CHARLES DARWIN UNIVERSITY AUSTRALIA

UNIT CODE: PRT582
SOFTWARE ENGINEERING: PROCESS AND TOOLS

Software Unit Testing Report

Submitted By:

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Introduction:

TDD is a test-first development process where we write our test first before writing functional code to fulfill that test so that we can think through our requirements or design before writing our functional code. By using TDD, we can write clean code that works. However, I have implemented a Scrabble Score using Test Driven Development in Python based on the following requirements. I am going to explain the process I followed and the test cases I performed.

The basic game requirements are:

- **i.** The numbers are added up correctly for a given word
- **ii.** Upper- and lower-case letters should have the same value
- **iii.** Your program should prompt the user with the right feedback if the user does not enter an alphabet.
- **iv.** A 15-second timer is shown. The user is asked to input a word of a certain length. The number of alphabets required in the word is randomly generated. The program will check to ensure that the correct length of the word is entered before generating the score. The score will be higher if less time is used to enter the correct length of the word.
- **v.** Ensure that the user enters a valid word from a dictionary. The program will not tabulate the score if the word is not a proper word from a dictionary. Prompts will be given asking the user to enter a valid word if the user does not enter a valid word.
- **vi.** The game will keep going:
    - a. Until the player quits the game and displays the total score of the player.
    - b. After 10 rounds, compute the total score of the player.

For programming language, I have used Python and for unit testing, I have used the Python Unit testing framework. As a static code analyzer for Python, I have utilized the Pylint library and to check the code base against coding style and programming errors, I used the Python Flake8 library. Finally, for the source code editor, I have set up my programming environment in Visual Studio Code.

Process:

The steps involved in the test-first development that I followed can be seen in the diagram below and the steps are:

- At first, we have to add a test quickly, basically just enough code to make it fail.
- Next, we run our tests to ensure that the new test does indeed fail.
- Then we update our functional code to make it pass the new tests.
- After that, we run our tests again.
- If they fail, we need to update our functional code and retest.
- Once the tests pass, the next step is to start over.

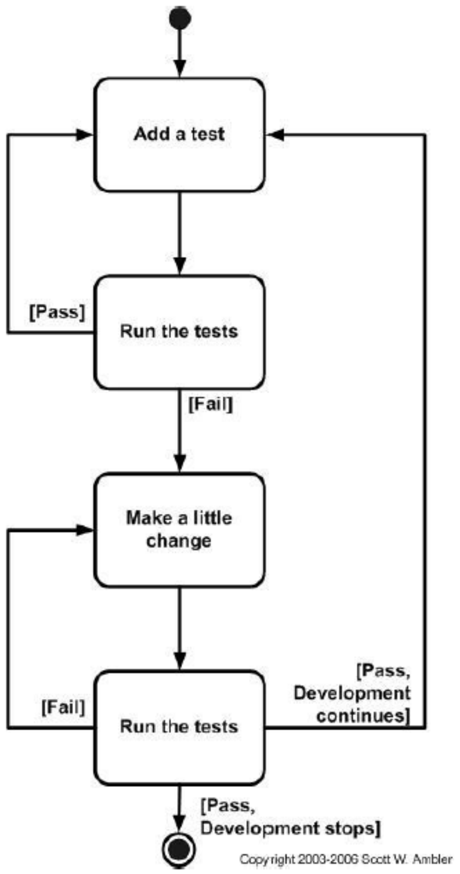
Add a test
[Pass]
Run the tests
[Fail]
Make a little change
[Fail]
Run the tests
[Pass, Development continues]
[Pass, Development stops]
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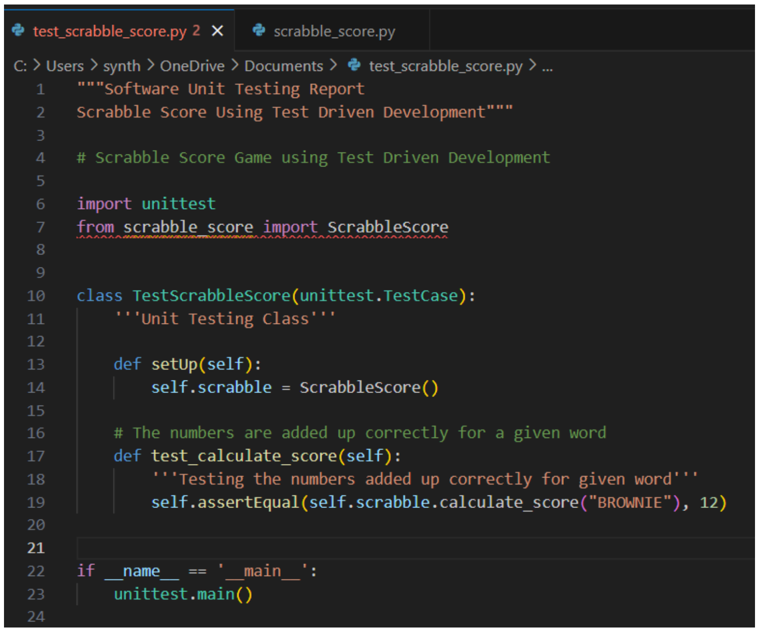
Figure 1: TDD Process

Step 1:

At first, I created a Python file named 'test_scrabble_score.py' by following the snake case naming convention. Now, I am going to follow this standard convention for the rest of my development process to make it understandable. However, then imported the unit testing framework to write my first test case. I have created the first test case based on the first requirement, which is "The numbers are added up correctly for a given word".

Unit testing code:



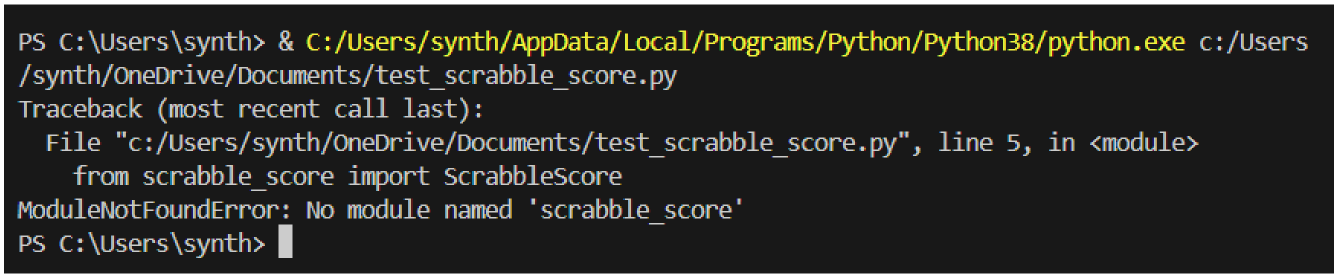
test_scrabble_score.py 2 × | scrabble_score.py

C: > Users > synth > OneDrive > Documents > test_scrabble_score.py > ...

```python
"""Software Unit Testing Report
Scrabble Score Using Test Driven Development"""

# Scrabble Score Game using Test Driven Development

import unittest
from scrabble_score import ScrabbleScore


class TestScrabbleScore(unittest.TestCase):
    '''Unit Testing Class'''

    def setUp(self):
        self.scrabble = ScrabbleScore()

    # The numbers are added up correctly for a given word
    def test_calculate_score(self):
        '''Testing the numbers added up correctly for given word'''
        self.assertEqual(self.scrabble.calculate_score("BROWNIE"), 12)


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

```

It is going to check if the numbers are added up correctly for a given word or not and I know that the test will fail as I haven't written my functional code for that method yet and what's more I haven't even created my scrabble score code file yet either.

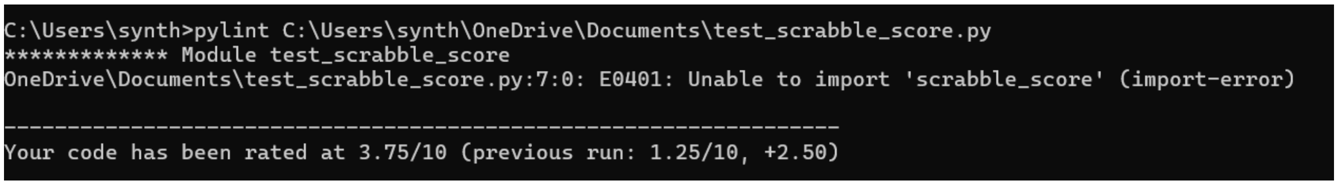
Test (Failed) output:



```
PS C:\Users\synth> & C:/Users/synth/AppData/Local/Programs/Python/Python38/python.exe c:/Users
/synth/OneDrive/Documents/test_scrabble_score.py
Traceback (most recent call last):
  File "c:/Users/synth/OneDrive/Documents/test_scrabble_score.py", line 5, in <module>
    from scrabble_score import ScrabbleScore
ModuleNotFoundError: No module named 'scrabble_score'
PS C:\Users\synth>
```

As expected, it got a "ModuleNotFoundError" exception in the output console.
"ModuleNotFoundError: No module named 'scrabble_score".
I am also going to check and analyze my coding style and programming errors often with the Pylint and flake8 libraries.

Pylint:

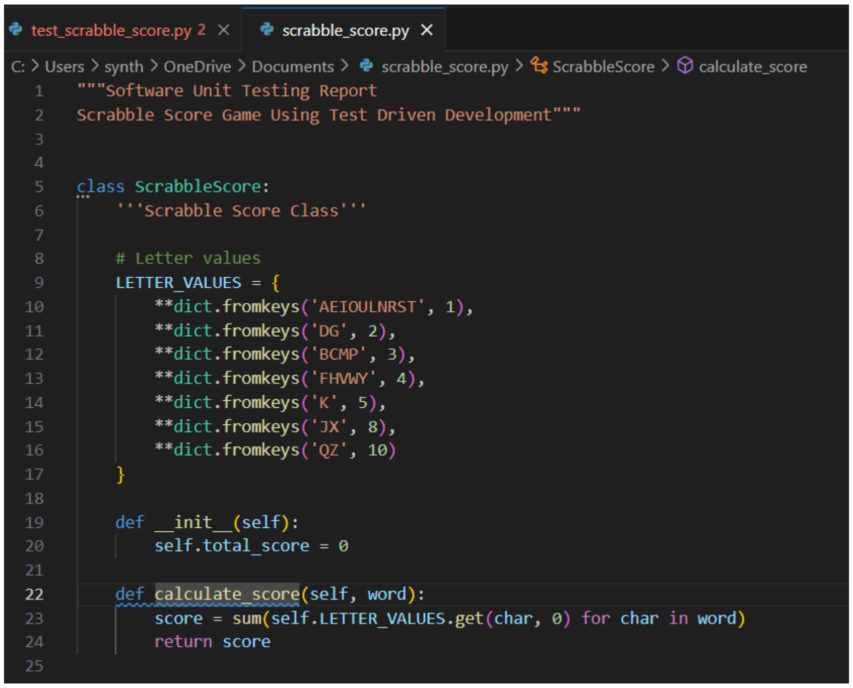


```
C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\test_scrabble_score.py
************* Module test_scrabble_score
OneDrive\Documents\test_scrabble_score.py:7:0: E0401: Unable to import 'scrabble_score' (import-error)

------------------------------------------------------------------
Your code has been rated at 3.75/10 (previous run: 1.25/10, +2.50)
```

After running Pylint for my test file, I can see that the score is quite low due to the error of not finding the functional coding file, but other than that, the coding convention seems right.

