CS1632, Lecture 11: Test-Driven Development

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THE DARK AGES

Bill Laboon

Nowadays…

- We know how important tests are to prevent issues like that
- Code quality is everyone’s responsibility, including developers’
- Developers write tests (usually unit tests)

But...

- What to test?
- How deep to go into testing?
- How many edge cases?
- How to prioritize testing and development?
- What order should I write tests?
- How do I structure code to be testable?

There is no one right answer

- Many studies done
- Different domains, different developers, different languages, etc…
- “No silver bullet”

Test-Driven Development

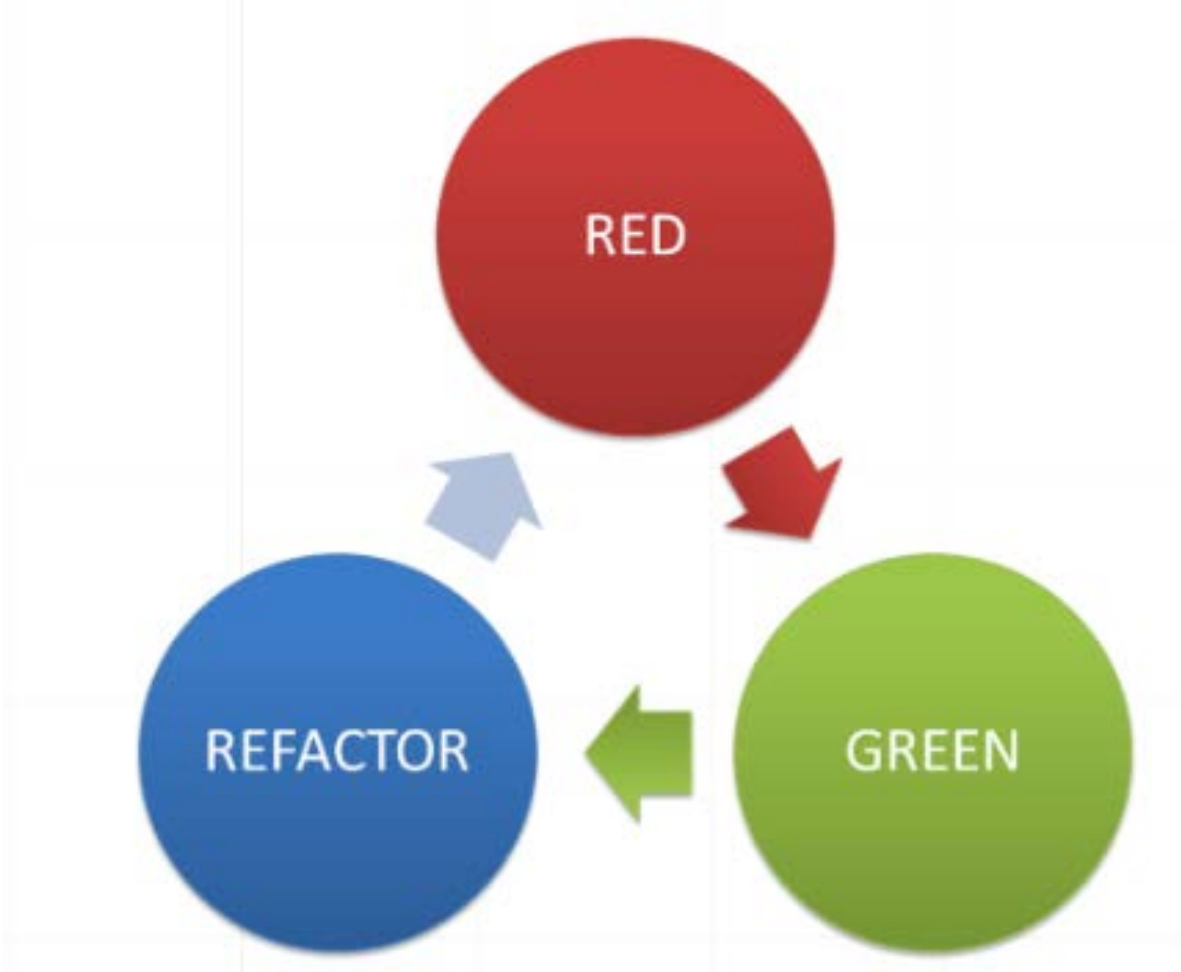
- A strategy for developing highly tested, quality software
- Not the be-all and end-all of strategies
- Google “TDD is dead” for a great argument against it
- Welcome to the still-forming world of software development!

So What is TDD?

A software development methodology that comprises:

1. Writing tests BEFORE writing code
2. Writing ONLY code that is tested
3. Writing ONLY tests that test the code
4. A very short turnaround cycle
5. Refactoring early and often

The Red-Green-Refactor Loop



The Red-Green-Refactor Loop

- Red – Write a test for new functionality
  - This should immediately fail!
- Green
  - Write only enough code to make the test pass
- Refactor
  - Review code and make it better

Detailed Run-Through of RGR Loop

1. Write a test for new functionality
2. Run test suite - only the new test should fail
3. Write only enough code to make test pass
4. Run test suite
5. If any tests fail, go to step 3
6. Refactor code
7. Run test suite
8. If any tests fail, go to step 6
9. If any more functionality, go to step 1; otherwise done

Fizzbuzzin’ With TDD

Print out the numbers from 1 to 100, each on a separate line. If a number is evenly divisible by 3, print "Fizz" instead. If a number is evenly divisible by 5, print "Buzz" instead. If a number is evenly divisible by 3 and 5, print "FizzBuzz" instead. Otherwise, just print the number.

