

Solution

1(a) P1: $(2000 \times 2 + 3000 \times 1 + 4000 \times 3) / (2000 + 3000 + 4000) = 19/9 = 2.11$
P2: $(4000 \times 2 + 2000 \times 1 + 4000 \times 3) / (4000 + 2000 + 4000) = 2.20$

1(b) P1: $(2000 \times 2 + 3000 \times 1 + 4000 \times 3) \times 1 \text{ ns} = 19 \text{ us}$
P2: $(4000 \times 2 + 3000 \times 1 + 4000 \times 3) \times 1 \text{ ns} = 20 \text{ us}$

1(c) It's true in this case, but not so in general.
Execution time = CPI * #instructions * cycle time
Even if the CPI is faster, there could be differences in the other terms.

1(d) $19 \text{ us} = 2.20 \times 10000 \times T \Rightarrow T = 19/22 \text{ ns}$

2(a)

I1: R1 ← R2 + R3
 I2: R4 ← Mem(R1)
 I3: R2 ← Mem(R2)
 I4: R4 ← R4 + R5
 I5: R6 ← Mem(R3)
 I6: R1 ← R6 + R7

RAW conflict from I1 to I2

WAW conflict from I1 to I6 (not critical for this hardware)

WAR conflict from I3 to itself (not critical for this hardware)

RAW conflict from I2 to I4

WAW conflict from I2 to I4

WAR conflict from I4 to itself

RAW conflict from I5 to I6

(b)

I1	IF	ID	EX	MEM	WB													
NOP		IF																
NOP			IF															
NOP				IF														
I2					IF	ID	EX	MEM	WB									
I3						IF	ID	EX	MEM	WB								
NOP							IF											
NOP								IF										
I4									IF	ID	EX	MEM	WB					
I5										IF	ID	EX	MEM	WB				
NOP											IF							
NOP												IF						
NOP													IF					
I6														IF	ID	EX	MEM	WB

(c)

11	IF	ID	EX	MEM	WB						
12		IF	ID	EX	MEM	WB					
13			IF	ID	EX	MEM	WB				
14				IF	ID	EX	MEM	WB			
15					IF	ID	EX	MEM	WB		
NOP						IF					
16							IF	ID	EX	MEM	WB

(d)

11	IF	ID	EX	MEM	WB					
12		IF	ID	EX	MEM	WB				
13			IF	ID	EX	MEM	WB			
15				IF	ID	EX	MEM	WB		
14					IF	ID	EX	MEM	WB	
16						IF	ID	EX	MEM	WB