

Desarrollo dirigido por pruebas (*Test-Driven Development*)

Raúl García García
Curso 2025/2026
Universidad San Pablo-CEU
Escuela Politécnica Superior
Campus de Montepríncipe

1



Motivation

- » One of the goals of the course is to introduce new development methodologies such as *eXtreme Programming (XP)* and *Test-Driven Development (TDD)*
 - TDD sits nicely in the XP “way of doing things”
 - › TDD can be used *without* practicing XP
 - Giving lectures is one such way of achieving that goal
 - › Practising them is *better*
 - Reduce the amount of re-testing that is required
 - › Especially when dealing with legacy applications
 - › Avoid introducing new bugs after *refactoring* existing code
- » TDD has “broader goals” that just insuring quality
 - Improve developers lives (coping, confidence)
 - Support design flexibility and change
 - Allow iterative development with working code early

29-agosto-25 Curso 2025/2026 página 2

2



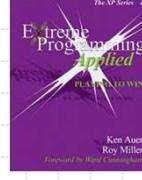
What is TDD?

» “Before you write code, think about what it will do.
Write a **test** that will use the methods you haven’t even written yet”

Extreme Programming Applied: Playing To Win
Ken Auer, Roy Miller (“The Purple Book”)

» A **test** is not something you “**do**”, it is something you “**write**” and run once, twice, three times, etc.

- It is a piece of code
 - Testing is therefore **automated**
- Repeatedly **executed**, even after small changes
- As much about **design** as about **testing**
 - Encourages design from a user’s point of view
 - Encourages testing classes in isolation
 - Produces **loosely-coupled, highly-cohesive** systems



29-agosto-25 Curso 2025/2026 página 3

3



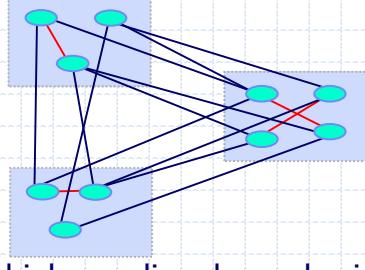
Sidenote: Cohesion and coupling

» Each module should be **highly cohesive**

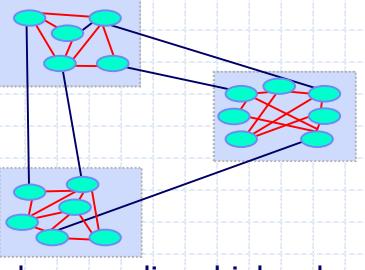
- module understandable as a **meaningful unit** (clarity)
- components of a module are **closely related to one another**

» Modules should exhibit **low coupling**

- modules have **low interactions** with others
- understandable **separately**



- high coupling, low cohesion



+ low coupling, high cohesion

29-agosto-25 Curso 2025/2026 página 4

4

What is TDD?

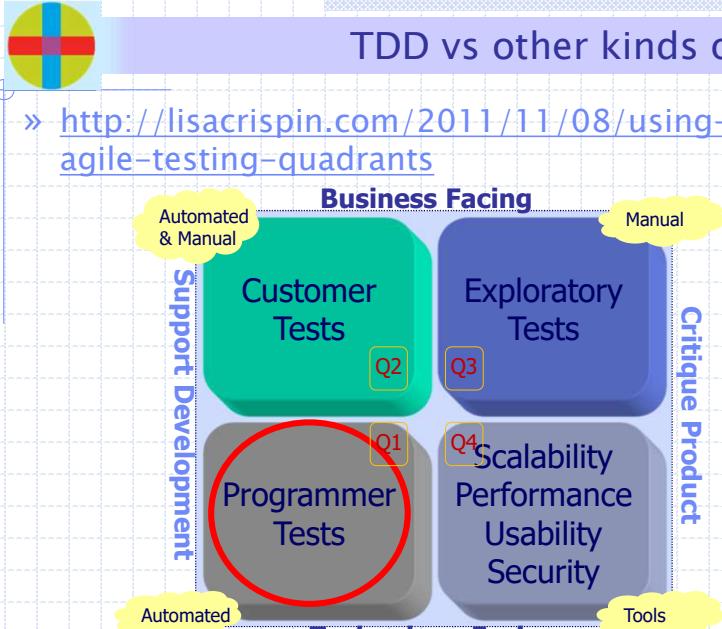


- » TDD is the process of thinking about a block of code from the perspective of the user of that code
- » TDD is a technique whereby you write your test cases before you write any implementation code
- » An iterative technique for developing software
 - Tests drive or dictate the code that is developed
 - Write a test that shows what you want the code to do
 - Letting your codebase grow organically as you create examples of what the code should do
 - Software is written from the outside in: tests provide a specification of "what" a piece of code actually does
 - Some say that "tests are part of the documentation"
 - Other say that "tests are part of the design"

