Control Flow: Looping

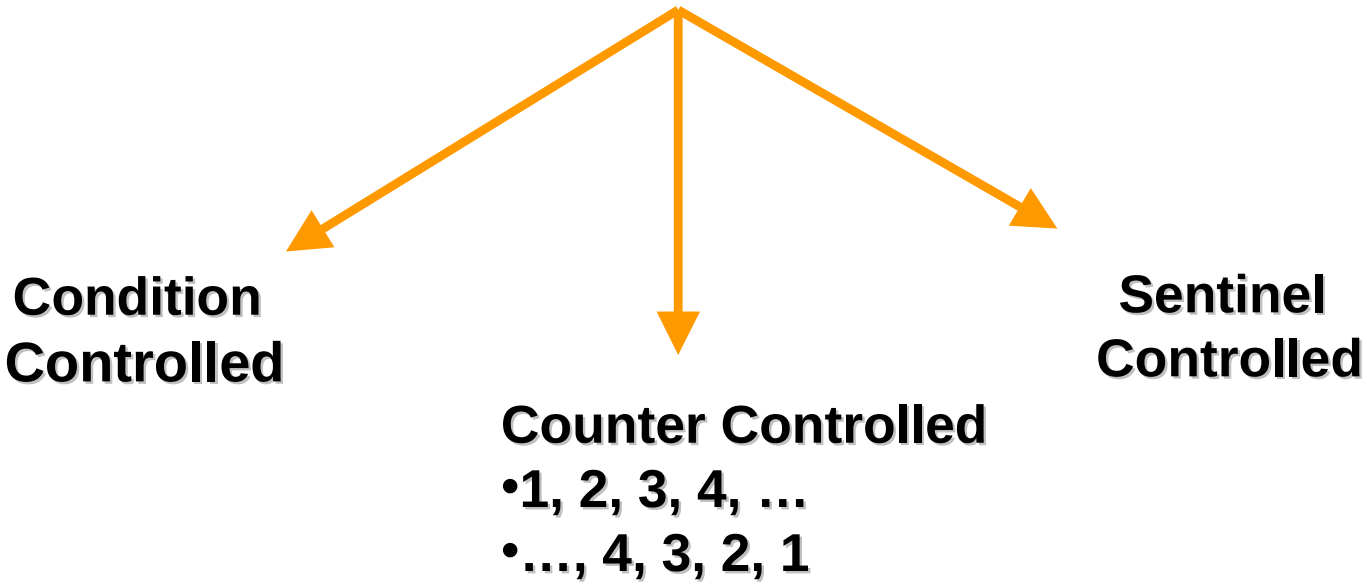
CS10001: Programming & Data Structures

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

Types of Repeated Execution

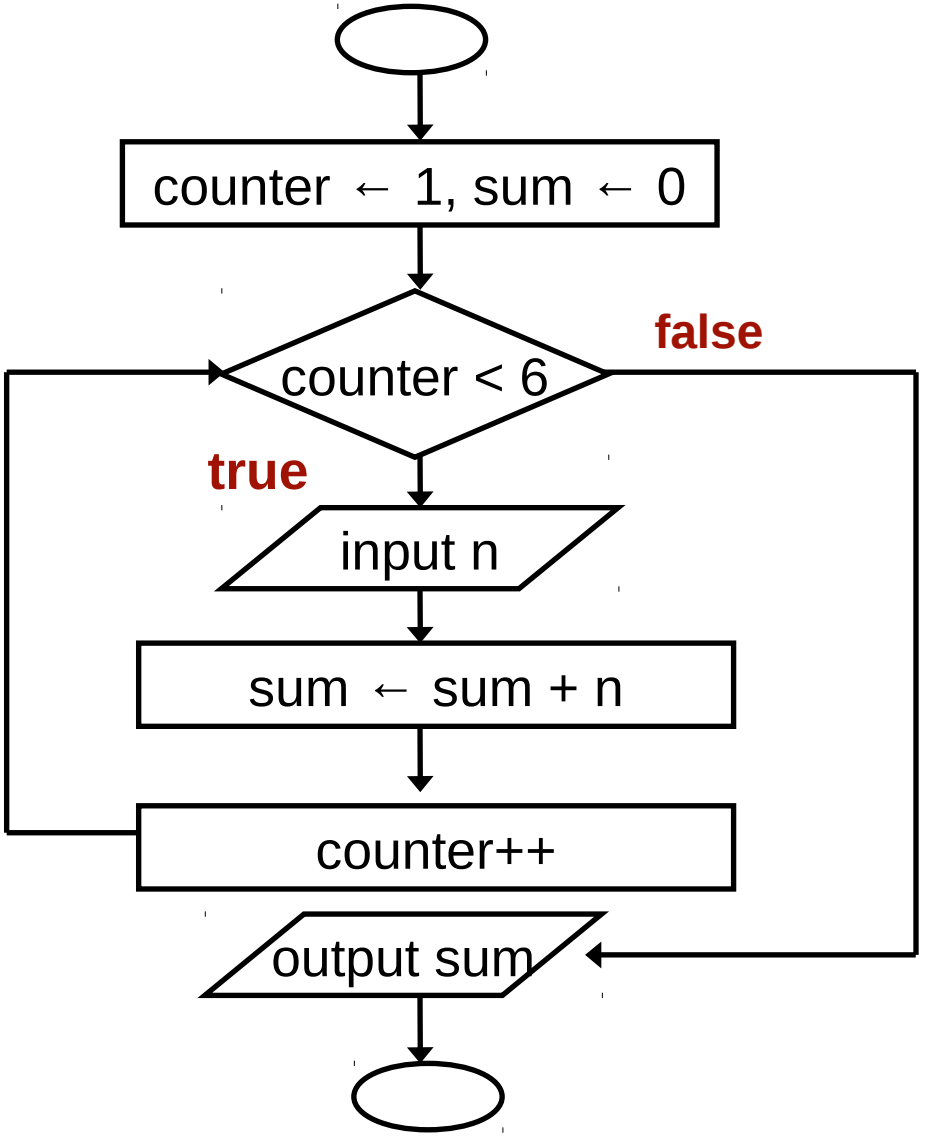
- **Loop**: Group of instructions that are executed repeatedly while some condition remains true.