Now it's time for me to create my Scrabble Python file named "scrabble_score.py" and write the first method to test the first requirement using the test case that I wrote before. So, I wrote the code for the correct number addition for Scrabble Score like below:

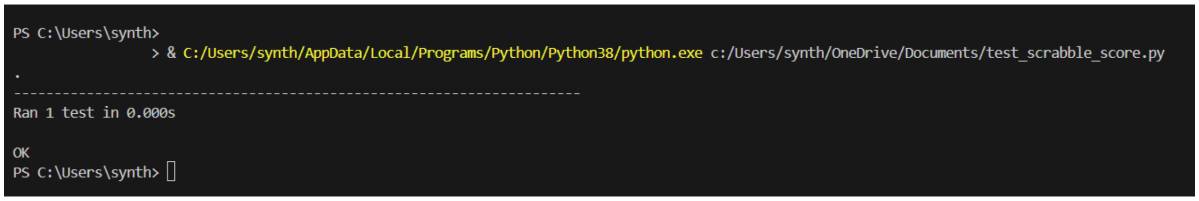
Functional code for method:



```
test_scrabble_score.py 2   scrabble_score.py
C: > Users > synth > OneDrive > Documents > scrabble_score.py > ScrabbleScore > calculate_score
"""Software Unit Testing Report
Scrabble Score Game Using Test Driven Development"""


class ScrabbleScore:
    '''Scrabble Score Class'''

    # Letter values
    LETTER_VALUES = {
        **dict.fromkeys('AEIOULNRST', 1),
        **dict.fromkeys('DG', 2),
        **dict.fromkeys('BCMP', 3),
        **dict.fromkeys('FHVWY', 4),
        **dict.fromkeys('K', 5),
        **dict.fromkeys('JX', 8),
        **dict.fromkeys('QZ', 10)
    }

    def __init__(self):
        self.total_score = 0

    def calculate_score(self, word):
        score = sum(self.LETTER_VALUES.get(char, 0) for char in word)
        return score

```

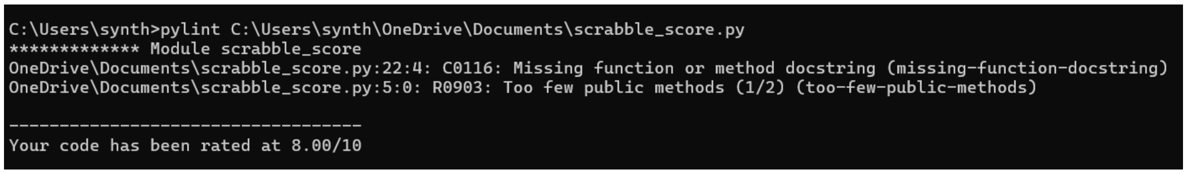
Now test our test case again and see what happens, I am expecting to get it to pass this time.

Unit Test (Passed) output:



```
PS C:\Users\synth>
                  > & C:/Users/synth/AppData/Local/Programs/Python/Python38/python.exe c:/Users/synth/OneDrive/Documents/test_scrabble_score.py
.
----------------------------------------------------------------------
Ran 1 test in 0.000s

OK
PS C:\Users\synth> 
```

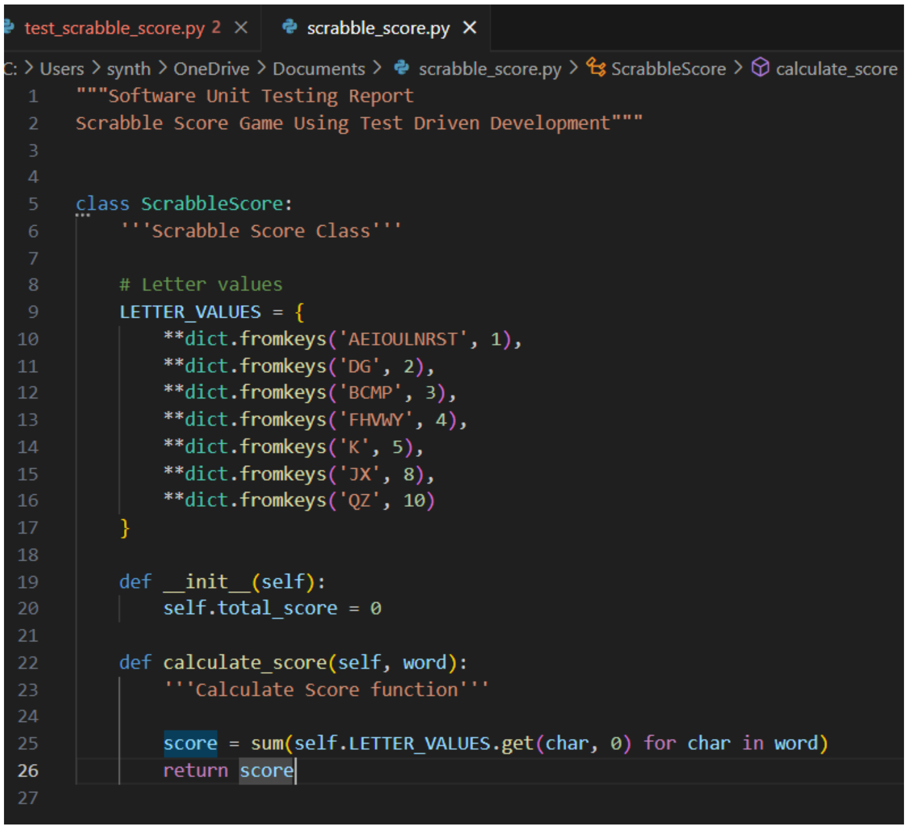
So, after running the unit test again it passed and got the output mentioned above.
Now I want to see if my coding style is correct or not, lets run Pylint on my code file
Pylint for functional code of "scrabble_score.py":



```
C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\scrabble_score.py
************* Module scrabble_score
OneDrive\Documents\scrabble_score.py:22:4: C0116: Missing function or method docstring (missing-function-docstring)
OneDrive\Documents\scrabble_score.py:5:0: R0903: Too few public methods (1/2) (too-few-public-methods)

-----------------------------------
Your code has been rated at 8.00/10
```

After running pylint, I can see that it is showing that my method doesn't have any docstring, so I am going to add that to my code file "scrabble_score.py".

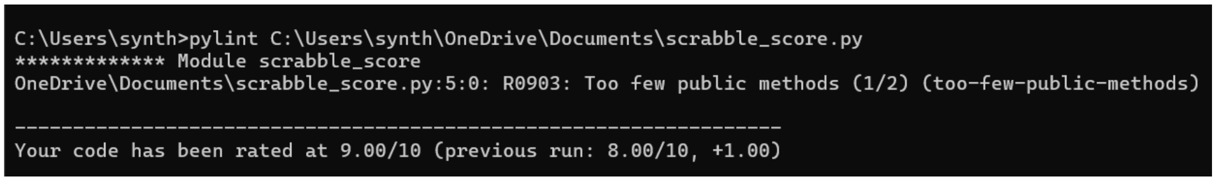
Fixing functional code:



test_scrabble_score.py 2
scrabble_score.py
C: > Users > synth > OneDrive > Documents > scrabble_score.py > ScrabbleScore > calculate_score

```python
"""Software Unit Testing Report
Scrabble Score Game Using Test Driven Development"""


class ScrabbleScore:
    '''Scrabble Score Class'''

    # Letter values
    LETTER_VALUES = {
        **dict.fromkeys('AEIOULNRST', 1),
        **dict.fromkeys('DG', 2),
        **dict.fromkeys('BCMP', 3),
        **dict.fromkeys('FHVWY', 4),
        **dict.fromkeys('K', 5),
        **dict.fromkeys('JX', 8),
        **dict.fromkeys('QZ', 10)
    }

    def __init__(self):
        self.total_score = 0

    def calculate_score(self, word):
        '''Calculate Score function'''

        score = sum(self.LETTER_VALUES.get(char, 0) for char in word)
        return score

```

Pylint:



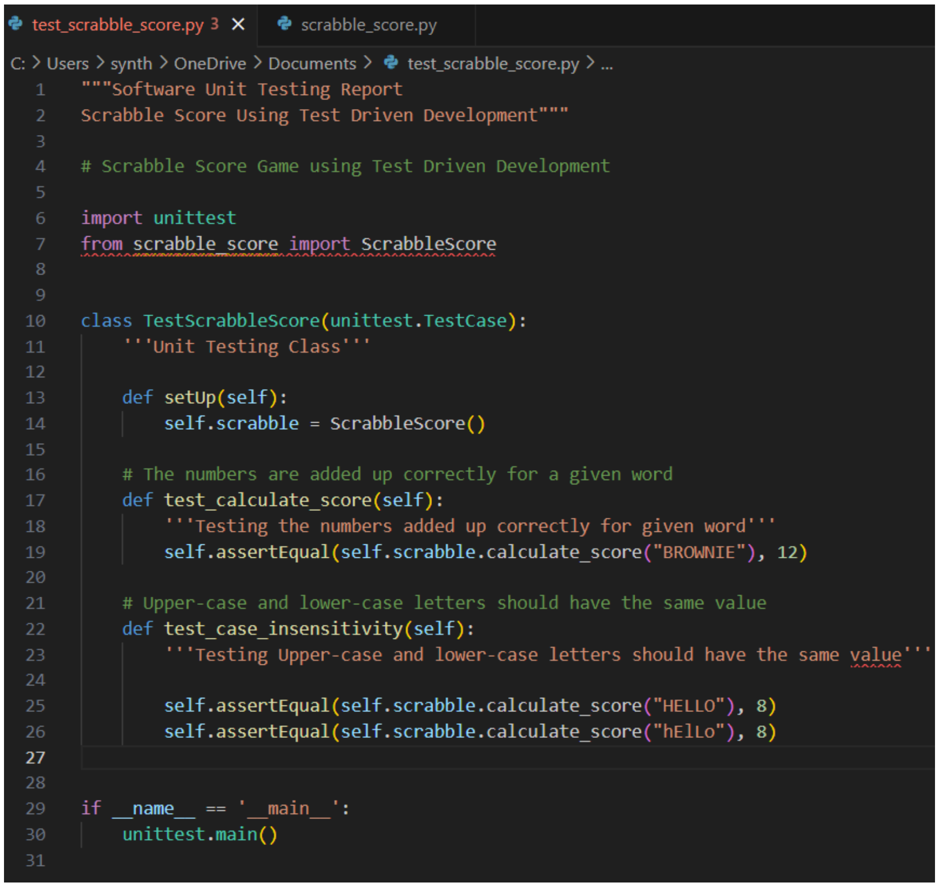
```
C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\scrabble_score.py
************* Module scrabble_score
OneDrive\Documents\scrabble_score.py:5:0: R0903: Too few public methods (1/2) (too-few-public-methods)

------------------------------------------------------------------
Your code has been rated at 9.00/10 (previous run: 8.00/10, +1.00)
```

After fixing the issue of the docstring, scores are improved. However, now I know my coding style is in the right format and will follow that style as I progress and will check for any issues at the end with Pylint and flake8.

Step 2:

Now, I am going to move to the next requirement which is “Upper-case and lower-case letters should have the same value” and create my test case based on that.

