Experiment No. 7
Implement Booth's algorithm using c-programming
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Date of Performance:
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Aim: To implement Booth's algorithm using c-programming.

Objective -

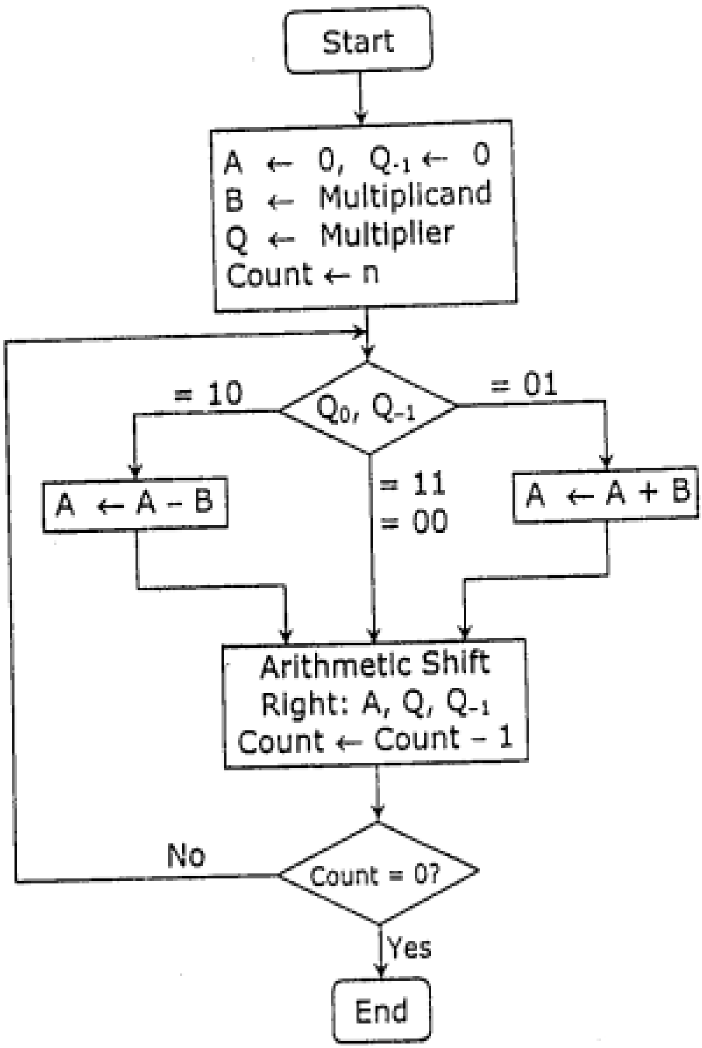
1. To understand the working of Booth's algorithm.
2. To understand how to implement Booth's algorithm using c-programming.

Theory:

Booth's algorithm is a multiplication algorithm that multiplies two signed binary numbers in 2's complement notation. Booth used desk calculators that were faster at shifting than adding and created the algorithm to increase their speed.

The algorithm works as per the following conditions :

1. If Qn and Q_{-1} are same i.e. 00 or 11 perform arithmetic shift by 1 bit.
2. If Qn Q_{-1} = 10 do A= A - B and perform an arithmetic shift by 1 bit.
3. If Qn Q_{-1} = 01 do A= A + B and perform arithmetic shift by 1 bit.



Multiplicand (B) ← 0 1 0 1 (5), Multiplier (Q) ← 0 1 0 0 (4)				
Steps	A	Q	Q_{-1}	Operation
	0 0 0 0	0 1 0 0	0	Initial
Step 1 :	0 0 0 0	0 0 1 0	0	Shift right
Step 2 :	0 0 0 0	0 0 0 1	0	Shift right
Step 3 :	1 0 1 1	0 0 0 1	0	A ← A – B
	1 1 0 1	1 0 0 0	1	Shift right
Step 4 :	0 0 1 0	1 0 0 0	1	A ← A + B
	0 0 0 1	0 1 0 0	0	Shift right
Result	0 0 0 1 0 1 0 0 = +20			