How loops are controlled



Counter Controlled Loop

Read 5 integers and display the value of their summation.

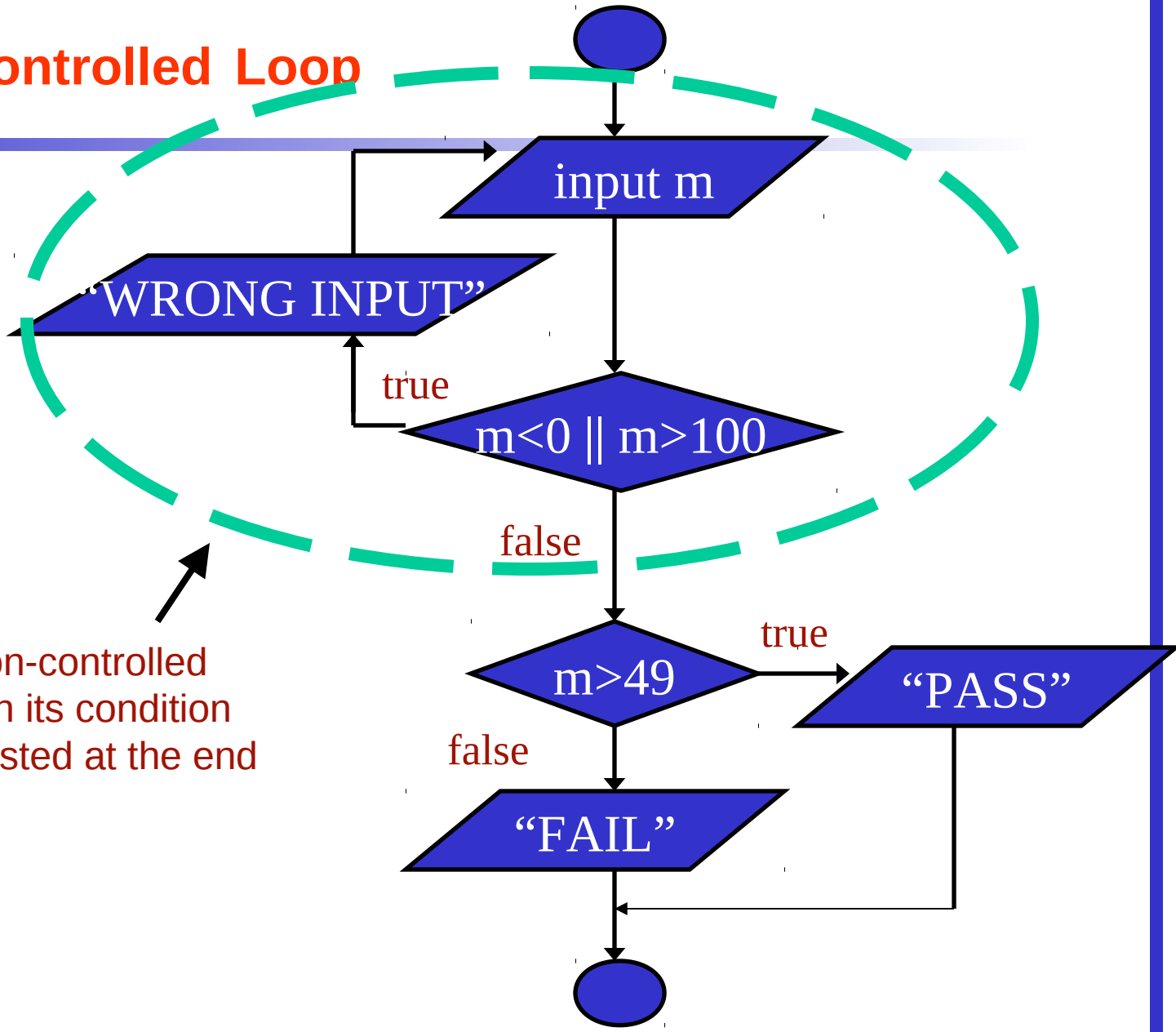


Condition-controlled Loop

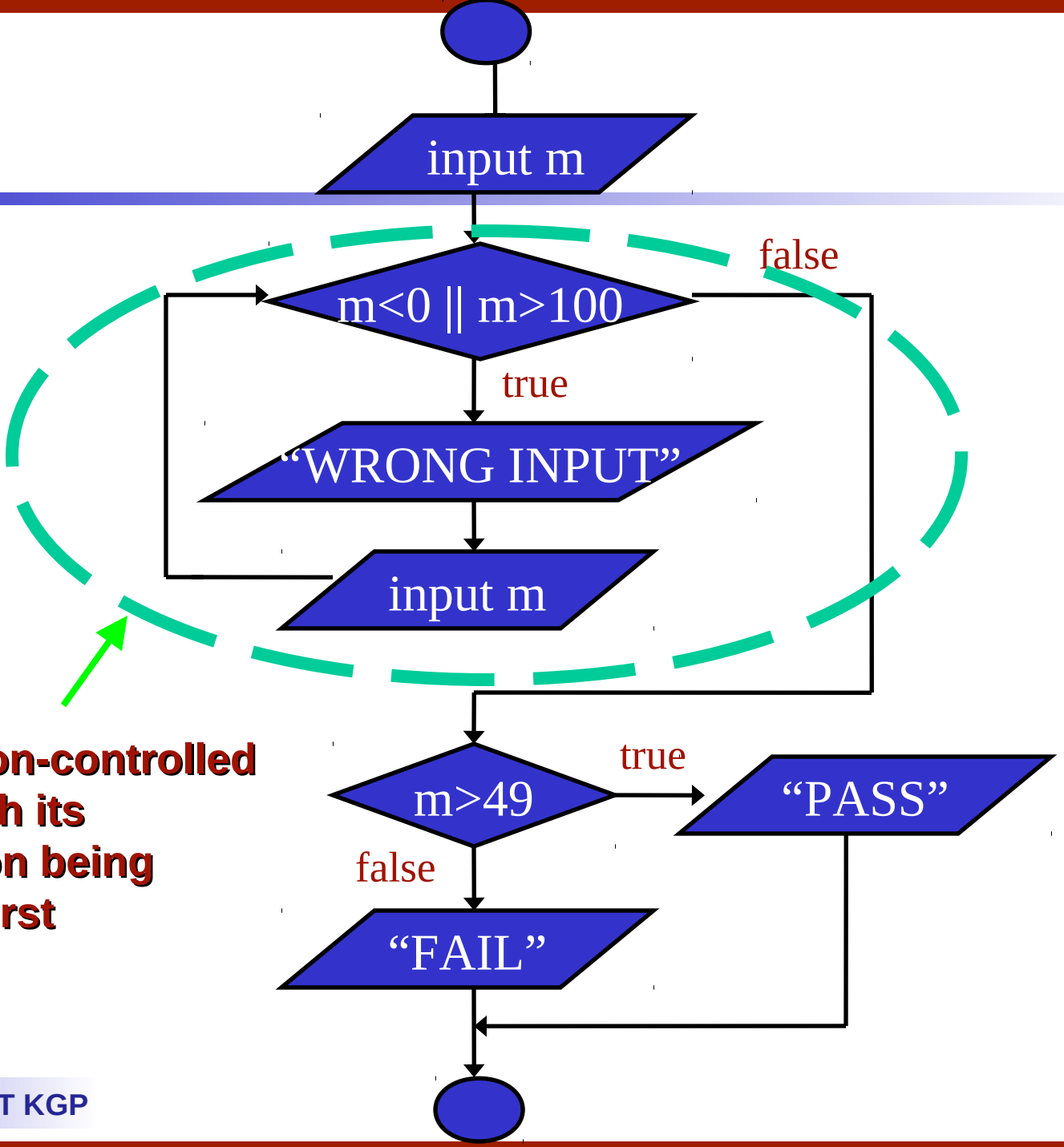
Given an exam marks as input, display the appropriate message based on the rules below:

