



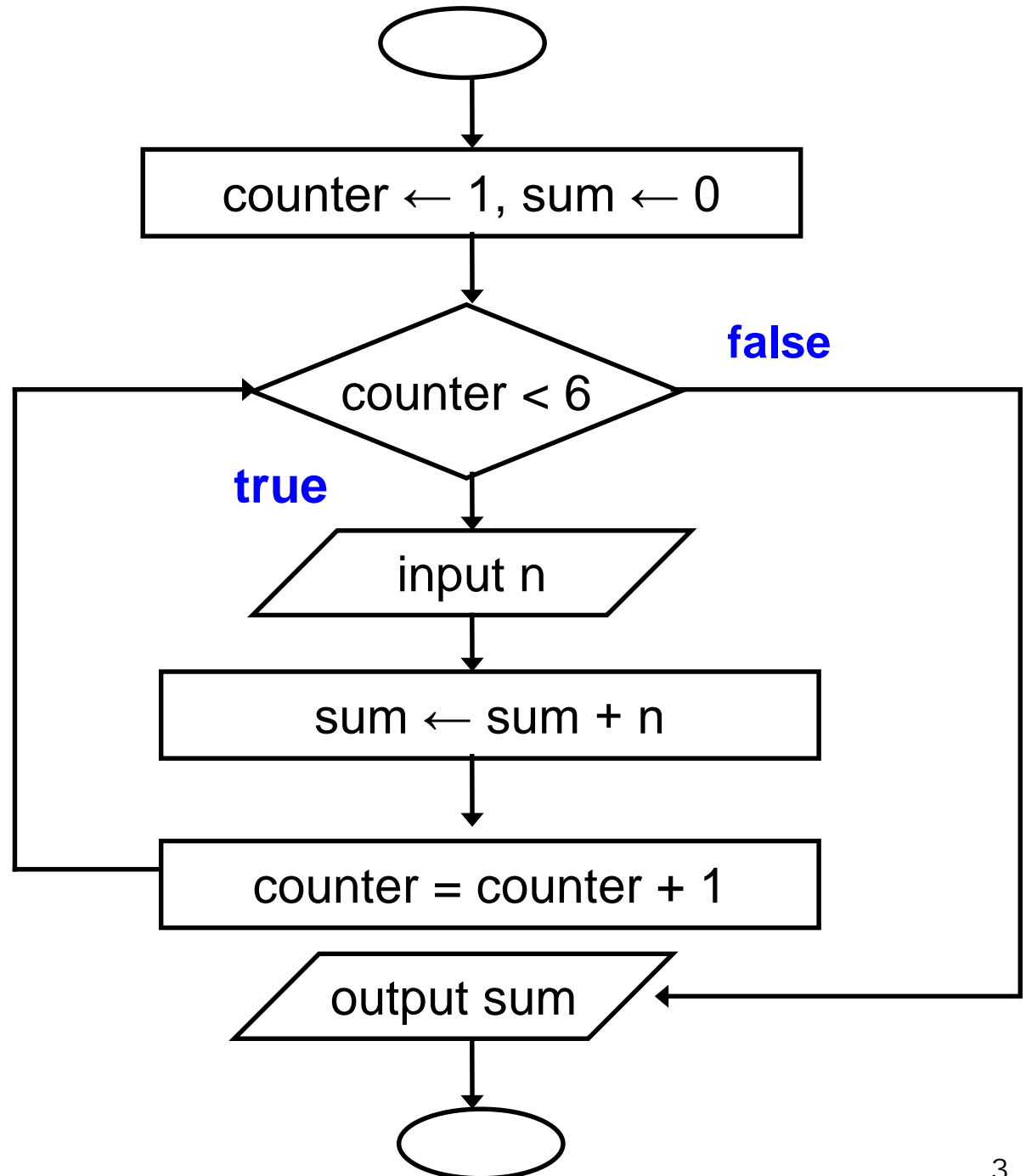
Looping

Loops

- Group of statements that are executed repeatedly while some condition remains true
- Each execution of the group of statements is called an **iteration** of the loop

