Ch6 Functions

Cover the following topics:

- Function declaration, arguments, and return values
    - named function, function expression, arrow function
- Variable scope in functions
- Nested functions and closures
- Function callbacks

1 What are functions?

- Functions are **reusable blocks** of code that can be called by **name**.
- Functions are **objects**
  - can be passed as arguments to other functions
  - can be returned by other functions
  - can be assigned to variables

BEST PRACTICE Do not repeat yourself.

- If you find yourself writing the same code multiple times, consider refactoring it into a function.
- It makes your codes more readable and maintainable.

2 Function declaration

- Function is an object.
- You declare a function and then call it by its name.
- There are three ways to declare a function:
    - `function` statement
    - `function` expression
    - Arrow function (ES6)

Function statement

Task: Create a function that takes two arguments and returns the sum of the two arguments.

- Use the `function` statement

```
function add(a, b) {
  return a + b;
}
```

Function expression

- Use the `function` expression to do the same task:

```
const add = function(a, b) {
  return a + b;
};
```

- the expression in the LHS create a function object and assign it to the variable `add`.

Arrow function (ES6)

- Use the arrow function
  - a short-hand syntax to create a function object.

```
const add = (a, b) => {return a+b;};
```

- If you have only one return statement in the function, you can omit the curly braces and the `return` keyword.

```
const add = (a, b) => a+b;
```

Concept review: When to append a semicolon to the end of a line?

- Append a semicolon to end of a statement to avoid unexpected behavior and improve code readability.
- Must add the semicolon to the end of a statement if you have multiple statements in the same line.
- You don't need to append a semicolon to the end of a code blocks.
  - e.g. if, for, while, function statements.

Lab 6.1: Write a function that takes the body weight and height of a person and returns the BMI of the person.

- The formula for BMI is `weight / (height**2)`.
- Use the `function` statement, `function` expression, and arrow function to create the function.
- Default the height to 0 if it is undefined, null, or not a number (false values).

BEST PRACTICE: Write comments for your functions.

- Describe the purpose of the function.
- Describe the arguments and return values.
- Follow the JSDoc format to allow tools to automatically generate documentation for your code.
- How to use JSDoc - Basics & Introduction @ youtube 13:04

Example of writing comments for a function using JSDoc format

```
/**
 * Calculate the BMI of a person.
 * @param {number} weight - The body weight of the person.
 * @param {number} height - The height of the person.
 * @returns {number} The BMI of the person.
 */
const calculateBMI = (weight, height) => {
  height = height || 0;
  return weight / (height ** 2);
};
```

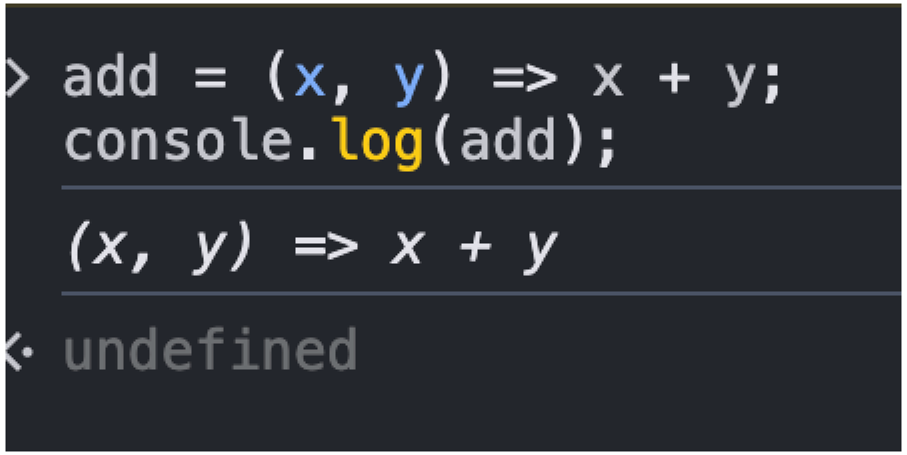
3 Invoking a function

- Invoke a function by calling its name followed by parentheses.
- Provide the arguments in the parentheses.

```
const sum = add(1, 2);
console.log(sum); // 3
```

