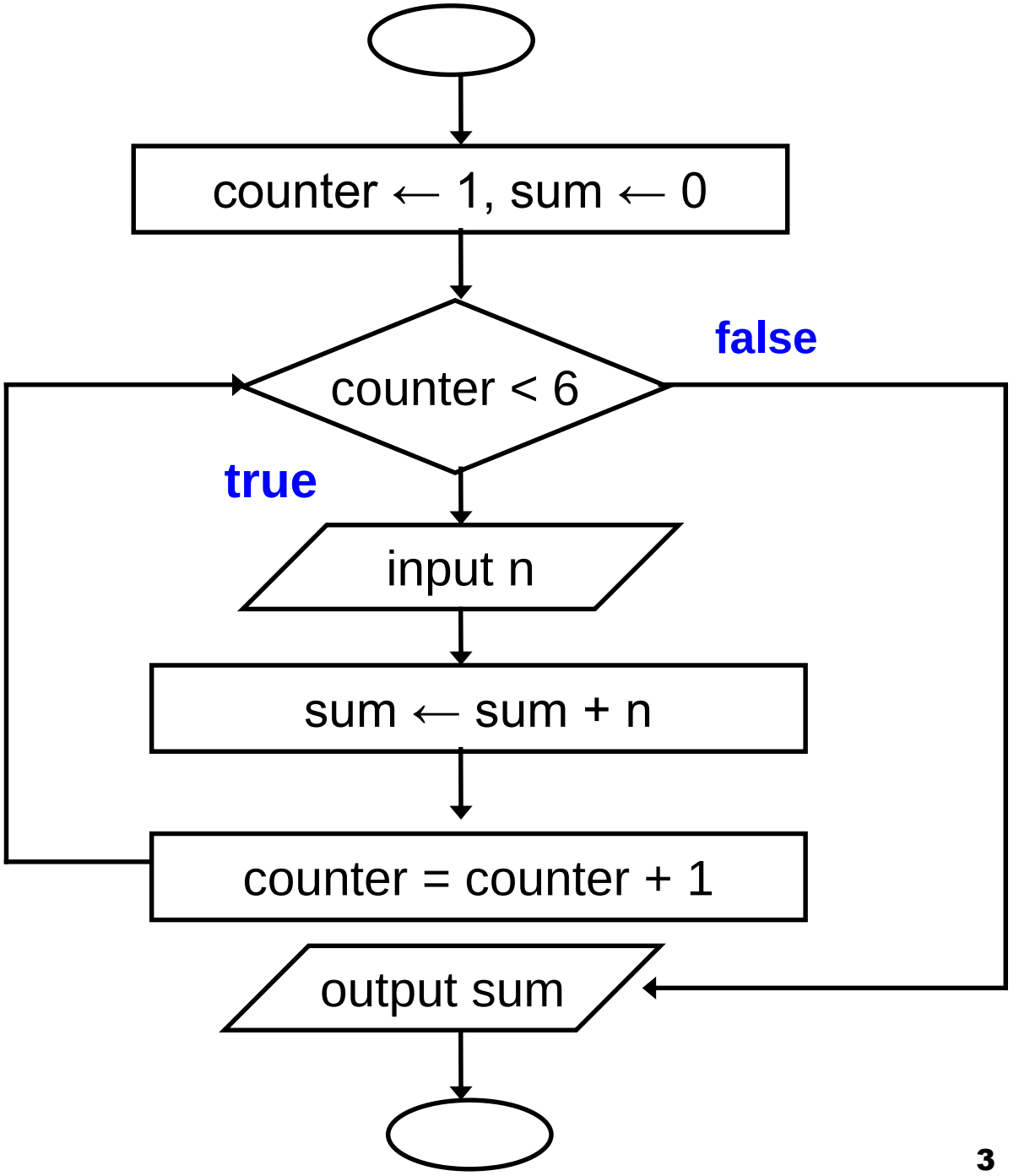
Looping

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