Unit testing code:

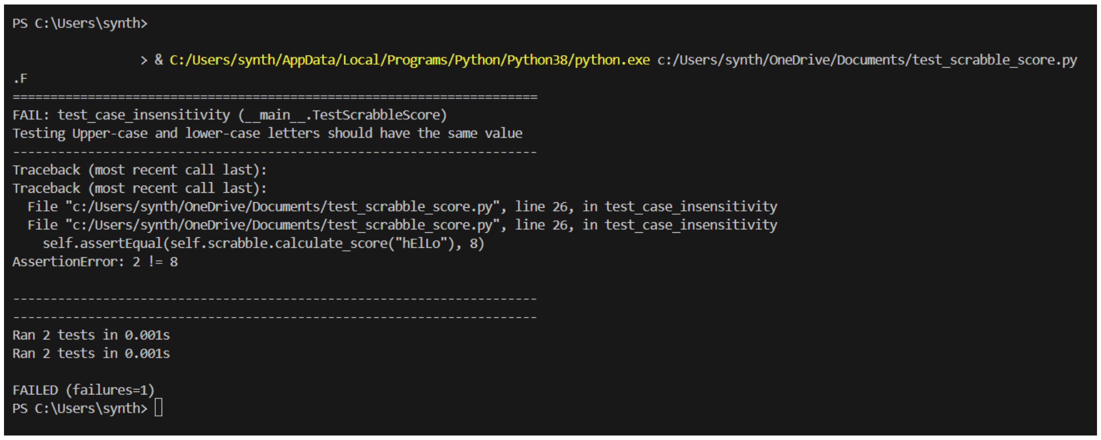


test_scrabble_score.py 3 × scrabble_score.py

C: > Users > synth > OneDrive > Documents > test_scrabble_score.py > ...

```python
"""Software Unit Testing Report
Scrabble Score Using Test Driven Development"""

# Scrabble Score Game using Test Driven Development

import unittest
from scrabble_score import ScrabbleScore


class TestScrabbleScore(unittest.TestCase):
    '''Unit Testing Class'''

    def setUp(self):
        self.scrabble = ScrabbleScore()

    # The numbers are added up correctly for a given word
    def test_calculate_score(self):
        '''Testing the numbers added up correctly for given word'''
        self.assertEqual(self.scrabble.calculate_score("BROWNIE"), 12)

    # Upper-case and lower-case letters should have the same value
    def test_case_insensitivity(self):
        '''Testing Upper-case and lower-case letters should have the same value'''

        self.assertEqual(self.scrabble.calculate_score("HELLO"), 8)
        self.assertEqual(self.scrabble.calculate_score("hElLo"), 8)


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

```

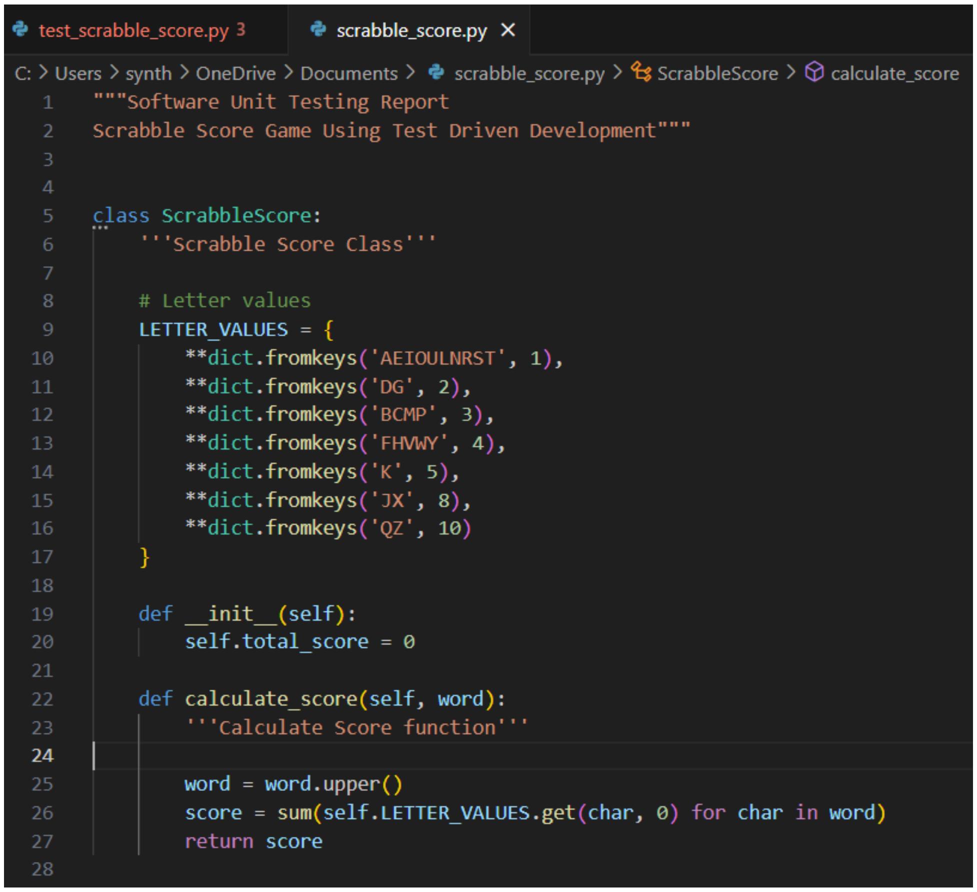
Unit Test (Failed) output:



```
PS C:\Users\synth>
                 > & C:/Users/synth/AppData/Local/Programs/Python/Python38/python.exe c:/Users/synth/OneDrive/Documents/test_scrabble_score.py
.F
======================================================================
FAIL: test_case_insensitivity (__main__.TestScrabbleScore)
Testing Upper-case and lower-case letters should have the same value
----------------------------------------------------------------------
Traceback (most recent call last):
Traceback (most recent call last):
  File "c:/Users/synth/OneDrive/Documents/test_scrabble_score.py", line 26, in test_case_insensitivity
  File "c:/Users/synth/OneDrive/Documents/test_scrabble_score.py", line 26, in test_case_insensitivity
    self.assertEqual(self.scrabble.calculate_score("hElLo"), 8)
AssertionError: 2 != 8

----------------------------------------------------------------------
----------------------------------------------------------------------
Ran 2 tests in 0.001s
Ran 2 tests in 0.001s

FAILED (failures=1)
PS C:\Users\synth> 
```

After running the unit testing, I can see that the new test case “test_case_insensitivity” failed because of one error as I have not added any logic to handle the case insensitivity condition in the functional code yet. So now I will add that conditional logic in the functional code for this case.

Functional code:

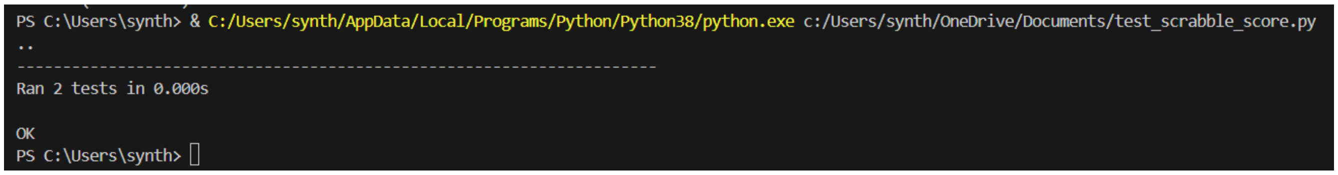


test_scrabble_score.py 3 | scrabble_score.py ×

C: > Users > synth > OneDrive > Documents > scrabble_score.py > ScrabbleScore > calculate_score

```python
"""Software Unit Testing Report
Scrabble Score Game Using Test Driven Development"""


class ScrabbleScore:
    '''Scrabble Score Class'''

    # Letter values
    LETTER_VALUES = {
        **dict.fromkeys('AEIOULNRST', 1),
        **dict.fromkeys('DG', 2),
        **dict.fromkeys('BCMP', 3),
        **dict.fromkeys('FHVWY', 4),
        **dict.fromkeys('K', 5),
        **dict.fromkeys('JX', 8),
        **dict.fromkeys('QZ', 10)
    }

    def __init__(self):
        self.total_score = 0

    def calculate_score(self, word):
        '''Calculate Score function'''

        word = word.upper()
        score = sum(self.LETTER_VALUES.get(char, 0) for char in word)
        return score

```

Unit Test (Passed) output:

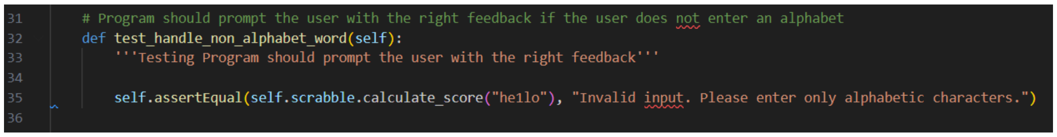


```
PS C:\Users\synth> & C:/Users/synth/AppData/Local/Programs/Python/Python38/python.exe c:/Users/synth/OneDrive/Documents/test_scrabble_score.py
..
----------------------------------------------------------------------
Ran 2 tests in 0.000s

OK
PS C:\Users\synth> 
```

Now, I can see that it ran 2 tests and both test cases passed. So, I am moving to the next requirement for the unit test.

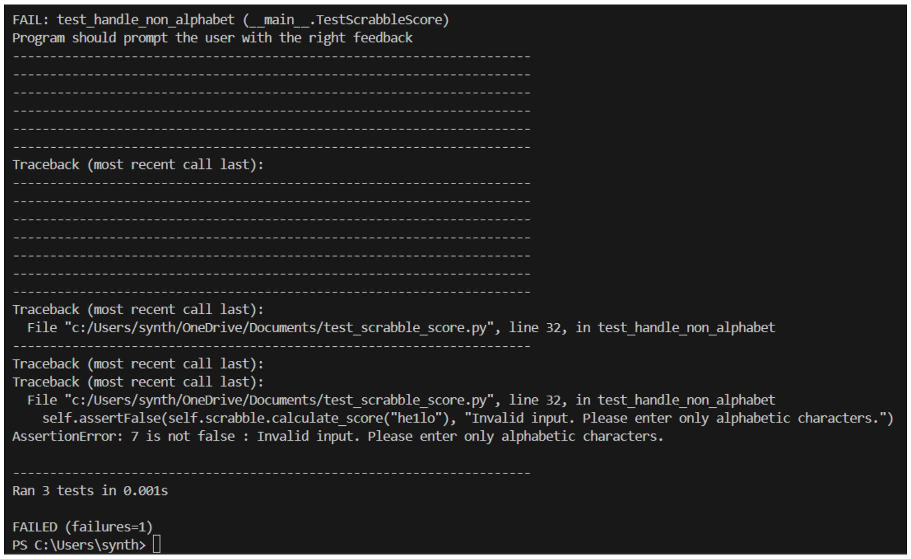
Step 3:

The next requirement is "The program should prompt the user with the right feedback if the user does not enter an alphabet". Now I am going to create my test case based on that and after running this test I am expecting it to fail.



```python
    # Program should prompt the user with the right feedback if the user does not enter an alphabet
    def test_handle_non_alphabet_word(self):
        '''Testing Program should prompt the user with the right feedback'''

        self.assertEqual(self.scrabble.calculate_score("he1lo"), "Invalid input. Please enter only alphabetic characters.")

```

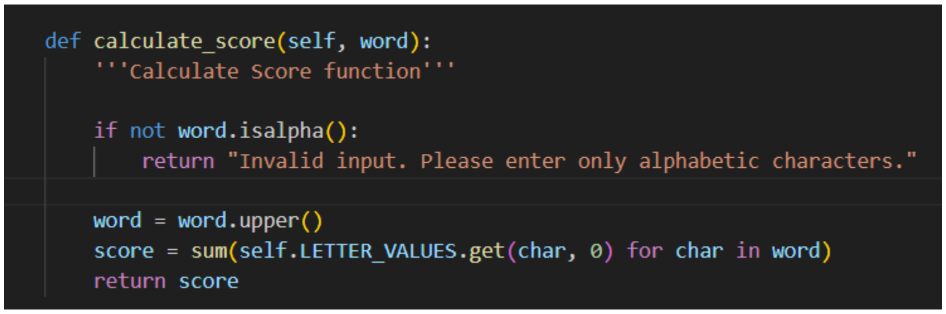
Unit Test (Failed) output:



```
FAIL: test_handle_non_alphabet (__main__.TestScrabbleScore)
Program should prompt the user with the right feedback
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
Traceback (most recent call last):
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
Traceback (most recent call last):
  File "c:/Users/synth/OneDrive/Documents/test_scrabble_score.py", line 32, in test_handle_non_alphabet
----------------------------------------------------------------------
Traceback (most recent call last):
Traceback (most recent call last):
  File "c:/Users/synth/OneDrive/Documents/test_scrabble_score.py", line 32, in test_handle_non_alphabet
    self.assertFalse(self.scrabble.calculate_score("he1lo"), "Invalid input. Please enter only alphabetic characters.")
AssertionError: 7 is not false : Invalid input. Please enter only alphabetic characters.

----------------------------------------------------------------------
Ran 3 tests in 0.001s

FAILED (failures=1)
PS C:\Users\synth> 
```

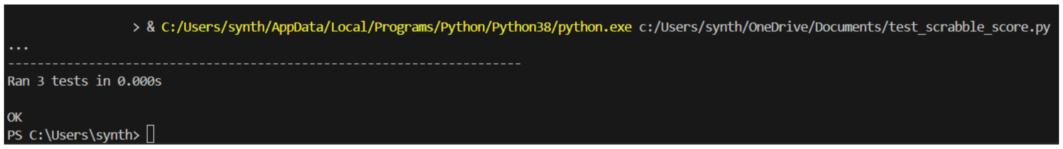
After running the test code as expected it failed with an error that invalid input is not matched because this condition is not added yet.

