C Loops

Repeating Code Multiple Times

SoftUni Team

Technical Trainers

Software University

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Loop: Definition

- A loop is a control statement that repeats the execution of a block of statements

```
while (condition)
{
    statements;
}
```

  - May execute a code block fixed number of times
  - May execute a code block while given condition holds
- Loops that never end are called infinite loops

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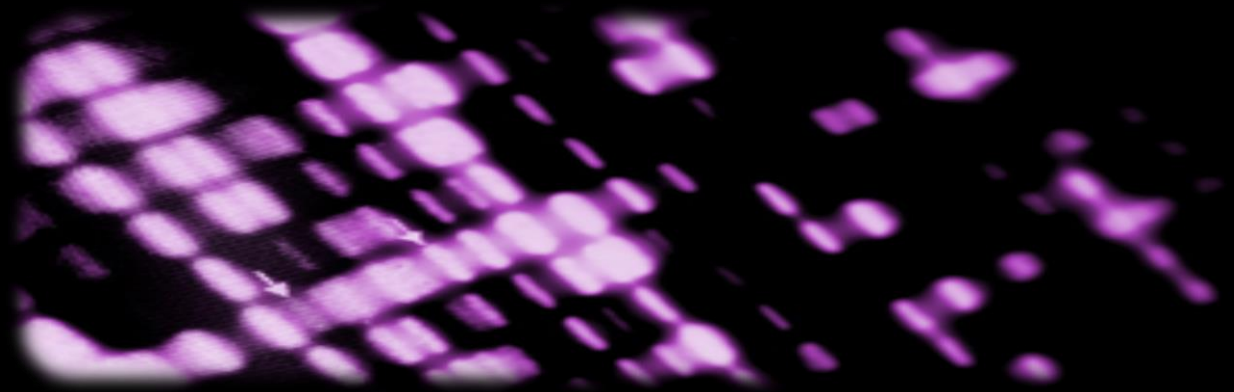
Using `while(…)` Loop

Repeating a Statement While Certain Condition Holds



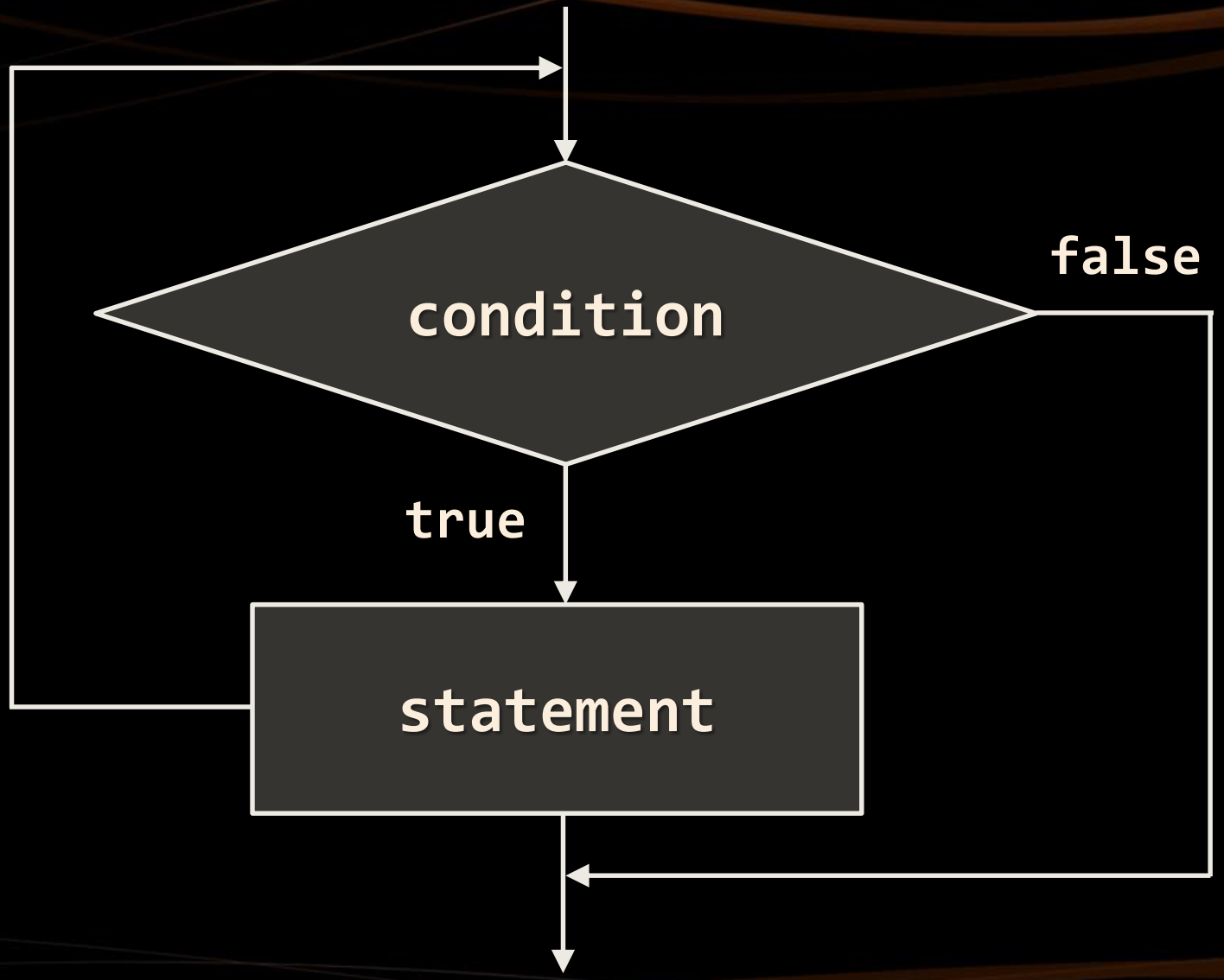
How To Use While Loop?

