Unit Testing For Data Scientists

Hanna Torrence

Data Scientist

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1. **Getting Started with Unit Tests**
2. Pytest
3. Fixtures
4. Mocks
5. Helpful Libraries
6. Resources

Testing Terms You May Have Heard

Unit test

Test of a single unit of code in isolation

Integration test

Test how different components of a system work together

Regression test

Testing a previously working program after a change to ensure no problems have been introduced

Smoke test

A subset of test cases verifying the core of a system

Alpha test

In-house test of final functionality of an application

Beta test

Initial release to a subset of real users

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Benefits of Unit Testing

Well-tested code helps you:

- Find bugs earlier
- Iterate faster
- Debug more easily
- Design better code

Benefits of Unit Testing

Confidence that your code does what you think it does

So why doesn’t everyone write unit tests?

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Learning to write good tests is an investment…

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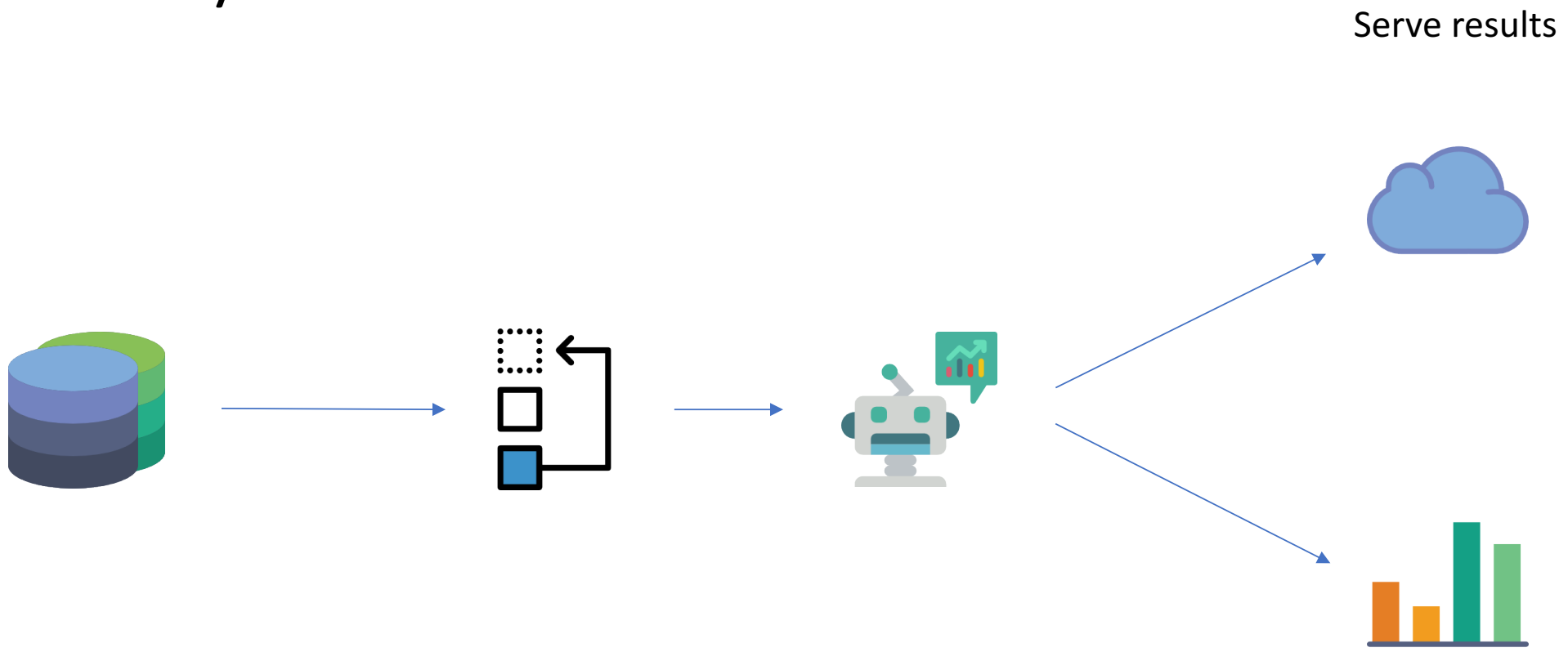
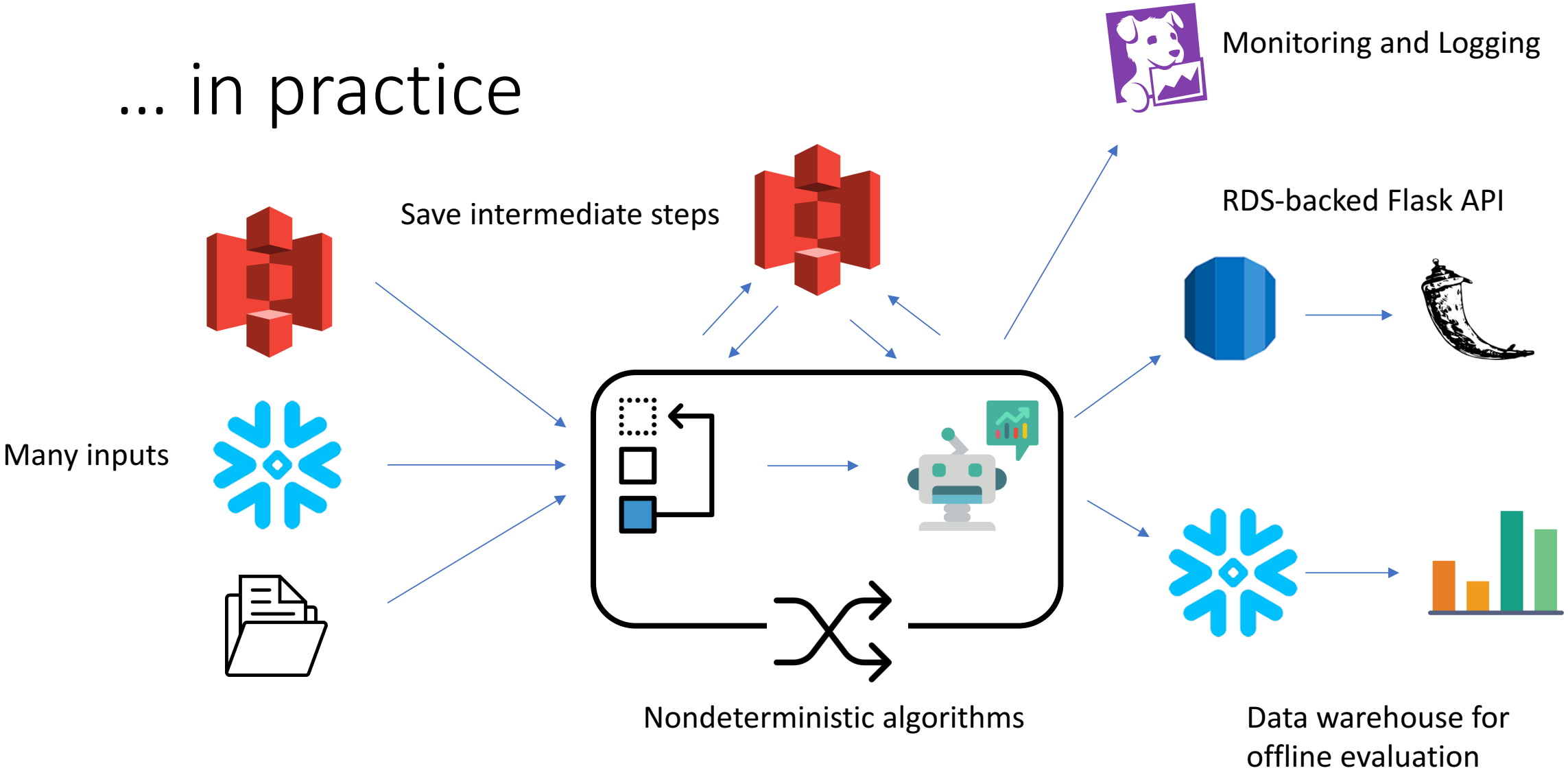
… and data science work follows different patterns that much of software engineering

