

# Control Flow: Looping

**CS10001: Programming & Data Structures**



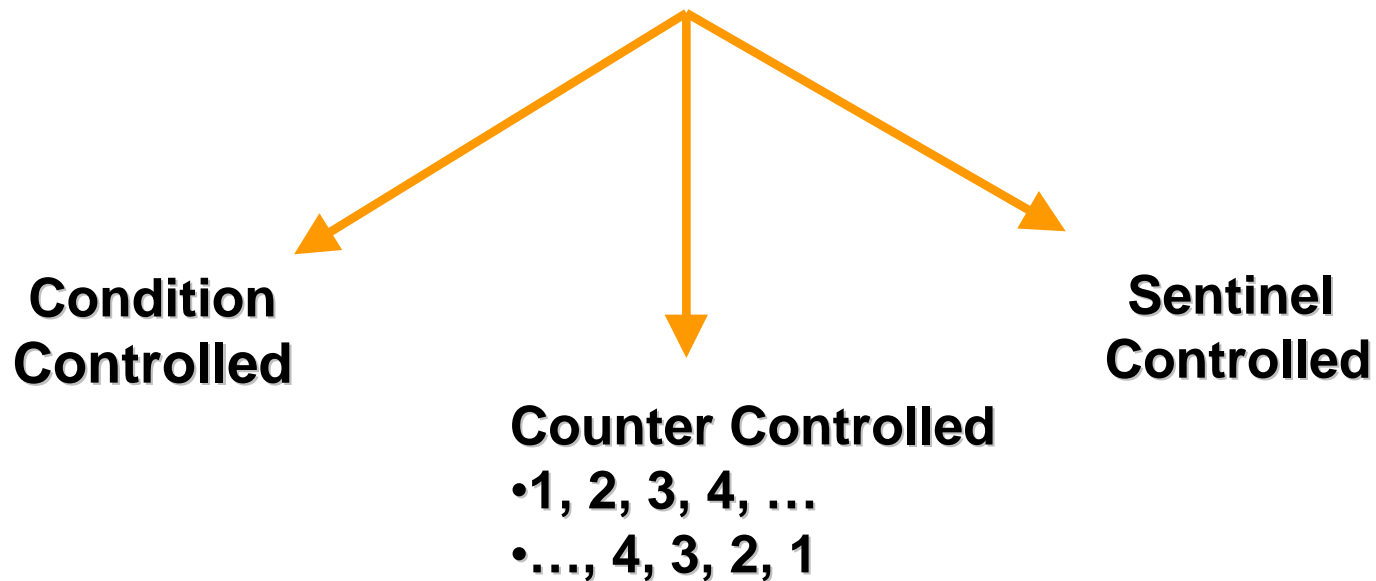
**Sudeshna Sarkar**

Professor, Dept. of Computer Sc. & Engg.,  
Indian Institute of Technology Kharagpur

# Types of Repeated Execution

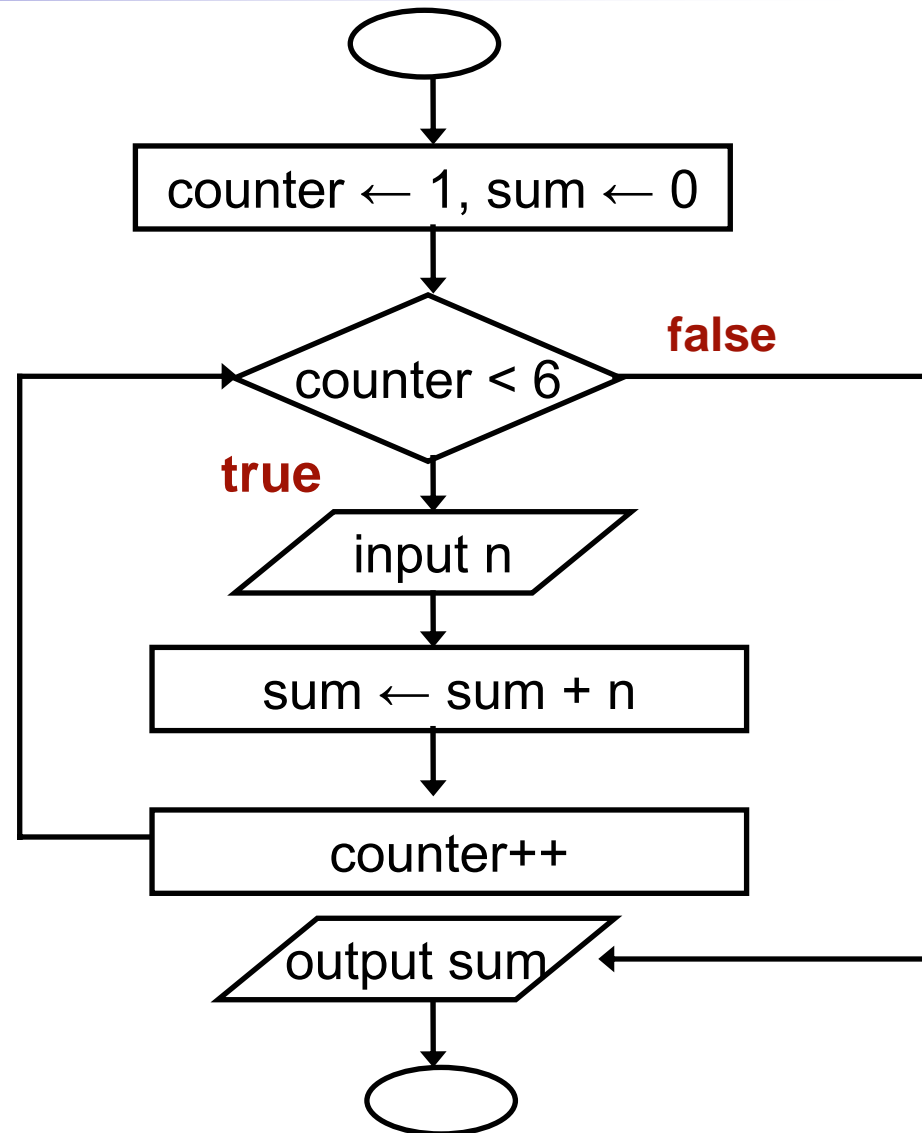
- **Loop**: Group of instructions that are executed repeatedly while some condition remains true.

## How loops are controlled



# Counter Controlled Loop

Read 5 integers and display the value of their summation.

