# Testing

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March 14, 2016

# Overview

1. Introduction
2. Testing
   - Unit testing
   - Integration testing
   - System testing
   - Acceptance testing
3. How to...
   - Unit test
   - Automate

# Bugs

A

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How many make it through to the customer?

- 0.5-3 per KLOC.
- How do we get it so low?
  - Testing.

Bugless


*“If I write good code it won’t have bugs.”*

–Every programmer ever

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- The gold standard for perfect code belongs to.....

# Bugless


*"If I write good code it won't have bugs."*

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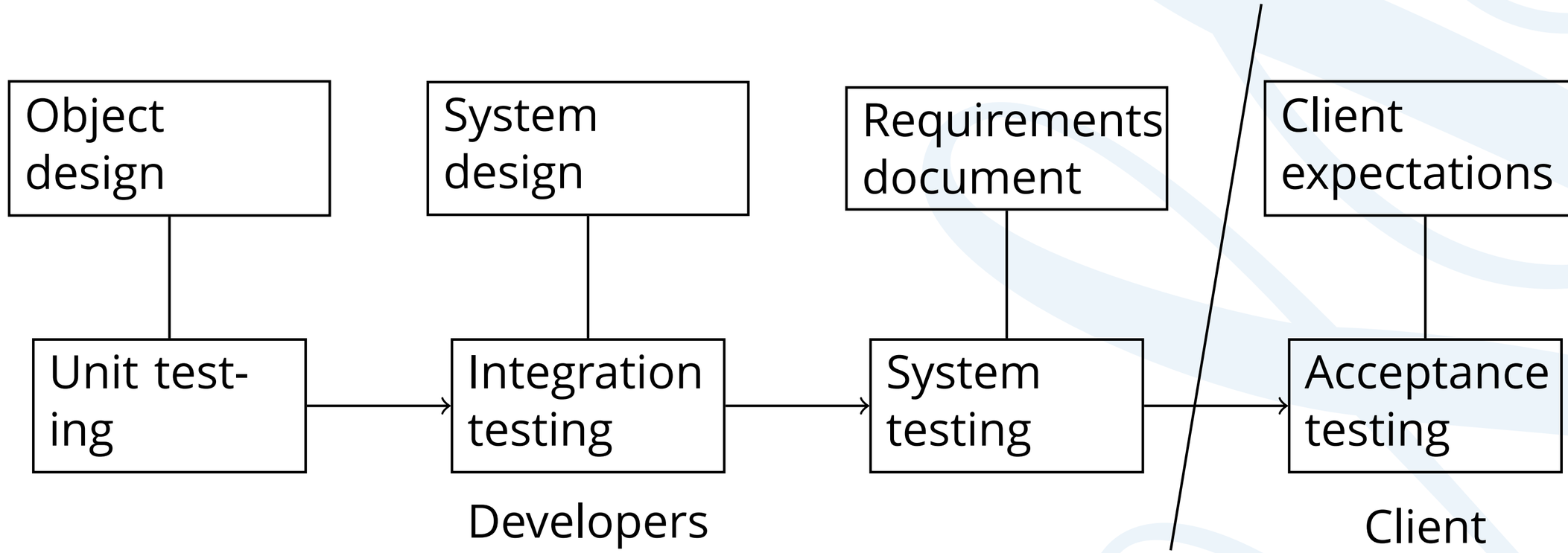
Your code will have bugs.

- The gold standard for perfect code belongs to.....The Space Shuttle.
- 420,000 lines of code.
  - Expect between 210 and 720 bugs.
- In 1996 the previous 3 versions had one known bug each.
  - 0.0024 per KLOC.