29-agosto-25 Curso 2025/2026 página 5

5

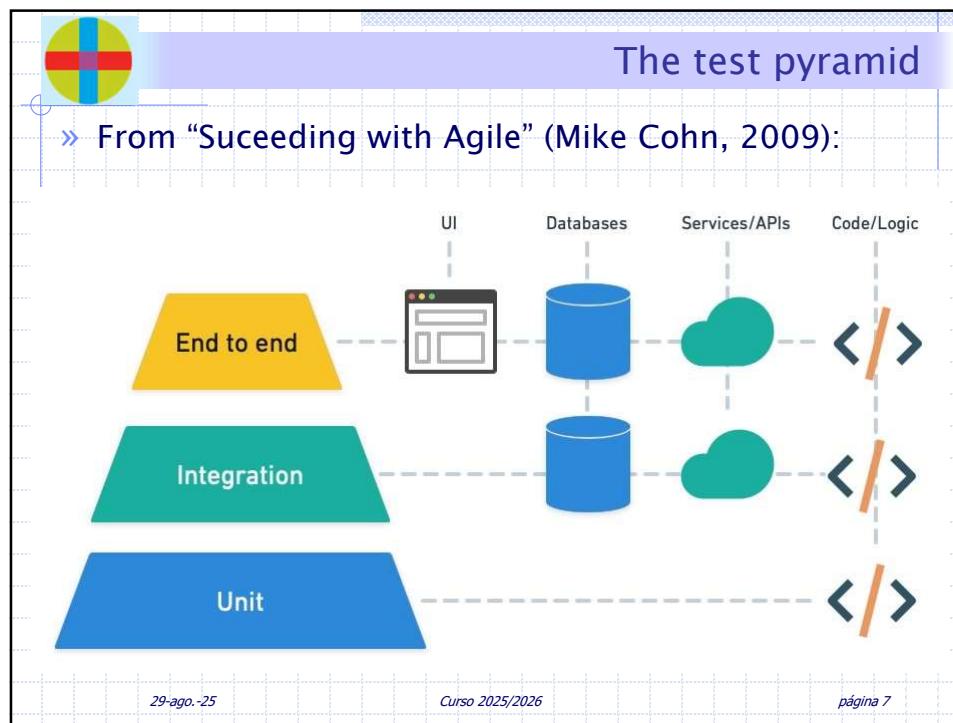
TDD vs other kinds of testing



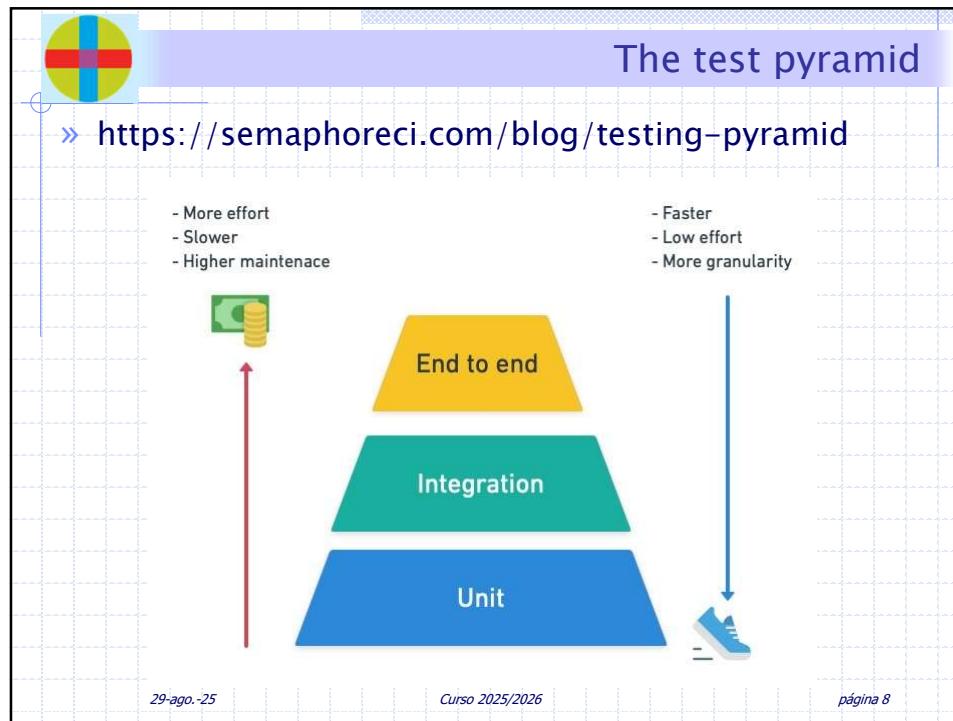
- » <http://lisacrispin.com/2011/11/08/using-the-agile-testing-quadrants>

29-agosto-25 Curso 2025/2026 página 6

6



7



8



Why TDD?