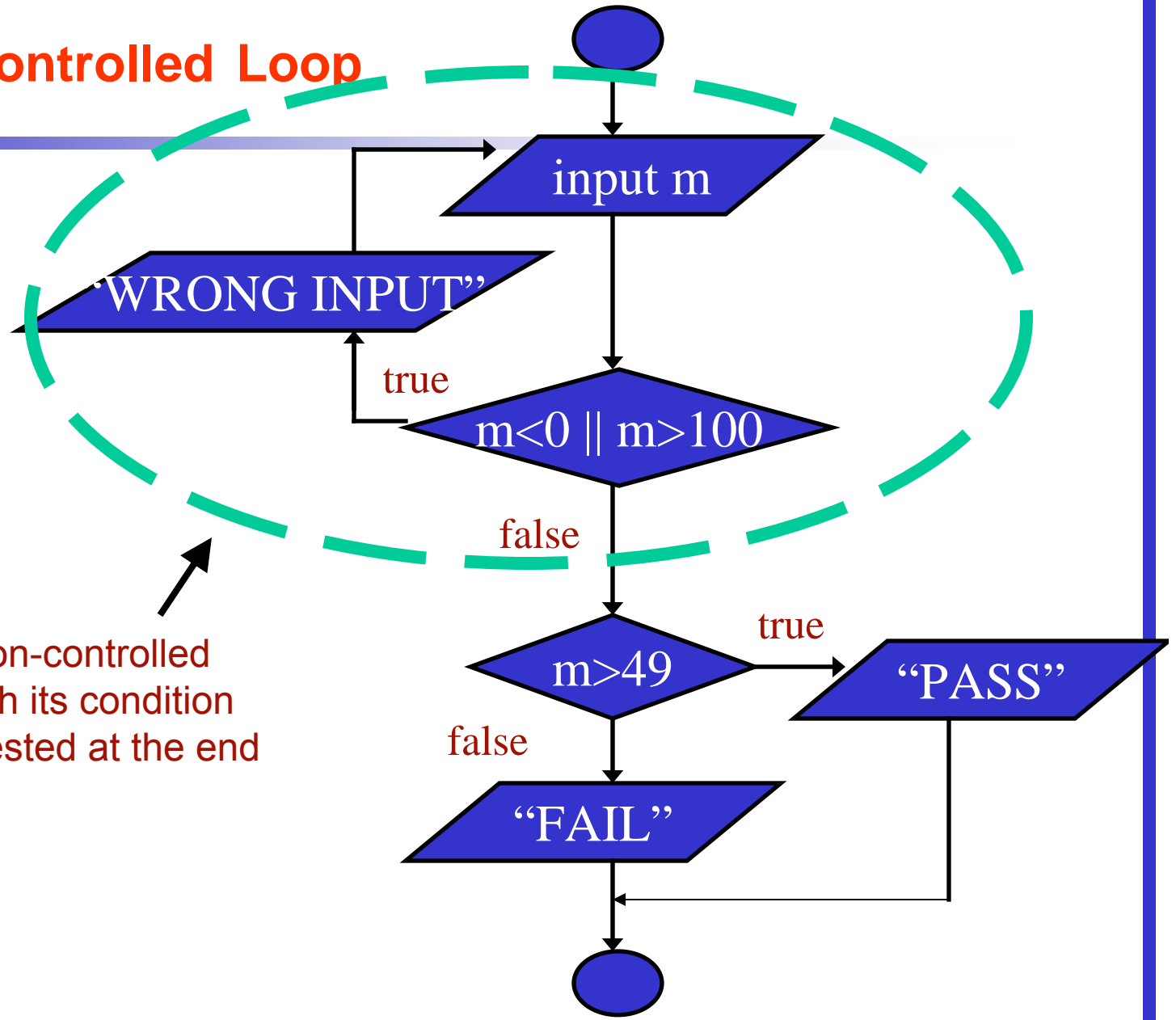


# Condition-controlled Loop

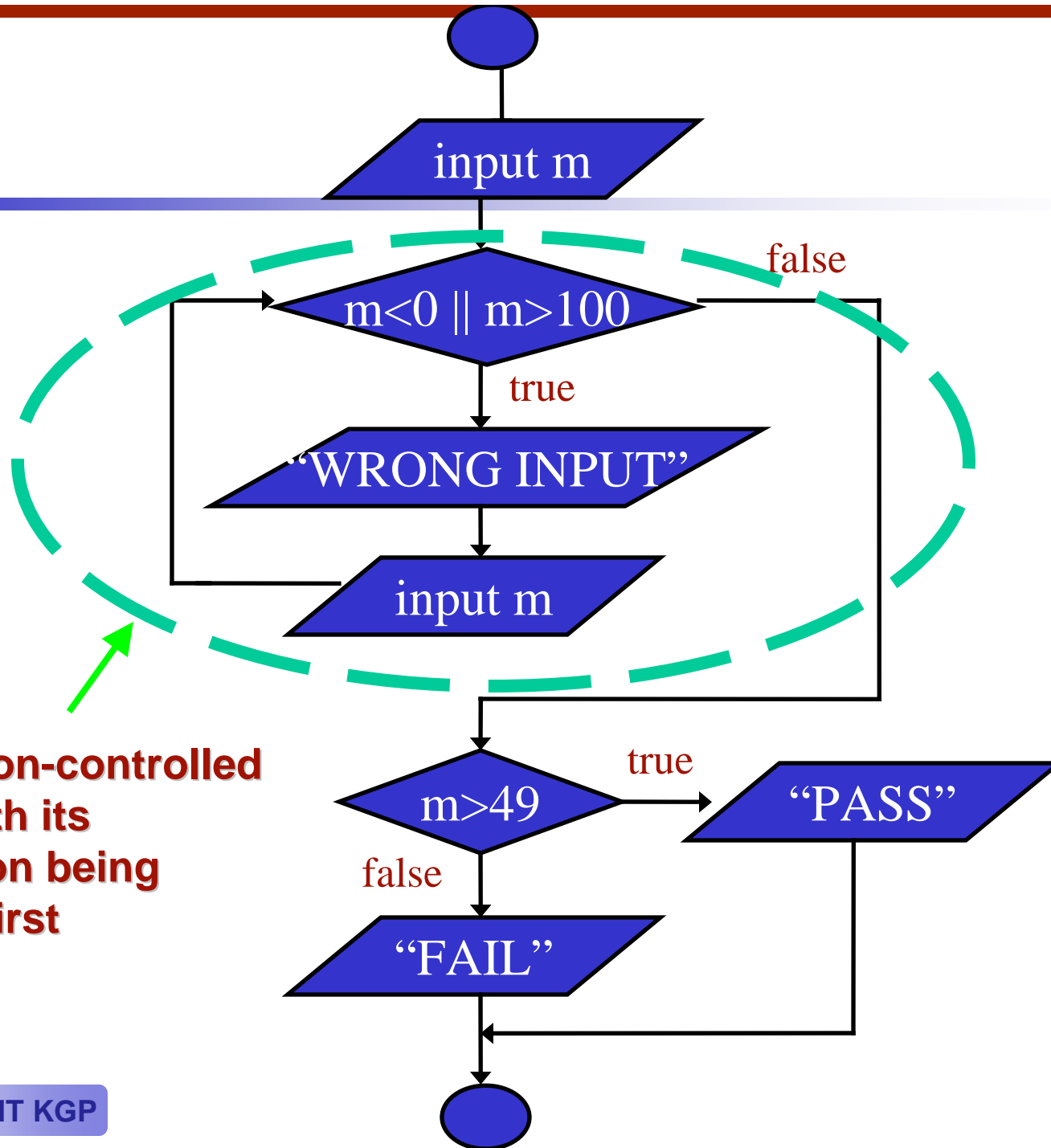
Given an exam marks as input, display the appropriate message based on the rules below:

- If marks is greater than 49, display “PASS”, otherwise display “FAIL”
- However, for input outside the 0-100 range, display “WRONG INPUT” and prompt the user to input again until a valid input is entered

# Condition-Controlled Loop



Condition-controlled loop with its condition being tested at the end



**Condition-controlled  
loop with its  
condition being  
tested first**

# Sentinel-Controlled Loop

- **Receive a number of positive integers and display the summation and average of these integers.**
- **A negative or zero input indicates the end of input process**