- **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

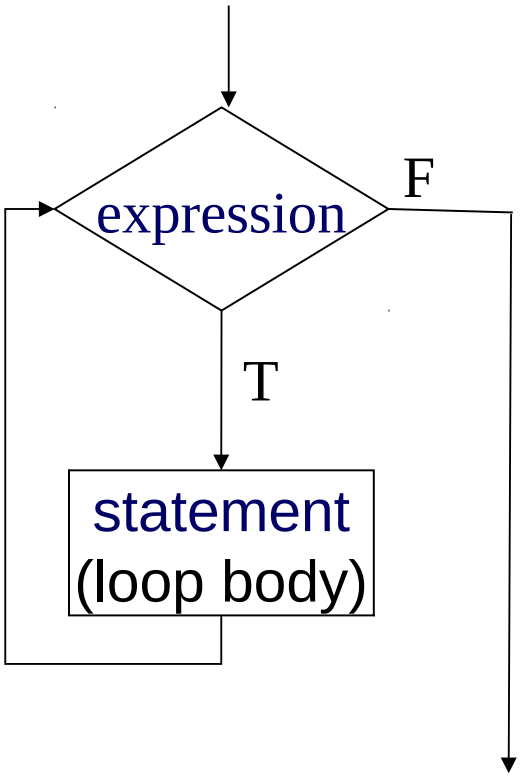
- **Output Example:**

  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;
}
```

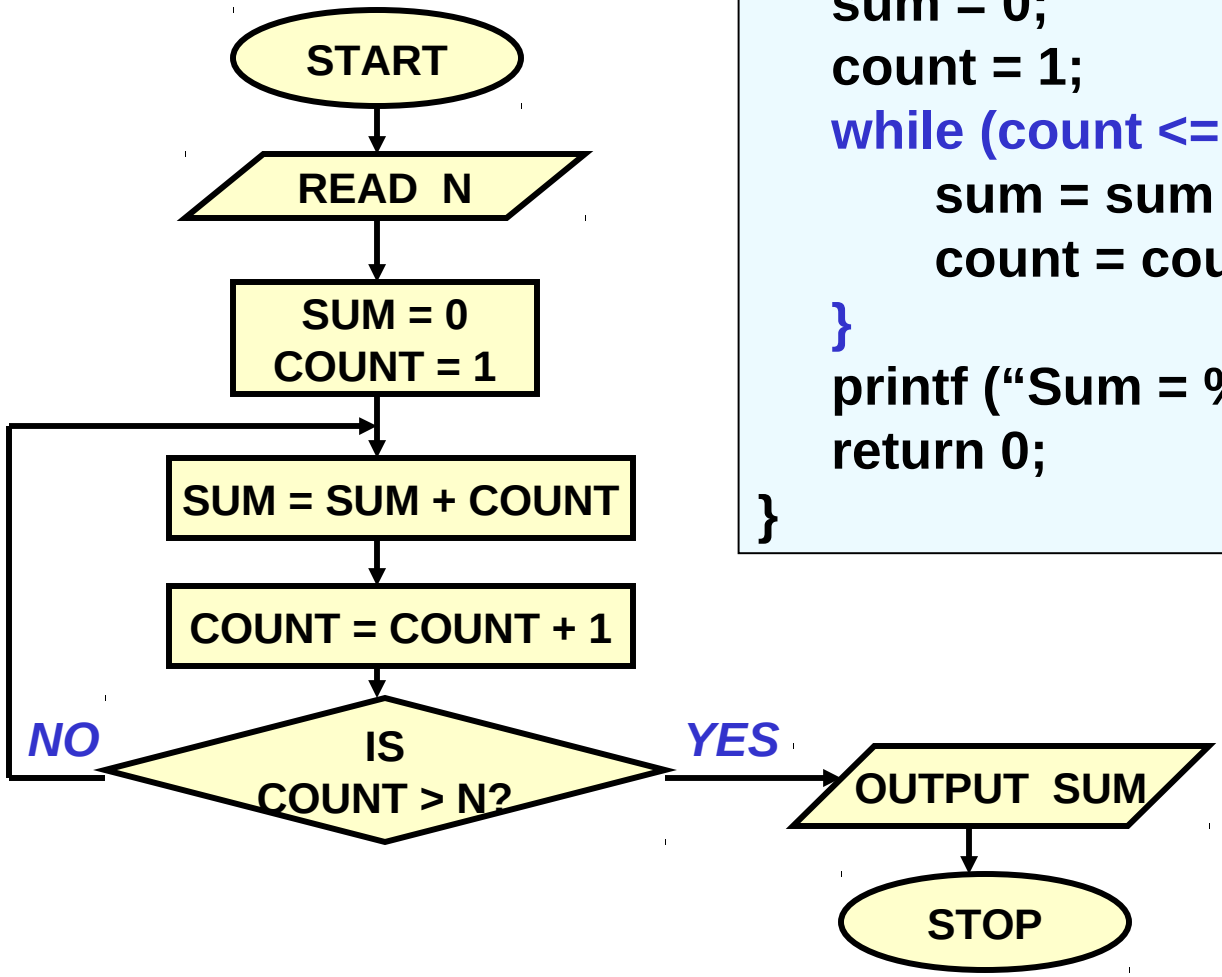
Note:
The while-loop will not be entered if the loop-control expression evaluates to false (zero) even before the first iteration.
break can be used to come out of the while loop.

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);
```