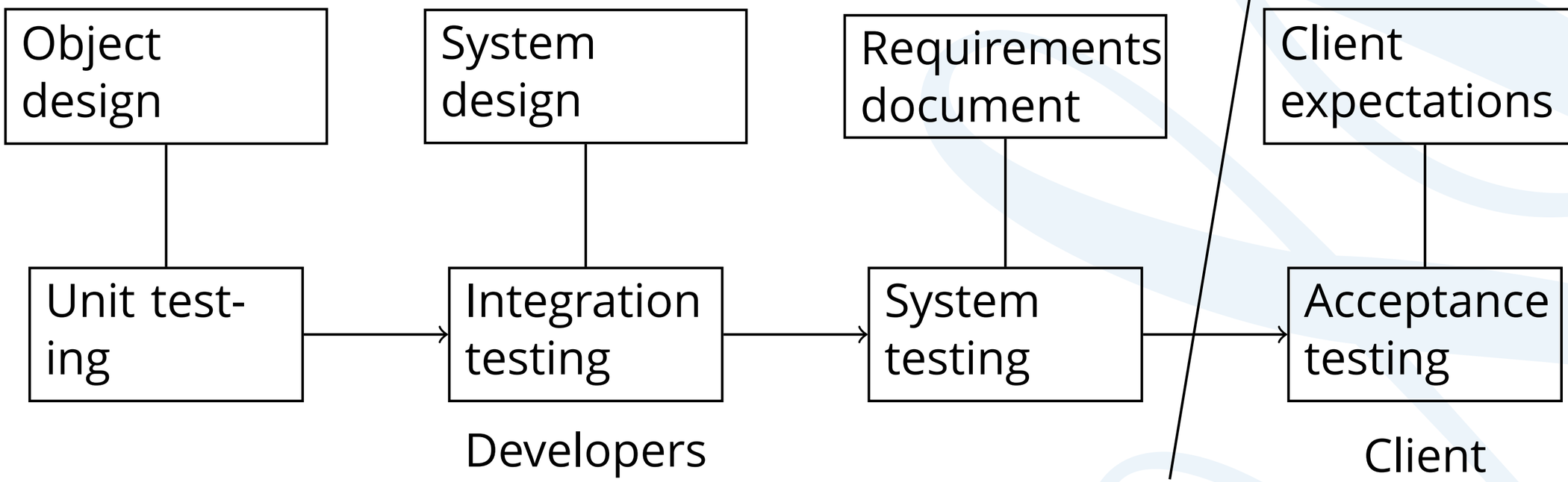
# Testing types

C



# Testing types

C




Ad-hoc
Acceptance
Accessibility
Agile
API
Automated
All Pairs
Beta
Black Box
Backward Compatibility
Boundary Value

Bottom up Integration
Branch
Compatibility
Component
Condition Coverage
Dynamic
Decision Coverage
End-to-end
Exploratory
Equivalence Partitioning
Functional

GUI
Glass box
Gorilla
Happy path
Integration
Interface
Internationalization
Keyword-driven
Load
Localization
Negative

Pair
Performance
Penetration
Regression
Risk based
Smoke
Security
Sanity
Scalability
Stability
Static

System
Soak
System Integration
Unit
Usability
User Acceptance
Volume
Vulnerability
White box

# More than bugfixing

C

Testing is not just about code.

- Testing expectations, documentation.
- Testing assumptions.

Absence of evidence is not evidence of absence.

- Just because you can't find the bugs doesn't mean they aren't there.

Formal verification is the exception.

- Mathematically proof of correctness.
- Mathematical model of an algorithms.
- Can still mess up the code.

# Testing

C

Once you've written your code, what is the most important step?

- Testing happens continuously during development.
  - Code compiles/runs/works?

# Testing

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Once you've written your code, what is the most important step?

- Testing happens continuously during development.
  - Code compiles/runs/works?
- Important to do formal testing
  - Just checking it runs as you code is not enough.
  - Make sure you've not missed anything
  - In depth, comprehensive testing.
- Extra attention to edge cases.
  - I.e. if code expects number between 0 and 100 make sure to test -1, 0, 1, 99, 100 and 101.
- Every return path.
  - I.e. every if-else.

# Unit testing


Test each individual 'unit' of your program.