- The simplest and most frequently used loop

```
while (condition)
{
    statements;
}
```

- The repeat condition
  - Returns a integer result of **0** or **1**
  - Also called loop condition

While Loop: How It Works?



While Loop – Example

```
int counter = 0;
while (counter < 10)
{
    printf("Number : %d\n", counter);
    counter++;
}
```

```
Loops
Number : 0
Number : 1
Number : 2
Number : 3
Number : 4
Number : 5
Number : 6
Number : 7
Number : 8
Number : 9

Process returned 0 (0x0)   execution time : 0.001 s
Press ENTER to continue.
```

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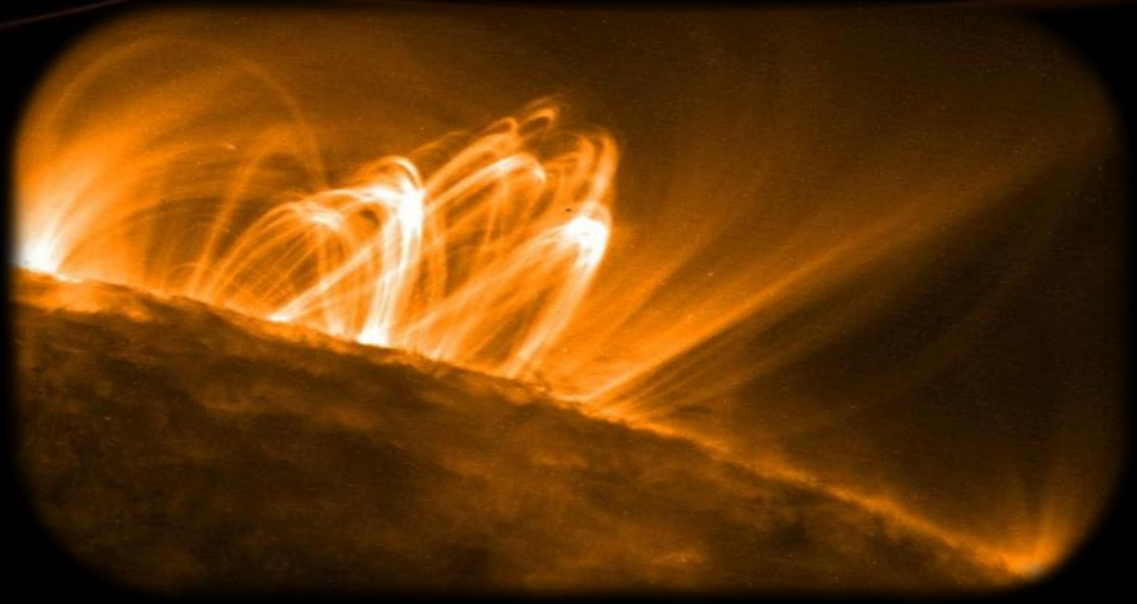

while(…) Loop

Examples

Sum 1..N – Example

- Calculate and print the sum of the first N natural numbers

```
int n;
printf("n = ");
scanf("%d", &n);
int number = 1, sum = 1;
printf("The sum 1");
while (number < n)
{
    number++;
    sum += number ;
    printf("+%d", number);
}
printf(" = %d\n", sum);
```

