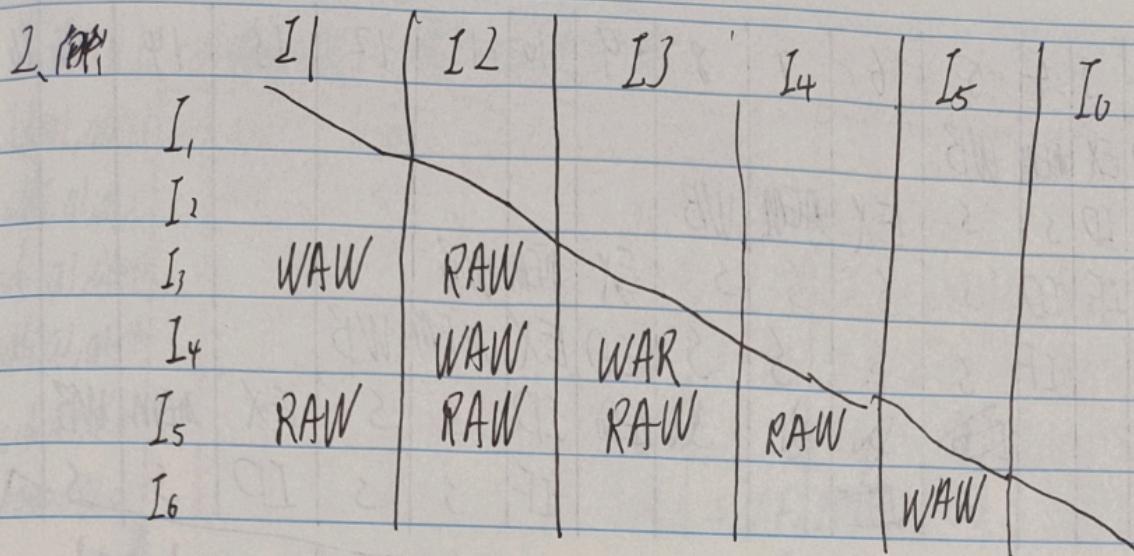


4.17.



$$4.17(1). \text{由題可得, } S_{BA} = \frac{T_A \cdot CPI_B}{T_B \cdot CPI_A} = \frac{1}{0.6} \times \frac{CPI_B}{CPI_A}$$

$$\text{且 } \frac{CPI_A}{CPI_B} = \frac{N + 5 - 1 + \frac{N}{3} \times 1}{N + 2 - 1 + \frac{4}{8} \times 3}, \text{ 且 } N \geq (K-1) \text{ 时, 有 } \frac{CPI_A}{CPI_B} = \frac{\frac{6}{5}N}{\frac{11}{8}N} = \frac{48}{55}$$

$$\text{于是 } S = \frac{1}{0.6} \times \frac{48}{55} = \frac{80}{55} \approx 1.45$$

$$(2). CPI_A = (1 - 0.2) \times (1 + \frac{1}{5}) + 0.2 \times [0.95 \times (1 + 0.2) + 0.05 \times (1 + 0.2 + 2)] \\ = 1.22$$

$$CPI_B = (1 - 0.2) \times (1 + \frac{3}{8}) + 0.2 \times [0.95 \times (1 + \frac{1}{8}) + 0.05 \times (1 + \frac{1}{8} + 5)] \\ = 1.425$$

6. 解(1) ①. ld a1, 0(a2)

addi a1, a1, 1

可能存 RAW, WAW

②. addi a1, a1, 1

sd a1, 0(a2)

可能存 WAW

③. ld a1, 0(a2)

sd a1, 0(a2)

可能存 WAW

④. sd a1, 0(a2)

addi a2, a2, 4

可能存 WAR

⑤. addi a2, a2, 4

sub a4, a3, a2

可能存 RAW

⑥. sub a4, a3, a2

bnez a4, loop

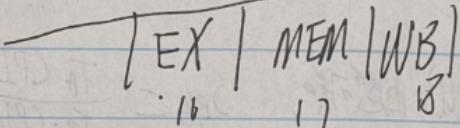
可能存 RAW

(2). 见下页

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ld a1, 0(a2)	IF	ID	EX	MEM	WB											8.
addi a1, a1, 1	IF	ID	S	S	EX	MEM	WB									ld a
sd a1, 0(a2)	IF	ID	S	S	S	S	EX	MEM	WB							addi
addi a2, a2, 4	IF	S	S	S	S	ID	EX	MEM	WB							sd
sub a4, a3, a2							ID	ID	S	S	EX	MEM	WB			addi
bnez a4, loop							IF	S	S	ID	S	S	IF	S	S	bnez

可知，在单循环中，共需 18 个时钟周期。

$$\text{总片数} = \frac{100}{4} = 25 \text{ 次循环, 故 } N_{cycle} = 18 \times 25 = 450$$



