

1.

(a) ~~sd, beq~~ (b) ~~sl, add, sub, beq~~ (c) ~~add, sub~~

2. (a)

FF4288E3_{hex} = = beq x5 x20 -8

Branch	MemRead	MemtoReg	ALUOp	MemWrite	ALUSrc	RegWrite
1	0	X	01	0	0	0

(b) Reg[5] Reg[20]

3.

Id will be the instruction whose latency is the longest.

$$Id: 30 (PC \text{ Read}) + 200 (I\text{-Mem}) + 140 (\text{Register File}) + 30 (\text{Mux}) + 160 (ALU) + 200 (D\text{-Mem}) + 30 (\text{Mux}) + 20 (\text{Register Setup}) = 810 \text{ ps}$$

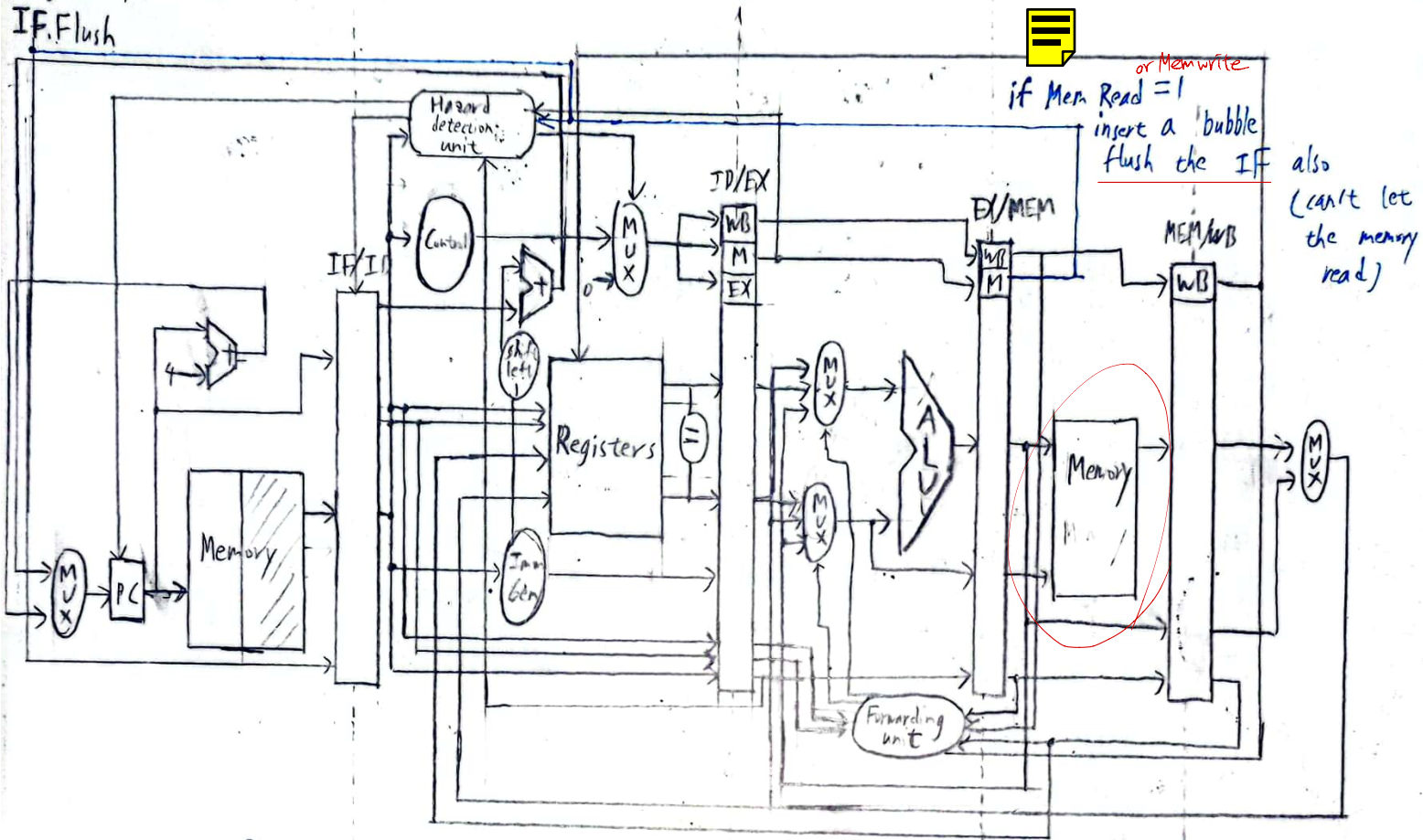
The shortest possible clock period should be long enough to process Id, so should be at least ~~810~~ ps.

