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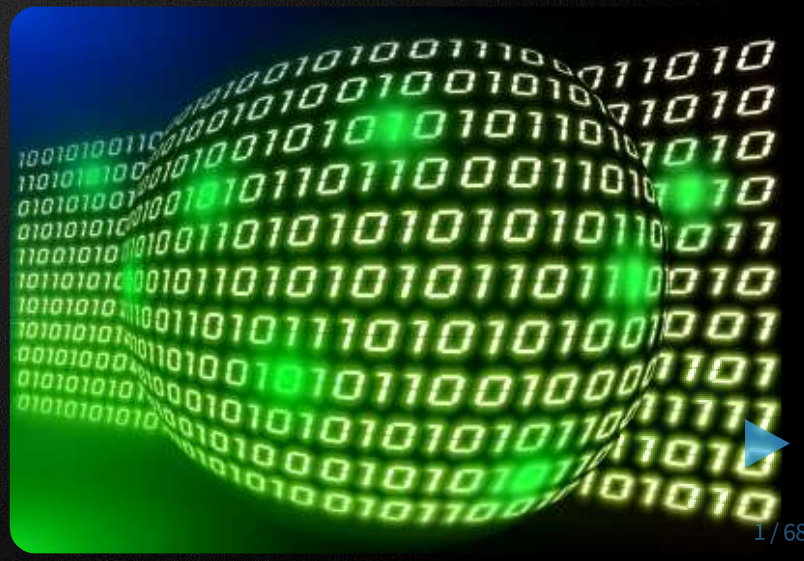
Primitive Data Types and Variables

Integer, Floating-point, Text Data, Characters, Variables, Literals



C# Fundamentals

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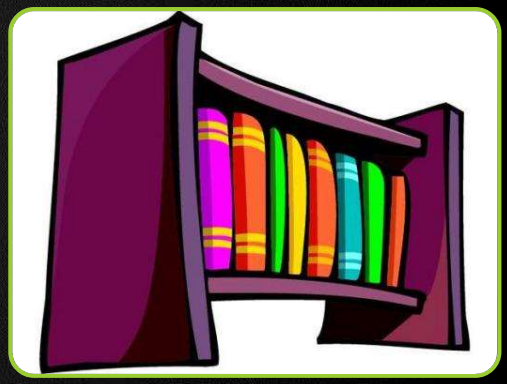

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Primitive Data Types

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How Computing Works?

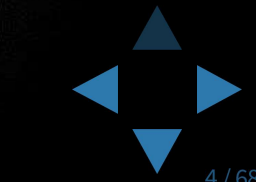
- Computers are machines that process data
  - Data is stored in the computer memory in variables
  - Variables have name, data type and value
- *Example* of variable definition and assignment in C#

```
int count = 5;
```

Variable name

Data type

Variable value



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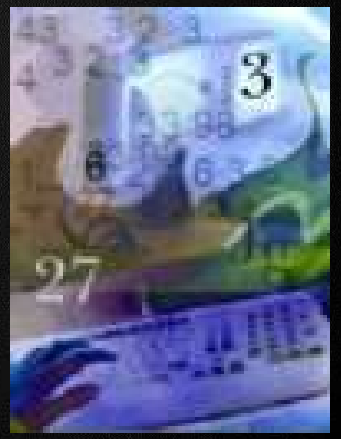
What Is a Data Type?

- A data type:
  - Is a domain of values of similar characteristics
  - Defines the type of information stored in the computer memory (in a variable)
- *Examples*:
  - Positive integers: 1, 2, 3, ...
  - Alphabetical characters: a, b, c, ...
  - Days of week: `Monday`, `Tuesday`, ...