7. 解：(1) 一次循环中完整的执行时序如下所示

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	(2)
ld a1, 0(a2)	IF	ID	EX	MEM	WB											lw
addi a1, a1, 1	IF	ID	S	EX	MEM	WB										addw
sd a1, 0(a2)	IF	S	ID	EX	MEM	WB										addiw
addi a2, a2, 4				ID	EX	MEM	WB									addiw
sub a4, a3, a2					ID	EX	MEM	WB								bnez
bnez a4, loop						ID	EX	MEM	WB							

可知，单次循环共需 11 个时钟周期

$$\text{故 } N_{cycle} = 11 \times 25 = 275 (\text{r})$$

(2). 若在一个工作于 IF-LB 的固定预测发生跳转且跳转目标位置的分支预测器，除了最后一个阶段不需要 11 个周期，其余均只需 7 个周期

$$\text{则 } N_{cycle}^{\prime} = 7 \times 24 + 11 = 179.$$

5 | 16 8. 题(1) 一次循环中的完整执行时序如下所示

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
lw a1, 0(a2)	IF	IF <sub>2</sub>	ID <sub>1</sub>	ID <sub>2</sub>	EX <sub>1</sub>	EX <sub>2</sub>	M <sub>1</sub>	M <sub>2</sub>	WB <sub>1</sub>	WB <sub>2</sub>											
addi a1, a1, 1	IF <sub>1</sub>	IF <sub>2</sub>	ID <sub>1</sub>	ID <sub>2</sub>	S	S	EX <sub>1</sub>	EX <sub>2</sub>	M <sub>1</sub>	M <sub>2</sub>	WB <sub>1</sub>	WB <sub>2</sub>									
sd a1, 0(a2)	IF <sub>1</sub>	IF <sub>2</sub>	ID <sub>1</sub>	S	S	S	ID <sub>2</sub>	S	EX <sub>1</sub>	EX <sub>2</sub>	M <sub>1</sub>	M <sub>2</sub>	WB <sub>1</sub>	WB <sub>2</sub>							
addi a2, a2, 4	IF <sub>1</sub>	IF <sub>2</sub>	S	S	S	ID <sub>1</sub>	S	ID <sub>2</sub>	EX <sub>1</sub>	EX <sub>2</sub>	M <sub>1</sub>	M <sub>2</sub>	WB <sub>1</sub>	WB <sub>2</sub>							
sub a4, a3, a2	IF <sub>1</sub>	S	S	S	IF <sub>2</sub>	S	ID <sub>1</sub>	ID <sub>2</sub>	S	EX <sub>1</sub>	EX <sub>2</sub>	M <sub>1</sub>	M <sub>2</sub>	WB <sub>1</sub>	WB <sub>2</sub>						
bne a4, loop					IF <sub>1</sub>	S	IF <sub>2</sub>	ID <sub>1</sub>	S	ID <sub>2</sub>	S	EX <sub>1</sub>	EX <sub>2</sub>	M <sub>1</sub>	M <sub>2</sub>	WB <sub>1</sub>	WB <sub>2</sub>				

IF<sub>1</sub> IF<sub>2</sub> S ID<sub>1</sub> S ID<sub>2</sub> - - -

但考虑到存在前总分支预测器因此预测发生跳转。

$$\text{故 } N_{cycle}''' = 10 \times 24 + 21 =$$

但由于到下一次循环之前，还需要 6 次停顿

$$\text{故 } N_{cycle}''' = 24 \times (10 + 6) + 21 = 405$$

(2) 第 6 题, CPI =  $\frac{450}{25 \times 6} = 3$

对 7(1), CPI<sub>1</sub> =  $\frac{275}{25 \times 6} = \frac{11}{6}$

对 7(2), CPI<sub>2</sub> =  $\frac{179}{25 \times 6} \approx 1.19$

对 8, CPI<sub>4</sub> =  $\frac{405}{25 \times 6} = 2.7$

19. 题(1) 需要 2 个周期: add, sd, bne

不需要 2 个周期: addi, ld, jal, jalr

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
lw a4, 0(a3)	IF	ID	EX	MEM	WB									
addw a1, a4, a1	IF	ID <sub>1</sub>	ID <sub>2</sub>	S	EX	MEM	WB							
addi a2, a2, 1	IF	S	S	ID	EX	MEM	WB							
addi a3, a3, 4				IF	ID	EX	MEM	WB						
bne a2, loop				IF	ID <sub>1</sub>	ID <sub>2</sub>	EX	MEM	WB					

可知，循环体每次迭代需要的周期数为12。

(3).	1	2	3	4	5	6	7	8	9	10
lw a4,0(a3)	IF	ID	EX	MEM	WB					
addw a1,a4+a1		IF	ID	EX	MEM	WB				
addiw a2,a3+a1			IF	ID	EX	MEM	WB			
addi a3,a3+4				IF	ID	EX	MEM	WB		
bne a3,loop					IF	ID	EX	MEM	WB	

可知，周期数为9。