1

2

Fizz

4

Buzz

Fizz

...

Start by adding a new test

```
@Test
public void testNumber() {
  assertEquals(_fb.value(1), "1");
 }
// Code
public String value(int n) {
  return “";
}
```

… Which fails.


WELCOME
TO
FAIL
POPULATION: YOU

Write code to make test pass

```
@Test
public void testNumber() {
  assertEquals(_fb.value(1), "1");
 }
// Code
public String value(int n) {
  return "1";
}
```

Nothing to refactor.

Next test!

Let’s Add Another Test

```
@Test
public void testNumber2() {
   assertEquals(_fb.value(2), "2");
 }
// Code
public String value(int n) {
  return "1";
}
```


WELCOME
TO
FAIL
POPULATION: YOU

Let’s Make Another Change

```
 public String value(int n) {
  if (n == 1) {
   return "1";
  } else {
   return "2";
  }
}
```

But could be better!

Refactor – now much nicer, and tests still pass!

```
public String value(int n) {
   return String.valueOf(n);
}
```

Add Another Test – it fails

```
@Test
public void testNumber3() {
  assertEquals(_fb.value(3), "Fizz");
}
```

We Need to Add Fizzy Code!

```
private boolean fizzy(int n) {
  return (n % 3 == 0);
}

public String value(int n) {
  if (fizzy(n)) {
   return "Fizz";
  } else {
   return String.valueOf(n);
  }
}
```


YESSS!!!
quickmeme.com

Let’s Add A Test For Buzziness - It should fail.

```
@Test
public void testNumber5() {
  assertEquals(_fb.value(5), "Buzz");
}
```

Add and Integrate buzzy(n) Method

```
private boolean buzzy(int n) {
   return (n % 5 == 0);
}
public String value(int n) {
   if (fizzy(n)) {
     return "Fizz";
   } else if (buzzy(n)) {
     return "Buzz";
   } else {
     return String.valueOf(n);
   }
}
```

The Final Equivalence Class

```
 @Test
public void testNumber15() {
  assertEquals(_fb.value(15), "FizzBuzz");
}
```

Modify The value() Method

```
public String value(int n) {
  if (fizzy(n) && buzzy(n)) {
   return "FizzBuzz";
  } else if  (fizzy(n)) {
   return "Fizz";
  } else if (buzzy(n)) {
   return "Buzz";
  } else {
   return String.valueOf(n);
  }
}
```

Result?

- We now have a working, tested implementation of FizzBuzz
- We have automated test coverage for all equivalence classes
- We had a path forward at all points

TDD = A Kind of Test-First Development

- Basic idea is to think about expected behavior FIRST, before code
- You don’t want to “corrupt” your mind with implementation details
- Figure out what the program should do (requirements!)

- Side note: there are other kinds of test-first development, such as ATDD (Acceptance Test Driven Development) and BDD (Behavior Driven Development)

YAGNI

- "You Ain't Gonna Need It“
- Don't add functionality you don't need right now. Chances are you won't need it and you're just going to waste time writing code for it.
- Code to the test!

KISS

- “Keep It Simple, Smarty-pants”
- Don't try to write overly complex, clever, over-engineered code. Make it easy to understand and modify.
- “Premature optimization is the root of all evil” –Donald Knuth
- Prefer:
  ```
  i++;
  ```
  over
  ```
  i += (NUM_A / (c.getNum() - d.getNum));
  ```

Fake It ‘til You Make It

- Obviously applies to mocks/stubs
- But you can apply to smaller levels of functionality