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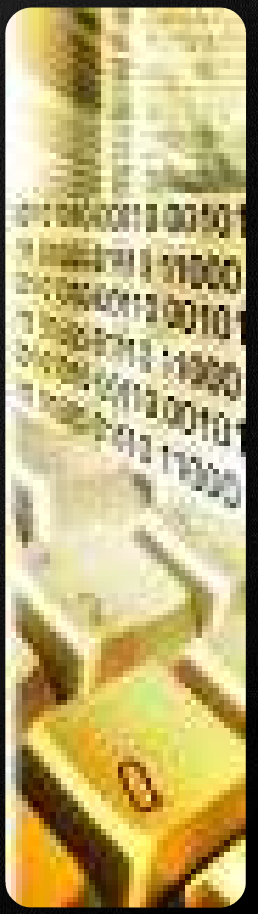
Data Type Characteristics

- A data type has:
  - Name (C# keyword or .NET type)
  - Size (how much memory is used)
  - Default value
- *Example*:
  - Integer numbers in C#
  - Name: `int`
  - Size: 32 bits (4 bytes)
  - Default value: `0`



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Integer Types

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Integer Types

- Integer types:
  - Represent integer numbers
  - May be signed or unsigned
  - Have range of values, depending on the size of memory used
- The default value of integer types is:
  - `0` – for integer types
    - except `0L` – for the `long` type

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Integer Types

- `sbyte` (signed 8-bit)
  - Min: `-128`
  - Max: `127`
- `byte` (unsigned 8-bit)
  - Min: `0`
  - Max: `255`
- `short` (signed 16-bit)
  - Min: `-32,768`
  - Max: `32,767`
- `ushort` (unsigned 16-bit)
  - Min: `0`
  - Max: `65,535`

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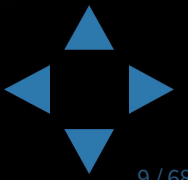

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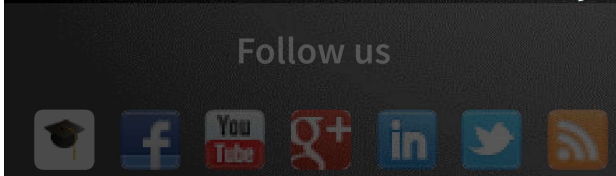
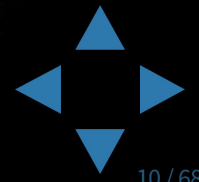
Integer Types (cont.)

- `int` (signed 32-bit)
  - Min: `-2,147,483,648`
  - Max: `2,147,483,647`
- `uint` (unsigned 32-bit)
  - Min:`0`
  - Max: `4,294,967,295`
- `long` (signed 64-bit)
  - Min: `-9,223,372,036,854,775,808`
  - Max: `9,223,372,036,854,775,807`
- `ulong` (unsigned 64-bit)
  - Min: `0`
  - Max: `18,446,744,073,709,551,615`





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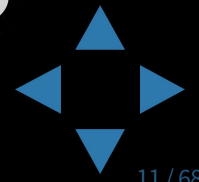
Integer Types: *Example*

- Depending on the unit of measure we may use different data types:
- *Example: Measuring times*

```
byte centuries = 20;    // Usually a small number
ushort years = 2000;
uint days = 730480;
ulong hours = 17531520; // May be a very big number
Console.WriteLine("{0} centuries is {1} years," +
                  " or {2} days, or {3} hours.",
                  centuries, years, days, hours);
```



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Integer Types

Demo

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Floating-point and Decimal Floating-Point Types

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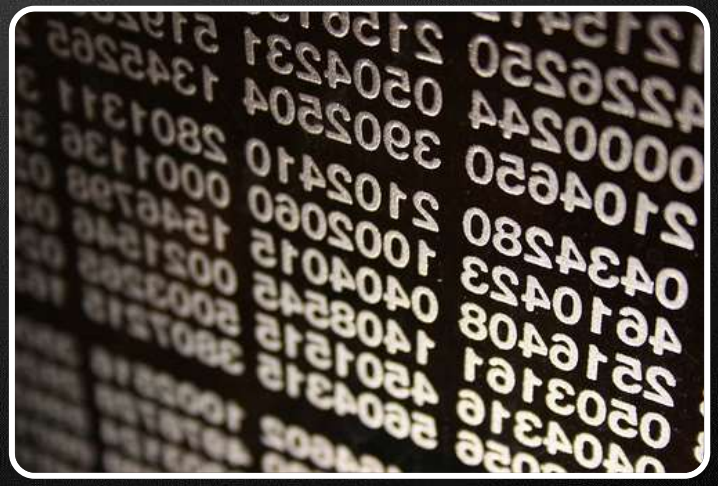
Floating-point Types

