INFO 151
Web Systems and Services

Week 5 (T2)

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Dr Zhili Zhao

Overview

- In this tutorial we will introduce:
  - JavaScript arrays including:
    - What is an array?
    - The nature of arrays and objects in JavaScript with associative arrays
    - Creating and working with arrays, array elements, and array methods
    - Merging (concatenating) two (or more) arrays into a single array
    - Array iteration (looping through arrays)

Sources of Resources

- The sources of information and resources for JavaScript may be found at:
  - The w3schools.com web-site
    - https://www.quanzhanketang.com/
  - The recommended course text book:
    - Sams Teach Yourself PHP, MySQL & JavaScript All in One SIXTH EDITION

What is an Array?

What is an Array?

- In computer science an array is a collection of same type data items that can be selected by indices computed at run-time, including:
  - Array *data structure*: an arrangement of items at equally spaced addresses in computer memory
  - Array *data type*: used in a programming language to specify a variable that can be indexed
  - *Associative array*: an abstract data structure model composed of key-value pairs, often implemented as a hash table or search tree
- Arrays can be very fast data structures:
  - High-level programming languages (e.g., Java) implement arrays and array methods

Array Variables

- In computer programming:
  - In general: a *variable* is a *memory location* that can store a *value*
  - The value held in memory can be changed
  - Each variable can only hold one item of data
- As we have seen in high-level programming languages (e.g., Java):
  - Variables are generally *strongly typed*
  - In such languages: array elements must be of the *same data type*
- As we have seen in JavaScript:
  - Variables are *untyped*
  - In an array in JavaScript elements can be of *any datatype*

JavaScript Methods

- In considering JavaScript arrays we have introduced
  - JavaScript *operators* / *operands* / *properties*/ *methods* / *functions*
- In JavaScript operators, methods, and functions can be used to manipulate *arrays* and the data held in *arrays*
- Comprehensive details of the available operators, methods, and functions can be found from the course resources
- The following slides show JavaScript methods with worked examples showing the program code and the results

JavaScript Arrays and Datatypes

- In JavaScript *variables* and *arrays* are *NOT* typed
- In the following example we can see that the elements of a single JavaScript array can hold different data types:

```
myArray[0] = Date.now;        //a method
myArray[1] = myFunction;      //a function
myArray[2] = myCars;          //an array
myArray[3] = "Philip";        //a string
myArray[4] = 9;               //a number
```

- A JavaScript arrays and elements can hold:
  - *Primitive* data types, *functions*, and *objects*
  - Any *legal* datatype can be held in array elements

JavaScript Arrays

- While we refer to *arrays* JavaScript does not incorporate arrays
  - For example: in JavaScript *variable* and *arrays* are *NOT* typed
- In JavaScript
  - An array is a special type of **`object`**
  - JavaScript automatically creates an *associative array* for each *object*
  - There are differences between JavaScript and PHP!
- When investigating arrays
  - The **`typeof`** operator in JavaScript returns **`object`** for an array

JavaScript Indexing

- It is important to note
  - While *arrays* are *objects* there are differences between JavaScript arrays and JavaScript objects
- The differences Between Arrays and Objects are:
  - JavaScript *arrays* use *numbered indexes*
  - JavaScript objects use *named indexes*
- Arrays are a special kind of objects with numbered indexes
- The following slide shows examples of numbered and named indexes

JavaScript Indexing

- In JavaScript *arrays* are *objects*
  - A specialized type of object with a length property and array methods
  - The array methods are useful when working with array elements
  - Arbitrary data values are associated with arbitrary names

- Named index (an *object*)

```
myArray["x"] = 1;
myArray["y"] = 2;
myArray["y"] = "Philip";
```

- Numbered index (an *array*)

```
myArray[0] = Date.now;
myArray[1] = myFunction;
myArray[2] = myCars;
myArray[3] = "Philip";
myArray[4] = 9;
```

JavaScript Arrays and Named Indexes

- Many high-level programming languages support arrays with named indexes
  - Arrays with *named* indexes are called *associative* arrays (or *hashes*)
- JavaScript does not support arrays with *named* indexes
  - In JavaScript arrays always use *numbered* indexes
- If *named* indexing is used JavaScript will *redefine* the array as a standard *object*
  - The result will be that some array methods and properties will produce incorrect results

```
var person = [];
person["firstName"] = "John";
person["lastName"] = "Doe";
person["age"] = 46;
var x = person.length;          (person.length will return 0)
var y = person[0];              (person.length will return undefined)
```

JavaScript Indexing

- In designing a JavaScript program
  - There is a choice to be made
    - When to Use Arrays
    - When to use Objects
- The factors to consider are:
  - JavaScript does not support associative arrays
  - You should use *objects* when you want the *element names* to be *strings* (text)
  - You should use *arrays* when you want the *element names* to be *numbers*

Why use an Object or an Array?

- To choose between an *object* and an *array*
  - We need to identify the purpose of each structure
  - JavaScript arrays model the way books store information
  - Objects model the way that newspapers store information
- *Arrays* are used when a defined order (of information) is the most important factor for organizing the information
  - For example: in a book which has a chapter structure
- *Objects* are used when information is organize based on data labels
  - For example: newspaper pages may be read in a random order

Identifying a JavaScript Array Object

Identifying an Array Object

- In a JavaScript program is often necessary to test the type of object
- The test uses the **`typeof`** JavaScript operator
- Unfortunately there is a problem
  - The **`typeof`** JavaScript operator returns **`object`**
- For example

```
var fruits = ["Banana", "Orange", "Apple", "Mango"];
typeof fruits;
```

  - Returns **`object`**

The Problem

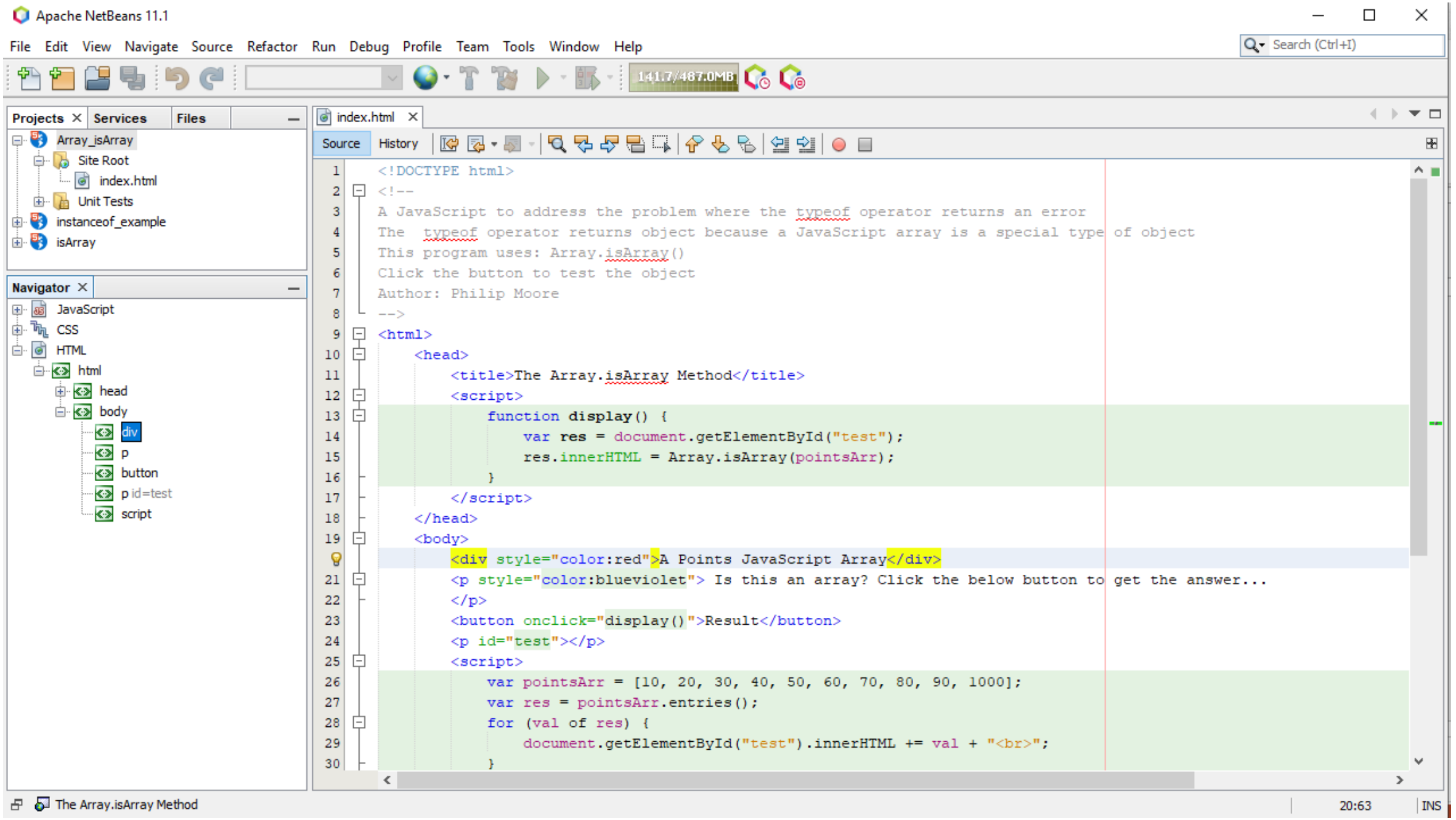
- The problem is created in JavaScript because:
  - The **`typeof`** operator returns **`object`** because a JavaScript *array* is a special type of **`object`**
- There are three potential solutions
  - The ECMAScript 5 standard method: **`Array.isArray()`**
  - Use of a user defined function: create an **`isArray()`**
  - To use the **`instanceof`** operator
- Each of the potential solutions has benefits and problems as shown in the following slides with worked examples

Solution One

- The ECMAScript 5 standard defines a new method:

```
Array.isArray()
Array.isArray(fruits); //returns true
```