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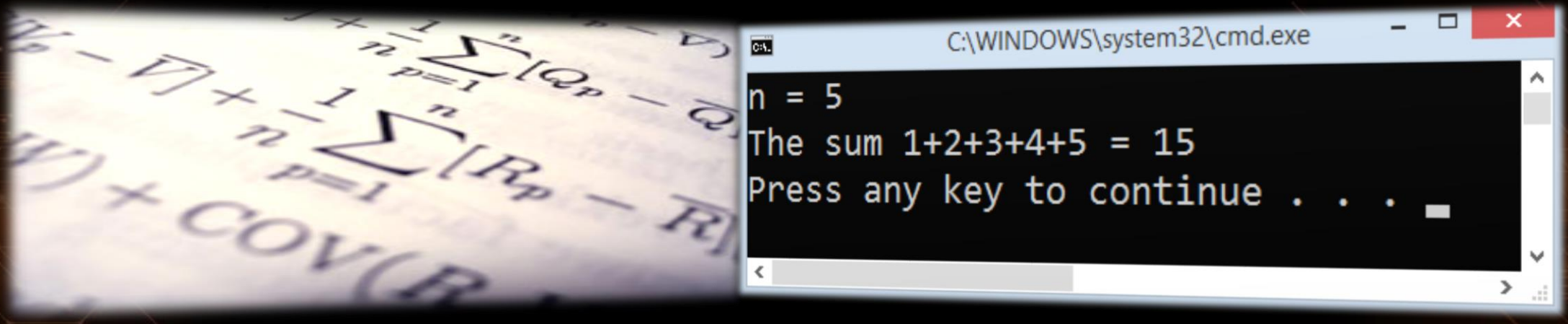
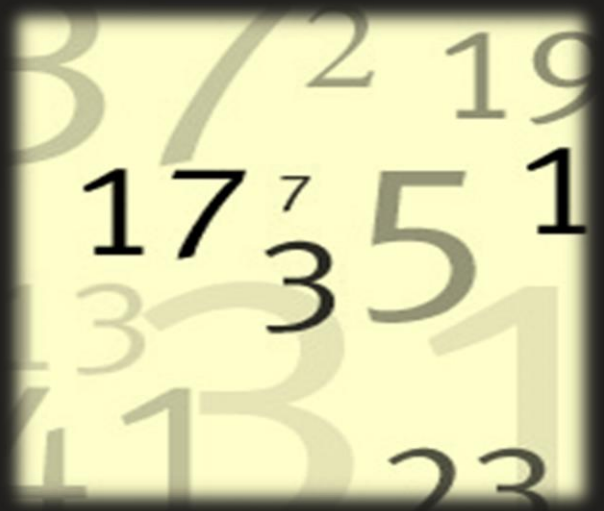
Calculating Sum 1..N

Live Demo



Prime Number Check – Example

```
printf("Enter a positive integer number: ");
unsigned int number;
scanf("%du", &number);
unsigned int divider = 2;
unsigned int maxDivider = (unsigned int) sqrt(number);
int isPrime = 1;
while (isPrime && (divider <= maxDivider))
{
    if ((number % divider) == 0)
    {
        isPrime = 0;
    }
    divider++;
}
printf("Prime? %s", isPrime ? "yes" : "no");
```



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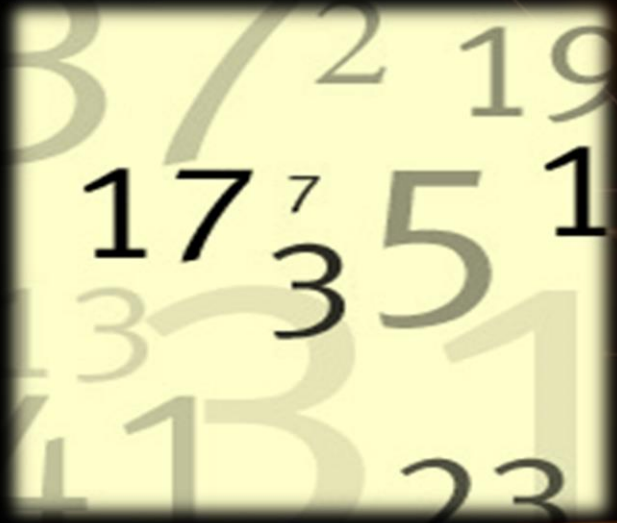
Checking Whether a Number Is Prime

Live Demo

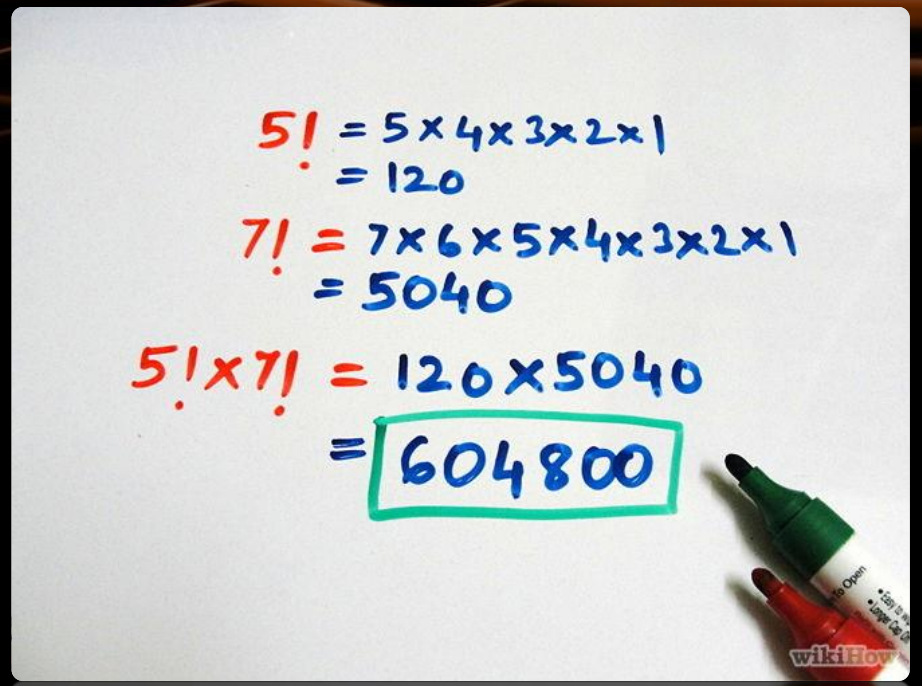


Using the break Operator

- The **break** operator exits the inner-most loop

```
int n;
scanf("%d", &n);

// Calculate n! = 1 * 2 * ... * n
int result = 1;
while (1)
{
    if (n == 1)
        break;
    result *= n;
    n--;
}
printf("n! = %d", result);
```