In theory…


Serve results
Read in data
Build features
Build a model
Evaluate offline

… in practice


Monitoring and Logging
Save intermediate steps
RDS-backed Flask API
Many inputs
Nondeterministic algorithms
Data warehouse for offline evaluation

This quickly gets overwhelming

Where to start?

- Pick a single, specific functionality to verify

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- Pick a single, specific functionality to verify
- Use available tools to get everything else out of the way
- In an existing codebase, don’t try to write all the tests at once
- Write tests as early as they can be valuable

1. Getting Started with Unit Tests
2. **Pytest**
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Pytest Framework

highly configurable + very little boilerplate

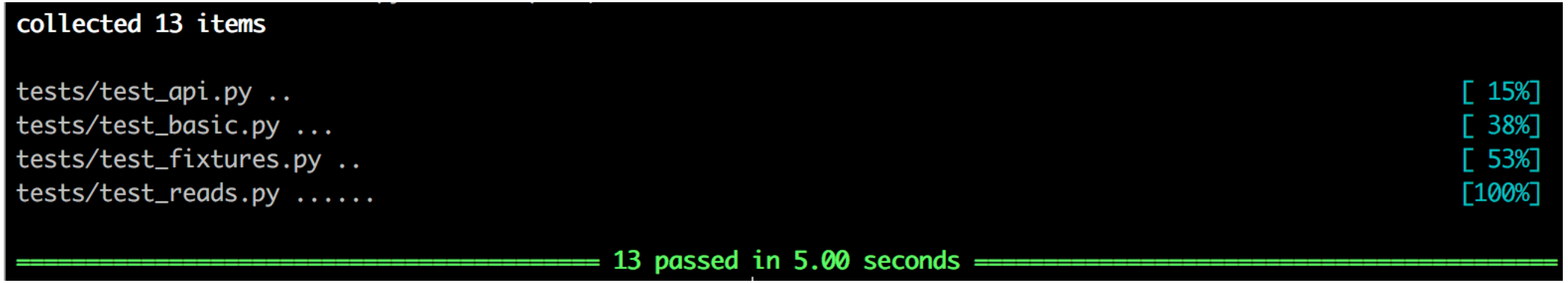
```
collected 13 items

tests/test_api.py ..                                                    [ 15%]
tests/test_basic.py ...                                                 [ 38%]
tests/test_fixtures.py ..                                               [ 53%]
tests/test_reads.py ......                                              [100%]

========================================== 13 passed in 5.00 seconds ==========================================
```

Useful Options for Pytest

-s (print all string output)
-v (print names of individual tests as they run)
-x (stop at first failure)
-k (only run tests matching following keywords)



Add a Column

```
def add_col(df, new_col_name, default_value):
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    df[new_col_name] = default_value

    return df
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Unit Test

```python
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```

```python
def test_add_col_passes():
    # setup
    df = pd.DataFrame({
        'col_a': ['a', 'a', 'a'],
        'col_b': ['b', 'b', 'b'],
        'col_c': ['c', 'c', 'c'],
    })

    # call function
    actual = add_col(df, 'col_d', 'd')

    # set expectations
    expected = pd.DataFrame({
        'col_a': ['a', 'a', 'a'],
        'col_b': ['b', 'b', 'b'],
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    # assertion
    pd.testing.assert_frame_equal(actual, expected)
```
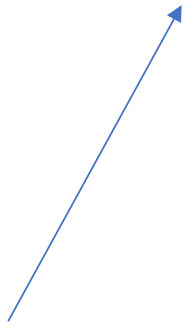

Unit Test



give our test a meaningful name starting with `test_`

```python
def test_add_col_passes():
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define the input to the function we're testing

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```

call the function we're testing →

Unit Test

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define the output we are expecting

Unit Test

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check that the actual output matches the output we were expecting

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2. Pytest
3. **Fixtures**
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Fixtures

- Special functions pytest keeps track of to safely share resources and/or resource definitions

- A modular approach to setup & teardown methods

Defining New Fixtures

```
@pytest.fixture()
def df():
    return pd.DataFrame({
        'col_a': ['a', 'a', 'a'],
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```

```
@pytest.fixture()
def df_with_col_d():
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    })
```

decorator tells pytest this is a fixture

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def df_with_col_d():
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```

normal python function

Defining New Fixtures

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```

Remember to import fixtures into `conftest.py` file!

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    })
```

```python
def test_add_col_passes_with_fixtures(df, df_with_col_d):
    actual = add_col(df, 'col_d', 'd')
    expected = df_with_col_d

    pd.testing.assert_frame_equal(actual, expected)
```

Defining New Fixtures

pytest passes in value returned from `df` function

```
@pytest.fixture()
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pytest passes in value returned from `df_with_col_d` function

```python
def test_add_col_passes_with_fixtures(df, df_with_col_d):
    actual = add_col(df, 'col_d', 'd')
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```

Useful Built-in Fixtures

`capsys` captures any values written to `stderr` or `stdout` during the execution of the test

To see all available fixtures, run:

```
pytest --fixtures
```

```
def test_function_1(capsys):
    function_1()
    out, err = capsys.readouterr()
    assert out == 'Inside function 1\n'
```

Flexibility of Fixtures

You can:

- Define the scope of a fixture
- Compose fixtures
- Execute custom teardown code when leaving scope
- Access the test context inside fixture
- Parameterize fixtures

Flexibility of Fixtures

