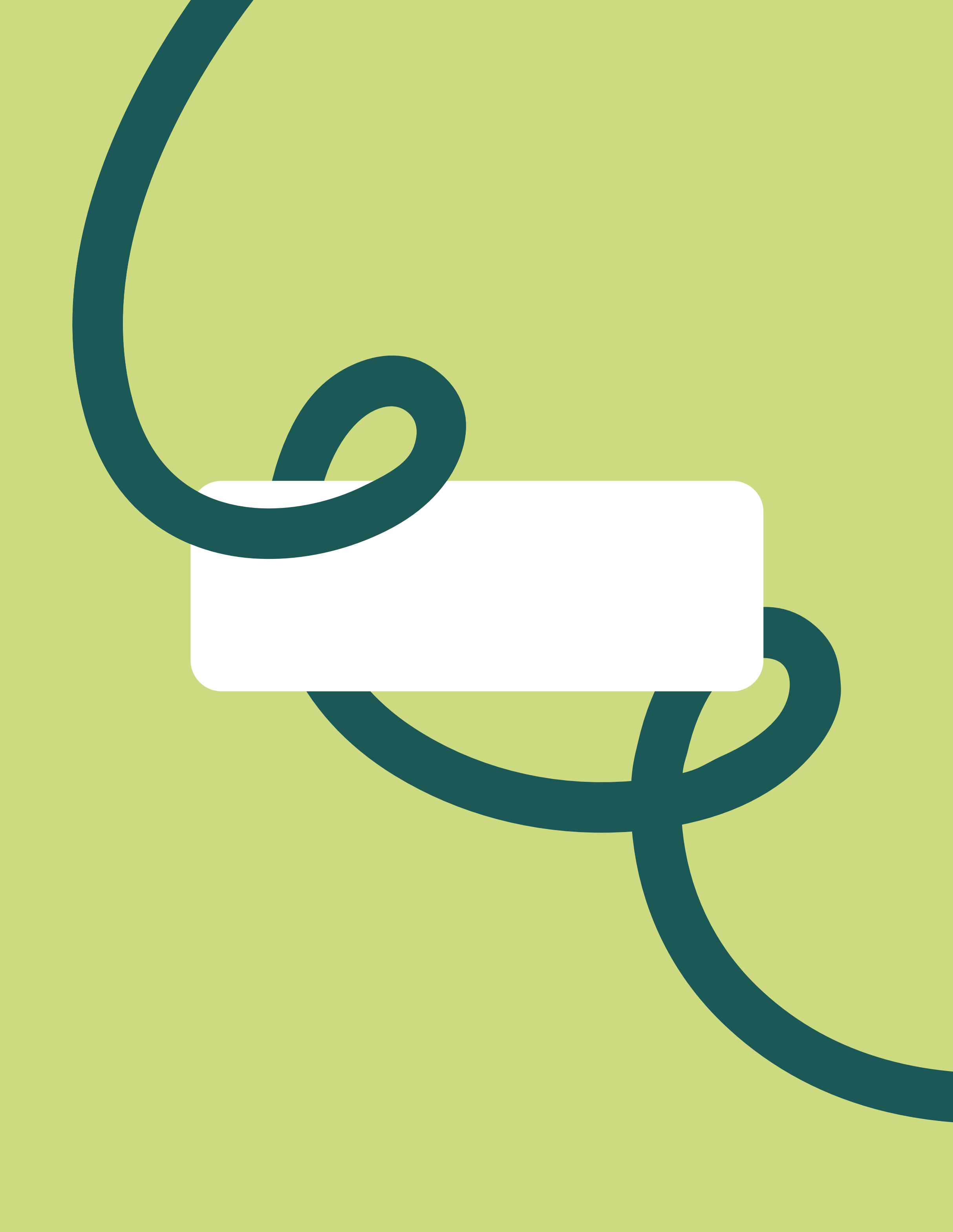


H.W

Number	Signed Repres.	1's Complement Repres	1's complement	2's complem. representat.	2's complement
43					
00101011	00101011	00101011	11010100	00101011	11010101
-34					
00100010	10100010	11011101	01011101	11011110	01011110