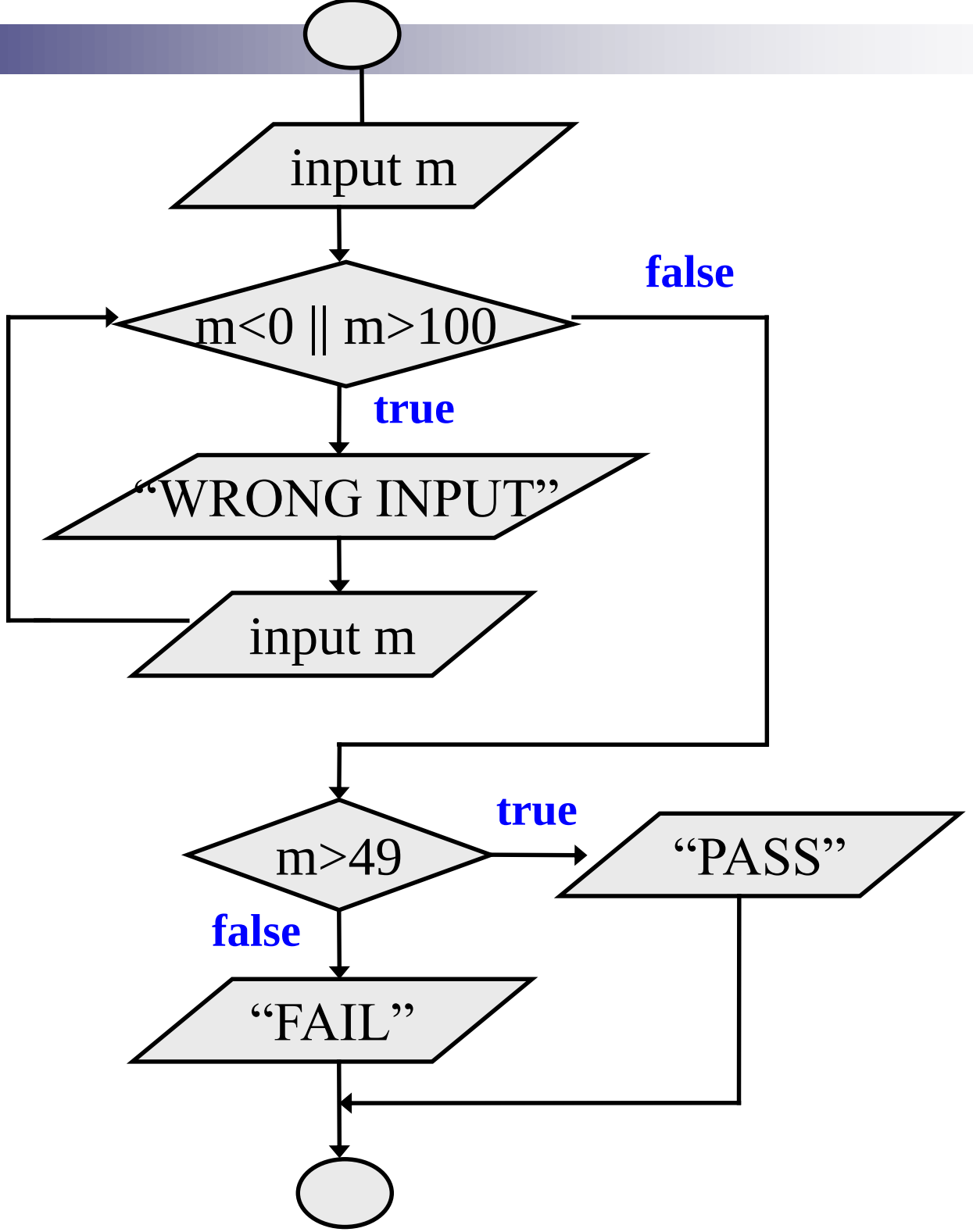
Read 5 integers and display the their sum