Calculating Factorial

Live Demo

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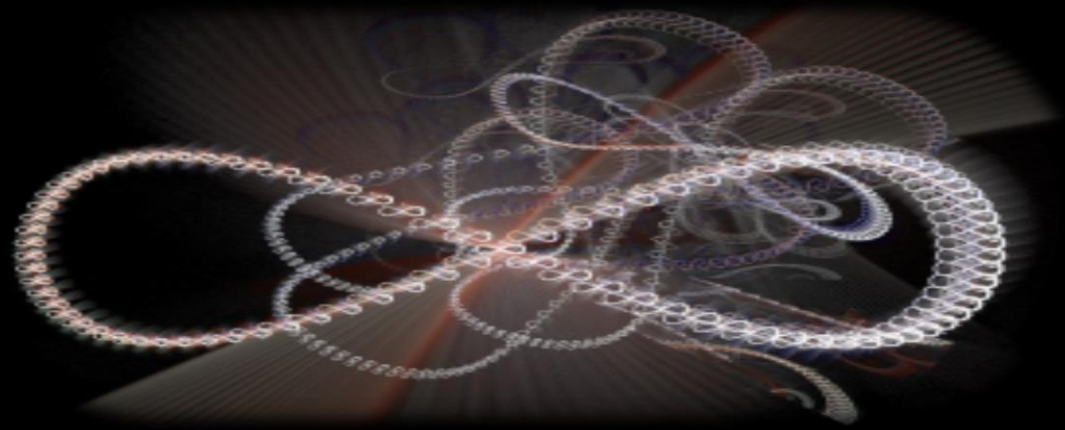
do { … } while (…) Loop



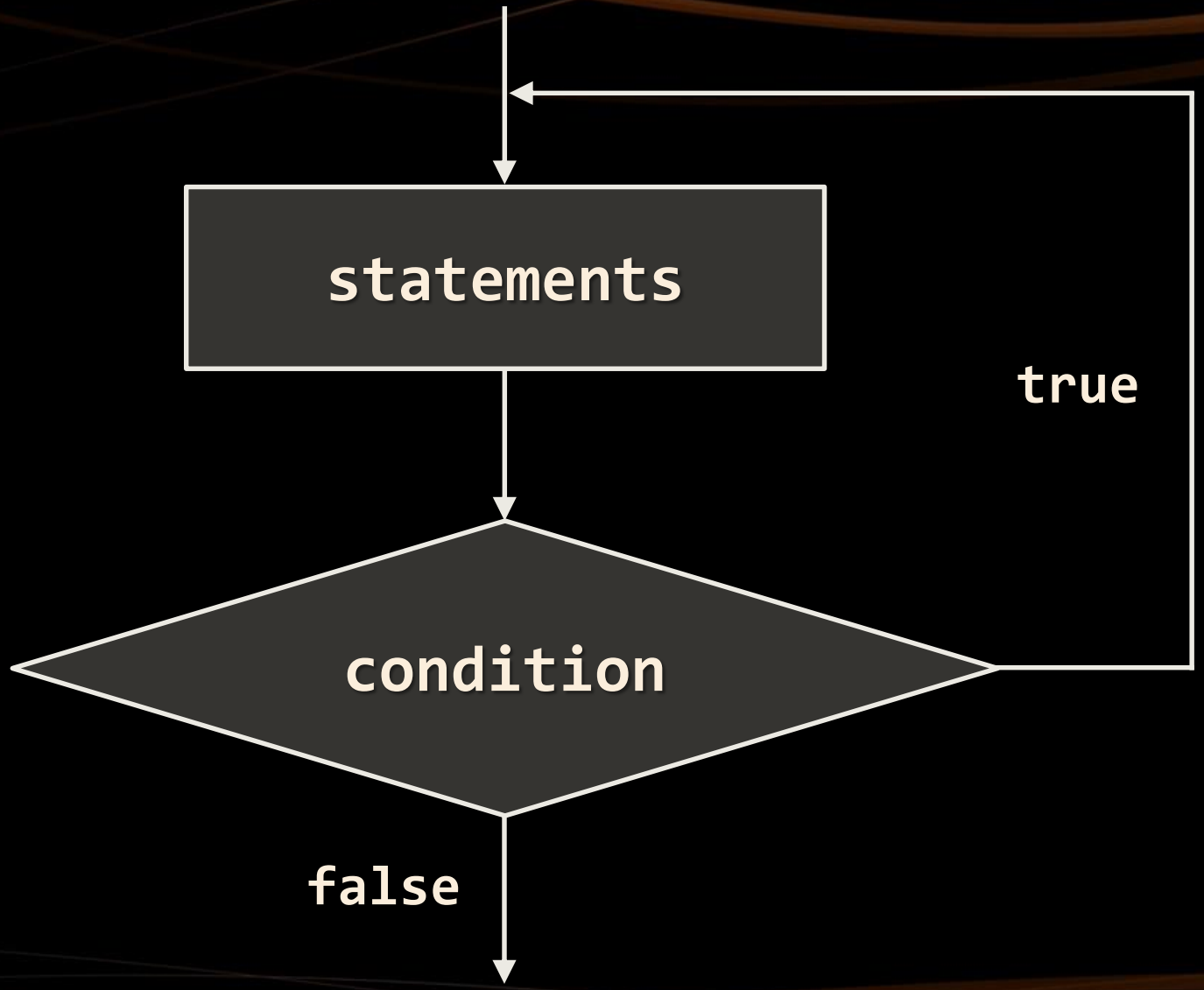
Using Do-While Loop

- Another classical loop structure is:

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

- The block of statements is repeated
  - While the boolean loop condition holds
- The loop is executed at least once

Do-While Statement: How It Works?