MULTIPLY

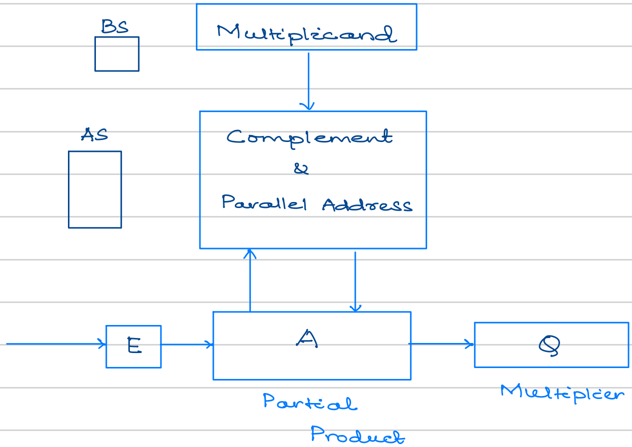
```
              1100110
            x 1010101
            ---------
              1100110
             0000000
            1100110
           0000000
          1100110
         0000000
        1100110
  -----------------
     10000111011110
```

Use of SHR & ASHR :-

101010

SHR - 010101

ASHR - 110101



Multiplicand	E	A	Q	SC
B = 101101				
	0	000000	111101	6
1) Qn=1 ADD B		101101		
		101101		
SHL EAQ	0	010110	111110	5
2) Qn=0 SHL EAQ		001011	011111	4
3) Qn = 1 Add B		101101		
	0	111000		
SHL EAQ		011100	001111	3
4) Qn= 1 Add B	1	101101		
		001001		
SHL EAQ		100100	100111	2
5) Qn=1 Add B		101101		
	1	010001		
SHL EAQ		101000	110011	1
6) Qn=1 Add B		101101		
	1	010101		
SHL EAQ		101010	111001	0

Multiplication of 2's Comp Data :-

Booth's Algorithm (to find magnitude)

11010110

← scan

* if you encounter a 1 substract the magnitude
* a 0 (prior to that there must be a 1) add the magnitude
* if there is a string of 1 ; no operation
* if there is a string of 0 ; no operation

$2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$ → magnitude

1) 1 1 0 1 0 1 1 0

$= -2^1 +$ (string of 1) $+ 2^3 - 2^4 + 2^5 - 2^6 +$ (string of 1)

$= -2 + 8 - 16 + 32 - 64$

$= -42$

7 6 5 4 3 2 1 0

2) 0 1 0 1 1 1 0 0

$= -2^2 + 2^5 - 2^6 + 2^7$

$= 92$

10	- Subtract
01	- Add
00	- NOP
11	- NOP

8 7 6 5 4 3 2 1 0

3) 1 1 1 0 0 0 1 1 1

$= -2^0 + 2^3 - 2^6$

$= -57$

4) 1 1 1 1 1 1

$= -2^0$

$= -1$

$\boxed{A - B = A + 2's \text{ comp of } B}$

Multiply 19 & −13.

19 → 10011

2's complement → $\boxed{010011}$

2	19 → 1
2	9 → 1
2	4 → 0
2	2 → 0
	1

−13 → 11101

2's complement → $\boxed{10011}$

$\overline{BR}$ → 101101 BR → 010011	Q_n	Q_{n+1}	AS	QR	Q_n Q_{n+1}	SC
1 Subtract BR or add $\overline{BR}+1$	1	0	000000	10011		5
			(+) 101101			
			101101			
ASHR ASQR			110110	11001	1	4
2 ASHR ASQR	1	1	111011	01100	1	3
3 Add BR	0	1	010011 (+)			
			001110			
			000111	00110	0	2
4 ASHR ASQR	0	0	000011	10011	0	1
5 Subtract BR or Add $\overline{BR}+1$	1	0	101101 (+)			
			110000			
ASHR ASQR			111000	01001	1	0