- If you don't provide the parentheses, you get the function reference, not call the function.

```
add = (x, y) => x + y;
console.log(add); // Prints the function object
```



```
> add = (x, y) => x + y;
  console.log(add);
  (x, y) => x + y
<· undefined
```

Immediately-Invoked Function Expressions (IIFE)

- An IIFE is a function that is immediately invoked after it is defined (self-invoking function).
  - Combine the function definition and invocation in a single expression.
- Merit: They don't pollute the global object
  - the variables declared inside the IIFE are not accessible outside the IIFE.
- Limitation: The IIFE cannot be reinvoked after it is executed
  - because it don't have a name (anonymous function).

When to use IIFE?

- Create private properties for a function/object.
- Use IIFE to avoid polluting the global namespace.
- Add event listeners to elements when the page is loaded.

Reading: IIFEs in JavaScript—Use cases

Syntax of IIFE

The syntax of an IIFE:

```
(function() {
  // code here
})(arguments);
```

- The first `()` is the function definition.
- The second `()` is to pass the arguments and invoke the function.

You can use the arrow function in the IIFE, too:

```
(() => {
  // code here
}
)();
```

Example: Define a function showing the sum of two numbers and execute it immediately.

```
((a, b) => {
  console.log(a + b);
})(1, 2);
```

Quick Practice

Write an IIFE function to reverse a string.

For example: Convert `"Hello World"` to `"dlroW olleH"`.

Hint for reversing a string: `Array.from(str).reverse().join('')` or `str.split('').reverse().join('')`

▶ Referenced Answer

IIFE application: Create a module with private properties and public methods.

Create a module that has two public functions and one private variable to the module.

- `increment` : increment a counter by 1.
- `setStartValue` : set the start value of the counter.
- The counter is a private variable of the module.

How to implement?

- Create a variable and two functions in the function definition of the IIFE.
    - these local variables and functions are private to the module.
- Encapsulate the two function into a object and expose it to the global or window object.

```
(function() {
    let counter = 0;

    function setStartValue(startValue) {
        counter = startValue;
    }
    function increment() {
        counter += 1;
        console.log(counter);
    }

    // Expose the private functions to the global or window objects publicly.
    // Use the global object to attach the module in the NODE.js environment
    // Use the window object to attach the module in the browser environment
    global.myModule = {
        increment: increment,
        setStartValue: setStartValue
    };
})();
```

Run the following code to test the module.

```
myModule.setStartValue(10);
myModule.increment()
myModule.increment();
myModule.increment();
```

Outputs:

```
11
12
13
```

Lab 6.2 Create a program that will randomly describe an inputted name.

Create a module that has a function that randomly describes a name.

- The module has a private array of descriptive words.
- The function takes a name as the argument.
  - Select a random value from the array of descriptive words.
  - Return a string that describes the name.

For example, the list of descriptive words is `['smart', 'funny', 'kind', 'hardworking']`. Given the name `Alice`, the program may print `Alice, your are smart`.

Hint:

- `Math.random()` returns a random number between 0 and 1.
- `Math.floor()` returns the largest integer less than or equal to a given number.

4 Function parameters and arguments

Parameters vs Arguments

- Parameters are the variables in the function declaration.
- Arguments are the values passed to the function when it is called.

```
const add = (a, b) => a + b;
const sum = add(1, 2);
```

- The function `add` has two parameters `a` and `b`.
- The function is called with the arguments `1` and `2`.

Flexible number of arguments

- The number of arguments passed to a function can be different from the number of parameters.
- When the number of arguments is fewer than the number of parameters, the missing parameters are assigned `undefined`.

Example:

```
const add = (a, b) => a + b;
const sum = add(1); // 1 + undefined = NaN
```

- parameter `b` is `undefined` because the argument is missing.