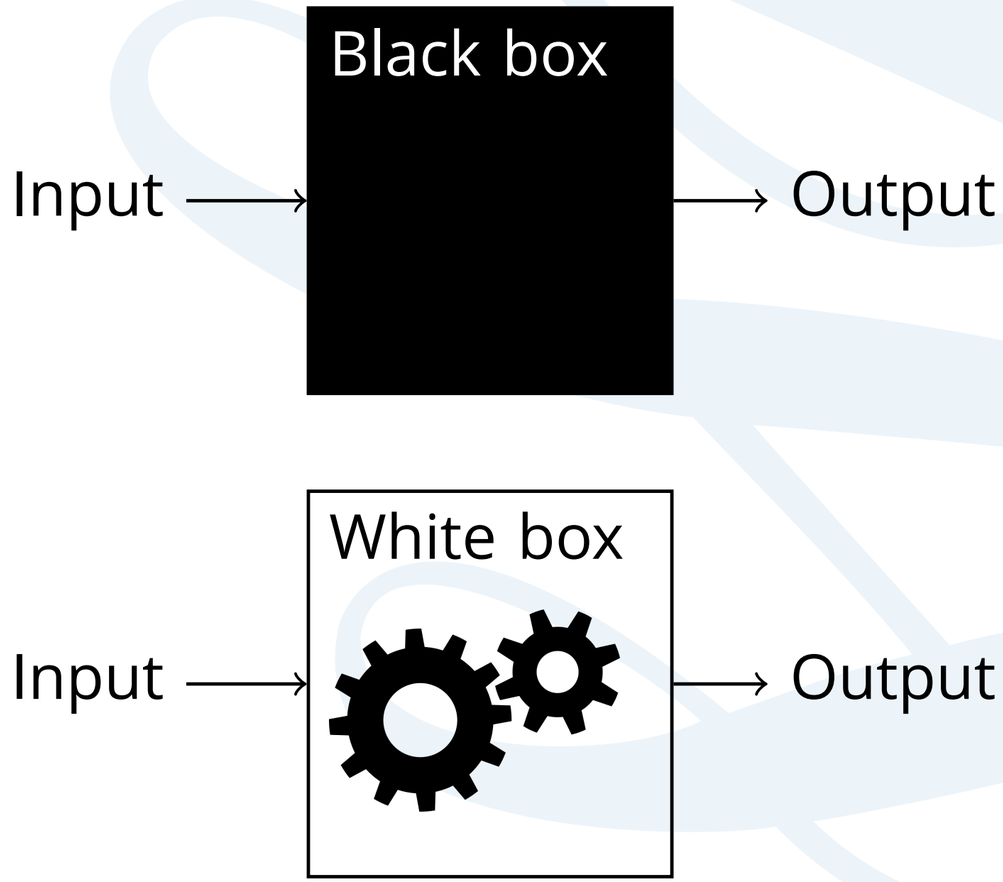
- Python/C++ lets you break your code into modules
  - import/include modules
- Test each module separately
  - Everything module can do
  - Works correctly.
  - Fails correctly.
- Can be white or black box.
  - White box - know/care how module works inside.
  - Black box - don't know/care how module works inside.
- Version control is great help here.
  - Multiple programmers working on separate units.
  - Commit code only if it passes unit testing.

# Black box White box

C

## Black and white box testing

- Black box.
  - Don’t see/know what’s going on inside.
  - Just supply inputs, test outputs.
- White box.
  - Do see/know what’s going on inside.
  - Test internal states/variables.



# Integration testing


Test how multiple modules/units work together when combined.

- Individual modules treated as black boxes.
  - Don’t care how they work.
  - Just care what they do.
- Make sure everyone is following agreed interfaces.
  - Function names/parameters etc.
  - Behaviour hasn’t changed.
- Continuous integration.
  - Bring together everyone’s latest code several times a day.

# System testing

Test system meets the specifications.

- Test the whole system works together.
- Black box testing.

- Ideally done by someone other than the developer/s.

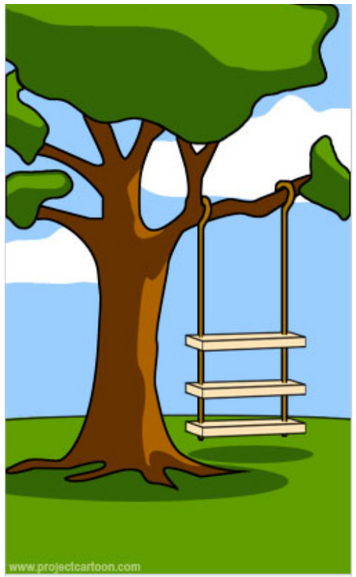
# Acceptance testing



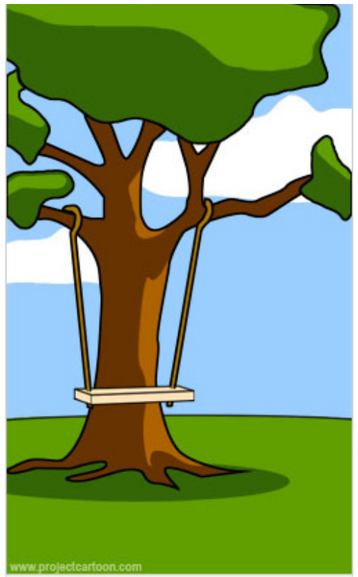
Not testing code directly.

