

Chapter 2 JavaScript Essentials

1 Lesson Overview

- Primitive data types
- string template
- null and undefined
- Data type conversion
 - Type inference and `typeof` operator
 - Implicit and explicit type conversion
- Operators
- Practical Technique: Set the default value of a variable

2 Variables

- Use variables to store values temporarily for later use.
- JS is a loosely typed (weakly) language, so you don't need to specify the data type of a variable when you declare it.
- JS determines the data type of a variable at runtime.
- Uninitialized variables have the value `undefined`.

Declaring variables

- Declare a variable to allocate memory for it.
- You can declare a variable with different scopes using `let`, `const`, and `var`.

Variable Scope

- Scope refers to the visibility of a variable in a program.
- Three types of scope in JS: block, function, and global scope.

The diagram illustrates variable scope in JavaScript using a code example with three nested scopes highlighted by colored boxes and numbered callouts:

- Global Scope (1):** The outermost scope, highlighted in light blue. It contains the variable `a` and the function `foo`. The label "global: a, foo" is associated with this scope.
- Function Scope (2):** The middle scope, highlighted in light green. It is the scope of the function `foo`, containing the parameter `x`, the variable `b`, and the inner function `bar`. The label "foo: x, b, bar" is associated with this scope.
- Block Scope (3):** The innermost scope, highlighted in light yellow. It is the scope of the function `bar`, containing the parameter `y` and the variable `c`. The label "bar: y, c" is associated with this scope.

```
var a = 4;

function foo(x) {
  var b = a * 4;

  function bar(y) {
    var c = y * b;
    return c;
  }

  return bar(b);
}

console.log(foo(a));
// 256
```

- Block Scope
 - Be visible only within the block in which it is declared.
 - declared using `let` and `const` .
- Function Scope
 - Be visible only within the function in which it is declared.
 - declared using `var` .
- Global Scope
 - Be visible throughout the program.
 - declared not in a block or a function (declared in the most outer scope).
 - No matter using `let` , `const` , or `var` .

Best practice for declaring variables

- Use `let` to declare local variables in a block. (block scope).
- Use `const` to declare constants. (block scope)
- Use `var` to declare variables of the function scope.
- Initialize variables when you declare them to avoid `undefined` values.



Example: Accessing variables with different scopes

```
let count = 0; // global variable
function aFunction(){
  for (let i = 0; i < 10; i++) {
    var sum = 10; // function-scoped variable
    var user; // undefined variable
  }
  // accessible from outside the block
  console.log('sum(inside):', sum);
  // undefined; accessible from outside the block.
  console.log('user: ', user);
  // out of scope; ReferenceError: i is not defined. i is a block-scoped variable.
  console.log('i:', i);
}

aFunction();
// accessible the global variable
console.log('count:', count);
// Try to access the function-scoped variable;
// out of scope; ReferenceError: sum is not defined. sum is block-scoped variable.
console.log('sum(outside):', sum);
```


See full example in [ex_02_01](#)

```
> for (let i = 0; i < 10; i++) {  
    var sum = 10;  
    var user; // undefined variable  
}  
console.log(sum);  
console.log(user); // undefined  
console.log(i); // out of scope; ReferenceError: i is not defined
```

10

undefined

✖ ▶ Uncaught
ReferenceError: i is not defined
at <anonymous>:7:13

>

See more: [Grammar and types - JavaScript | MDN](#)

Naming variables

Best practices:

- Use Intention-Revealing names for variables to show their purpose and make the code easier to read.

```
let d = 0; // bad  
let daysSinceCreation = 0; // good; self-explanatory
```

- Use camelCase for variable names, e.g., `ageOfBuyer` .
- Use Pronounceable names, e.g., `modificationTimestamp` instead of `modydhms` .

3 Primitive data types

The primitive data type is a data type that is not an object and has no methods.

Available primitive data types:

- string, number, bigint, boolean, undefined, symbol, null
 - See [Primitive - MDN Web Docs Glossary: Definitions of Web-related terms | MDN](#)
- they are all in lowercase
 - `string` is a primitive data type; `String` is an object.