Example

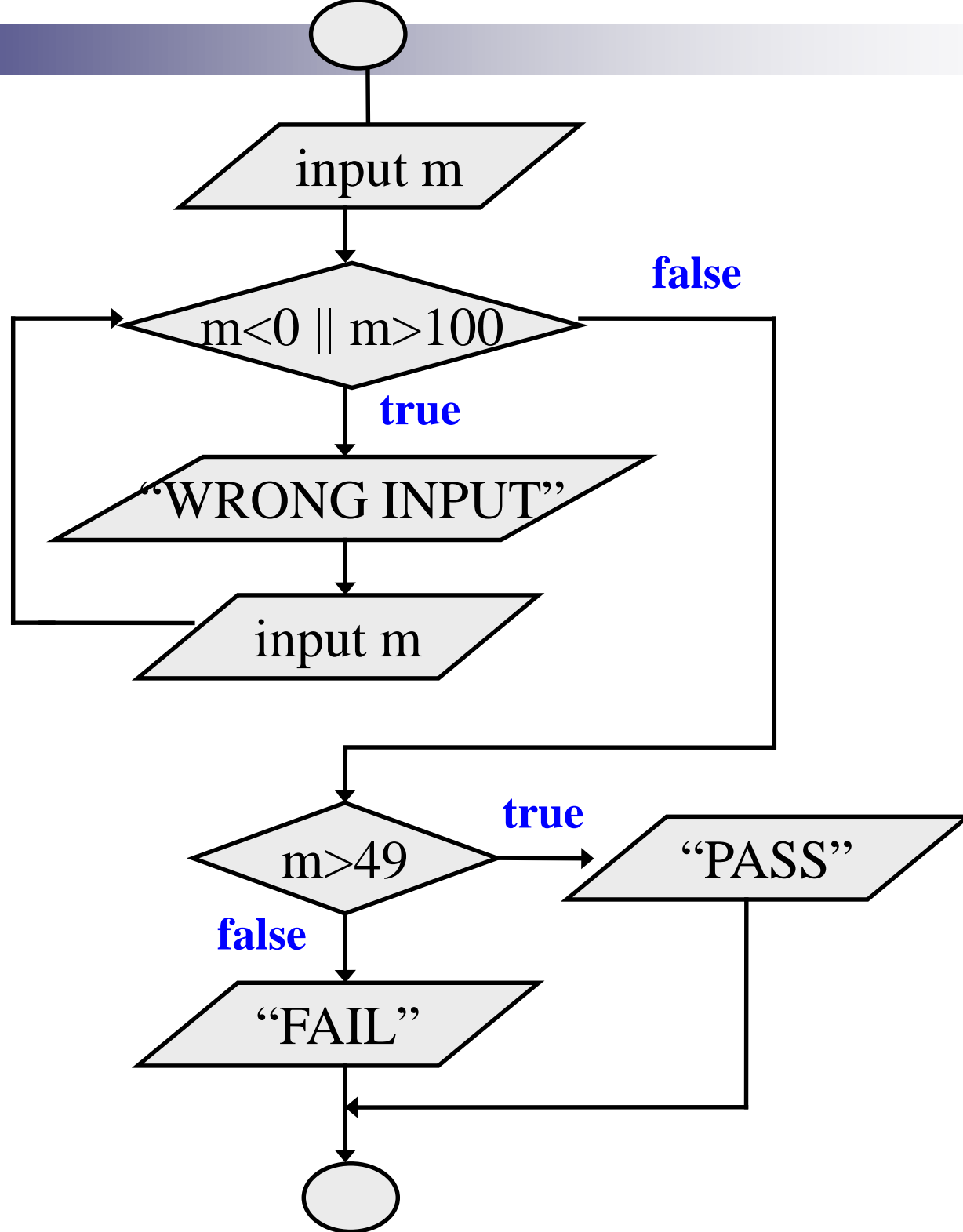
Read 5 integers
and display the
their sum