- Floating-point types:
  - Represent real numbers
  - May be signed or unsigned
  - Have range of values and different precision depending on the size of memory used
  - Can behave abnormally in the calculations



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Floating-Point Types

- Floating-point types are:
  - `float` (32-bits)
    - Min: $\pm 1.5 \times 10^{-45}$
    - Max: $\pm 3.4 \times 10^{38}$
    - Precision: 7 digits
  - `double` (64-bits)
    - Min: $\pm 5.0 \times 10^{-324}$
    - Max: $\pm 1.7 \times 10^{308}$
    - Precision: 15-16 digits
- The default value of floating-point types:
  - Is `0.0F` for the `float` type
  - Is `0.0D` for the `double` type

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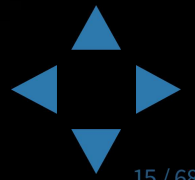

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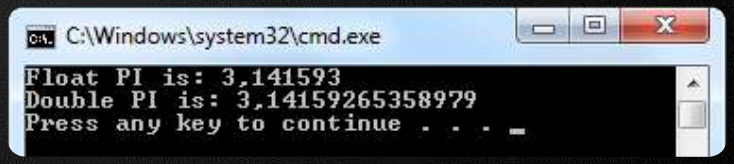
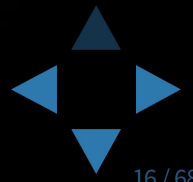
PI Precision – *Example*

- See below the difference in precision when using `float` and `double`:
- *Note*: The `f` suffix in the first statement!
  - Real numbers are by default interpreted as `double`!
  - One should explicitly convert them to `float`

```
float floatPI = 3.14159265358979238f;
double doublePI = 3.14159265358979238;
Console.WriteLine("Float PI is: {0}", floatPI);
Console.WriteLine("Double PI is: {0}", doublePI);
```





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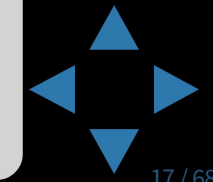
Abnormalities in the Floating-Point Calculations

- Sometimes abnormalities can be observed when using floating-point numbers
  - Comparing floating-point numbers can not be performed directly with the == operator
- *Example*:

```
double a = 1.0f;
double b = 0.33f;
double sum = 1.33f;
bool equal = (a+b == sum); // False!!!
Console.WriteLine("a+b={0}  sum={1}  equal={2}",
                  a+b, sum, equal);
```



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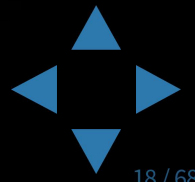
Decimal Floating-Point Types

- There is a special decimal floating-point real number type in C#:
  - `decimal` (128-bits)
    - Min: $\pm 1,0 \times 10^{-28}$
    - Max: $\pm 7,9 \times 10^{28}$
    - Precision: 28-29 digits
  - Used for financial calculations
  - No round-off errors
  - Almost no loss of precision
- The default value of `decimal` type is:
  - `0.0M` (`M` is the suffix for decimal numbers)



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Floating-Point and Decimal Floating-Point Types

Demo

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Boolean Type

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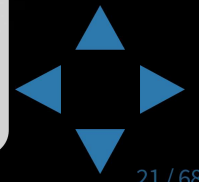
The Boolean Data Type

- The Boolean data type:
  - Is declared by the `bool` keyword
  - Has two possible values: `true` and `false`
  - Is useful in logical expressions
- The default value is `false`
- *Example:* boolean variables with values `true` and `false`:

```
int a = 1;
int b = 2;
bool greaterAB = (a > b);
Console.WriteLine(greaterAB);  // False
bool equalA1 = (a == 1);
Console.WriteLine(equalA1);    // True
```