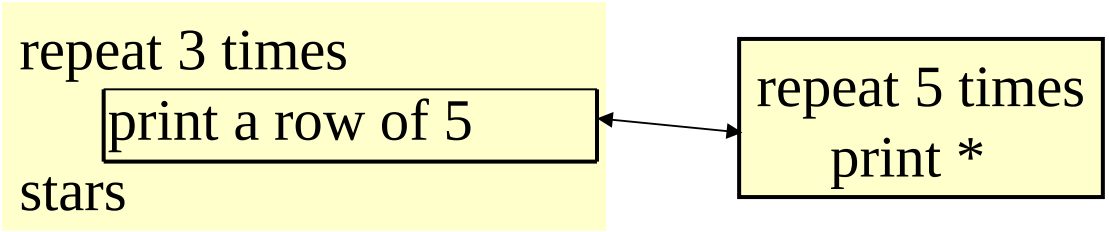
Maximum of inputs

```
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?**

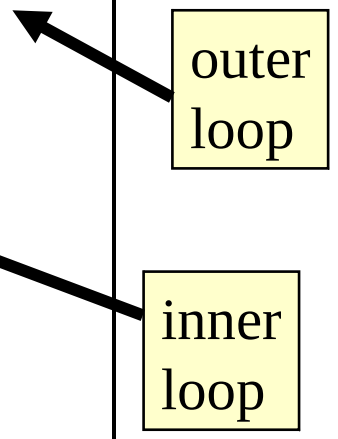
```
* * * * *
* * * * *
* * * * *
```



Nested Loops

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

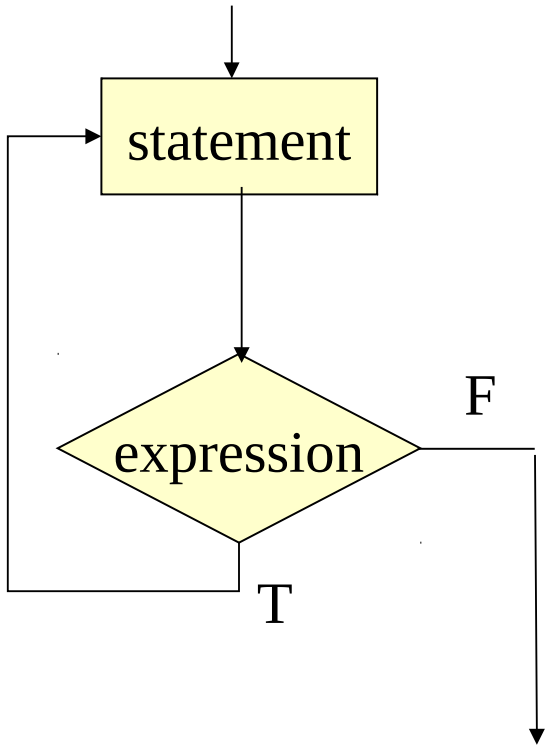
```
row=1;
while (row <= ROWS) {
      /* print a row of 5 *'s */
      col=1;
      while (col <= COLS) {
            printf ("* ");
            col++;
      }
      printf("\n");
      row++;
}
```



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*

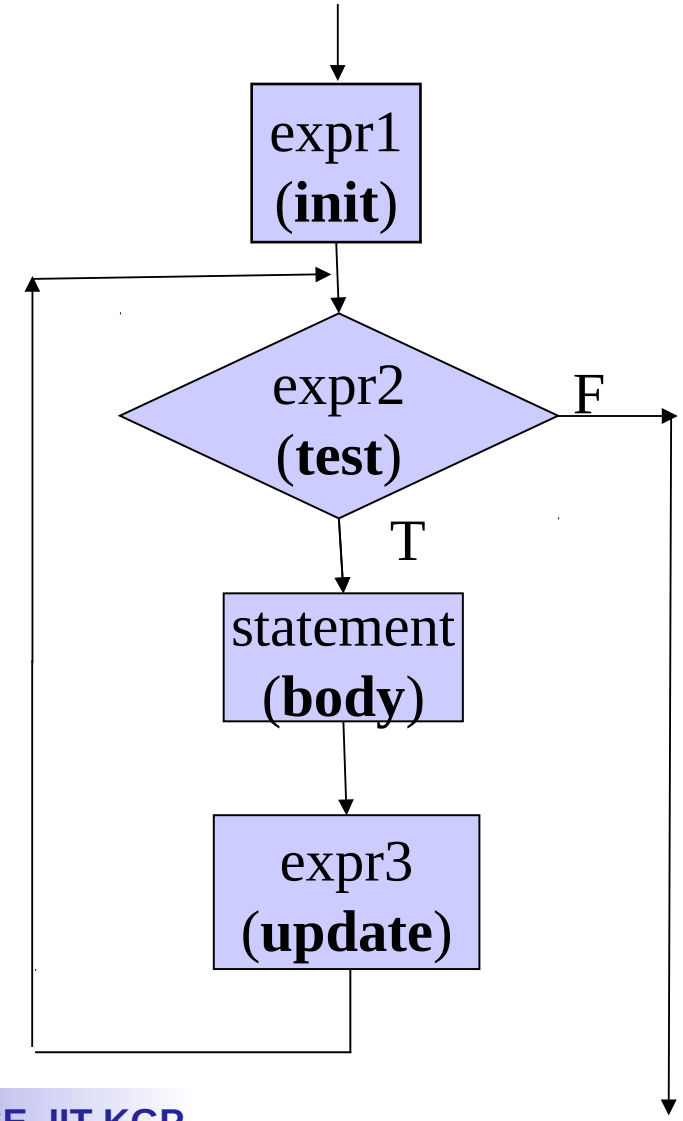
