Digital and Embedded Systems
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Tutorial 4 – Assembly Programming

1. Given the following fragment of assembly code
(a) Complete the table below.

1. LDS R16, $0050
2. LDI R17, $51
3. STS $004A, R16
4. STS $004B, R17

Registers	Initial Values	After 1.	After 2.	After 3.	After 4.
(PC)	$00				
(R16)	$00				
(R17)	$FF				
($004A)	$3C				
($004B)	$1D				
($0050)	$42				
($0051)	$B9				

Note:
- Word size in program memory is 16 bits
- Word size in data memory is 8 bits
- LDI instruction (opcode+operand) has a length of 16 bits, while LDS and STS have a length of 32bits.
- Therefore LDI instruction takes up only 1 memory word and PC only increments by 1 after execution.

(b) Given that the Butterfly is running at 16 MHz, calculate the total execution time required to execute the 4 instructions in the code in question 1.

2. What is the value in the following registers and/or memory locations after executing the following instructions?

1. LDS R16, $0400

Before	*After*
R16 =$76	R16 =
[$0400] =$89	[$0400] =

2. LDI R16, $04

Before	*After*
R16 =$76	R16 =
[$0400] =$89	[$0400] =

3. CPI R16, $76

Before	*After*
R16 =$76	R16 =
[$0400] =$89	[$0400] =
--	[CC] = (overflow flag is set to 0, negative is 0, zero is 1, carry is 0)

4. LDS R16, $0400
   STS $0401, R16

Before	*After*
R16 =$76	R16 =
[$0400] =$89	[$0400] =
[$0401] =$00	[$0401] =

5. ADD R16, R17

Before	*After*
R16 =$76	R16 =
R17 =$12	R17 =

6. AND R16, R17

Before	*After*
R16 =$76	R16 = 0111 0110 AND 0001 0010 =
R17 =$12	R17 =

7. OR R16, R17

Before	*After*
R16 =$76	R16 = 0111 0110 OR 0001 0010 =
R17 =$12	R17 =

8. INC R30

Before	*After*
R30 =$79	R30 =

9. DEC R30

Before	*After*
R30 =$00	R30 =

10. CLR R30

Before	*After*
R30 =$FF	R30 =

11. SER R30

Before	*After*
R30 =$55	R30 =

12. SBR R18, 1

Before	*After*
R18 =$50	R18 =

13. CBR R18, 7

Before	*After*
R18 =$FF	R18 =

14. COM R18

Before	*After*
R18 =$55	R18 = NOT 0101 0101 =

15. NEG R18

Before	*After*
R18 =$55	R18 = $AA+1 =

16. MOV R18, R1

Before	*After*
R18 =$55	R18 =

R1 =$66 R1 =

17. MOVW R18, R0

Before	*After*
R19 =$66	R18 =
R18 =$55	R18 =
R1 =$03	R1 =
R0 =$02	R0 =

18. LD R18,X

Before	*After*
R18 =$55	R18 =
X =$0450	X =
[$0450] =$20	[$0450] =

19. LD R18,X+

Before	*After*
R18 =$55	R18 =
X =$0450	X =
[$0450] =$20	[$0450] =

20. ST -Y,R18

Before	*After*
R18 =$55	R18 =
Y =$0450	Y =
[$0450] =$20	[$0450] =
[$044F] =$10	[$044F] =