(2) x13 = 23, x14 = 26

4. a) EX hazard L1 & L2, L4 & L5 Load-use hazard L3 & L4,

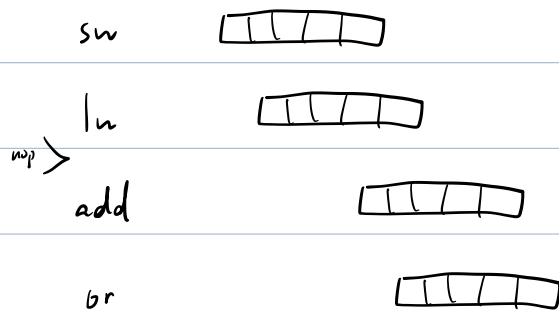


b) Load-use hazard L3 & L4, 11 cycles



c) Load-use hazard L3 & L4, 10 cycles





5. a) no effect because there is no load-use hazard

b) cycle 1: PCWrite = 1, ZF/ZDWrite = 1, Hazard = 0 sub

Forward A = 00, Forward B = 00,

ln

cycle 2: PCWrite = 1, ZF/ZDWrite = 1, Hazard = 0 ln

Forward A = 00, Forward B = 00,

or

cycle 3: PCWrite = 1, ZF/ZDWrite = 1, Hazard = 0 sw

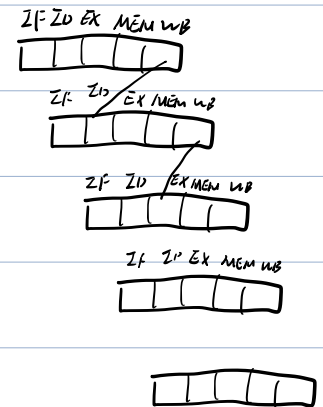
Forward A = 00, Forward B = 00,

cycle 4: PCWrite = 1, ZF/ZDWrite = 1, Hazard = 0

Forward A = 10, Forward B = 00,

cycle 5: PCWrite = 1, ZF/ZDWrite = 1, Hazard = 0

Forward A = 00, Forward B = 01,



(c) Inputs: EX/MEM RegWrite

ZD/EX RegWrite

EX/MEM Register Rd

Without forwarding, hazards can only be solved by stalling.

Hazard Detection needs to know when to stall