- There is however a problem with this solution
  - The ECMAScript 5 standard is not supported in older browsers
  - As older browsers are replaced this will become less of a problem
- The following slides implement this solution in the NetBeans embedded web kit and Microsoft Edge browser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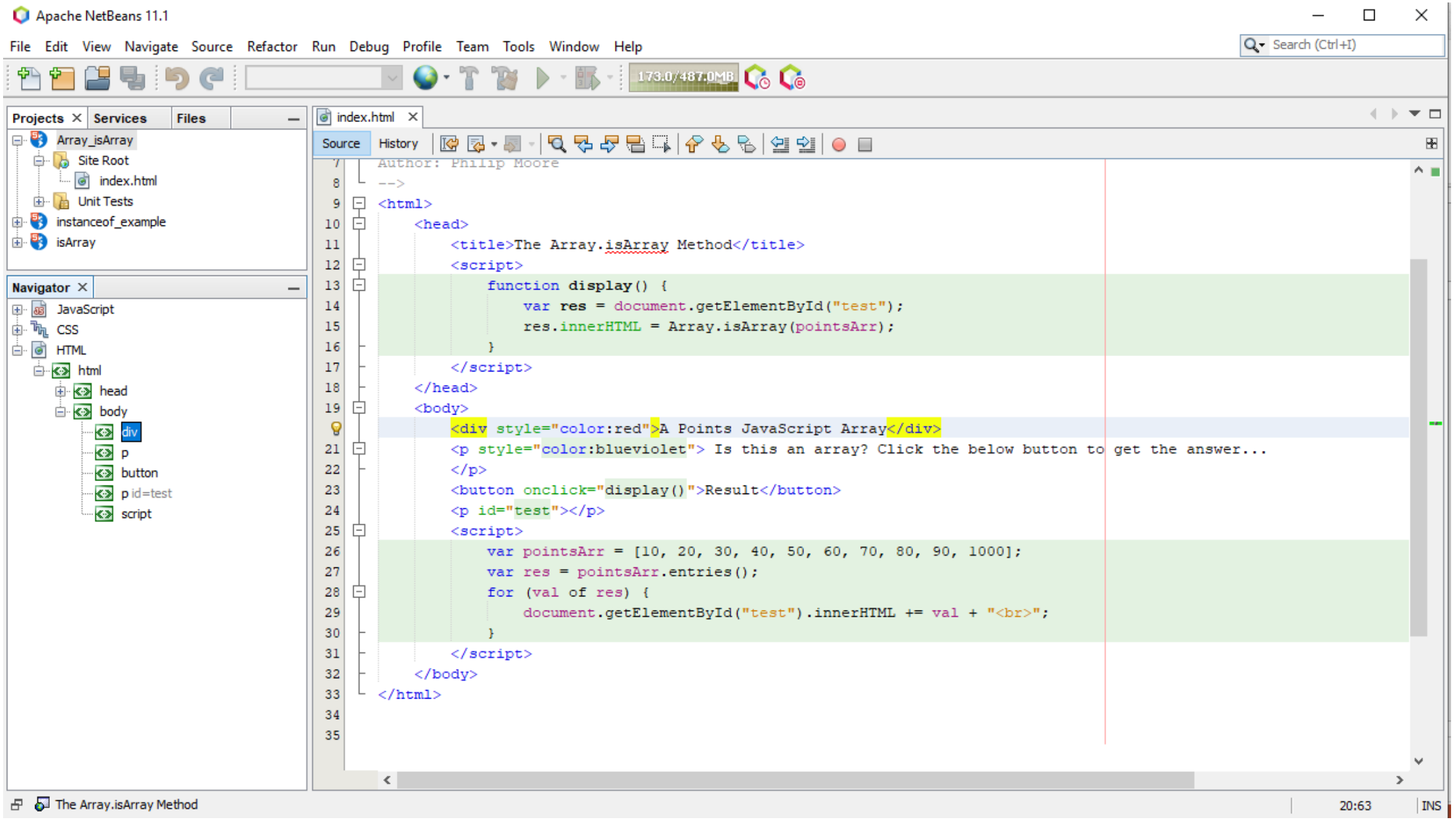
1 <!DOCTYPE html>
2 <!--
3 A JavaScript to address the problem where the typeof operator returns an error
4 The typeof operator returns object because a JavaScript array is a special type of object
5 This program uses: Array.isArray()
6 Click the button to test the object
7 Author: Philip Moore
8 -->
9 <html>
10 <head>
11 <title>The Array.isArray Method</title>
12 <script>
13 function display() {
14 var res = document.getElementById("test");
15 res.innerHTML = Array.isArray(pointsArr);
16 }
17 </script>
18 </head>
19 <body>
A Points JavaScript Array
21 Is this an array? Click the below button to get the answer...
22
23 <button onclick="display()">Result</button>
24
25 <script>
26 var pointsArr = [10, 20, 30, 40, 50, 60, 70, 80, 90, 1000];
27 var res = pointsArr.entries();
28 for (val of res) {
29 document.getElementById("test").innerHTML += val + "
";
30 }
The Array.isArray Method
20:63
INS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Author: Philip Moore
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<button onclick="display()">Result</button>