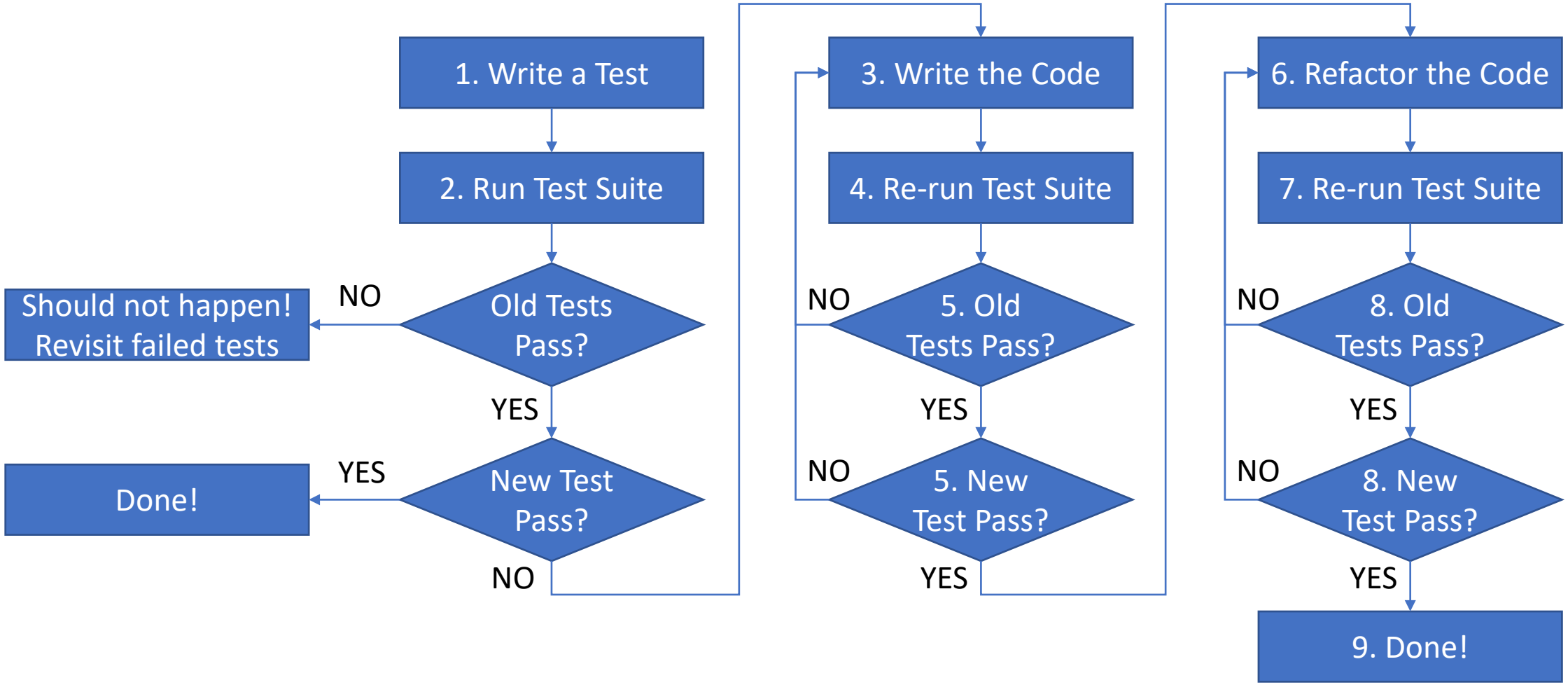
Test:

```
assertEquals(sqrt(4), 2);
```