```
@pytest.fixture(scope='session')
def spark(request):
    spark = (
        SparkSession
        .builder
        .appName('pytest-pyspark-local-testing')
        .master('local[2]')
        .getOrCreate()
    )

    request.addfinalizer(lambda: spark.stop())

    return spark
```

Flexibility of Fixtures

define fixture scope

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@pytest.fixture(scope='session')
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access test context with `request` argument

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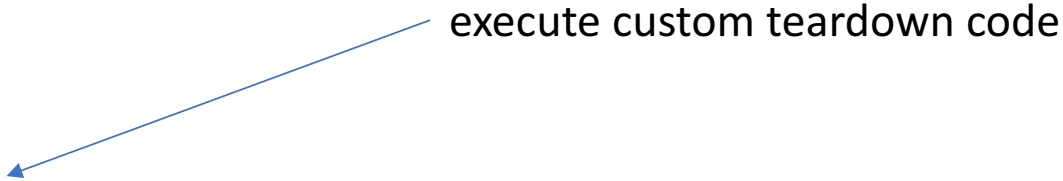

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        .master('local[2]')
        .getOrCreate()
    )

    request.addfinalizer(lambda: spark.stop())

    return spark
```

define a new fixture that depends on the first


```python
@pytest.fixture()
def spark_df(spark):
    return spark.createDataFrame(
        [
            ('a', 'b', 'c', 'd'),
            ('a', 'b', 'c', 'd')
        ],
        ['col_a', 'col_b', 'col_c', 'col_d']
    )
```

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Reading from a Database

```
def generate_features(db_creds):

    #  ... some setup code ...

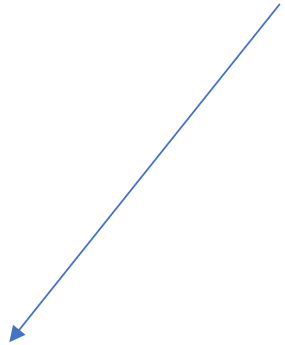
    eng = sqlalchemy.create_engine('fake_connection_string')
    df = pd.read_sql('SELECT col1, col2 FROM data_table;',con=eng)

    #  ... processing on df ...

    return features
```

Reading from a Database

Replace connection with a dummy object



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    #  ... processing on df ...

    return features
```

Return some fake data into df

Test with Mock

```python
@mock.patch('pytest_examples.functions_to_test.sqlalchemy.create_engine')
@mock.patch('pytest_examples.functions_to_test.pd.read_sql')
def test_generate_features(read_sql_mock, engine_mock, db_creds, df):
    read_sql_mock.return_value = df

    actual_features = generate_features(db_creds)

    pd.testing.assert_frame_equal(actual_features, df)
```

```python
def generate_features(db_creds):

    #  ... some setup code ...

    eng = sqlalchemy.create_engine('fake_connection_string')
    df = pd.read_sql('SELECT col1, col2 FROM data_table;',con=eng)

    #  ... processing on df ...

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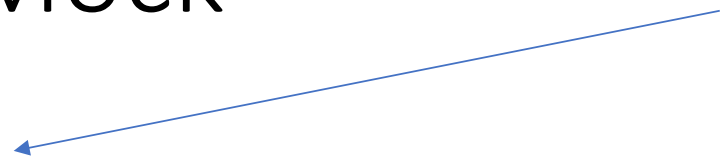
```

Test with Mock

patch things we want to cut out with Mock objects



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Test with Mock

patch things we want to cut out with Mock objects

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@mock.patch('pytest_examples.functions_to_test.sqlalchemy.create_engine')
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    read_sql_mock.return_value = df

    actual_features = generate_features(db_creds)

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```

set return value

```
def generate_featur

    #  ... some setup code ...

    eng = sqlalchemy.create_engine('fake_connection_string')
    df = pd.read_sql('SELECT col1, col2 FROM data_table;',con=eng)