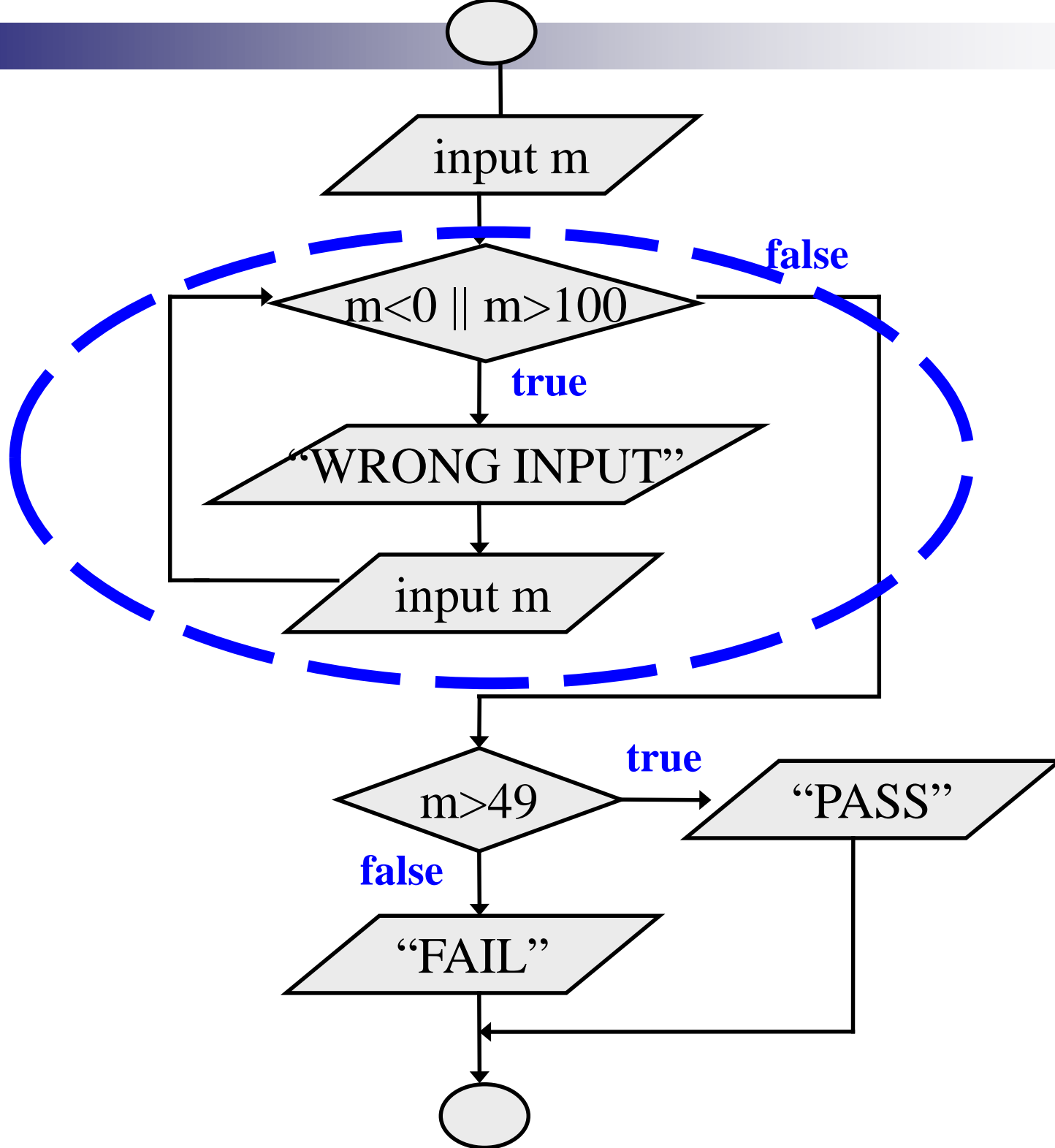


Example

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





Looping: **while** statement

```
while (expression)  
    statement;
```

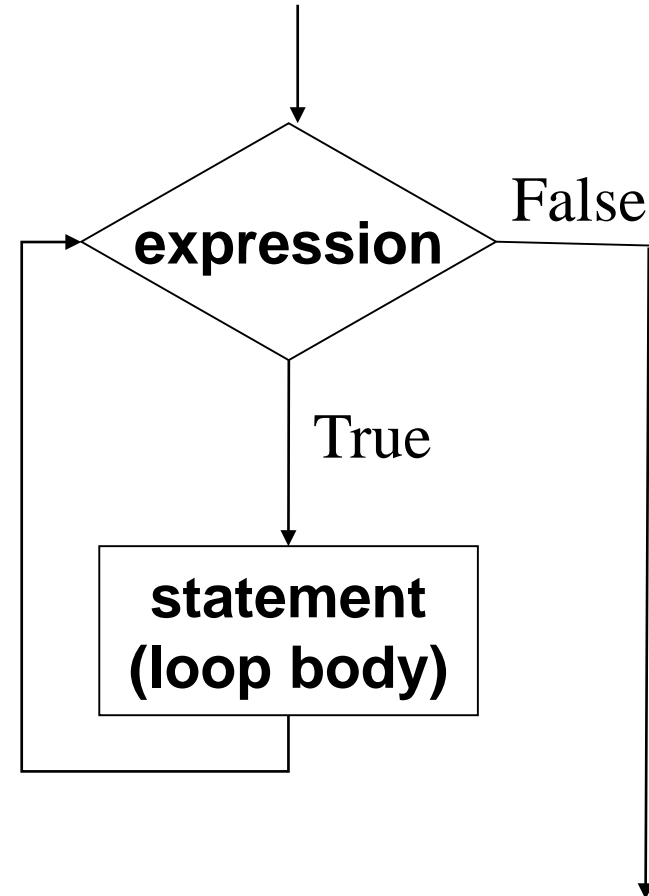
```
while (expression) {  
    Block of statements;  
}
```

The condition to be tested is any expression enclosed in parentheses. The expression is evaluated, and if its value is non-zero, the statement is executed. Then the expression is evaluated again and the same thing repeats. The loop **terminates** when the expression evaluates to 0.