- When the number of arguments is more than the number of parameters, the extra arguments are ignored.

```
const add = (a, b) => a + b;
const sum = add(1, 1, 4); // 1 + 1 = 2
```

- The extra argument `4` is ignored because no extra parameter to take it.

Optional parameters (Or default parameters)

- Some parameters might be optional when you invoke the function.
- You need to provide a default value for the optional parameters.
- Set the default value in the function declaration.

```
function greet(name = 'Alice') {
  return `Hello, ${name}`;
}
console.log(greet()); // Hello, Alice
console.log(greet('Bob')); // Hello, Bob
```

Quick Practice

- Review the following `randomWord` function. The `descWords` is an array of descriptive words.
- Set a default value for `descWords` to `['smart', 'funny', 'kind', 'hardworking']`.
- Call the `randomWord` function without providing the second argument.

```
// The descWords parameter is optional.
function randomWord(name, descWords ) {
    // scale the random number to the length of the array and round down to the nearest whole number
    let randomIndex = Math.floor(Math.random() * descWords.length);
    return `${name}, you are ${words[randomIndex]}.`;
}
```

▶ Referenced Answer

Pass an array to a function as a list of arguments: the spread operator ...

Consider the following scenario:

- You have an array of numbers `[1, 2, 3, 4]`.
- You have defined a function that takes four arguments and returns the maximum value of the four arguments.
  `(x, y, z, w) => Math.max(x, y, z, w)`
- How do you apply the function to the array of numbers?

Use the spread operator `...` to spread elements of an array into a list of arguments.

Use the spread operator in the function invocation.

```
const numbers = [1, 2, 3, 4];
const maxValue = (x, y, z, w) => Math.max(x, y, z, w);
const max = maxValue(...numbers); // equivalent to maxValue(1, 2, 3, 4). Result: 4
```

Rest of the parameters (ES6): Handling indefinite number of arguments

- You might not know the number of arguments passed to a function in advance.
- The feature of "Rest of the parameters" will help you to handle the indefinite number of arguments.
- e.g. Design a function to find the maximum value of a indefinite number of arguments.
- A function that can take variable indefinite number of arguments is call **vararg (or variadic) function**

The syntax of the rest of the parameters

```
function yourFunction(param1, param2, ...restOfParams) {
  // code here
}
```

- `restOfParams` is an **array** that contains the rest of the arguments passed to the function.
- Use the spread operator `...` to declare the rest of the parameters.

Example: indefinite arguments

- Create a function that takes a indefinite number of arguments and returns the max value.

e.g. Write a function to sum up all parameters passed to the function.

```
const sum = (...values) =>
  values.reduce((acc, val) => acc + val, 0);

const result = sum(1, 2, 3, 4);
console.log(result); // 10
```

Application of the rest of the parameters:

High order function: A function calls another function with arguments.

e.g. Create a function that takes the add function and a list of arguments, and calls the add function with the arguments.

```
const add = (a, b) => a + b;

function invokeFunction(func, ...args) {
  // args is an array. Use the spread operator to take the elements out of the array.
  return func(...args);
}

const sum = invokeFunction(add, 1, 2); // 3
```

- the `invokeFunction` is a high order function.

Quick Practice

Given the array of numbers `[1, 2, 3, 4]`, use the `invokeFunction` to call the `sum` function with the array of numbers as arguments.

▶ Referenced Answer

Lab 6.3: Create a simple addition and multiplication calculator.