- » Programmers dislike testing
 - They will test reasonably thoroughly the first time
 - The second time however, testing is usually less thorough
 - The third time, well...
- » Testing is considered a boring task
 - Testing might be the job of another department / person
- » TDD encourages programmers to maintain an exhaustive set of repeatable tests
 - With tool support, tests can be run selectively
 - The tests can be run after every single change
 - Must be learned and practiced: if it feels natural at first, you're probably doing it wrong
- » More productive than debug-later programming
 - Developers work in a predictable way of developing code
 - It's an addiction rather than a discipline – Kent Beck

29-agosto-25 Curso 2025/2026 página 9

9



Which is TDD?

- » Bob Martin: "The act of writing a unit test is more an act of design than of verification"
 - Disclaimer: Developer = Programmer
- » We're talking about unit testing – i.e. testing the internals of a class
 - There is some debate about what constitutes a unit
 - Here are some common definitions of a unit:
 - The smallest chunk that can be compiled by itself
 - A stand-alone procedure or function
 - Something so small that it would be developed by a single person
 - Black box testing for objects
 - Classes are tested in isolation
 - Remember: the goal is to produce loosely coupled, highly cohesive architectures

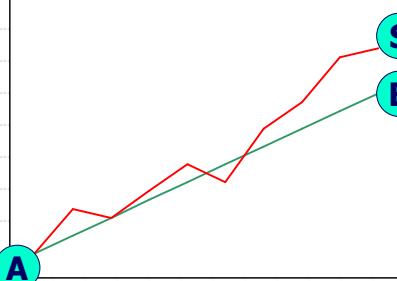
29-agosto-25 Curso 2025/2026 página 10

10



Who should write the tests?

- » The programmers should write the tests
 - They can't wait for somebody else to write tests
- » TDD promotes “**small steps**”, and lots of them
 - Small steps: the **real** shortest distance between two points
 - Use TDD to get from A to B in very small, verifiable steps
 - › You often end up in a better place



BDUF (Big Design Up-Front)
Software development method where a "big" design is created before coding and testing takes place.

Spike
A quick (minutes, hours) exploration by coding of an area in which the development team lacks confidence.

