2. 解:

| | I1 | I2 | I3 | I4 | I5 | I6 |
|---|---|---|---|---|---|---|
| I1 | | | | | | |
| I2 | | | | | | |
| I3 | WAW | RAW | | | | |
| I4 | | WAW/WAR | WAR | | | |
| I5 | RAW | RAW | RAW | RAW | | |
| I6 | | | | | RAW | |

4. 解:

(1) $S = \frac{T_A \cdot CPI_A}{T_B \cdot CPI_B} = \frac{1 \times \frac{6}{5}}{0.6 \times \frac{8}{11} \times \frac{11}{8}} \approx 1.45$

(2) $CPI_A = \frac{0.8N \times \frac{6}{5} + 0.2N \times \frac{6}{5} \times 95\% + 0.2N \times 2 \times 5\%}{N} = 1.208$

$CPI_B = \frac{0.8N \times \frac{11}{8} + 0.2N \times \frac{11}{8} \times 95\% + 0.2N \times 5 \times 5\%}{N} = 1.41125$

6. (1) ① 第一条与第二条 RAW 和 WAW

② 第一条与第二条 RAW

③ 第二条与第三条 RAW

④ 第四条与第五条 RAW

⑤ 第五条与第六条 RAW

(2)

~~$N_{cycle}$~~ =

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | s | s | EX | MEM | WB | | | | | | | |
| addi a2,a2,4 | | | | s | s | IF | s | s | ID | EX | MEM | WB | | | | | | |
| sub a4,a3,a2 | | | | | s | s | s | s | IF | ID | s | s | EX | MEM | WB | | | |
| bnez a4,Loop | | | | | | s | s | s | s | IF | s | s | ID | s | s | EX | MEM | WB |

每执行一次循环，a2值加4，a3-a2为0时循环结束，~~a3不~~

∴一共执行25次循环

∴ $N_{cycle} = 25 \times 18 = 450$

7. (1)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ld a1,0(a2) | IF | ID | EX | MEM | WB | | | | | | |
| addi a1,a1,1 | | IF | ID | s | EX | MEM | WB | | | | |
| sd a1,0(a2) | | | IF | s | ID | EX | MEM | WB | | | |
| addi a2,a2,4 | | | | s | IF | ID | EX | MEM | WB | | |
| sub a4,a3,a2 | | | | | s | IF | ID | EX | MEM | WB | |
| bnez a4,Loop | | | | | | s | IF | ID | EX | MEM | WB |

$N_{cycle} = 25 \times 11 = 275$

(2) $N_{cycles} = 24 \times 7 + 11 = 179$

8.

1)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ld a1,0(a2) | IF1 | IF2 | ID1 | ID2 | EX1 | EX2 | MEM1 | MEM2 | WB1 | WB2 | | | | | | |
| addi a1,a1,1 | | IF1 | IF2 | ID1 | ID2 | s | s | s | EX1 | EX2 | MEM1 | MEM2 | WB1 | WB2 | | |
| sd a1,0(a2) | | | IF1 | IF2 | ID1 | s | s | s | ID2 | s | EX1 | EX2 | MEM1 | MEM2 | WB1 | WB2 |
| addi a2,a2,4 | | | | IF1 | IF2 | s | s | s | ID1 | s | ID2 | EX1 | EX2 | MEM1 | MEM2 | WB1 |
| sub a4,a3,a1 | | | | | IF1 | s | s | s | IF2 | s | ID1 | ID2 | s | EX1 | EX2 | MEM1 |
| bnez a4,Loop | | | | | | s | s | s | IF1 | s | IF2 | ID1 | s | ID2 | s | EX1 |

| 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|
| | | | | WB2 |
| | | | MEM2 | WB1 |
| | | | EX2 | MEM1 |

$N_{cycles} = 10 \times 24 + 21 = 261$

(2) 6: $CPI = \frac{18}{6} = 3$

7(1): $CPI = \frac{11}{6} = 1.83$

7(2): $CPI = \frac{N_{cycles}}{25 \times 6} = 1.19$

8: $CPI = \frac{N_{cycle}}{25 \times 6} = 1.74$

(2) $N_{cycles} = 24 \times 7 + 11 = 179$

8.

i)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ld a1,0(a2) | IF1 | IF2 | ID1 | ID2 | EX1 | EX2 | MEM1 | MEM2 | WB1 | WB2 | | | | | | |
| addi a1,a1,1 | | IF1 | IF2 | ID1 | ID2 | s | s | s | EX1 | EX2 | MEM1 | MEM2 | WB1 | WB2 | | |
| sd a1,0(a2) | | | IF1 | IF2 | ID1 | s | s | s | ID2 | s | EX1 | EX2 | MEM1 | MEM2 | WB1 | WB2 |
| addi a2,a2,4 | | | | IF1 | IF2 | s | s | s | ID1 | s | ID2 | EX1 | EX2 | MEM1 | MEM2 | WB1 |
| sub a4,a3,a2 | | | | | IF1 | s | s | s | IF2 | s | ID1 | ID2 | s | EX1 | EX2 | MEM1 |
| bnez a4,Loop | | | | | | s | s | s | IF1 | s | IF2 | ID1 | s | ID2 | s | EX1 |

| 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|
| | | | | WB2 |
| | | | MEM2 | WB1 |
| | | EX2 | MEM1 | MEM2 |

$N_{cycles} = 10 \times 24 + 21 = 261$

(2) 6: $CPI = \frac{18}{6} = 3$

7(1): $CPI = \frac{11}{6} = 1.83$

7(2): $CPI = \frac{N_{cycles}}{25 \times 6} = 1.19$

8: $CPI = \frac{N_{cycle}}{25 \times 6} = 1.74$

19. 解:

(1)

| add | addi | ld | sd | bne | jal | jalr |
|---|---|---|---|---|---|---|
| 需要 | 不需要 | 不需要 | 需要 | 需要 | 不需要 | 不需要 |

(2) 若为跳转指令则ID分2周期完成，分为ID1，ID2

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lw a4,0(a3) | IF | ID | EX | MEM | WB | | | | | | | |
| addw a1,a4,a1 | | IF | ID1 | ID2 | s | EX | MEM | WB | | | | |
| addiw a2,a2,-1 | | | IF | s | s | ID | EX | MEM | WB | | | |
| addiw a3,a3,4 | | | | s | s | IF | ID | EX | MEM | WB | | |
| bnez a2,Loop | | | | s | s | IF | ID1 | ID2 | EX | MEM | WB | |

单次迭代 Ncycle = 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 | s | EX | MEM | WB | | | |
| addiw a2,a2,-1 | | | IF | s | ID | EX | MEM | WB | | |
| addiw a3,a3,4 | | | | s | IF | ID | EX | MEM | | |
| bnez a2,Loop | | | | | s | IF | ID | EX | MEM | WB |

单次迭代 Ncycle = 10