Result :- 11100001001

2 | 45 → 1
2 | 22 → 0
2 | 11 → 1
2 | 5 → 1
2 | 2 → 0
1

Multiply −45 × −39

−45 = 0101101

2's complement = 1010011

−39 = 0100111

2's complement = 1011001

$\overline{BR}$+1 → 0101101 BR → 1010011	Q_n	Q_{n+1}	AS	QR (Q_n)	Q_{n+1}	SC
1> Subtract BR (add $\overline{BR}$+1)	1	0	0000000	1011001	0	7
			−1010011			
ASHR ASQR			0101101			
			0010110	1101100	1	6
2> Add BR	0	1	1010011			
ASHR ASQR			1101001			
			1110100	1110110	0	5
3> ASHR ASQR	0	0	111101	0111011	0	4
4> Sub BR or add $\overline{BR}$+1	1	0	0101101			
			0100111			
ASHR ASQR			0010011	1011101	1	3
5> ASHR ASQR	1	1	0001001	1101110	1	2
6> Add BR	0	1	1010011			
			1011100			
ASHR ASQR			1101110	0110111	0	1
7> Sub BR (add $\overline{BR}$+1)	1	0	0101101			
			0011011			
ASHR ASQR			0001101	101101	1	0

0001101 101101 (Ans)

Division

(first check magnitude ; then borrow & do)

```
10001 | 0 1 1 1 0 0 0 0 0 0 | 11010
      | 0 1 1 1 0 0         |
  (-)     1 0 0 0 1
  -----------------
          0 1 0 1 1 0
  (-)       1 0 0 0 1
  -----------------
            0 0 1 0 1 0 0
  (-)           1 0 0 0 1
  -----------------
                0 0 0 1 1 0
```

11010 — quotient

000110 — remainder

if subtracted then write 1 in Q.
if taken an extra zero then write 0

2 types/methods

* Restoring

* Non Restoring

Restoring Division :-

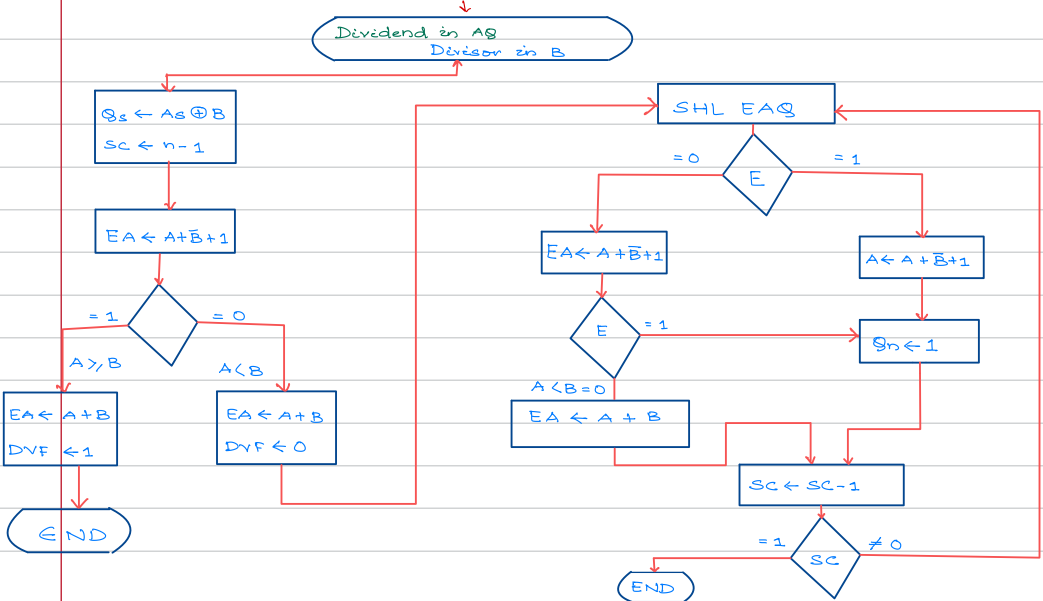
$\bar{B}+1 = 01111$ $B = 10001$	E	A	Q	SC
		01110	00000	5
1) SHL EAQ	0	11100	00000	
Subtract B		01111		
(add $\bar{B}+1$)	1	01011	00001	4
E=1 ; So $Q_n=1$				
2) SHL EAQ	0	10110	00010	
Subtract B		01111		
(add $\bar{B}+1$)	1	00101	00011	3
E=1; so $Q_n=1$				
4) SHL EAQ	0	01010	00110	
subtract B (add $\bar{B}+1$)		01111		
E=0; so $Q_n=0$		11001	00110	
restore A,		10001		
add B	1	01010		2
5) SHL EAQ	0	10100	01100	
subtract B		01111		
(add $\bar{B}+1$) E=1 ; $Q_n=1$	1	00011	01101	1
6) SHL EAQ	0	00110	11010	
sub B (add $\bar{B}+1$)		01111		
		10101	11010	
E=0; $Q_n=0$		10001		
restore A, add B	1	00110	11010	0
		↓ remainder	↓ quotient	