29-agosto-25 Curso 2025/2026 página 11

11



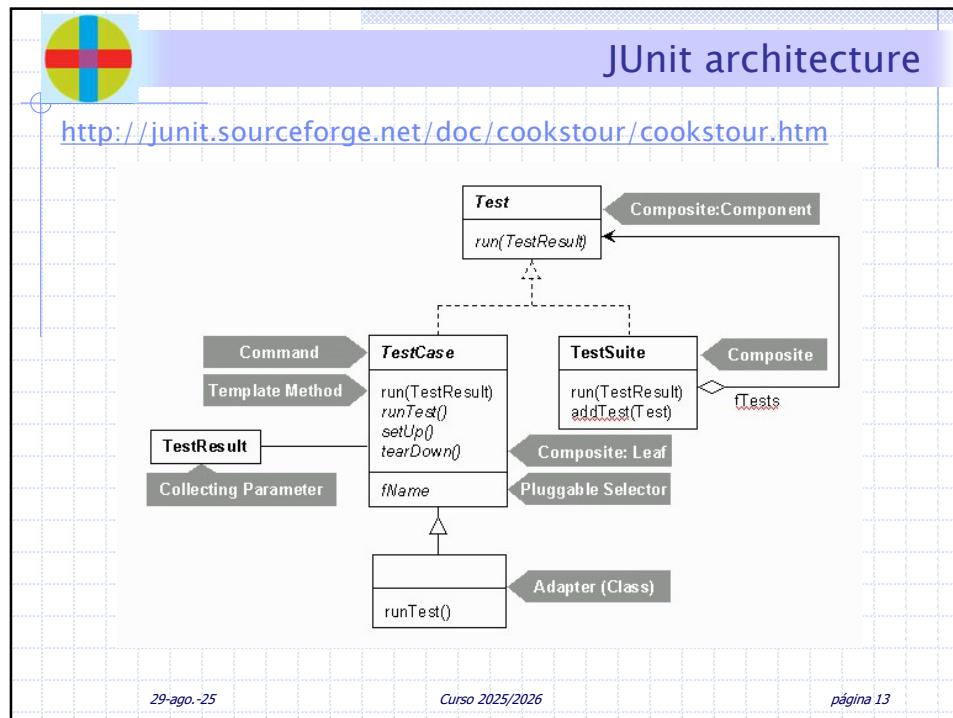
Unit Testing Frameworks

- » Test must be **automated**
 - If not, they won't be run
- » **xUnit** is a colloquial umbrella term
 - Most languages have a testing framework
 - **JUnit**, **CppUnit**, **PyUnit**, **XMLUnit**
 - › Simple tool (platform-specific implementations)
 - › Collects, organizes and automatically calls your test code
- » Graphical test runner
 - Green bar makes you feel good

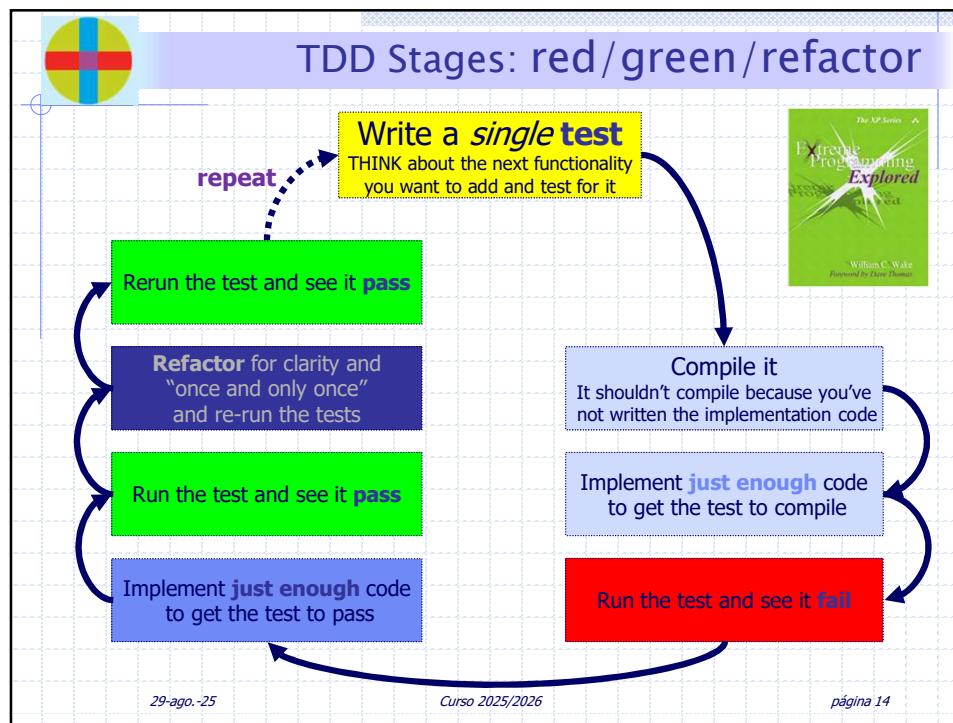


29-agosto-25 Curso 2025/2026 página 12

12



13



14



A Test Life Cycle

- 1. Write a test (red): the test fails**
 - The test must not work; must not even compile at first
 - Think about how you would like the feature to appear in code
 - > Invent the API you wish you had
 - Include all the elements in the story that you imagine will be necessary to calculate the right answers
- 2. Make it run (green): make the test pass**
 - Make the test work quickly, doing whatever sins be necessary
 - Quickly getting the test to pass dominates everything else
 - > If a clean simple solution is obvious, type it in
 - > If the clean, simple solution is obvious but will take a minute, make a note of it and get back to the main problem – making the test pass
 - Quick test success excuses all sins, but only for the moment
- 3. Make it right (refactor): change the design**
 - Now that the system is ok, put the sins of the recent past out
 - > Step back onto the straight and narrow path of software righteousness
 - Eliminate the duplication created in just getting the test to work