Program:

```
#include <stdio.h>

#include <math.h>

 int a = 0,b = 0, c = 0, a1 = 0, b1 = 0, com[5] = { 1, 0, 0, 0, 0};

int anum[5] = {0}, anumcp[5] = {0}, bnum[5] = {0};

int acomp[5] = {0}, bcomp[5] = {0}, pro[5] = {0}, res[5] = {0};


void binary(){

    a1 = fabs(a);

    b1 = fabs(b);

    int r, r2, i, temp;

    for (i = 0; i < 5; i++){

        r = a1 % 2;

        a1 = a1 / 2;

        r2 = b1 % 2;

        b1 = b1 / 2;

        anum[i] = r;

        anumcp[i] = r;

        bnum[i] = r2;

        if(r2 == 0){

            bcomp[i] = 1;

        }

        if(r == 0){

            acomp[i] =1;

        }

    }
```

```
//part for two's complementing
c = 0;
for ( i = 0; i < 5; i++){
        res[i] = com[i]+ bcomp[i] + c;
        if(res[i] >= 2){
             c = 1;
        }
        else
             c = 0;
        res[i] = res[i] % 2;
  }
for (i = 4; i >= 0; i--){
  bcomp[i] = res[i];
}
//in case of negative inputs
if (a < 0){
   c = 0;
  for (i = 4; i >= 0; i--){
        res[i] = 0;
  }
  for ( i = 0; i < 5; i++){
        res[i] = com[i] + acomp[i] + c;
        if (res[i] >= 2){
             c = 1;
        }
```

```
        else
            c = 0;
        res[i] = res[i]%2;
    }
    for (i = 4; i >= 0; i--){
        anum[i] = res[i];
        anumcp[i] = res[i];
    }


  }
  if(b < 0){
    for (i = 0; i < 5; i++){
        temp = bnum[i];
        bnum[i] = bcomp[i];
        bcomp[i] = temp;
    }
  }
}
void add(int num[]){
   int i;
   c = 0;
   for ( i = 0; i < 5; i++){
        res[i] = pro[i] + num[i] + c;
        if (res[i] >= 2){
            c = 1;
```

```
        }
        else{
            c = 0;
        }
        res[i] = res[i]%2;
    }
    for (i = 4; i >= 0; i--){
        pro[i] = res[i];
        printf("%d",pro[i]);
    }
  printf(":");
  for (i = 4; i >= 0; i--){
        printf("%d", anumcp[i]);
    }
}
void arshift(){//for arithmetic shift right
   int temp = pro[4], temp2 = pro[0], i;
   for (i = 1; i < 5  ; i++){//shift the MSB of product
      pro[i-1] = pro[i];
   }
   pro[4] = temp;
   for (i = 1; i < 5  ; i++){//shift the LSB of product
      anumcp[i-1] = anumcp[i];
   }
   anumcp[4] = temp2;
```

```
    printf("\nAR-SHIFT: ");//display together
    for (i = 4; i >= 0; i--){
        printf("%d",pro[i]);
    }
    printf(":");
    for(i = 4; i >= 0; i--){
        printf("%d", anumcp[i]);
    }
}

void main(){
   int i, q = 0;
   printf("\t\tBOOTH'S MULTIPLICATION ALGORITHM");
   printf("\nEnter two numbers to multiply: ");
   printf("\nBoth must be less than 16");
   //simulating for two numbers each below 16
   do{
        printf("\nEnter A: ");
        scanf("%d",&a);
        printf("Enter B: ");
        scanf("%d", &b);
    }while(a >=16 || b >=16);

    printf("\nExpected product = %d", a * b);
    binary();
```

```
printf("\n\nBinary Equivalents are: ");
printf("\nA = ");
for (i = 4; i >= 0; i--){
  printf("%d", anum[i]);
}
printf("\nB = ");
for (i = 4; i >= 0; i--){
  printf("%d", bnum[i]);
}
printf("\nB'+ 1 = ");
for (i = 4; i >= 0; i--){
  printf("%d", bcomp[i]);
}
printf("\n\n");
for (i = 0;i < 5; i++){
    if (anum[i] == q){//just shift for 00 or 11
      printf("\n-->");
      arshift();
      q = anum[i];
    }
    else if(anum[i] == 1 && q == 0){//subtract and shift for 10
      printf("\n-->");
      printf("\nSUB B: ");
      add(bcomp);//add two's complement to implement subtraction
      arshift();
```

```
            q = anum[i];
        }
        else{//add ans shift for 01
            printf("\n-->");
            printf("\nADD B: ");
            add(bnum);
            arshift();
            q = anum[i];
        }
    }

    printf("\nProduct is = ");
    for (i = 4; i >= 0; i--){
        printf("%d", pro[i]);
    }
    for (i = 4; i >= 0; i--){
        printf("%d", anumcp[i]);
    }
}
```

Output:

```
Terminal
BOOTH'S MULTIPLICATION ALGORITHM
Enter two numbers to multiply:
Both must be less than 16
Enter A: 10
Enter B: 05
Expected product = 50

Binary Equivalents are:
A = 01010
B = 00101
B'+ 1 = 11011



-->
AR-SHIFT: 00000:00101
-->
SUB B: 11011:00101
AR-SHIFT: 11101:10010
-->
ADD B: 00010:10010
AR-SHIFT: 00001:01001
-->
SUB B: 11100:01001
AR-SHIFT: 11110:00100
-->
ADD B: 00011:00100
AR-SHIFT: 00001:10010
Product is = 0000110010
```

Conclusion -

In conclusion, this experiment successfully implemented Booth's multiplication algorithm using C programming. Booth's algorithm is an efficient method for multiplying signed binary numbers in 2's complement notation, known for its speed in comparison to traditional multiplication techniques. The C program efficiently emulated the algorithm's steps, including arithmetic shifting, addition, and subtraction based on the binary inputs. By analysing the binary representations of the numbers and correctly applying the algorithm, the program generated the expected product of the given input numbers. This experiment deepened our understanding of Booth's algorithm, its practical implementation, and its role in optimising the multiplication of binary numbers in digital computing.