Functional Code:



```python
def calculate_score(self, word):
    '''Calculate Score function'''

    if not word.isalpha():
        return "Invalid input. Please enter only alphabetic characters."

    word = word.upper()
    score = sum(self.LETTER_VALUES.get(char, 0) for char in word)
    return score
```

Unit Test (Passed) output:



```
                > & C:/Users/synth/AppData/Local/Programs/Python/Python38/python.exe c:/Users/synth/OneDrive/Documents/test_scrabble_score.py
...
----------------------------------------------------------------------
Ran 3 tests in 0.000s

OK
PS C:\Users\synth> 
```

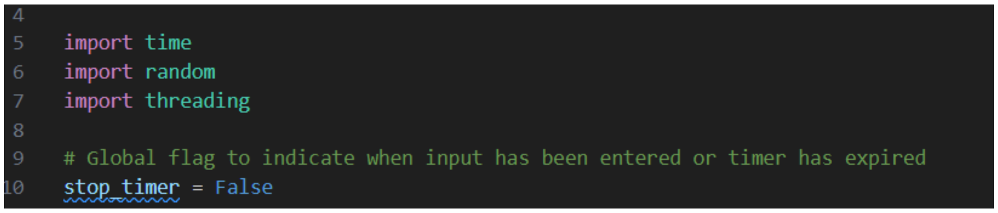
Step 4:

Now I am going to create my next test case for the requirement "A 15-second timer is shown. The user is asked to input a word of a certain length. The number of alphabets required in the word is randomly generated. The program will check to ensure that the correct length of the word is entered before generating the score. The score will be higher if less time is used to enter the correct length of the word". Before creating unit test case, I need to add functional code first.

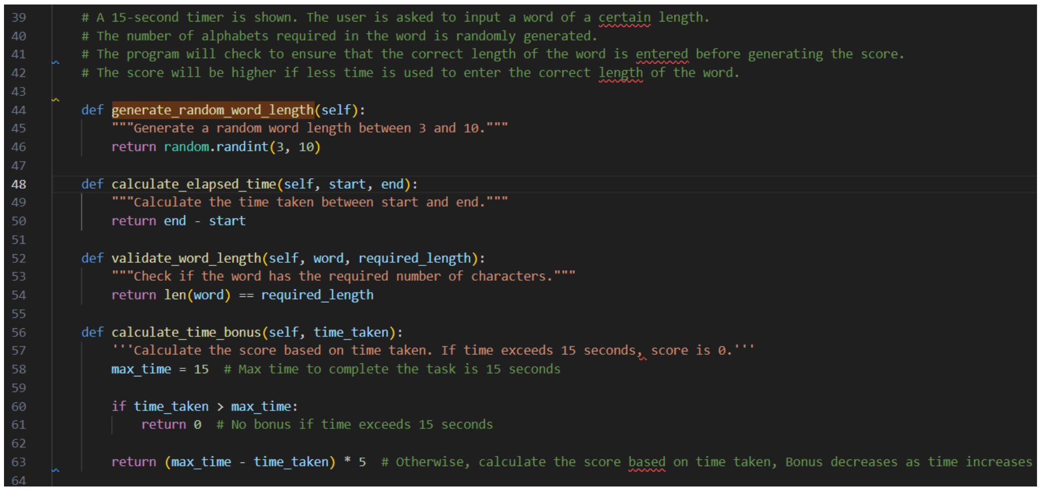
For functional code, I will breakdown the steps for simplicity:

- Generate random word length for user input to match the length.
- Get user input.
- Calculate the time taken between start and end of the input given.
- Validate the word length
- Calculate the time bonus if time is taken less than 15sec. It can be done by subtracting the time taken from maximum time 15 and then multiplying by 5.
- Countdown the timer until 15sec. If 15 sec exceeds, then user needs to press Enter to proceed.

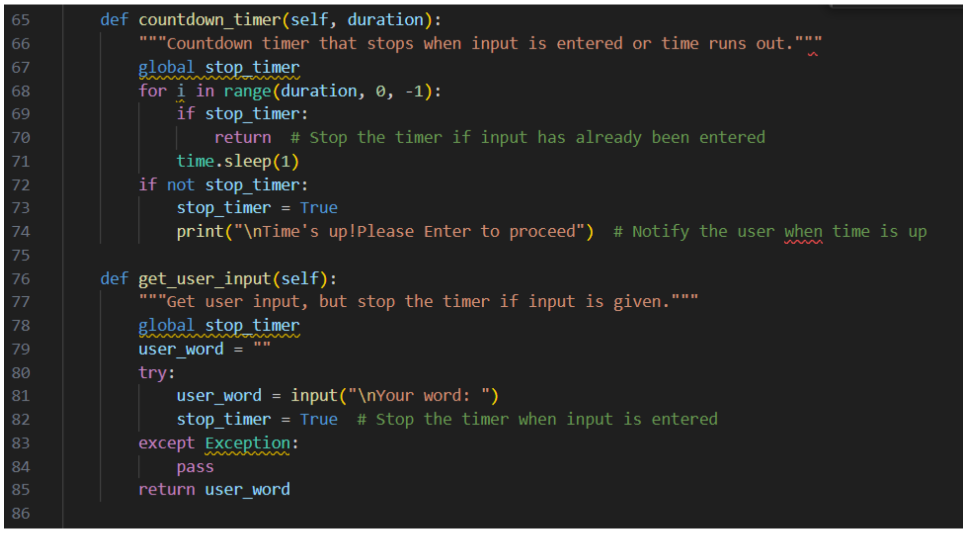
Functional Code:



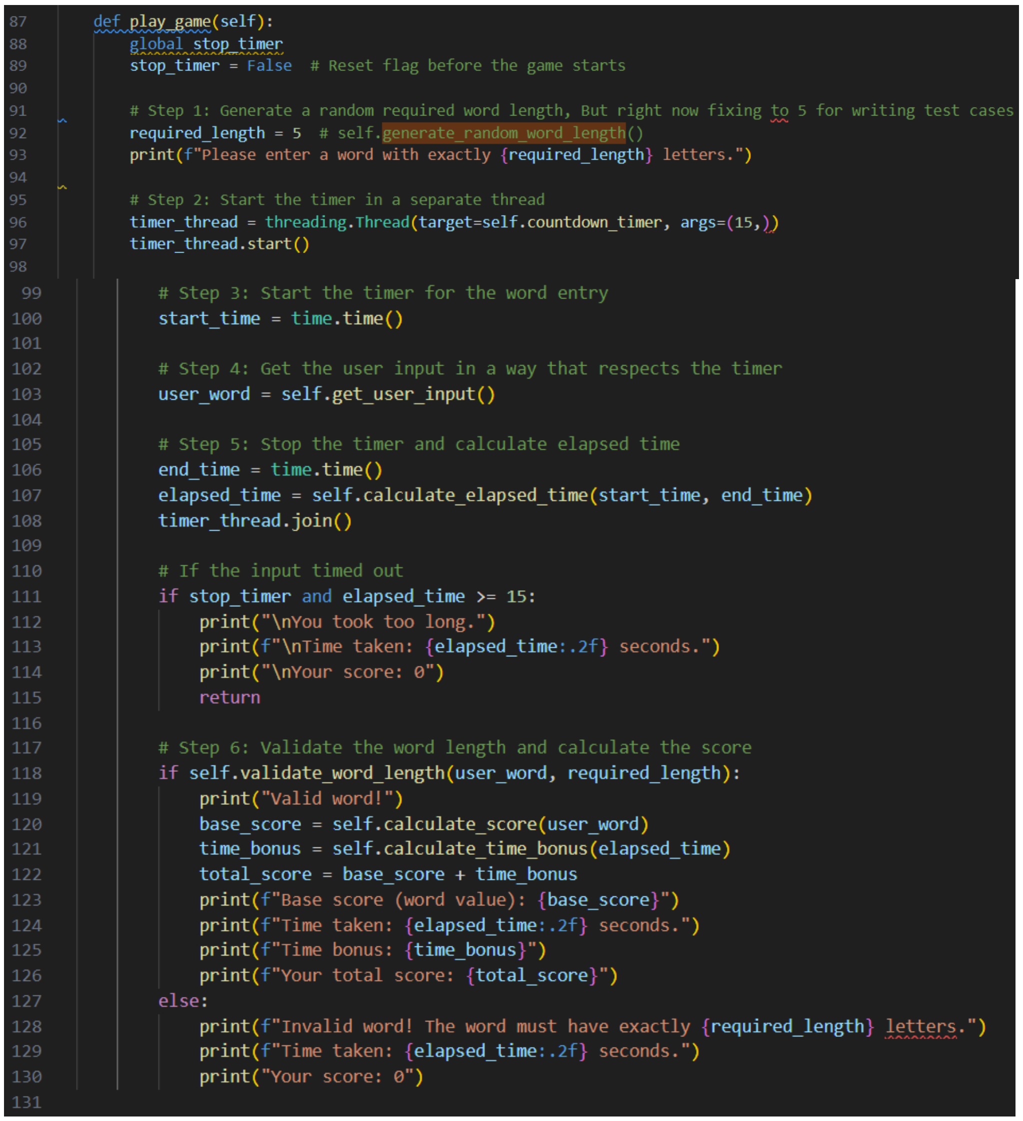
```python

import time
import random
import threading

# Global flag to indicate when input has been entered or timer has expired
stop_timer = False
```



```python
    # A 15-second timer is shown. The user is asked to input a word of a certain length.
    # The number of alphabets required in the word is randomly generated.
    # The program will check to ensure that the correct length of the word is entered before generating the score.
    # The score will be higher if less time is used to enter the correct length of the word.

    def generate_random_word_length(self):
        """Generate a random word length between 3 and 10."""
        return random.randint(3, 10)

    def calculate_elapsed_time(self, start, end):
        """Calculate the time taken between start and end."""
        return end - start

    def validate_word_length(self, word, required_length):
        """Check if the word has the required number of characters."""
        return len(word) == required_length

    def calculate_time_bonus(self, time_taken):
        '''Calculate the score based on time taken. If time exceeds 15 seconds, score is 0.'''
        max_time = 15  # Max time to complete the task is 15 seconds

        if time_taken > max_time:
            return 0  # No bonus if time exceeds 15 seconds

        return (max_time - time_taken) * 5  # Otherwise, calculate the score based on time taken, Bonus decreases as time increases

