Nested Loops

Printing a 2-D Figure

How would you print the following diagram?

repeat 3 times

print a row of 5 stars

repeat 5 times

print *

It seems as if a loop within a loop is needed.

Nested Loop

```
#define ROWS    3
#define COLS    5
…
row = 1;
while ( row  <=  ROWS ) {
   /* print a row of 5 *'s */
      …
   row =  row + 1;
}
```


Nested Loop

```
row = 1;
while ( row  <=  ROWS ) {
   /* print a row of 5 *'s */
   col = 1;
   while (col <= COLS) {
      printf("*");
      col = col + 1;
   }
   printf( "\n" );
   row =  row + 1;
}
```

outer loop: print 3 rows

inner loop: print one row

Trace

row:

col:

output:

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
       col = 1;
       while (col <= COLS) {
          printf("*");
          col = col + 1;
       }
       printf( "\n" );
       row =  row + 1;
}
```


Trace

row: 1

col:

output:

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
       col = 1;
       while (col <= COLS) {
          printf("*");
          col = col + 1;
       }
       printf( "\n" );
       row =  row + 1;
}
```

Trace

row: 1

col: 1

output:

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
       col = 1;
       while (col <= COLS) {
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          col = col + 1;
       }
      printf( "\n" );
      row =  row + 1;
}
```


Trace

row: 1

col: 1

output: *

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
       col = 1;
       while (col <= COLS) {
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          col = col + 1;
       }
      printf( "\n" );
      row =  row + 1;
}
```

Trace

row: 1

col: 1 2

output: *

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row = 1;
while ( row  <=  ROWS ) {
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Trace

row: 1

col: 1 2

output: * *

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row = 1;
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       }
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}
```

Trace

row: 1

col: 1 2 3

output: * *

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row = 1;
while ( row  <=  ROWS ) {
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       col = 1;
       while (col <= COLS) {
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       }
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      row =  row + 1;
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```


Trace

row: 1

col: 1 2 3

output: * * *

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row = 1;
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       }
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      row =  row + 1;
}
```

Trace

row: 1

col: 1 2 3 4

output: * * *

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row = 1;
while ( row  <=  ROWS ) {
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Trace

row: 1

col: 1 2 3 4

output: * * * *

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Trace

row: 1

col: 1 2 3 4 5

output: * * * *

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row = 1;
while ( row  <=  ROWS ) {
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row: 1

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Trace

row: 1

col: 1 2 3 4 5 6

output: * * * * *

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row = 1;
while ( row  <=  ROWS ) {
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       while (col <= COLS) {
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Trace

row: 1 2

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output: * * * * *

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row: 1 2

col: 1 2 3 4 5 6 1

output: * * * * *

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Trace

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col: 1 2 3 4 5 6 1

output: * * * * *
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Trace

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col: 1 2 3 4 5 6 1 2

output: * * * * *
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Trace

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col: 1 2 3 4 5 6 1 2

output: * * * * *
* *

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       }
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}
```

Trace

row: 1 2

col: 1 2 3 4 5 6 1 2 3

output:
```
* * * * *
* *
```

```
row = 1;
while ( row  <=  ROWS ) {
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Trace

row: 1 2

col: 1 2 3 4 5 6 1 2 3

output:
```
* * * * *
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Trace

row: 1 2

col: 1 2 3 4 5 6 1 2 3 4

output:
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* * * * *
* * *
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Trace

row: 1 2

col: 1 2 3 4 5 6 1 2 3 4

output:
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}
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Trace

row: 1 2

col: 1 2 3 4 5 6 1 2 3 4 5

output:

```
* * * * *
* * * *
```

```
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}
```


Trace

row: 1 2

col: 1 2 3 4 5 6 1 2 3 4 5

output:

```
* * * * *
* * * * *
```

```
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Trace

row: 1 2

col: 1 2 3 4 5 6 1 2 3 4 5 6

output:

```
* * * * *
* * * * *
```

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Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6

output:

```
* * * * *
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Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1

output:

```
* * * * *
* * * * *
```

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Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1

output:

```
* * * * *
* * * * *
*
```

```
row = 1;
while ( row  <=  ROWS ) {
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      col = 1;
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         col = col + 1;
      }
      printf( "\n" );
      row =  row + 1;
}
```

Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1 2

output:

```
* * * * *
* * * * *
*
```

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
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      }
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```


Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1 2

output:

```
* * * * *
* * * * *
* *
```

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
      col = 1;
      while (col <= COLS) {
         printf("*");
         col = col + 1;
      }
      printf( "\n" );
      row =  row + 1;
}
```

Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3

output:

```
* * * * *
* * * * *
* *
```

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
      col = 1;
      while (col <= COLS) {
         printf("*");
         col = col + 1;
      }
      printf( "\n" );
      row =  row + 1;
}
```


Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3

output:

```
* * * * *
* * * * *
* * *
```

```
row = 1;
while ( row  <=  ROWS ) {
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      col = 1;
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      }
      printf( "\n" );
      row =  row + 1;
}
```

Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4

output:

```
* * * * *
* * * * *
* * *
```

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
      col = 1;
      while (col <= COLS) {
         printf("*");
         col = col + 1;
      }
      printf( "\n" );
      row =  row + 1;
}
```


Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4

output:

```
* * * * *
* * * * *
* * * *
```

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
      col = 1;
      while (col <= COLS) {
         printf("*");
         col = col + 1;
      }
      printf( "\n" );
      row =  row + 1;
}
```

Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5

output:

```
* * * * *
* * * * *
* * * *
```

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
      col = 1;
      while (col <= COLS) {
         printf("*");
         col = col + 1;
      }
      printf( "\n" );
      row =  row + 1;
}
```


Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5

output:

```
* * * * *
* * * * *
* * * * *
```

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
      col = 1;
      while (col <= COLS) {
         printf("*");
         col = col + 1;
      }
      printf( "\n" );
      row =  row + 1;
}
```

Trace

row: 1 2 3

col: 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6

output:

```
* * * * *
* * * * *
* * * * *
```

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row = 1;
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      col = 1;
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         col = col + 1;
      }
      printf( "\n" );
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}
```


Trace

row: 1 2 3 4

col: 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6

output:

```
* * * * *
* * * * *
* * * * *
```

```
row = 1;
while ( row  <=  ROWS ) {
    /* print a row of 5 *'s */
      col = 1;
      while (col <= COLS) {
         printf("*");
         col = col + 1;
      }
      printf( "\n" );
      row =  row + 1;
}
```

Print a Multiplication Table

	1	2	3
1	1	2	3
2	2	4	6
3	3	6	9
4	4	8	12

Print a Multiplication Table

	1	2	3
1	1	2	3
2	2	4	6
3	3	6	9
4	4	8	12

	1	2	3
1	1 * 1	1 * 2	1 * 3
2	2 * 1	2 * 2	2 * 3
3	3 * 1	3 * 2	3 * 3
4	4 * 1	4 * 2	4 * 3

	1	2	3
1	1	2	3
2	2	4	6
3	3	6	9
4	4	8	12

Print Row 2

```
col = 1;
while (col <= 3) {
    printf("%4d", 2 * col );
    col = col + 1;
}
printf("\n");
```

row number

Nested Loops

Print 4 rows

Print one row

```
row = 1;
while (row <= 4)  {
    col = 1;
    while (col <= 3) {
        printf("%4d",  row  * col );
        col = col + 1;
    }
    printf("\n");
    row = row + 1;
}
```

Loop Trace

row	col	
1	1	print 1
	2	print 2
	3	print 3
		print \n
2	1	print 2
	2	print 4
	3	print 6
		print \n

Loop Trace

row	col	
1	1	print 1
	2	print 2
	3	print 3
		print \n
2	1	print 2
	2	print 4
	3	print 6
		print \n

row	col	
3	1	print 3
	2	print 6
	3	print 9
		print \n
4	1	print 4
	2	print 8
	3	print 12
		print \n

Counting in *for* Loops

```
/* Print n asterisks */
for ( count = 1 ; count <= n ;  count = count + 1 ) {
    printf ( "*" ) ;
}
```


Counting in *for* Loops

```
/* Print n asterisks */
for ( count = 1 ; count <= n ;  count = count + 1 ) {
    printf ( "*" ) ;
}
```

```
/* Different style of counting */
for (  count = 0 ; count < n ;  count = count + 1 ) {
    printf ( "*" );
}
```

"3 Rows of 5" as a Nested *for* Loop

```
#define ROWS    3
#define COLS    5
...
for ( row = 1;  row  <=  ROWS ;  row =  row + 1 ) {
    for ( col = 1 ;  col <= COLS ;  col = col + 1 ) {
        printf( "*" );
    }
    printf( "\n" );
}
```