expr1 (init) : initialize parameters

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

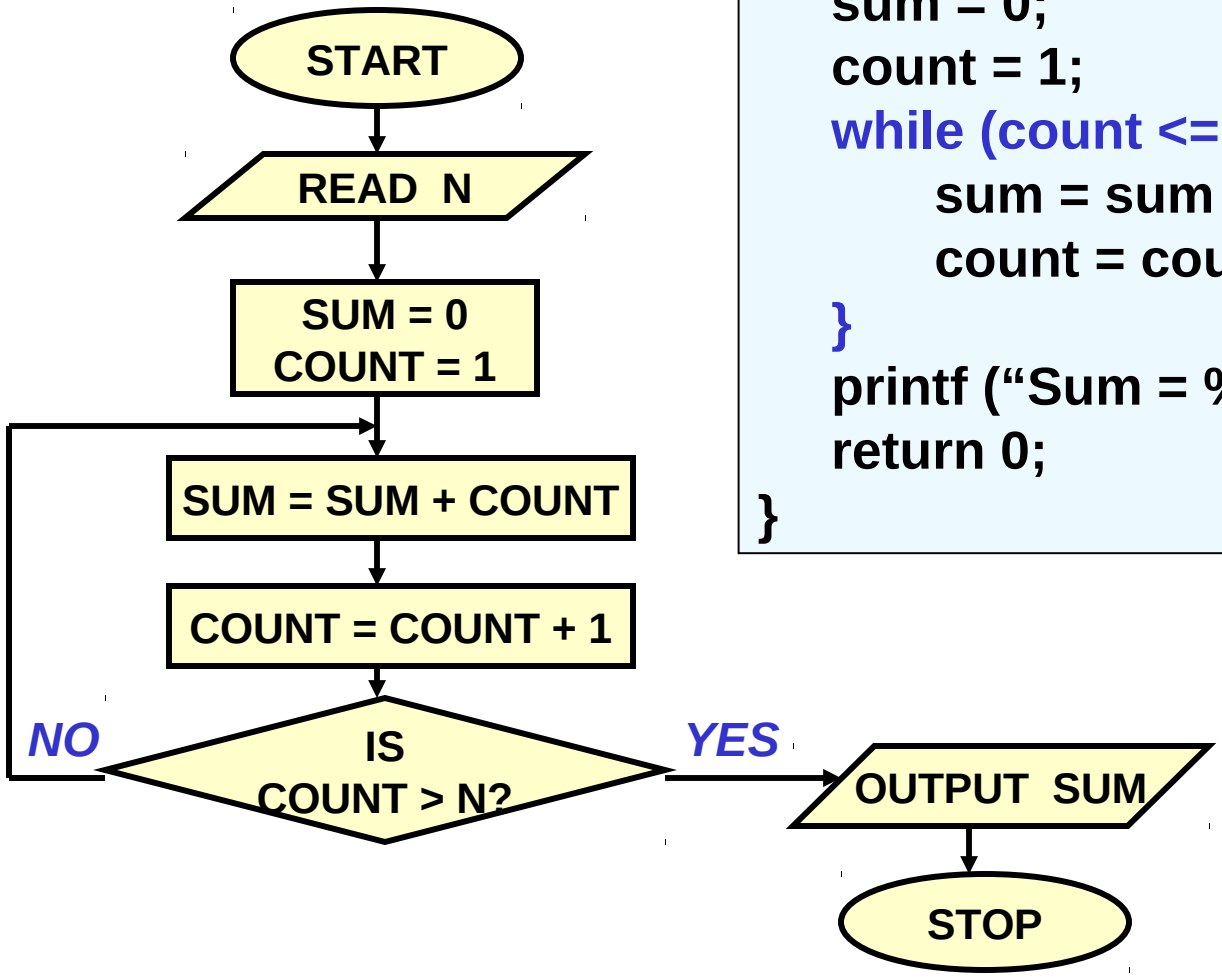
- **Skips the remaining statements in the body of a *while*, *for* or *do/while* structure.**
  - **Proceeds with the next iteration of the loop.**
- **while and do/while**
  - **Loop-continuation test is evaluated immediately after the continue statement is executed.**
- **for structure**
  - ***expression3*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

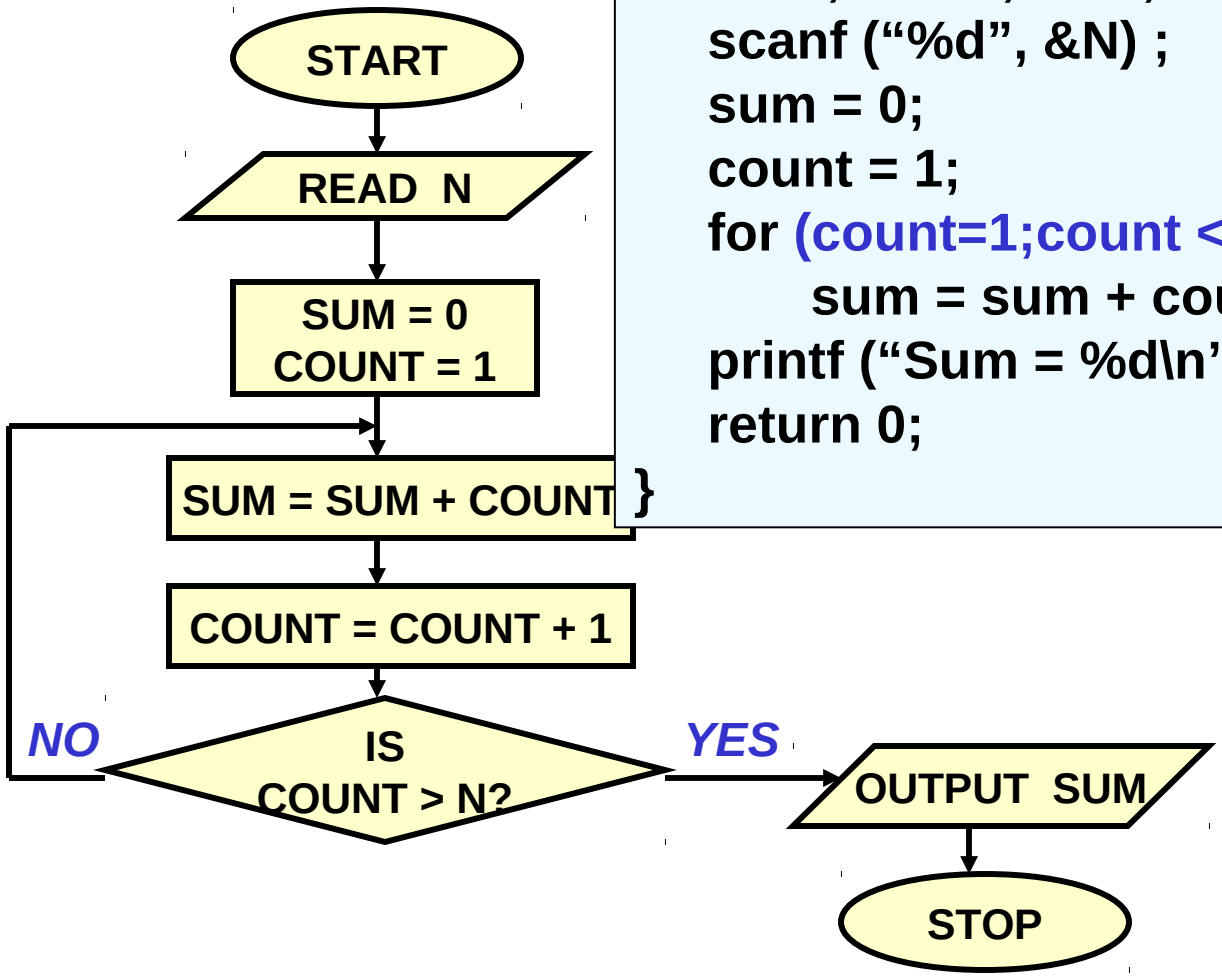
Some Examples

Sum of first N natural numbers



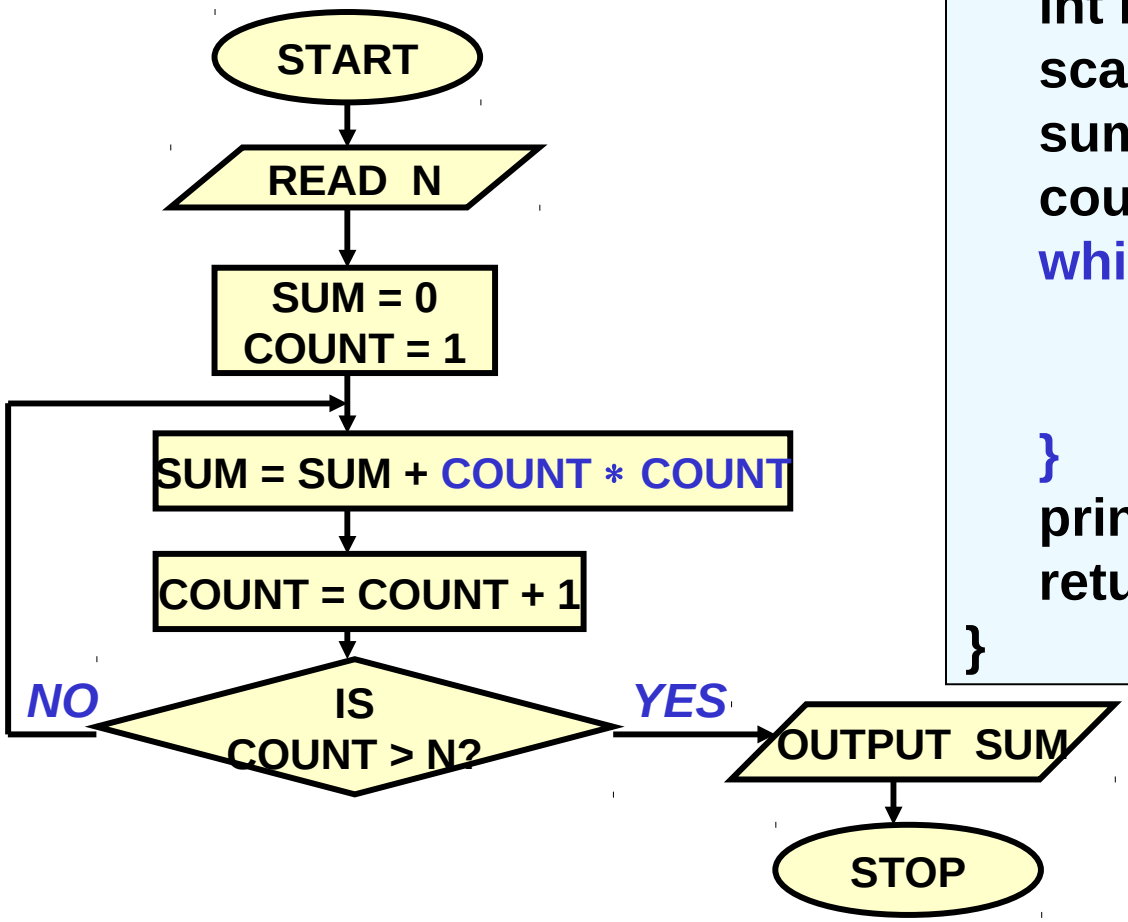

