CHAP 09
Computers Arithmetic

ALU (Arithmetic and Logic Unit) –

→ does calculations

→ Handles integers, may handle floating point num,

→ May be separate FPU (math's coprocessor)

→ May be on chip separate FPU

☐ Integers Representation – no sign, no period

41 → 00101001

☐ Sign-Magnitude – left most bit is sign bit → 0 (positive), 1 (-tive)

+18 → 00010010

-18 → 10010010

Problem → need to consider sign, magnitude in arithmetic

→ two representation of 0

Subject:.....

Date :.....

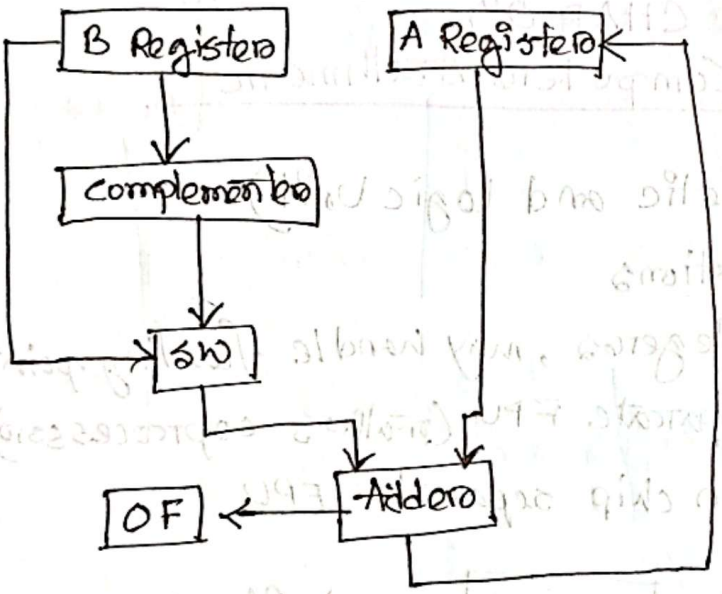
+0 → 0000 0000

-0 → 1000 0000

Two's Complement

+3 → 0000 0011	+0 → 0000 0000
-3 → 1111 1101	-0 → 0000 0000

Hardware for addition



a - b
= a + (-b)

Multiplication – complex

```
  1011   Multiplicand (11)
 x1101   Multiplier (13)
 ------
  1011   }
 0000    } Partial Product
1011     }
1011
(sum) 10001111   (143 = 11x13)
```

Multiplication of Unsigned Binary Integers

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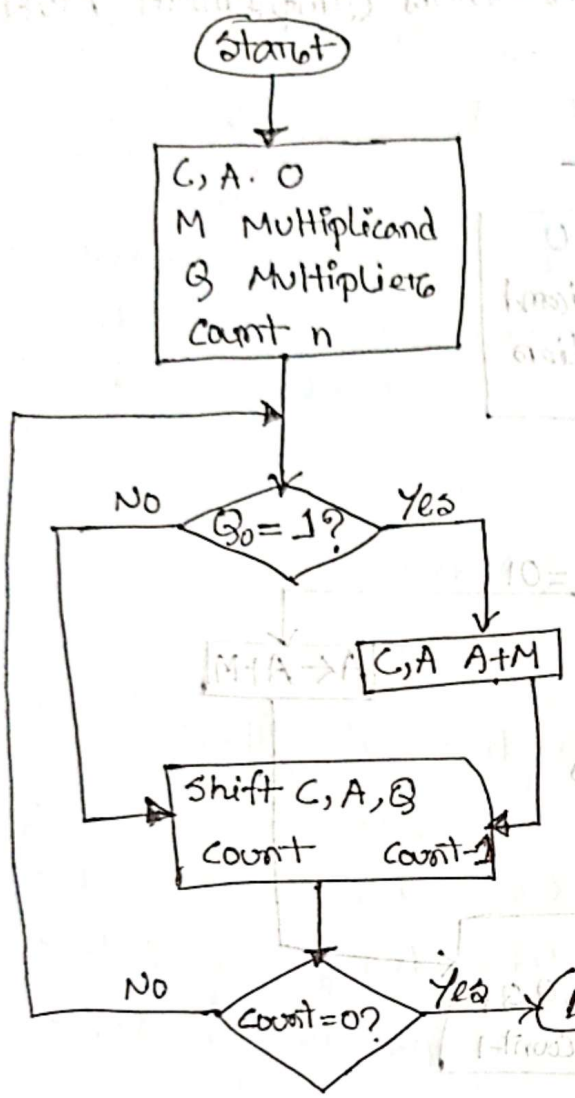
Flowchart for unsigned Binary Multiplication