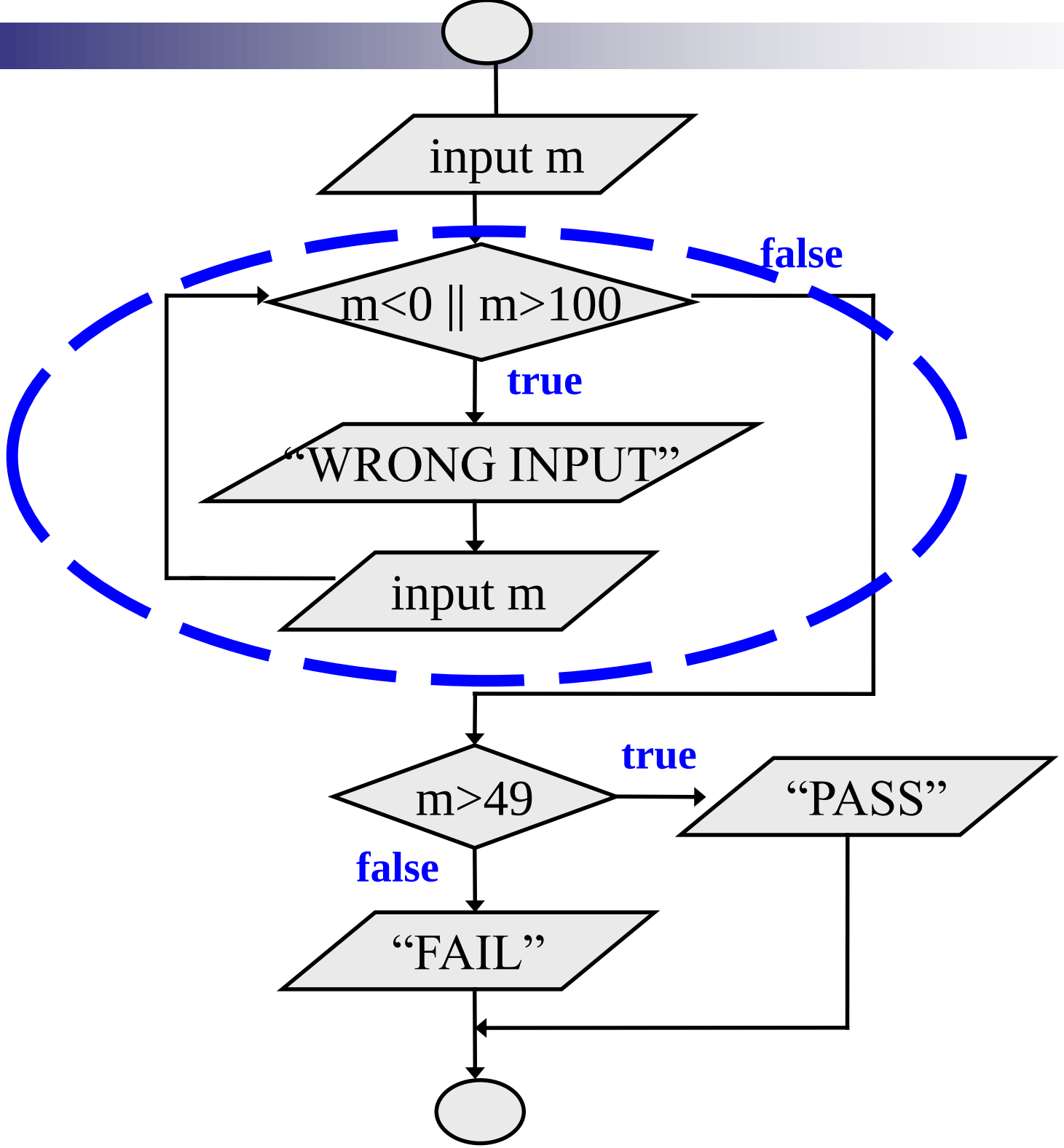


Example

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


input m
m<0 || m>100
false
true
“WRONG INPUT”
input m
m>49
true
“PASS”
false
“FAIL”


input m
m<0 || m>100
false
true
“WRONG INPUT”
input m
m>49
true
“PASS”
false
“FAIL”

