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

Objective -

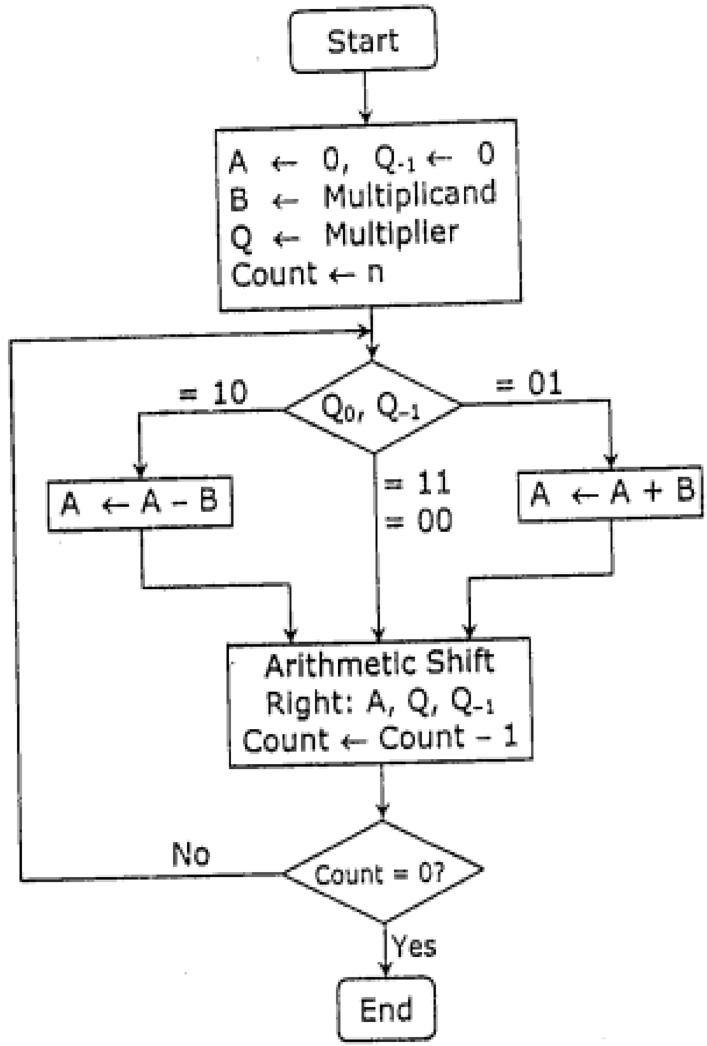
1. To understand the working of Booths algorithm.
2. To understand how to implement Booth's algorithm using c-programming.

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 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 -

The Booth's algorithm experiment underscored its pivotal role in streamlining binary multiplication. This algorithm effectively decreases the count of partial products and trims down the overall operation count for multiplication. This leads to improved computational speed and reduced hardware intricacy. Booth's algorithm is a potent asset for optimizing multiplication procedures, constituting a fundamental concept in digital arithmetic. Our experiment successfully showcased its practical relevance in both computer architecture and digital circuit design.