Looping: **while** statement

```
while (expression)  
    statement;
```

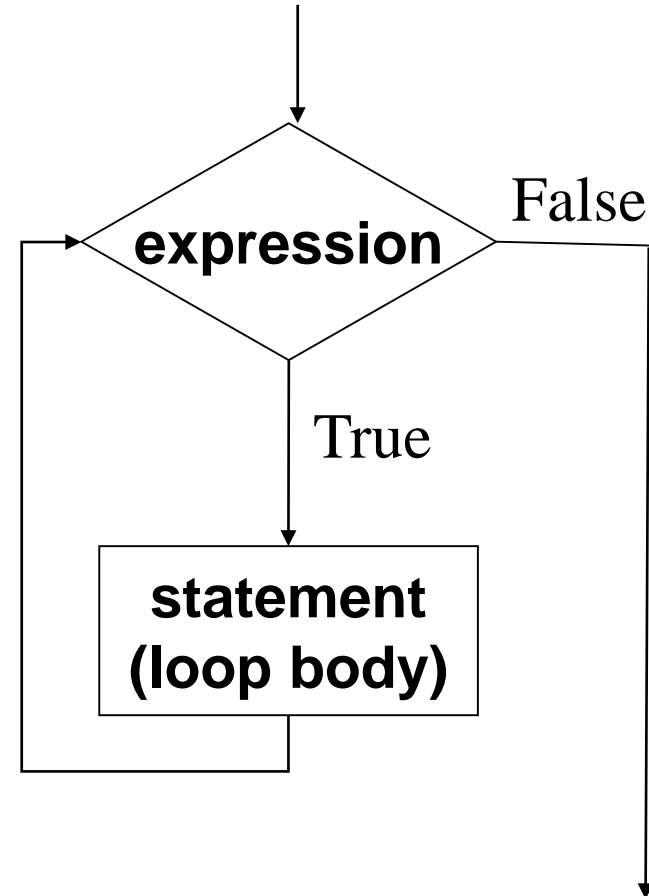
```
while (expression) {  
    Block of statements;  
}
```



Looping: **while** statement

```
while (expression)  
    statement;
```

```
while (expression) {  
    Block of statements;  
}
```



The condition to be tested is any expression enclosed in parentheses. The expression is evaluated, and if its value is non-zero, the statement is executed. Then the expression is evaluated again and the same thing repeats. The loop **terminates** when the expression evaluates to 0.