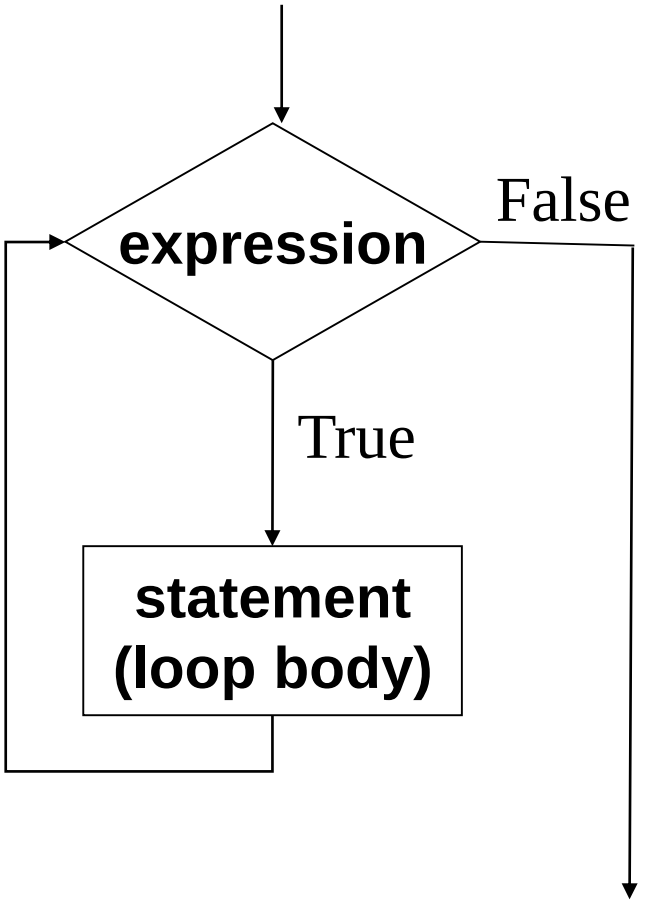
Looping: while statement

```
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

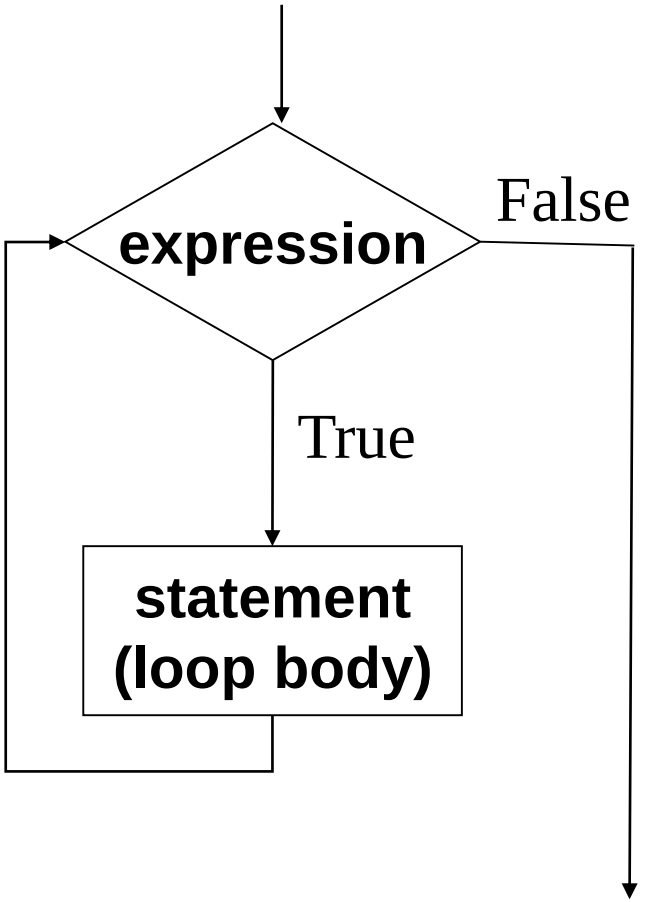
```
while (expression)
        statement;


