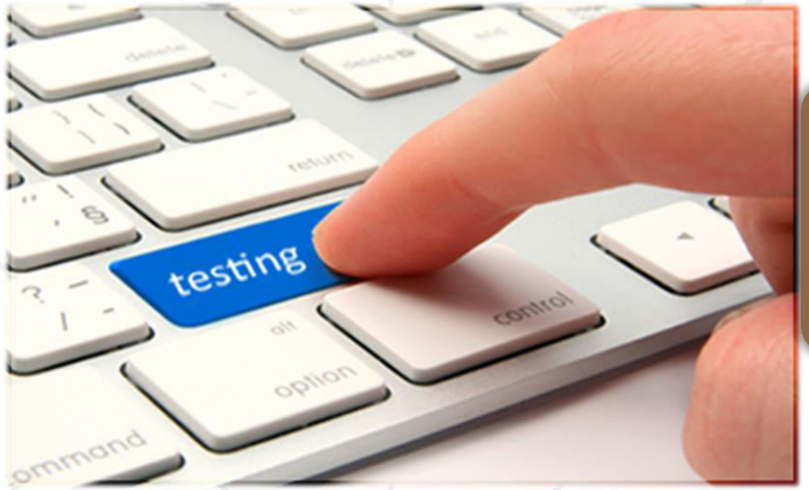
Error Handling
Unit Testing with Mocha

Errors and Exceptions, Unit Testing, Tests Cases, Assertions, Hooks



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#JSCORE

Error Handling in JS

Error Handling – Concepts

- In programming, the fundamental principle of error handling says:

> **A function (method) should either do what its name suggests or indicate a problem.**
>
> **Any other behavior is incorrect.**

- In JavaScript, a function failed to do what its name suggests should:
  - Return a special value (e.g. **undefined / false / -1**)
  - Throw an exception / error

Error Handling – Examples

- Normal execution → a function does what its name says

```
let str = "Hello, SoftUni";
console.log(str.indexOf("Uni")); // 11
console.log(str.indexOf("")); // 0
```

- Special case → return a special value to indicate "*not found*"

```
let str = "Hello, SoftUni";
console.log(str.indexOf("Sofia")); // -1
console.log(str.indexOf(undefined)); // -1
```

Error Handling – Exceptions (Errors)

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- Exception → a function is unable to do its work (fatal error)

```
let arr = new Array(-1); // Uncaught RangeError
```

```
let bigArr = new Array(9999999999); // RangeError
```

```
let index = undefined.indexOf("hi"); // TypeError
```

```
console.log(asfd); // Uncaught ReferenceError
```

```
console.print('hi'); // Uncaught TypeError
```

Error Handling – Special Values

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```
let sqrt = Math.sqrt(-1); // NaN (special value)
```

```
let sub = "hello".substring(2, 1000); // llo
// Soft error → substring still does its job: takes all
available chars
```

```
let sub = "hello".substring(-100, 100); // hello
// Soft error → substring still does its job: takes all avai
lable chars
```

```
let inv = new Date("Christmas"); // Invalid Date
let dt = inv.getDate(); // NaN
```

Unexpected (Not Obvious) Behavior

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```
let d = new Date(2016, 1, 20); // Feb 20 2016 (Jan = 0, Feb = 1)
```

```
let dn = new Date(2016, 1, 30); // Mar 01 2016 (next month)
```

```
let dp = new Date(2016, -1, 30); // Dec 30 2015 (prev month)
```

```
let d1 = new Date(1, 1, 1); // Feb 01 1901
```

```
let dMinus1 = new Date(-1, -1, -1); // Nov 29 -2
```

```
let pi = new Date(3.14, 3.14, 3.14); // Month / year truncated
// Apr 03 1903 03:21:36 (fractial day turned to hours / minutes)
```

Problem: Sub-Sum

- Write a JS function to sum a range of elements from array

```
subsum([10, 20, 30, 40, 50, 60], 3, 4)
```

```
90
```

- This is a sample solution:

```
function subsum(arr, startIndex, endIndex) {
  let sum = 0;
  for (let i = startIndex; i <= endIndex; i++)
    sum += arr[i];
  return sum;
}
```

Problem: Sub-Sum – Error Handling

- Think about the special cases:

```
subsum([10, 20, 30, 40, 50, 60], 3, 300)
```

```
150
```

```
subsum([1.1, 2.2, 3.3, 4.4, 5.5], -3, 1)
```

```
3.3
```

```
subsum([10, 'twenty', 30, 40], 0, 2)
```

```
NaN
```

```
subsum([], 0, 0)
```

```
subsum([], 1, 2)
```

```
0
```

```
subsum('text', 0, 2)
```

```
subsum({}, 0, 2)
```

```
NaN
```

Solution: Sub-Sum (with Error Handling)

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```
function subsum(arr, startIndex, endIndex) {
  if (!Array.isArray(arr))
    return NaN;
  if (startIndex < 0)
    startIndex = 0;
  if (endIndex > arr.length - 1)
    endIndex = arr.length - 1;
  let sum = 0;
  for (let i = startIndex; i <= endIndex; i++)
    sum += Number(arr[i]);
  return sum;
}
```

explicit error handling / special case handling

Check your solution here: https://judge.softuni.bg/Contests/307

Exception Handling in JS

Throwing Errors / Catching Errors

Exceptions vs. Special Values

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- Return a special value for expected behavior
  - Return a value if no problem / a recoverable problem occurs
  - Valid input arguments → return valid value or special value
  - E.g. searching something → return the item found or **undefined**
- Thrown an exception for unexpected behavior
  - When unrecoverable problem occurs
  - Invalid input arguments / invalid object state / missing resource
  - E.g. create a card "-2 hearts" or create array of -5 elements

Throwing Errors (Exceptions)

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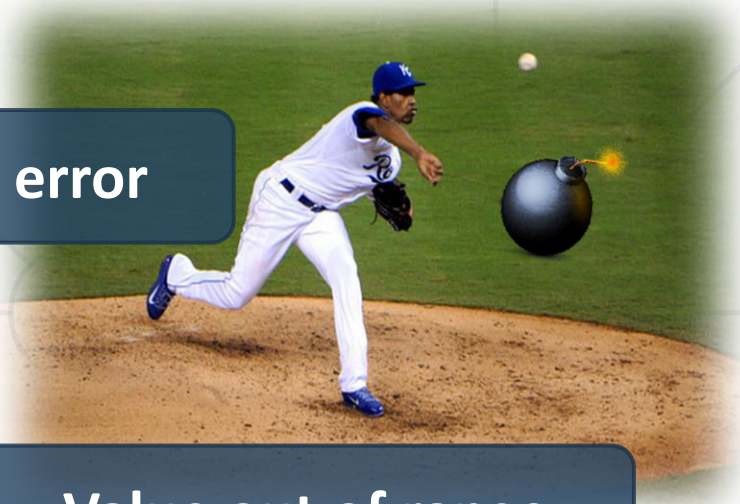
```
throw new Error("Invalid state");
```

General error