Input: A set of integers ending with a negative integer or a zero

Output: Summation and Average of these integers

- **Input Example:**

30    16    42

**-9**

**Sentinel  
Value**



- **Output Example:**

**Sum = 88**

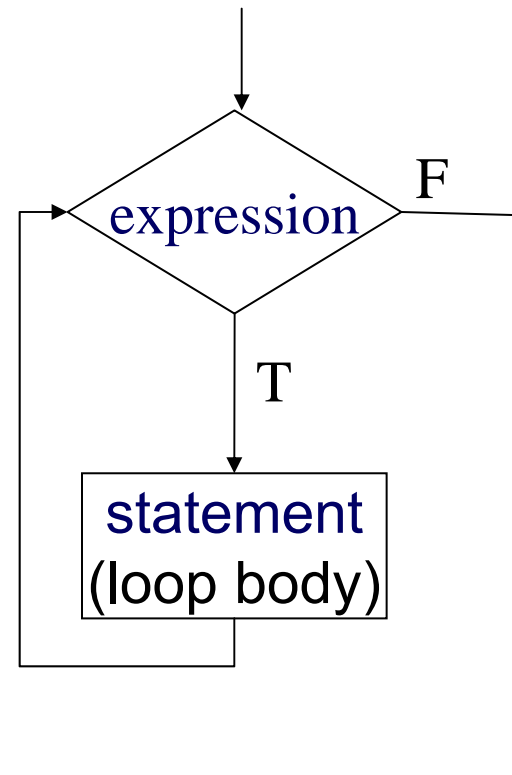
**Average = 29.33**



# while loop

```
while (expression)  
statement
```

```
while (i < n) {  
    printf ("Line no : %d.\n",i);  
    i++;  
}
```



## while Statement

- The “while” statement is used to carry out looping operations, in which a group of statements is executed repeatedly, as long as some condition remains satisfied.

```
while (condition)
    statement_to_repeat;
```

```
while (condition) {
    statement_1;
    ...
    statement_N;
}
```

Note:

The while-loop will not be entered if the loop-control expression evaluates to false (zero) even before the first iteration.

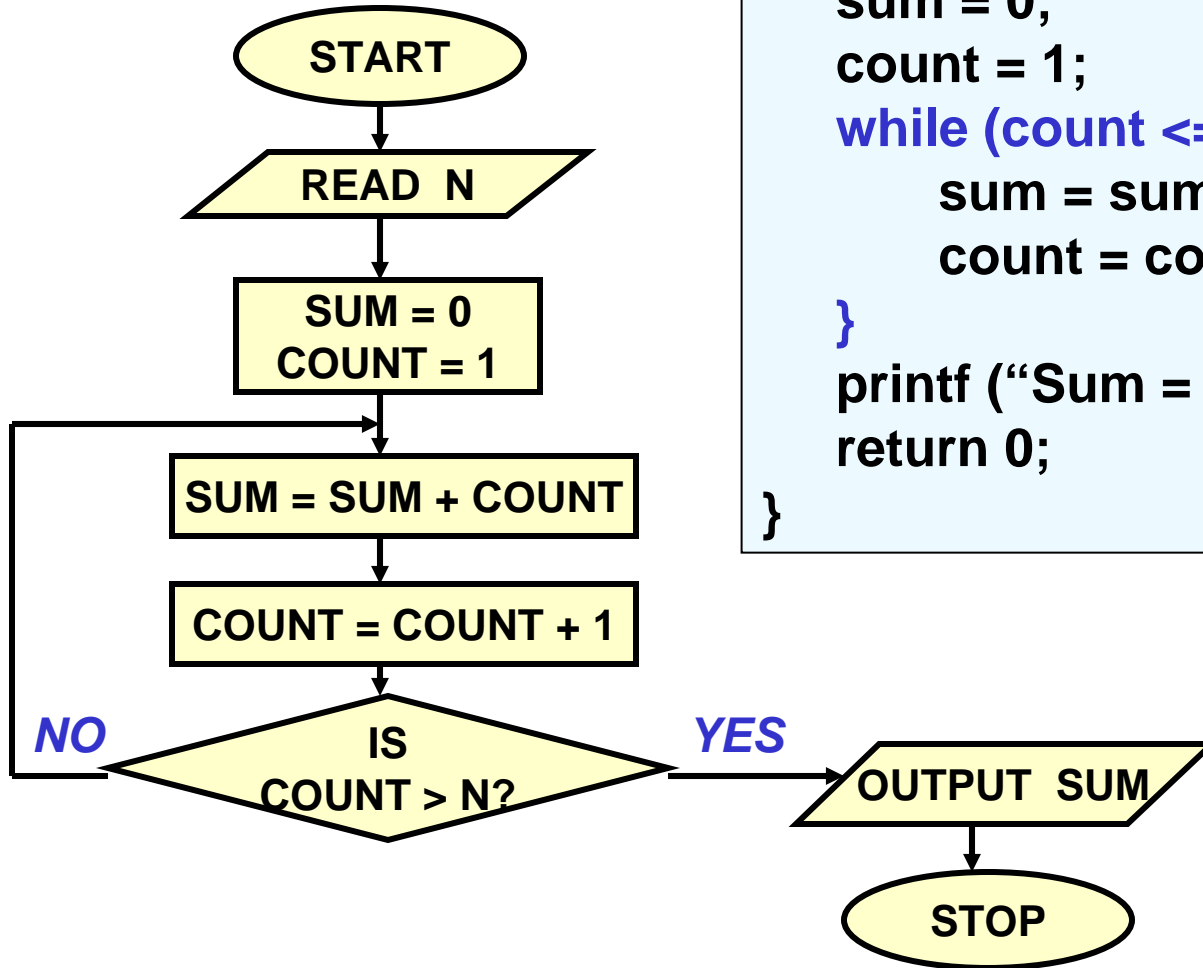
`break` can be used to come out of the `while` loop.

## while :: Examples

```
int weight;  
  
while ( weight > 65 ) {  
    printf ("Go, exercise, ");  
    printf ("then come back. \n");  
    printf ("Enter your weight: ");  
    scanf ("%d", &weight);  
}
```

# Sum of first $N$ natural numbers

```
int main () {  
    int N, count, sum;  
    scanf ("%d", &N) ;  
    sum = 0;  
    count = 1;  
    while (count <= N) {  
        sum = sum + count;  
        count = count + 1;  
    }  
    printf ("Sum = %d\n", sum) ;  
    return 0;  
}
```



## Double your money

- Suppose your Rs 10000 is earning interest at 1% per month. How many months until you double your money ?

```
my_money=10000.0;
n=0;
while (my_money < 20000.0) {
    my_money = my_money*1.01;
    n++;
}
printf ("My money will double in %d months.\n",n);
```

## Maximum of inputs

```
printf ("Enter positive numbers to max, end with -  
1.0\n");  
max = 0.0;  
count = 0;  
scanf("%f", &next);  
while (next != 1.0) {  
    if (next > max)  
        max = next;  
    count++;  
    scanf("%f", &next);  
}  
printf ("The maximum number is %f\n", max) ;
```

# Printing a 2-D Figure

- How would you print the following diagram?