```
int main () {
    int N, count, sum;
    scanf ("%d", &N) ;
    sum = 0;
    count = 1;
    while (count <= N)  {
        sum = sum + count;
        count = count + 1;
    }
    printf ("Sum = %d\n", sum) ;
    return 0;
}
```

Sum of first N natural numbers



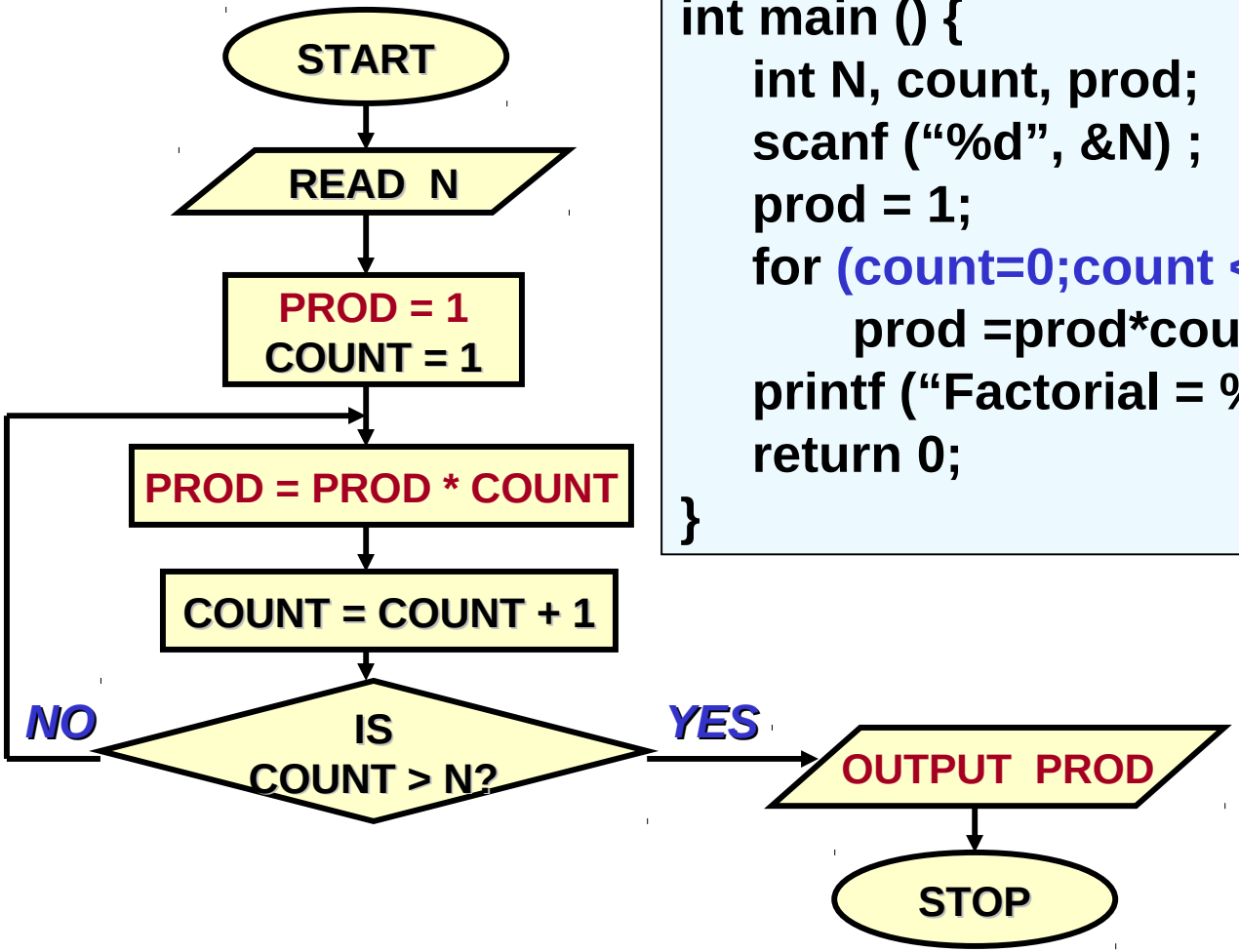