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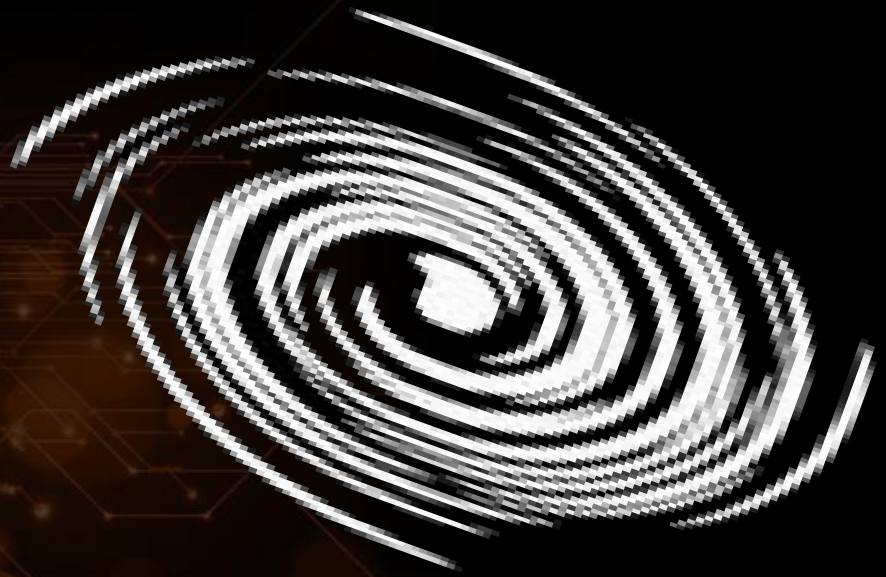
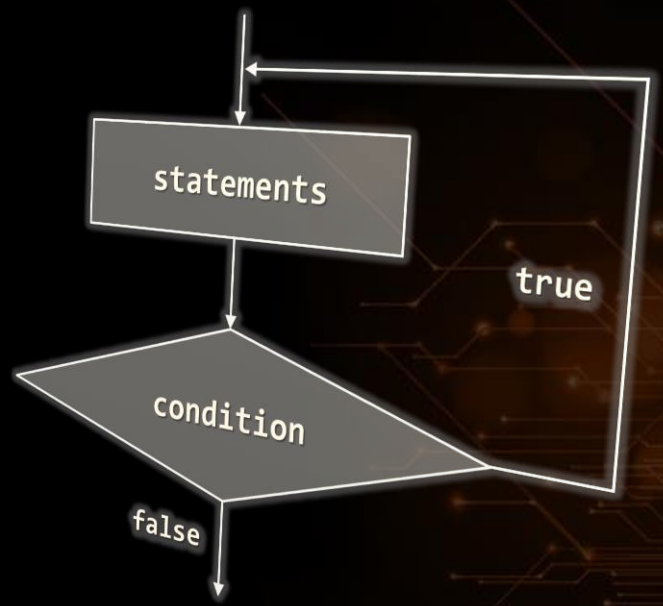
do { … } while (…)