Immutability of primitive data types

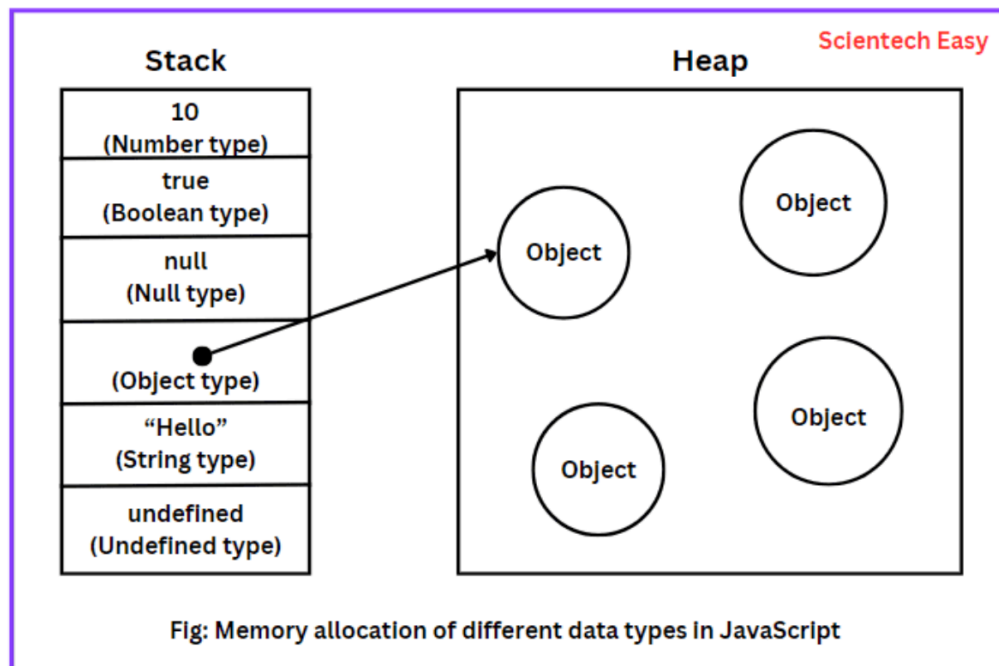
- Primitive data types are **immutable**, meaning that their values cannot be changed once they are created.
- But you can assign a new value to it.

```
let str = "Hello";  
str[0] = "h"; // Attempt to change the first character  
console.log(str); // Output: "Hello" (unchanged)
```

Primitive data types vs reference data types

The another difference between primitive and reference data types is that

- primitive data types are stored in the **stack**,
- while reference data types are stored in the **heap**.



Auto-boxing of primitive data types to objects

- Primitives have no methods but still behave as if they do.
 - JS runtime automatically converts primitive values to objects when you call a method on them.
 - This is called **auto-boxing**.

Example: Convert a string to uppercase using the `toUpperCase()` method.

```
let userName = "Alice";  
// ALICE. A String wrapper object is created and then destroyed by auto-boxing.  
console.log(userName.toUpperCase());  
// Alice. The original value is not changed.  
console.log(userName);
```

Example: Convert a number to a string using the `toString()` method.

```
let x = 10;  
// Convert the number 10 to a base-2 string "1010"  
console.log(x.toString(2));
```

See more: [Primitive - MDN Web Docs Glossary: Definitions of Web-related terms | MDN](#)

Comparing primitive data types by value

Primitives are also compared by value, not by reference.

Example of comparing by value:

```
let x = 10;  
let y = 10;  
console.log(x === y); // true. x and y have the same value but don't share the same memory location.
```

Example of comparing by reference:

```
let a = [1, 2, 3];  
let b = [1, 2, 3];  
console.log(a === b); // false. a and b don't share the same memory location, although they have the same value.  
let c = a;  
console.log(a === c); // true. a and c share the same memory location.
```

ex_02_02

4 Summary of primitive data types

Primitive data types are:

- not objects and have no methods.
- immutable.
- stored in the stack.
- compared by value, not by reference.
- auto-boxed to objects when you call methods on them.

5 **string** template

Use the string template to make your code:

- more readable
- allowing for multi-line strings
- embedding expressions in strings
- avoiding the **+** operator to concatenate strings.