```
> throw new Error("Invalid state");
✖ ▶ Uncaught Error: Invalid state(…)
```



```
throw new RangeError("Invalid index");
```

Value out of range

```
throw new TypeError("String expected");
```

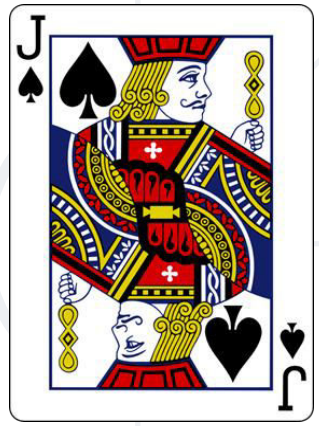
Expected a different type

```
throw new ReferenceError("Missing age");
```

Accessing non-existing object

Problem: Playing Cards

- A function creates a **Card** to hold card face + suit
  - Valid card faces are: **2, 3, 4, 5, 6, 7, 8, 9, 10, J, Q, K, A**
  - Valid card suits are: **S (♠), H (♥), D (♦), C (♣)**
  - Throw an error in case of invalid face or suit



```
console.log('' + makeCard('A', 'S'));  // A♠
console.log('' + makeCard('10', 'H')); // 10♥
console.log('' + makeCard('2', 'D'));  // 2♦
```

```
console.log('' + makeCard('1', 'C')); // Error
console.log('' + makeCard('4', 'W')); // Error
```

Solution: Playing Cards – Factory Function

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```
function makeCard(face, suit) {
  const validFaces = ['2','3','4','5','6','7','8','9','10','J','Q',
'K','A'];
  const validSuits = ['S', 'H', 'D', 'C'];
  if (!validFaces.includes(face))
    throw new Error("Invalid card face: " + face);
  if (!validSuits.includes(suit))
    throw new Error("Invalid card suit: " + suit);
  let card = {
    face: face,
    suit: suit,
    toString: () => { … }
  };
  return card;
}
```

```
Uncaught Error: Invalid card face: 1(…)
    set face                @ VM1177:13
    Card                    @ VM1177:3
    (anonymous function)    @ VM1177:41
```

Solution: Playing Cards – toString()

```
toString() {
  let suitToChar = {
    'S': "\u2660", // ♠
    'H': "\u2665", // ♥
    'D': "\u2666", // ♦
    'C': "\u2663", // ♣
  };
  return card.face + suitToChar[card.suit];
}
```

```
> console.log('' + new Card('A', 'S'));
A♠
```

```
> console.log('' + new Card('10', 'D'));
10♦
```

Check your solution here: **https://judge.softuni.bg/Contests/307**

The try-catch block

- Use **try-catch** block to catch errors (exceptions)
  - If an error occurs, the control is passed to the **catch** section

```
try {
  // code that can throw an exception
  // some other code → not executed in case of error!
} catch (ex) {
  // this code is executed in case of exception
  // ex holds the info about the exception
}
```

Exceptions and Their Properties

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```
try {
  throw new RangeError("Invalid range.");
  console.log("This will not be executed.");
} catch (ex) {
  console.log("----------------");
  console.log("Exception object: " + ex);
  console.log("Type: " + ex.name);
  console.log("Message: " + ex.message);
  console.log("Stack: " + ex.stack);
  console.log("----------------");
}
```

Problem: Print Deck of Cards

- Write a method to take a deck of cards (each given as string) and print them as sequences of cards (space separated)
  - Print "Invalid card: [card]" when invalid card is passed as input

```
printDeckOfCards(['AS', '10D', 'KH', '2C']);
// A♠ 10♦ K♥ 2♣
```

```
printDeckOfCards(['5S', '3D', 'QD', '1C']);
// Invalid card: 1C
```

```
printDeckOfCards(['3D', 'JC', '2S', '10H', '5X']);
// Invalid card: 5X
```

Solution: Print Deck of Cards

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```
function printDeckOfCards(cards) {
  let deck = [];
  for (let cardStr of cards) {
    let face = cardStr.substring(0, cardStr.length-1);
    let suit = cardStr.substr(cardStr.length-1, 1);
    try {
      deck.push(makeCard(face, suit));
    }
    catch (err) {
      console.log("Invalid card: " + cardStr);
      return;
    }
  }
  console.log(deck.join(' '));
}
```

Insert the factory function here

This can throw an error (when the card is invalid)

Check your solution here: https://judge.softuni.bg/Contests/307

What is Unit Testing?

Unit Testing – Definition

A unit test is a piece of code, written by a developer that checks whether a piece of functionality (e.g. function or method), is working as expected.

Source code

```
function sortNums(arr) {
  arr.sort(
    (a,b) => a-b
  );
}
```

Test code (unit tests)

```
let nums = [2, 15, -2, 4];
sortNums(nums);
if (JSON.stringify(nums)
    != "[-2,2,4,15]")
  console.error("test failed!");
```

Unit Tests – Structure

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- The AAA Pattern: Arrange, Act, Assert

```
// Arrange all necessary preconditions and inputs
let nums = [2, 15, -2, 4];
// Act on the object or method under test
sortNums(nums);
// Assert that the obtained results are what we expect
if (JSON.stringify(nums) != "[-2,2,4,15]")
  console.error("test failed!");
```

Unit Test – Sum Numbers – Example

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```
function sum(arr) {
  let sum = 0;
  for (num of arr)
    sum += Number(num);
  return sum;
}
function testSum() {
  if (sum([1, 2]) != 3) throw new Error("1+2 != 3");
  if (sum([-2]) != -2) throw Error("-2 != -2");
  if (sum([]) != 0) throw new Error("0 != 0");
}
```

Unit Testing Framework

- Unit testing frameworks make writing unit tests simple
  - Provides test cases, assertions, hooks, test runners, etc.
  - JUnit, NUnit, Visual Studio Team Test (VSTT), PHPUnit
  - JS unit testing: Mocha, QUnit, Unit.js, Jasmine, …
- Assertion frameworks (perform checks)
  - Chai, Assert.js, Should.js
- Mocking frameworks (mocks and stubs)
  - Sinon, JMock, Mockito, Moq

Mocha and Chai

Unit Testing in JavaScript

Mocha and Chai

- Mocha is JS testing framework
  - Runs in Node.js and in Web browsers
  - Usually used together with Chai (assertion library)

