2.

	I1	I2	I3	I4	I5	I6
I1	-					
I2	~	-				
I3	-	RAW	-			
I4	—	—	—	-		
I5	—	—	RAW	RAW	-	
I6	—	—	—	—	WAW	-

4.

(1) $S = \dfrac{T_B}{T_b} \cdot \dfrac{CPI_B}{CPI_b} = \dfrac{0.6}{1} \times \dfrac{\frac{N+12-1}{N} + \frac{3}{8}}{\frac{N+5-1}{N} + \frac{1}{5}}$

$= 0.6 \times \dfrac{N+11+\frac{3}{8}N}{N+4+\frac{4}{5}N} = 0.6 \times \dfrac{\frac{11}{8}N+11}{\frac{9}{5}N+4} = 0.6 \times \dfrac{\frac{11}{8}}{\frac{9}{5}} = \dfrac{11}{24}$

加速比 $\dfrac{24}{11} = 2.18$

(2) $CPI_B = (0.8+0.2\times0.95) \times \dfrac{N+12-1}{N} + (0.2\times0.05)\times\left(\dfrac{N+12-1}{N}+5\right) + \dfrac{3}{8}$

$= 0.99\dfrac{N+11}{N} + 0.01\dfrac{6N+11}{N} + \dfrac{3}{8} = 1.425 + \dfrac{11}{N} = 1.425$

$CPI_b = (0.8+0.2\times0.95) \times \dfrac{N+5-1}{N} + (0.2\times0.05)\times\left(\dfrac{N+5-1}{N}+2\right) + \dfrac{1}{5}$

$= 0.99\dfrac{N+4}{N} + 0.01\dfrac{3N+4}{N} + \dfrac{1}{5}$

$= 1.22 + \dfrac{4}{N} = 1.22$

6.

(1) 1.2 RAW
4.5 RAW
2.3 WAW
5.6 WAW

(2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ld a1,0(a2)	IF	ID	EX	MEM	WB									
addi a1,a1,1		IF	ID	s	s	EX	MEM	WB						
Sd a1,0(a2)			IF	S	S	ID	EX	MEM	WB					
addi a2,a2,4				S	S	IF	ID	EX	MEM	WB				
Sub a4,a3,a2					S	S	IF	ID	S	S	EX	MEM	WB	
bnez a4,loop								IF	S	S	ID	EX	MEM	WB

14个周期

7.

(1)
```
ld   a1,0(a2)      IF ID EX MEM WB
addi a1,a1,1          IF ID EX  MEM WB
sd   a1,0(a2)            IF ID  EX  MEM WB
addi a2,a2,4                IF  ID  EX  MEM WB
sub  a4,a3,a2                   IF  ID  EX  MEM WB
bnez a4,Loop                       IF  ID  EX  MEM WB
```
10个周期

(2)   9个周期

8.

(1)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ld a1,0(a2)	IF1	IF2	ID1	ID2	EX1	EX2	M1	M2	WB1	WB2											
addi a1,a1,1		IF1	IF2	ID1	ID2	s	s	s	EX1	EX2	M1	M2	WB1	WB2							
sd a1,0(a2)			IF1	IF2	ID1	s	s	s	ID2	EX1	EX2	M1	M2	WB1	WB2						
addi a2,a2,4				IF1	IF2	s	s	s	ID1	ID2	EX1	EX2	M1	M2	WB1	WB2					
sub a4,a3,a2					IF1	s	s	s	IF2	ID1	ID2	s	s	s	EX1	EX2	M1	M2	WB1	WB2	
bneza4,Loop						s	s	s	IF1	IF2	ID1	s	s	s	ID2	EX1	EX2	M1	M2	WB1	WB2

21个周期

(2)
6: $CPI = \frac{14}{6} = 2.33$ 7-2: $CPI = \frac{9}{6} = 1.5$

7.1: $CPI = \frac{10}{6} = 1.67$ 8: $CPI = \frac{21}{6} = 3.5$

19

(1)

	add	addi	ld	sd	bne	jal	jalr
是否需要2周期?	✓	✗	✗	✗	✓	✗	✗

(2)
```
IF ID EX MEM WB
   IF ID1 ID2 EX MEM WB
      IF  S  ID EX MEM WB
          S  IF ID EX MEM WB
             S  IF ID EX MEM WB
```
10周期

(3)
```
IF ID EX MEM WB
   IF ID EX MEM WB
      IF ID EX MEM WB
         IF ID EX MEM WB
            IF ID EX MEM WB
```
9周期