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Boolean Type

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Character Type

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The Character Data Type

- The character data type:
  - Represents symbolic information
  - Is declared by the `char` keyword
  - Gives each symbol a corresponding integer code
  - Has a `'\0'` default value
  - Takes 16 bits of memory (from `U+0000` to `U+FFFF`)

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Characters and Codes

- *Example*: Symbols have unique Unicode codes:

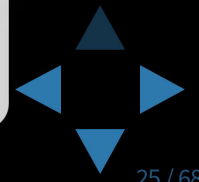
```
char symbol = 'a';
Console.WriteLine("The code of '{0}' is: {1}",
    symbol, (int) symbol);

symbol = 'b';
Console.WriteLine("The code of '{0}' is: {1}",
    symbol, (int) symbol);

symbol = 'A';
Console.WriteLine("The code of '{0}' is: {1}",
    symbol, (int) symbol);

symbol = '0';
Console.WriteLine("The code of '{0}' is: {1}",
    symbol, (int) symbol);
```

'a' has code value 97

'b' has code value 98

'A' has code value 65

'0' has code value 48



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Character Type

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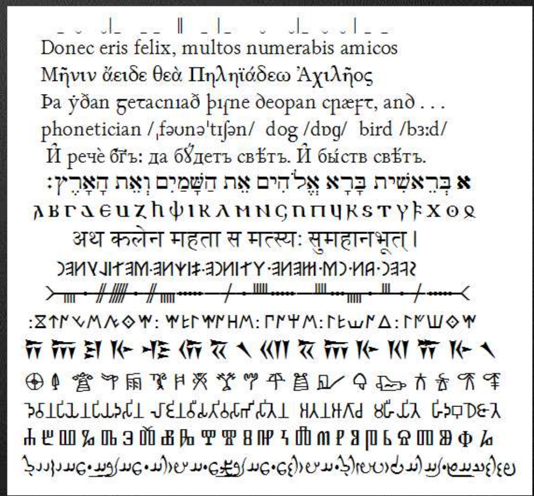
String Type



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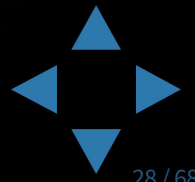
The String Data Type

- The string data type:
  - Represents a sequence of characters
  - Is declared by the `string` keyword
  - Has a default value `null` (no value)
- Strings are enclosed in quotes:

```
string s = "Microsoft .NET Framework";
```

- Strings can be concatenated
  - Using the + operator



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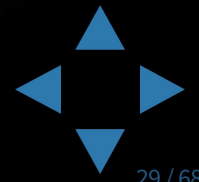
String Concatenation: *Example*

- *Example:* Concatenating the two names of a person to obtain his full name:
  - *Note*: a space is missing between the two names! We have to add it manually

```
string firstName = "Ivan";
string lastName = "Ivanov";
Console.WriteLine("Hello, {0}!\n", firstName);

string fullName = firstName + " " + lastName;
Console.WriteLine("Your full name is {0}.",
  fullName);
```



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String Type

Demo

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Object Type

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The Object Type

- The object type:
  - Is declared by the `object` keyword
  - Is the base type of all other types
  - Can hold values of any type

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Using Objects

- *Example* of an object variable taking different types of data:

```
object dataContainer = 5;
Console.Write("The value of dataContainer is: ");
Console.WriteLine(dataContainer);

dataContainer = "Five";
Console.Write("The value of dataContainer is: ");
Console.WriteLine(dataContainer);
```