```
let expect = require("chai").expect;
describe("sum(arr)", function() {
  it("should return 3 for [1, 2]", function() {
    expect(sum([1, 2])).to.be.equal(3);
  });
});
```

Installing Mocha and Chai

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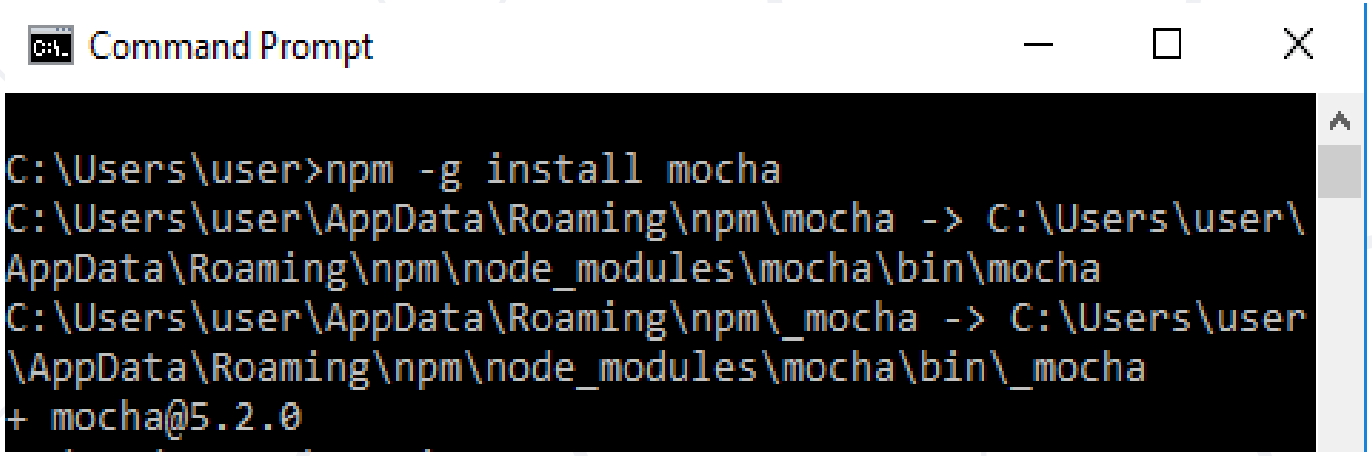
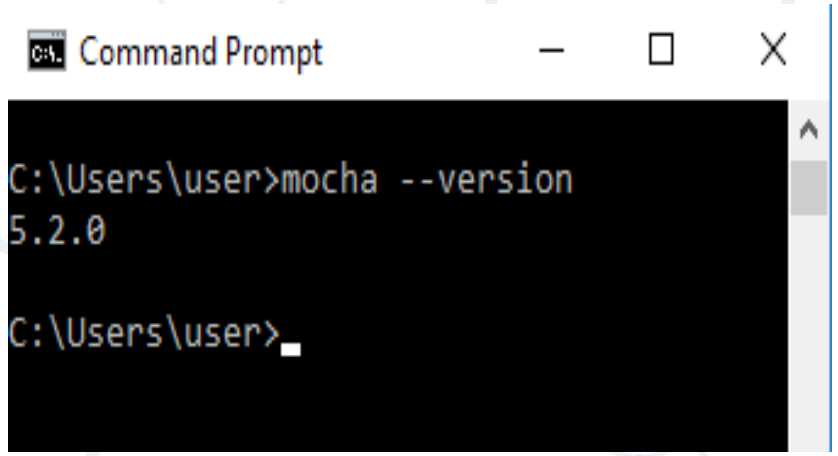
- Install Mocha through **npm**

```
npm -g install mocha
```



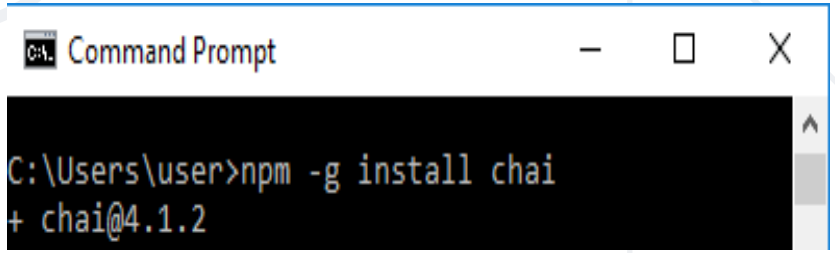
- Check if Mocha is installed

```
mocha --version
```



- Install Chai through **npm**

```
npm -g install chai
```



Configuring NODE_PATH

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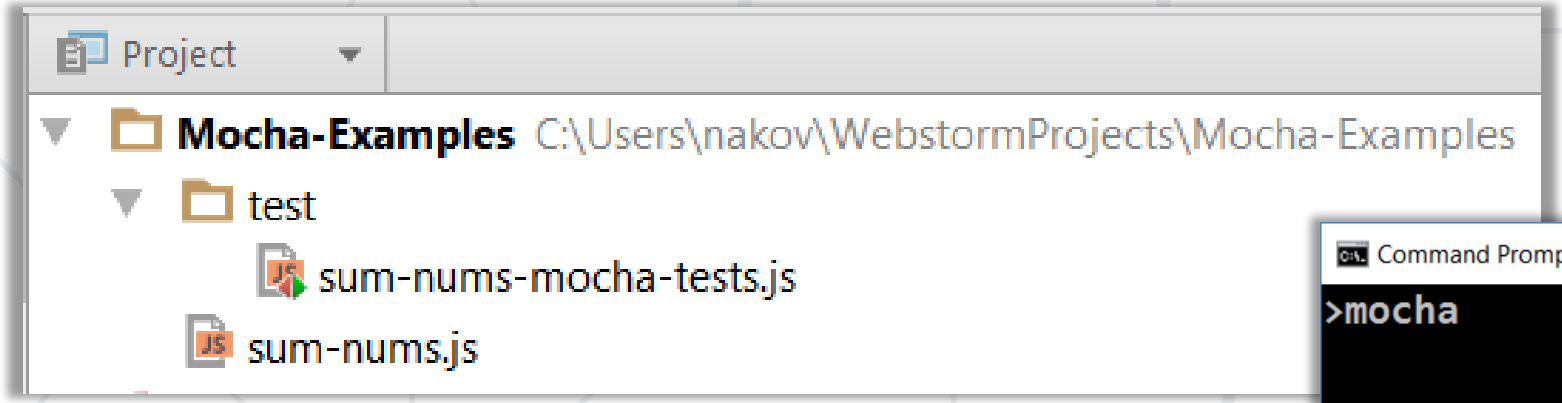
- By default Node.js does not find its globally-installed modules
- You need to set the **NODE_PATH** environment variable

```
rem for any future sessions
setx NODE_PATH %AppData%\npm\node_modules
rem for current session
set NODE_PATH=%AppData%\npm\node_modules
```

- You may need to restart your IDE after changing **NODE_PATH**

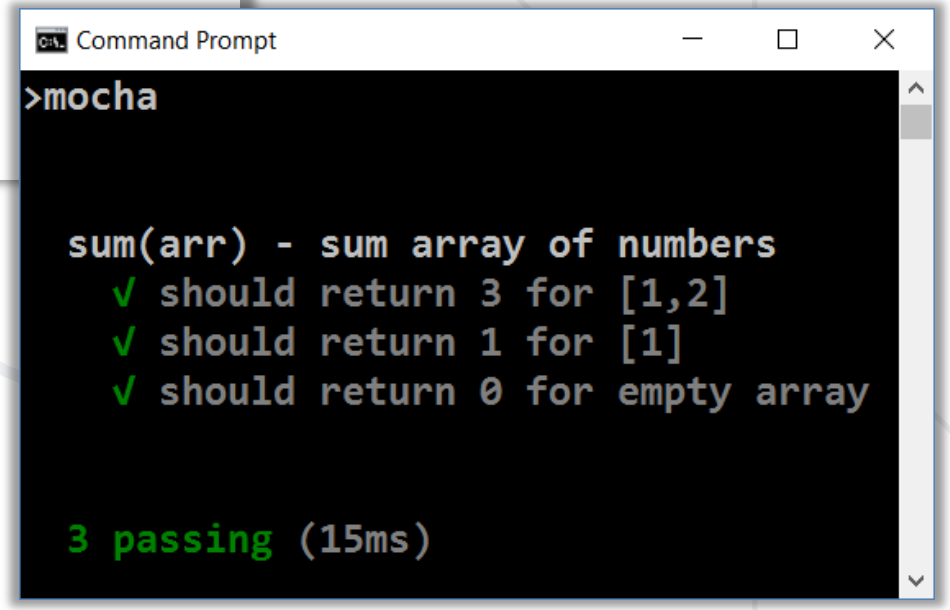
Running Mocha

- Create folder **"test"** in your JS project
  - Put your test code in **test/{test-group-name}.js**



- Run Mocha from the console