inner loop: print one row

outer loop: print 3 rows


```
1.  /*
2.   * Illustrates a pair of nested counting loops
3.   */
4.
5.  #include <stdio.h>
6.
7.  int
8.  main(void)
9.  {
10.       int i, j;    /* loop control variables */
11.
12.       printf("            I    J\n");            /* prints column labels          */
13.
14.       for  (i = 1;  i < 4;  ++i) {               /* heading of outer for loop     */
15.           printf("Outer %6d\n", i);
16.           for  (j = 0;  j < i;  ++j) {           /* heading of inner loop         */
17.               printf("  Inner%9d\n", j);
18.           }   /* end of inner loop */
19.       }   /*  end of outer loop */
20.
21.       return (0);
22. }
```

```
            I   J
Outer       1
  Inner         0
Outer       2
  Inner         0
  Inner         1
Outer       3
  Inner         0
  Inner         1
  Inner         2
```

```
#define SENTINEL   0
#define NUM_MONTHS 12

int
main(void)
{
        int month,      /* number of month being processed              */
            mem_sight,  /* one member's sightings for this month        */
            sightings;  /* total sightings so far for this month        */

        printf("BALD EAGLE SIGHTINGS\n");
        for (month = 1;
             month <= NUM_MONTHS;
             ++month) {
            sightings = 0;
            scanf("%d", &mem_sight);
            while (mem_sight != SENTINEL) {
                if (mem_sight >= 0)
                    sightings += mem_sight;
                else
                    printf("Warning, negative count %d ignored\n",
                           mem_sight);
                scanf("%d", &mem_sight);
            }   /* inner while */

            printf(" month %2d: %2d\n", month, sightings);
        }   /* outer for */

        return (0);
}
```

```
Input data
2 1 4 3 0
1 2 0

0

5 4 -1 1 0
. . .
```

```
Results
BALD EAGLE SIGHTINGS
  month  1: 10
  month  2:  3
  month  3:  0
Warning, negative count -1 ignored
  month  4: 10
. . .
```


Yet Another 2-D Figure

How would you print the following diagram?

```
*
* *
* * *
* * * *
* * * * *
```

Algorithm:

For every row (**row** = 1, 2, 3, 4, 5)

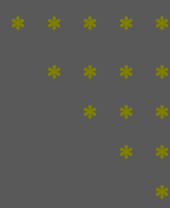
    Print **row** stars

Solution: Another Nested Loop

```
#define ROWS 5
...
int  row, col ;
for ( row = 1 ;  row <= ROWS ;  row = row + 1 ) {
    for ( col = 1 ;  col <= row ;  col = col + 1) {
        printf( "*" ) ;
    }
    printf( "\n" );
}
```


Yet One More 2-D Figure

How would you print the following diagram?



For every row (row = 0, 1, 2, 3, 4)

Print row spaces followed by (5 - row) stars

Yet Another Nested Loop

```
#define ROWS 5
...
int  row, col ;
for ( row = 0 ;  row < ROWS ;  row = row + 1 ) {
    for ( col = 1 ;  col <= row ;  col = col + 1)
        printf( "  " ) ;
    for ( col = 1 ;  col <= ROWS – row ;  col = col + 1)
        printf( "*" ) ;
    printf( "\n" );
}
```


Some Loop Pitfalls

```
while ( sum < 10 ) ;
   sum = sum + 2;
```

Some Loop Pitfalls

```
while ( sum < 10 ) ;
   sum = sum + 2;
```

```
for ( i = 0; i <= 10; i = i + 1);
   sum = sum + i ;
```


Some Loop Pitfalls

```
while ( sum < 10 ) ;
   sum = sum + 2;
```

```
for ( i = 0; i <= 10; i = i + 1);
   sum = sum + i ;
```

```
for ( i = 1;  i != 10 ; i = i + 2 )
   sum = sum + i ;
```

Use *int*s as Loop Counters

```
int i ;
double x ;
for ( i = 0 ; i < 50 ; i = i + 1 )
{
    x = (double) i / 5.0 ;
    printf("%.18f", x) ;
}
```


Exercises:
The for Statement: Nested Loop

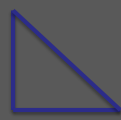
Write a program to display the following outputs :

```
   *
  ***
 *****
*******
```

1

```
*
***
*****
*******
```

2



```
*********
*******
*****
***
*
```

3

```
*********
*******
*****
***
*
```

4

```
#include <stdio.h>
#define COL  7
#define ROWS 4
int
main()
{
    int r,c,i;
    for ( r = 1; r<=ROWS ; r++)
    {
        for (c = 1; c <=4-r; c++)
            printf("#");
        for (i=1; i <= 2* r - 1 ; i++)
            printf("%d",ROWS-c);
        for (c = 1; c <=4-r; c++)
            printf("#");
        printf("\n");
    }

    return(0);
}
```

```
#include <stdio.h>
#define COL  7
#define ROWS 4
int
main()
{
    int r,c,i;
    for ( r = 1; r<=ROWS ; r++)
    {
        for (c = 1; c <=4-r; c++)
            printf(" ");
        for (i=1; i <= 2* r - 1 ; i++)
            printf("%d",ROWS-c);

        printf("\n");
    }

    return(0);
}
```