Examples

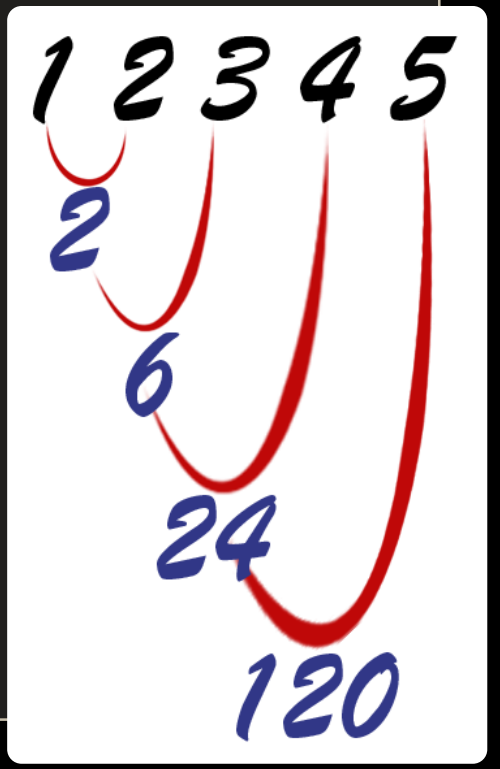




Calculating N Factorial – Example

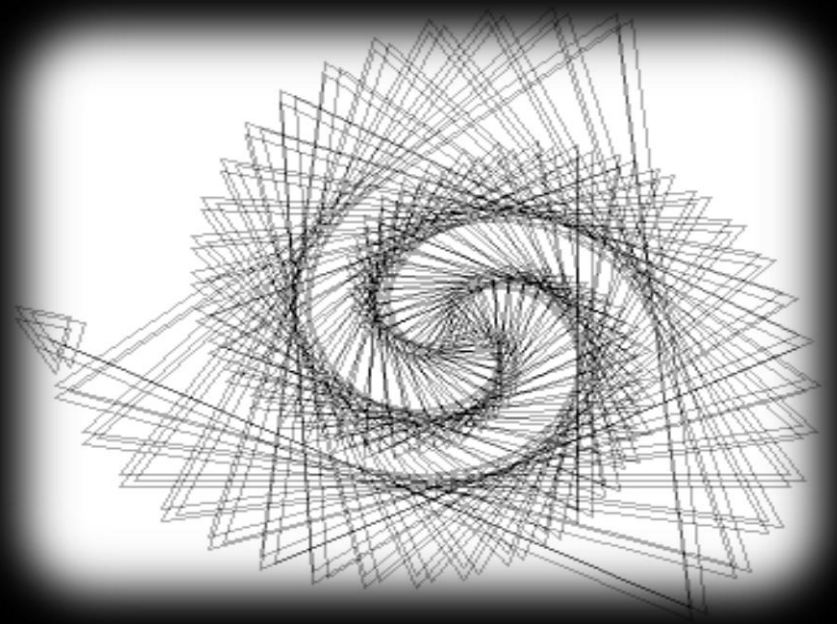
```
int n;
scanf("%d", &n);
int factorial = 1;
do
{
    factorial *= n;
    n--;
}
while (n > 0);

printf("n! = %d", factorial);
```



Factorial (do ... while)

Live Demo



Product of Integers [N..M] – Example

- Calculating the product of all integers in the interval [**n**..**m**]:

```
int n, m;
scanf("%d %d", &n, &m);
int number = n;
long product = 1;

do
{
    product *= number;
    number++;
}
while (number <= m);

printf("product[%d..%d] = %ld", n, m, product);
```

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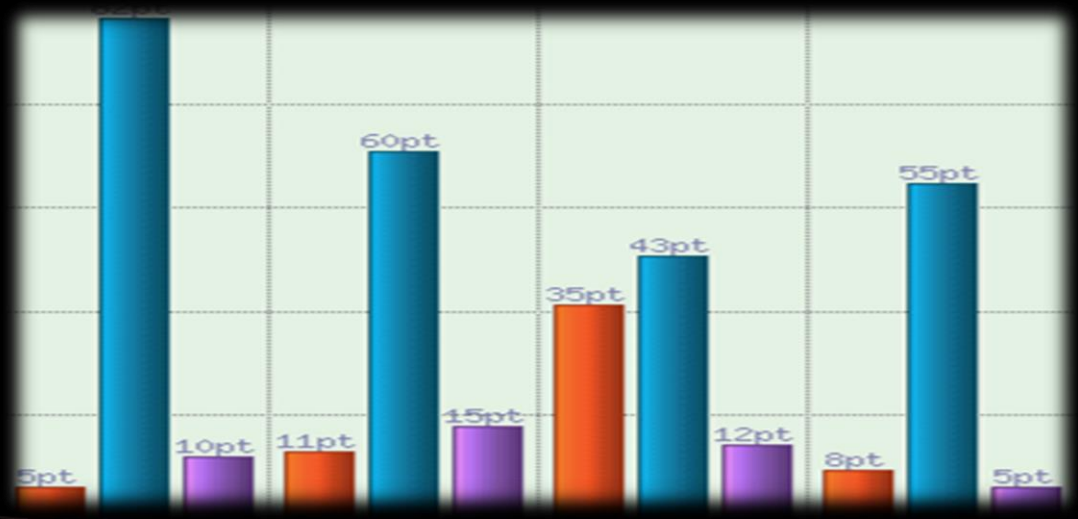
Product of the Integers in the Interval [n..m]

Live Demo



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for Loops

For Loops

- The typical `for` loop syntax is:

```
for (initialization; test; update)
{
    statements;
}
```

- Consists of
  - Initialization statement
  - Boolean test expression
  - Update statement
  - Loop body block

The Initialization Expression

```
for (int number = 0; ...; ...)
{
    // Can use number here
}
// Cannot use number here (out of scope)
```

- The initialization expression
  - Executed once, just before the loop is entered
  - Like it is out of the loop, just before it
- Typically used to declare a counter variable

The Test Expression

```
for (int number = 0; number < 10; ...)
{
    // Can use number here
}
// Cannot use number here (out of scope)
```

- The test expression is evaluated before each loop iteration
  - If `true`, the loop body is executed
  - If `false`, the loop finishes (and the loop body is skipped)
- Used as a loop condition

The Update Expression


```
for (int number = 0; number < 10; number++)
{
    // Can use number here
}
// Cannot use number here (out of scope)
```

- The update expression
  - Executed at each iteration after the body of the loop is finished
  - Typically used to update the loop counter
  - Can update multiple variables

for-loop Variants

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C89 Standard

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

C99 Standard

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

- To use the C99 standard, add the -std=c99 compiler flag, e.g.:

```
gcc -std=c99 main
```