Code:

```
public void sqrt(int n) {
   return 2;
}
```

Flow Chart of the RGR Loop



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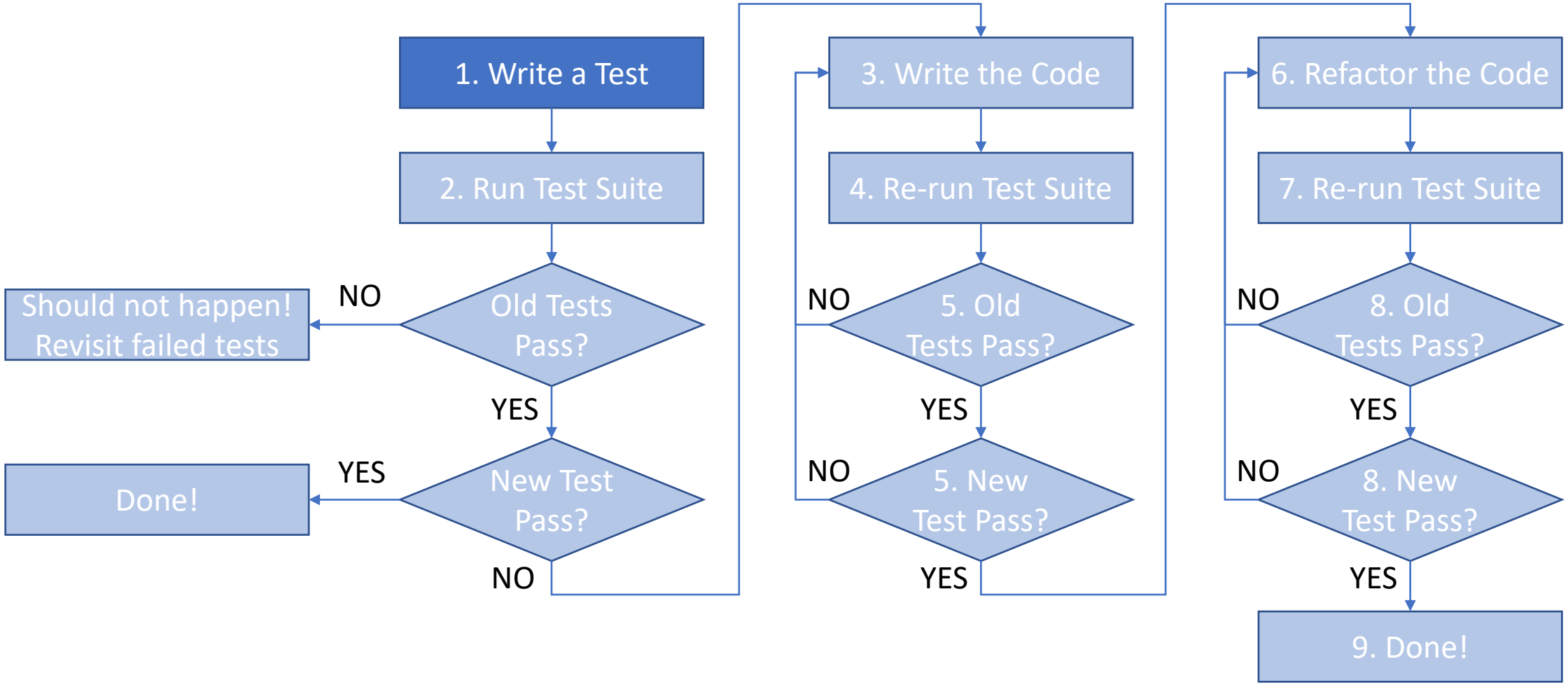
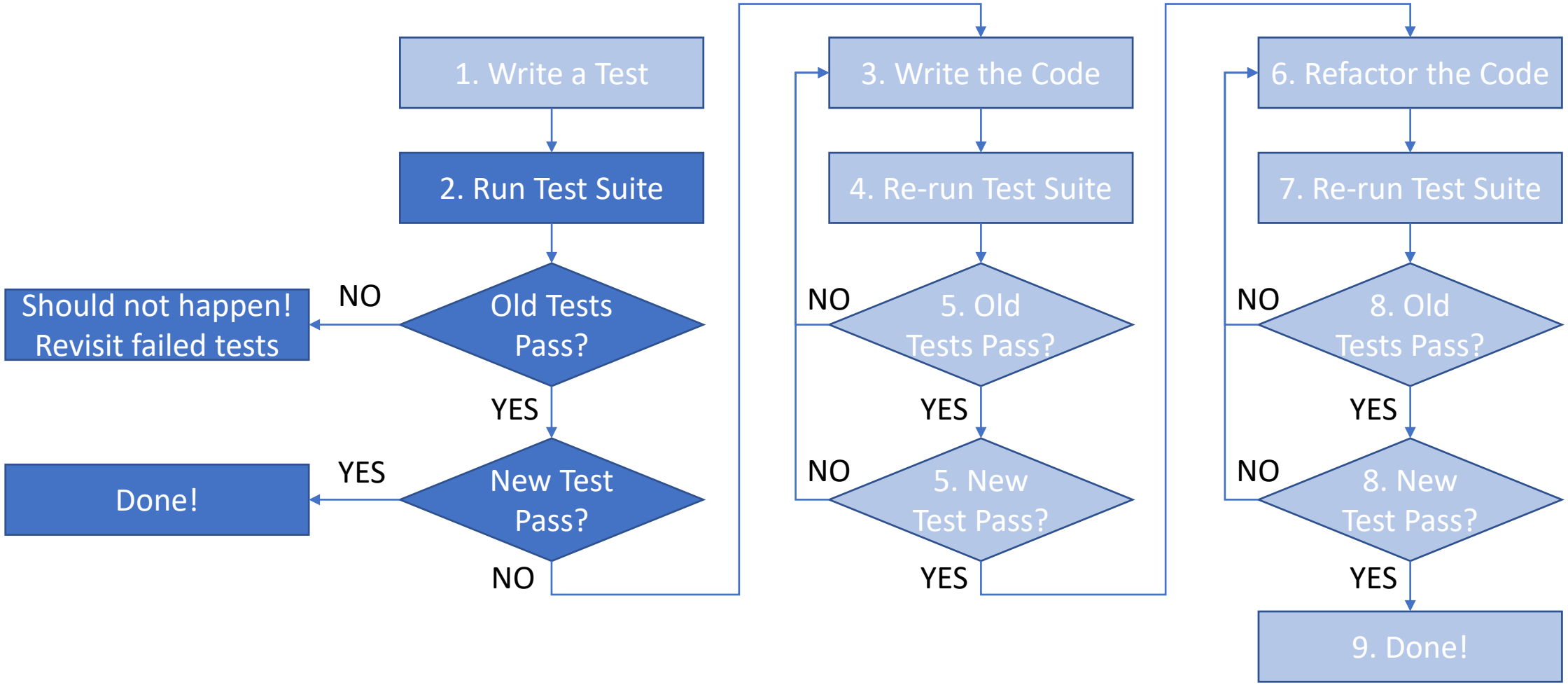


Step 1 – Write a test

- This test should be a small unit of functionality, say one input value and output value for a method.
- For pure TDD, you should not write multiple tests or tests which are very complex.