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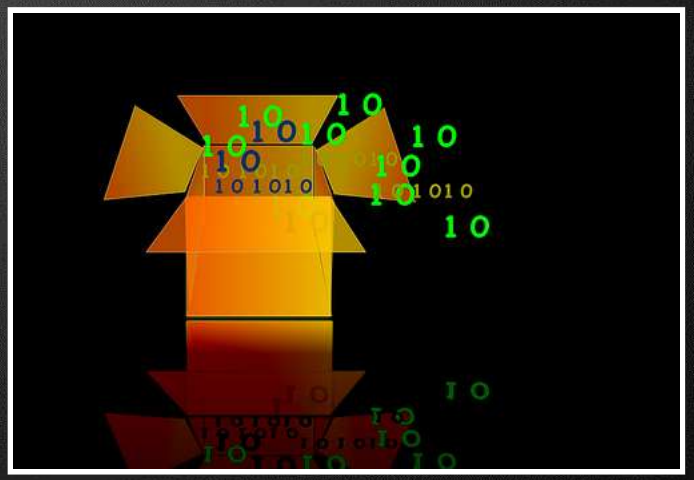
Introducing Variables



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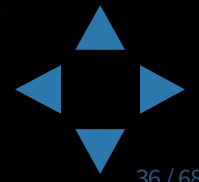
What Is a Variable?

- A variable is a:
  - Placeholder of information that can usually be changed at run-time
- Variables allow you to:
  - Store information
  - Retrieve the stored information
  - Manipulate the stored information



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Variable Characteristics

- A variable has:
  - Name
  - Type (of stored data)
  - Value
- *Example*:
  - Name: `counter`
  - Type: `int`
  - Value: `5`

```
int counter = 5;
```

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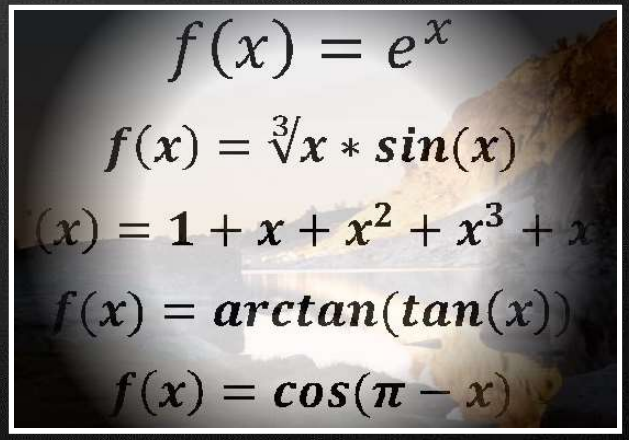
Declaring and Using Variables



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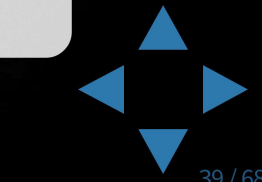
Declaring Variables

- When declaring a variable we:
  - Specify its type
  - Specify its name (called identifier)
  - May give it an initial value
- The syntax is the following:

```
<data_type> <identifier> [= <initialization>];
```

- *Example:*

```
int height = 200;
```



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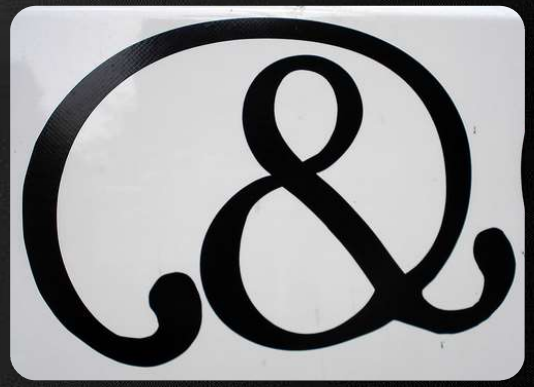
Identifiers

- Identifiers may consist of:
  - Letters (Unicode)
  - Digits [0-9]
  - Underscore _
- Identifiers
  - Must begin with either a letter or an underscore
  - Cannot be a C# keyword



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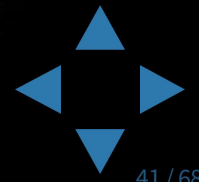
Identifiers

- Identifiers
  - Should have a descriptive name
  - It is recommended to use only Latin letters
  - Should be neither too long nor too short
- *Note*:
  - In C# small letters are considered different than the capital letters (case sensitivity)