    #  ... processing on df ...

    return features
```

Mocks

Replacing an object with a “mock” allows you to avoid external dependencies

Things you might want to mock:

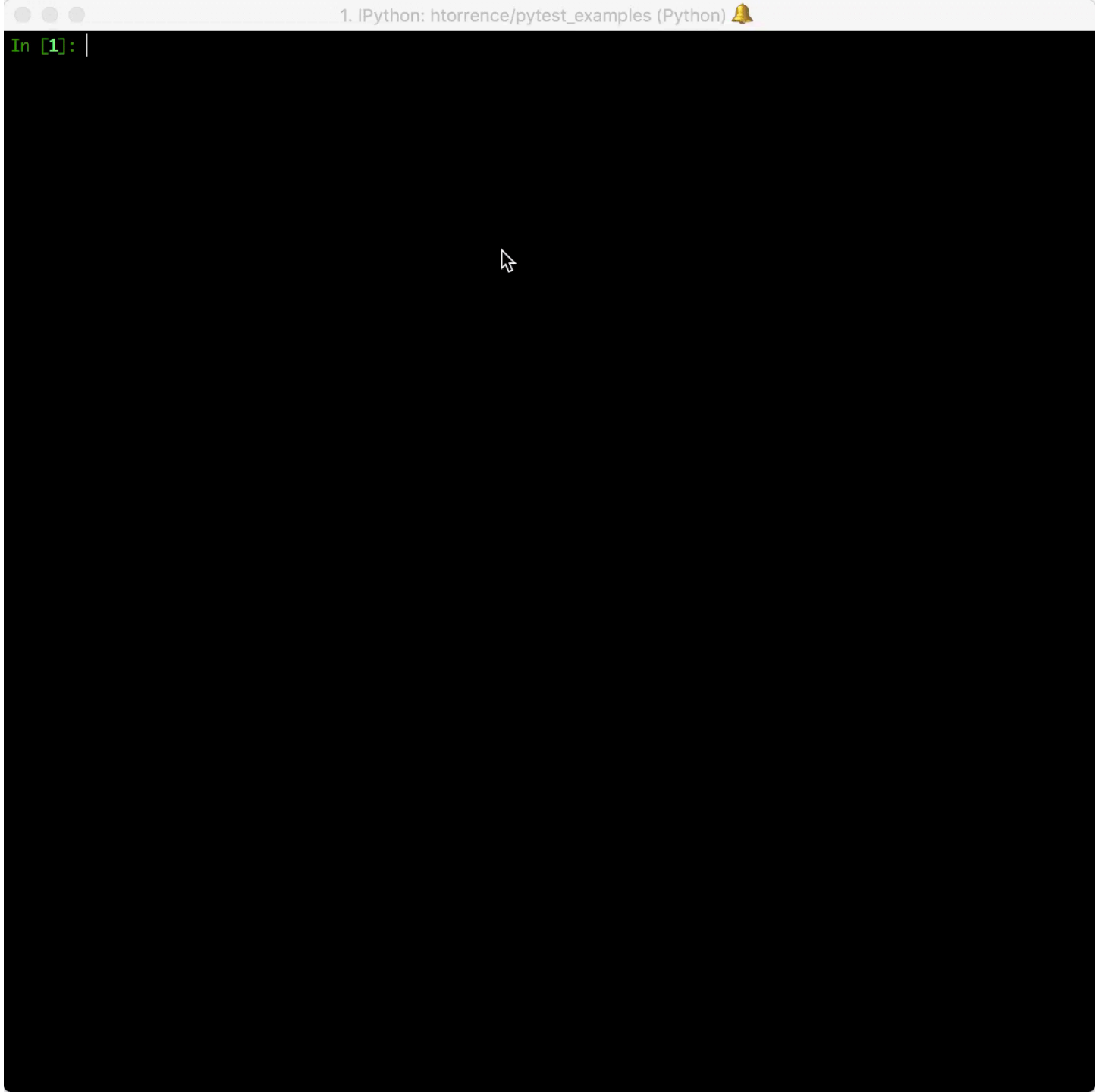
- Data reads or writes
- API calls
- External functions you don’t want to test

Mocks

Python's `unittest.mock` module uses MagicMock objects

Their behavior can be altered in many ways, but by default they:

- accept any call and any attribute access
- return a new MagicMock object for all call return values and all accessed attributes
- record all calls made to them


1. IPython: htorrence/pytest_examples (Python)
In [1]:

Mocks

Actions taken by mock object:

To return the same value for each call

```
mock_obj.return_value = object_to_return
```

To return different values for each call

```
mock_obj.side_effect = [first_object, second_object]
```

To throw an exception

```
mock_obj.side_effect = Exception()
```

To return different values depending on input

```
mock_obj.side_effect = lambda x: 'odd' if x%2 else 'even'
```

Mocks

Assertions on mock objects:

Called at least one time

```
mock_obj.assert_called()
```

Called exactly one time

```
mock_obj.assert_called_once()
```

Last called with certain arguments

```
mock_obj.assert_called_with(arg1, arg2)
```

Called a several times with certain arguments

```
assert mock_obj.call_args_list == [mock.call(arg1, arg2)]
```

Mocks

Be wary of assertion typos!

Throws an exception if the mock object was not called:

```
mock_obj.assert_called_once()
```

Never throws an exception:

```
mock_obj.called_once()  # does not exist!
```

However, nonexistent methods starting with `assert` do throw an exception:

```
mock_obj.assert_caled()  # typo
```

Gotchas for Mocks

Mock an object where it is used, not where it is defined

```
@mock.patch('pytest_examples.functions_to_test.pd.read_csv')
```

```
@mock.patch('pandas.read_csv')
```

Gotchas for Mocks

Mock an object where it is used, not where it is defined

```
@mock.patch('pytest_examples.functions_to_test.pd.read_csv')
```

```
@mock.patch('pandas.read_csv')
```

Pay attention to decorator order

```
@mock.patch('pytest_examples.functions_to_test.function_1')
@mock.patch('pytest_examples.functions_to_test.function_2')
@mock.patch('pytest_examples.functions_to_test.function_3')
def test_multiple_mocks(function_3_mock, function_2_mock, function_1_mock, df):
```

Gotchas for Mocks

Mock an object where it is used, not where it is defined