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

repeat 3 times

print a row of 5

stars

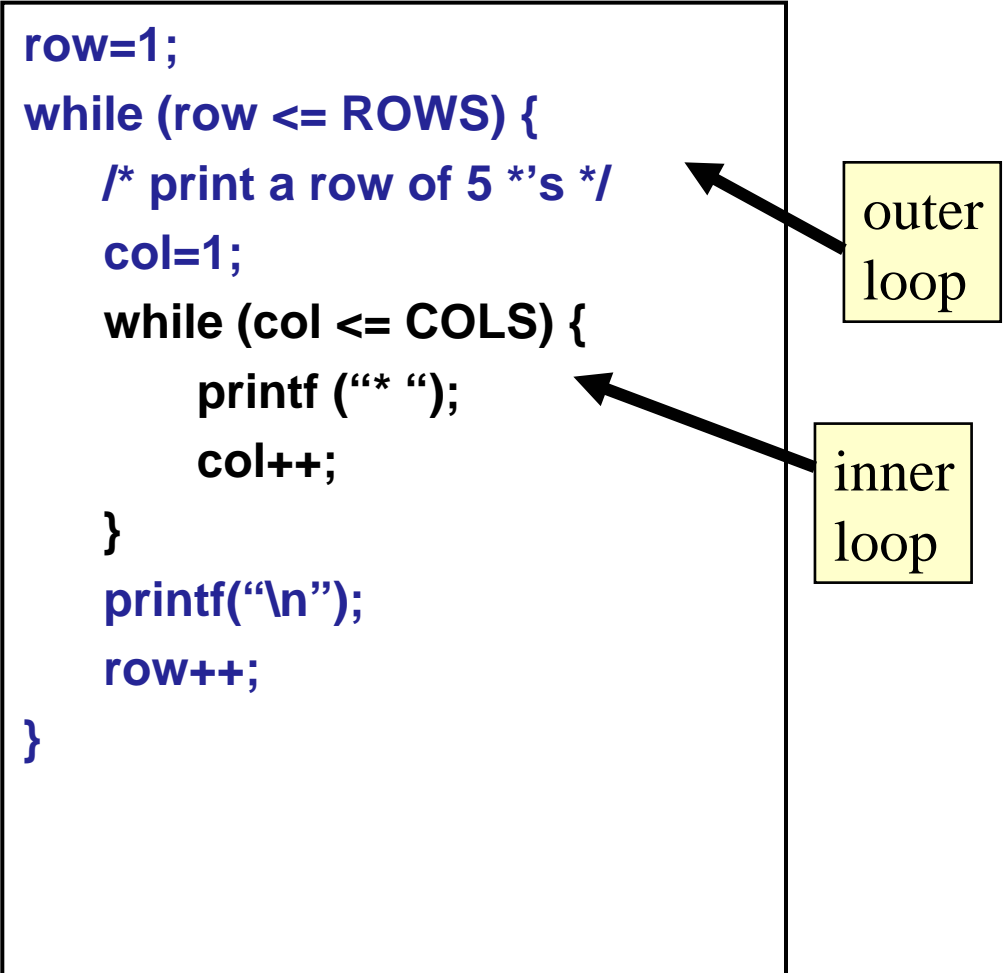
repeat 5 times  
print \*

# Nested Loops

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

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

outer  
loop



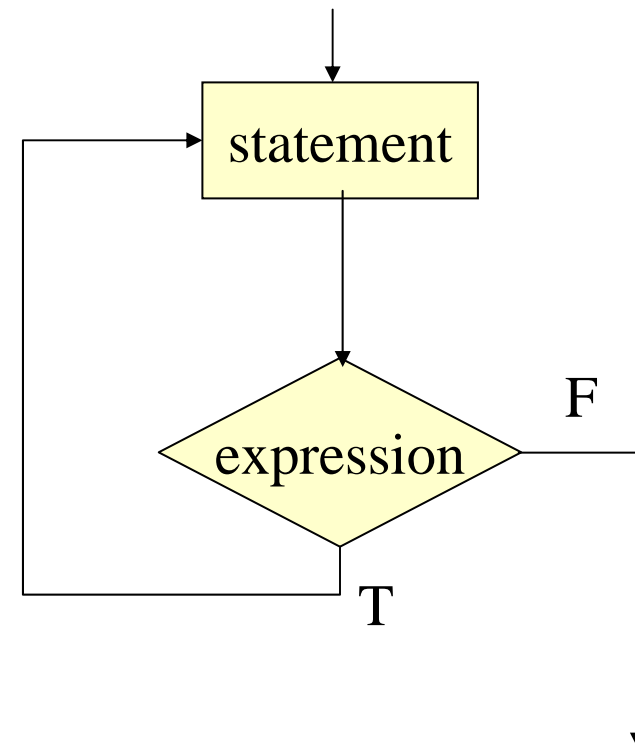
inner  
loop



# do-while statement

**do statement while (expression)**

```
main () {  
    int digit=0;  
    do  
        printf(“%d\n”,digit++);  
    while (digit <= 9) ;  
}
```



## Example for do-while

Usage: Prompt user to input “month” value, keep prompting until a correct value of moth is input.

```
do {  
    printf (“Please input month {1-12}”);  
    scanf (“%d”, &month);  
} while ((month < 1) || (month > 12));
```

```
int main () {  
    char echo ;  
    do {  
        scanf ("%c", &echo);  
        printf ("%c",echo);  
    } while (echo != '\n') ;  
}
```

## for Statement

- The “for” statement is the most commonly used looping structure in C.
- General syntax:

***for ( expr1; expr2; expr3) statement***

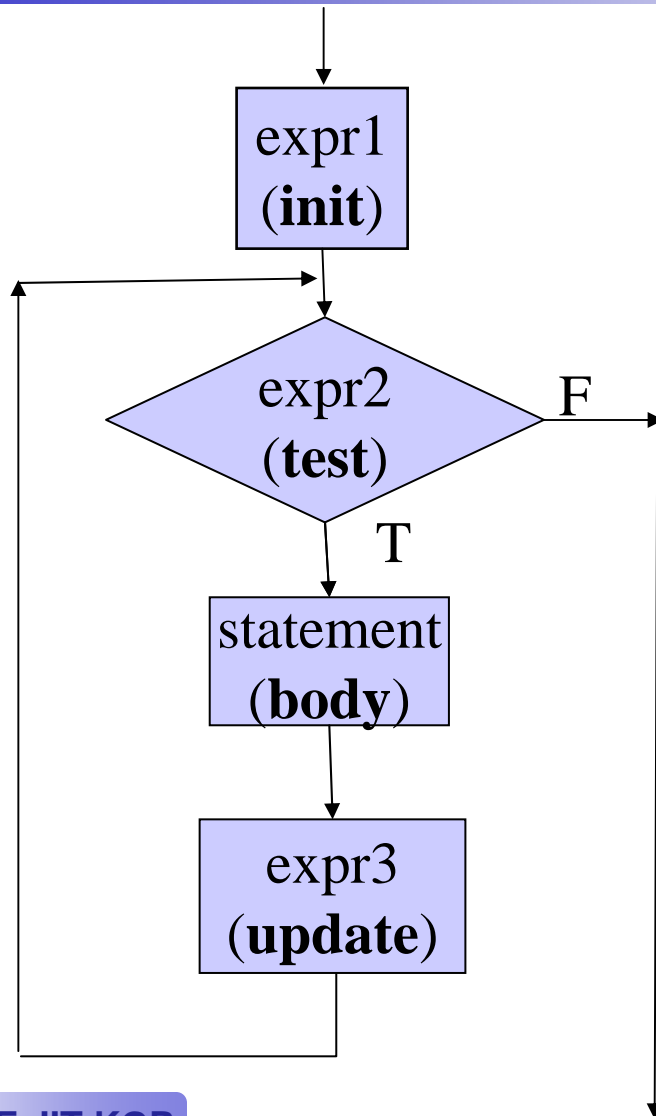
**expr1** (init) : initialize parameters

**expr2** (test): test condition, loop continues if satisfied

**expr3** (update): used to alter the value of the parameters after each iteration

**statement** (body): body of the loop

**for ( expression1; expression2; expression3)  
statement**



```
expr1;  
while (expr2) {  
    statement  
    expr3;  
}
```

## *Sum of first N natural numbers*

```
int main () {  
    int N, count, sum;  
    scanf ("%d", &N) ;  
    sum = 0;  
    count = 1;  
    while (count <= N) {  
        sum = sum + count;  
        count = count + 1;  
    }  
    printf ("Sum = %d\n", sum) ;  
    return 0;  
}
```

## Sum of first $N$ natural numbers

```
int main () {  
    int N, count, sum;  
    scanf ("%d", &N) ;  
    sum = 0;  
    count = 1;  
    while (count <= N) {  
        sum = sum + count;  
        count = count + 1;  
    }  
    printf ("Sum = %d\n", sum)  
    return 0;  
}
```

```
int main () {  
    int N, count, sum;  
    scanf ("%d", &N) ;  
    sum = 0;  
    for (count=1; count <= N; count++)  
        sum = sum + count;  
  
    printf ("Sum = %d\n", sum) ;  
    return 0;  
}
```