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var res = pointsArr.entries();
for (val of res) {
document.getElementById("test").innerHTML += val + "
";
}
</script>
</body>
</html>
The Array.isArray Method
20:63
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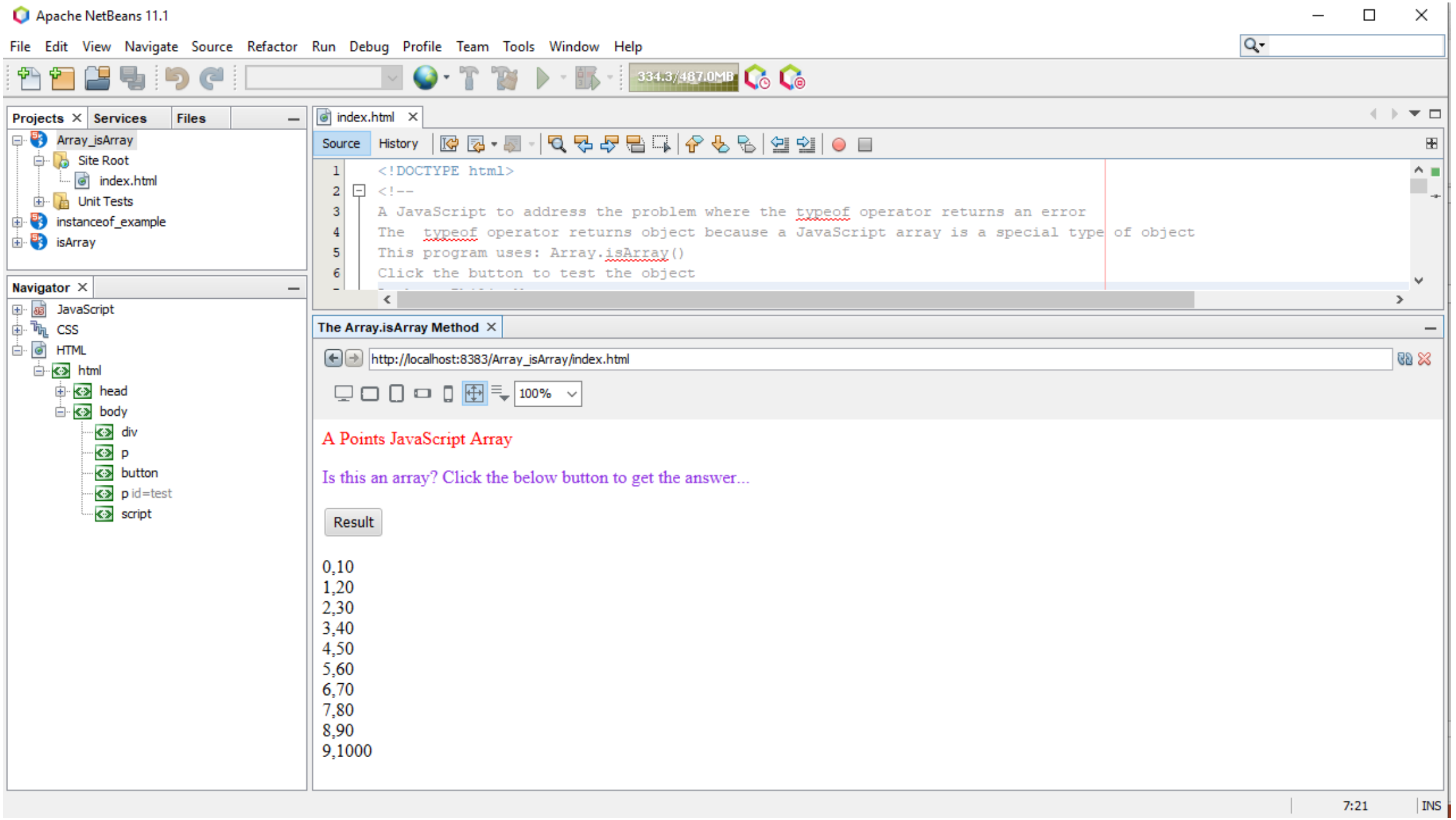
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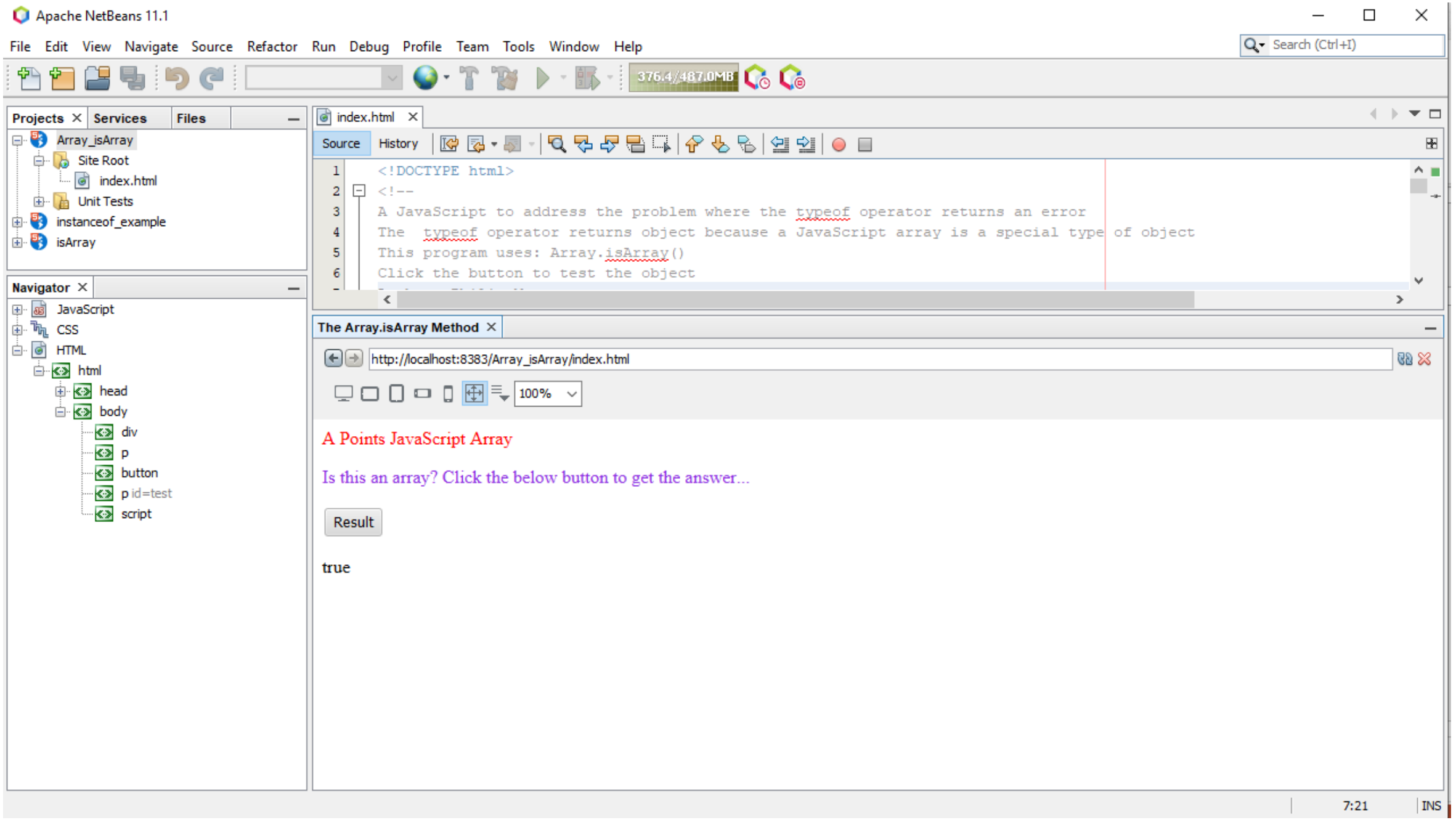
5 This program uses: Array.isArray()
6 Click the button to test the object
The Array.isArray Method
http://localhost:8383/Array_isArray/index.html
100%
A Points JavaScript Array
Is this an array? Click the below button to get the answer...
Result
0,10
1,20
2,30
3,40
4,50
5,60
6,70
7,80
8,90
9,1000
7:21
INS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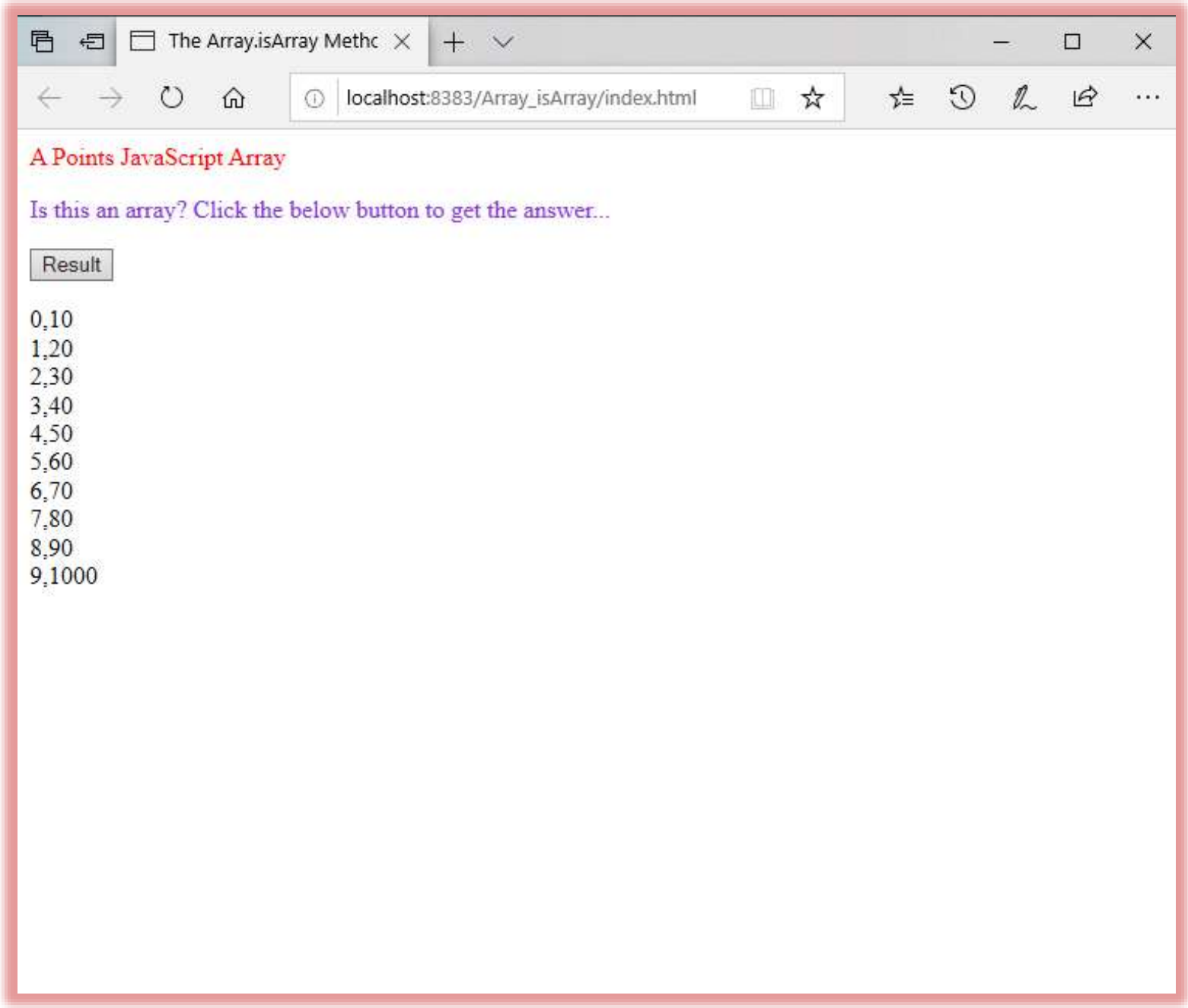
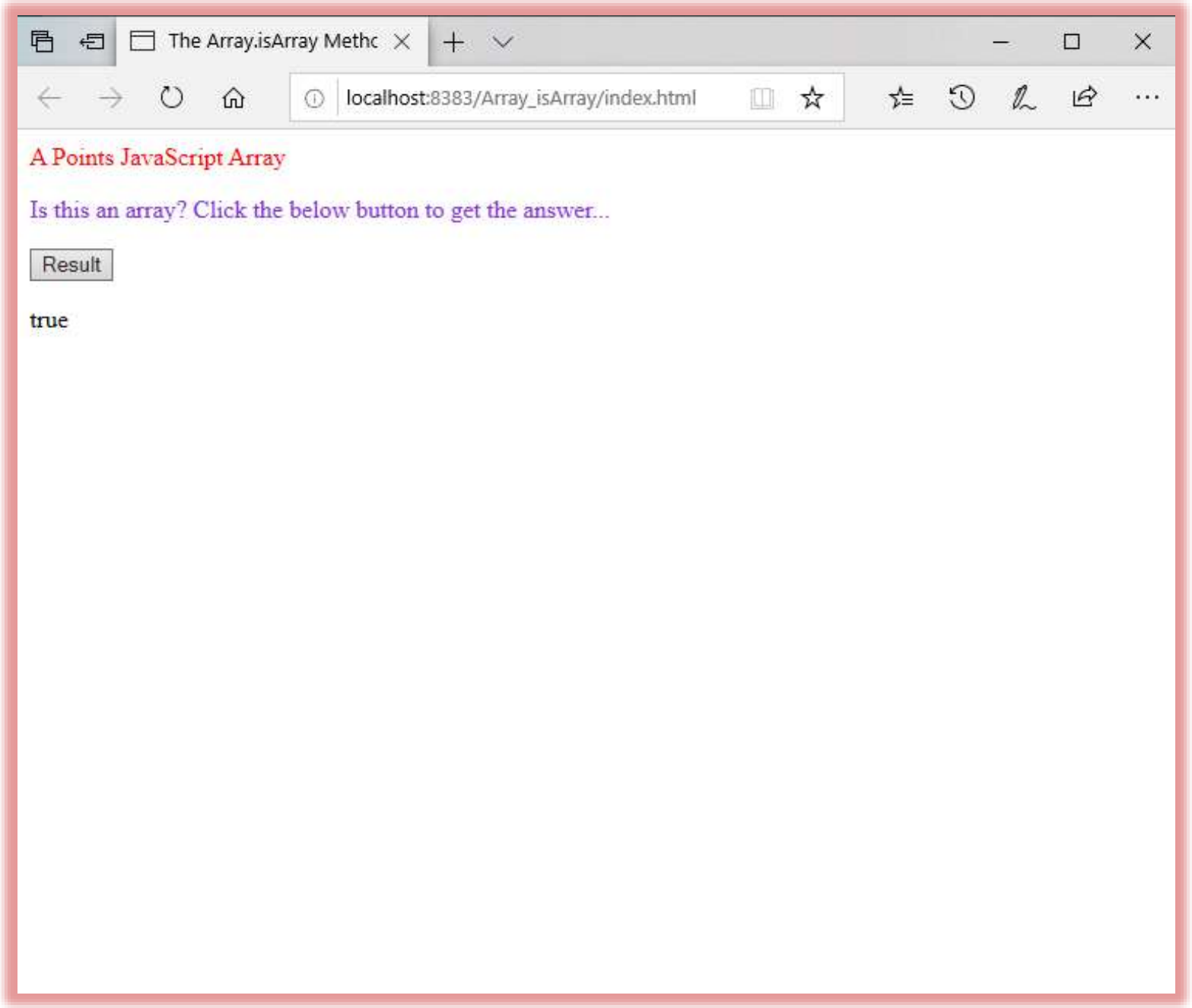
6 Click the button to test the object
The Array.isArray Method
http://localhost:8383/Array_isArray/index.html
100%
A Points JavaScript Array
Is this an array? Click the below button to get the answer...
Result
true
7:21
INS