```
int main () {
    int N, count, sum;
    scanf ("%d", &N) ;
    sum = 0;
    count = 1;
    for (count=1;count <= N;count++)  {
        sum = sum + count;
    printf ("Sum = %d\n", sum) ;
    return 0;
}
```

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



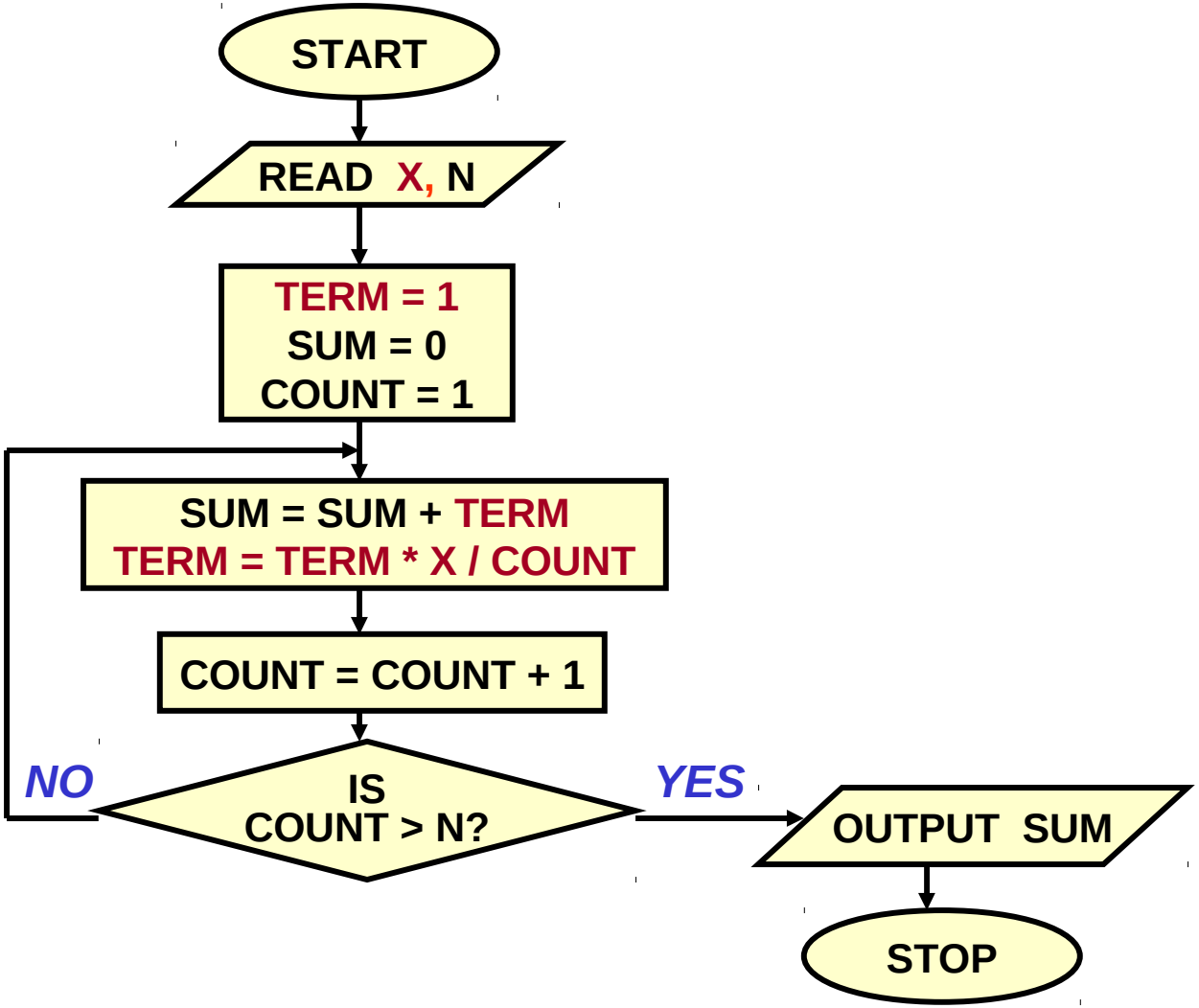