## 2-D Figure

### Print

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

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



## Another 2-D Figure

### Print

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

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

## For - Examples

- Problem 1: Write a For statement that computes the sum of all odd numbers between 1000 and 2000.
- Problem 2: Write a For statement that computes the sum of all numbers between 1000 and 10000 that are divisible by 17.
- Problem 3: Printing square problem but this time make the square hollow.
- Problem 4: Print

```
* * * * *
```

```
 * * * *
```

```
  * * *
```

```
   * *
```

```
    *
```

## Problem 4 : solution

**Print**

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

```
#define ROWS 5
```

```
....
```

```
int row, col;
```

```
for (row=0; row<ROWS; row++) {
```

```
    for (col=1; col<=row; col++)
```

```
        printf(" ");
```

```
    for (col=1; col<=ROWS-row; col++)
```

```
        printf("* ");
```

```
    printf ("\n");
```

```
}
```

## The comma operator

- We can give several statements separated by commas in place of “expression1”, “expression2”, and “expression3”.

```
for (fact=1, i=1; i<=10; i++)  
    fact = fact * i;
```

```
for (sum=0, i=1; i<=N, i++)  
    sum = sum + i * i;
```

## for :: Some Observations

- Arithmetic expressions
  - Initialization, loop-continuation, and increment can contain arithmetic expressions.  
`for ( k = x; k <= 4 * x * y; k += y / x )`
- "Increment" may be negative (decrement)  
`for (digit=9; digit>=0; digit--)`
- If loop continuation condition initially *false*:
  - Body of *for* structure not performed.
  - Control proceeds with statement after *for* structure.

# Specifying “Infinite Loop”

```
while (1) {  
    statements  
}
```

```
for (;;)   
{  
    statements  
}
```

```
do {  
    statements  
} while (1);
```

# The break Statement

- Break out of the loop { }
  - can use with
    - while
    - do while
    - for
    - switch
  - does not work with
    - if
    - else
- Causes immediate exit from a *while*, *do/while*, *for* or *switch* structure.
- Program execution continues with the first statement after the structure.

# An Example

```
#include <stdio.h>
int main() {
    int fact, i;

    fact = 1; i = 1;

    while ( i<10 ) {          /* run loop –break when fact >100*/
        fact = fact * i;
        if ( fact > 100 ) {
            printf ("Factorial of %d above 100", i);
            break;           /* break out of the while loop */
        }
        i ++ ;
    }
}
```



# The continue Statement

- Skips the remaining statements in the body of a *while*, *for* or *do/while* structure.
  - Proceeds with the next iteration of the loop.
- *while* and *do/while*
  - Loop-continuation test is evaluated immediately after the *continue* statement is executed.
- *for* structure
  - *expression3* is evaluated, then *expression2* is evaluated.

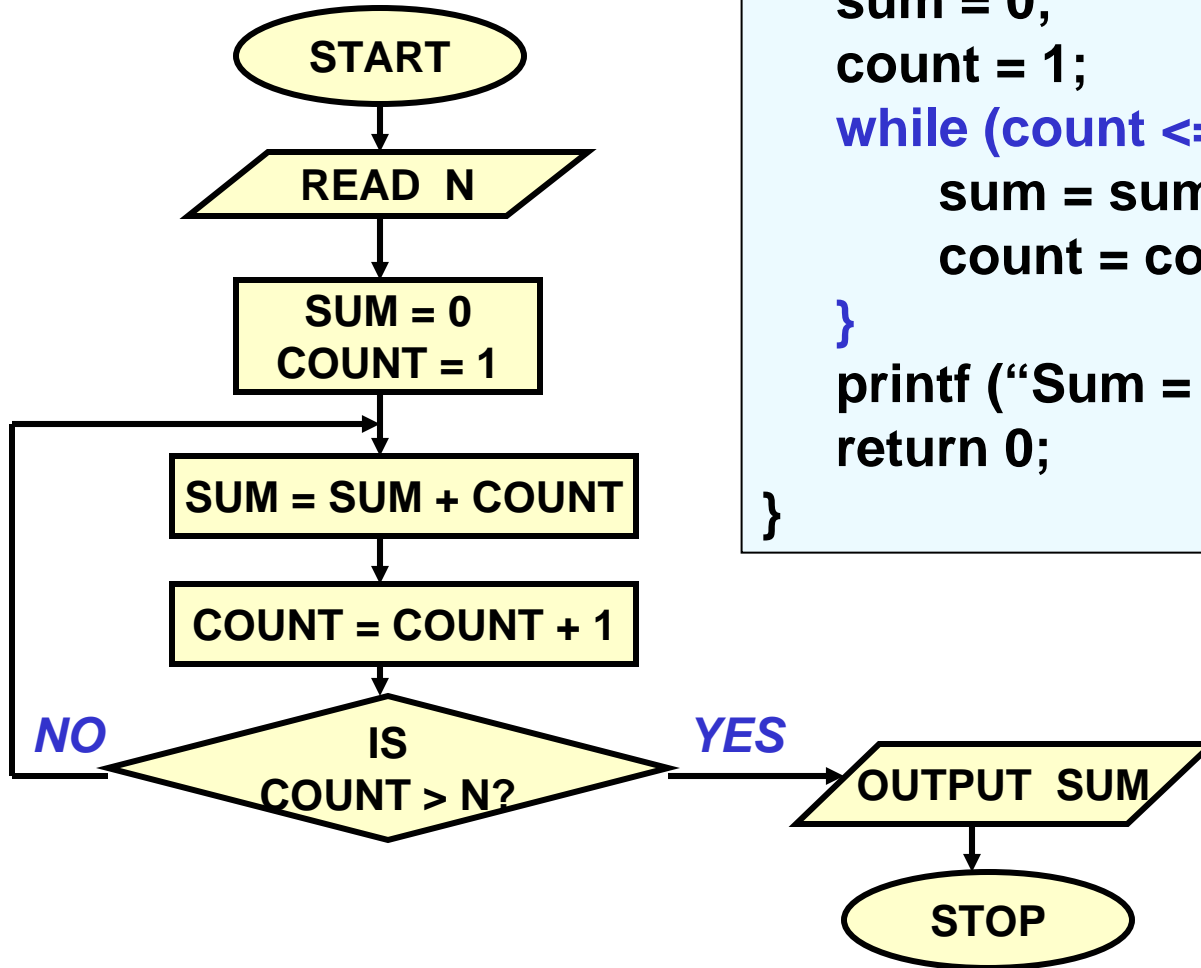
## An Example with “break” & “continue”

```
fact = 1; i = 1;           /* a program segment to calculate 10 !  
while (1) {  
    fact = fact * i;  
    i ++ ;  
    if ( i < 10 )  
        continue;        /* not done yet ! Go to loop and  
                           perform next iteration*/  
    break;  
}
```