```
@mock.patch('pytest_examples.functions_to_test.pd.read_csv')
```

```
@mock.patch('pandas.read_csv')
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Pay attention to decorator order

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@mock.patch('pytest_examples.functions_to_test.function_1')
@mock.patch('pytest_examples.functions_to_test.function_2')
@mock.patch('pytest_examples.functions_to_test.function_3')
def test_multiple_mocks(function_3_mock, function_2_mock, function_1_mock, df):

test_multiple_mocks()
```

Gotchas for Mocks

Mock an object where it is used, not where it is defined

```
@mock.patch('pytest_examples.functions_to_test.pd.read_csv')
```

```
@mock.patch('pandas.read_csv')
```

Pay attention to decorator order

```
@mock.patch('pytest_examples.functions_to_test.function_1')
@mock.patch('pytest_examples.functions_to_test.function_2')
@mock.patch('pytest_examples.functions_to_test.function_3')
def test_multiple_mocks(function_3_mock, function_2_mock, function_1_mock, df):

patch_3(test_multiple_mocks())
```

Gotchas for Mocks

Mock an object where it is used, not where it is defined

```
@mock.patch('pytest_examples.functions_to_test.pd.read_csv')
```

```
@mock.patch('pandas.read_csv')
```

Pay attention to decorator order

```
@mock.patch('pytest_examples.functions_to_test.function_1')
@mock.patch('pytest_examples.functions_to_test.function_2')
@mock.patch('pytest_examples.functions_to_test.function_3')
def test_multiple_mocks(function_3_mock, function_2_mock, function_1_mock, df):
```

```
patch_2(patch_3(test_multiple_mocks()))
```

Gotchas for Mocks

Mock an object where it is used, not where it is defined

```
@mock.patch('pytest_examples.functions_to_test.pd.read_csv')
```

```
@mock.patch('pandas.read_csv')
```

Pay attention to decorator order

```
@mock.patch('pytest_examples.functions_to_test.function_1')
@mock.patch('pytest_examples.functions_to_test.function_2')
@mock.patch('pytest_examples.functions_to_test.function_3')
def test_multiple_mocks(function_3_mock, function_2_mock, function_1_mock, df):
```

```
patch_1(patch_2(patch_3(test_multiple_mocks())))
```

1. Getting Started with Unit Tests
2. Pytest
3. Fixtures
4. Mocks
5. **Helpful Libraries**
6. Resources

Helpful Libraries

- Responses
  - Provides `@responses.activate` decorator
  - Add API responses with

```
@responses.activate
def test_cat_api_404():
    responses.add(
        responses.GET,
        'https://cat.reactjsgirls.com/cats',
        json={'whoops, there are no cats!'},
        status=404,
    )
```

Helpful Libraries

- Responses
- Click CliRunner
  - Test command line interface tools built with Click