```
int main () {
    int N, count, sum;
    scanf ("%d", &N) ;
    sum = 0;
    count = 1;
    while (count <= N)  {
        sum = sum + count*count;
        count = count + 1;
    }
    printf ("Sum = %d\n", sum) ;
    return 0;
}
```

Example: *Computing Factorial*



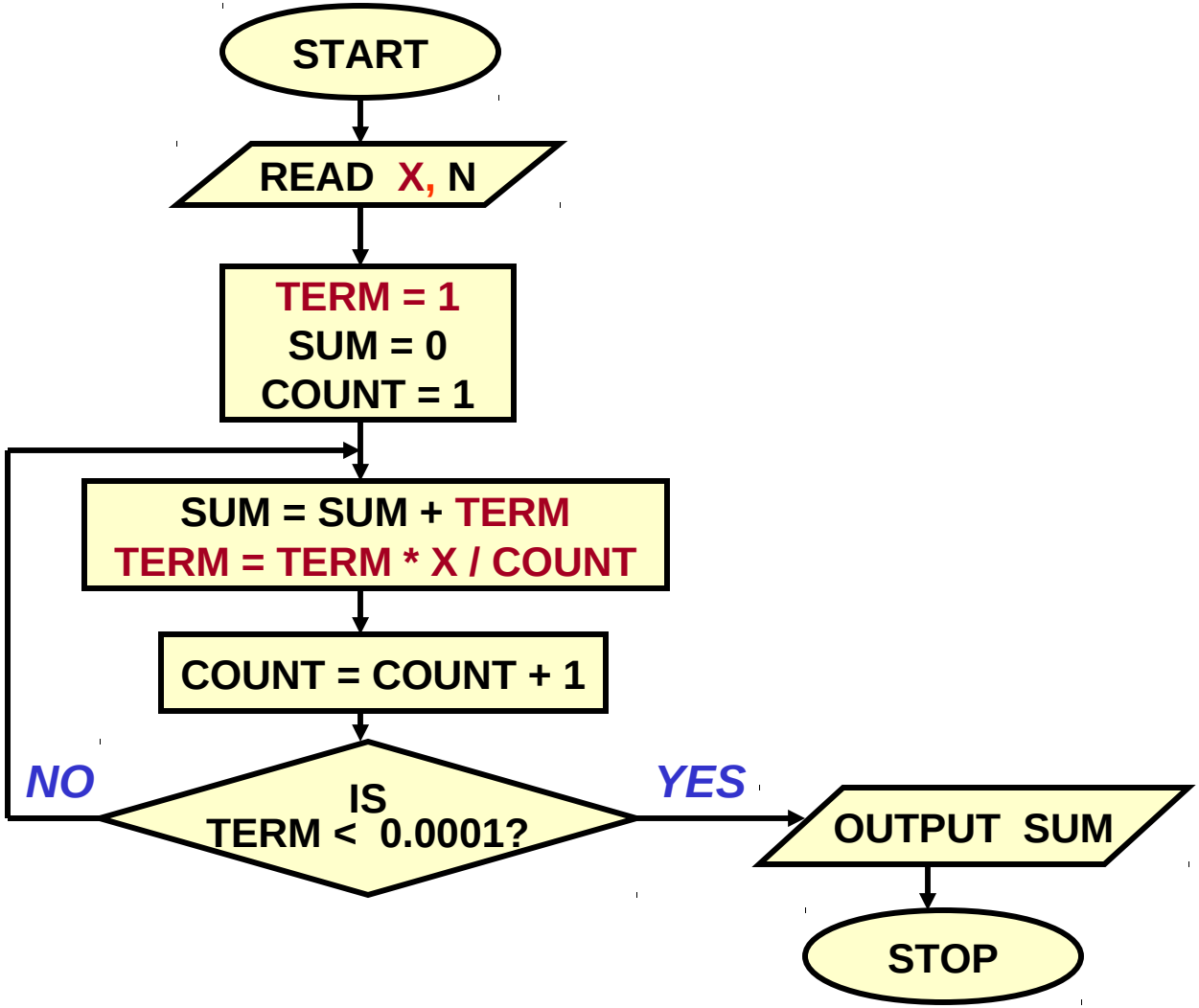

```
int main () {
    int N, count, prod;
    scanf ("%d", &N) ;
    prod = 1;
    for (count=0;count < N; count++)  {
        prod =prod*count;
    printf ("Factorial = %d\n", prod) ;
    return 0;
}
```

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);
}
```

```
12 )  45  (  3
      36
      --
       9 )  12  (  1
              9
              -
              3 )  9  (  3
                     9
                     -
                     0
```

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.