29-agosto-25 Curso 2025/2026 página 15

15

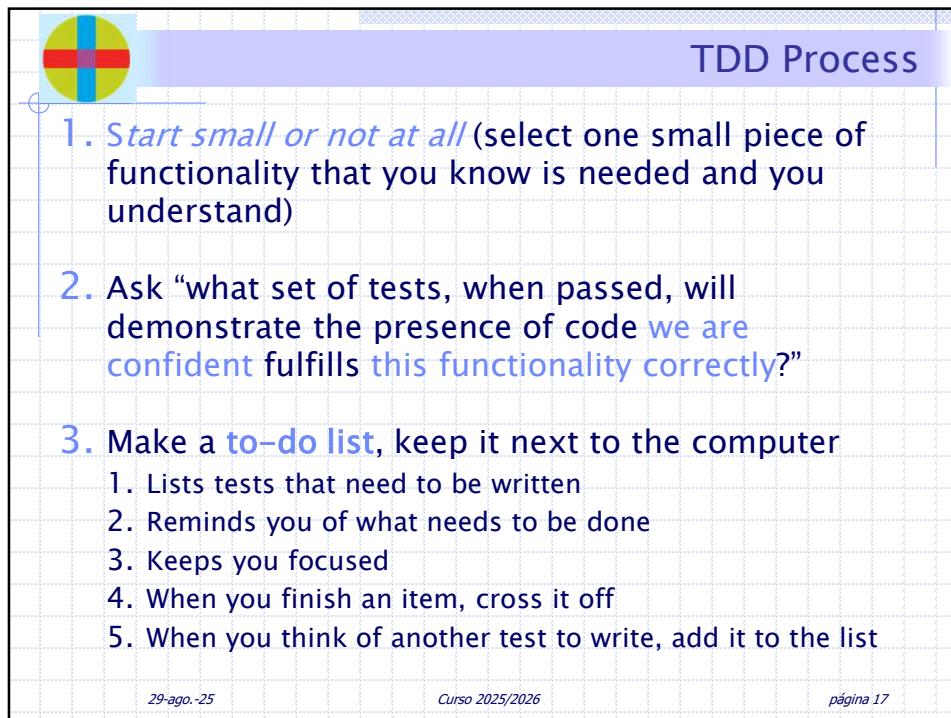


TDD Process

- » **Features and benefits**
 - Once a test passes, it is re-run with every change
 - Broken tests are not tolerated
 - Side-effects defects are detected immediately
 - Assumptions are continually checked
 - How should running of tests affect one another?
 - > Not at all – isolated tests
 - Automated tests provide a safety net that gives you the courage to refactor
- » **What do you test?**
everything that could possibly break – Ron Jeffries
- » **Don't test anything that could not possibly break**
(always a judgment call)
 - Example: Simple accessors and mutators

29-agosto-25 Curso 2025/2026 página 16

16

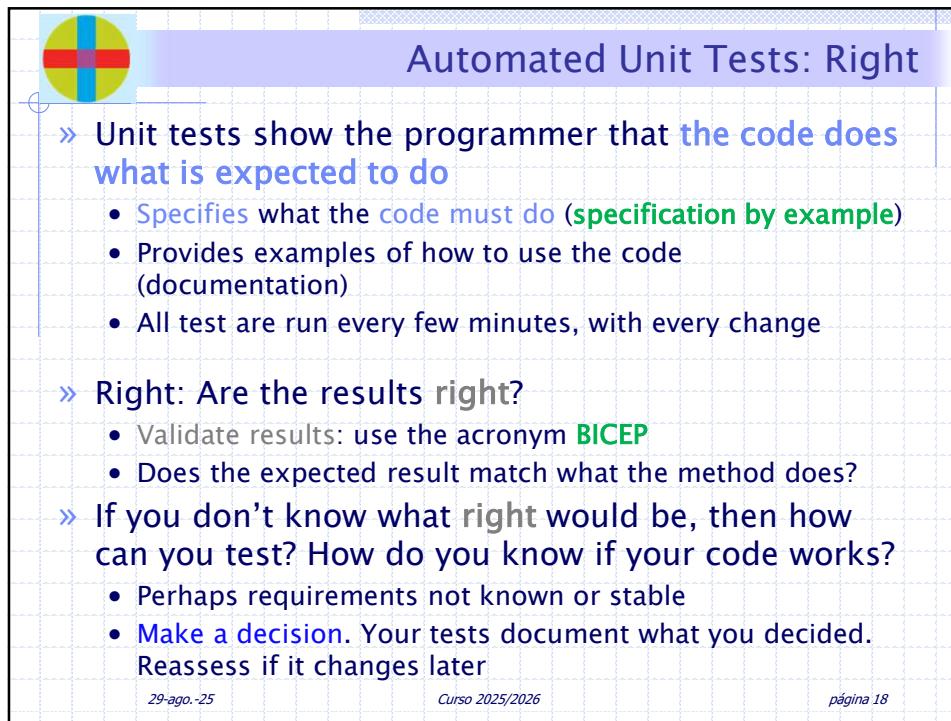


TDD Process

1. Start small or not at all (select one small piece of functionality that you know is needed and you understand)
2. Ask “what set of tests, when passed, will demonstrate the presence of code we are confident fulfills this functionality correctly?”
3. Make a **to-do list**, keep it next to the computer
 1. Lists tests that need to be written
 2. Reminds you of what needs to be done
 3. Keeps you focused
 4. When you finish an item, cross it off
 5. When you think of another test to write, add it to the list