Example

```
int main()
{
    int i = 1, n;
    scanf("%d", &n);
    while (i <= n) {
        printf ("Line no : %d\n",i);
        i = i + 1;
    }
}
```

Output

```
4
Line no : 1
Line no : 2
Line no : 3
Line no : 4
```

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 of first %d numbers = %d\n", N, sum);  
    return 0;  
}
```

Output

```
9  
Sum of first 9 numbers = 45
```

Double your money

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

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

Maximum of positive numbers

```
int main() {  
    double max = 0.0, next;  
    printf ("Enter positive numbers only, end with 0 or a  
negative number\n");  
    scanf("%lf", &next);  
    while (next > 0) {  
        if (next > max) max = next;  
        scanf("%lf", &next);  
    }  
    printf ("The maximum number is %lf\n", max) ;  
    return 0;  
}
```

Output

Enter positive numbers only, end with 0 or a negative number

45

32

7

5

0

The maximum number is 45.000000

Find the sum of digits of a number

```
int main()
{
    int n, sum=0;
    scanf ("%d", &n);
    while (n != 0) {
        sum = sum + (n % 10);
        n = n / 10;
    }
    printf ("The sum of digits is %d\n", sum);
    return 0;
}
```

Output

```
573254
The sum of digits is 26
```

Compute GCD of two numbers

```
int 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);  
    return 0;  
}
```

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

Initial: $A=12, B=45$
Iteration 1: $temp=9, B=12, A=9$
Iteration 2: $temp=3, B=9, A=3$
 $B \% A = 0 \rightarrow$ GCD is 3

Looping: **for** Statement

- Most commonly used looping structure in C

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

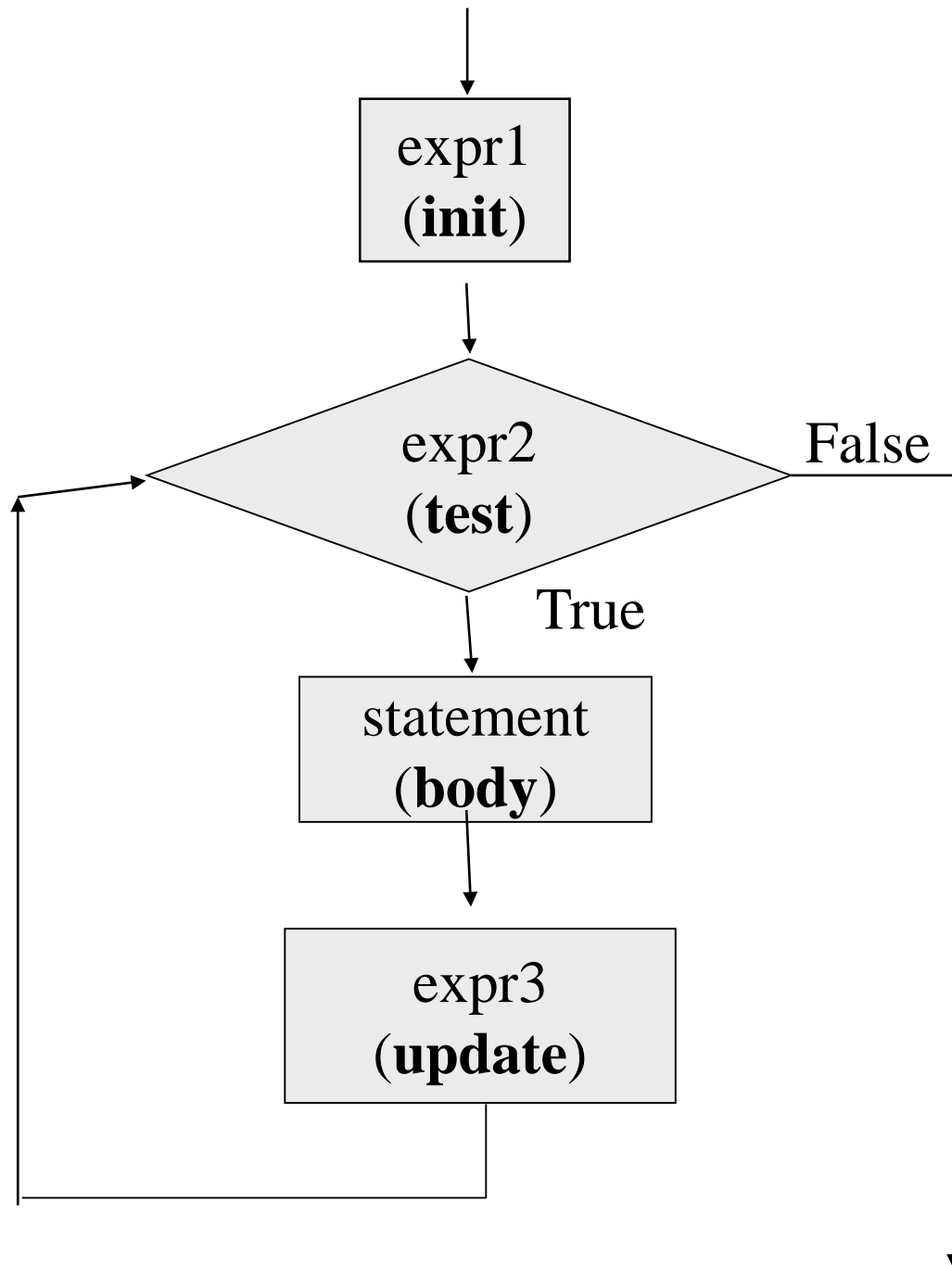
```
for ( expr1; expr2; expr3)  
{  
    Block of statements;  
}
```

expr1 (init) : initialize parameters

expr2 (test): test condition, loop continues if expression is non-0

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

statement (body): body of loop



Example: Computing Factorial

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

Output

