Fundamentals of Computer and Programming

Lecture 7
Repeating Statements

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Spring 2025

What We Will Learn

- Introduction
- **`while`** statement
- **`do-while`** statement
- **`for`** statement
- Arrays
- Advanced loops
- Bugs and avoiding them

Repetition

- Example: Write a program that read 3 integer and compute average
  - It is easy.
  - Three *scanf*, an *addition*, a *division* and, a *printf*
- Example: Write a program that read **3000** integer and compute average
  - Do we need 3000 *scanf*?!!!
- Example: Write a program that read ***n*** integer and compute average
  - Do we need N *scanf*?!!!

Repetition: counter controlled

- When we know the number of iteration
  - Average of 10 number

Initialize counter ← 0

Initialize other variables

While (counter < number of loop repetition)

    do something (e.g., read input, take sum)

    counter ← counter + 1

Repetition: sentinel controlled

- When we do NOT know the number of iteration
- But we know, when loop terminates
  - E.g., Average of arbitrary positive numbers ending with <0

n ← Get first input

While (n is not sentinel)

do something (sum, …)

n ← get the next input

if (there is not any valid input) then S1

else S2

Repetition

- Repetition is performed by loops
  - Put all statements to repeat in a loop
- Do not loop to infinity
  - **Stop** the repetition
  - Based on some conditions (counter, sentinel)
- C has three statements for loops
  - `while` statement
  - `do-while` statement
  - `for` statement

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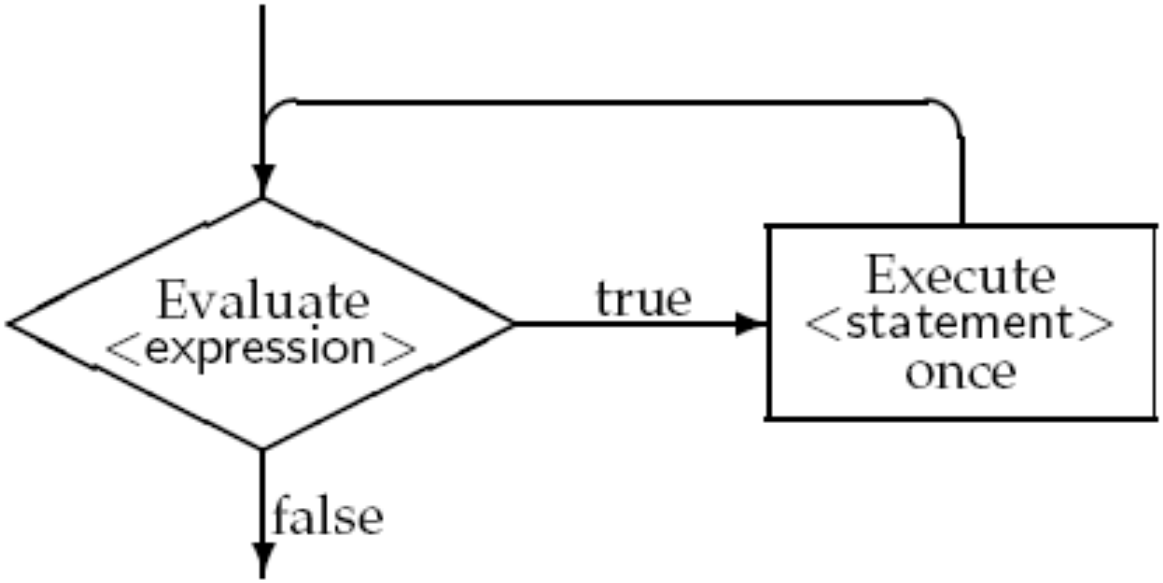
`while` statement

```
while ( <expression> )
  <statements>
```



Example: Print *n* numbers

برنامه‌ای بنویسید که عدد n را از کاربر بگیرد و اعداد 0 تا n را چاپ کند.

```
#include <stdio.h>

int main(void){
   int n, number;
   number = 0;
   printf("Enter n: ");
   scanf("%d", &n);
   while(number <= n){
        printf("%d \n", number);
        number++;
   }
   return 0;
}
```

Count *positive* and *negative* numbers

برنامه‌ای بنویسید که یک سری عدد را از کاربر بگیرد و تعداد اعداد مثبت و منفی آن‌را بشمارد.