29-agosto-25 Curso 2025/2026 página 17

17



Automated Unit Tests: Right

- » Unit tests show the programmer that **the code does what is expected to do**
 - Specifies what the code must do (**specification by example**)
 - Provides examples of how to use the code (documentation)
 - All test are run every few minutes, with every change
- » Right: Are the results **right**?
 - Validate results: use the acronym **BICEP**
 - Does the expected result match what the method does?
- » If you don't know what **right** would be, then how can you test? How do you know if your code works?
 - Perhaps requirements not known or stable
 - **Make a decision.** Your tests document what you decided. Reassess if it changes later

29-agosto-25 Curso 2025/2026 página 18

18



Right-BICEP

» **Boundary** conditions: consider

- Garbage input values
- Badly formatted data
- Empty or missing values (0, null, etc.)
- Values out of reasonable range
- Duplicates (if they're not allowed)
- Unexpected orderings

» Use this acronym, **CORRECT**, to remember:

- Conformance
- Ordering
- Range
- Reference: Does the code reference anything external outside of its control?
- Existence
- Cardinality
- Time (absolute and relative time): Are things happening in order? On time? In time?

29-agosto-25 Curso 2025/2026 página 19

19



Right-BICEP

» **Check Inverse** relationships

- If your method does something that has an inverse, then apply the inverse
 - Square and square-root
 - Insertion then deletion.
- Beware errors that are common to both your operations
 - Seek alternative means of applying inverse if possible

» **Cross-check** using other means

- Can you do something more than one way?
 - Your way, and then the other way. Match?
- Are there overall consistency factors you can check?
 - Overall agreement

29-agosto-25 Curso 2025/2026 página 20

20



Right-BICEP

- » Force Error conditions
 - Some are easy: invalid parameters, out of range values, ...
 - Others not so easy: exceptions, ...
 - Failures outside your code:
 - > Out of memory, disk full, network down, etc.
 - > Can simulate such failures
 - Example: use Mock Objects
- » Performance
 - Perhaps absolute performance, or
 - Perhaps how performance changes as input grows
 - Perhaps separate test suite in JUnit
 - But... Other, perhaps better ways to do this
 - > JUnitPerf: <https://github.com/clarkware/junitperf>

29-agosto-25 Curso 2025/2026 página 21

21



Sidenote: Mock Objects

- » Fake objects that replace real ones
- » Why use them?
 - Avoid external dependencies
 - Reduce coupling
 - Keep tests fast
 - Test object interactions
 - Promote interface based design
 - Ensure tests are durable
- » Example: Sending email?
- » Web site: <http://www.mockobjects.com>

29-agosto-25 Curso 2025/2026 página 22

22



Continuing ...

- » **Use the compiler**
 - Let it tell you about errors and omissions
 - Read carefully its warning and error messages

- » **One assertion (check/assert) per test**
 - Subject of furious debate on Yahoo's TDD group

- » **Use this four techniques**
 1. Design: Do the Simplest Thing
 2. Fake It ('Til You Make It)
 3. Triangulate
 4. Obvious Implementation

29-agosto-25 *Curso 2025/2026* *página 23*

23



Design: Do the Simplest Thing

- » **Do the simplest thing that works**
 - KISS Principle – Keep It Simple and Stupid
 - Consider the simplest thing that could possibly work
 - Simplicity is the ultimate sophistication – Leonardo Da Vinci
 - Perfection is reached not when there is nothing left to add, but when there is nothing left to take away – St. Exupéry

- » **When Coding: YAGNI – You Aint't Gonna Need It**
 - Build the simplest possible code that will pass the tests
 - Ron Jeffries: "Always implement things when you **actually** need them, never when you just **foresee** that you need them"
 - DRY Principle – Don't Repeat Yourself
 - Refactor the code to have the simplest design possible

- » **Bad smells**
 - Duplication: eliminate it → OAOO – Once And Once Only
 - SetUp / TearDown: duplicated code reveals itself as common 'initialization' code and/or as 'cleanup' code

29-agosto-25 *Curso 2025/2026* *página 24*

24



Fake It ('Til You Make It)

» What is your first implementation once you have a broken test?