```
7  
Factorial = 5040
```

Computing e^x series up to N terms

```
int main () {  
    float x, term, sum;  
    int n, count;  
    scanf ("%f", &x);  
    scanf ("%d", &n);  
    term = 1.0; sum = 0;  
    for (count = 1; count <= n; ++count) {  
        sum += term;  
        term *= x/count;  
    }  
    printf ("The series sum is %f\n", sum);  
    return 0;  
}
```

Output

```
2.3  
10  
The series sum is 7.506626
```

Computing e^x series up to 4 decimal places

```
int main() {  
    float x, term, sum;  
    int cnt;  
    scanf ("%f", &x) ;  
    term = 1.0; sum = 0;  
    for (cnt = 1; term >= 0.0001; ++cnt) {  
        sum += term;  
        term *= x/cnt;  
    }  
    printf ("%f\n", sum);  
    return 0;  
}
```

Equivalence of **for** and **while**

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

Same as



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

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

Sum of first N Natural Numbers

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

Some observations on **for**

- Initialization, loop-continuation test, and update can contain arithmetic expressions

for (k = x; k <= 4 * x * y; k += y / x)

- Update may be negative (decrement)

for (digit = 9; digit >= 0; --digit)

- If loop continuation test is initially 0 (**false**)

- ☐ Body of **for** structure not performed

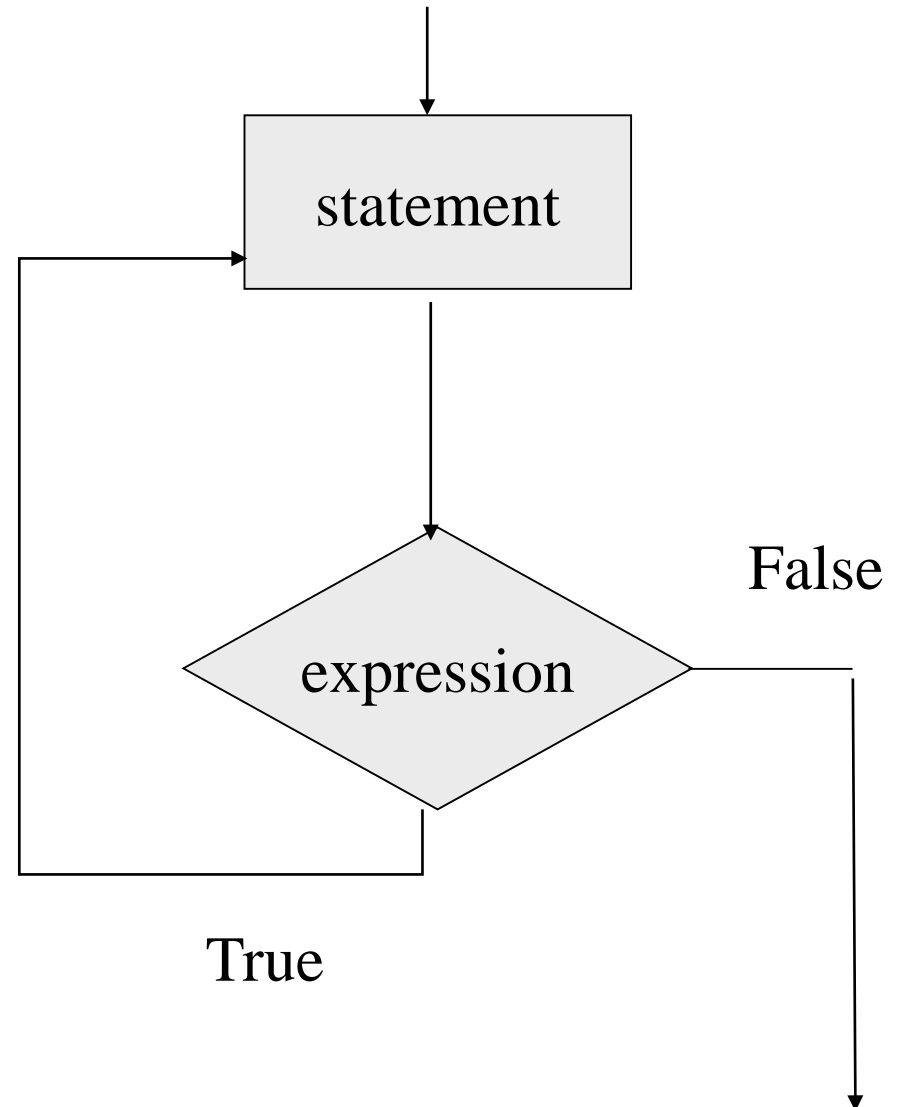
- No statement executed

- ☐ Program proceeds with statement after **for** structure

Looping: **do-while** statement

```
do  
    statement;  
while (expression);
```

```
do {  
    Block of statements;  
} while (expression);
```



Example

Problem: Prompt user to input “month” value, keep prompting until a correct value of month is given as input

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

Decimal to binary conversion (prints binary in reverse order)

```
int main() {  
    int dec;  