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Identifiers – *Examples*

- *Examples* of correct identifiers:

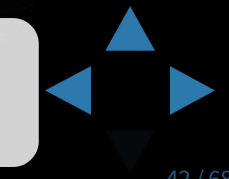
```
int New = 2; // Here N is capital
int _2Pac; // This identifiers begins with _
string поздрав = "Hello"; // Unicode symbols used

// The following is more appropriate:
string greeting = "Hello";
int n = 100; // Undescriptive
int numberOfClients = 100; // Descriptive

// Overdescriptive identifier:
int numberOfPrivateClientOfTheFirm = 100;
```

- *Examples* of incorrect identifiers:

```
int new;  // new is a keyword
int 2Pac; // Cannot begin with a digit
```



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Assigning Values To Variables

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Assigning Values

- Assigning of values to variables
  - Is achieved by the = operator
- The = operator has
  - Variable identifier on the left
  - Value of the corresponding data type on the right
  - Could be used in a cascade calling, where assigning is done from right to left

```
int firstValue = 3;
int secondValue;

secondValue = firstValue;

firstValue = secondValue = 3; // Avoid this!
```

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Initializing Variables

- Initializing
  - Is assigning of initial value
  - Must be done before the variable is used!
  - By using the new keyword

```
int num = new int(); // num = 0
```

  - By using a literal expression

```
float heightInMeters = 1.74f;
```

  - By referring to an already initialized variable

```
string greeting = "Hello World!";
string message = greeting;
```

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Assigning and Initializing Variables

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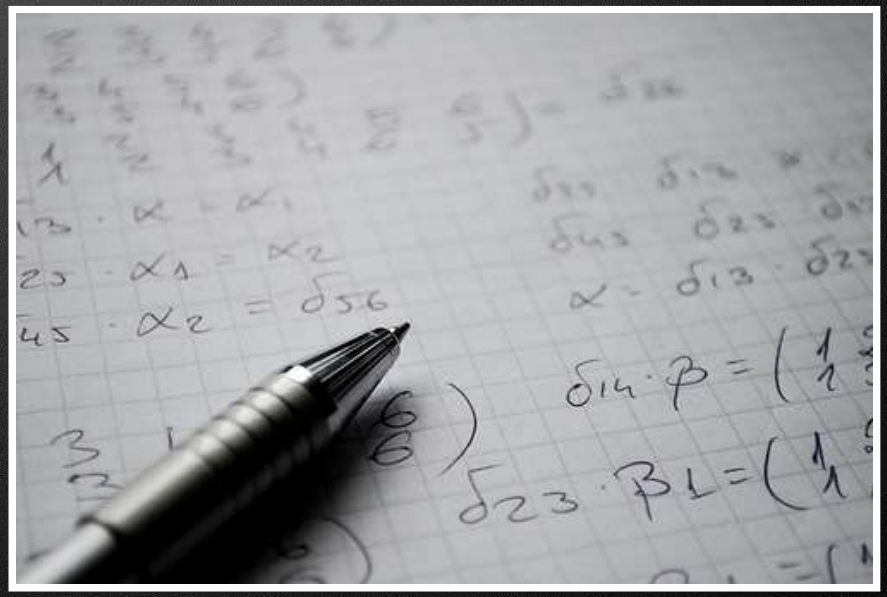
Literals



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What are Literals?

