→ Binary representation –

→ binary 5 in 5 bits ⇒ 00101
" 9 " " " ⇒ 01001

- Representation of signed ~~negative~~ numbers – 2-Complement's scheme

i) Positive numbers represented as it is.
ii) Negative numbers – $\underbrace{\text{Compliment of +ve}}_{\text{bit by bit compliment is done.}}$ is done + 1

$+5 = 00101$
$-5 = (00101)' + 1$
$= (11010) + 1$
$= 11011$

$+5 = (-5)' + 1 = (11011)' + 1 = \underline{00101}$

- Add -5 and +9

$-5 = 11011$
$9 = + 01001$
$\boxed{1}00100$ Ans ⇒ $\boxed{00100} = +4$

carry is dropped

Add ⇒ -9 and +5 ⇒ $-9 = (01001)' + 1 = 10110 + 1$
$= 10111$

$+5 = 00101$
$-9 = 10111$
$\boxed{11100 = -4}$ as $(11100)' + 1 = 00011 + 1 = \underline{00100}$

⇒ Add −5 and −9

$-5 = 11011$
$-9 = 10111$

$\boxed{1}\ 10010 \Rightarrow 10010 \Rightarrow (10010)' + 1$
$= 01101 + 1 = 01110$
$= 14$

$\boxed{-14}$

− 9 + 9 in 5 bits

$9 = 01001$
$9 = 01001$
$+$
$10010 \Rightarrow (10010)' + 1 = 01101 + 1$
$= 01110 = 14$

-14

− Subtraction

$+9 - (-5)$

$9 = 01001$ $0 - 1 = 1$ with borrow 1
$-5 = 11011$
$-$
$\boxed{1}\ 01110 = +14$
borrow

Instructions

- Every instruction has 4 digits
- $\boxed{abcd \text{ means } [ab] = [cd]}$
5423 means in memory 54 put contents of 23.
- $\boxed{90cd \text{ means } [90] = cd}$ → value, not memory
eg- 9045 means [90] = 45 and not [90] = [45]

- WAP, to store 72 in 56

9072, 5690

- $\boxed{93 \text{ memory will store } [88] + [89]}$ Always in sync with [88] and [89]
eg - [88] has 243; [89] has 432
and let memory 56 have 314 → [88]+[89]
then after instruction 9356; 93 stores 675 not 314

- WAP, 156 is stored in memory 42.

9078, 8890, 8990, 4293

WAP, 240 is stored in memory 59

9080, 8890, 8990, 8893, 5993
is wrong

18

8843 is not allowed. Similarly 8993 not allowed

[88] = [88] + [89] not allowed

Correct Solution - 9080, 8890, 8990, 5693, 8856, 5993

use extra memory

→ Output of 9060, 8890, 9005, 8990, 5393, 8853

⇒ At last.

[53] = 65

[88] = 65

[89] = 5

[93] = 70

[90] = 5

- 91cd means ~~[91] cd and~~ print [cd]

- [94] = [88] - [89]

[95] = " * "

[96] = " / "

- 97cd means [97] = cd and goto instruction cd.

	0	1	2	3	4	5	6
- eg -	9060,	8890,	9005,	8890,	9193,	8891,	9704

Output is 60, 65, 70, ...

- Print = -27

9000
8890
9027
8990
~~9~~
9194

⇒ 98cd means [97] = cd and goto instruction cd
if [94] ≥ 0

- eg · 9060, 8890, 9005, 8990, 9194, 8891, 9804

⇒ 55, 50, 45, ..., 0

→ Vector Processors -

$x = 12$
$y = 4$
$z = x + y$

$p = [12, 34, 52, 9]$
$q = [4, 11, 5, 4]$
$r = p + q = [16, 45, 57, 13]$ in unit time using vector processors

$t = 3:2:12 = [3, 5, 7, 9, 11]$ ⇒ 3 ~~12~~ $i=3; i<=12; i+=2$

$m = p * q = [48, 374, 260, 36]$ in unit time.

- suppose R is matrix.

1-based index i.e. 2nd row, 4th column

$$\begin{matrix} 2 & 4 & 6 & 7 \\ 8 & 3 & 5 & 9 \\ 7 & 2 & 5 & 4 \end{matrix}, \quad k[2,4] = 9$$

$k[2,:] = [8\ 3\ 5\ 9]$

$k[:,4] = [7;9;4]$ or

$[7,9,4]^T$ or

$$\begin{matrix} 7 \\ 9 \\ 4 \end{matrix}$$

suppose; $a = b + c \Rightarrow b, c$ are matrices of size $3, 4$

for $i = 1:1:3$
  $a[i,:] = b[i,:] + c[i,:]$

for $i = 1:1:4$
  $a[:,i] = b[:,i] + c[:,i]$

$[p,q] = size(b)$

Let matrix size is m, n. then addition in $O(\min(m,n))$

To get some row in matrix add^n $\Rightarrow$ unit time

(2i)

Camlin Page
Date / /

- Suppose ⇒ $b(m,n)$ $c(n,r)$ multiply
To get arbitrary element, $b*c$ in normal operation ⇒ $O(n)$

$a(i,j)$
⇒ $s=0;$
for $k=1:1:n$
$s += b[i,k] * c[k,j]$

To get first row of $a = b*c$, by normal operation

time = $\underline{n*r}$

To get single element of $a = b*c$ in vector, $\boxed{\text{time} = n}$

To get single row of $a = b*c$ in vector ⇒ $r+n-1$

eg - $b = \begin{bmatrix} 6 & 2 & 3 \\ 1 & 7 & 5 \end{bmatrix}$; $c = \begin{bmatrix} 3 & 2 & 5 & 1 \\ 5 & 2 & 7 & 5 \\ 3 & 8 & 4 & 2 \end{bmatrix}$

We need $a[0,:]$ e;

$[6\ 2\ 3] * [3\ 5\ 3] = [18\ 10\ 9]$
$[6\ 2\ 3] * [2\ 2\ 8] = [12\ 4\ 24]$
" " $[5\ 7\ 4] = [30, 14, 12]$
" " $[1\ 5\ 2] = [6, 10, 6]$

This took $\underline{r}$ time

Now

$$a[0,:] = \left(\begin{bmatrix} 18 & 10 & 9 \\ 12 & 4 & 24 \\ 30 & 14 & 12 \\ 6 & 10 & 6 \end{bmatrix}'\right) \text{ column sum}$$

This takes $n-1$ time

Hence total time = $r+n-1$

Q) Program to find 1st row of matrix; $a = b*c$.

$$\underbrace{\left(\underbrace{c[:,1]}_{\text{column}}\right)'}_{\text{row}} = [3,5,3]$$

- d = 1st row of a

for $i = 1:1:r$
$d[i,:] = b[1,:]*c[:,i]'$