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

Example

```
int  weight;
scanf(“%d”, &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

```
void 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) ;
}
```

SUM = $1^2 + 2^2 + 3^2 + \ldots + N^2$

```
void 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;
}
```

Compute GCD of two numbers

```
void 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

Double your money

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

```
void 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);
}
```

Maximum of positive Numbers

```
void main() {
    double max = 0.0, next;
    printf (“Enter positive numbers, 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) ;
}
```

Find the sum of digits of a number

```
void 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);
}
```

Looping: for Statement

- Most commonly used looping structure in C

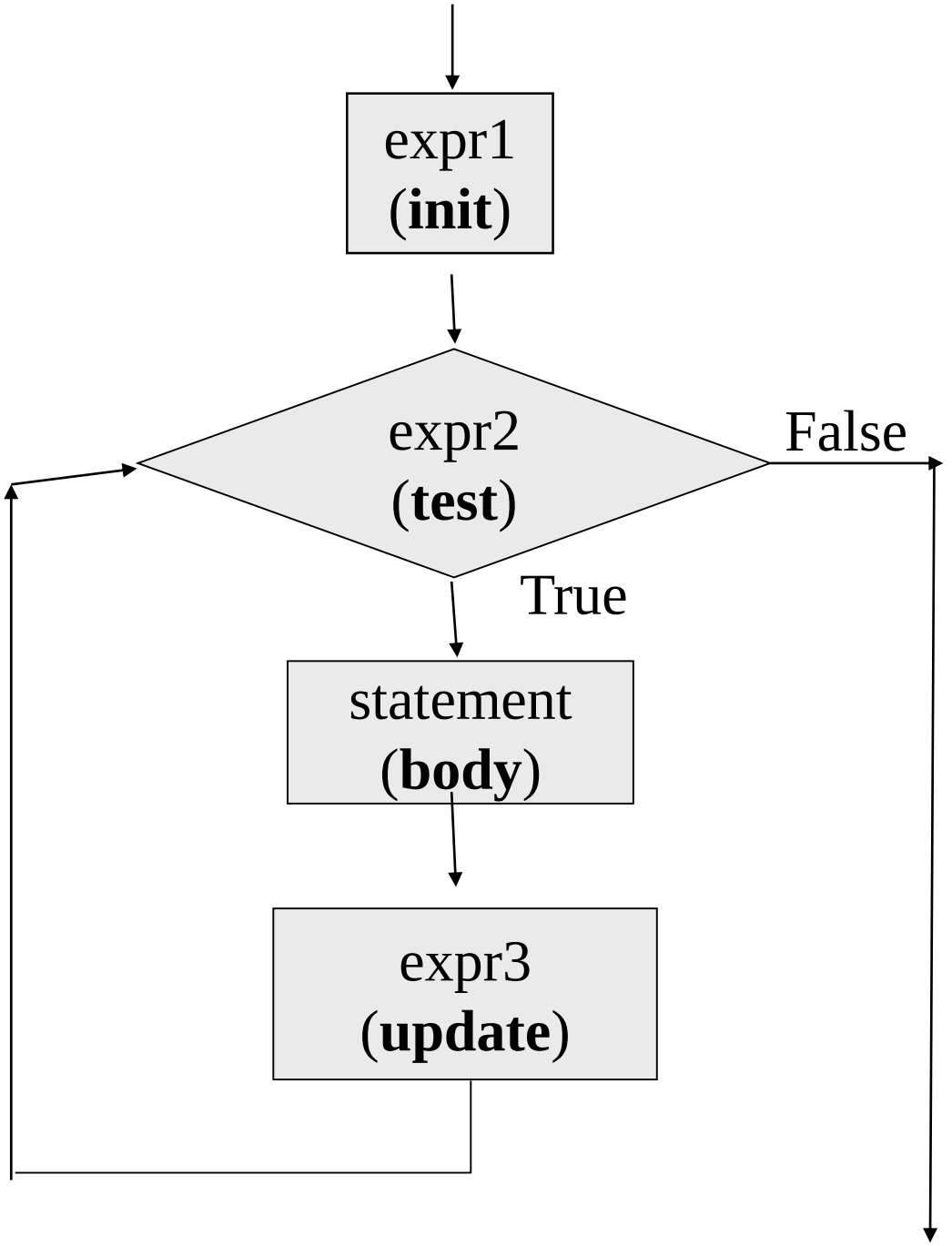
```
for ( expr1; expr2; expr3)
    statement;

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


expr1
(**init**)
expr2
(**test**)
False
True
statement
(**body**)
expr3
(**update**)

Example: Computing Factorial

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

Computing e^x series up to N terms

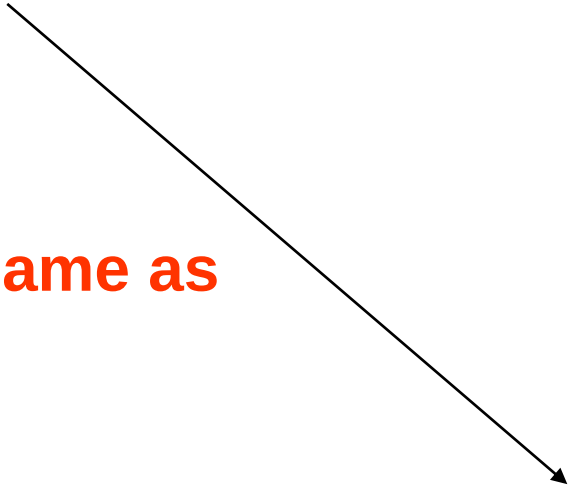
```
void main () {
    float x, term, sum;
    int n, count;
    scanf (“%f”, &x);
    scanf (“%d”, &n);
    term = 1.0; sum = 0;
    for (count = 1; count <= n; ++count)  {
        sum += term;
        term *= x/count;
     }
    printf (“%f\n”, sum);
}
```

Computing e^x series up to 4 decimal places