- Literals are:
  - Representations of values in the source code
- There are six types of literals
  - Boolean
  - Integer
  - Real
  - Character
  - String
  - The `null` literal

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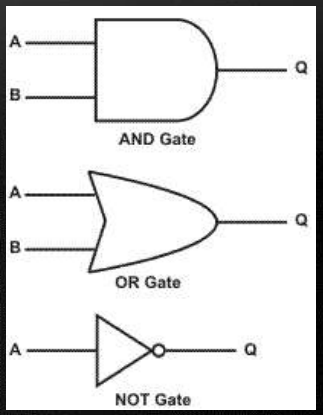
Boolean and Integer Literals

- The boolean literals are:
  - `true`
  - `false`
- The integer literals:
  - Are used for variables of type `int`, `uint`, `long`, and `ulong`
  - Consist of digits
  - May have a sign (+, -)
  - May be in a hexadecimal format



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Integer Literals

- *Examples* of integer literals
  - The `'0x'` and `'0X'` prefixes mean a hexadecimal value

```
0xA8F1
```

  - The `'u'` and `'U'` suffixes mean a `ulong` or `uint` type

```
12345678U
```

  - The `'l'` and `'L'` suffixes mean a `long` or `ulong` type

```
9876543L
```

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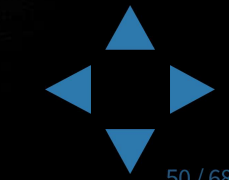

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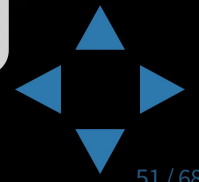
Integer Literals – *Example*

- *Note*: the letter `'l'` is easily confused with the digit 1 so it's better to use `'L'`!!!

```
// The following variables are
// initialized with the same value:
int numberInHex = -0x10;
int numberInDec = -16;

// The following causes an error,
//because 234u is of type uint
int unsignedInt = 234u;

// The following causes an error,
//because 234L is of type long
int longInt = 234L;
```



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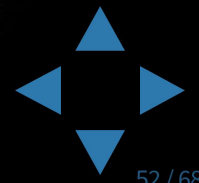
Real Literals

- The real literals:
  - Are used for values of type `float`, `double` and `decimal`
  - May consist of digits, a sign and `.`
  - May be in exponential notation: `6.02e+23`
- The `f` and `F` suffixes mean `float`
- The `d` and `D` suffixes mean `double`
- The `m` and `M` suffixes mean `decimal`
- The default interpretation is `double`



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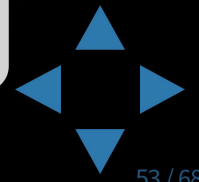
Real Literals – *Example*

- *Example* of incorrect `float` literal:

```
// The following causes an error
// because 12.5 is double by default
float realNumber = 12.5;
```

- A correct way to assign floating-point value (using also the exponential format):

```
// The following is the correct
// way of assigning the value:
float realNumber = 12.5f;
// This is the same value in exponential format:
realNumber = 1.25e+7f;
```



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Character Literals

- The character literals:
  - Are used for values of the `char` type
  - Consist of two single quotes surrounding the character value: `'<value>'`
- The value may be:
  - Symbol
  - The code of the symbol
  - Escaping sequence

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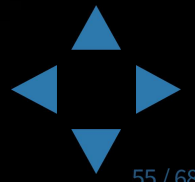
Escaping Sequences

- Escaping sequences are:
  - Means of presenting a symbol that is usually interpreted otherwise (like ')
  - Means of presenting system symbols (like the new line symbol)
- Common escaping sequences are:
  - \' for single quote \" for double quote
  - \\ for backslash \n for new line
  - \uXXXX for denoting any other Unicode symbol



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Character Literals – *Example*

- *Examples* of different character literals:

```
char symbol = 'a'; // An ordinary symbol

// Unicode symbol in hexadecimal format (letter 'o')
symbol = '\u006F';

symbol = '\u8449'; // 葉 (Leaf in Traditional Chinese)
symbol = '\''; // single quote symbol
symbol = '\\'; // backslash symbol
symbol = '\n'; // new line symbol
symbol = '\t'; // TAB symbol
symbol = "a"; // Incorrect: use single quotes
```

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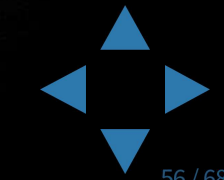

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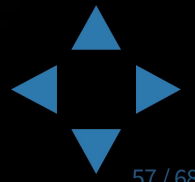
String Literals