- Testing expectations.
- Does the whole thing work as expected?
  - Were specifications correct?
  - Were specifications complete?

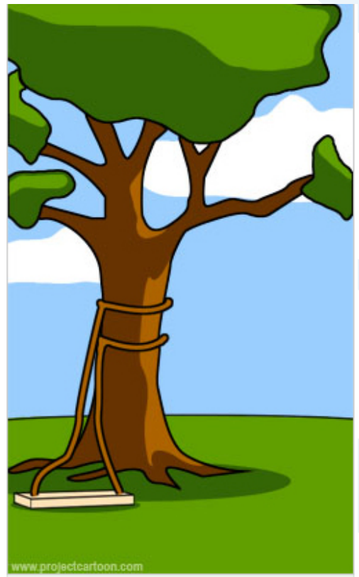
# Expectations



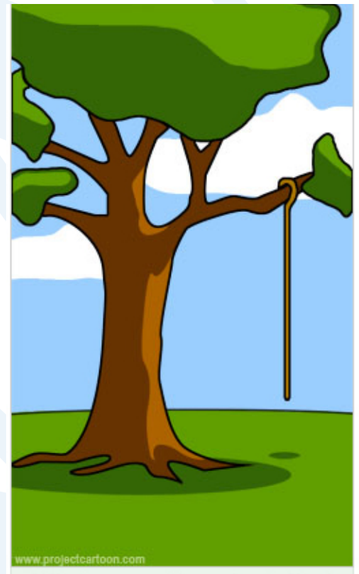

How the customer explained it



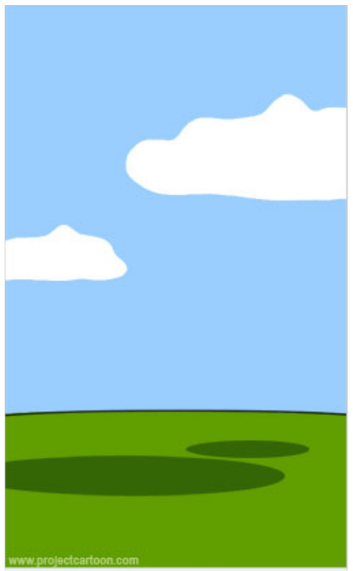

How the project leader understood it



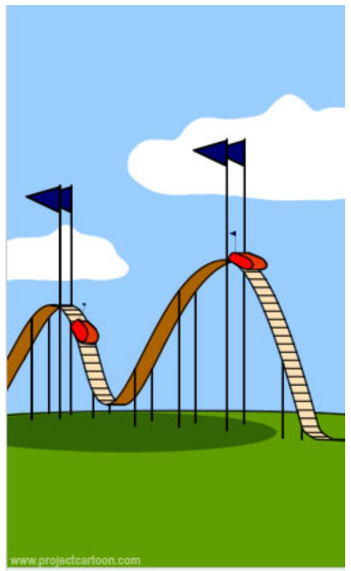

How the programmer wrote it




What operations installed




How the project was documented




How the customer was billed


What marketing advertised


What the customer really needed

# How to Unit test your Dragon I


Just looking at unit testing in 122COM.

Good unit testing is very time consuming.

- Should be testing before committing any changes.

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  - Bored? unit test

Why bother??

- Debugging is simpler, know where bugs are.
- Bugs stay dead (or detected).
  - Spot new bugs.
  - Every 3 bugs solved creates 1 new one (Glenford Myers - Art of Software Testing).

# How to Unit test your Dragon II



Basic unit testing.

- Grab your spreadsheet.
- Example - testing your stack code from data structures week.

| ID | Description | Test | Expected | Success | Why |
|---|---|---|---|---|---|
| 1a | Push to empty stack | .push('A') | .size() =1, .top() = 'A' | Pass | |
| 1b | Push to full stack | .push('Z') | StackFull exception | Pass | |
| 1c | Push to !full !empty stack | .push('Q') | .size() += 1, .top() = 'Q' | Pass | |
| 2a | Pop from empty stack | .pop() | StackEmpty exception | Fail | No exception raised |
| 2b | Pop from full stack | .pop() | .size() -= 1, .top() = element at .size()-1 | Pass | |
| 2c | Pop from !full !empty stack | .pop() | .size() -= 1, .top() = element at .size()-1 | Pass | |


I don't wanna

Running unit tests manually is a massive time sink.

