DIVISION TUTORIAL

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1.) Given Dividend = 11 and Divisor = 3, what will be values of Q and A at the end of 3rd iteration for following

1.) Restoring Division Method
2.) Non-Restoring Division Method

1.) 1.) Restoring Division Method

Dividend = Q = $(11)_{10}$ = $(1011)_2$

Divisor = B = $(3)_{10}$ = $(00011)_2$

A = $(00000)_2$

n = 4 iterations

complement of B ⇒ B-minus = $(11101)_2$

Steps	A	Q
	00000	1011
1. Shift Left AQ	00001	011 □
A = A-B	00001 + 11101 = 11110	011 □
A<0 then A = A+B, q_0 = 0	11110 + 00011 = [1] 00001 (1 ↓ neglect)	011 [0] (q_0 = 0)

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	00001	0110
2.)		
Shift Left A, Q	00010	1100
A = A-B	00010	
	+ 11101	
	11111	1100
A<0 then		
A = A+B	+ 00011	
$Q_0 = 1$	11 00010	1100
	neglect	
	00010	1100
3.)		
Shift Left A, Q	00101	100
A = A-B	00101	
	+ 11101	
	1 00010	
	neg. 00010	100
Ans: A>0		
$Q_0 = 1$	00010	1001
4.)		
Shift Left A, Q	00101	001
A = A-B	00101	
	+ 11101	
	1 00010	001
A>0		
$Q_0 = 1$	00010	0011

Ans: After 3rd iteration, Value of Q = $(1001)_2 = (9)_{10}$

Value of A = $(00010)_2 = (2)_{10}$

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2.> Non Restoring Method

Dividend = Q = $(1011)_2$

B = $(00011)_2$

-B = $(11101)_2$

A = $(00000)_2$ n = 4

Steps	A	Q
1.)	00000	1011
Shift Left A, Q	00001	011 □
A > 0 then		
A = A - B	0008 1 (1)	
	+ 11101	
	11110	011 □
A < 0		
$Q_0 = 0$	11110	0110
2.)		
Shift Left	11100	110 □
A < 0 then	11100	
A = A + B	+ 00011	
	11111	110 □
A < 0 then		
$Q_0 = 0$	11111	110 [0]
3.)		
Shift Left	11111	100 □
A < 0 then	(1) 11111 (0)(0)(0)	
A = A + B	+ 00011	
	00010	100 □
A > 0 then		
$Q_0 = 1$	00010	100 [1]

4.)

Shift Left	00101	001 □
A>0 then	① ① ① 00101	
A=A-B	+ 11101	
	Ⓧ 00010 (neglect)	001 □
A>0 then	00010	0011
$Q_0 = 1$		

After 3rd iteration value of ~~Q~~ ~~and~~ ~~A~~ $Q = (1001)_2 = (9)_{10}$

$A = (00010)_2 = (2)_{10}$

2> What will be the values of Quotient and Remainder of following cases?

1.> $-12/3$ using Restoring Division

Neglect sign of Decimal Number

Divident = $Q = (12)_{10} = (1100)_2$

Divisor = $B = (3)_{10} = (00011)_2$

$A = (00000)_2$

$-B = (11101)_2$ [n = 4]

	A	Q
1.)	00000	1100
Shift Left	00001	100 □
A = A-B	① 00001	
	+ 11101	
	11110	100 □
A<0 then	① ① ① 11110	
A = A+B	+ 00011	
$Q_0 = 0$	Ⓧ 00001 (neglect)	100 0

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2.)	00001	1000
Shift left	00011	000 □
	(Dis) (A)	
A = A - B	00011	
	+ 11101	
	~~1~~ 00000	000 □
A ≥ 0 then		
$Q_0 = 1$	00000	000 [1]
3.)		
Shift left	00000	001 □
A = A - B	00000	
	11101	
	11101	001 □
A < 0 then		
A = A + B	11101	
$Q_0 = 0$	+ 00011	
	~~1~~ 00000	001 [0]
4.)		
Shift left	00000	010 □
A = A - B	00000	
	+ 11101	
	11101	010 □
A < 0 then	11101	
A = A + B	+ 00011	
$Q_0 = 0$	~~1~~ 00000	010 [0]

R = 00000 Q = 0100

Ans: [R = 0 Q = -4] [After doing sign correction]

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2> 12/-3 using Non-Restoring Division

Neglect sign of Decimal number

Dividend = Q = $(12)_{10}$ = $(1100)_2$ Divisor = B = $(3)_{10}$ = $(00011)_2$

-B = $(11101)_2$ A = $(00000)_2$ n = 4

	A	Q
1.)	00000	1100
Shift Left	0000 1	100 □
A > 0 then	①	
A = A - B	0000 1	
	+ 1 1 1 0 1	
	1 1 1 1 0	100 □
A < 0 then		
$Q_0 = 0$	1 1 1 1 0	100 0
2.)		
Shift Left	1 1 1 0 1	000 □
A < 0 then	① ① ① ①	
A = A + B	1 1 1 0 1	
	+ 0 0 0 1 1	
	✗ 0 0 0 0 0	000 □
	neglect	
A ≥ 0 then		
$Q_0 = 1$	0 0 0 0 0	000 1
3.)		
Shift Left	0 0 0 0 0	001 □
A ≥ 0 then	0 0 0 0 0	
A = A - B	- 1 1 1 0 1	
	1 1 1 0 1	001 □
A < 0 then		
$Q_0 = 0$	1 1 1 0 1	001 0

4)

Shift Left	\11010	010 □
A<0 then A = A+B	11010 + 00011 11101	010 □
A<0 then $Q_0 = 0$	11101	010 0
if A<0 then A = A+B	①①①① ① 11101 + 00011 \ 00000	0100

R = 00000 Q = 0100

We know if divident or divisor negative then Q will be negative.

R = 0 Q = -4

3.) Justify the statement with proper reasoning "Non-Restoring Division method is faster than Restoring Division method"

3.) In each step of division calculation the result of the step is either 1 or 0, depending if dividend is less than / larger than divisor

You generally do a test subtraction for each step (quotient)

if result is positive or zero : ⇒ note down 1 as next digit of ~~quo~~

if result is negative : ⇒ Proceed with one of two strategies : (digit)

Restoring Method: We add the divisor back, and put 0 as next quotient

Non-Restoring Method : We keep negative remainder, and a digit 1 and basically correct things by a supplementary addition afterwards.

Non-Restoring is faster (max "n+1" steps for n digits) whereas restoring method (which is more natural needs up to 2n-1 steps). So,

Non-Restoring is faster than Restoring Method.