```
mocha
```



Mocha in Action – Sample Project

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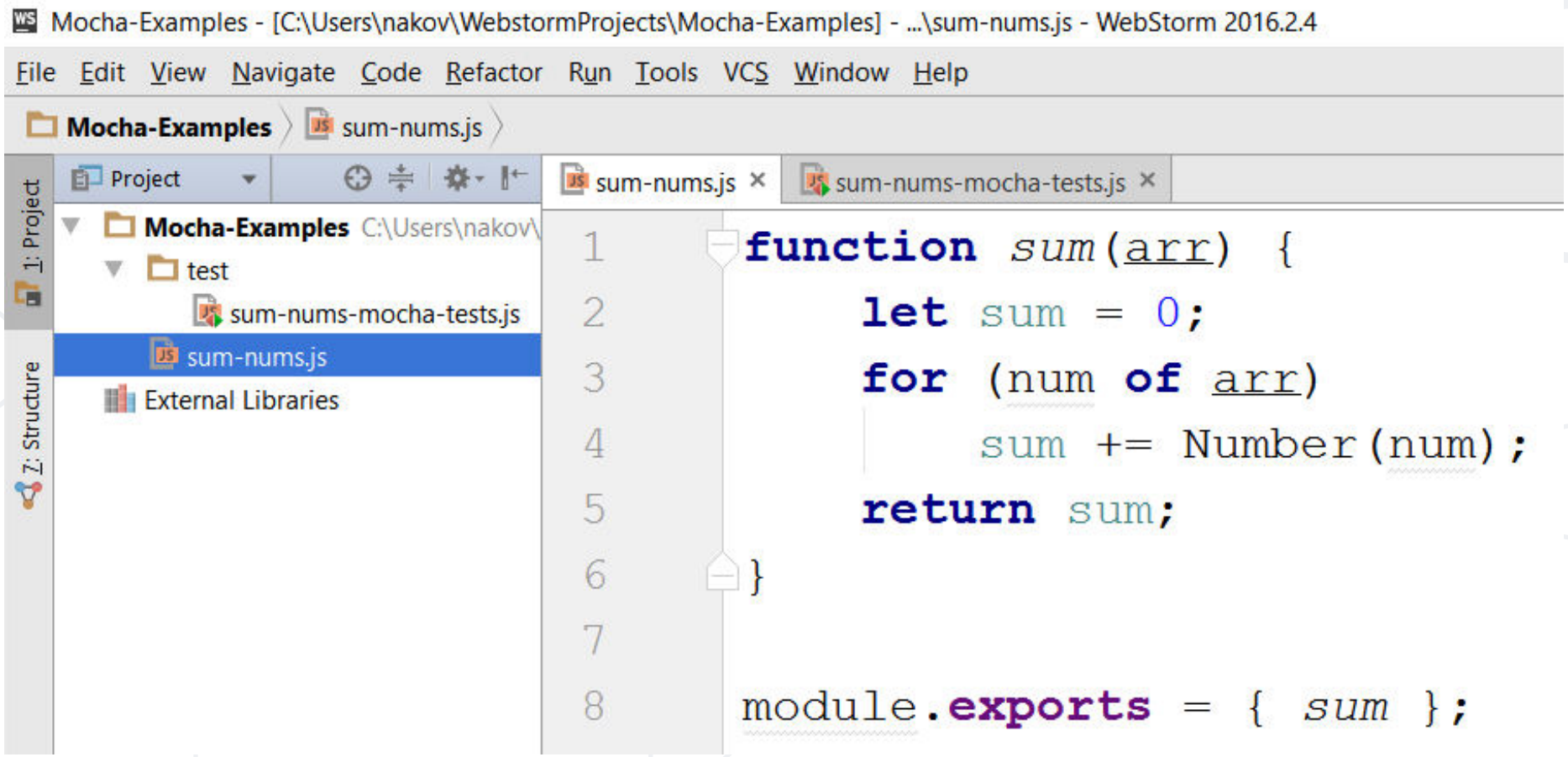
- Source code to be tested



Mocha in Action – Sample Unit Tests

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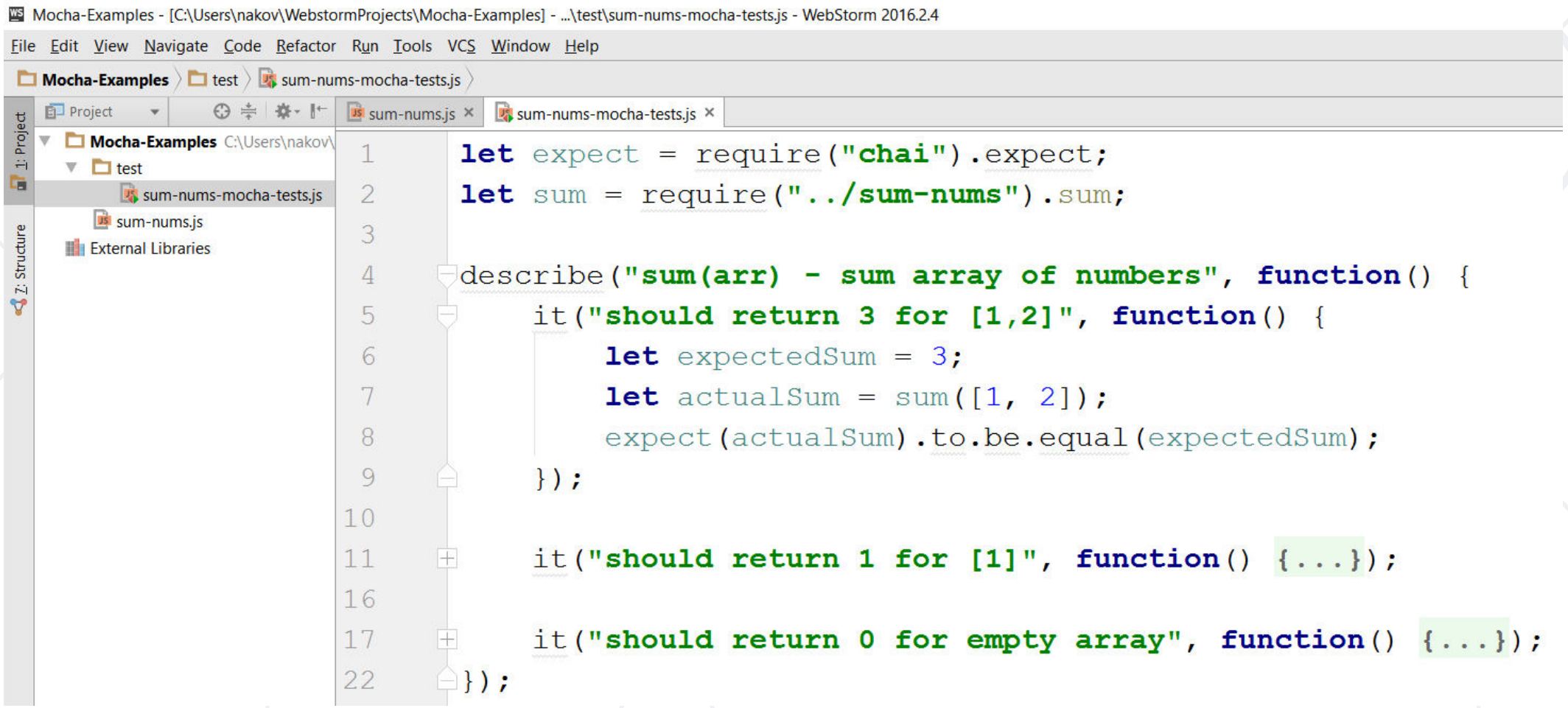
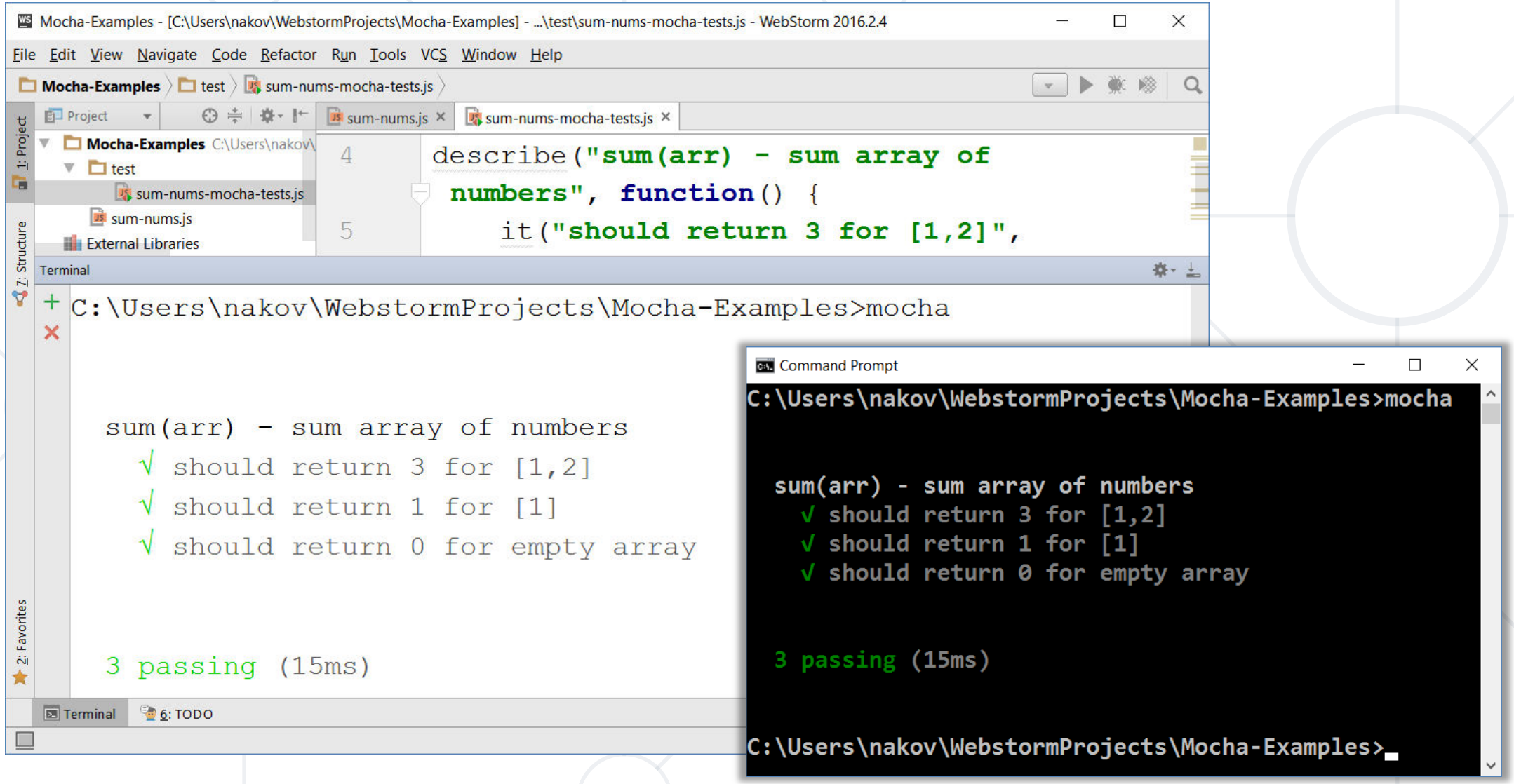
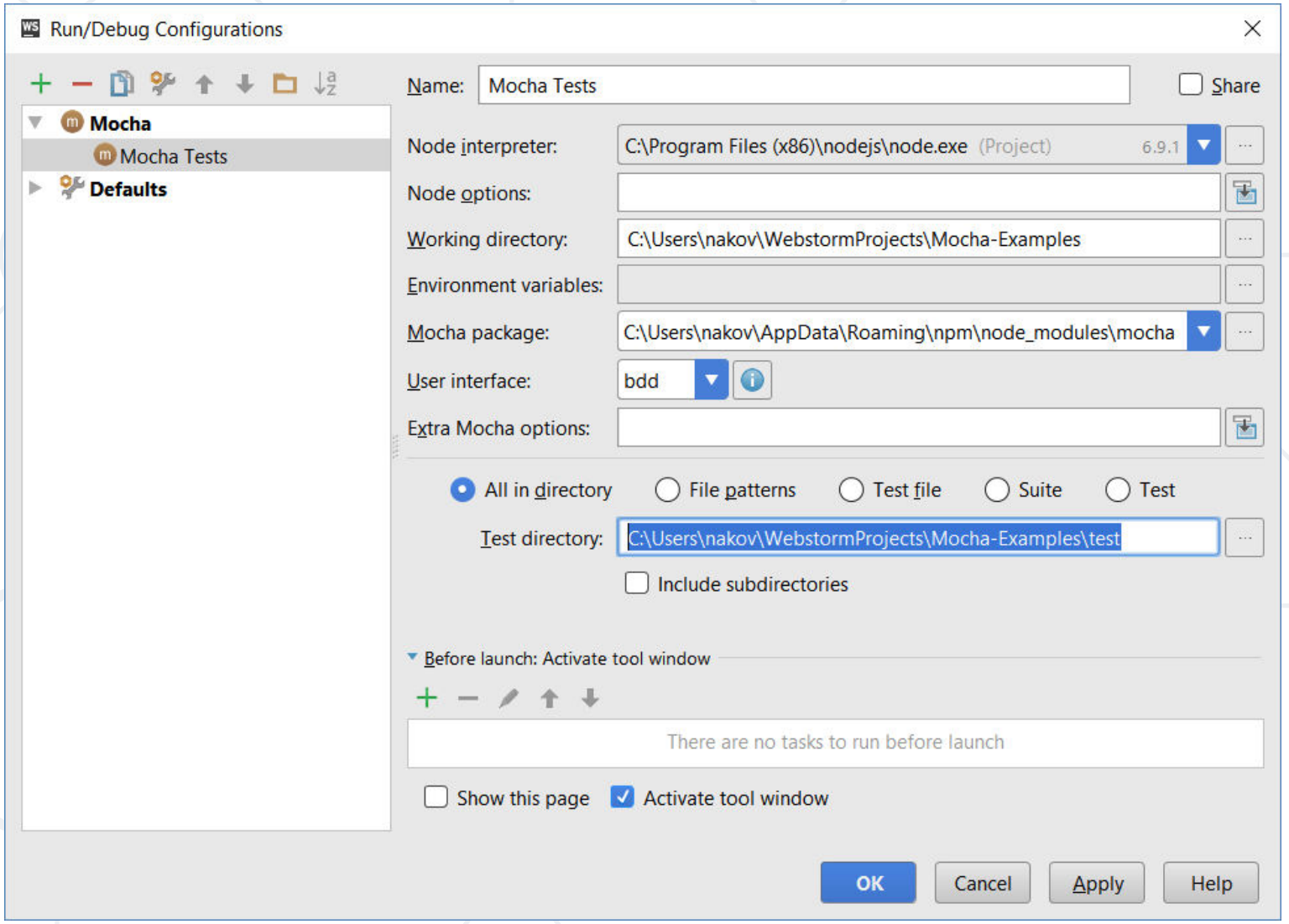
- Tests for the **sum(arr)** function