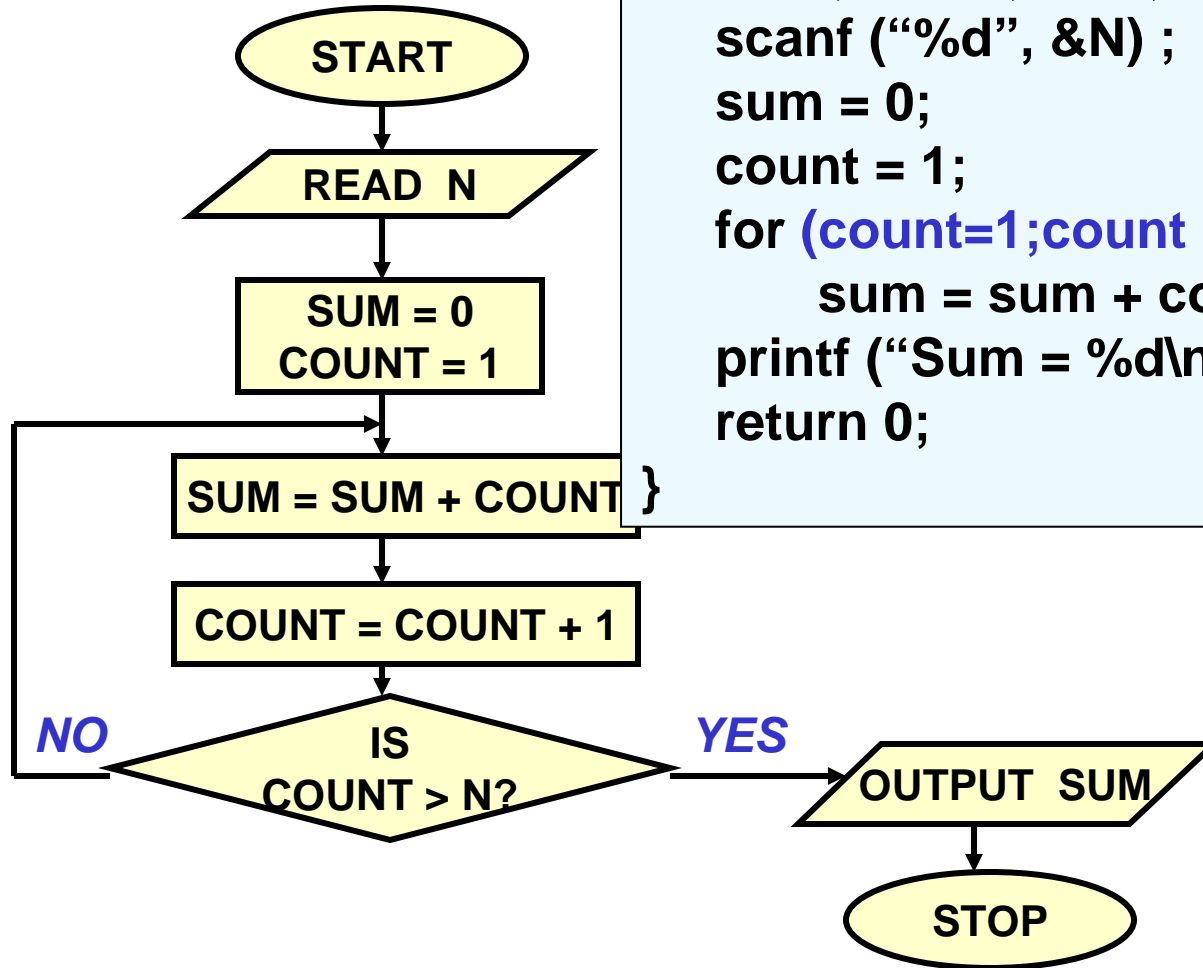
# Some Examples

## Sum of first $N$ natural numbers

```
int main () {  
    int N, count, sum;  
    scanf ("%d", &N) ;  
    sum = 0;  
    count = 1;  
    while (count <= N) {  
        sum = sum + count;  
        count = count + 1;  
    }  
    printf ("Sum = %d\n", sum) ;  
    return 0;  
}
```

