

Project Assignment # 3

Solution

1. Multiple pipeline with hazards and forwarding
Forwarding is shown in bold.

(a) Execution clock cycles of the loop: 14 cycles

Instruction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
LD F2,0(R1)	F	D	E	M	W														
DIV F8, F2, F0		F	D	S	E	E	E	E	E	E	M	W							
MULT F2, F6, F2			F	S	D	E	E	E	M	W									
LD F4, 0(R2)				S	F	D	E	M	W										
ADD F4, F0, F4						F	D	S	E	M	W								
ADD F10, F8, F2							F	S	D	S	E	M	W						
ADDI R1, R1, 8								S	F	S	D	E	M	W					
ADDI R2, R2, 8										S	F	D	E	M	W				
SD F4, 0(R2)												F	D	E	M	W			
SUB R20, R4, R1													F	D	E	M	W		
BNZ R20, Loop														F	S	D	E	M	W

(b) Execution clock cycles of the loop: 15 cycles

$$\text{Speedup of b over a is: } speedup = \frac{T_a}{T_b} = \frac{14 \times 1}{15 \times (1 - 10\%)} \approx 1.04$$

Instruction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
LD F2,0(R1)	F	D	E	M	W															
DIV F8, F2, F0		F	D	S	E	E	M	W												
MULT F2, F6, F2			F	S	D	S	E	E	M	W										
LD F4, 0(R2)				S	F	S	D	E	M	S	W									
ADD F4, F0, F4						S	F	D	S	S	E	M	W							
ADD F10, F8, F2								F	S	S	D	E	M	W						
ADDI R1, R1, 8									S	S	F	D	E	M	W					
ADDI R2, R2, 8												F	D	E	M	W				
SD F4, 0(R2)													F	D	E	M	W			
SUB R20, R4, R1														F	D	E	M	W		
BNZ R20, Loop															F	S	D	E	M	W

2. Tomasulos algorithm

Instruction	Issue	Execution	Write-back	Reason to Stall
LD F0, 0(R0)	1	2	3	
MUL.D F1, F0, F1	2	4-9	10	RAW(F0)
ADD.D F0, F0, F2	3	4-6	7	
SD F1, 0(R1)	4	11	12	RAW(F1)
LD F2, 4(R0)	5	6	8	CDB
MUL.D F3, F2, F1	6	11-16	17	RAW(F1, F2)
ADD.D F4, F1, F2	7	11-13	14	RAW(F1)
SD F3, 4(R3)	8	18	19	RAW(F3)
ADDI F2, F2, 1	9	10	11	
ADD.D F0, F4, F1	10	15-17	18	RAW(F4)