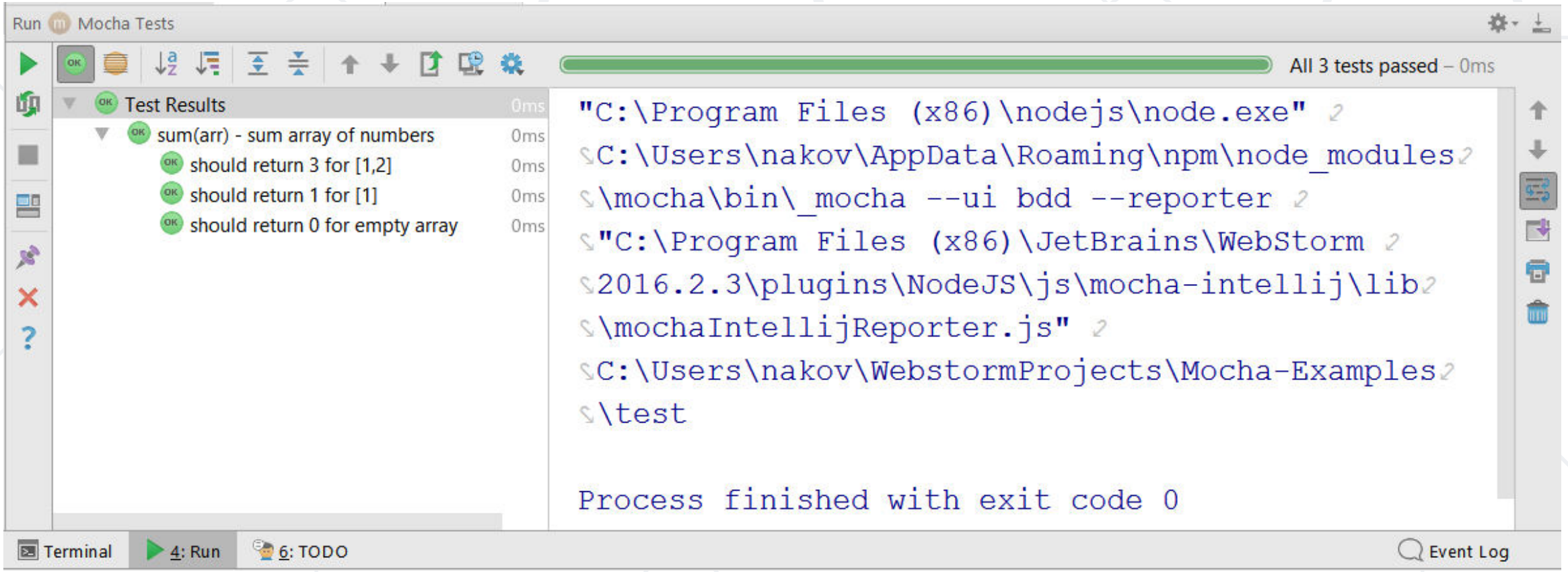
Mocha in Action – Running the Tests



Running Mocha Tests from WebStorm



Running Mocha Tests from WebStorm (2)



Configuring Libraries in WebStorm

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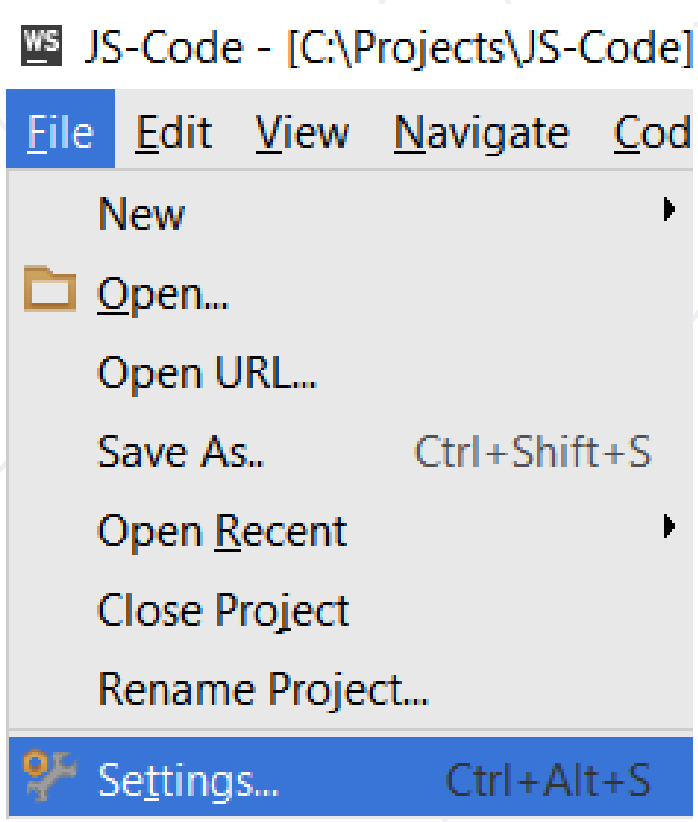
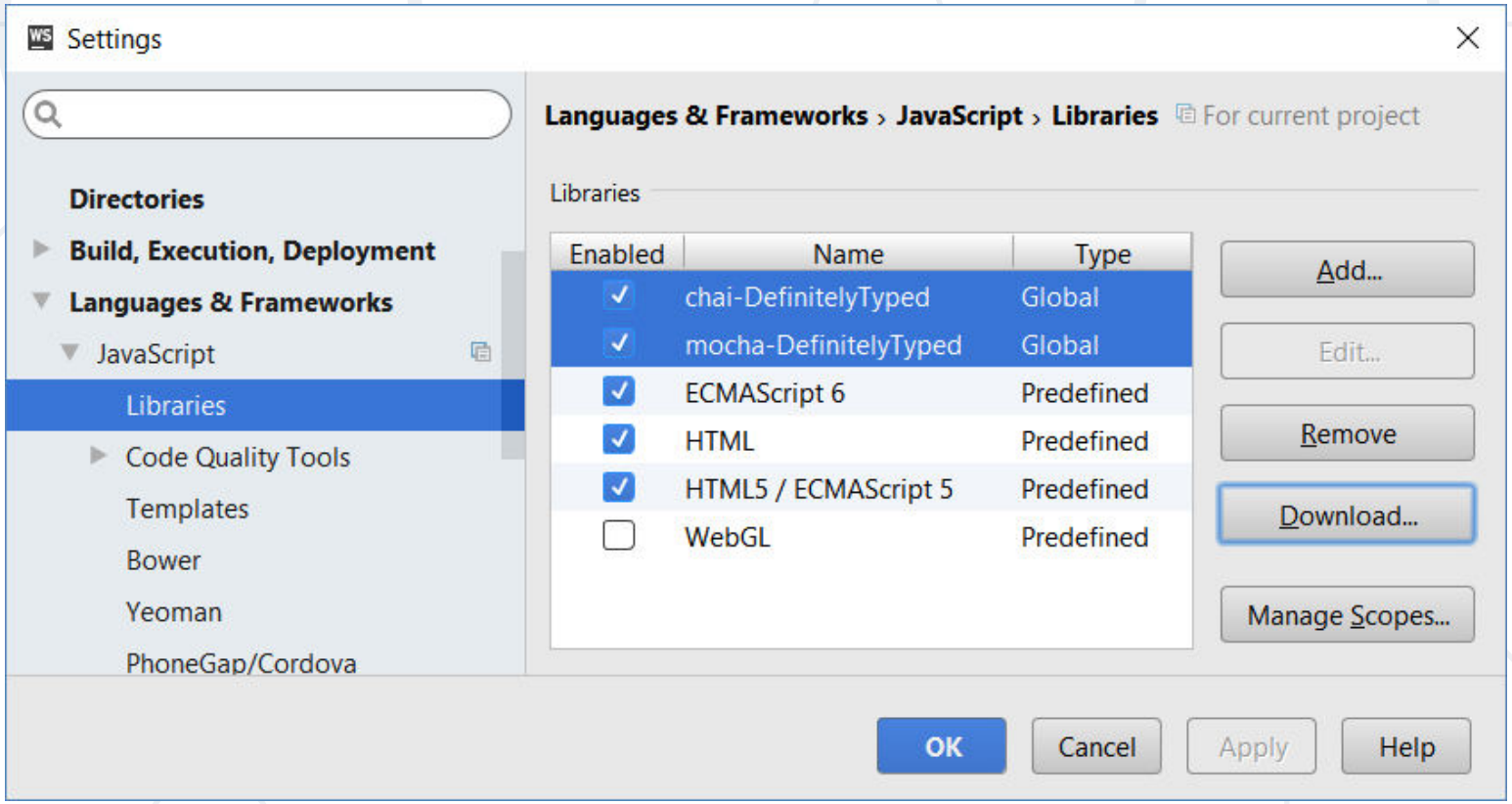
- To get the "auto complete" and "syntax checks" working for Mocha and Chai, add them as libraries in WebStorm





Test Groups and Test Cases

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```
describe("Test group #1", function() {
  it("should… when…", function() {
    expect(actual).to.be.equal(expected);
  });
  it("should… when…", function() { … });
});
describe("Test group #2", function() {
  it("should… when…", function() {
    expect(actual).to.be.equal(expected);
  });
  …
});
```