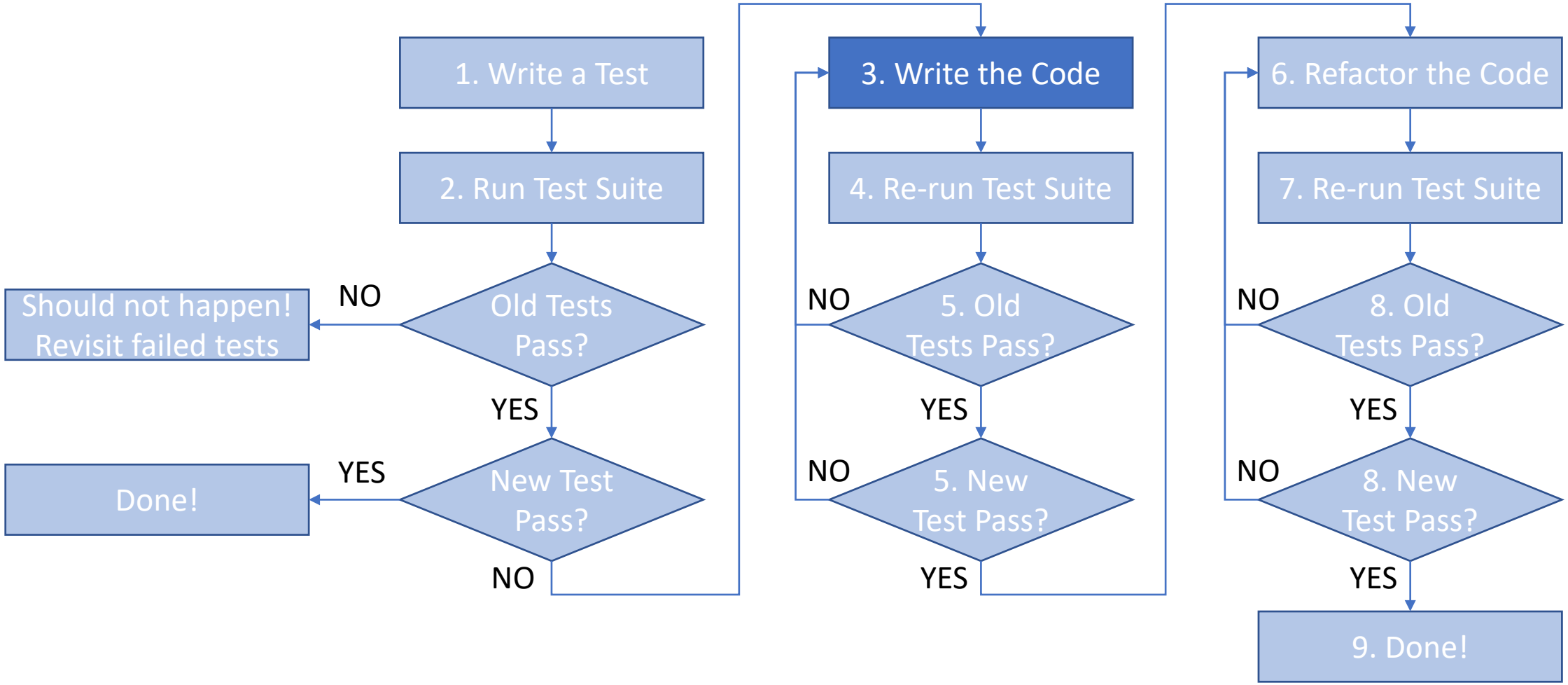
Flow Chart of the RGR Loop



Step 2 – Run Test Suite

- Run all the tests - only the one you've just added should fail.
- If old tests fail, something weird happened. Old tests should all pass if you did the RGR loop properly for previous iterations.
- If new test doesn’t fail, you've already written the code for it! Done!