```



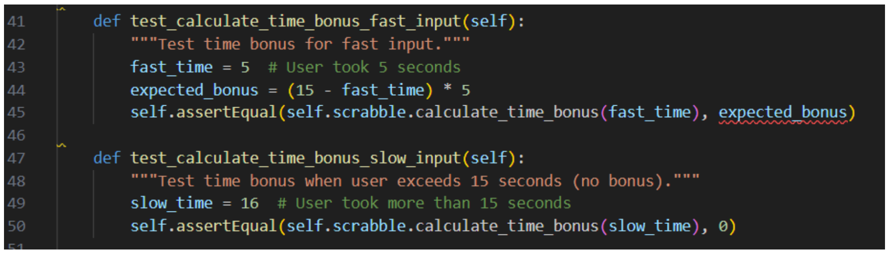
```python
    def countdown_timer(self, duration):
        """Countdown timer that stops when input is entered or time runs out."""
        global stop_timer
        for i in range(duration, 0, -1):
            if stop_timer:
                return  # Stop the timer if input has already been entered
            time.sleep(1)
        if not stop_timer:
            stop_timer = True
            print("\nTime's up!Please Enter to proceed")  # Notify the user when time is up

    def get_user_input(self):
        """Get user input, but stop the timer if input is given."""
        global stop_timer
        user_word = ""
        try:
            user_word = input("\nYour word: ")
            stop_timer = True  # Stop the timer when input is entered
        except Exception:
            pass
        return user_word

```



```python
    def play_game(self):
        global stop_timer
        stop_timer = False  # Reset flag before the game starts

        # Step 1: Generate a random required word length, But right now fixing to 5 for writing test cases
        required_length = 5  # self.generate_random_word_length()
        print(f"Please enter a word with exactly {required_length} letters.")

        # Step 2: Start the timer in a separate thread
        timer_thread = threading.Thread(target=self.countdown_timer, args=(15,))
        timer_thread.start()

        # Step 3: Start the timer for the word entry
        start_time = time.time()

        # Step 4: Get the user input in a way that respects the timer
        user_word = self.get_user_input()

        # Step 5: Stop the timer and calculate elapsed time
        end_time = time.time()
        elapsed_time = self.calculate_elapsed_time(start_time, end_time)
        timer_thread.join()

        # If the input timed out
        if stop_timer and elapsed_time >= 15:
            print("\nYou took too long.")
            print(f"\nTime taken: {elapsed_time:.2f} seconds.")
            print("\nYour score: 0")
            return

        # Step 6: Validate the word length and calculate the score
        if self.validate_word_length(user_word, required_length):
            print("Valid word!")
            base_score = self.calculate_score(user_word)
            time_bonus = self.calculate_time_bonus(elapsed_time)
            total_score = base_score + time_bonus
            print(f"Base score (word value): {base_score}")
            print(f"Time taken: {elapsed_time:.2f} seconds.")
            print(f"Time bonus: {time_bonus}")
            print(f"Your total score: {total_score}")
        else:
            print(f"Invalid word! The word must have exactly {required_length} letters.")
            print(f"Time taken: {elapsed_time:.2f} seconds.")
            print("Your score: 0")
```

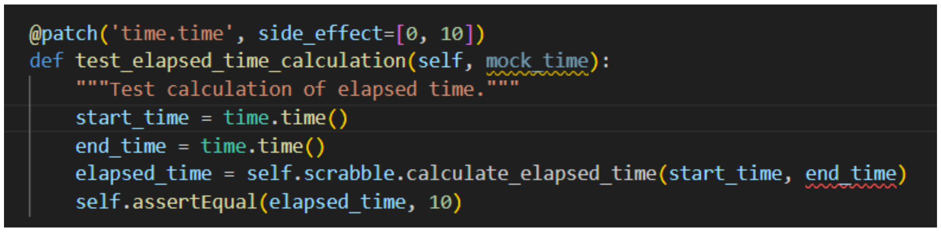
Unit testing code:

- I have written two test cases for both faster time taken for input and slower time taken for user input.



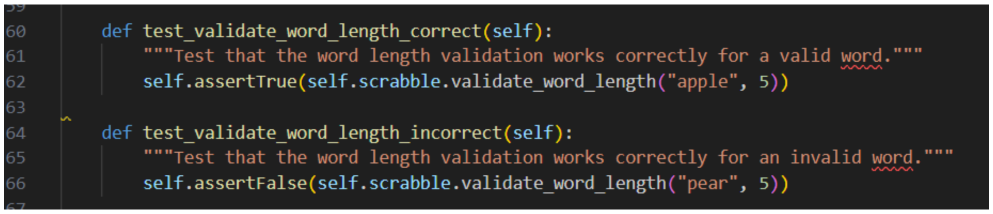
```python
    def test_calculate_time_bonus_fast_input(self):
        """Test time bonus for fast input."""
        fast_time = 5  # User took 5 seconds
        expected_bonus = (15 - fast_time) * 5
        self.assertEqual(self.scrabble.calculate_time_bonus(fast_time), expected_bonus)

    def test_calculate_time_bonus_slow_input(self):
        """Test time bonus when user exceeds 15 seconds (no bonus)."""
        slow_time = 16  # User took more than 15 seconds
        self.assertEqual(self.scrabble.calculate_time_bonus(slow_time), 0)
```

- Then I have written test case for the calculation of elapsed time taken by user while giving input.



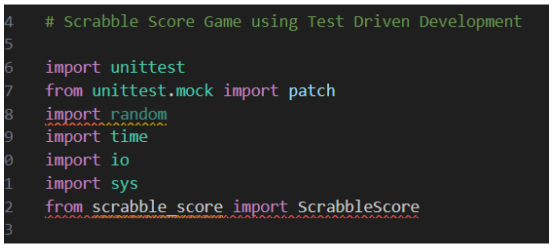
```python
@patch('time.time', side_effect=[0, 10])
def test_elapsed_time_calculation(self, mock_time):
    """Test calculation of elapsed time."""
    start_time = time.time()
    end_time = time.time()
    elapsed_time = self.scrabble.calculate_elapsed_time(start_time, end_time)
    self.assertEqual(elapsed_time, 10)
```

- After that, I have written two test cases for validating word length with both correct and incorrect length.

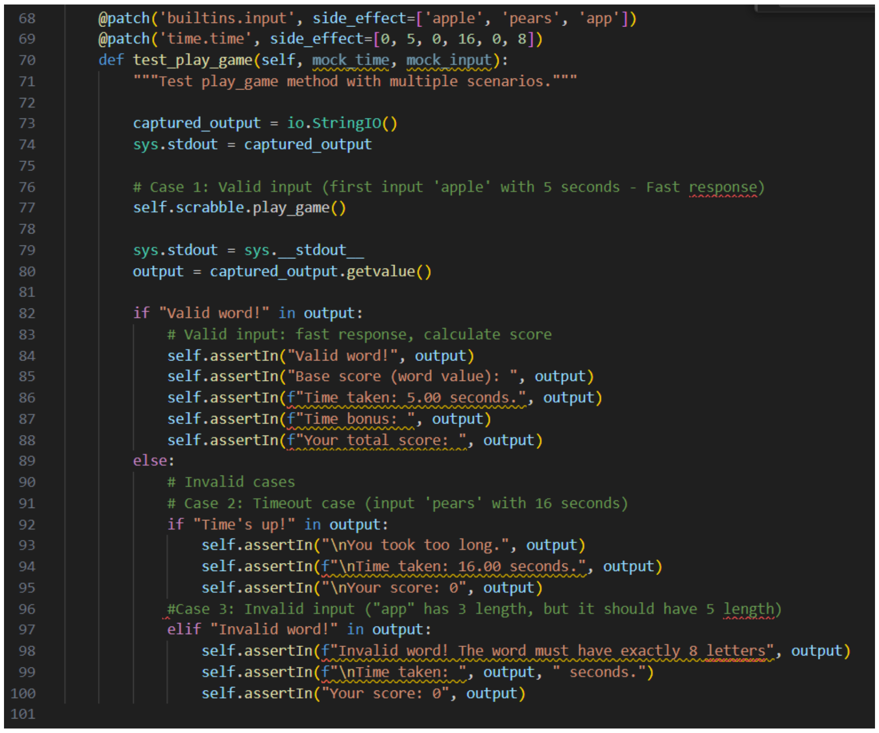


```python
    def test_validate_word_length_correct(self):
        """Test that the word length validation works correctly for a valid word."""
        self.assertTrue(self.scrabble.validate_word_length("apple", 5))

    def test_validate_word_length_incorrect(self):
        """Test that the word length validation works correctly for an invalid word."""
        self.assertFalse(self.scrabble.validate_word_length("pear", 5))
```

- Now, I have written test case for play_game. Since, it takes simulation of user input, so I Since, there is input prompts in this case, so to test this functionality, I need to mock user input and time. I am going to write unit tests for it using "unittest.mock".



```python
# Scrabble Score Game using Test Driven Development

import unittest
from unittest.mock import patch
import random
import time
import io
import sys
from scrabble_score import ScrabbleScore
```



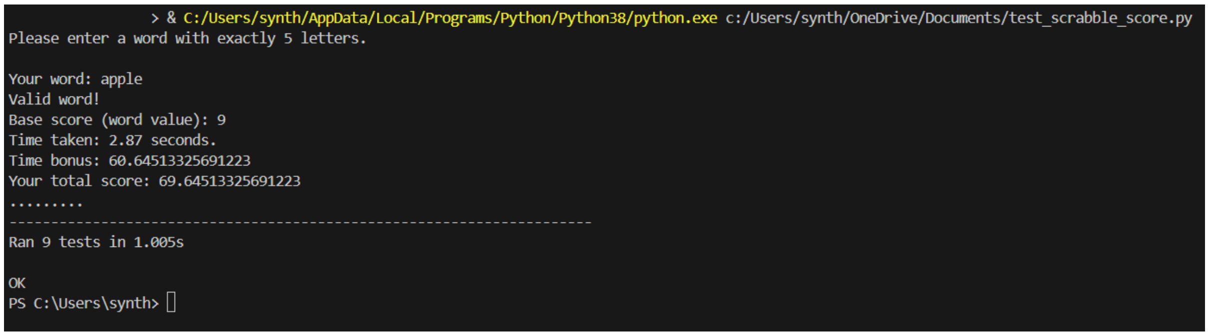
```python
    @patch('builtins.input', side_effect=['apple', 'pears', 'app'])
    @patch('time.time', side_effect=[0, 5, 0, 16, 0, 8])
    def test_play_game(self, mock_time, mock_input):
        """Test play_game method with multiple scenarios."""

        captured_output = io.StringIO()
        sys.stdout = captured_output

        # Case 1: Valid input (first input 'apple' with 5 seconds - Fast response)
        self.scrabble.play_game()

        sys.stdout = sys.__stdout__
        output = captured_output.getvalue()

        if "Valid word!" in output:
            # Valid input: fast response, calculate score
            self.assertIn("Valid word!", output)
            self.assertIn("Base score (word value): ", output)
            self.assertIn(f"Time taken: 5.00 seconds.", output)
            self.assertIn(f"Time bonus: ", output)
            self.assertIn(f"Your total score: ", output)
        else:
            # Invalid cases
            # Case 2: Timeout case (input 'pears' with 16 seconds)
            if "Time's up!" in output:
                self.assertIn("\nYou took too long.", output)
                self.assertIn(f"\nTime taken: 16.00 seconds.", output)
                self.assertIn("\nYour score: 0", output)
            #Case 3: Invalid input ("app" has 3 length, but it should have 5 length)
            elif "Invalid word!" in output:
                self.assertIn(f"Invalid word! The word must have exactly 8 letters", output)
                self.assertIn(f"\nTime taken: ", output, " seconds.")
                self.assertIn("Your score: 0", output)
```

Here,

- **mock_input** is used with the @patch decorator to simulate user input:
  - **Case 1**: Simulates the input 'apple' (valid case).
  - **Case 2**: Simulates the input 'pear' (timeout case).
  - **Case 3**: Simulates the input 'app' (invalid word length).
- **mock_time** is used to simulate the passage of time:
  - **Case 1**: Simulates 5 seconds for a fast response.
  - **Case 2**: Simulates 16 seconds for a timeout.
  - **Case 3**: Simulates 8 seconds for a valid input with an invalid word length.
- **Case 1**: Runs with mock_input('apple') and mock_time simulating 5 seconds. It checks that the output reflects the valid input case.
- **Case 2**: Runs with mock_input('pear') and mock_time simulating 16 seconds. It checks that the output reflects the timeout case.
- **Case 3**: Runs with mock_input('app') and mock_time simulating 8 seconds. It checks that the output reflects the invalid word length case.