- Use **backticks** to create a string template.
- You can embed expressions in a string template using `${}`.

```
let name = 'Alice';  
let age = 20;  
let message = `Hello, ${name}. You are ${age} years old.`;  
console.log(message); // Hello, Alice. You are 20 years old.
```

The string template is more readable than using the `+` operator to concatenate strings.

```
// Using the + operator to concatenate strings  
// not recommended  
let message = 'Hello, ' + name + '. You are ' + age + ' years old.';  
console.log(message); // Hello, Alice. You are 20 years old.
```

6 null and undefined

- `null` and `undefined` both represent an absence of value.
- `undefined` is used by **JS** to indicate an **uninitialized state**.
 - e.g. a variable that has been declared but not assigned a value.
 - e.g. a function that does not return anything.
- `null` is used by **programmers** to explicitly indicate "**no value**" or "**empty**".

Be careful with the two values:

- might cause unexpected results if you don't handle them properly.

7 Data type conversion

Type inference and `typeof` operator

- JS infers the data type of a variable at runtime.

```
let foo = 42;    // foo is a number
let foo = 'bar'; // foo is a string
let foo = true;  // foo is a boolean
let foo;         // foo is undefined
```

- When you want to know the data type of a variable at the runtime, use the `typeof` operator.

```
let x = 10;
console.log(typeof x); // number
```

Conversion between data types

- Two different data types cannot be operated together.
- You explicitly convert a data type to another (explicit type conversion) or
- Let JS convert it automatically for you (implicit type conversion) according to the default rules.
- Example: What is the result of $1 + "1"$?

```
let result = 1 + "1"; // "11"  
console.log(typeof result); // string
```

- Example: What is the result of $1 - "1"$?

```
let result = 1 - "1"; // 0  
console.log(typeof result); // number
```

8 Explicit type conversion

- Use the explicit type conversion to avoid unexpected results (Also showing your intention clearly).
- Data type conversion functions:
 - Use the `Number()`, `String()`, `Boolean()`, `BigInt()`, `Symbol()` functions to convert a value to a specific data type.
 - These are standard built-in functions in JS.

```
let x = "1";  
// Explicitly convert the string "1" to a number 1  
let y = 1 + Number(x);  
console.log(y); // 2
```


Convert a string to a number

- `Number()` vs `parseInt()` and `parseFloat()`
- When you want to convert a number string of base-10 to a number, use `Number()`.
 - e.g. Convert "101" to 101.
- When you want to convert a string of a specific radix to an integer or a floating-point number, use `parseInt()` and `parseFloat()`.
 - binary, octal, decimal, or hexadecimal strings => integer
 - e.g. Convert "11" to 3 in binary.

Example of using `parseInt()` :

```
// parse the string "11" as a binary number and convert it to a decimal number
console.log(parseInt("11", 2)); // 3
// parse the string "11" as a hexadecimal number and convert it to a decimal number
console.log(parseInt("11", 16)); // 17
```

Convert a number to a string

- Convert a number to a string of a specific base (radix) using the `toString()` method.
 - e.g. Convert the number 10 to a binary string "1010".
- Apply the `toString()` object method to convert a number to a string in a specific radix.
 - JS auto-boxes the `number` to a `Number` object when you call the `toString()` method.

```
let x = 10;  
  
// Wrap x in a Number object automatically and convert it to a string in binary: "1010"  
console.log(x.toString(2)); // binary string "1010"  
  
// Equivalent to the above code  
console.log(Number(x).toString(2));
```

Explicit conversion idioms

- You can use the **default conversion rules** of some operators to explicitly convert a value to a specific data type.
 - Save your time but make your code less readable.
- Convert to string:
 - `x + ""` : convert x to a string. `+` is a binary operator (with two operands).
- Convert to number:
 - `+x` : convert x to a number. `+` is the unary operator: unary plus
 - `x-0` : convert x to a number. `-` is a binary operator: subtraction.
- Convert to boolean:
 - `!!x` : convert x to a boolean. `!` is the unary operator: logical NOT.

9 Implicit type conversion

- JS can convert data types for you automatically when you operate or compare with two different data type values.
- The conversion rules depend on the operator or the context in which the conversion occurs.
- Introduce two most famous operators with special conversion rules: `+` and `==`.