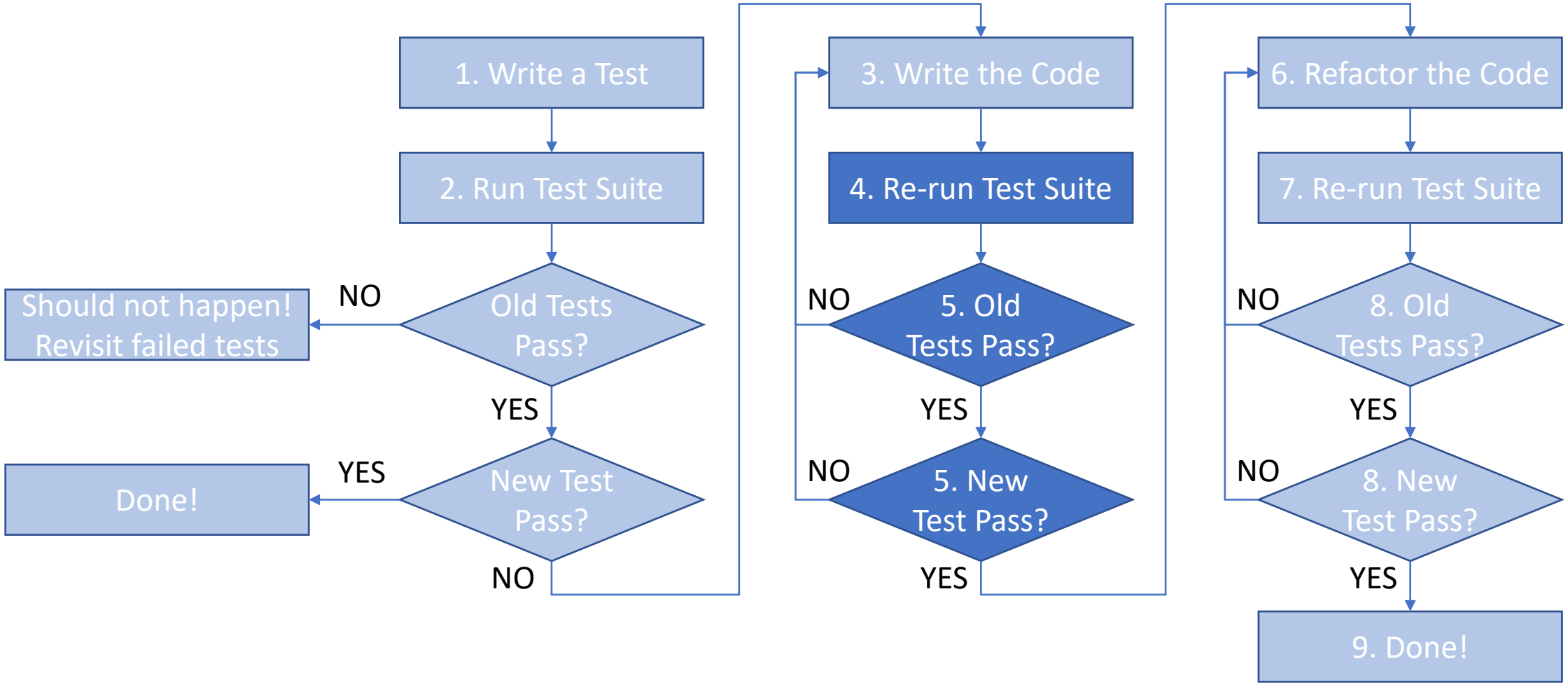
Flow Chart of the RGR Loop



Step 3 – Write the Code

- Write just enough code to have the test pass.
- Avoid the temptation to over-engineer your solution or add more functionality than the test covers!

Flow Chart of the RGR Loop



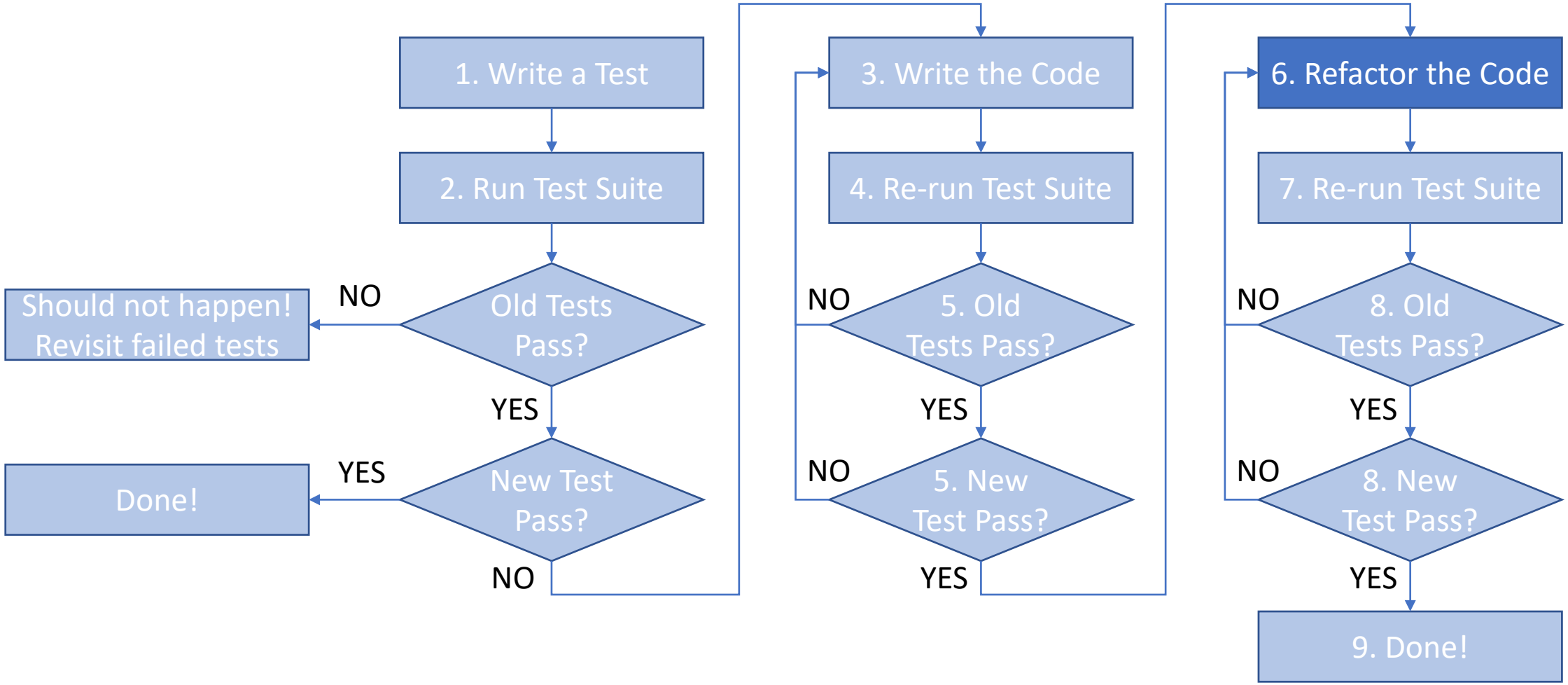
Step 4 – Re-run the Test Suite

- All tests should pass this time, assuming you actually added the functionality.
- Otherwise:
  - If only your new test fails:
    - You have not written your code (or possibly test) correctly.
  - If old tests fail:
    - You have created a regression failure; that is, you've broken other functionality on the system!
  - Note that these are not mutually exclusive!