- Return a constant
- Once you have a test running, gradually transform the constant into an expression using variables

» Example from **PyUnit** implementation

- First version

```
return "1 run, 0 failed"
```

- Second version

```
return "%d run, 0 failed" % self.runCount
```

- Third version

```
return "%d run, %d failed" % (self.runCount, self.failureCnt)
```

Beck

29-agosto-25 Curso 2025/2026 página 25

25



Triangulate

» How do you most conservatively drive abstraction with tests?

» Abstract only when you have two or more examples

```
import unittest

class TestClass(unittest.TestCase):
    def test_plus(self):
        self.assertEqual(4, plus(3,1))
```

Test 1

```
def plus(augend, addend):
    return 4
```

Code

```
import unittest

class TestClass(unittest.TestCase):
    def test_plus_1(self):
        self.assertEqual(4, plus(3,1))
    def test_plus_2(self):
        self.assertEqual(7, plus(3,4))
```

Test 2

29-agosto-25 Curso 2025/2026 página 26

26



Obvious Implementation

- » How do you implement simple operations?
 - Just implement them
- » *Fake It* and *Triangulation* are for taking tiny steps
- » If you know what to type, and you can do it quickly, then do it
- » Keep track of how often you are surprised by red bars using *Obvious Implementation*

Solving “clean code” at the same time that you solve “that works” can be too much to do at once. As soon as it is, go back to solving “that works”, and then “clean code” at your leisure.

Kent Beck

29-agosto-25 Curso 2025/2026 página 27

27



After the first cycle you have...

1. Made a list of tests we knew we needed to have working
2. Told a story with a snippet of code about how we wanted to view one operation
3. Made the test compile with stubs
4. Made the test run by committing horrible sins
5. Gradually generalized the working code, replacing constants with variables
6. Added items to our to-do list rather than addressing them all at once

29-agosto-25 Curso 2025/2026 página 28

28



Refactoring

- » Refactoring cannot change the semantics of the program under any circumstance
- » This is called *Observation equivalence*
 - All test that pass before refactoring must pass after it
 - Places burden on you to have enough tests to detect unintended behavioral changes due to refactoring
- » Levels of scale
 - Two **loop structures** are similar
 - › By making them identical, you can merge them
 - Two **branches of a conditional** are similar
 - › By making them identical, you can eliminate the conditional
 - Two **methods** are similar
 - › By making them identical, you can eliminate one
 - Two **classes** are similar
 - › By making them identical, you can eliminate one

29-agosto-25 Curso 2025/2026 página 29

29



Summary

- » TDD does not replace traditional testing
 - It defines a proven way that ensures effective unit testing
 - Tests are working examples of how to invoke a code
 - › Essentially provides a working specification for the code
 - No code should go into production unless it has associated tests
 - › Catch bugs before they are shipped to your customer
 - No code without tests
 - Tests determine, or dictate, the code
- » TDD isn't new
 - To quote Kent Beck: "...you type the expected output tape from a real input tape, then code until the actual results matched the expected result..."
- » TDD means less time spent in the debugger

29-agosto-25 Curso 2025/2026 página 30

30



Summary

- » TDD negates fear
 - Fear makes developers communicate less
 - Fear makes developers avoid repeatedly testing code
 - > Afraid of negative feedback
- » TDD creates a set of “programmer tests”
 - Automated tests that are written by the programmer
 - Exhaustive: can be run over and over again
- » TDD allows us to refactor, or change the implementation of a class, without the fear of breaking it
 - TDD and refactoring go hand-in-hand
- » With care, [some] User Acceptance Tests can be codified and run as part of the TDD process

29-agosto-25 Curso 2025/2026 página 31

31



Benefits of TDD

- » How can it help my project?
 - You will produce better code and designs
 - Your code will be easier to maintain when others' read it days/months/years from now
 - You will have more confidence when you code
 - It will make your life easier
- » How can I convince my...
 - ...coworkers?
 - > Just do it. They will see how well it works.
 - ...team?
 - > Just do it. When someone asks for help, help them by writing a test.
 - ...boss?
 - > Start with a small project (but not too small)
 - > Measure the results
 - > Describe the experience

29-agosto-25 Curso 2025/2026 página 32

32



Notable Quotes

"TDD is clean code that works" – Ron Jeffries

"The best way that I know to write code is to shape it from the beginning with tests" – Ron Jeffries