این سری اعداد با صفر تمام می‌شود.

```
#include <stdio.h>

int main(void){
    int negative_num, positive_num;
    int number;
    negative_num = positive_num = 0;
    printf("Enter Zero to stop \n");
    printf("Enter first number: ");
    scanf("%d", &number);
    while(number != 0){
          if(number > 0)
                    positive_num++;
          else
                    negative_num++;

          printf("Enter the next number: ");
          scanf("%d", &number);
    }
    printf("The number of positive numbers = %d\n", positive_num);
    printf("The number of negative numbers = %d\n", negative_num);
    return 0;
}
```

What We Will Learn

- Introduction
- `while` statement
- **`do-while` statement**
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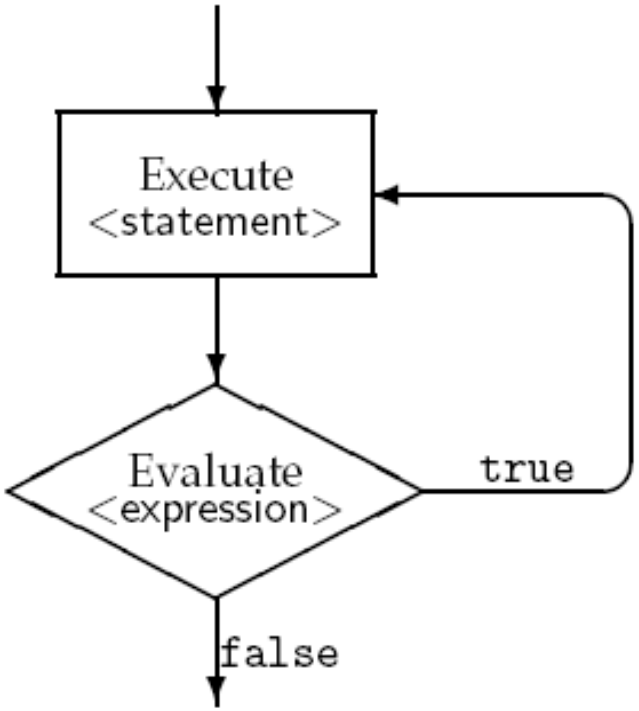
do-while statement

```
do
   <statements>
while ( <expression> );
```



Example: Sum of series

برنامه‌ای بنویسید که عدد n را بگیرد و مجموع n جمله اول رشته زیر را حساب کند

1.0/2.0 + 2.0/3.0 + 3.0/4.0 + …

```
#include <stdio.h>
int main(void){
   int n;
   double number, sum;
   printf("Enter n > 0: ");
   scanf("%d", &n);
   if(n < 1){printf("wrong input"); return -1;}

   sum = 0;
   number = 0.0;
   do{
        number++;
        sum += number / (number + 1.0);
   }while(number < n);

   printf("sum = %lf\n", sum);
   return 0;
}
```

Count *positive* and *negative* numbers

برنامه‌ای بنویسید که یک رشته عدد را از کاربر بگیرد و تعداد اعداد مثبت و منفی آن‌را بشمارد. این رشته اعداد با صفر تمام می‌شود.

```
#include <stdio.h>
int main(void){
   int negative_num=0, positive_num=0;
   int number;
   printf("Enter Zero to stop \n");
   do{
        printf("Enter next number: ");
        scanf("%d", &number);
        if(number > 0)
                positive_num++;
        else if(number < 0)
                negative_num++;
   }while(number != 0);

   printf("The number of positive numbers = %d\n", positive_num);
   printf("The number of negative numbers = %d\n", negative_num);
   return 0;
}
```