    scanf ("%d", &dec);  
    do  
    {  
        printf ("%2d", (dec % 2));  
        dec = dec / 2;  
    } while (dec != 0);  
    printf ("\n");  
    return 0;  
}
```

Output

```
277  
101010001
```

Echo characters typed on screen until end of line

```
int main () {  
    char echo ;  
    do {  
        scanf ("%c", &echo);  
        printf ("%c",echo);  
    } while (echo != '\n') ;  
    return 0;  
}
```

Output

```
This is a test line  
This is a test line
```

Specifying “Infinite Loop”

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

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

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

The **break** Statement

- Break out of the loop body { }
 - 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

```
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;  
    }  
    return 0;  
}
```

Test if a number is prime or not

```
int main() {  
    int n, i=2;  
    scanf ("%d", &n);  
    limit = sqrt(n);  
    for (i = 2, i <= limit; i++) {  
        if (n % i == 0) {  
            printf ("%d is not a prime \n", n);  
            break;  
        }  
    }  
    if (i > limit) printf ("%d is a prime \n", n);  
    return 0;  
}
```


Another Way

```
int main() {  
    int n, i = 2, flag = 0;  
    double limit;  
    scanf ("%d", &n);  
    limit = sqrt(n);  
    while (i <= limit) {  
        if (n % i == 0) {  
            printf ("%d is not a prime \n", n);  
            flag = 1; break;  
        }  
        i = i + 1;  
    }  
    if (flag == 0) printf ("%d is a prime \n", n);  
    return 0;  
}
```

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
 - Loop-continuation test is evaluated immediately after the continue statement is executed
- for loop
 - **expr3** is evaluated, then **expr2** is evaluated

Example with **break** and **continue**:

Add positive numbers until a 0 is typed, but ignore any negative numbers typed