8.

Cycle	IF	II	ID	EX	MEM	WB
1	ld x5, 0(x28)					
2	sub x6, x6, x5	ld x5, 0(x28)				
3	sub x6, x6, x5	sub x6, x6, x5		ld x5, 0(x28)		
4	beq x28, x29, L1	sub x6, x6, x5		nop	ld x5, 0(x28)	
5	sd x28, 0(x29)	beq x28, x29, L1		sub x6, x6, x5	nop	ld x5, 0(x28)
6	exception handler	nop		nop	sub x6, x6, x5	nop

4

(a) -7
IF.Flush



(b)

Cycle	1	2	3	4	5	6	7	8	9	10	11	12	13
Instruction													
sd x31, 16(x18)	IF	ID	EX	MEM	WB								
ld x31, 8(x18)		IF	ID	EX	MEM	WB							
ld x28, 0(x18)			IF	ID	EX	MEM	WB						
add x17, x15, x11				IF	ID	EX	MEM	WB					
Nop					NOP	NOP							
Nop						NOP	NOP						
beq x16, x0, Label							IF	ID	EX	MEM	WB		
and x19, x11, x14								IF	ID	EX	MEM	WB	
or x29, x30, x14									IF	ID	EX	MEM	WB

-5

6. Clock rate : 300MHz

(a) $30ns \Rightarrow 9 \text{ cycles} = (7-1) + S \Rightarrow S=3$
 $SS=15 \Rightarrow 15 + (7-1) = 21 \text{ cycles} \Rightarrow 70ns$

(b) $40ns \Rightarrow 27 \text{ cycles}$, 5 instructions $(N-1) + S = 27 \Rightarrow S=12, N=16$
 $240ns \Rightarrow 87 \text{ cycles}$, 65 instructions $(N-1) + 65 = 87$

7.
 (a) always-taken : $\frac{3}{8} = 37.5\%$
 always-not-taken : $\frac{5}{8} = 62.5\%$

(b)

		✓		✓	✓	✓			
Outcome	T	NT	NT	NT	NT	T	NT	T	
State	T	T	NT	NT	NT	NT	T	NT	
Predict	T	T	NT	NT	NT	NT	T	NT	

Accuracy : $\frac{4}{8} = 50\%$

(c)

		✓	✓	✓	✓	✓		
Outcome	T	NT	NT	NT	NT	T	NT	T
State	SNT	WNT	SNT	SNT	SNT	SNT	WNT	SNT
Predict	NT	NT	NT	NT	NT	NT	NT	NT

ST: Strongly taken
 WT: Weakly taken

SNT: Strongly Not taken
 WNT: Weakly Not taken

Accuracy : $\frac{5}{8} = 62.5\%$

5.
 (a) ~~ld x5, -32(x4)~~
~~NOP~~
~~NOP~~
~~ld x6, -16(x4)~~
~~NOP~~
~~NOP~~
~~add x6, x5, x6~~
~~NOP~~
~~NOP~~
~~add x6, x6, x6~~

(b) ~~ld x5, -32(x4)~~
~~NOP~~
~~ld x6, -16(x4)~~
~~NOP~~
~~add x6, x5, x6~~
~~add x6, x6, x6~~

(c) ~~ld x5, -32(x4)~~
~~ld x6, -16(x4)~~
~~NOP~~
~~add x6, x5, x6~~
~~add x6, x6, x6~~

(d) $5+4=9 \text{ cycles}$

- (i) 5
 (ii) 7
 (iii) 6