

Name: G. Nithish  
 Regno: 19BCS0012  
 Sub : Computer  
 Architecture  
 Code : CSC2004

## Problem Solving-I

1) Determine the microoperation that will be executed when the following 4 bit Control words are applied:-

Soln

a) 00101001100101

SELA	SELB	SELD	OPR	Micro-operation
$R_1$	$R_2$	$R_3$	SUB	$R_3 \leftarrow R_1 - R_2$

b) 00000000000000

SELA	SELB	SELD	OPR	Micro-operation
Input		None	Transfer A	Output $\leftarrow$ Input.

c) 01001001001100

SELA	SELB	SELD	OPR	Micro-operation
$R_2$	$R_2$	$R_2$	XOR	$R_2 \leftarrow R_2 \oplus R_2$



2) Specify the control word that must be applied to the processor to implement the following operation.

- a)  $R_4 \leftarrow R_4$       b)  $R_5 \leftarrow R_5 - 1$   
 c)  $R_6 \leftarrow \text{shl } R_1$       d)  $R_7 \leftarrow \text{input}$

Soln

s.no	Equation	SELA	SELB	SELD	OPR	Control word
a)	$R_4 \leftarrow R_4$	$R_4$		$R_4$	COMA	100 xxx 100 01110
b)	$R_5 \leftarrow R_5 - 1$	$R_5$		$R_5$	DECA	101 xxx 101 00110
c)	$R_6 \leftarrow \text{shl } R_1$	$R_1$		$R_6$	SHLA	001 xxx 110 11000
d)	$R_7 \leftarrow \text{input}$	Input		$R_7$	TSFA	000 xxx 111 00000

3) Convert the following arithmetic expressions from infix to reverse polish notation.

a)  $A * B + F * G + C * D$        $(A * B + F * G + C * D)$

b)  $A * B + A * (B + C)$

c)  $A * [B + C] / F * (G + L + M)$

d)  $(1 + 2 + 3) * (4 + 5 + 6)$



$$\text{or } A^*B + F^*G + C^*D$$

Result:

$$AB \star FG \star CD \star ++$$

				B	B	B+C		
	B	*	A	A	A	A	$A(B+C)$	
A	A	AB	AB	AB	AB	AB	AB	$A^*B + A^*(B+C)$
A	B	*	A	B	C	+	*	+

### Reverse Polish notation:-

$$AB \star ABC + \star +$$

Handwritten work on grid paper showing a sequence of operations and a final expression.

Top row:  $C$

Second row:  $B \ B \ B+C \ A^*$

Third row:  $A \ A \ A \ A \ C$

Bottom row:  $A \ B \ C \ + \ *$

Operations and expressions:

- $F \ A^*[B+C] \rightarrow$
- $\frac{A^*[B+C]}{F}$
- $G \ G \ G+L \ G+L \ G+L+M$
- $\frac{A^*[B+C]}{F^*(G+L+C)}$



Result:

$$abc + *f/g| + m + *$$

$$a) (1+2+3) * (4+5+6)$$

						5		6					
	2		3		4	4	4+5	4+5	4+5+6				
1	1	1+2	1+2	1+2+3	1+2+3	1+2+3	1+2+3	1+2+3	1+2+3	1+2+3	1+2+3	1+2+3	1+2+3
1	2	+	3	+	4	5	+	6	+	*			

Result

$$12 + 3 + 45 + 6 + *$$

4) Convert the following arithmetic expression from reverse polish notation to infix notation:-

$$a) ABCDE + * - | \quad c) ABCDEFG + * + * + *$$

Soln

$$\frac{A}{B - C + D + E}$$

Soln

$$A + B + C + D + E + F + G$$

$$b) ABCDE * / - +$$

Soln

$$\frac{A + B - C}{D * E}$$



54 write the 3-address, 2-address, 1-address, 0-address for the given instruction

$$a \rightarrow X = (A/B)^* C + B$$

Three address:-

DIV  $R_1, A, B$   $R_1 \leftarrow A/B$

MUL  $R_1, R_1, C$   $R_1 \leftarrow R_1 * C$

ADD  ~~$R_1, R_1, B$~~   ~~$R_1 \leftarrow R_1 + B$~~

Two address:-

MOV  $R_1, A$   $R_1 \leftarrow M[A]$

DIV  $R_1, B$   $R_1 \leftarrow R_1 / M[B]$

MUL  $R_1, C$   $R_1 \leftarrow R_1 * C$

ADD  $R_1, B$   $R_1 \leftarrow R_1 + B$

One address.