The Array.isArray Methc
localhost:8383/Array_isArray/index.html
A Points JavaScript Array
Is this an array? Click the below button to get the answer...
Result
0,10
1,20
2,30
3,40
4,50
5,60
6,70
7,80
8,90
9,1000

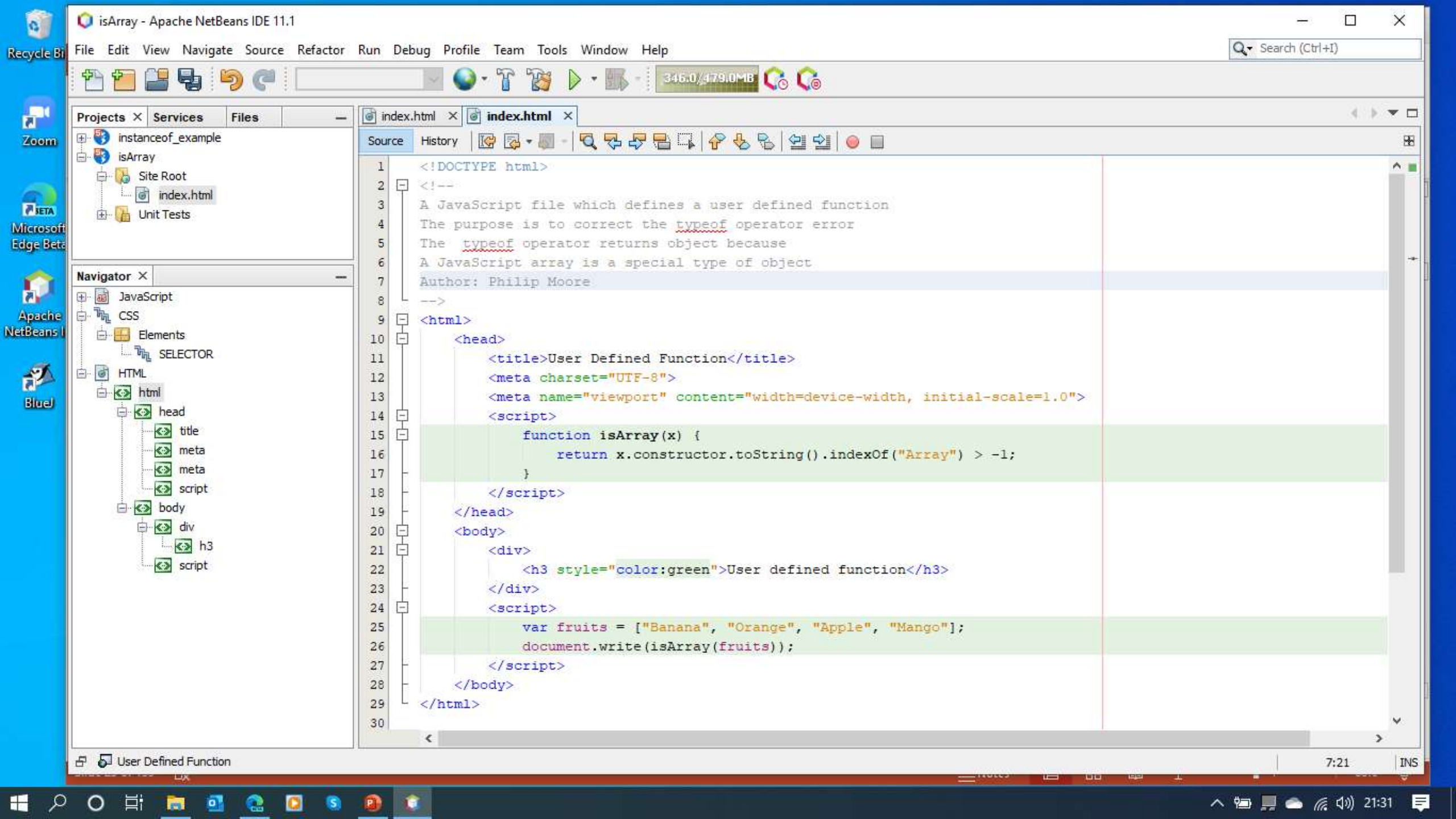

The Array.isArray Methc
localhost:8383/Array_isArray/index.html
A Points JavaScript Array
Is this an array? Click the below button to get the answer...
Result
true

Solution Two

- Create an **`isArray()`** user defined function as follows:

```
function isArray(x) {
    return x.constructor.toString().indexOf("Array") > -1;
}
```

- The user defined function above always returns **`true`** if the argument is an array
- Recall the concept of a **`function prototype`**
  - The user defined function returns **`true`** if the **`object prototype`** contains the word *Array*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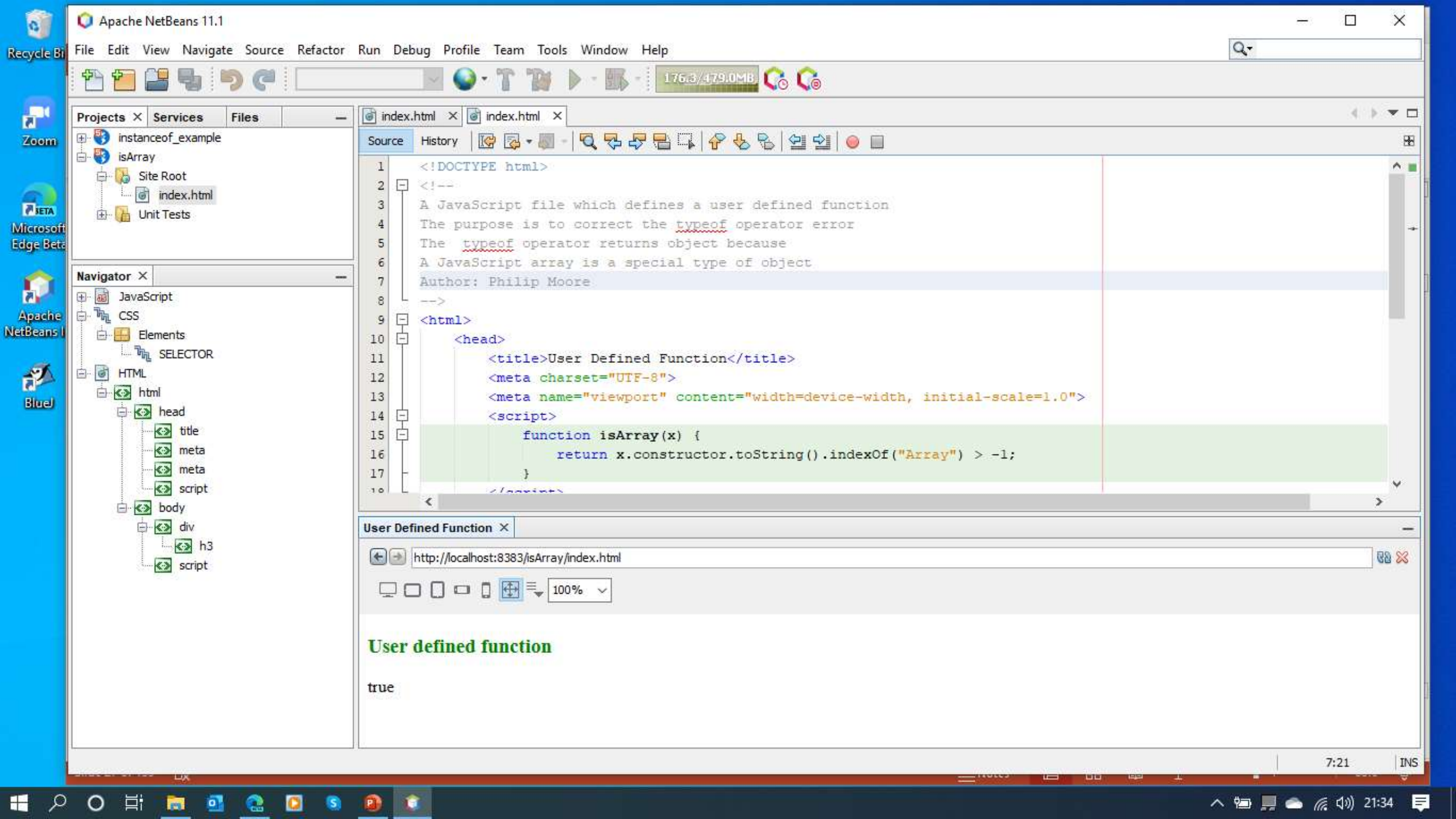
Source History
<!DOCTYPE html>
<!--
A JavaScript file which defines a user defined function
The purpose is to correct the typeof operator error
The typeof operator returns object because
A JavaScript array is a special type of object
Author: Philip Moore
-->
<html>
<head>
<title>User Defined Function</title>
<meta charset="UTF-8">
<meta name="viewport" content="width=device-width, initial-scale=1.0">
<script>
function isArray(x) {
return x.constructor.toString().indexOf("Array") > -1;
}
</script>
</head>
<body>