```
int main() {  
    int sum = 0.0, next;  
    while (1) {  
        scanf("%d", &next);  
        if (next < 0) continue;  
        else if (next == 0) break;  
        sum = sum + next;  
    }  
    printf ("Sum = %d\n", sum) ;  
    return 0;  
}
```

Output

```
10  
-20  
30  
40  
-5  
10  
0  
Sum = 90
```

Some Loop Pitfalls

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

```
for (i=0; i<=NUM; ++i);  
    sum = sum+i;
```

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

```
double x;  
for (x=0.0; x<2.0; x=x+0.2)  
    printf("%.18f\n", x);
```

Nested Loops: Printing a 2-D Figure

- How would you print the following diagram?

* * * * *

* * * * *

* * * * *

repeat 3 times

print a row of 5 *'s

repeat 5 times
print *

Nested Loops

```
const int ROWS = 3;
const int 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**

2-D Figure: with for loop

Print

* * * * *

* * * * *

* * * * *

```
const int ROWS = 3;
const int COLS = 5;

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

Another 2-D Figure

Print

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

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


Yet Another One

Print

* * * * *

* * * *

* * *

* *

*

```
const int 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("* ");
```

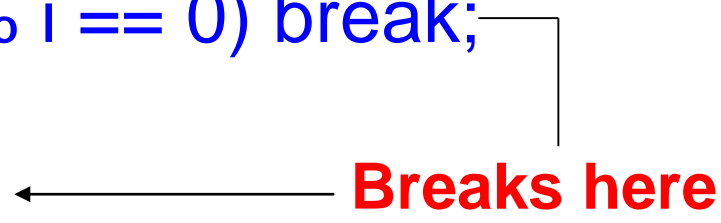
```
    printf ("\n");
```

```
}
```

break and continue with nested loops

- For nested loops, break and continue are matched with the nearest loops (for, while, do-while)
- Example:

```
while (i < n) {  
    for (k=1; k < m; ++k) {  
        if (k % i == 0) break;  
    }  
    i = i + 1;  
}
```



Example

```
int main()
{
    int low, high, desired, i, flag = 0;
    scanf("%d %d %d", &low, &high, &desired);
    i = low;
    while (i < high) {
        for (j = i+1; j <= high; ++j) {
            if (j % i == desired) {
                flag = 1;
                break;
            }
        }
        if (flag == 1) break;
        i = i + 1;
    }
    return 0;
}
```

Breaks here

Breaks here

The comma operator

- Separates expressions

- Syntax

`expr-1, expr-2, ...,expr-n`

□ `expr-1, expr-2,...`are all expressions

- Is itself an expression, which evaluates to the value of the last expression in the sequence
- Since all but last expression values are discarded, not of much general use
- But useful in for loops, by using side effects of the expressions

Example

- We can give several expressions separated by commas in place of `expr1` and `expr3` in a for loop to do multiple assignments for example

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

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

Practice Problems

(do each with both for and while loops separately)

1. Read in an integer N. Then print the sum of the squares of the first N natural numbers
2. Read in an integer N. Then read in N numbers and print their maximum and second maximum (do not use arrays even if you know it)
3. Read in an integer N. Then read in N numbers and print the number of integers between 0 and 10 (including both), between 11 and 20, and > 20 . (do not use arrays even if you know it)
4. Repeat 3, but this time print the average of the numbers in each range.
5. Read in a positive integer N. If the user enters a negative integer or 0, print a message asking the user to enter the integer again. When the user enters a positive integer N finally, find the sum of the logarithmic series ($\log_e(1+x)$) upto the first N terms
6. Read in an integer N. Then read in integers, and find the sum of the first N positive integers read. Ignore any negative integers or 0 read (so you may actually read in more than N integers, just find the sum with only the positive integers and stop when N such positive integers are read)
7. Read in characters until the '\n' character is typed. Count and print the number of lowercase letters, the number of uppercase letters, and the number of digits entered.