Conversion rules of the `+` operator

- Operator `+` (the operator with addition and string concatenation functions):
 - The `+` operator can perform two operations: **string concatenation** and **number addition**.
 - This is called **operator overloading**.
- Rules:
 - If one of the operands is a string, JS converts the other to a string and concatenates them.
 - Otherwise, JS tries to convert the non-number operand to a number and performs addition.

```
console.log(2 + 2); // Expected output: 4
```

```
// Adding two numbers. "true" is converted to 1.
```

```
console.log(2 + true); // Expected output: 3
```

Conversion rules of the equal operator `==`

- Operator `==`: Equality operator with type coercion (Also called the **loosely** equality operator)
- The `==` operator compares two values and returns `true` if they are equal.
 - If the two values have different data types, JS converts one to the other's data type.
 - This is called **type coercion**.
 - The `==` operator is not recommended because it can lead to unexpected results.
- Use the `===` operator (strict equality operator) to compare two values **without** type coercion.

Examples of the `==` operator

```
// true; Type Coercion: convert the string "1" to a number 1
console.log("1" == 1);

// true; Type coercion occurs:
console.log(1 == "1");

// true; Type coercion occurs: convert the boolean false to a number 0
console.log(0 == false);

// not perform type coercion between null and any other value except undefined.
console.log(0 == null); // false

// not perform type coercion between null and any other value except undefined.
console.log(0 == undefined); // false
```

```
// Explicitly convert null to boolean false before comparison
// !! is a conversion idiom to convert a value to a boolean.
// true. !!null is false -> false converted to 0 -> 0 == 0 is true
console.log(0 == !!null);

// Explicitly convert undefined to boolean false before comparison
// !! is a conversion idiom to convert a value to a boolean.
// true. !!undefined is false -> false converted to 0 -> 0 == 0 is true
console.log(0 == !!undefined);

// According to the ECMAScript specification,
// null and undefined are only equal to themselves and each other.
console.log(null == undefined); // true
```

Ref: See [Equality \(==\) - JavaScript | MDN](#) for the detailed rules of the `==` operator.

Best Practice for comparing values

- Always use the strict equality operator `===` to compare two values without type coercion.
- **Do not rely on the default type coercion rules if you want to write clear and predictable code.**

Programming meme about the implicit type conversion in JS:



Summary of the implicit conversion rules

Value	Converted to:			
	String	Number	Boolean	Object
undefined	"undefined"	NaN	false	throws <i>TypeError</i>
null	"null"	0	false	throws <i>TypeError</i>
true	"true"	1		new Boolean(true)
false	"false"	0		new Boolean(false)
"" (empty string)		0	false	new String("")
"1.2" (nonempty, numeric)		1.2	true	new String("1.2")
"one" (nonempty, non-numeric)		NaN	true	new String("one")
0	"0"		false	new Number(0)
-0	"0"		false	new Number(-0)
NaN	"NaN"		false	new Number(NaN)
Infinity	"Infinity"		true	new Number(Infinity)
-Infinity	"-Infinity"		true	new Number(-Infinity)
1 (finite, non-zero)	"1"		true	new Number(1)
{ } (any object)	see §3.8.3	see §3.8.3	true	
[] (empty array)	""	0	true	
[9] (1 numeric elt)	"9"	9	true	
[' a '] (any other array)	use <i>join()</i> method	NaN	true	
function(){} (any function)	see §3.8.3	NaN	true	

10 Operators

- Various kinds of operators in JS:
 - Arithmetic operators: `+`, `-`, `*`, `/`, `%` (modulus), `++` (increment), `--` (decrement), `**` (exponentiation)
 - Assignment operators: `=`, `+=` (Addition assignment), `-=`, `*=`, `/=`, `%=`, `**=`
 - Comparison operators: `==`, `===`, `!=`, `!==`, `>`, `<`, `>=`, `<=`
 - Logical operators: `&&` (AND), `||` (OR), `!` (NOT)

- Pay attention to the differences between the prefix and postfix increment and decrement operators.
 - `++x` and `x++` are different.

Example:

```
let x = 1;
// x is incremented after the value is logged.
console.log(x++); // 1;
// x is incremented after the value is logged.
console.log(x); // 2;

let y = 1;
// y is incremented before the value is logged.
console.log(++y); // 2;
y is incremented before the value is logged.
console.log(y); // 2;
```

Please read the section on the operators in Chapter 2 of the textbook.