What We Will Learn

- Introduction
- `while` statement
- `do-while` statement
- **`for` statement**
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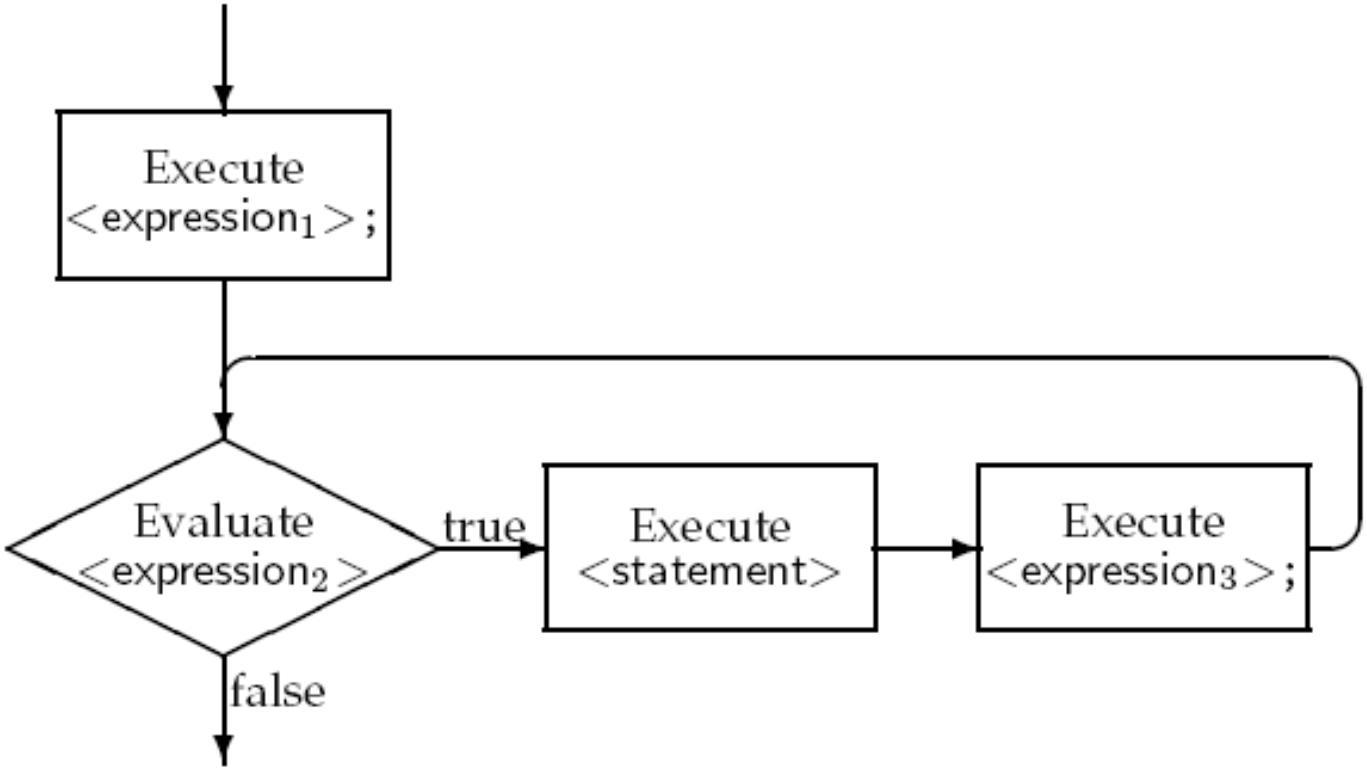
for statement

```
for(<expression1>; <expression2>; <expression3>)
    <statements>
```