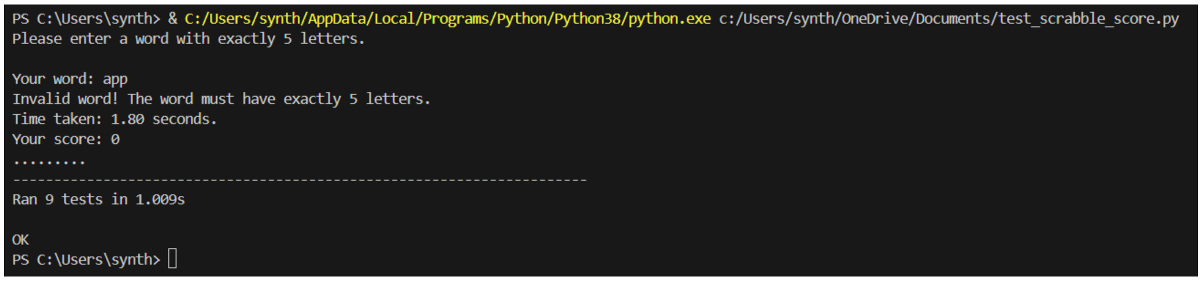
Unit Test (Passed) Output:

- **Valid case:**



```
                  > & C:/Users/synth/AppData/Local/Programs/Python/Python38/python.exe c:/Users/synth/OneDrive/Documents/test_scrabble_score.py
Please enter a word with exactly 5 letters.

Your word: apple
Valid word!
Base score (word value): 9
Time taken: 2.87 seconds.
Time bonus: 60.64513325691223
Your total score: 69.64513325691223
.........
----------------------------------------------------------------------
Ran 9 tests in 1.005s

OK
PS C:\Users\synth> 
```

- **Invalid case:**



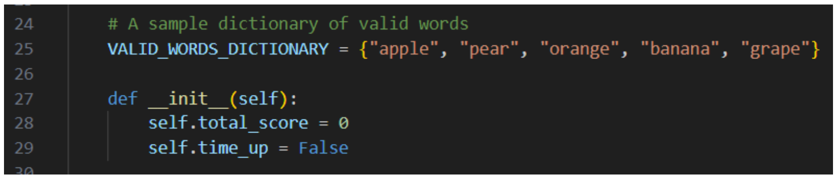
```
PS C:\Users\synth> & C:/Users/synth/AppData/Local/Programs/Python/Python38/python.exe c:/Users/synth/OneDrive/Documents/test_scrabble_score.py
Please enter a word with exactly 5 letters.

Your word: app
Invalid word! The word must have exactly 5 letters.
Time taken: 1.80 seconds.
Your score: 0
.........
----------------------------------------------------------------------
Ran 9 tests in 1.009s

OK
PS C:\Users\synth> 
```

Step 5:

Next requirement is: “Ensure that the user enters a valid word from a dictionary. The program will not tabulate the score if the word is not a proper word from a dictionary. Prompts will be given asking the user to enter a valid word if the user does not enter a valid word.”

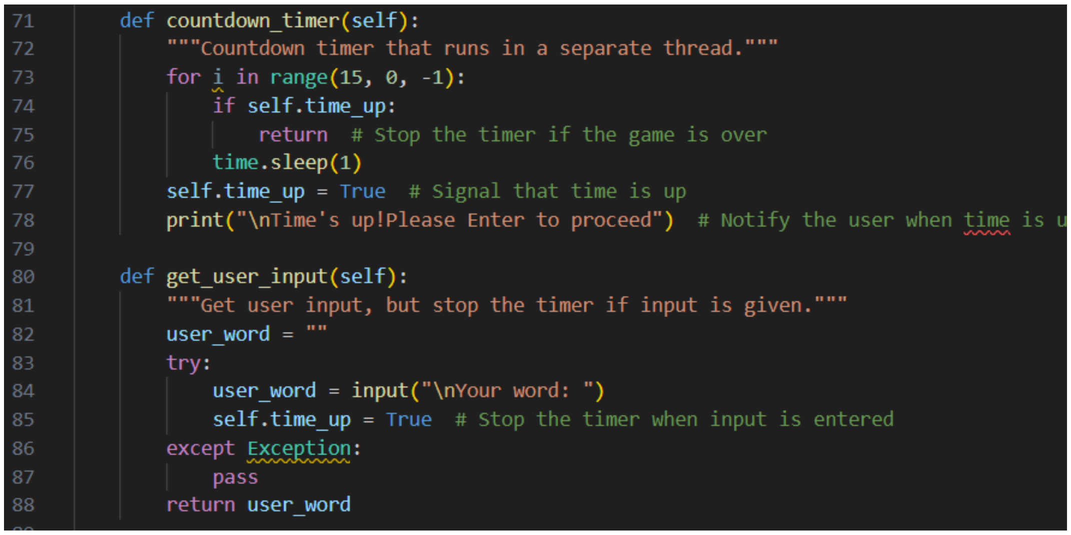
Functional Code:

- For this requirement, in the functional code, at first I removed the global flag of timer and set a private variable flag of “time_up” and initialized a sample dictionary with pre-defined values.

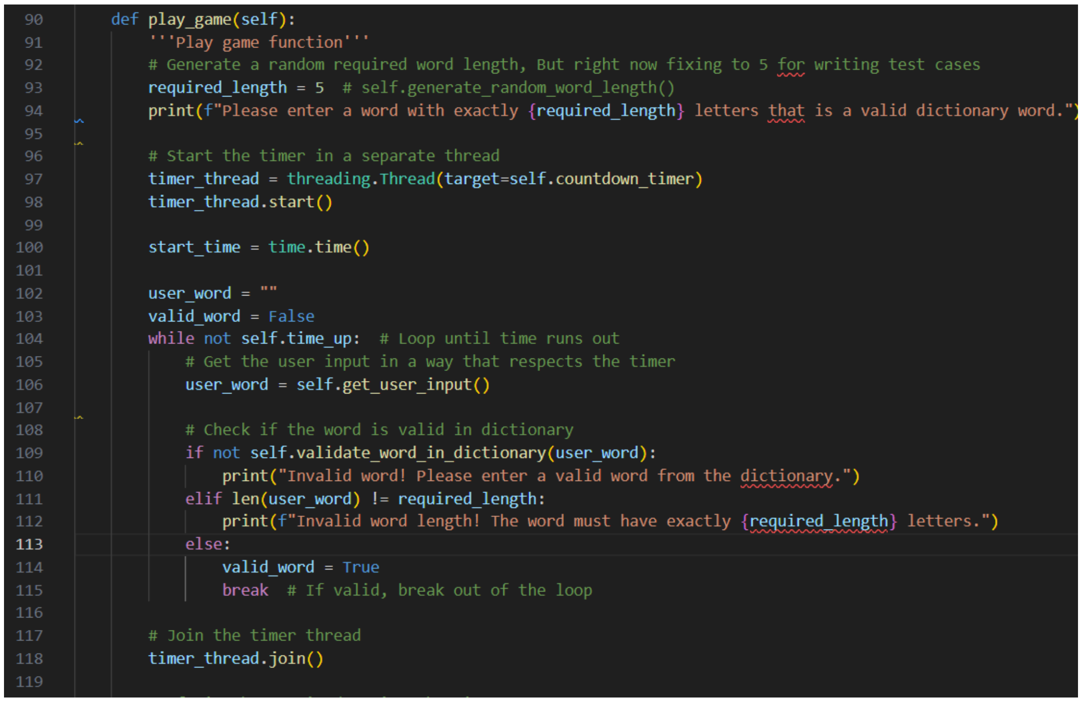


```python
    # A sample dictionary of valid words
    VALID_WORDS_DICTIONARY = {"apple", "pear", "orange", "banana", "grape"}

    def __init__(self):
        self.total_score = 0
        self.time_up = False
```

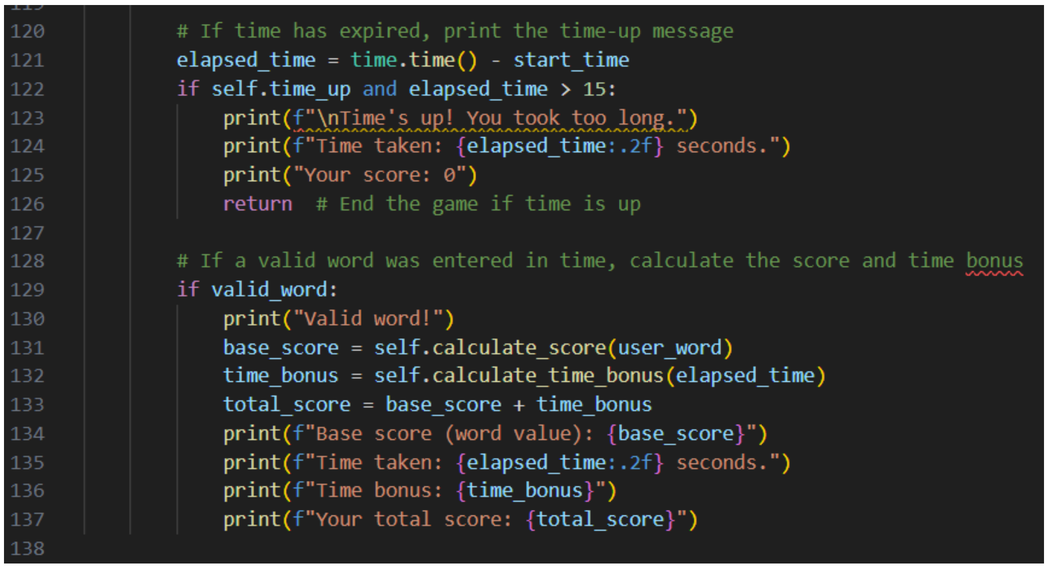
- Then I modified the necessary methods.



```python
    def countdown_timer(self):
        """Countdown timer that runs in a separate thread."""
        for i in range(15, 0, -1):
            if self.time_up:
                return  # Stop the timer if the game is over
            time.sleep(1)
        self.time_up = True  # Signal that time is up
        print("\nTime's up!Please Enter to proceed")  # Notify the user when time is u

    def get_user_input(self):
        """Get user input, but stop the timer if input is given."""
        user_word = ""
        try:
            user_word = input("\nYour word: ")
            self.time_up = True  # Stop the timer when input is entered
        except Exception:
            pass
        return user_word
```



```python
    def play_game(self):
        '''Play game function'''
        # Generate a random required word length, But right now fixing to 5 for writing test cases
        required_length = 5  # self.generate_random_word_length()
        print(f"Please enter a word with exactly {required_length} letters that is a valid dictionary word.")

        # Start the timer in a separate thread
        timer_thread = threading.Thread(target=self.countdown_timer)
        timer_thread.start()

        start_time = time.time()

        user_word = ""
        valid_word = False
        while not self.time_up:  # Loop until time runs out
            # Get the user input in a way that respects the timer
            user_word = self.get_user_input()

            # Check if the word is valid in dictionary
            if not self.validate_word_in_dictionary(user_word):
                print("Invalid word! Please enter a valid word from the dictionary.")
            elif len(user_word) != required_length:
                print(f"Invalid word length! The word must have exactly {required_length} letters.")
            else:
                valid_word = True
                break  # If valid, break out of the loop

        # Join the timer thread
        timer_thread.join()
```