- Solution?

# I don't wanna


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- Solution?

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Running unit tests manually is a massive time sink.

- Solution?
  - Automate our testing.
  - Write code to test our code.

# Automated unit testing


Already encountered this idea in this module.

- C++ intro, searching, pointers, data structures and sorting labs.
  - Had code to automatically test your code

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Advantages.

- Fully tested your code.
  - Every time.
- Quickly tested your code

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  - Every time.
- Quickly tested your code

Disadvantages.

- Messy, confusing testing code.
- Results not clear.

# Automated unit testing libraries

C

Solution?

- Unit testing libraries.
- Available for every significant language I can think of.
  - Multiple libraries per language.
- Same concept
  - Write small test functions.
  - Run them all.
  - Report what failed and summary.

# Python testing


Using unittest module.

- Built in.

- Test ways things are correct.
- Test that things go wrong.
  - Test for expected exceptions.

```
import unittest

class Tests(unittest.TestCase):
  def test_bigger(self):
    self.assertTrue( 1 < 0 )

  def test_equals(self):
    self.assertEqual( 1+1, 2 )

  def test_div(self):
    with self.assertRaises(ZeroDivisionError):
      1 / 0

if __name__ == '__main__':
  unittest.main()
```

lec_unittest.py

# Python testing results

```
F..
======================================================================
FAIL: test_bigger (__main__.Tests)
----------------------------------------------------------------------
Traceback (most recent call last):
  File "lec_unittest.py", line 5, in test_bigger
    self.assertTrue( 1 < 0 )
AssertionError: False is not true

----------------------------------------------------------------------
Ran 3 tests in 0.000s

FAILED (failures=1)
```

# C++ testing



Using cxxtest.

- Very similar to Python unittest.
- Slightly more complicated to run.
- Header file, .h file.

```
#include <cxxtest/TestSuite.h>

class SomeTests : public CxxTest::TestSuite
{
public:
  void test_bigger()
  {  TS_ASSERT( 1 < 0 );
  }

  void test_equals()
  {  TS_ASSERT_EQUALS( 1+1, 2 );
  }

  void test_except()
  {  TS_ASSERT_THROWS_ANYTHING( throw 1 );
  }
};
```

lec_unittest.h

# C++ testing results

```
Running cxxtest tests (3 tests)
In SomeTests::test_bigger:
lec_unittest.h:8: Error: Assertion failed: 1 < 0
..
Failed 1 and Skipped 0 of 3 tests
Success rate: 66%
```

# Running the tests

## Python

- Just run it.

```
>> python3 -m unittest TESTCASES.py
```

If you have `unittest.main()`

```
>> python3 TESTCASES.py
```

## C++

- Generate a ‘runner’ that will actually run the tests.

```
>> cxxtestgen --error-printer TESTCASES.h -o runner.cpp
```

- Compile the runner.

```
>> g++ --std=c++11 runner.cpp -o runner
```

- Run the runner.

```
>> ./runner
```

# putUp, tearDown

Running multiple tests.

- Will have lots of commonalities.
- Each test run on fresh structure.
  - I.e. testing stack/queue
- Have to create/clean up structure for every test.
  - Is hassle.
- Built in feature to do it for you.
  - `setUp()`
  - `tearDown()`

# putUp, tearDown II

```
from lab_stack import *
import unittest

class StackTest(unittest.TestCase):
    def setUp(self):
        self.testvalues = 'abcde'
        self.s = Stack( len(self.testvalues) )

    def tearDown(self):
        pass

    def test_size(self):
        """ test that stack reports the correct number of things
↪    on the stack """
```

# Advanced tricks

A

Can be integrated into projects in many ways.

- Build scripts - every time you compile, tests run automatically.
- Commit tests - every time you try and commit a new version, tests run automatically.
- Reports - automatically generate reports on current bugs, track progress.

# Quiz

# Recap

- Unit test - test individual ‘units’ of code.
  - Functions, classes etc.
- Integration test
  - Test multiple units work correctly when combined.
- System test.
  - Test the whole thing matches what the user said they wanted.
- Acceptance test.
  - User/s test what they said they wanted is what they actually wanted.
- Automated unit testing.
  - What is it?
  - Why do it?
  - How to do it.

# The End