LOAD  $A$   $AC \leftarrow M[A]$

DIV  $B$   $AC \leftarrow AC / B$

MUL  $C$   $AC \leftarrow AC * C$

ADD  $B$   $AC \leftarrow AC + B$

STORE  $X$   $M[X] \leftarrow AC$

Zero address:-

PUSH  $A$   $Tos \leftarrow A$

PUSH  $B$   $Tos \leftarrow B$

DIV  $Tos \leftarrow (A/B)$

PUSH  $C$   $Tos \leftarrow C$

MUL  $Tos \leftarrow (A/B)^* C$

ADD  $B$   $Tos \leftarrow B$

ADD  $Tos \leftarrow (A/B)^* C + B$

POP  $X$   $M[X] \leftarrow Tos$



$$⑥ Y = (A+B) * (C-D)$$

2 address

ADD  $R_1, A, B \quad R_1 \leftarrow M[A] + M[B]$

SUB  $R_2, C, D \quad R_2 \leftarrow M[C] - M[D]$

MUL  $X, R_1, R_2 \quad M[X] \leftarrow R_1 * R_2$

2 address:-

MOV  $R_1, A \quad R_1 \leftarrow M[A]$

ADD  $R_1, B \quad R_1 \leftarrow R_1 + M[B]$

MOV  $R_2, C \quad R_2 \leftarrow M[C]$

SUB  $R_2, D \quad R_2 \leftarrow R_2 - M[D]$

MUL  $R_1, R_2 \quad R_1 \leftarrow R_1 * R_2$

MOV  $X, R_1 \quad M[X] \leftarrow R_1$

1 address:-

Load  $A \quad AC \leftarrow M[A]$

ADD  $B \quad AC \leftarrow AC + M[B]$

STORE  $T \quad M[T] \leftarrow AC$

LOAD  $C \quad AC \leftarrow M[C]$

SUB  $D \quad AC \leftarrow AC - M[D]$

MUL  $M[T] \quad AC \leftarrow AC * M[T]$

STORE  $M[X] \quad M[X] \leftarrow AC$

Zero address

PUSH  $A \quad TOS \leftarrow A$

PUSH  $B \quad TOS \leftarrow B$

ADD  $\quad TOS \leftarrow (A+B)$

PUSH  $C \quad TOS \leftarrow C$

PUSH  $D \quad TOS \leftarrow D$

SUB  $\quad TOS \leftarrow (C-D)$

MUL  $\quad TOS \leftarrow (A+B) * (C-D)$

POP  $\quad M[X] \leftarrow TOS$



27  
d7  $W = A + B * C * D$

3 address:-

ADD  ~~$R_1, A, B$~~   $R_1 \leftarrow M[A] + M[B]$

MUL  $R_1, C, D$   $R_1 \leftarrow M[C] * M[D]$

MUL  $R_1, R_1, B$   $R_1 \leftarrow R_1 * M[B]$

ADD  $R_1, R_1, A$   $R_1 \leftarrow R_1 + M[A]$

ADD  $M[W], R_1, A$   $M[W] \leftarrow$

2 address:-

MOV  $R_1, B$   $R_1 \leftarrow M[B]$

MUL  $R_1, C$   $R_1 \leftarrow R_1 * M[C]$

MUL  $R_1, D$   $R_1 \leftarrow R_1 * M[D]$

ADD  $R_1, A$   $R_1 \leftarrow R_1 + M[A]$

MOV  $M[W], R_1$   $M[W] \leftarrow R_1$

② address:- one address

LOAD B  $AC \leftarrow M[B]$

MUL C  $AC \leftarrow AC * M[C]$

MUL D  $AC \leftarrow AC * M[D]$

ADD A  $AC \leftarrow AC + M[A]$

STORE W  $M[W] \leftarrow AC$

4/ Zero-address instruction:-

PUSH D  $TOS \leftarrow D$

PUSH C  $TOS \leftarrow C$

MUL  $TOS \leftarrow D * C$

~~MUL~~ PUSH B  $TOS \leftarrow B$

MUL  $TOS \leftarrow B * D * C$

PUSH A  $TOS \leftarrow A$

ADD  $TOS \leftarrow A + B * C * D$

POP W  $M[W] \leftarrow TOS$



③  $Z = (A * B) - C$

### 3 address

MUL  $R_1, A, B \quad R_1 \leftarrow M[A] * M[B]$

SUB  $Z, R_1, C \quad M[Z] \leftarrow R_1 - M[C]$

### 2 address

MOV  $R_1, A \quad R_1 \leftarrow M[A]$

MUL  $R_1, B \quad R_1 \leftarrow R_1 * M[B]$

SUB  $R_1, C \quad R_1 \leftarrow R_1 - M[C]$

MOV  $Z, R_1 \quad M[Z] \leftarrow R_1$

### 1 address

LOAD  $A \quad AC \leftarrow M[A]$

MUL  $B \quad AC \leftarrow AC * M[B]$

SUB  $C \quad AC \leftarrow AC - M[C]$

STORE  $Z \quad M[Z] \leftarrow AC$

### Zero address

PUSH  $A \quad \text{Tos} \leftarrow A$

PUSH  $B \quad \text{Tos} \leftarrow B$

~~PUSH~~ MUL  $\text{Tos} \leftarrow A * B$

~~PUSH~~ ~~C~~ ~~Tos~~  $\leftarrow A * B$

PUSH  $C \quad \text{Tos} \leftarrow C$

~~PUSH~~ SUB  $\text{Tos} \leftarrow (A * B) - C$

POP ~~Tos~~  $M[Z] \leftarrow \text{Tos}$