- String literals:
  - Are used for values of the string type
  - Consist of two double quotes surrounding the value: `"<value>"`
  - May have a @ prefix which ignores the used escaping sequences: `@"<value>"`
- The value is a sequence of character literals

```
string s = "I am a sting literal";
```



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String Literals – *Example*

- Benefits of quoted strings (the @ prefix):
- In quoted strings \" is used instead of ""!

```
// Here is a string literal using escape sequences
string quotation = "\"Hello, Jude\", he said.";
string path = "C:\\WINNT\\Darts\\Darts.exe";

// Here is an example of the usage of @
quotation = @"""Hello, Jimmy!"", she answered.";
path = @"C:\WINNT\Darts\Darts.exe";

string str = @"some
        text";
```

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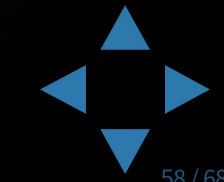

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String Literals

Demo

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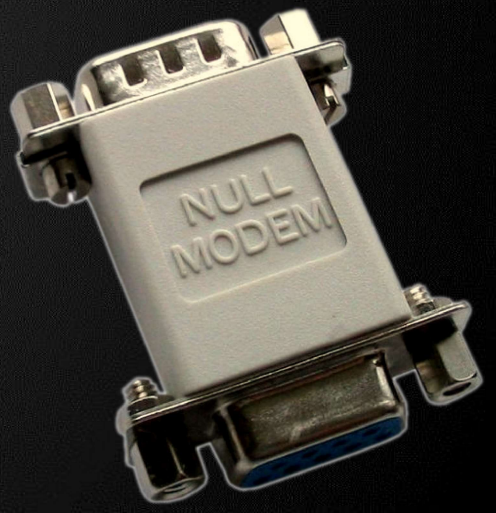
Nullable Types

NULL



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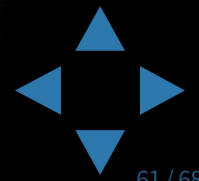
Nullable Types

- Nullable types are instances of the `System.Nullable` struct
  - Wrapper over the primitive types
  - E.g. `int?`, `double?`, etc.
- Nullabe type can represent the normal range of values for its underlying value type, plus an additional `null` value
- Useful when dealing with Databases or other structures that have default value `null`



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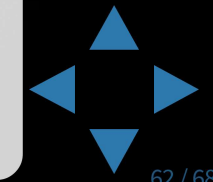
Nullable Types – *Example*

- *Example* with Integer:

```
int? someInteger = null;
Console.WriteLine(
  "This is the integer with Null value -> "
    + someInteger);
someInteger = 5;
Console.WriteLine(
  "This is the integer with value 5 -> "
    +  someInteger);
```

```
double? someDouble = null;
Console.WriteLine(
  "This is the real number with Null value -> "
  + someDouble);
someDouble = 2.5;
Console.WriteLine(
  "This is the real number with value 5 -> "
    + someDouble);
```



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Nullable Types

Demo

```
int?
```

```
double?
```

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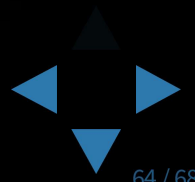
Dynamic Types in C#

Types Holding Anything & Evaluated at Runtime



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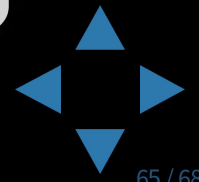
Dynamic Types

- Dynamic types in C# (keyword `dynamic`)
  - Can hold anything (string, number, object, function / method reference)
  - Operations evaluated at runtime
  - Behave like types in JavaScript / PHP

```
dynamic a = 5;
dynamic b = 3;
Console.WriteLine(a + b); // 8 (sum of integers)
a = "5";
b = 3;
Console.WriteLine(a + b); // 53 (string concatenation)
```



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Dynamic Types

Demo

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Primitive Data Types and Variables

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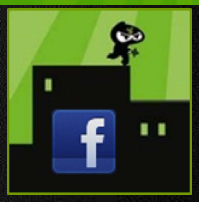

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