C	A	Q	Q_0	M	
0	0000	1101		1011	
0	1011	1101		1011	ADD
0	0101	1110		1011	SHIFT
0	0010	1111		1011	SHIFT (Q_0=0)
0	1101	1111		1011	ADD (A+M)
0	0110	1111		1011	SHIFT
1	0001	1111		1011	ADD
0	1000	1111		1011	SHIFT

(7×3)

	A	Q	Q_{-1}	M	
	0000	0011	0	0111	Q_0Q_{-1}
	1001	0011	0	0111	(10)
	1100	1001	1	0111	
	1110	0100	1	0111	
A+M	0101	0100	1	0111	
	0010	1010	0	0111	
	0001	0101	0	0111	

$Q_0, Q_{-1} \rightarrow 10$ ($A \leftarrow A-M$)

$\rightarrow 01$ ($A \leftarrow A+M$)

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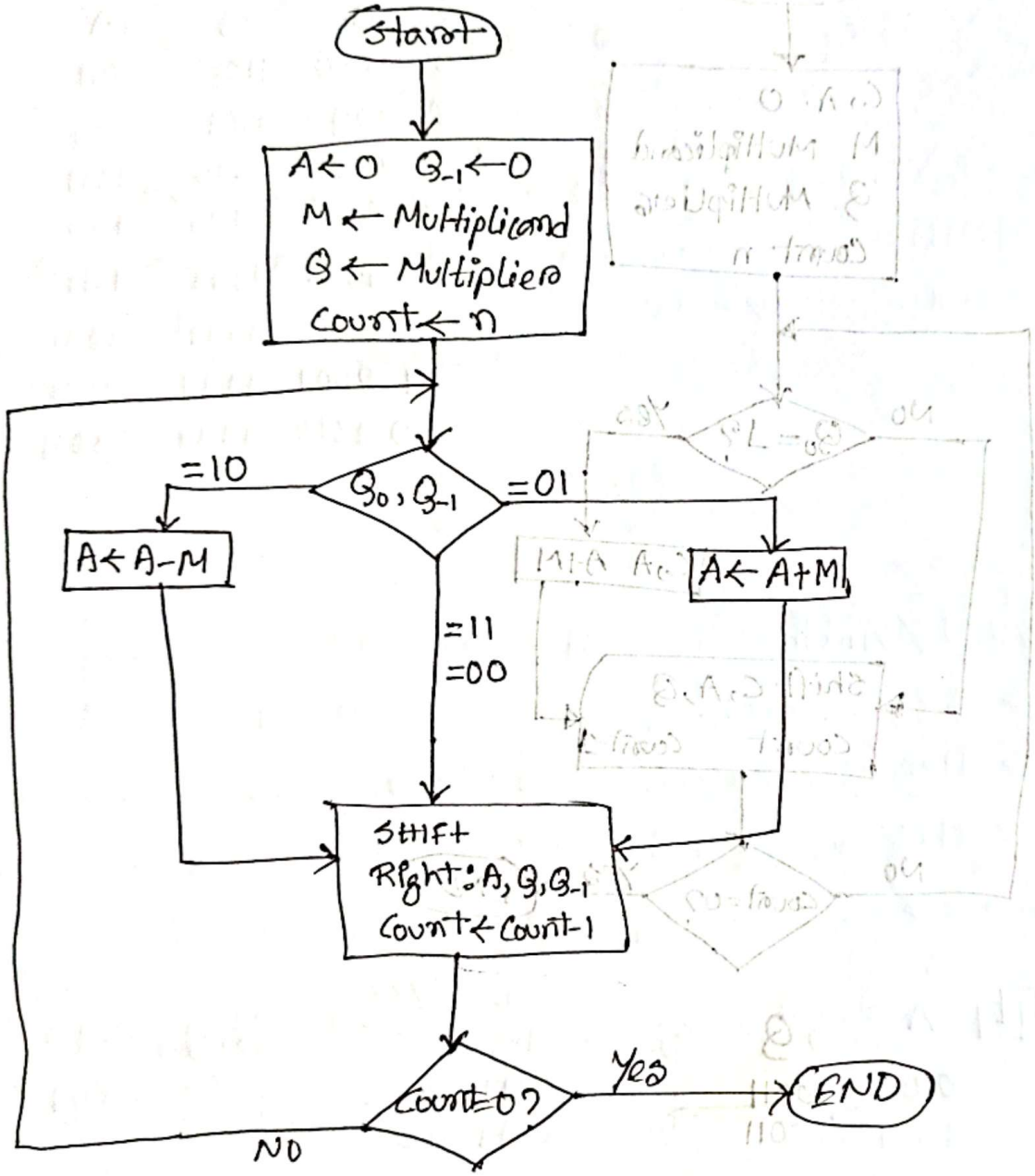
Booth's Algorithm for Two Complement Multiplication