```
runner = CliRunner()
result = runner.invoke(
    configure,
    input=( )
)
assert result.output == expected_stdout
```

Helpful Libraries

- Responses
- Click CliRunner
- Pandas.testing
  - Testing utilities for pandas dataframes
  - `pd.testing.assert_frame_equal(df1, df2)`

Helpful Libraries

- Responses
- Click CliRunner
- Pandas.testing
- Numpy.testing
  - Testing utilities for numpy arrays
  - `np.testing.assert_almost_equal(arr1, arr2)`

Helpful Libraries

- Responses
- Click CliRunner
- Pandas.testing
- Numpy.testing
- Pytest-cov
  - Plugin for pytest to assess code coverage

Helpful Libraries

- Responses
- Click CliRunner
- Pandas.testing
- Numpy.testing
- Pytest-cov

- For specialized tools, check if someone has written testing helpers

Helpful Libraries

- Responses
- Click CliRunner
- Pandas.testing
- Numpy.testing
- Pytest-cov

- For specialized tools, check if someone has written testing helpers
- If not, write your own!

1. Getting Started with Unit Tests
2. Pytest
3. Fixtures
4. Mocks
5. Helpful Libraries
6. **Resources**

Useful Blog Posts

Getting Started With Pytest *Jacob Kaplan-Moss*

Surrender Python Mocking! I Have You Now *Matt Pease*

Python Mocking 101: Fake It Before You Make It *Mike Lin*

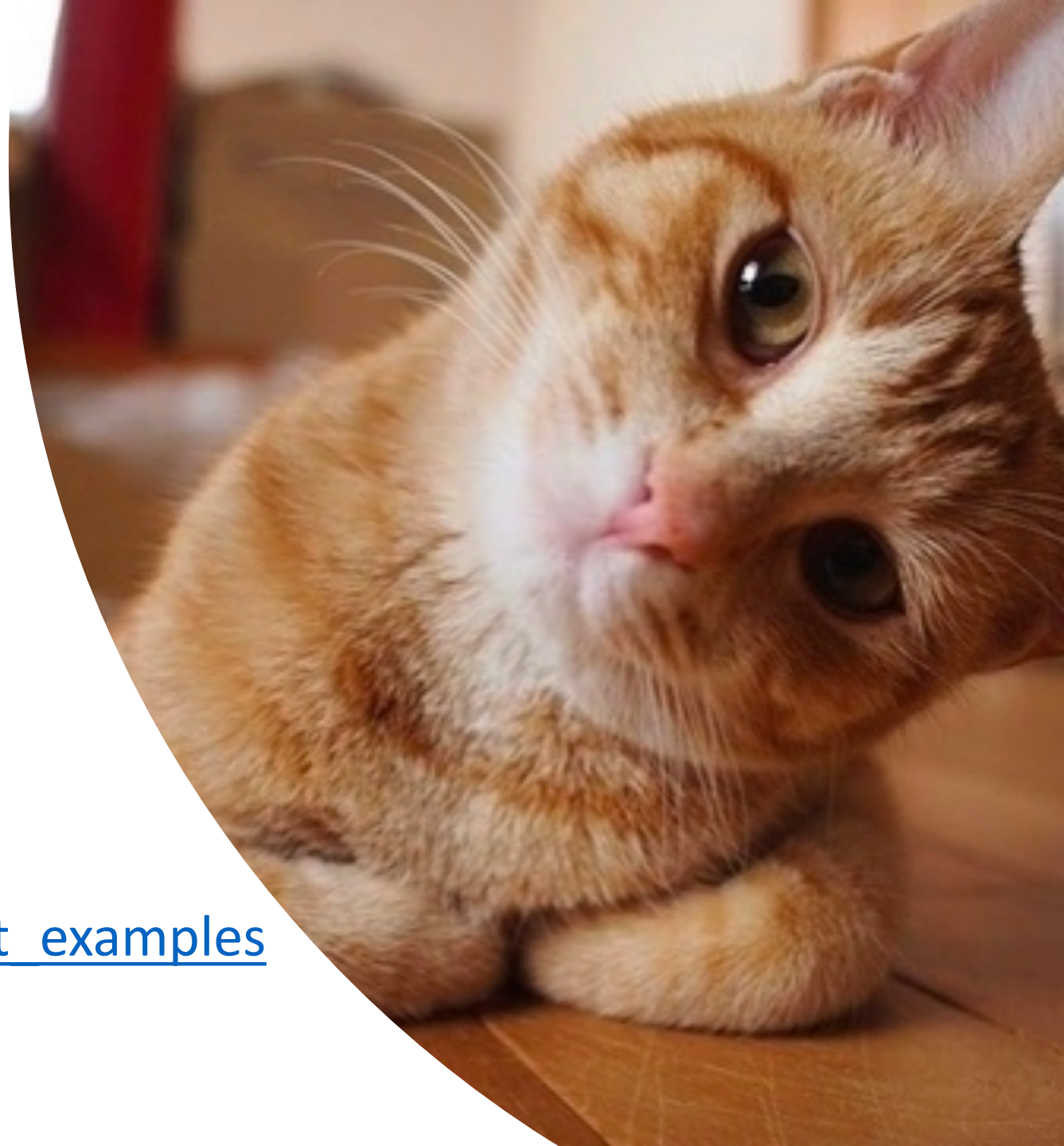
Full reading list in a gist at:

bit.ly/pytest_reading

Questions?

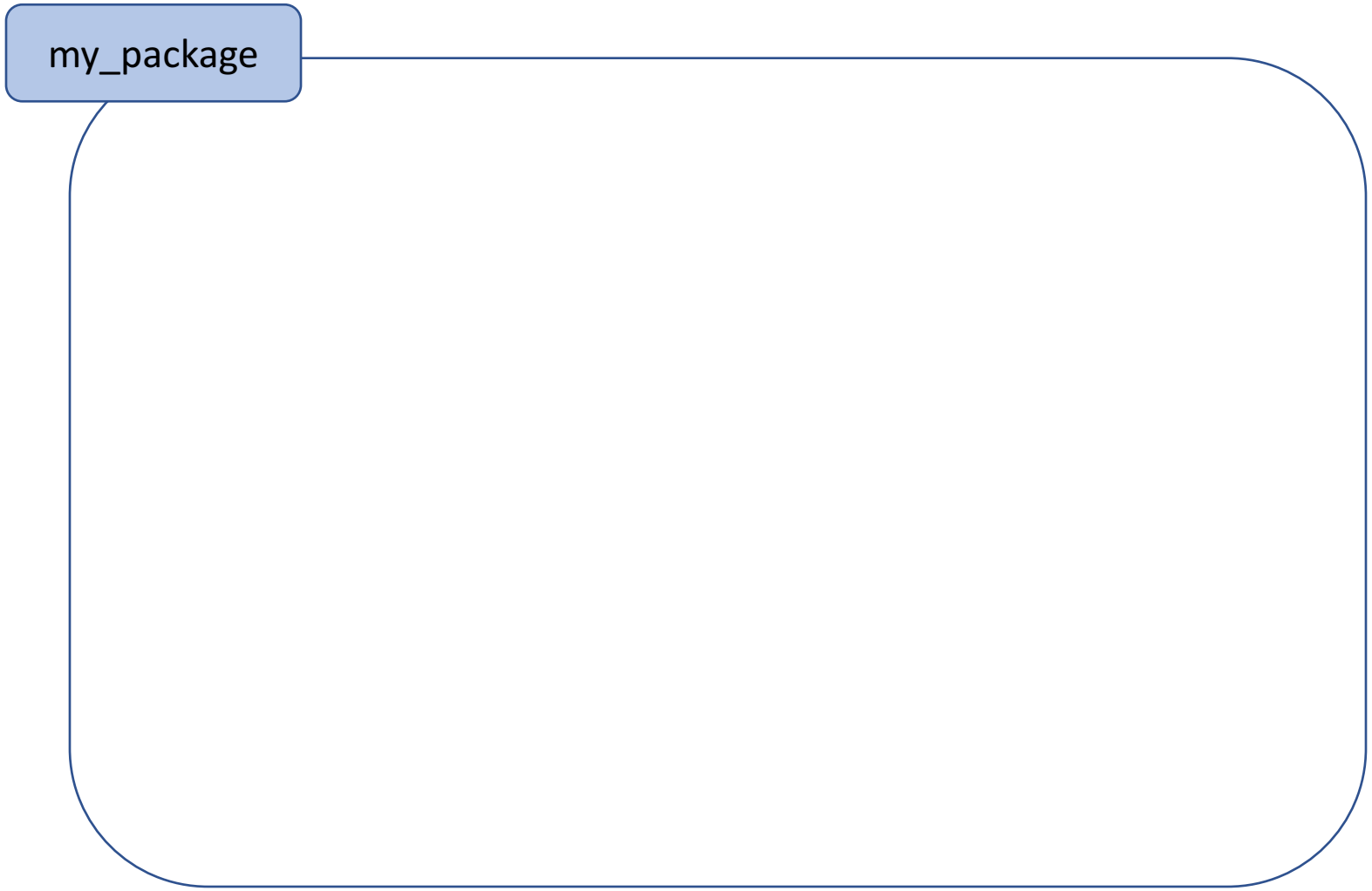
@HannaTorrence
htorrence@shoprunner.com

Extended Code Examples:
https://github.com/htorrence/pytest_examples



Appendix

Imports



Imports

my_package

functions_to_test.py