```
void 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) ;
}
```

Equivalence of for and while

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



Same as

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

Sum of first N Natural Numbers

```
void 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) ;
}
```

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

Some observations on for

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

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

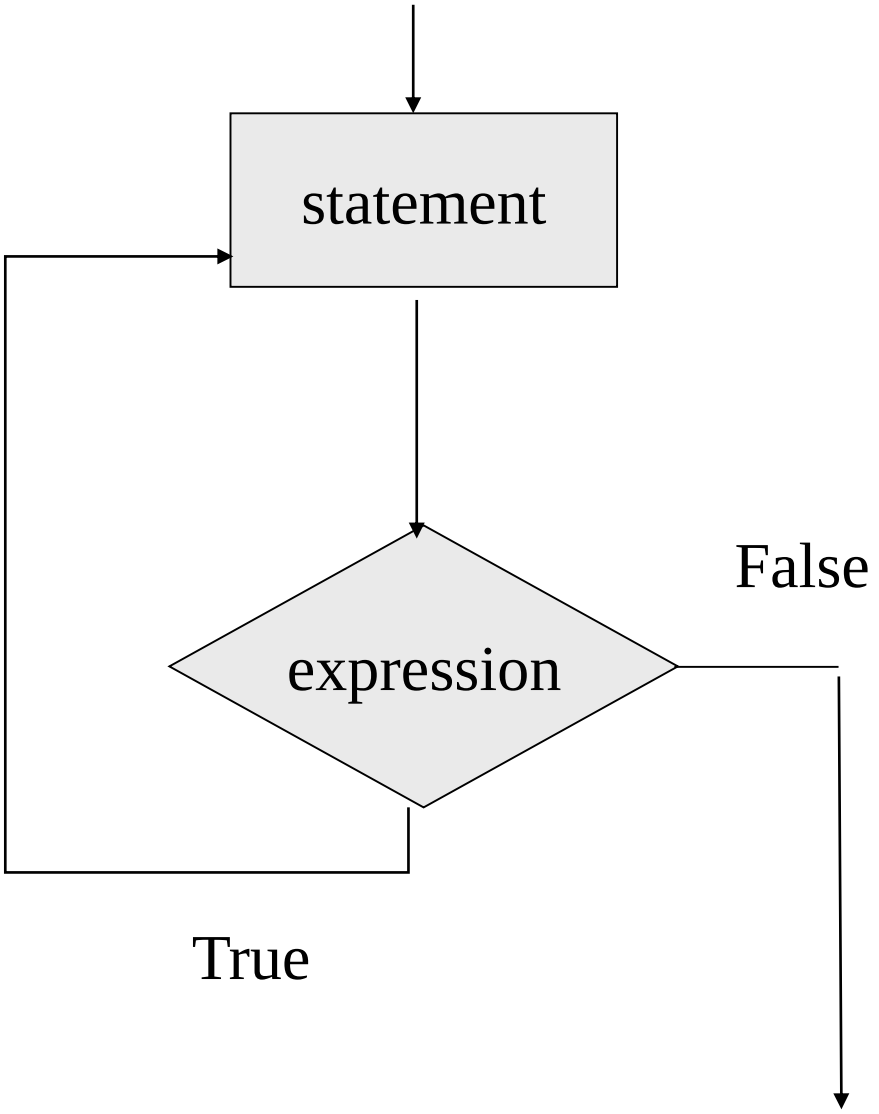
- Update may be negative (decrement)