Problem – Sum of Numbers

- You are given a JS code intended to sum an array of numbers:

```
function sum(arr) {
  let sum = 0;
  for (num of arr)
    sum += Number(num);
  return sum;
}
```

- Write unit tests to test the **sum(arr)** function with Mocha

Check your solution here: **https://judge.softuni.bg/Contests/307**

Solution – Sum of Numbers – Test Cases

- Design the cases
  - sum([1, 2]) → 3
  - sum([1]) → 1
  - sum([]) → 0
  - sum([1.5, 2.5, -1]) → 3
  - sum("invalid data") → NaN

Solution – Sum of Numbers – Test Code

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```
describe("sum(arr) - sum array of numbers", function() {
  it("should return 3 for [1, 2]", function() {
    expect(sum([1, 2])).to.be.equal(3);
  });
  it("should return 1 for [1]", function() {
    expect(sum([1])).to.be.equal(1);
  });
  it("should return 0 for empty array", function() { … });
  it("should return 3 for [1.5, 2.5, -1]", function() { … });
  it("should return NaN for invalid data", function() { … });
});
```

Check your solution here: **https://judge.softuni.bg/Contests/307**

Problem – Check for Symmetry

- You are given the following JS code:

```
function isSymmetric(arr) {
  if (!Array.isArray(arr))
    return false; // Non-arrays are non-symmetric
  let reversed = arr.slice(0).reverse(); // Clone + reverse
  let equal =
    (JSON.stringify(arr) == JSON.stringify(reversed));
  return equal;
}
```

- Write unit tests to test the above function with Mocha

Check your solution here: **https://judge.softuni.bg/Contests/307**

Solution – Check for Symmetry – Test Cases

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- Design the cases
  - [1,2,3,3,2,1] → true
  - [1,2,3,4,2,1] → false
  - [-1,2,-1] → true
  - [-1,2,1] → false
  - [1,2] → false
  - [1] → true
  - [5,'hi',{a:5},new Date(),{a:5},'hi',5] → true
  - [5,'hi',{a:5},new Date(),{X:5},'hi',5] → false
  - 1,2,2,1 → false (not an array)

Solution – Check for Symmetry – Test Code

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```
describe("isSymmetric(arr) ", function() {
  it("should return true for [1,2,3,3,2,1]", function() {
    let symmetric = isSymmetric([1,2,3,3,2,1]);
    expect(symmetric).to.be.equal(true);
  });
  it("should return false for [1,2,3,4,2,1]", function() { … });
  it("should return true for [-1,2,-1]", function() { … });
  it("should return false for [-1,2,1]", function() { … });
  …
});
```

Check your solution here: **https://judge.softuni.bg/Contests/307**

Problem – RGB to Hex Color

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- Using Mocha write unit tests for the following function:

```
function rgbToHexColor(red, green, blue) {
  if (!Number.isInteger(red) || (red < 0) || (red > 255))
    return undefined; // Red value is invalid
  if (!Number.isInteger(green) || (green < 0) || (green > 255))
    return undefined; // Green value is invalid
  if (!Number.isInteger(blue) || (blue < 0) || (blue > 255))
    return undefined; // Blue value is invalid
  return "#" +
    ("0" + red.toString(16).toUpperCase()).slice(-2) +
    ("0" + green.toString(16).toUpperCase()).slice(-2) +
    ("0" + blue.toString(16).toUpperCase()).slice(-2);
}
```

Solution – RGB to Hex Color – Test Cases

- Design the cases
  - (255, 158, 170) → #FF9EAA
  - (0, 0, 0) → #000000
- Start from the typical (normal) cases
  - (12, 13, 14) → #0C0D0E
  - (255, 255, 255) → #FFFFFF
- Then, test the special cases, e.g. invalid input
  - (-1, 0, 0), (0, -1, 0), (0, -1, 0) → undefined
  - (256, 0, 0), (0, 256, 0), (0, 0, 256) → undefined
  - (3.14, 0, 0), (0, 3.14, 0), (0, 0, 3.14) → undefined
  - ("5", [3], {8:9}), (*empty input*) → undefined