Step 5 – Check Test Results

- If any tests fail, fix them – either tests or code!
- Never move on before having an ENTIRELY GREEN (passing) test suite!

Flow Chart of the RGR Loop



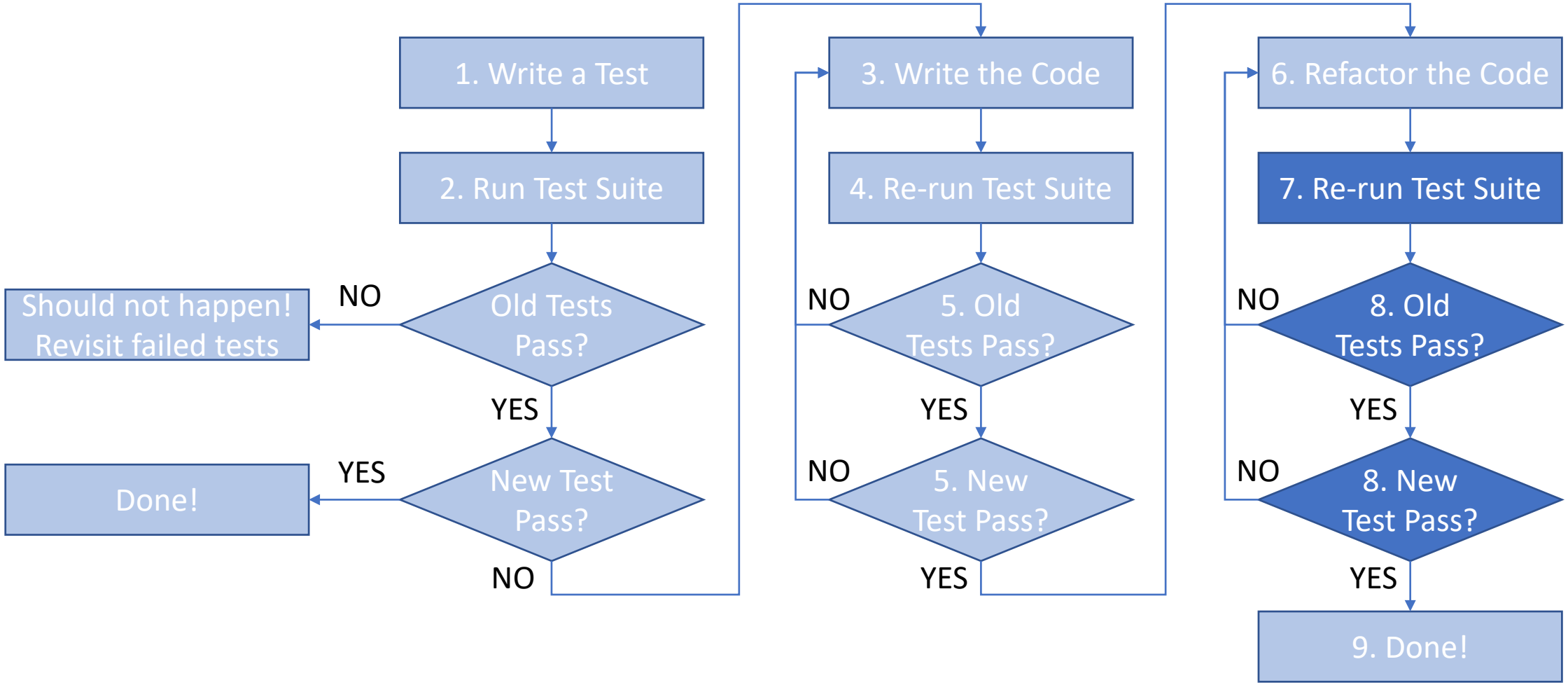
Step 6 - Refactor

- Your first attempt at writing code will probably not be perfect
  - Poor algorithm choice?
  - Bad variable names?
  - Poor performance?
  - Badly documented?
  - Magic numbers?
  - Not easily comprehensible?
  - General bad design?

Step 6 - Refactor

- Remember – you already have a working version before you refactor
  - We know it works because the entire unit test suite passes at this point
- Remember – being right is more important than being good-looking