See more: [Expressions and operators - JavaScript | MDN](#)

11 Practical Technique: Set the default value of a variable when your source is `null` or `undefined`

- You often set a value to a variable according to the value of another variable.
- When the source variable is `null` or `undefined`, you want to set a default value to the target variable.
- Consider the following example:

```
function greet(name) {  
    // parameter name might be null or undefined  
    let userName = name;  
    console.log(`Hello, ${userName}`);  
}
```

Set default value using the `||` or `??` operators

Handling only `null` and `undefined`:

- use the `??` operator (nullish coalescing operator) to set a default value only when the source value is `null` or `undefined`.
 - Default a value when the source value is `null`
- The above example can be rewritten as follows:

Example: set a default to the function parameter to avoid the `null` or `undefined` value.

```
function greet(name) {  
  // parameter name might be null or undefined  
  // set the default value to "Guest" when name is null or undefined  
  let userName = name ?? "Guest";  
  console.log(`Hello, ${userName}`);  
}
```


Handling the falsy values `null`, `undefined`, `0`, `false`, `""`:

- use the logical OR operator `||` to set a default value when the source value is falsy.
- falsy values are those that are considered false in a Boolean context.

Example: set a default to the function parameter to avoid the falsy values.

```
function greet(name) {  
    // parameter name might be falsy (null, undefined, empty string, 0, false)  
    // set the default value to "Guest" when name is falsy  
    let userName = name || "Guest";  
    console.log(`Hello, ${userName}`);  
}  
  
// Test cases  
greet("Alice");           // Output: Hello, Alice  
greet("");               // Output: Hello, Guest  
greet(null);             // Output: Hello, Guest  
greet(undefined);        // Output: Hello, Guest  
greet(0);                // Output: Hello, Guest  
greet(false);            // Output: Hello, Guest
```

Ref: [The Ultimate Guide to Default Values in JavaScript: || and ?? Operators Explained](#)

12 Summary

- Declaring and naming variables
- Primitive data types: string, number, bigint, boolean, undefined, symbol, null
- null vs undefined
- Data type conversion: explicit and implicit
- Operators: arithmetic, assignment, comparison, logical

13 Symbol data type (Optional)

- A symbol is a unique and immutable data type
- It is often used as an object property key to avoid being overwritten by other programs.
- Be available after ES6.

Create public and private symbols

- Create a **private** symbol by using the `Symbol('optional_description')` function.
 - Each symbol is unique, even if they have the same description.
- Create a **public** symbol by using the `Symbol.for('key')` function.
 - If a symbol with the same key already exists, it returns the existing symbol.
 - Shareable symbols are stored in the **global symbol registry**.

```
//Create a private symbol
privateId = Symbol('id');

// create a public in the public symbol registry
sharedId = Symbol.for('id');

console.log(privateId === sharedId);

// Get the symbol by key from the public symbol registry
retrievedId = Symbol.for('id');
console.log(retrievedId === sharedId);
```

Ref: [Symbol - JavaScript | MDN](#)

Advanced Reading: Using the symbol data type to create private properties

Example of object properties that are overwritten by other programs:

```
// Define an object with a property
let user = {
  name: "John Doe"
};

console.log(user.name); // Output: John Doe
```

```
// Later in the code or in another script, the property is overridden  
user.name = "Jane Doe";
```

```
console.log(user.name); // Output: Jane Doe
```

```
// Another example, a third-party library might modify the object  
function updateUser(user) {  
    // A function from a library that modifies the user object  
    user.name = "Library User";  
}
```

```
updateUser(user);
```

```
console.log(user.name); // Output: Library User
```


Example of using a symbol to create a private property:

```
// Create a unique symbol
const uniqueName = Symbol('name');

// Define an object using the symbol as a property key
let user = {
  [uniqueName]: "John Doe"
};

console.log(user[uniqueName]); // Output: John Doe
```

```
// Even if another part of the code or a library tries to set 'name' property,  
//It won't affect the unique symbol property  
user.name = "Jane Doe";  
console.log(user.name); // Output: Jane Doe  
console.log(user[uniqueName]); // Output: John Doe  
  
// Another script or library using a symbol with the same description  
// will not override the original property, as each symbol is unique  
const anotherUniqueName = Symbol('name');  
user[anotherUniqueName] = "Library User";  
  
console.log(user[uniqueName]); // Output: John Doe  
console.log(user[anotherUniqueName]); // Output: Library User
```