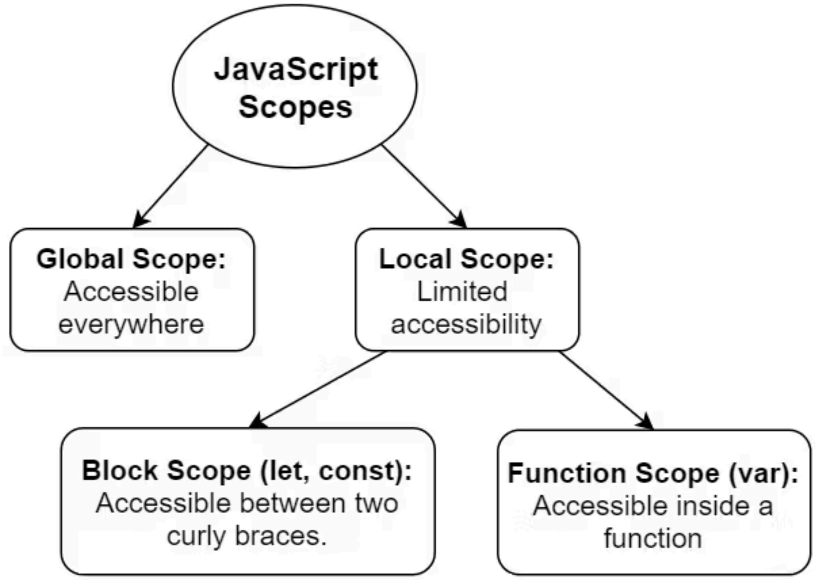
1. Create an `sum` function that takes a variable number of arguments and returns the sum of the arguments.
2. Create a `multiply` function that takes a variable number of arguments and returns the product of the arguments.
3. Yon must write a function to invoke the `sum` and `multiply` functions with the arguments provided.
4. For the inputted string "sum 1 2 3 4", your program should call the `sum` function with the arguments 1, 2, 3, and 4 and print the result.
5. For the inputted string "multiply 1 2 3 4", your program should call the `multiply` function with the arguments 1, 2, 3, and 4 and print the result.

Hint:

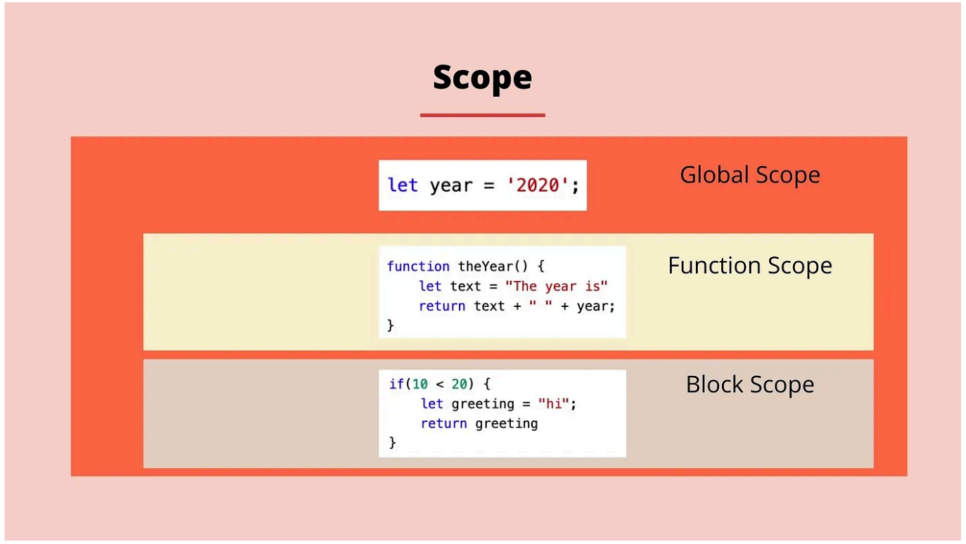
- Use the `split` method of String to split the inputted string into an array of strings. Then, assign them to an array of variables (array destructuring technique).
    - `let [operation, ...args] = str.split(" ");`
- Use the map data structure to index and store the functions if you don't want to use a switch or if-else statement.