Example: Compute average of grades

برنامه‌ای که تعداد دانشجویان و نمره‌های آنها را خوانده و میانگین را محاسبه کند.

```
#include <stdio.h>
int main(void){
   int grade, count, i;
   double average, sum;
   sum = 0;
   printf("Enter the number of students: ");
   scanf("%d", &count);
   for(i = 0; i < count; i++){
        printf("Enter the grade of %d-th student: ", (i + 1));
        scanf("%d", &grade);
        sum += grade;
   }
   average = sum / count;
   printf("The average of your class is %0.3lf\n", average);
   return 0;
}
```

Example: Print even numbers

برنامه‌ای که عدد n را از کاربر بگیرد و همه اعداد زوج کوچکتر مساوی آن را چاپ کند.

```
#include <stdio.h>
int main(void){
   int n, number;
   printf("Enter n: ");
   scanf("%d", &n);

   for(number = 2; number <= n; number += 2)
       printf("%d \n", number);

   return 0;
}
```

Combining `for` and `if` statements

برنامه‌ای که عدد n را از کاربر بگیرد و همه اعداد زوج کوچکتر مساوی آن را چاپ کند.

```
#include <stdio.h>

int main(void){
   int n, number;
   printf("Enter n: ");
   scanf("%d", &n);

   for(number = 1; number <= n; number++)
       if((number % 2) == 0)
             printf("%d \n", number);

   return 0;
}
```

Expressions in `for` statements

- Expression1 and Expression3 can be **any number of expressions**, they execute in the order
  - `for(i = 0, j = 0; i < 10; i++, j--)`
- Expression2 at most should be **a single expression**
  - If multiple expressions → the value of the last one is evaluated as True/False
  - `for(i = 0, j = 0; i < 10, j > -100; i++, j--)`
- Any expression can be empty expression
  - `for( ; i < 10; i++)`
  - `for(;;)`

Prime number

```
# include <stdio.h>

int main (){
  int n;
  printf ("Enter a natural number:\n");
  scanf ("%d", &n);
  if (n < 2){
          printf ("%d is no prime nor composite \n", n);
          return 0;
}
  if (n == 2){
    printf ("%d is prime \n", n);
    return 0;
}
  if (n % 2 == 0){
        printf ("%d is not prime \n", n);
        return 0;
}
…
```

Prime number (cont'd)

```
  …
  int flag = 1;
  for (int i = 3; i <= n / 2 && flag; i += 2)
      if (n % i == 0)
        flag = 0;

  if (flag)
      printf (" %d is prime \n", n);
  else
      printf (" %d is not prime \n", n);

  return 0;
}
```

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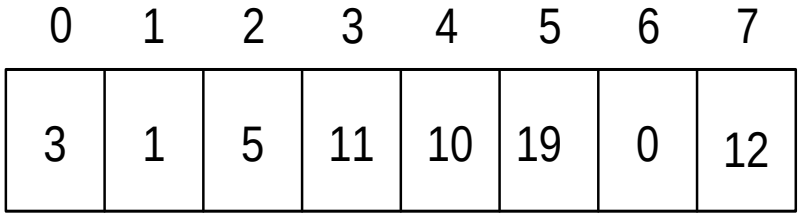
Introduction

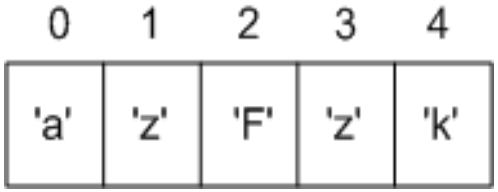
- Algorithms usually work on large data sets
  - Sort a set of numbers
  - Search a specific number in a set of numbers
- How to read and store a set of data?
- To read
  - Repeat the scanf statement
  - Use the loop statements
- To store the data
  - Save each data in a single variable??
    - 3000 int variables! ! ! !