523 = 1000001011

Restoring Division :-

$\bar{B}+1 = 011110$ $B = 100010$	E	A	Q	SC
		100000	1011	4
1) SHL EAQ	1	000001		
(sub B or add $\bar{B}+1$)		011110	0110	
E = 1 ; Qn = 1		011111	0111	3
2) SHL EAQ	0	111110	1110	
(sub B or		011110		
add $\bar{B}+1$)	1	011100	1111	2
E = 1 ; Qn = 1				
3) SHL EAQ	0	111001	1110	
(sub B or		011110		
add $\bar{B}+1$)	1	010111	1111	1
E = 1 ; Qn = 1				
4) SHL EAQ	0	101111	1110	
(sub B or		011110		
add $\bar{B}+1$) E = 1 ; Qn = 1	1	001101	1111	0

DIVIDE OPERATION



Non-Restoring Division

SHL EAQ

E = ? ; E = 1 , Sub B

E = 1 , Add B

E = ? ; E = 0 , Qn = 0

E = 1 , Qn = 1

273 = 0100010001

3 : 01101

	E	A	Q	SC
1> SHL EAQ	0	0 1 0 0 0	1 0001	5
E = 0, Sub B		1 0 0 0 1	0 0010	
		1 0 0 1 1		
E = 1, Qn = 1	1	0 0 1 0 0	00011	4
2> SHL EAQ	0	0 1 0 0 0	00110	
		1 0 0 1 1		
E = 0, Qn = 0		1 1 0 1 1	0011 0	3
3> SHL EAQ	1	1 0 1 1 0	01100	
E = 1 , Qn = 1		0 1 1 0 1		
	1	0 0 0 1 1	0 1 1 0 1	2
4> SHL EAQ	0	0 0 1 1 0		
E = 0 , Sub B		1 0 0 1 1		
E = 0, Qn = 0		1 1 0 0 1	1 1 0 1 0	
5> SHL EAQ	1	1 0 0 1 1	1 0 1 0 0	1
E = 1 , ADDB		0 1 1 0 1		
E = 1 , Qn = 1	1	0 0 0 0 0	1 0 1 0 1	0

Divide 12/3 in restoring method.