<h3 style="color:green">User defined function</h3>

<script>
var fruits = ["Banana", "Orange", "Apple", "Mango"];
document.write(isArray(fruits));
</script>
</body>
</html>
User Defined Function
7:21
INS
21:31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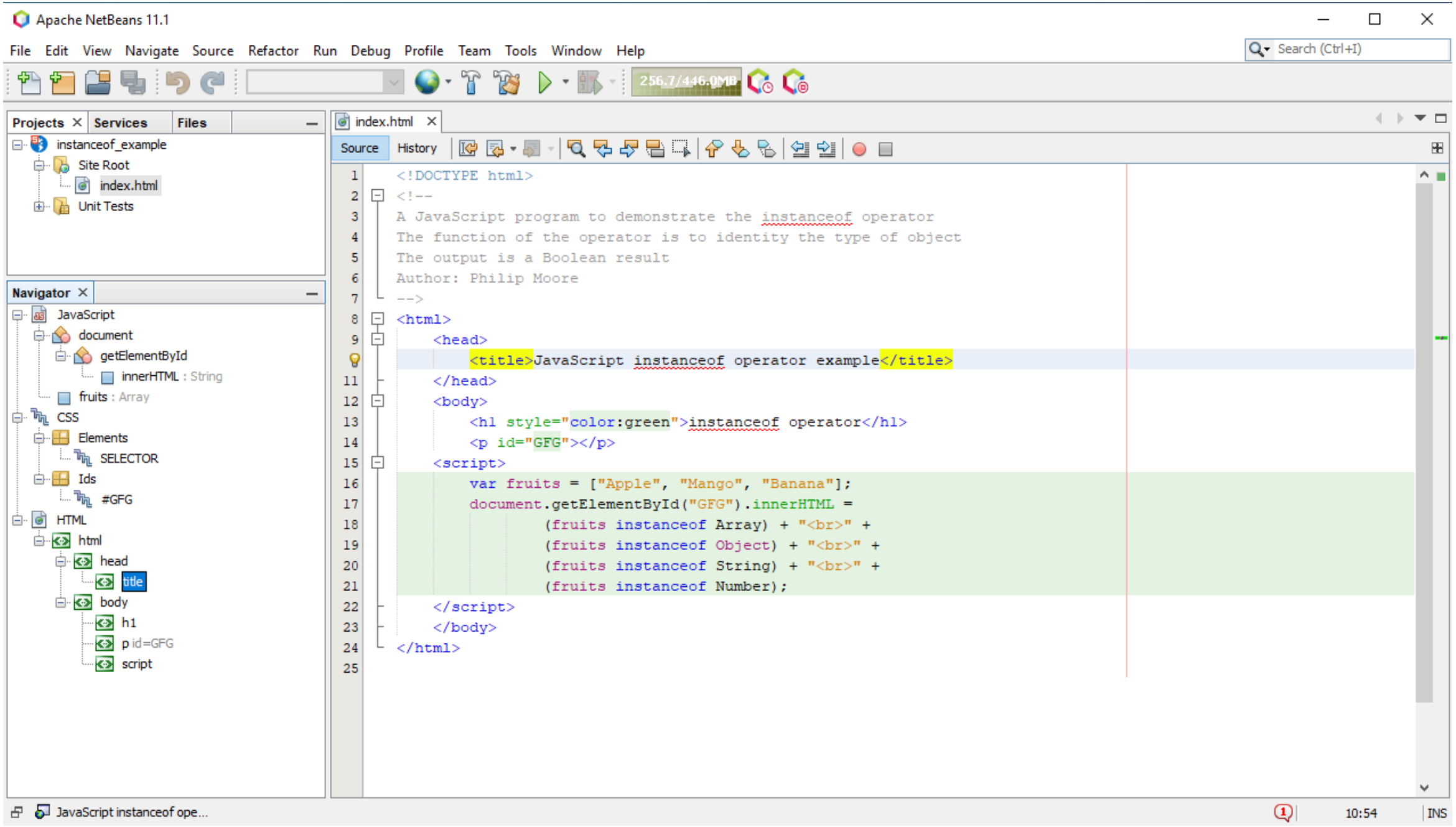
9 <html>
10 <head>
11 <title>User Defined Function</title>
12 <meta charset="UTF-8">
13 <meta name="viewport" content="width=device-width, initial-scale=1.0">
14 <script>
15 function isArray(x) {
16 return x.constructor.toString().indexOf("Array") > -1;
17 }
User Defined Function
http://localhost:8383/isArray/index.html
100%
User defined function
true
7:21
INS
21:34

Solution Three

- And alternative solution is
  - To use the **`instanceof`** operator
  - the operator returns **`true`** if an object is created by a constructor
- For example

```
var fruits = ["Banana", "Orange", "Apple", "Mango"];
fruits instanceof Array;
```

- The **`instanceof`** operator returns **`true`**
- For an worked example see the following slides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fruits : Array
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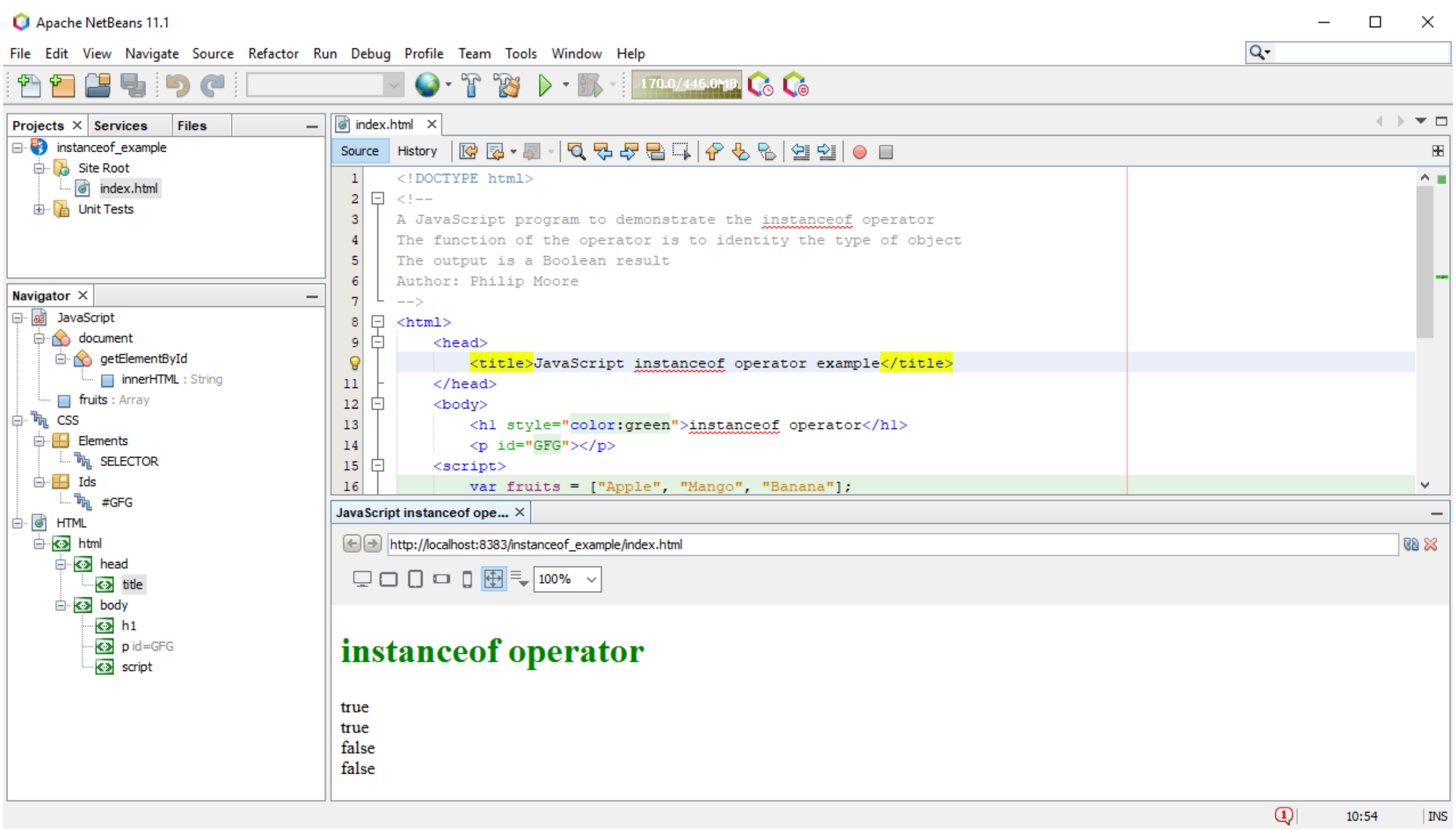
History
1 <!DOCTYPE html>
2 <!--
3 A JavaScript program to demonstrate the instanceof operator
4 The function of the operator is to identity the type of object
5 The output is a Boolean result
6 Author: Philip Moore
7 -->
8 <html>
9 <head>
11 </head>
12 <body>
13 <h1 style="color:green">instanceof operator</h1>
14
15 <script>
16 var fruits = ["Apple", "Mango", "Banana"];
17 document.getElementById("GFG").innerHTML =
18 (fruits instanceof Array) + "
" +
19 (fruits instanceof Object) + "
" +
20 (fruits instanceof String) + "
" +
21 (fruits instanceof Number);
22 </script>
23 </body>
24 </html>
25
JavaScript instanceof ope...
10:54
INS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fruits : Array
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Source History
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2 <!--
3 A JavaScript program to demonstrate the instanceof operator
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5 The output is a Boolean result
6 Author: Philip Moore
7 -->
8 <html>
9 <head>
<title>JavaScript instanceof operator example</title>
11 </head>
12 <body>
13 <h1 style="color:green">instanceof operator</h1>
14
15 <script>
16 var fruits = ["Apple", "Mango", "Banana"];
JavaScript instanceof ope...
http://localhost:8383/instanceof_example/index.html
100%
instanceof operator
true
true
false
false
10:54
INS