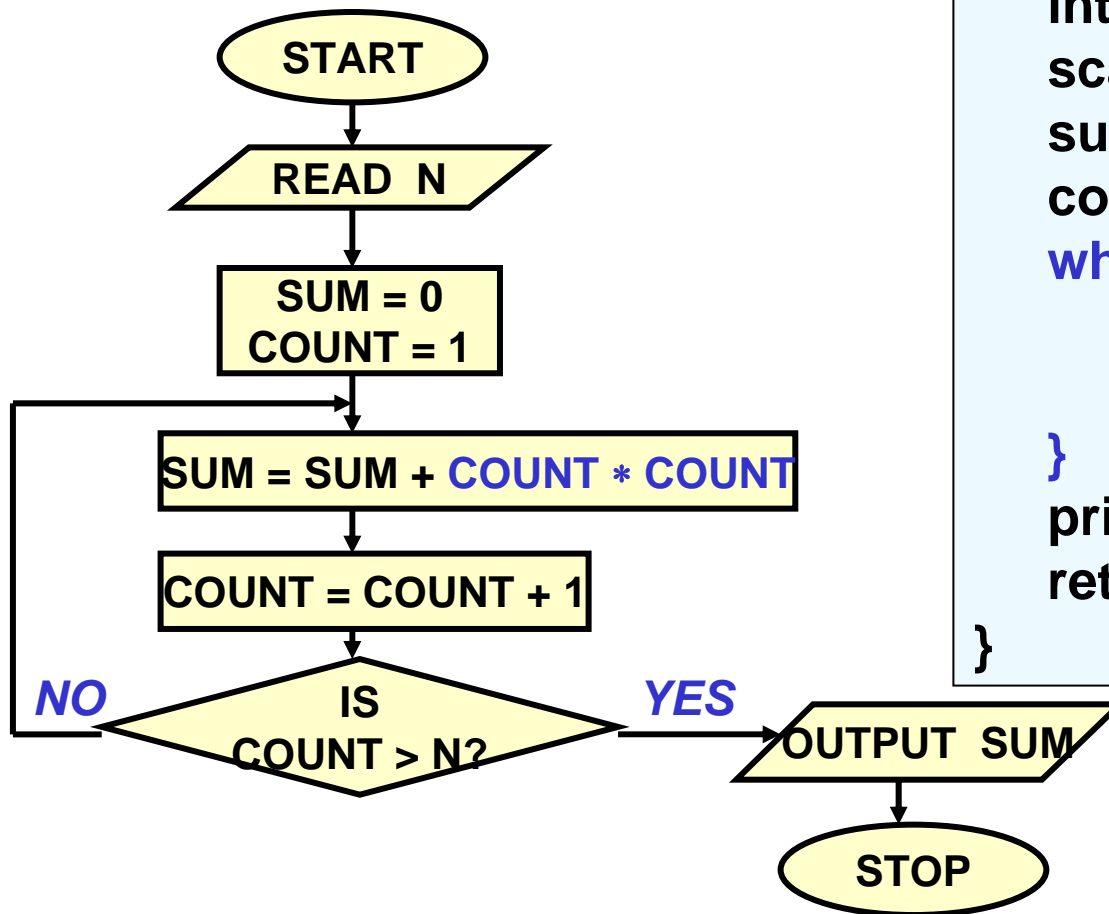


## Sum of first $N$ natural numbers



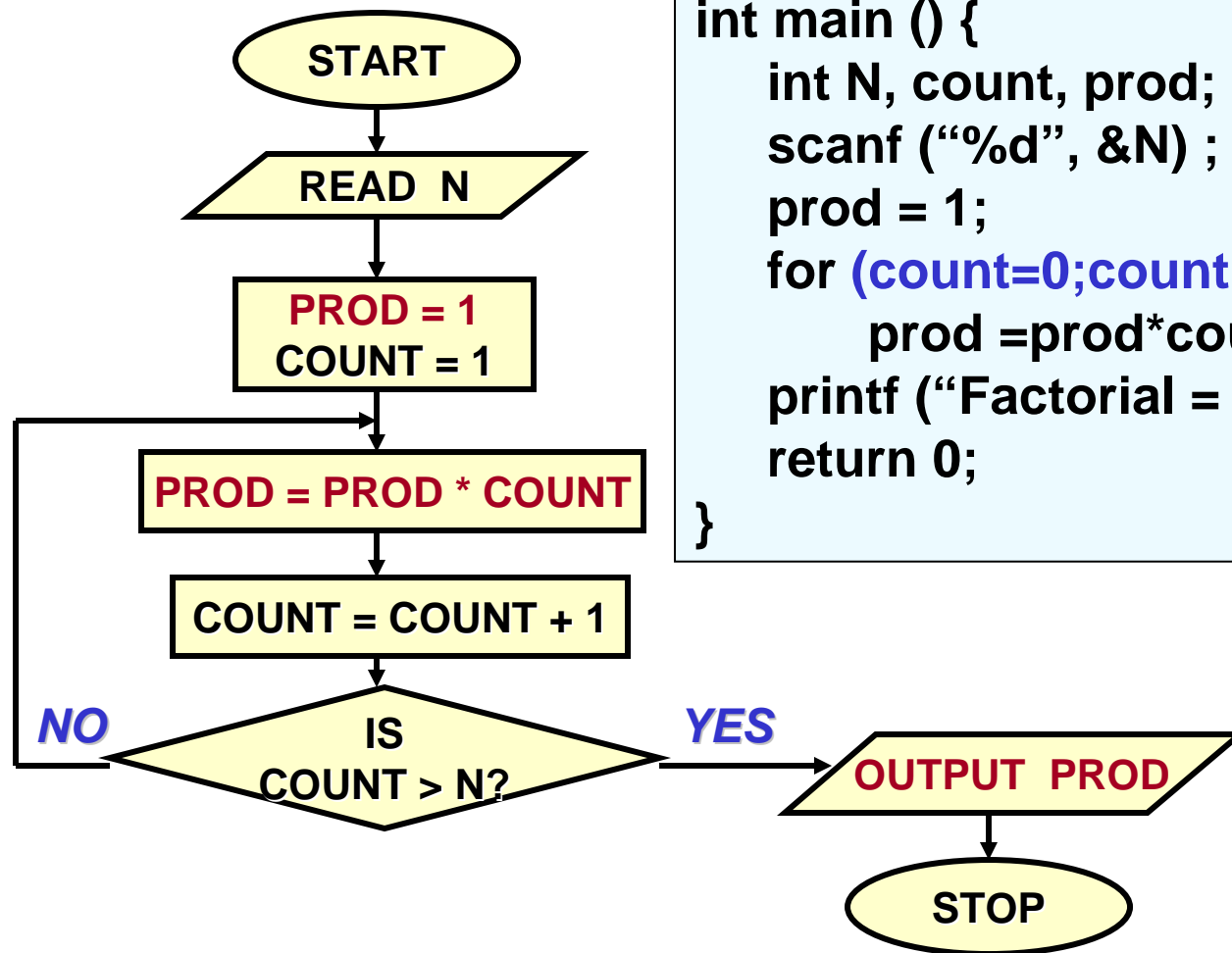
```
int main () {  
    int N, count, sum;  
    scanf ("%d", &N) ;  
    sum = 0;  
    count = 1;  
    for (count=1;count <= N;count++) {  
        sum = sum + count;  
    }  
    printf ("Sum = %d\n", sum) ;  
    return 0;  
}
```

## Example 5: $SUM = 1^2 + 2^2 + 3^2 + N^2$



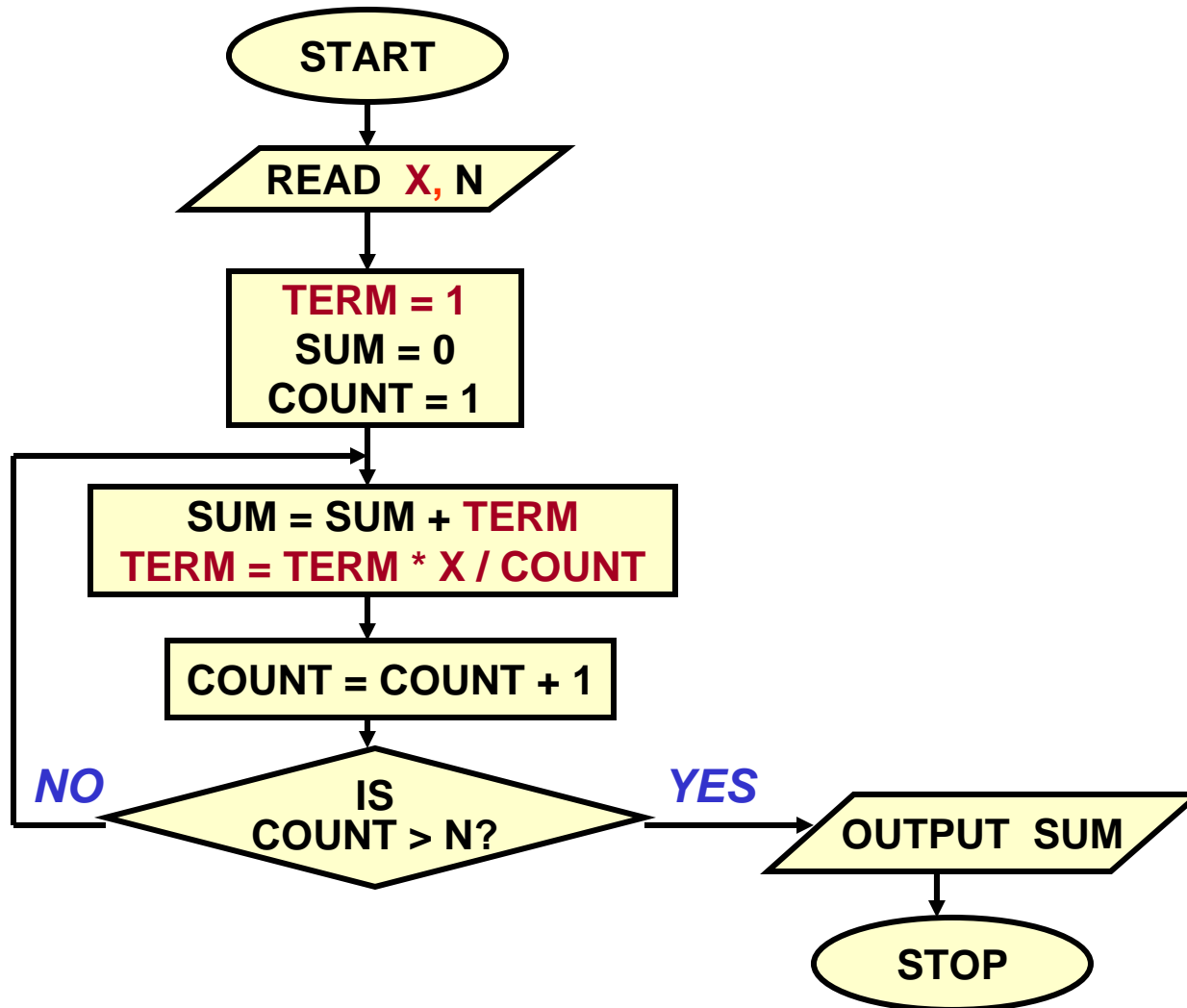
```
int main () {  
    int N, count, sum;  
    scanf ("%d", &N) ;  
    sum = 0;  
    count = 1;  
    while (count <= N) {  
        sum = sum + count*count;  
        count = count + 1;  
    }  
    printf ("Sum = %d\n", sum) ;  
    return 0;  
}
```

## Example: Computing Factorial



```
int main () {  
    int N, count, prod;  
    scanf ("%d", &N) ;  
    prod = 1;  
    for (count=0;count < N; count++) {  
        prod =prod*count;  
    }  
    printf ("Factorial = %d\n", prod) ;  
    return 0;  
}
```