B = 00011 $\overline{B}+1$ = 11101	E	A	Q	SC
		00000	1100	4
1) SHL EAQ	0	00001	1000	
sub B (Add $\overline{B}+1$)		(+) 11101		
E = 0 ; Q_n = 0		11110	1000	
Restore A, Add B		(+) 00011		
	1	00001		3
2) SHL EAQ	0	00011		
sub B (Add $\overline{B}+1$)		(+) 11101		
	1	00000	0001	2
E = 1 ; Q_n = 1				
3) SHL EAQ	0	00000	0010	
sub B (Add $\overline{B}+1$)		(+) 11101		
E = 0 ; Q_n = 0		11101	0010	
Restore A, Add B		(+) 00011		
	1	00000		1
4) SHL EAQ	0	00000	0100	
sub B (Add $\overline{B}+1$)		(+) 11101		
E = 0 , Q_n = 0		11101		
Restore A, Add B		00011		
	1	00000	0100	0

*imp If "E = 0" is in last step ; then Add B

Divide 12/3 in non restoring method.

B = 00011 $\overline{B}$+1 = 11101	E	A	Q	SC
		00000	1100	4
1) SHL EAQ	0	00001	1000	
E = 0 ; sub B or add $\overline{B}$+1		(+) 11101		
E = 0 ; Qn = 0		11110	1000	3
2) SHL EAQ	1	11101	0000	
E = 1 ; Add B or sub $\overline{B}$+1		(+) 00011		
E = 1 ; Qn = 1	1	00000	0001	2
3) SHL EAQ	0	00000	0010	1
E = 0 ; Sub B or add $\overline{B}$+1		(+) 11101		
E = 0 ; Qn = 0	0	11101	0010	
4) SHL EAQ	1	11010	0100	0
E = 1 ; Add B or sub $\overline{B}$+1		(+) 00011		
E = 0 ; Qn = 0	0	11101		
* E = 0 ; Add B		(+) 00011		
	1	00000	0100	

Ans → 000000100

Floating Point Nos

23.356×10^{21}

← 32 →		
	~~	
s		$2^{31}-1$

$\boxed{m \times I^{e}}$

M → Mantisa

e → exponent

I → base

eg:- $1101.101001 \times 2^{110101}$

110101
2 + 11
111000

Memory Representation

0	we can't store decimal. eg:- 1101.101001	110101
s	M^{32}	e

Normalization

m → normalized

1101 . 101001

↓

$1.101101001 \times 2^{111000}$

s	M	e
0	101101001	111000

Biasing

23.34×10^{6}

$+\ 28.62 \times 10^{4}$

we can't add like this ; so

23.34×10^{6}

0.2862×10^{6}

Any higher positive no which is added to make the no positive is biasing.

Very Imp

IEEE Standardization :-

↳ worldwide standardization

Single Precision Format (32 bit)

32 bits

S	E'	M
1	8	23

E' → biased / excessed

Value Representation

$\pm 1.M \times 2^{E' - Bias}$

$\pm 1.M \times 2^{E' - 127}$

Range of E' → 00000000 to 11111111

0 to 255

(0 & 255 are reserved)

E' = 1 to 254

Bias = 127

E = 1 − 127 to 254 − 127

= −126 to 127

Double Precision Format (64 bit)

64 bits

S	E'	M
1	11	52

E' → biased / excessed

Value Representation

$\pm 1.M \times 2^{E' - Bias}$

$\pm 1.M \times 2^{E' - 1023}$

Range of E' → 0 to 2047

(0 & 2047 are reserved)

E' = 1 to 2046

Bias = 1023

E = −1022 to 1023

Special Values

E'	M	
0	0	→ exact 0
255	0	→ infinity ∞
0	non zero	→ Denormal number
255	non zero	→ NAN (not a number)

Q1)

S	e'	M
1	10101010	1101010

$$= -1.1101010 \times 2^{10101010 - 01111111}$$

$$= -1.1101010 \times 2^{00101011}$$

Q2) $101.10101 \times 2^{1100110}$

$$\begin{array}{r} 1100110 \\ (+) \quad 10 \\ \hline 1101000 \end{array}$$

1.0110101×2

$2 \rightarrow 10$

↳ bcoz shifted 2 places

$1.0110101 \times 2^{1101000 + 1111111}$