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for Loop

Examples

Simple for Loop – Example

- A simple **for**-loop to print the numbers 0…9:

```
for (int number = 0; number < 10; number++)
{
    printf("%d\n", number);
}
```

- A simple **for**-loop to calculate n!:

```
long factorial = 1;
for (int i = 1; i <= n; i++)
{
    factorial *= i;
}
```

Complex for Loop – Example

- A complex **for**-loop could have several counter variables:

```
for (int i = 1, sum = 1; i <= 128; i = i * 2, sum += i)
{
    printf("i=%d, sum=%d", i, sum);
}
```

- Result:

```
i=1, sum=1
i=2, sum=3
i=4, sum=7
i=8, sum=15
...
```

For Loops

Live Demo

N^M – Example

- Calculating **n** to power **m** (denoted as **n^m**):

```
static void Main()
{
    int n, m;
    scanf("%d %d", &n, &m);
    long result = 1;
    for (int i = 0; i < m; i++)
    {
        result *= n;
    }
    printf("n^m = %d", result);
}
```

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Calculating N^M

Live Demo

Using the continue Operator

- **continue** bypasses the iteration of the inner-most loop
- Example: sum all odd numbers in [1…n], not divisors of 7:

```
int n, sum = 0;
scanf("%d", &n);
for (int i = 1; i <= n; i += 2)
{
    if (i % 7 == 0)
    {
        continue;
    }
    sum += i;
}
printf("sum = %d", sum);
```

Using the `continue` Operator

Live Demo

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Nested Loops

Using a Loop Inside a Loop

What Is Nested Loop?

- A composition of loops is called a nested loop
  - A loop inside another loop

```
for (initialization; test; update)
{
    for (initialization; test; update)
    {
        statements;
    }
    …
}
```

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Nested Loops

Examples

Triangle – Example

- Print the following triangle of numbers:

```
1
1 2
…
1 2 3 … n
```

```
int n;
scanf("%d", &n);
for (int row = 1; row <= n; row++)
{
    for (int column = 1; column <= row; column++)
    {
        printf("%d ", column);
    }

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

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Triangle of Numbers

Live Demo

Primes in the Range [N … M] – Example