Working with Arrays

Array Methods

- We must enable actions on arrays using array methods including:
  - *Accessing* arrays
  - *Changing* and *Updating* arrays
  - *Adding* to array elements
  - *Deleting* from array elements
  - *Sorting* arrays
  - *Concatenating* (merging) arrays
  - *Converting* array elements to *strings*
  - Running *methods* on arrays
- In the following slides we introduce some of these actions with worked examples
- We will complete the introduction in subsequent tutorials

The JavaScript `length` Property

JavaScript `length` Property

- The **`length`** property:
  - Is used in many methods in JavaScript and general programming
  - For example: the following code snippet is used to test a **`for`** loop:

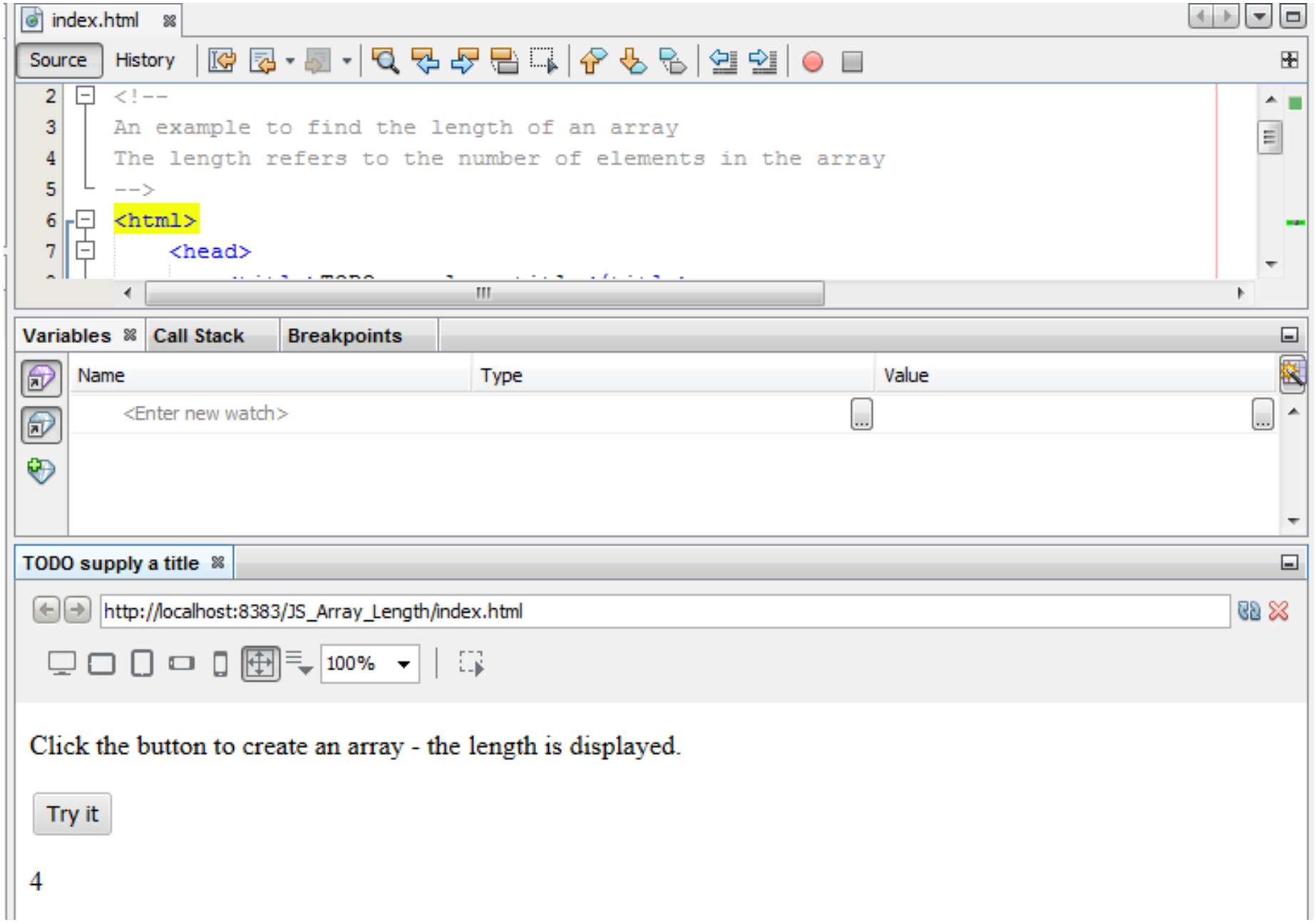
```
for (i = 0; i < fLen; i++) {
    text += "<li>" + fruits[i] + "</li>";
}
```

- The **`length`** property of an array returns the length of an array (the number of array elements)

index.html

Source | History

```
<!--
An example to find the length of an array
The length refers to the number of elements in the array
-->
<html>
    <head>
        <title>TODO supply a title</title>
        <meta charset="UTF-8">
        <meta name="viewport" content="width=device-width, initial-scale=1.0">
    </head>
    <body>
        <p>Click the button to create an array - the  length is displayed.</p>
        <button onclick="arrayLength()">Try it</button>
        <p id="demo"></p>
        <script>
            function arrayLength() {
                var fruits = ["Banana", "Orange", "Apple", "Mango"];
                document.getElementById("demo").innerHTML = fruits.length;
            }
        </script>
    </body>
</html>
```


index.html
Source
History
2 <!--
3 An example to find the length of an array
4 The length refers to the number of elements in the array
5 -->
6 <html>
7 <head>
Variables
Call Stack
Breakpoints
Name
Type
Value
<Enter new watch>
TODO supply a title
http://localhost:8383/JS_Array_Length/index.html
100%
Click the button to create an array - the length is displayed.
Try it
4

Creating a JavaScript Array?

Creating Arrays (1)

- There are 2 methods to create a new array

```
var cars = ["Saab",  "Volvo",  "BMW"];
var cars = new Array("Saab", "Volvo", "BMW");
```

- The general recommendation:
  - Avoid `new Array()`
  - There is no need to use the JavaScript's built-in array constructor `new Array()`
  - Use `[ … ]` instead

Creating new Arrays (2)

- The following two different statements both create a new empty array named **points**:

```
var points = new Array(); //not recommended
var points = [];          // recommended
```

- The two different statements both create a new **points** array containing 6 numbers:

```
var points = new Array(40, 100, 1, 5, 25, 10);
var points = [40, 100, 1, 5, 25, 10];
```

The **new** keyword

- In a high-level programming language (such as Java) the new keyword is used to create a new object – the **`new`** keyword performs the same function in JavaScript
- However - In JavaScript the **`new`** keyword only complicates the code
  - It can produce some unexpected results such as:

```
var points = new Array(40, 100);
```

    - Creates an array with two elements (40 and 100)
  - Removing one of the elements?

```
var points = new Array(40);
```

    - Creates an array with 40 undefined elements !!!!!

Accessing Arrays

Accessing Arrays

- To *access* JavaScript arrays we may use *iteration*
  - To *iterate* over *array elements* we may use a **`for`** loop
- For example:

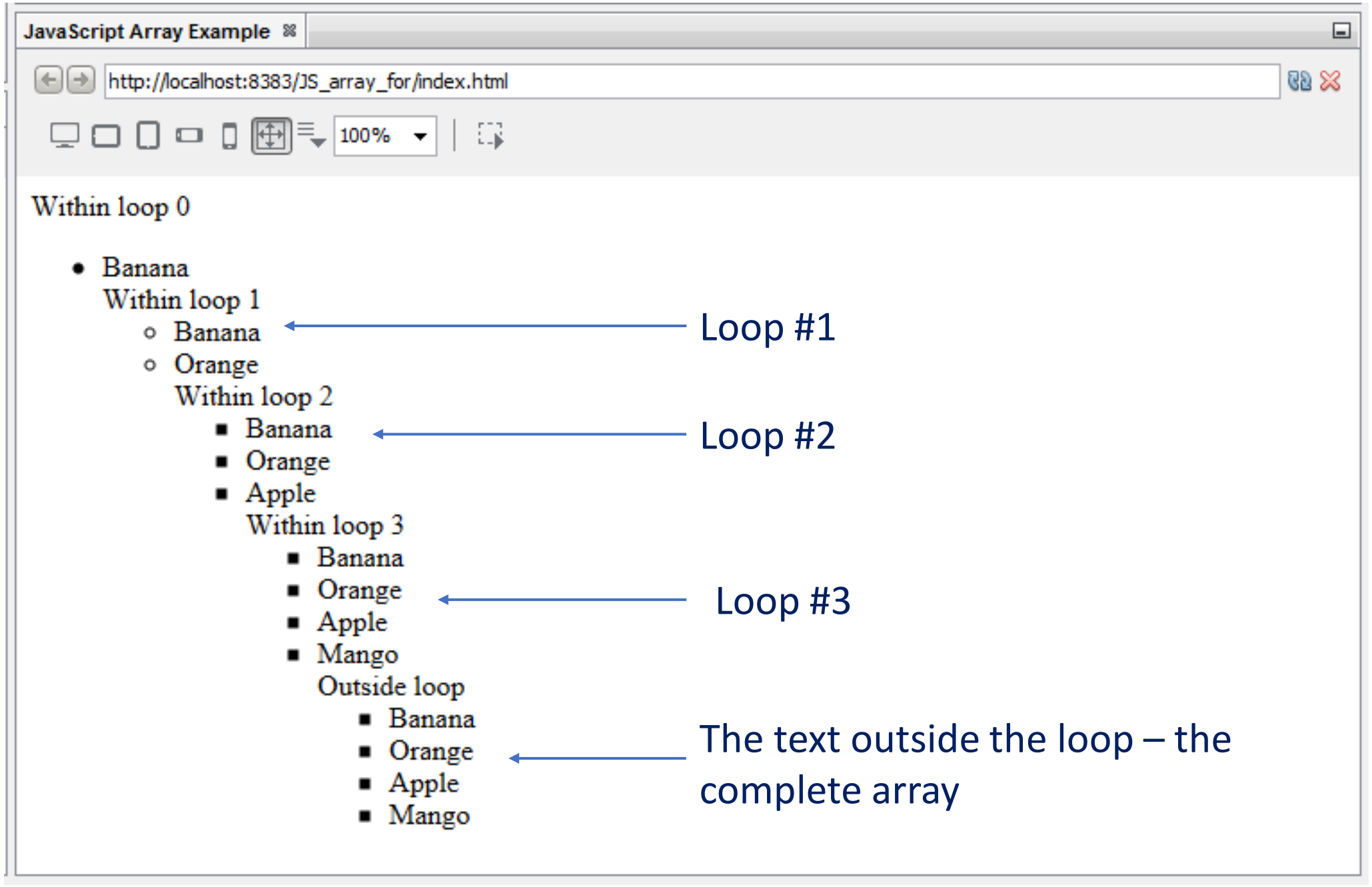
```
var fruits, text, fLen, i;
fruits = ["Banana", "Orange", "Apple", "Mango"];
fLen = fruits.length; //assign the method to the variable fLen
text = "<ul>"; //the list structure
for (i = 0; i < fLen; i++) {
      text += "<li>" + fruits[i] + "</li>";
}
```