"The act of writing a unit test is more an act of design than of verification" – Robert C. Martin

"The code is the design" – Martin Fowler

"Test-Driven Development is a powerful way to produce well designed code with fewer defects" – Martin Fowler

29-agosto-25 Curso 2025/2026 página 33

33



Notable Quotes

"Legacy code is code without tests" – Alan Francis

"Fewer defects, less debugging, more confidence, better design, and higher productivity in my programming practice" – Kent Beck

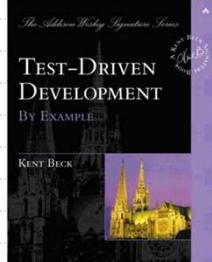
"Writing test cases before the code takes the same amount of time and effort as writing the test cases after the code, but it shortens the defect-detection-debug cycle" – Steve McConnell

"I'm trying to preserve the right for a programmer to think while he's typing. If you feel that it's not going well, you can stop and say 'What did I get wrong? Let me correct it'" – Ward Cunningham

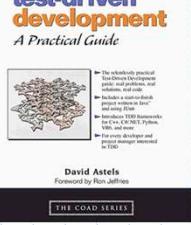
29-agosto-25 Curso 2025/2026 página 34

34

Resources (Books)



» **Test-Driven Development: By Example**
Kent Beck
Addison-Wesley, 2003
ISBN 0-321-14653-0



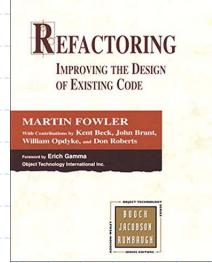
» **Test-Driven Development: A Practical Guide**
Dave Astels
Prentice-Hall/Pearson Education, 2003
ISBN 0-13-101649-0

Reviewed BUG developers' magazine,
Nov/Dec 2003

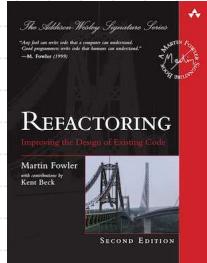
29-agosto-25 Curso 2025/2026 página 35

35

Resources (Books)



» **Refactoring: Improving the Design of Existing Code**
Martin Fowler
Addison-Wesley, 1999
ISBN 0-201-48567-2



» **Refactoring: Improving the Design of Existing Code (Second Edition)**
Martin Fowler & Kent Beck
Addison-Wesley, 2018
ISBN 0-134-75759-9

29-agosto-25 Curso 2025/2026 página 36

36



Other books

- » Percival, Harry “*Test-Driven Development with Python*” O'Reilly 2014
- » Freeman, Steve & Pryce, Nat. “*Growing Object-Oriented Software, Guided by Tests*” Addison-Wesley 2009
- » McConnell, Steve “*Code Complete 2. A Practical Handbook of Software Construction*” Microsoft Press 2004
- » Binder, R.V. “*Testing Object-Oriented Systems*” Addison-Wesley 1999

29-agosto-25 Curso 2025/2026 página 37

37



Articles

- » Beck, Kent and Gamma, Erich “*Test Infected: Programmers Love Writing Tests*”
<http://members.pingnet.ch/gamma/junit.htm>
- » Martin, Robert C. and Koss, Robert S. “*Test Driven Development of bowling scoring code*”
<http://butunclebob.com/ArticleS.UncleBob.TheBowlingGameKata>
- » Janzen, David (Simex LLC) and Saiedian, Hossein (University of Kansas) “*Test-Driven Development: Concepts, Taxonomy, and Future Direction*”, IEEE Computer Magazine (Sept, 2005)
<https://www.computer.org/csdl/mags/co/2005/09/r9043-abs.html>
<https://works.bepress.com/djanzen/6/>

29-agosto-25 Curso 2025/2026 página 38

38



Resources (web sites)

- » xUnit implementations
 - https://en.wikipedia.org/wiki/List_of_unit_testing_frameworks
 - <http://www.junit.org>
- » Relevant web sites
 - <http://www.testdriven.com>
 - <http://www.refactoring.com>
 - <http://opensourcetesting.org>
- » Mock Objects
 - <http://www.mockobjects.com>
 - <https://www.agilealliance.org/glossary/mocks>
- » testdrivendevelopment group (Yahoo)
 - <https://groups.yahoo.com/neo/groups/testdrivendevelopment>



29-agosto-25 Curso 2025/2026 página 39

39



¿Preguntas?



RED
GREEN
REFACTOR

40