Array

- An ordered collection of same type variables
- A *nx1* vector of
  - Integers, chars, floats, …
- Example
  - An array of 8 integer



  - An array of 5 chars



Arrays in C

- Array declaration in C

  <Elements' Type> <identifier>[<size>]

- <Elements' Type>: int, char, float, …
- <size>
  - Old compilers (standard): it should be constant
  - New compilers (standard): it can be variable
- Elements in array
  - From 0 to (size – 1)

Example

```
int num[20];
```

- **num** is array of 20 integers
- **num[0]** is the first integer variable
- **num[19]** is the last integer

```
float farr[100];
```

- **farr** is array of 100 floats
- **farr[0]** is the first float
- **farr[49]** is the 50th float
- **farr[99]** is the last float

Example: Arrays

```
int number[10];
int i, j = 3;


i = 5; // -1 < i < 10
number[i] = 0;              //6th number is 0
number[i + j] = 1;//??
j = number[i];              //?
j = number[i + 1];//?
j = number[i] + 1;//?
```

Example: Array with fixed size

```
#include <stdio.h>
#define SIZE 20
void main(void){
    int number[SIZE];
    double average;
    int sum, large_size, small_size, i;
    sum = large_size = small_size = 0;
    for(i = 0; i < SIZE; i++){
          int tmp;
          scanf("%d", &tmp);
          number[i] = tmp;
          sum += number[i];
    }
    average = (1.0 * sum) / SIZE;
    for(i = 0; i < SIZE; i++)
          if(number[i] >= average)
                    large_size++;
          else
                    small_size++;
    printf("average = %lf\n", average);
    printf("Small Size = %d, Large Size = %d\n", small_size, large_size);
}
```

برنامه‌ای که ۲۰ عدد را بگیرد و تعداد اعداد بزرگتر و کوچکتر از میانگین را حساب کند.

Example: for statement on arrays

برنامه‌ای که تعداد اعداد و یک رشته عدد را بگیرد و تعداد اعداد بزرگتر و کوچکتر از میانگین را حساب کند.

```
# include <stdio.h>
# include <stdlib.h>
void main(void){
    int n;
    printf("Enter n: ");
    scanf("%d", &n);
    int *number = (int *) malloc( n * sizeof(int) );// int number[n];
    double average;
    int sum, large_size, small_size, i;
    sum = large_size = small_size = 0;
    for(i = 0; i < n; i++)
        scanf("%d", &(number[i]));
    for(i = 0; i < n; i++)
        sum += number[i];
    average = (1.0 * sum) / n;
    for(i = 0; i < n; i++)
        if(number[i] >= average)
            large_size++;
        else
            small_size++;
    printf("average = %lf\n", average);
    printf("Small Size = %d, Larg Size = %d\n", small_size, large_size);
}
```

Array Initialization: Known Length

```
int num[3]={10, 20, 60};
```

- **num** is the array of 3 integers, **num[0]** is 10, …

```
int num[]={40, 50, 60, 70, 70, 80};
```

- **num** is the array of 6 integers

```
int num[10]={40, 50, 60};
```

- **num** is the array of 10 integers
- **num[0]** is 40, **num[1]** is 50, **num[2]** is 60
- **num[3], num[4], ..., num[9]** are 0

Array Initialization (cont'd)

```
int num[2]={40, 50, 60, 70};
/* Compile warning */
```

```
int num[5]={[0] = 3, [4] = 6};
```

/* num[5] = {3, 0, 0, 0, 6} */

Initializing Variable Length Arrays

```
int n;
scanf("%d", &n);
int num[n]={0}; /* Compile error */
```

- Variable length arrays cannot be initialized!
- Solution:

```
for(i = 0; i < n; i++)
    num[i] = 0;
```

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Empty statements

- <statement> in loops can be empty

```
while(<expression>)   ;
E.g.,
  while(i++ <= n) ;

for(<expression1>; <expression2>; <expression3>)
  ;
E.g.,
  for(i = 0; i < 10; printf("%d\n",i), i++) ;
```

Nested loops

- <statement> in loops can be loop itself

```
while(<expression0>)
   for(<expression1>; <expression2>;
   <expression3>)
       <statements>


for(<expression1>; <expression2>;
   <expression3>)
   do
       <statements>
   while(<expression>)
```