```
int n, m;
scanf("%d %d", &n, &m);
for (int number = n; number <= m; number++)
{
    int prime = 1;
    int divider = 2;
    int maxDivider = (int) sqrt(number);
    while (divider <= maxDivider)
    {
        if (number % divider == 0)
        {
            prime = 0;
            break;
        }
        divider++;
    }
    if (prime)
        printf("%d ", number);
}
```

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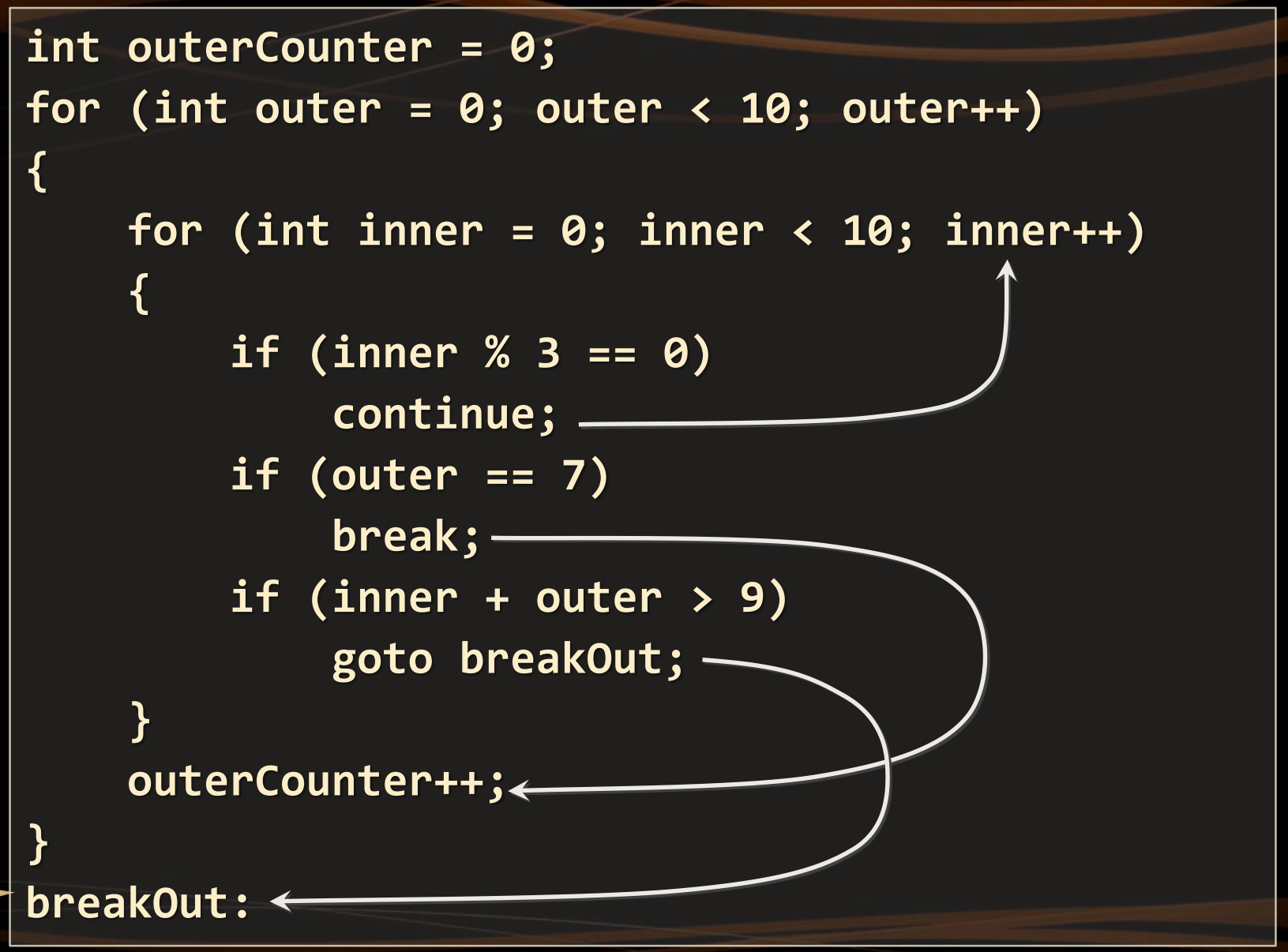
Primes in the Range [n, m]

Live Demo

C Jump Statements

- Jump statements are:
  - **`break`**, **`continue`**, **`goto`**
- How **`continue`** woks?
  - In **`while`** and **`do-while`** loops jumps to the test expression
  - In **`for`** loops jumps to the update expression
- To exit the most-inner loop use **`break`**
- To exit from an outer loop use **`goto`** with a label
  - Note: avoid using **`goto`**! (it is considered harmful)

C Jump Statements – Example



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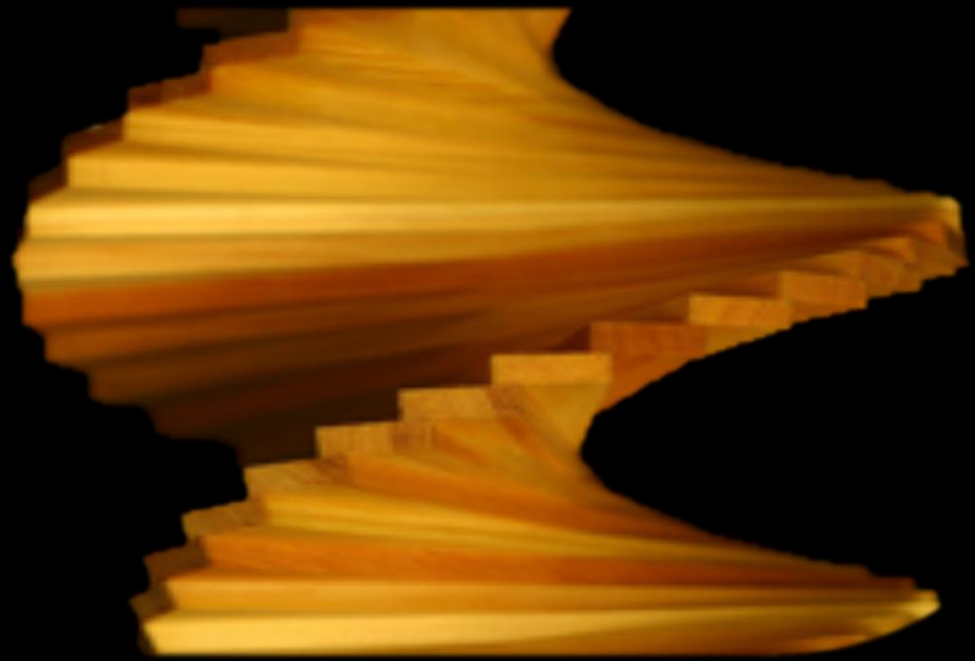
Loops: More Examples



Nested Loops – Examples

- Print all four digit numbers in format **ABCD** such that **A+B = C+D** (known as happy numbers)

```
for (int a = 1; a <= 9; a++)
  for (int b = 0; b <= 9; b++)
    for (int c = 0; c <= 9; c++)
      for (int d = 0; d <= 9; d++)
        if ((a + b) == (c + d))
          printf("%d%d%d%d", a, b, c, d);
```

Can you improve this algorithm to use only 3 nested loops?

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Happy Numbers

Live Demo

Nested Loops – Examples

- Print all combinations from TOTO 6/49 lottery

```
int i1, i2, i3, i4, i5, i6;
for (i1 = 1; i1 <= 44; i1++)
  for (i2 = i1 + 1; i2 <= 45; i2++)
    for (i3 = i2 + 1; i3 <= 46; i3++)
      for (i4 = i3 + 1; i4 <= 47; i4++)
        for (i5 = i4 + 1; i5 <= 48; i5++)
          for (i6 = i5 + 1; i6 <= 49; i6++)
            printf("%d %d %d %d %d %d",
              i1, i2, i3, i4, i5, i6);
```

Warning: the execution of this code could take a very long time.

TOTO 6/49

Live Demo

Summary

- C supports four types of loops:
  - `while` loops
  - `do-while` loops
  - `for` loops

- Nested loops are used to implement more complex logic
- The operators `continue`, `break` & `goto` can change the default loop execution behavior

C Programming – Loops

Questions?

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