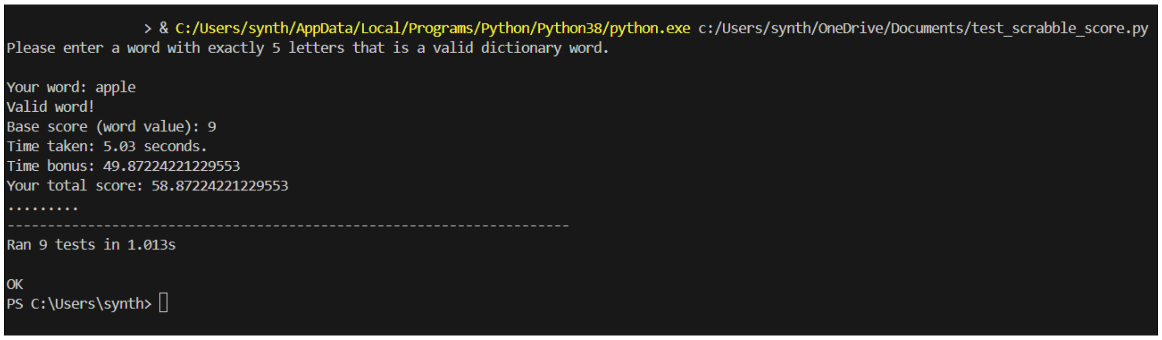
```python
        # If time has expired, print the time-up message
        elapsed_time = time.time() - start_time
        if self.time_up and elapsed_time > 15:
            print(f"\nTime's up! You took too long.")
            print(f"Time taken: {elapsed_time:.2f} seconds.")
            print("Your score: 0")
            return  # End the game if time is up

        # If a valid word was entered in time, calculate the score and time bonus
        if valid_word:
            print("Valid word!")
            base_score = self.calculate_score(user_word)
            time_bonus = self.calculate_time_bonus(elapsed_time)
            total_score = base_score + time_bonus
            print(f"Base score (word value): {base_score}")
            print(f"Time taken: {elapsed_time:.2f} seconds.")
            print(f"Time bonus: {time_bonus}")
            print(f"Your total score: {total_score}")

```

Unit Test Code:

- It should pass with the existing unit testing code.

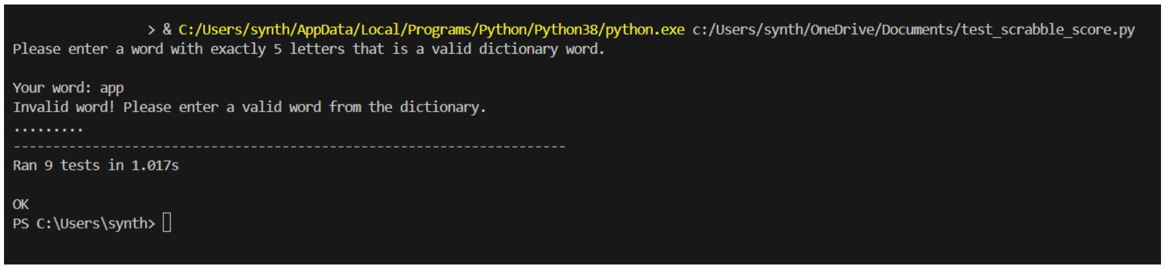
Unit Test (Passed) Output:

1. **Valid Case:**



```
> & C:/Users/synth/AppData/Local/Programs/Python/Python38/python.exe c:/Users/synth/OneDrive/Documents/test_scrabble_score.py
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: apple
Valid word!
Base score (word value): 9
Time taken: 5.03 seconds.
Time bonus: 49.87224221229553
Your total score: 58.87224221229553
.........
----------------------------------------------------------------------
Ran 9 tests in 1.013s

OK
PS C:\Users\synth>
```

2. **Invalid Case:**



```
> & C:/Users/synth/AppData/Local/Programs/Python/Python38/python.exe c:/Users/synth/OneDrive/Documents/test_scrabble_score.py
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: app
Invalid word! Please enter a valid word from the dictionary.
.........
----------------------------------------------------------------------
Ran 9 tests in 1.017s

OK
PS C:\Users\synth>
```

After running the test cases, as expected all the test cases passed.

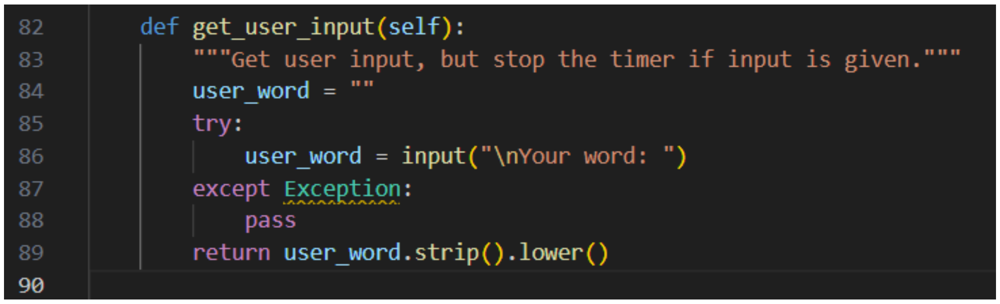
Step 6:

The final requirement is “The game will keep going:

i. Until the player quits the game and displays the total score of the player.
ii. After 10 rounds, compute the total score of the player.”

- Functional Code: To write the functional code for this requirement, we can consider the following things:
    i. The game will stop automatically after 10 rounds and the total score will be computed by summing up.
    ii. The total score will be calculated over the rounds and displayed at the end.

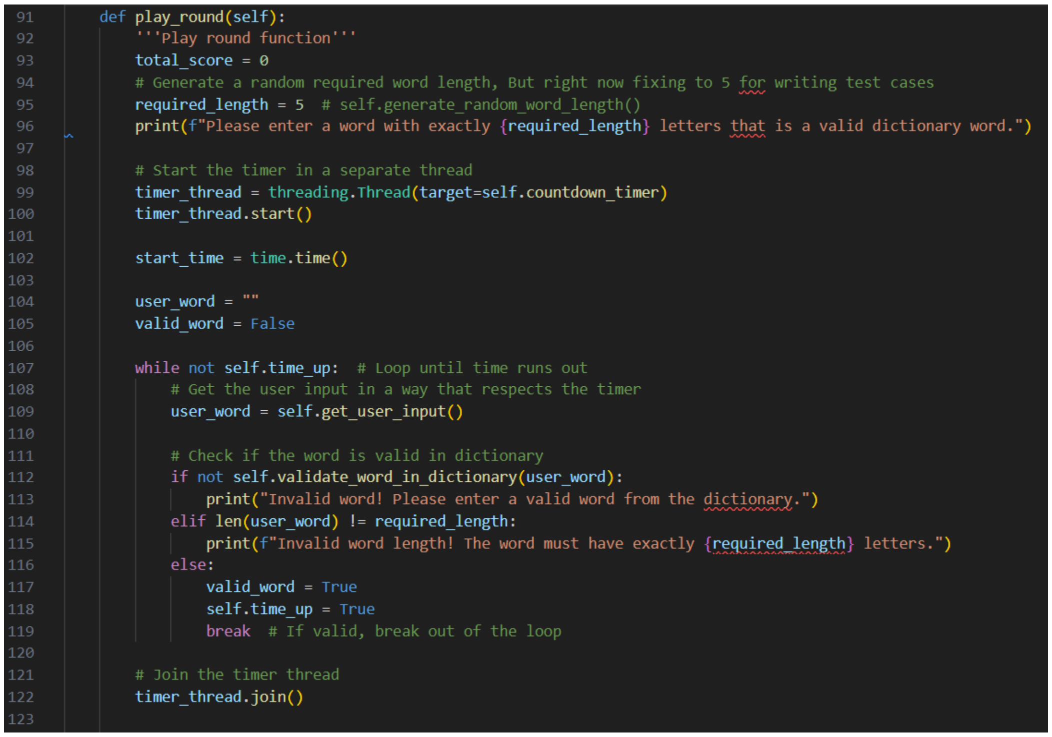
  So, now I am going to modify the code:



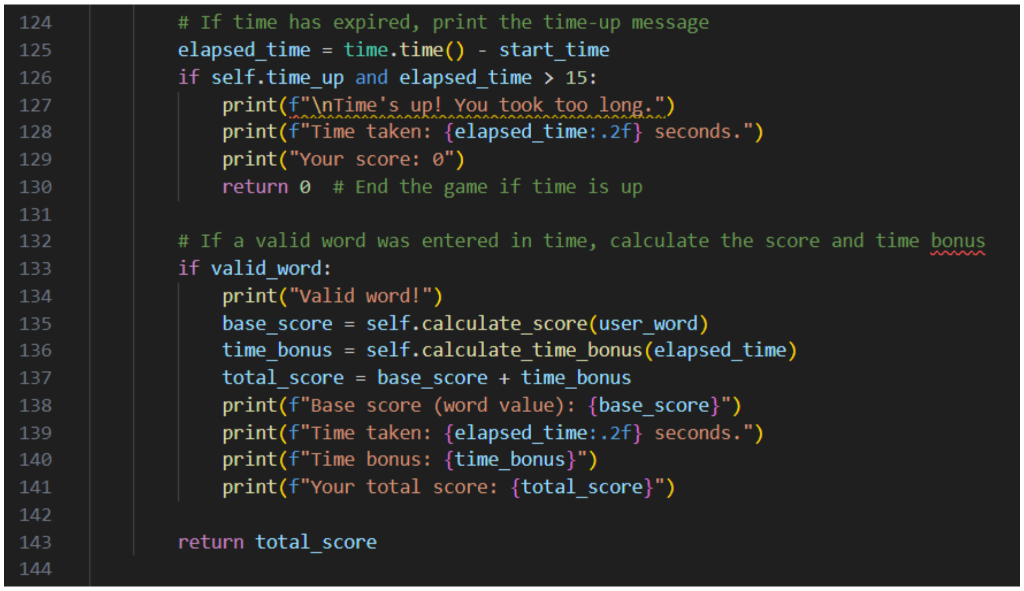
```python
    def get_user_input(self):
        """Get user input, but stop the timer if input is given."""
        user_word = ""
        try:
            user_word = input("\nYour word: ")
        except Exception:
            pass
        return user_word.strip().lower()

```

Here, I needed to remove self.time_up = True after taking input because if I set this flag as true after taking input immediately, then even after the word is invalid it will go to next round. So, rather I need to set this flag true after checking validation of this word in the dictionary for all the rounds functioning properly.