5 Variable scope in functions

- Scope defines where you can access a certain variable.
- JavaScript has three types of scope


JavaScript Scopes
Global Scope: Accessible everywhere
Local Scope: Limited accessibility
Block Scope (let, const): Accessible between two curly braces.
Function Scope (var): Accessible inside a function

- Global scope: variables declared outside of a function.
- Function scope: variables declared inside of a function.
  - Use the `var` keyword to declare a variable with function scope.
  - Can be accessed in the entire function.
- Local scope: variables declared inside a block in a function.
  - Use the `let` or `const` keyword to declare a variable with local scope.



```
let year = '2020';
```

```
function theYear() {
    let text = "The year is"
    return text + " " + year;
}
```

```
if(10 < 20) {
    let greeting = "hi";
    return greeting
}
```

Example: function and local scope

```
var x = 1;  // Global Scope

function myFunction(p) {
  // parameter p is function scope variable
  var functionScopeVar = 10;   // function scope variable
  if (true){
    let y = 20;  // block scope variable
    var z = 30; // function scope variable
  }
  // leave the if block
  console.log(x); // 1 (Global)
  console.log(y); // ReferenceError: y is not defined (block scope)
  console.log(z); // 30 (Function scope)
  console.log(p); // 100 (Function scope)
}

myFunction(100);
console.log(x); // 1
console.log(y); // ReferenceError: y is not defined
console.log(z); // ReferenceError: z is not defined
console.log(p); // ReferenceError: param is not defined
```

Hoisting characteristics of `var` variable declarations

- For variables declared with `var`, their declarations are hoisted (move) to the top of the function and is initialized with `undefined`.
- No initialization is done for the variables declared with `let` and `const`.

For example:

```
// hoisting characteristics of var
function hoisting() {
  // use of the variable `a` before declaring it.
  // Since the variable declaration is moved
  // to the top of the function (hoisted) and are set to `undefined`.
  console.log(a); // undefined
  // Assign a value to a; Not declare a new variable
  var a = 10;
  console.log(a); // 10
}
```

Temporal Dead Zone (TDZ) for `let` and `const` declarations

- variable `b` is hoisted to the top of the function but not initialized.
- Before the initialization, the variable is in the **temporal dead zone (TDZ)**.
- Accessing the variable in the TDZ will cause a ReferenceError.

```
function hoisting() {
  console.log(b); // ReferenceError: Cannot access 'b' before initialization
  let b = 20;
  console.log(b); // 20
}
```

6 Nested functions

- A function (inner) can be defined inside another function (outer).
    - Let call the former the **inner** function and the latter the **outer** function.
- Be careful of the variable scope and visibility issue when using nested functions.

```
function outerFunction() {
  let outerVar = 10;
  ...
  function innerFunction() {
    let innerVar = 20;
    ...
  }
```

Rules of the variable scope in nested functions

- Rule 1: An inner function can access the variables and parameters of the outer function.
- The inner function is within the scope of the outer function.
    - So, it can access the variables and parameters of the outer function.

```
function outerFunction(x) {
  let outerVar = 10;
  function innerFunction() {
    console.log(x); // Hi, the argument passed to the outer function
    console.log(outerVar); // 10
  }
  innerFunction();
}
outerFunction('Hi');
```

- Rule 2: An outer function cannot access the variables and parameters of the inner function.
    - The inner function is close to the outer function.

```
function outerFunction() {
  function innerFunction() {
    // function scope starts
    let innerVar = 20;
  } // function scope ends

  console.log(innerVar); // ReferenceError: innerVar is not defined
}
outerFunction();
```

- Rule 3: The variable in the inner function has a higher priority when there is a variable with the same name in the outer function.

```
function outerFunction() {
  let outerVar = 10;
  function innerFunction() {
    let outerVar = 20;
    console.log(outerVar); // 20
  }
  innerFunction();
}
outerFunction();
```

- Rule 4: We cannot invoke the inner function from the outside of the outer function.
    - The inner function is only visible within the outer function.

```
function outerFunction() {
  function innerFunction() {
    console.log('Inner function');
  }
}
innerFunction(); // ReferenceError: innerFunction is not defined
```

7 Closures

What is a closure?

- A closure is a feature that allows inner function to access variables in the outer function even after that outer function has finished executing
- The closure often happens when you create a high order function that returns a function.
- The closure is a common pattern and a powerful feature in JavaScript.