Nested loops example

- A program that takes *n* and *m* and prints a *m* * *n rectangle.*

*** ….* (*m* * *in* each line)

*** ….*

…

*** ….*

(n lines)

Answer

```
#include <stdio.h>

int main(void){
    int i, j, n, m;
    printf("Enter n & m: ");
    scanf("%d%d", &n, &m);
    for(i = 0; i < n; i++){
        for(j = 0; j < m; j++)
            printf("*");
        printf("\n");
    }
    return 0;
}
```


What is the output of this program?

```
#include <stdio.h>
int main(void){
    int i, j, n;
    printf("Enter n: ");
    scanf("%d", &n);

    i = 1;
    while(i <= n){
          for(j = 0; j < i; j++)
                printf("*");

          printf("\n");
          i++;
    }

   return 0;
}
```

Answer

- A program that takes *n* and prints

```
*                    (i * in i-th line)
**
***
***  ....*
```

(*n* lines)

What is the output of this program?

- **n = 5**

```
for(i= 1; i <= n; i++){
        for(j = 0; j < i-1; j++)
                printf(" ");

        for(j = 1; j <= i; j++)
                printf("*");

        printf("\n");
}

for(i= n-1; i >= 1; i--){
        for(j = 1; j < i; j++)
                printf(" ");
        for(j = 1; j <= i; j++)
                printf("*");
        printf("\n");
}
```

Answer

- A program that takes a number and generates the following pattern

```
n = 5

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

```
for(i= 1; i <= n; i++){
        for(j = 0; j < i-1; j++)
                printf(" ");

        for(j = 1; j <= i; j++)
                printf("*");

        printf("\n");
}

for(i= n-1; i >= 1; i--){
        for(j = 1; j < i; j++)
                printf(" ");
        for(j = 1; j <= i; j++)
                printf("*");
        printf("\n");
}
```

break statement

- **Exit from loop** based on some conditions

```
do{
   scanf("%d", &a);
   scanf("%d", &b);
   if(b == 0)
       break;
   res = a / b;
   printf("a / b = %d\n", res);
}while(b > 0);
```

`continue` statement

- **Jump to end of loop** and continue repetition

```
do{
   scanf("%f", &a);
   scanf("%f", &b);
   if(b == 0)
       continue;
   res = a / b;
   printf("a / b = %f\n", res);
}while(a > 0);
```

Which loop?

- When you know the number of repetition
  - Counter-controlled loops
  - Usually, **`for`** statements
- When you do not know the number of repetitions (sentinel loop)
  - Some condition should be check before starting loop
    - Usually, **`while`** statement
  - The loop should be executed at least one time
    - Usually, **`do-while`**

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Common bugs and avoiding them

- Loop should terminate
  - *E.g.*, in **for** loops, after each iteration, we should approach to the stop condition

```
for(i = 0; i < 10; i++)    //OK
for(i = 0; i < 10; i--) //Bug
```

- Initialize loop control variables

```
int i;

for( ; i < 10; i++)
```

Common bugs and avoiding them

- Do not modify **for** loop controller inside the loop body:

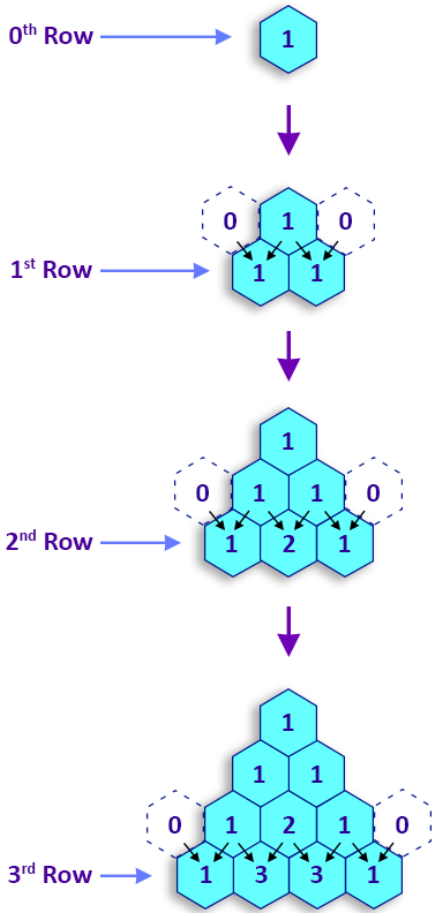
```
for(i = 0; i < 10; i++){
    ...
    i--; //Bug
}
```

- Take care about wrong control conditions
  - < vs. <=
  - = vs. ==