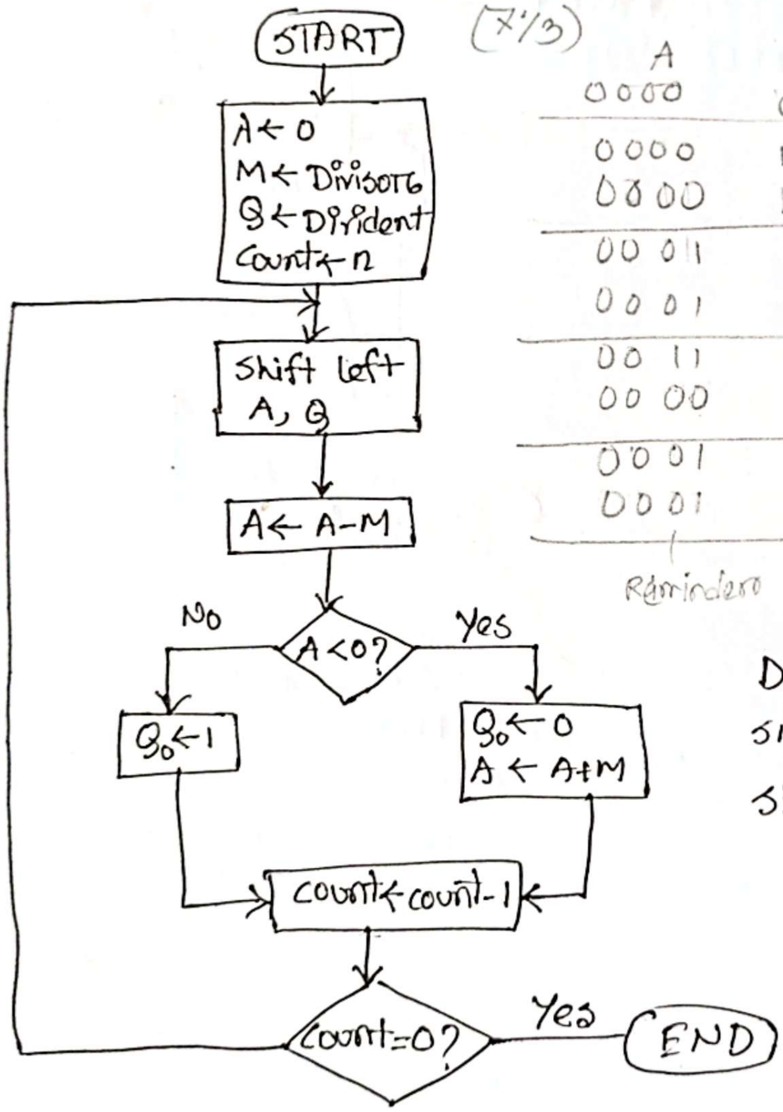


Subject:

Date:

□ Division

```
                 00001101   <---------- Quotient
Divisor --> 1011|10010011  <---------- Divident
                 .1011
                 001110  <------+----- Partial Reminder
                   1011         |
                   001111 <-----+
                     1011
                     0100  <---------- Remainder
```



(X/3)

M ← 0011
1101 (2's com)

A	Q	
0000	0111	
0000	1110	A−M=1101
0000	1110	A ← previous
0011	1100	
0001	1100	
0011	1000	
0000	1001	
0001	0010	
0001	0010	
Reminder	Quotient	

$D = Q \times V + R$

$sign(R) = sign(D)$

$sign(Q) = sign(D) \times sign(V)$