Generating a closure: Return a function from a high-order function

The following example shows how to create a closure:

```
function outerFunction() {
  let outerVar = 10;
  function innerFunction() {
    console.log(outerVar);
  }
  // return the inner function object (not invoking the inner function)
  return innerFunction;
}

// aFunc and innerFunction refer to the same function object
const aFunc = outerFunction();
```

Can the returned function access the variable in the high-order function?

A question arises: Can `aFunc` access the variable `outerVar` in the `outerFunction`?

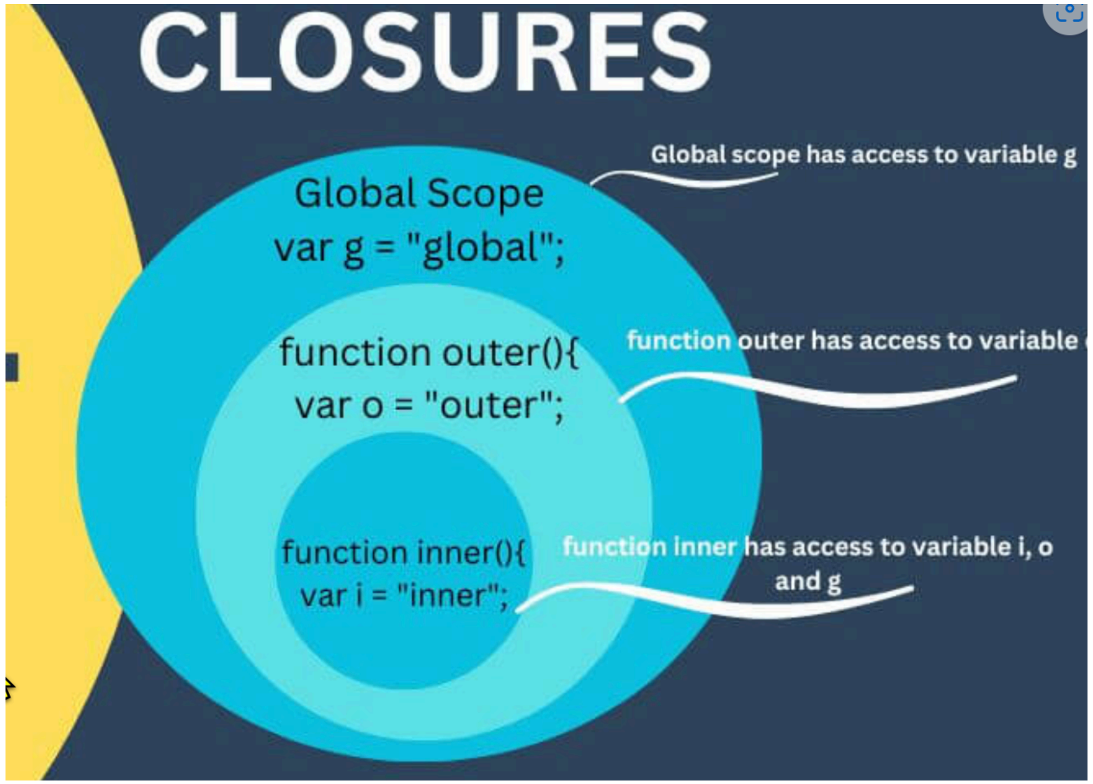
- The `outerVar` is a local variable of the `outerFunction`.

We need to understand the concept of the **lexical scope** to answer the question.

Lexical Scope of a closure

- **Lexical scope** indicate that the variable's scope is defined by its location in the source code.