```
int b = 10;
while(a = b){  //it means while(true)
  scanf("%d", &a)
  …
```

Exercise

Write a C program to display Pascal's triangle.



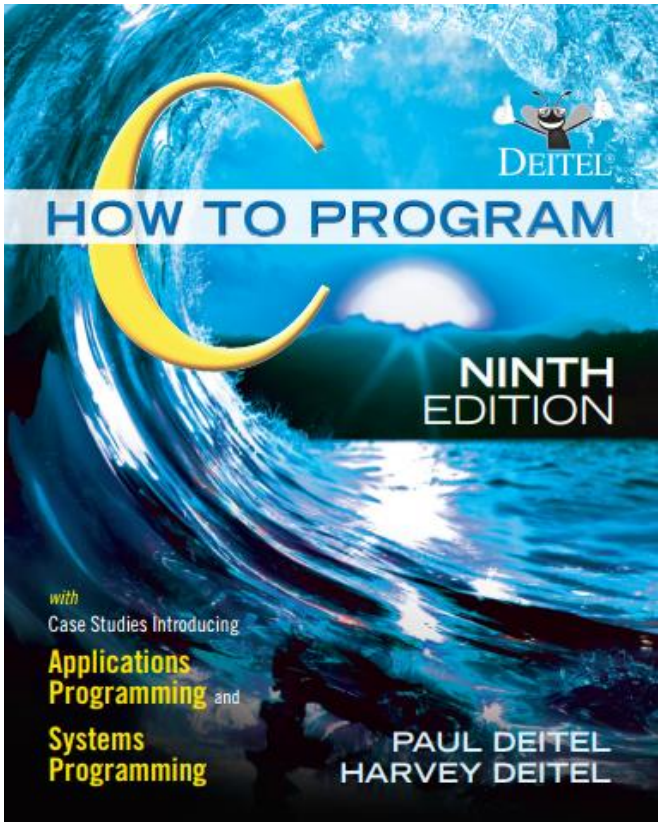

```
Input number of rows: 5
                1
              1   1
            1   2   1
          1   3   3   1
        1   4   6   4   1
```

Answer:

https://www.w3resource.com/c-programming-exercises/for-loop/c-for-loop-exercises-33.php

Reference

- Reading Assignment: **Chapter 4** of "C How to Program"



Questions

- What will be the output of the following code?

```
int i = 0;
while (i < 5)
printf("%d ", i++);
```

A) 0 1 2 3 4

B) 0 1 2 3 4 5

C) Infinite loop

D) No output

- Answer: A

Questions

- What will be the output of the following code?

```
int main() {
  int i = 0; 29
  for (; i < 5; i++) {
    if (i % 2 == 0){
      continue;
    }
    printf("%d ", i);
  }
  return 0;
}
```

A) 1 3

B) 0 2 4

C) 1 2 3

D) 1 3 5

- Answer: A

Questions

- What will be the output of this nested loop?

```
int main() {
  int i, j;
  for (i = 0; i < 3; i++) {
    for (j = i; j < 3; j++) {
      if (i == j)
      continue;
      printf("%d%d ", i, j);
    }
  }
  return 0;
}
```

A) 01 02 12
B) 00 01 02
C) 01 12 02
D) 00 01 10

- Answer: A