Flow Chart of the RGR Loop



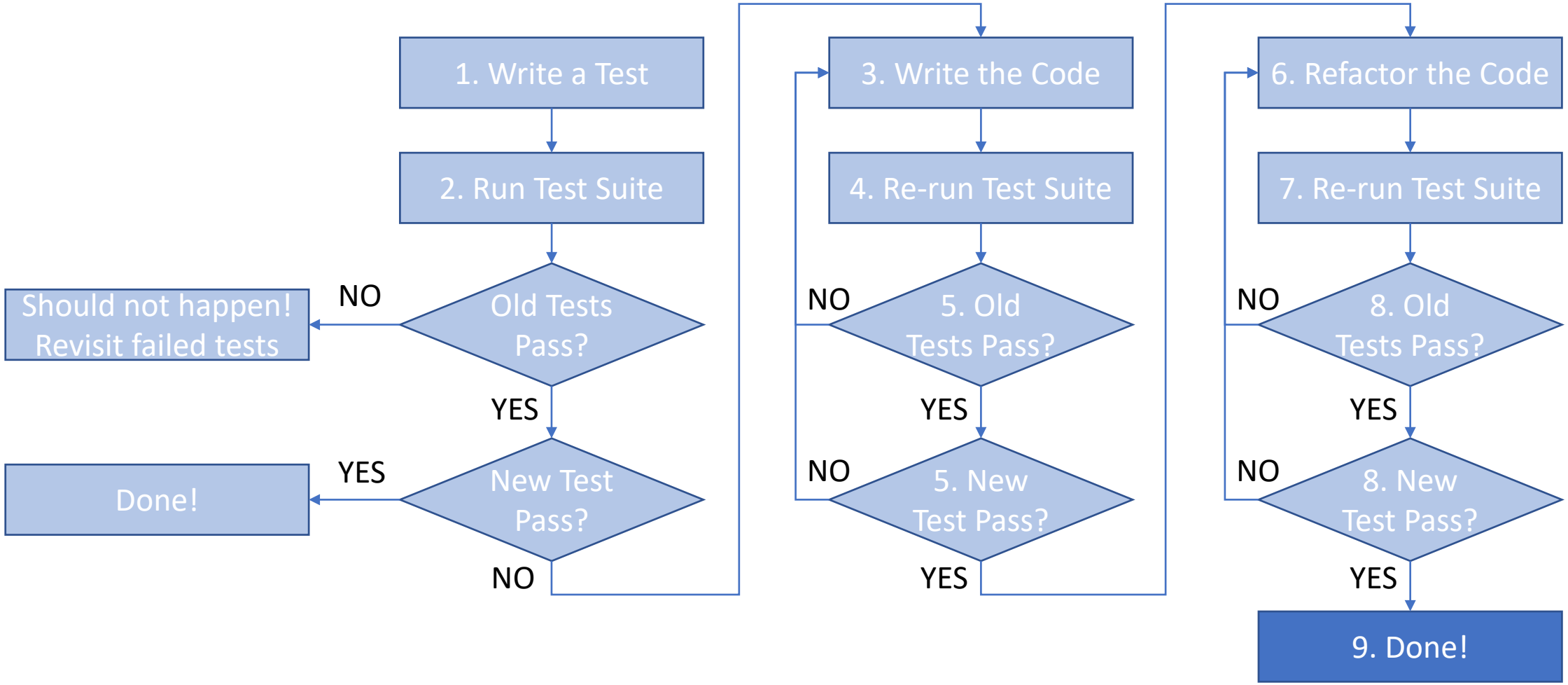
Step 7 – Re-run Test Suite Again

- Make sure that your refactoring did not cause any problems
- It should have the same functionality, just better code
- That is, all unit tests should still pass

Step 8 – Check test results

- If any tests fail, something broke.
- Go and fix it before moving on!
- We are always aiming to have all-green tests

Flow Chart of the RGR Loop



Step 9 - Done

- Congratulations!
- You now have provably working code with new functionality.

- To add to functionality, go back to Step 1 and work on next increment.

- If not, SHIP IT.

Avoid Slow-Running Tests

- Note that each iteration requires at least three test suite runs. If your tests take a long time to run, TDD is impractical.

- That means using test doubles / mocks aggressively to fake delay-prone components like DB, file, network connections

Principles, Not Laws

- Nobody will throw you in jail if you write two tests during an iteration
- Sometimes tests are hard to make fast
- Etc.
- But they’re code smells if you are using TDD.

Benefits of TDD

- Automatically create tests!
  - Research shows that more tests are correlated with fewer defects
- Makes writing tests easy because it’s done often
  - Anything you do often, you learn how to do better
- Tests are relevant
  - They are testing the exact functionality you are implementing
- Developer is focused on end result, not code
  - Code is a way to get the functionality the user wants

Benefits of TDD

- Ensures that you take small steps
  - You know where defects lie; help localize errors
  - Research shows more senior engineers take smaller steps
- Code is extensible
  - You are already constantly extending the codebase
- Large test suite automatically created for you!
  - Helps avoid regression errors
  - High code coverage
- Confidence in the codebase

Drawbacks of TDD

- Focus on unit tests may mean other aspects of testing get short shrift
  - Remember that unit tests focus on small units of code, not integration
- Extra up-front time
  - May be saved in large projects due to fewer defects / test coverage
- May not be appropriate for prototyping
  - You may not always know expected behavior
- Hard to do large architectural changes
  - Some things just aren’t possible to do in small steps

Drawbacks of TDD

- Complex or mission-critical systems will require a more robust testing strategy
- Tests become part of the overhead of the project
  - Especially if they are brittle/fragile, or poorly written!
- Could fall into trap of overtesting
  - More time-consuming test suite runs, which hurts productivity

Now Please Read Textbook Chapter 15