Lexical scopes for the closure:


CLOSURES
Global Scope
var g = "global";
function outer(){
var o = "outer";
function inner(){
var i = "inner";
Global scope has access to variable g
function outer has access to variable
function inner has access to variable i, o and g

- outer() can access the variable g and o.
- inner() can access the variable g, o, and i

Example: Determine the lexical scope for the inner function

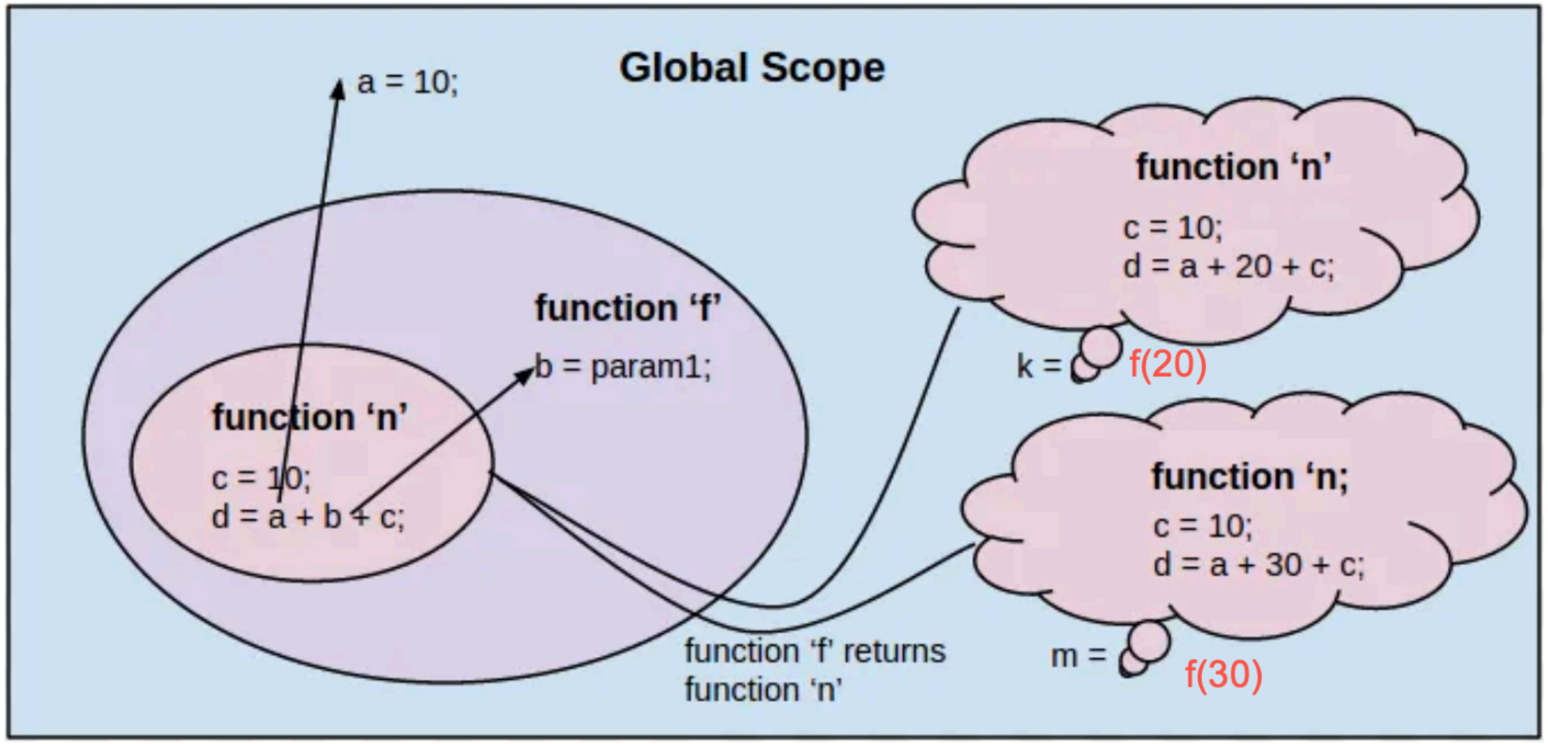
What are the values of `k` and `m` in the following code?

```
const a = 10; // Global variable
function f(b){
    // The return function can access the variables a, b, and c
    // variables a and b have the lexical scope to the inner function
    return function (){
        let c = 10;
        return a + b + c;
    }
}
funcN1 = f(20);
// funcN1 has the variable b = 20, a = 10
const k = funcN1();
console.log(k); // 40

funcN2 = f(30);
// funcN2 has the variable b = 30, a = 10
const m = funcN2()
console.log(m); // 50
```

The following figure depicts the closure in the above example.