- Note: the loop body { … } and the `i++` operator (shorthand for `i = i + 1`)

```
<!DOCTYPE html>
<!--
A JavaScript Array Example using a for loop
-->
<html>
    <head>
        <title>JavaScript Array Example</title>
        <meta charset="UTF-8">
        <meta name="viewport" content="width=device-width, initial-scale=1.0">
    </head>
    <body>
        <div>
            <script>
                var fruits, text, fLen, i;
                fruits = ["Banana", "Orange", "Apple", "Mango"];
                fLen = fruits.length;
                text = "<ul>";
                for (i = 0; i < fLen; i++) {
                    text += "<li>" + fruits[i] + "</li>";
                    document.write("Within loop " + i + " " + text);
                }
                document.write("Outside loop" + text);
            </script>

        </div>
    </body>
</html>

```


JavaScript Array Example
http://localhost:8383/JS_array_for/index.html
100%
Within loop 0
Banana
Within loop 1
Banana
Orange
Within loop 2
Banana
Orange
Apple
Within loop 3
Banana
Orange
Apple
Mango
Outside loop
Banana
Orange
Apple
Mango
Loop #1
Loop #2
Loop #3
The text outside the loop – the complete array

Merging Arrays

Merging (Concatenating) Arrays

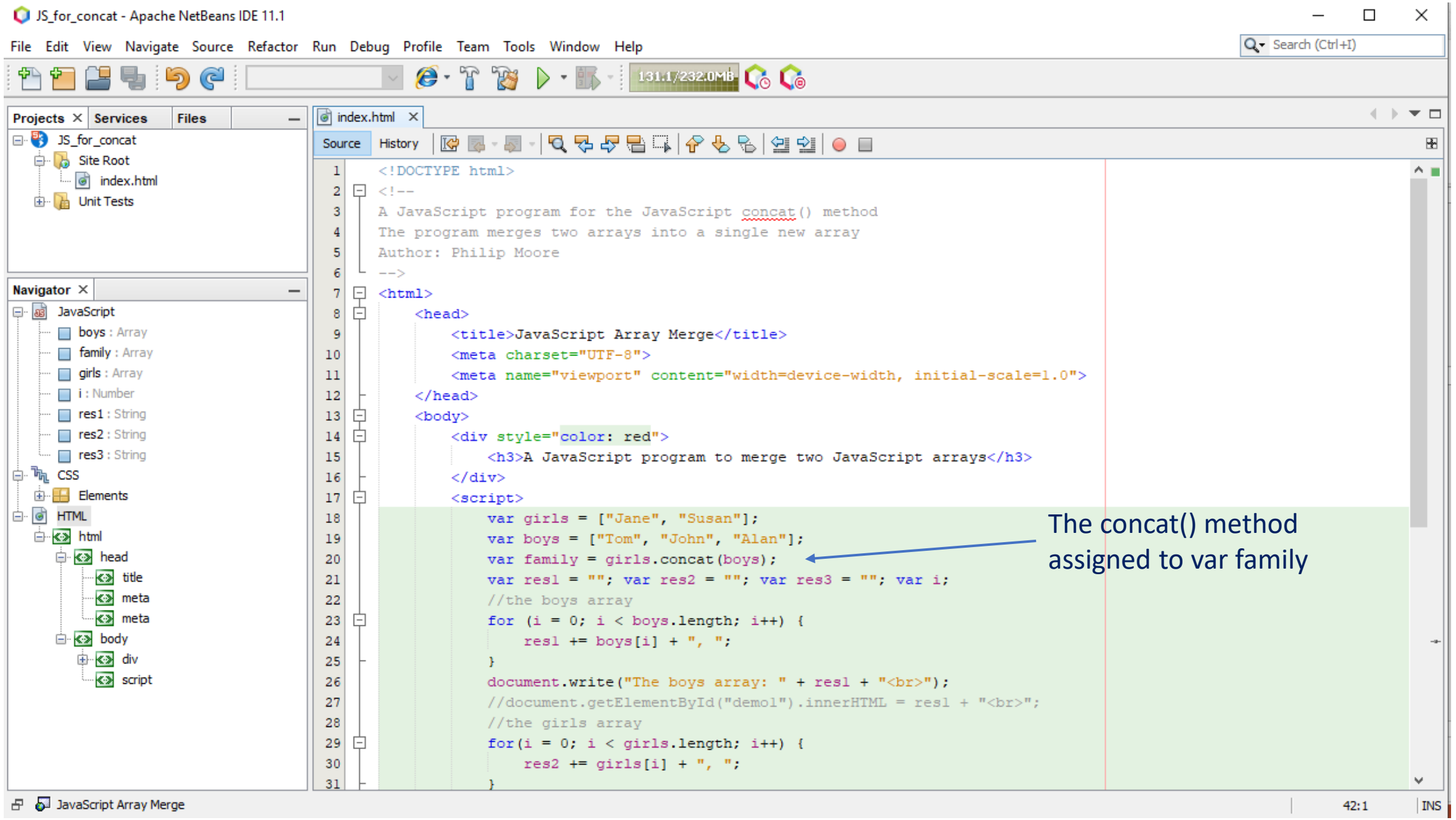
- The *concat()* method creates a new array by merging (concatenating) existing arrays
- For example to merge two arrays:

```
var myGirls = ["Cecilie", "Lone"];
var myBoys = ["Emil", "Tobias", "Linus"];
var myChildren = myGirls.concat(myBoys);
```

- The example JavaScript code concatenates (merges) `myGirls` and `myBoys` arrays into a single array `myChildren`

Merging (Concatenating) Arrays

- The concat() method:
  - Can take any number of array arguments
    - Multiple arrays can be merged into one single array
  - The method always returns a new array
- In operation:
  - The method does not delete or change the existing arrays
  - The method always returns a new array
  - `myGirls` and `myBoys` merge into `myChildren`