Solution – RGB to Hex Color – Test Code

SoftUni Foundation

```
describe("rgbToHexColor(red, green, blue)", function() {
  describe("Nominal cases (valid input)", function() {
    it("should return #FF9EAA on (255, 158, 170)", function() {
      let hex = rgbToHexColor(255, 158, 170);
      expect(hex).to.be.equal('#FF9EAA');
    });
    …
  });
  describe("Special cases (invalid input)", function() {
    …
  });
});
```

Check your solution here: https://judge.softuni.bg/Contests/307

Testing Incorrect Code

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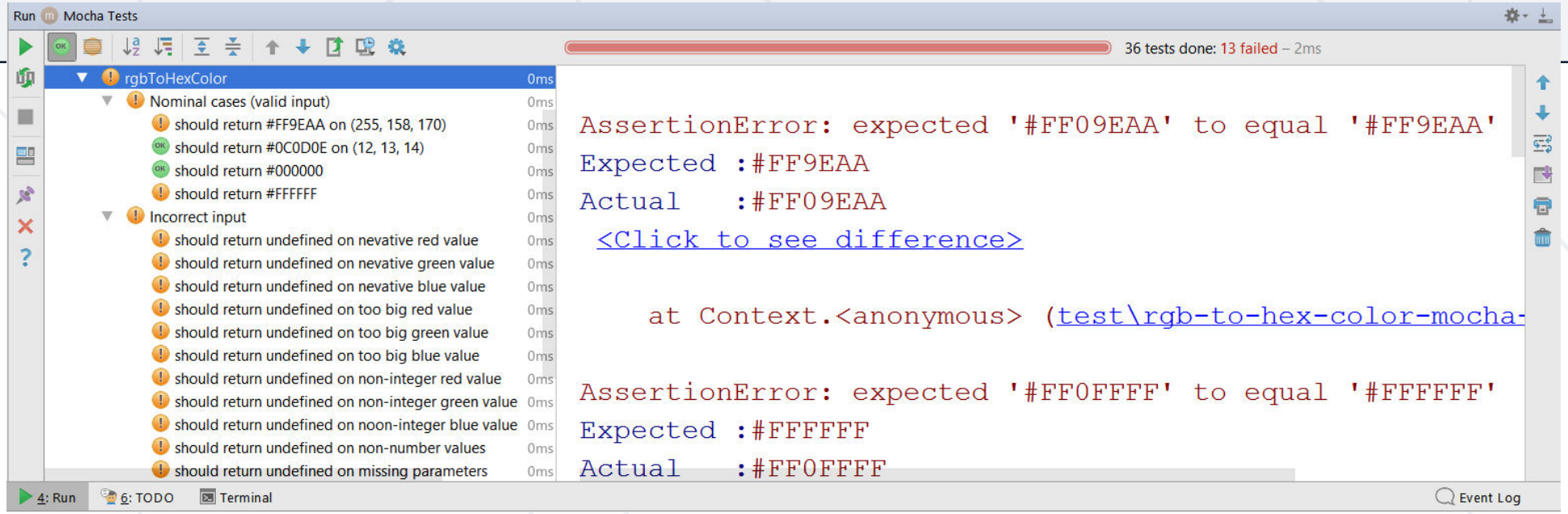
```
function rgbToHexColor(red, green, blue) {
  return "#" +
    ("0" + red.toString(16).toUpperCase()).slice(-2) +
    ("0" + green.toString(16).toUpperCase().slice(-2)) +
    ("0" + blue.toString(16).toUpperCase()).slice(-2);
}
```



Problem – Add / Subtract Module

- You are given the following JS code:

```
function createCalculator() {
  let value = 0;
  return {
    add: function(num) { value += Number(num); },
    subtract: function(num) { value -= Number(num); },
    get: function() { return value; }
  }
}
```

- Write unit tests to test the above code with Mocha

Check your solution here: **https://judge.softuni.bg/Contests/307**

Solution – Add / Subtract – Test Cases

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- Design the test cases
  - create; get → 0
  - create; add(2); add(3); get → 5
  - create; subtract(3); subtract(2); get → -5
  - create; add(5.3); subtract(1.1); get → 4.2
  - create; add(10); subtract('7'); add('-2'); subtract(-1); get → 2
  - create; add('hello'); get → NaN
  - create; subtract('hello'); get → NaN

Solution – Add / Subtract – Test Code

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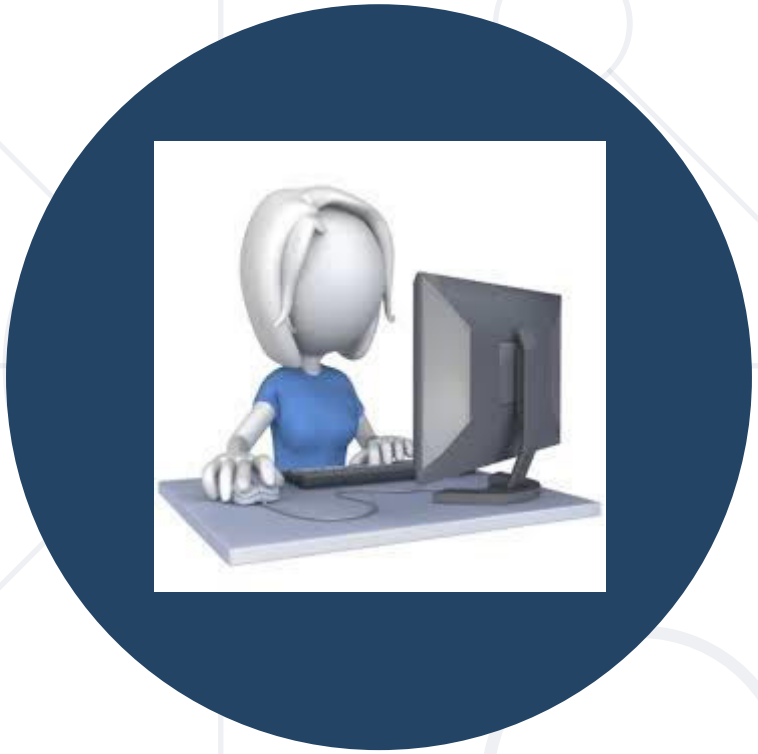
```
describe("createCalculator()", function() {
  let calc;
  beforeEach(function() {
    calc = createCalculator();
  });
  it("should return 5 after {add 3; add 2}", function() {
    calc.add(3); calc.add(2); let value = calc.get();
    expect(value).to.be.equal(5);
  });
  …
});
```

Mocha hook: called before each test

Check your solution here: https://judge.softuni.bg/Contests/307



Live Exercises in Class (Lab)

Practice: Unit Testing in JS

Summary

- JS functions should do what their name says or indicate a problem
- Unit tests are programs that check whether a piece of code works as expected

```
let expect = require("chai").expect;

describe("sum(arr)", function() {
  it("shoud sum 1+2 = 3", function() {
    expect(sum([1, 2])).to.be.equal(3);
  });
});
```

Questions?

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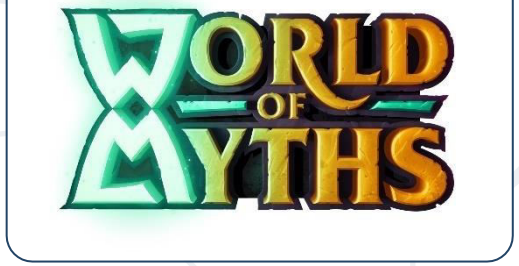

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