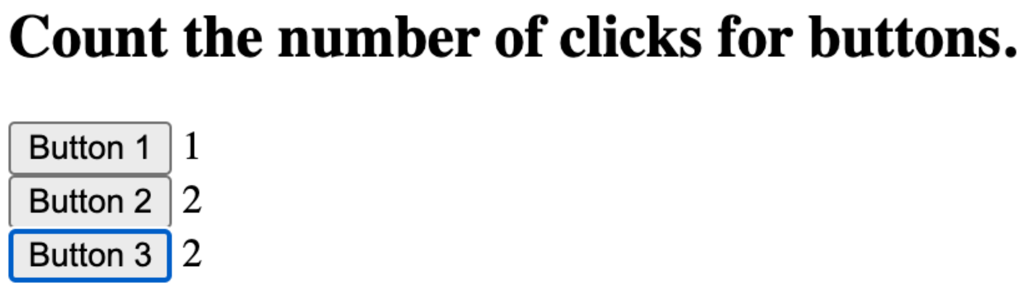
Note: the parameter `b` becomes a private variable of the inner function.



Lab 6.4: Count the number of clicks for buttons (Application of closures)

This lab demonstrates using the closure technique to **create a private counter for each event listener**.

1. Create a HTML page with three buttons, each with a label to indicate the number of clicks. Give each button a unique id.
2. Create a function that returns a function as the event handler.
   - The returned function increments a counter and updates the label with the counter.
3. Add the event listener to each button



Count the number of clicks for buttons.

Button 1 1
Button 2 2
Button 3 2

Demo in CodePen

Hint:

- Need the use the closure technique to have each listener function to have its own counter.
- You may use the IIFE technique to shorten the code.

Quick Question to review the Lexical scope and closure

What wrong with the following code marked with `#1`?

```
// add event listener to the buttons
    // HTML collection
    var buttons = document.getElementsByTagName("button");
    for (let idx = 0; idx < buttons.length; idx++) {
        // add the event listener to the button
        var counter = 0; // #1
        buttons[idx].addEventListener("click", function(){
            console.log('clicked btn ' + idx);
            counter++;
            console.log(counter);
        });
    } // end of for loop
```

- variable `idx` and `counter` are declared in the outer block.
- They are lexically scoped to the inner function.
- However, the `counter` is shared by all event listeners since it is declared with `var` that make it a function scope variable.

8 Function callbacks: passing a function as an argument

- A callback function is a function that is passed as an argument to another function.
- The invoking function can call the callback function.

Example: Executing a function at an interval.

- Use the built-in `setInterval()` to execute a function at a specified interval.

Example:

```
function sayHello() {
  console.log('Hello');
}
setInterval(sayHello, 1000); // print 'Hello' every second
```

9 Summary

- Functions are objects in JavaScript.
- To define a function, you can use the `function` statement, `function` expression, or arrow function.
- IIFE is an expression that combine the function definition and invocation.
  - use it when
    - to avoid polluting the global namespace
    - to create a module with private properties and public methods.
    - to add event listeners to elements when the page is loaded.

- Calling a function with a flexible number of arguments.
  - JS allows you to pass more or fewer arguments than the number of parameters.
  - Lang features: optional parameters, rest of the parameters, and spread operator.
- Variable are hoisted in the function scope.
  - `var` variables are hoisted to the top of the function and initialized with `undefined`.
  - `let` and `const` variables are hoisted but not initialized (Temporal Dead Zone).

- Nested functions and closures.
    - A closure is a feature that allows inner function to access variables in the outer function even after that outer function has finished executing.
    - The inner function can access the variables with the lexical scope to it.