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

Objective -

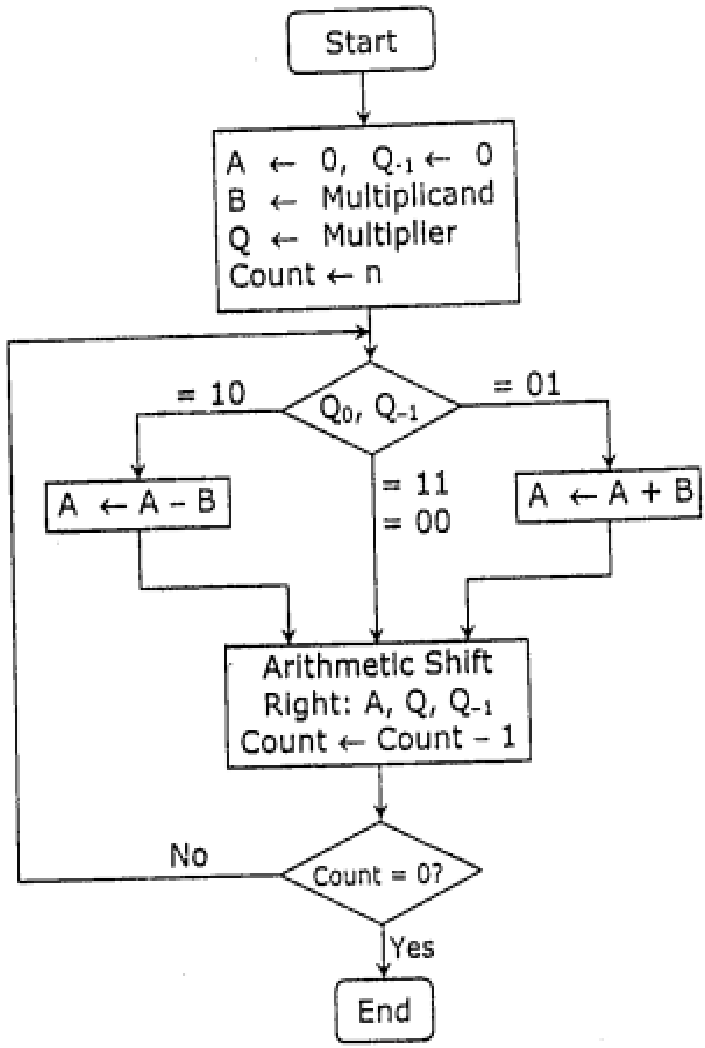
1. To understand the working of Booths algorithm.
2. To understand how to implement Booth's algorithm using c-programming.

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;
}
}
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];
}
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(){
int temp = pro[4], temp2 = pro[0], i;
for (i = 1; i < 5 ; i++){
pro[i-1] = pro[i];
}
pro[4] = temp;
for (i = 1; i < 5 ; i++){
anumcp[i-1] = anumcp[i];
}
anumcp[4] = temp2;
printf("\nAR-SHIFT: ");
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){
printf("\n-->");
arshift();
q = anum[i];
}
else if(anum[i] == 1 && q == 0){
printf("\n-->");
printf("\nSUB B: ");
add(bcomp);
arshift();
q = anum[i];
}
else{
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:
BOOTH'S MULTIPLICATION ALGORITHM

Enter two numbers to multiply:
Both must be less than 16
Enter A: -7
Enter B: -10

Expected product = 70

Binary Equivalents are:
A = 11001
B = 10110
B'+ 1 = 01010

```
-->
SUB B: 01010:11001
AR-SHIFT: 00101:01100
-->
ADD B: 11011:01100
AR-SHIFT: 11101:10110
-->
AR-SHIFT: 11110:11011
-->
SUB B: 01000:11011
AR-SHIFT: 00100:01101
-->
AR-SHIFT: 00010:00110
Product is = 0001000110
```

Conclusion -

This experiment successfully implemented Booth's algorithm using C programming, demonstrating its efficiency in multiplying two signed binary numbers in 2's complement form. By following the algorithm's conditions for different values of Qn and Q-1, it handled both positive and negative numbers effectively. The program carried out the necessary arithmetic operations (addition and subtraction) and performed the required bit shifts. Booth's algorithm was validated as an efficient method for multiplication, reducing the number of required operations compared to standard multiplication techniques, especially in the case of large numbers.