JS_for_concat - Apache NetBeans IDE 11.1
File Edit View Navigate Source Refactor Run Debug Profile Team Tools Window Help
Search (Ctrl+I)
131.1/232.0MB
Projects
Services
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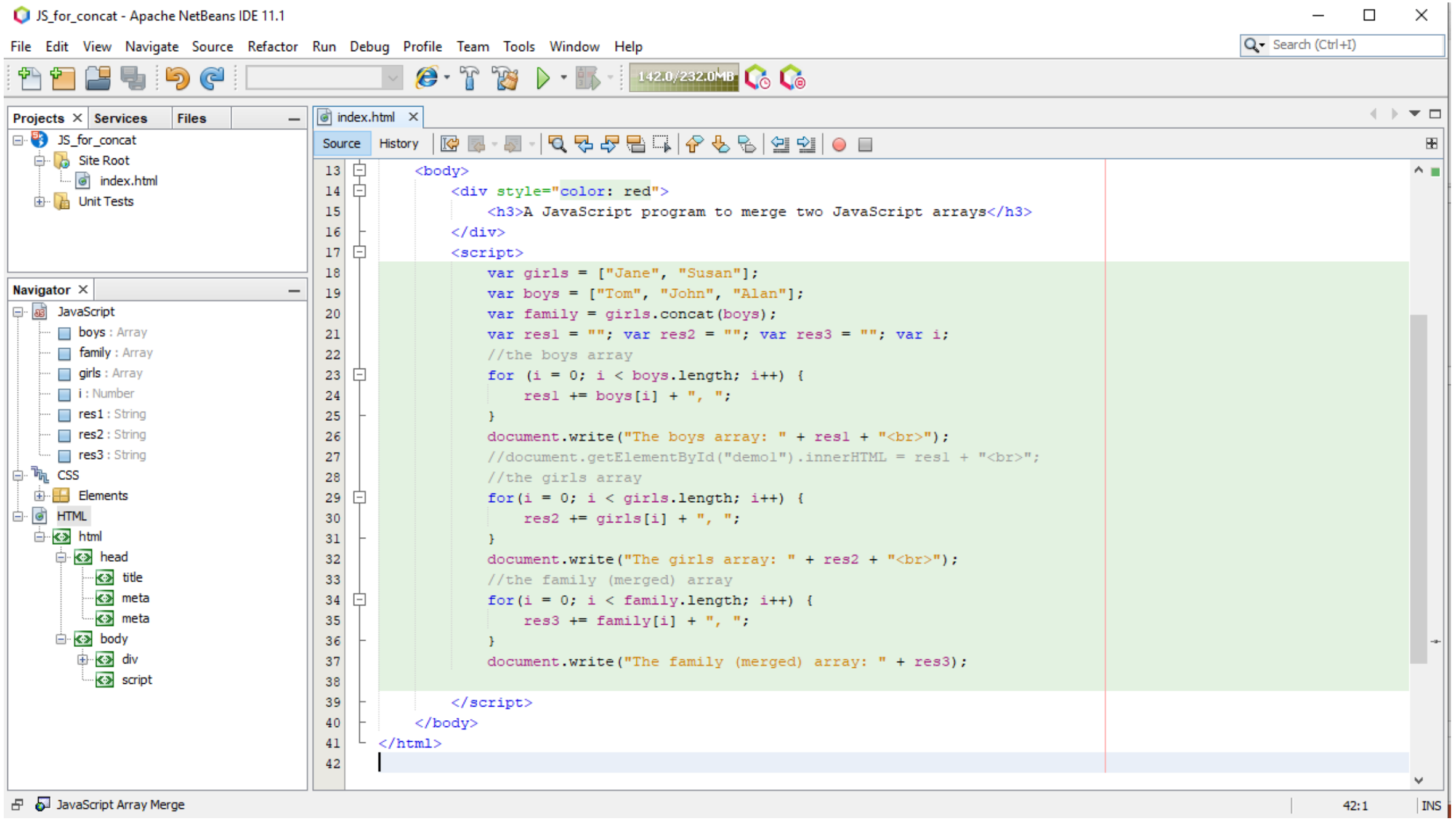
JS_for_concat
Site Root
index.html
Unit Tests
Navigator
JavaScript
boys : Array
family : Array
girls : Array
i : Number
res1 : String
res2 : String
res3 : String
CSS
Elements
HTML
html
head
title
meta
meta
body
div
script
index.html
Source
History
1 <!DOCTYPE html>
2 <!--
3 A JavaScript program for the JavaScript concat() method
4 The program merges two arrays into a single new array
5 Author: Philip Moore
6 -->
7 <html>
8 <head>
9 <title>JavaScript Array Merge</title>
10 <meta charset="UTF-8">
11 <meta name="viewport" content="width=device-width, initial-scale=1.0">
12 </head>
13 <body>
14
15 <h3>A JavaScript program to merge two JavaScript arrays</h3>
16
17 <script>
18 var girls = ["Jane", "Susan"];
19 var boys = ["Tom", "John", "Alan"];
20 var family = girls.concat(boys);
21 var res1 = ""; var res2 = ""; var res3 = ""; var i;
22 //the boys array
23 for (i = 0; i < boys.length; i++) {
24 res1 += boys[i] + ", ";
25 }
26 document.write("The boys array: " + res1 + "
");
27 //document.getElementById("demo1").innerHTML = res1 + "
";
28 //the girls array
29 for(i = 0; i < girls.length; i++) {
30 res2 += girls[i] + ", ";
31 }
The concat() method assigned to var family
JavaScript Array Merge
42:1
INS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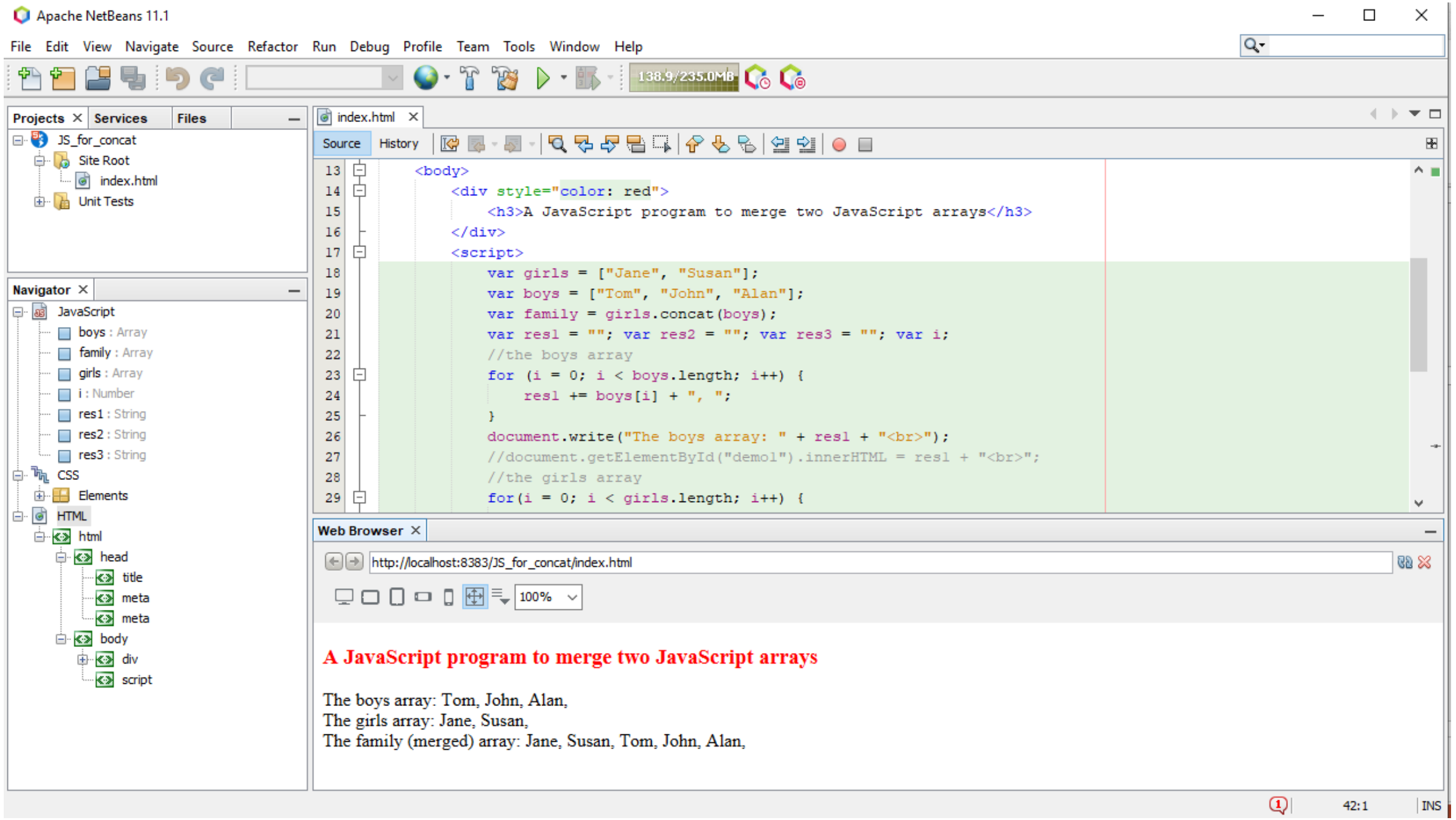
27 //document.getElementById("demo1").innerHTML = res1 + "
";
28 //the girls array
29 for(i = 0; i < girls.length; i++) {
30 res2 += girls[i] + ", ";
31 }
32 document.write("The girls array: " + res2 + "
");
33 //the family (merged) array
34 for(i = 0; i < family.length; i++) {
35 res3 += family[i] + ", ";
36 }
37 document.write("The family (merged) array: " + res3);
38
39 </script>
40 </body>
41 </html>
42
JavaScript Array Merge
42:1
INS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";
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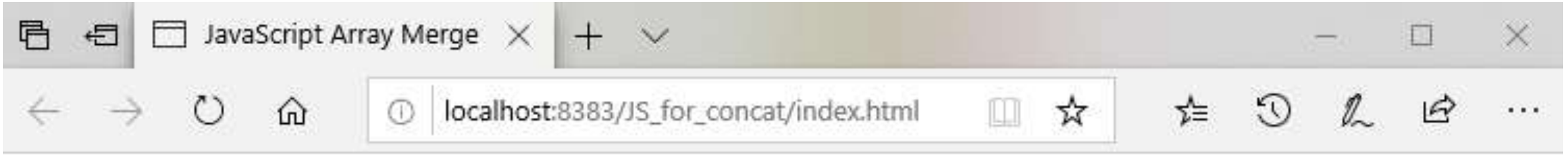
29 for(i = 0; i < girls.length; i++) {
Web Browser
http://localhost:8383/JS_for_concat/index.html
100%
A JavaScript program to merge two JavaScript arrays
The boys array: Tom, John, Alan,
The girls array: Jane, Susan,
The family (merged) array: Jane, Susan, Tom, John, Alan,
42:1
INS



A JavaScript program to merge two JavaScript arrays

The boys array: Tom, John, Alan,
The girls array: Jane, Susan,
The family (merged) array: Jane, Susan, Tom, John, Alan,

Combining Arrays and Objects

- In JavaScript *strings* may be stored and processed in *arrays* and *objects*
- Other basic *data types* (numbers and Booleans) may be stored and processed in *arrays* and *objects*
- There are other available options:
  - Arrays may be used within objects
  - Objects may be used within arrays
  - Arrays may be used within other arrays
  - Objects may be used within other objects

Combining Arrays and Objects

- The three basic operations in computer programming are:
  - Sequential / selection / iteration
  - These three operation apply in JavaScript and working with arrays and objects
- While the basic concepts in computing and JavaScript arrays and objects and arrays are very simple:
  - Using the available options and combination of options is a JavaScript program can be very complex
- In ‘real-world’ JavaScript programs:
  - There is almost always need for a combination operations on arrays and objects to store data in a scalable and manageable way

Overview

- In this tutorial we have introduced:
  - JavaScript arrays including:
    - What is an array?
    - The nature of arrays and objects in JavaScript with associative arrays
    - Creating and working with arrays, array elements, and array methods
    - Merging (concatenating) two (or more) arrays into a single array
    - Array iteration (looping through arrays)