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Homework 3

1. a) pipeline: 350 ps. The longest stage is ID, it takes 350 ps.
non-pipeline: 1250ps. A clock cycle include 5 stages.

b) pipeline: 1250 ps. lw should take all 5 stages, so no matter pipeline or not, it will both take 1250ps.
non-pipeline: 1250 ps.

c) We cut the longest stage ID, then the longest will be MEM. It takes 300 ps, so the new clock cycle should be 300 ps.

d) Load and store use data memory. 20% + 15% = 35%

e) ~~Beq~~ ALU/Logic and Load need write back. 45% + 20% = 65%

f) clock cycle times:
- single-cycle: 1250 ps
- multi-cycle: 350 ps
- pipeline: 350 ps

execution times:
- single-cycle: 1250 ps per instruction
- multi-cycle: $45\% \times$ ~~1250ps~~ 1400ps $+ 20\% \times$ ~~1250ps~~ 1050ps $+ 20\% \times$ ~~1250ps~~ 1750ps $+ 15\% \times$ ~~1250ps~~ 1400ps
$= $ ~~1250~~ 1400 ps per instruction
- pipeline: 350 ps per instruction

2. a) Before, need $(n+4n)\cdot 250\,ps = 1250n\,ps$
After, need $(n+0.05n)\cdot 300\,ps = 315n\,ps$
speedup $= \frac{1250n}{315n} = 3.97$

~~b) $\frac{(1+x)\cdot 250}{(1+0.05)\cdot 300} = 1 \Rightarrow x = 0.26$~~
~~Only~~

b) $\frac{(1+4)\cdot 250}{(1+x)\cdot 300} = 1 \Rightarrow x = 3.17$

3.17n NOPs can remain.

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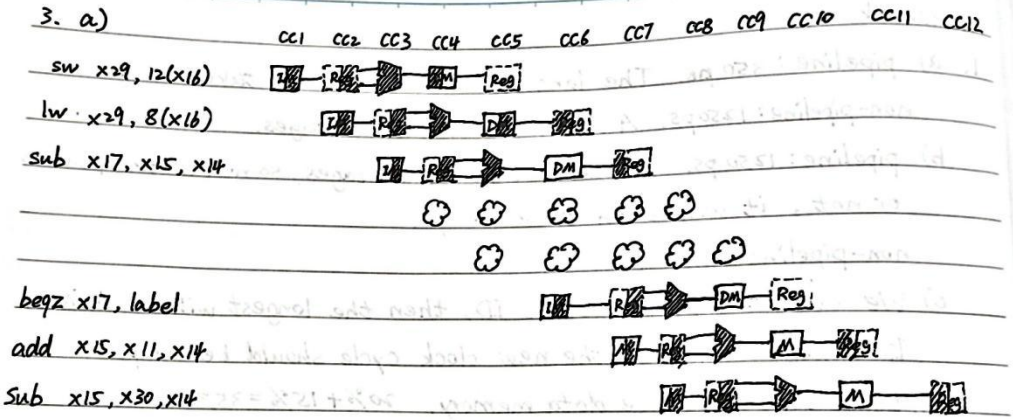
3. a)



b) No. If we put load and store at the end, there will be some problems about branch.

c) No. NOP is "addi zero, zero, 0", it still needs fetch instruction.

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4. a)

	1	2	3	4	5	6	7	8	9	10
li x12,0	IF	ID	EX	MEM	WB					
jal ENT		IF	ID	EX	MEM	WB				
bne x12,x13, TOP			IF	ID	EX	MEM	WB			
slli x5, x12, 2				IF	ID	EX	MEM	WB		
add x6,x10,x5					IF	ID	EX	MEM	WB	
lw x7, 0(x6)						IF	ID	EX	MEM	WB
lw x29, 4(x6)							IF	ID	EX	MEM
sub x30, x7, x29								IF	ID	EX
add x31, x11, x5									IF	ID
sw x30, 0(x31)										IF
addi x12, x12, 2										IF
~~bne x12, x13, TOP~~										
bne x12, x13, TOP										
slli x5, x12, 2										
add x6, x10, x5										
lw x7, 0(x6)										
lw x29, 4(x6)										
sub x30, x7, x29										
add x31, x11, x5										
sw x30, 0(x31)										
addi x12, x12, 2										
bne x12, x13, TOP										

b) For one-issue, a loop needs 9 cycles. For two-issue, a loop needs 8 cycles. Hence, speed up is $\frac{9}{8} = 1.25$

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c) beqz x13, OUT
li x12, 0
jal ENT
TOP: lw x7, 0(x10)
lw x29, 4(x10)
sub x30, x7, x29
sw x30, 0(x11)
addi x12, x12, 2
addi x10, x10, 8
addi x11, x11, 8
ENT: bne x12, x13, TOP
OUT:

d) beq x13, DONE
li x12, 0
TOP: lw x7, 0(x6)
addi x12, x12, 2
lw x29, 4(x6)
addi x6, x6, 8
sub x30, x7, x29
sw x30, 0(x31)
bne x12, x13, TOP

e) One-issue needs 8 cycles a loop, two-issue needs 6 cycles a loop.
Speedup is $\frac{8}{6} = 1.33$