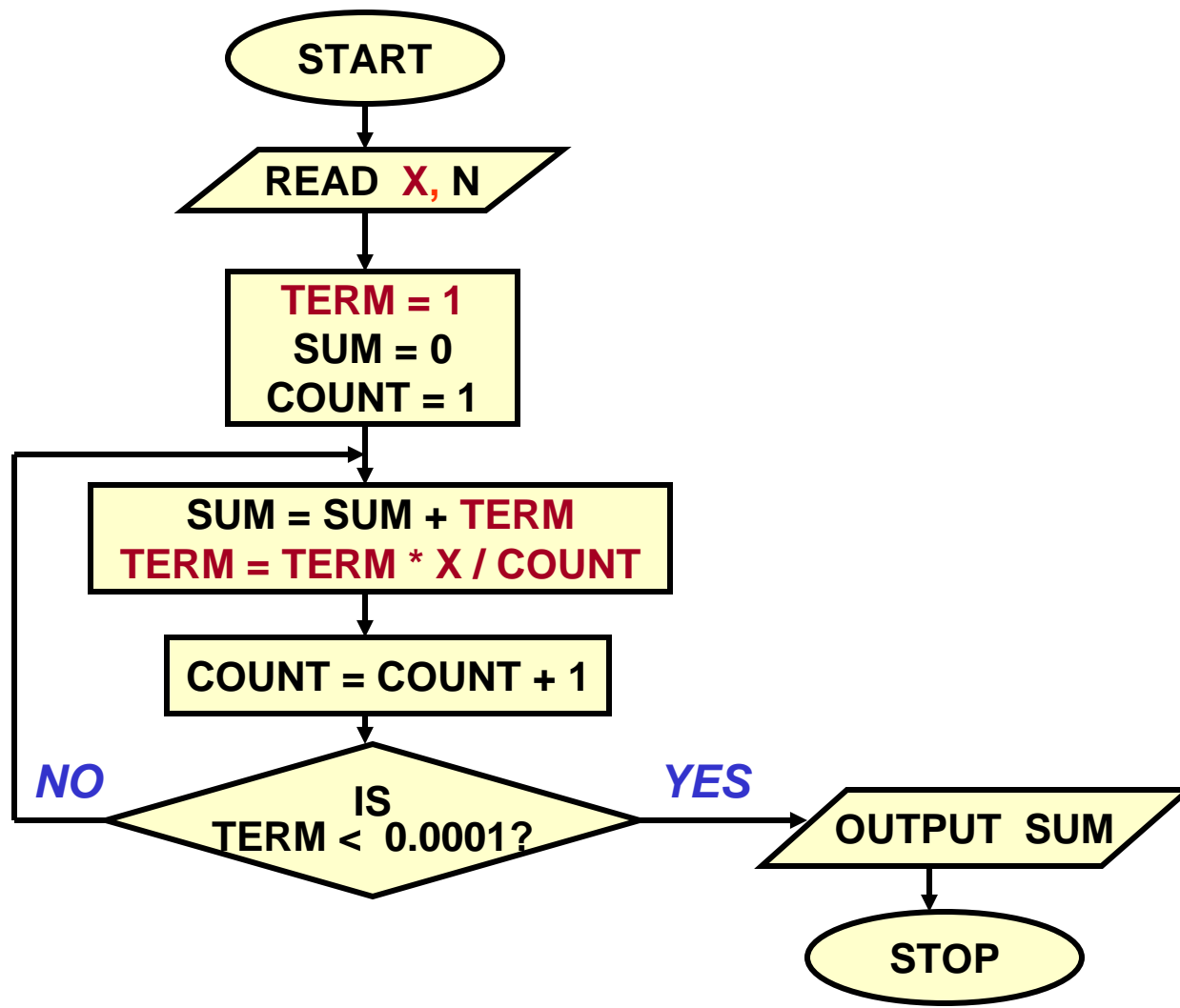
## Example: Computing $e^x$ series up to $N$ terms





```
int main () {
    float x, term, sum;
    int n, count;
    scanf ("%d", &x) ;
    scanf ("%d", &n) ;
    term = 1.0; sum = 0;
    for (count = 0; count < n; count++) {
        sum += term;
        term *= x/count;
    }
    printf ("%f\n", sum) ;
}
```

## Example 8: Computing $e^x$ series up to 4 decimal places



```
int main () {  
    float x, term, sum;  
    int n, count;  
    scanf ("%d", &x) ;  
    scanf ("%d", &n) ;  
    term = 1.0; sum = 0;  
    for (count = 0; term<0.0001; count++) {  
        sum += term;  
        term *= x/count;  
    }  
    printf ("%f\n", sum) ;  
}
```

## Example 1: Test if a number is prime or not

```
#include <stdio.h>
int main() {
    int n, i=2;
    scanf ("%d", &n);
    while (i < n) {
        if (n % i == 0) {
            printf ("%d is not a prime \n", n);
            exit;
        }
        i++;
    }
    printf ("%d is a prime \n", n);
}
```

## More efficient??

```
#include <stdio.h>
main()
{
    int n, i=3;
    scanf ("%d", &n);
    while (i < sqrt(n)) {
        if (n % i == 0) {
            printf ("%d is not a prime \n", n);
            exit;
        }
        i = i + 2;
    }
    printf ("%d is a prime \n", n);
}
```

## Example 2: Find the sum of digits of a number

```
#include <stdio.h>
main()
{
    int  n, sum=0;
    scanf ("%d", &n);
    while (n != 0) {
        sum = sum + (n % 10);
        n = n / 10;
    }
    printf ("The sum of digits of the number is %d \n", sum);
}
```

## Example 3: Decimal to binary conversion

```
#include <stdio.h>
main()
{
    int dec;
    scanf ("%d", &dec);
    do
    {
        printf ("%2d", (dec % 2));
        dec = dec / 2;
    } while (dec != 0);
    printf ("\n");
}
```

## Example 4: Compute GCD of two numbers

```
#include <stdio.h>
main()
{
    int A, B, temp;
    scanf ("%d %d", &A, &B);
    if (A > B) { temp = A; A = B; B = temp; }
    while ((B % A) != 0) {
        temp = B % A;
        B = A;
        A = temp;
    }
    printf ("The GCD is %d", A);
}
```

$$\begin{array}{r} 12 \ ) \ 45 \ ( \ 3 \\ \underline{36} \\ 9 \ ) \ 12 \ ( \ 1 \\ \underline{9} \\ 3 \ ) \ 9 \ ( \ 3 \\ \underline{9} \\ 0 \end{array}$$

*Initial:            A=12, B=45*  
*Iteration 1: temp=9, B=12, A=9*  
*Iteration 2: temp=3, B=9, A=3*  
*B % A = 0    →    GCD is 3*



# More about scanf and printf

# Entering input data :: scanf function

- **General syntax:**

**scanf (control string, arg1, arg2, ..., argn);**

- “control string refers to a string typically containing data types of the arguments to be read in;
- the arguments arg1, arg2, ... represent pointers to data items in memory.

**Example: scanf ("%d %f %c", &a, &average, &type);**

- **The control string consists of individual groups of characters, with one character group for each input data item.**
  - ‘%’ sign, followed by a conversion character.

– **Commonly used conversion characters:**

- c**      **single character**
- d**      **decimal integer**
- f**      **floating-point number**
- s**      **string terminated by null character**
- X**      **hexadecimal integer**

– **We can also specify the maximum field-width of a data item, by specifying a number indicating the field width before the conversion character.**

**Example:** `scanf ("%3d %5d", &a, &b);`

# Writing output data :: printf function

- **General syntax:**

- `printf (control string, arg1, arg2, ..., argn);`

- “control string refers to a string containing formatting information and data types of the arguments to be output;
    - the arguments arg1, arg2, ... represent the individual output data items.

- **The conversion characters are the same as in scanf.**

- **Examples:**

```
printf ("The average of %d and %d is %f", a, b, avg);
```

```
printf ("Hello \nGood \nMorning \n");
```

```
printf ("%3d %3d %5d", a, b, a*b+2);
```

```
printf ("%7.2f %5.1f", x, y);
```

- **Many more options are available:**

- Read from the book.
- Practice them in the lab.

- **String I/O:**

- Will be covered later in the class.