```
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)

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

Echo characters typed on screen until end of line

```
void main () {
        char echo ;
        do {
              scanf (“%c”, &echo);
              printf (“%c”,echo);
         }  while (echo != ‘\n’) ;
}
```

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

```
void 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;
    }
}
```

Test if a number is prime or not

```
void main() {
    int  n, i=2;
    scanf (“%d”, &n);
    while (i < n)  {
        if (n % i == 0)  {
            printf (“%d is not a prime \n”, n);
            break;
        }
        ++i;
    }
    if (i == n) printf (“%d is a prime \n”, n);
}
```

More efficient??

```
void 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);
}
```

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

An Example with break and continue

```
void main() {
    int fact = 1, i = 1;
    while  (1)  {
        fact = fact * i;
        ++i;
        if  ( i <=10 )
            continue;    /* not done yet ! Go to loop and
                            perform next iteration*/
        break;
    }
}
```

Some Loop Pitfalls

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

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

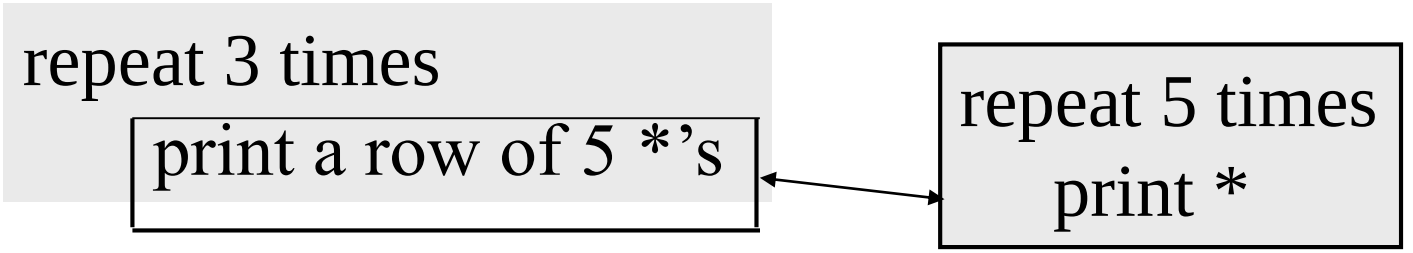
```
for (i=1; i!=10; i=i+2)
    sum = sum+i;
```

```
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?

```
* * * * *

* * * * *

* * * * *
```



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;
}
```

Breaks here

Example

```
void 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;
    }
}
```

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;
```