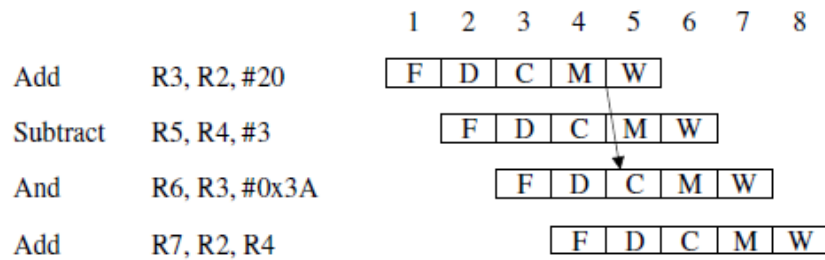


Solution for Chapter 6

6.2 (a) The pipeline execution diagram for the given code is shown below.



The description of activity in each stage during each cycle is the same as in part (a) of Problem 6.1, except that the previous contents of register R3 are read by the And instruction in cycle 4, but the Compute stage uses the new value of 2020 that has been computed by the first Add instruction. The differences with the solution for part (a) of Problem 6.1 are highlighted in *italics* in the partial table given below.

Cycle	Stage	Activity
1	F	fetching Add instruction
2	F	fetching Subtract instruction
	D	decoding Add instruction, reading register R2 (value 2000)
3	F	fetching And instruction
	D	decoding Subtract instruction, reading register R4 (value 50)
	C	performing arithmetic $2000 + 20 = 2020$ for Add instruction
4	F	fetching Add instruction
	D	decoding And instruction, <i>reading register R3 (value unknown)</i>
	C	performing arithmetic $50 - 3 = 47$ for Subtract instruction
	M	no operation for Add instruction
5	D	decoding Add instruction, reading register R2 (value 2000) and register R4 (value 50)
	C	performing logic operation $2020 \wedge 3A = 52$ for And instruction
	M	no operation for Subtract instruction
	W	write result of 2020 for Add instruction to register R3
6	C	performing arithmetic for Add instruction
	M	no operation for And instruction
	W	write result of 47 for Subtract instruction to register R5
7	M	no operation for Add instruction
	W	write result of 52 for And instruction to register R6

(b) The contents of each register during each cycle are described in the table below. The differences with the equivalent table in part (b) of Problem 6.1 are highlighted in **boldface**.

	2	3	4	5	6	7	8
IR	Add	Sub	And	Add			
PC	1004	1008	1012	1016	1020	1024	1028
RA		2000	50	Pre R3	2000		
RB					50		
RZ			2020	47	32	2050	
RY				2020	47	32	2050

The contents of RZ in cycle 4 and RY in cycle 5 are determined as follows:

$$2020 \wedge 3A_{16} = 7E4_{16} \wedge 3A_{16} = 20_{16} = \mathbf{32}$$