```
5    import pandas as pd

19   def df_from_csv(filename):
20       """Return a dataframe read from a csv"""
21       return pd.read_csv(filename)
22
```

Imports

my_package

functions_to_test.py

1. Go find pandas module
2. Add module to namespace as `my_package.functions_to_test.pd`

```
5    import pandas as pd


19   def df_from_csv(filename):
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21       return pd.read_csv(filename)
22
```

Imports

my_package

functions_to_test.py

1. Go find pandas module
2. Add module to namespace as `my_package.functions_to_test.pd`

```
5    import pandas as pd

19   def df_from_csv(filename):
20       """Return a dataframe read from a csv"""
21       return pd.read_csv(filename)
22
```

Call `my_package.functions_to_test.pd.read_csv`

Imports

Replace `my_package.functions_to_test.pd.read_csv` with a mock object

my_package

test_functions_to_test.py

```
13    @pytest.mark.usefixtures('df')
14    @mock.patch('pytest_examples.functions_to_test.pd.read_csv')
15    def test_df_from_csv_mock_function(read_csv_mock, df):
16        # setup
17        read_csv_mock.return_value = df
18
19        # call function
20        actual = df_from_csv('fake_file_name.csv')
```

With Mocking

my_package

functions_to_test.py

1. Go find pandas module
2. Add module to namespace as `my_package.functions_to_test.pd`

```
5    import pandas as pd

19   def df_from_csv(filename):
20       """Return a dataframe read from a csv"""
21       return pd.read_csv(filename)
22
```

Call Mock object called `my_package.functions_to_test.pd.read_csv`