The below code is for one round:

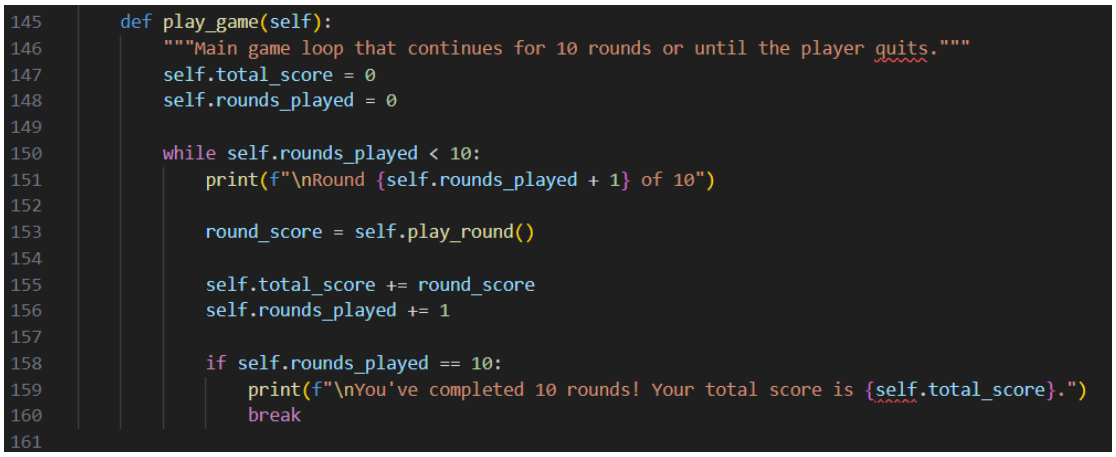


```python
    def play_round(self):
        '''Play round function'''
        total_score = 0
        # Generate a random required word length, But right now fixing to 5 for writing test cases
        required_length = 5  # self.generate_random_word_length()
        print(f"Please enter a word with exactly {required_length} letters that is a valid dictionary word.")

        # Start the timer in a separate thread
        timer_thread = threading.Thread(target=self.countdown_timer)
        timer_thread.start()

        start_time = time.time()

        user_word = ""
        valid_word = False

        while not self.time_up:  # Loop until time runs out
            # Get the user input in a way that respects the timer
            user_word = self.get_user_input()

            # Check if the word is valid in dictionary
            if not self.validate_word_in_dictionary(user_word):
                print("Invalid word! Please enter a valid word from the dictionary.")
            elif len(user_word) != required_length:
                print(f"Invalid word length! The word must have exactly {required_length} letters.")
            else:
                valid_word = True
                self.time_up = True
                break  # If valid, break out of the loop

        # Join the timer thread
        timer_thread.join()

```



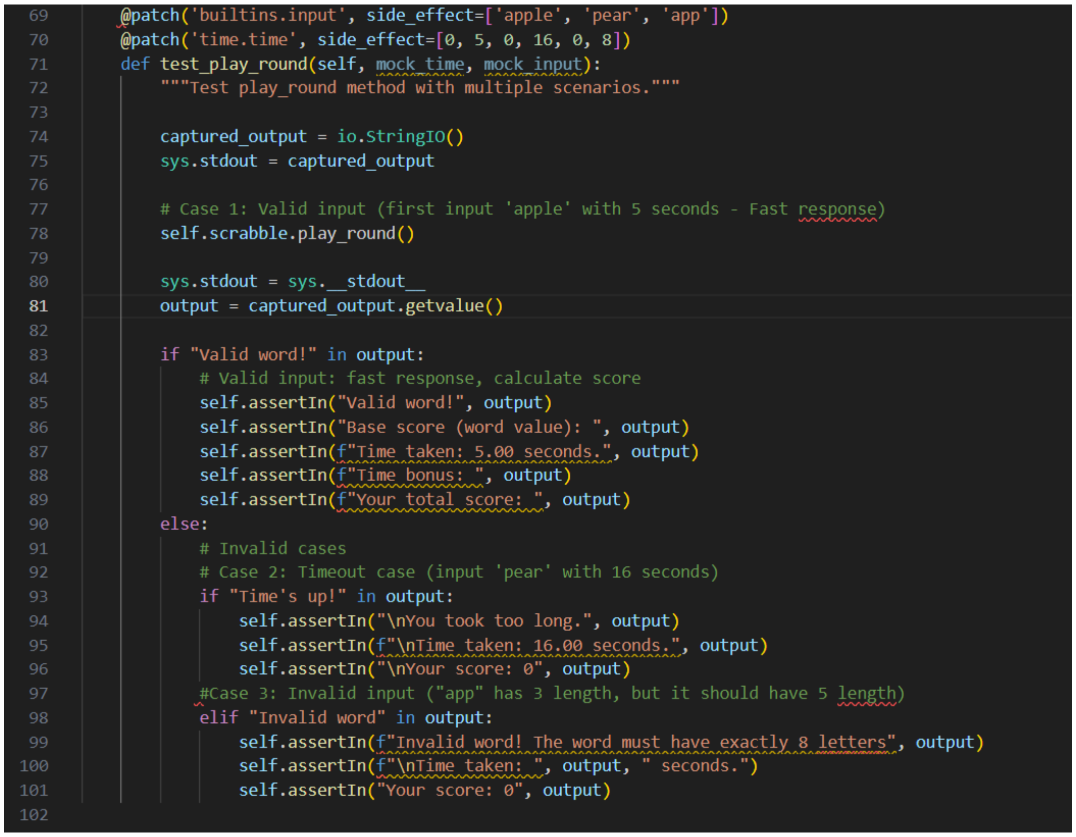
```python
        # If time has expired, print the time-up message
        elapsed_time = time.time() - start_time
        if self.time_up and elapsed_time > 15:
            print(f"\nTime's up! You took too long.")
            print(f"Time taken: {elapsed_time:.2f} seconds.")
            print("Your score: 0")
            return 0  # End the game if time is up

        # If a valid word was entered in time, calculate the score and time bonus
        if valid_word:
            print("Valid word!")
            base_score = self.calculate_score(user_word)
            time_bonus = self.calculate_time_bonus(elapsed_time)
            total_score = base_score + time_bonus
            print(f"Base score (word value): {base_score}")
            print(f"Time taken: {elapsed_time:.2f} seconds.")
            print(f"Time bonus: {time_bonus}")
            print(f"Your total score: {total_score}")

        return total_score

```

Now, I am writing the functional code for all ten rounds calling the above method:



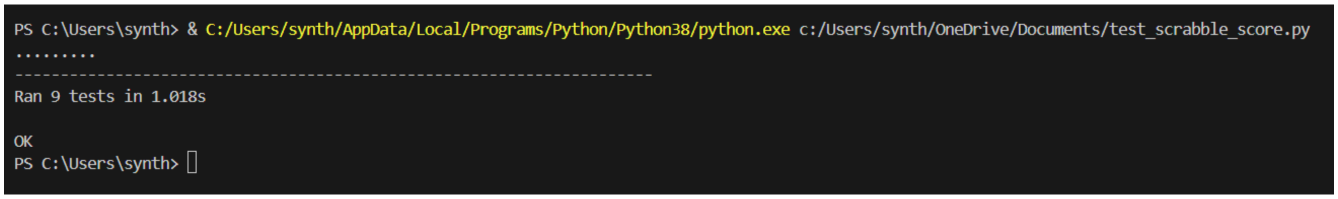
```python
    def play_game(self):
        """Main game loop that continues for 10 rounds or until the player quits."""
        self.total_score = 0
        self.rounds_played = 0

        while self.rounds_played < 10:
            print(f"\nRound {self.rounds_played + 1} of 10")

            round_score = self.play_round()

            self.total_score += round_score
            self.rounds_played += 1

            if self.rounds_played == 10:
                print(f"\nYou've completed 10 rounds! Your total score is {self.total_score}.")
                break

```

Unit Test Code: Since, it has multiple rounds and there can be multiple scenarios, unit test code cannot be written for "play_game" method due to limitations of multiple scenarios. That is why I only tested for one round game for "play_round" method.



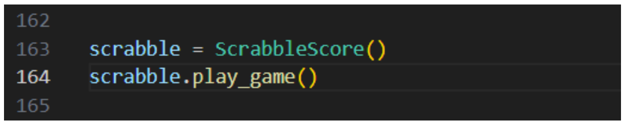
```python
    @patch('builtins.input', side_effect=['apple', 'pear', 'app'])
    @patch('time.time', side_effect=[0, 5, 0, 16, 0, 8])
    def test_play_round(self, mock_time, mock_input):
        """Test play_round method with multiple scenarios."""

        captured_output = io.StringIO()
        sys.stdout = captured_output

        # Case 1: Valid input (first input 'apple' with 5 seconds - Fast response)
        self.scrabble.play_round()

        sys.stdout = sys.__stdout__
        output = captured_output.getvalue()

        if "Valid word!" in output:
            # Valid input: fast response, calculate score
            self.assertIn("Valid word!", output)
            self.assertIn("Base score (word value): ", output)
            self.assertIn(f"Time taken: 5.00 seconds.", output)
            self.assertIn(f"Time bonus: ", output)
            self.assertIn(f"Your total score: ", output)
        else:
            # Invalid cases
            # Case 2: Timeout case (input 'pear' with 16 seconds)
            if "Time's up!" in output:
                self.assertIn("\nYou took too long.", output)
                self.assertIn(f"\nTime taken: 16.00 seconds.", output)
                self.assertIn("\nYour score: 0", output)
            #Case 3: Invalid input ("app" has 3 length, but it should have 5 length)
            elif "Invalid word" in output:
                self.assertIn(f"Invalid word! The word must have exactly 8 letters", output)
                self.assertIn(f"\nTime taken: ", output, " seconds.")
                self.assertIn("Your score: 0", output)
```

Unit Test Code (Passed) Output:



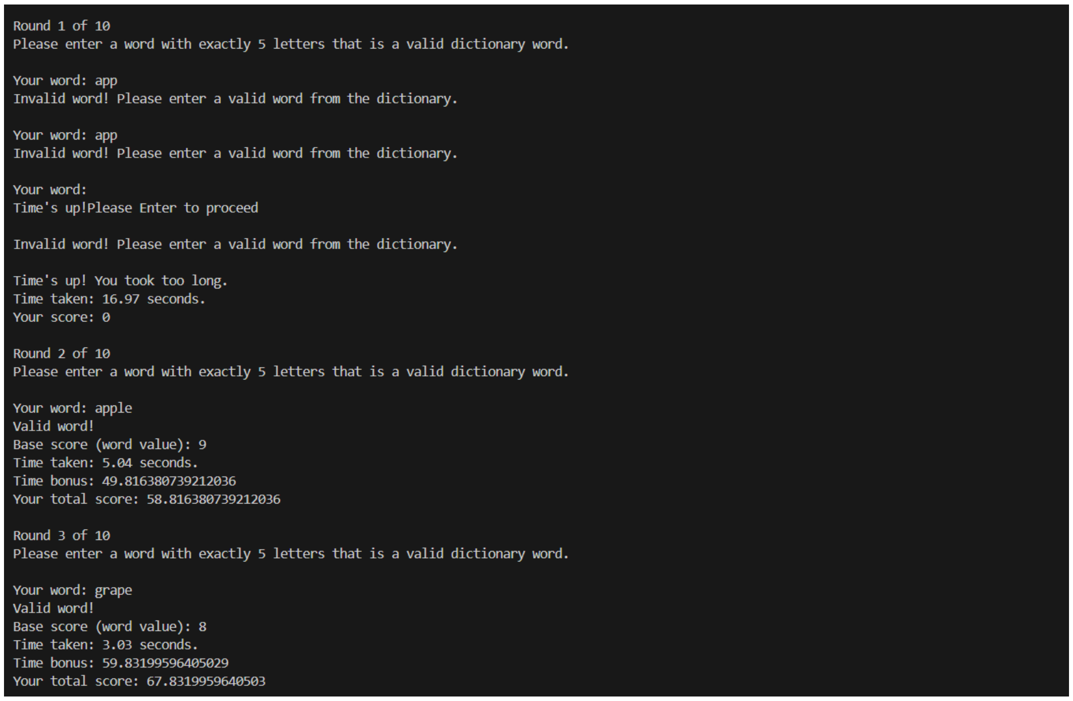
```
PS C:\Users\synth> & C:/Users/synth/AppData/Local/Programs/Python/Python38/python.exe c:/Users/synth/OneDrive/Documents/test_scrabble_score.py
.........
----------------------------------------------------------------------
Ran 9 tests in 1.018s

OK
PS C:\Users\synth> 
```

As my Test Driven Development is completed. Now I can run the functional code python file to play the game and check all the conditions and requirements that need to be satisfied. So let's play our Scrabble Score game to see the outputs and results by using the following code:

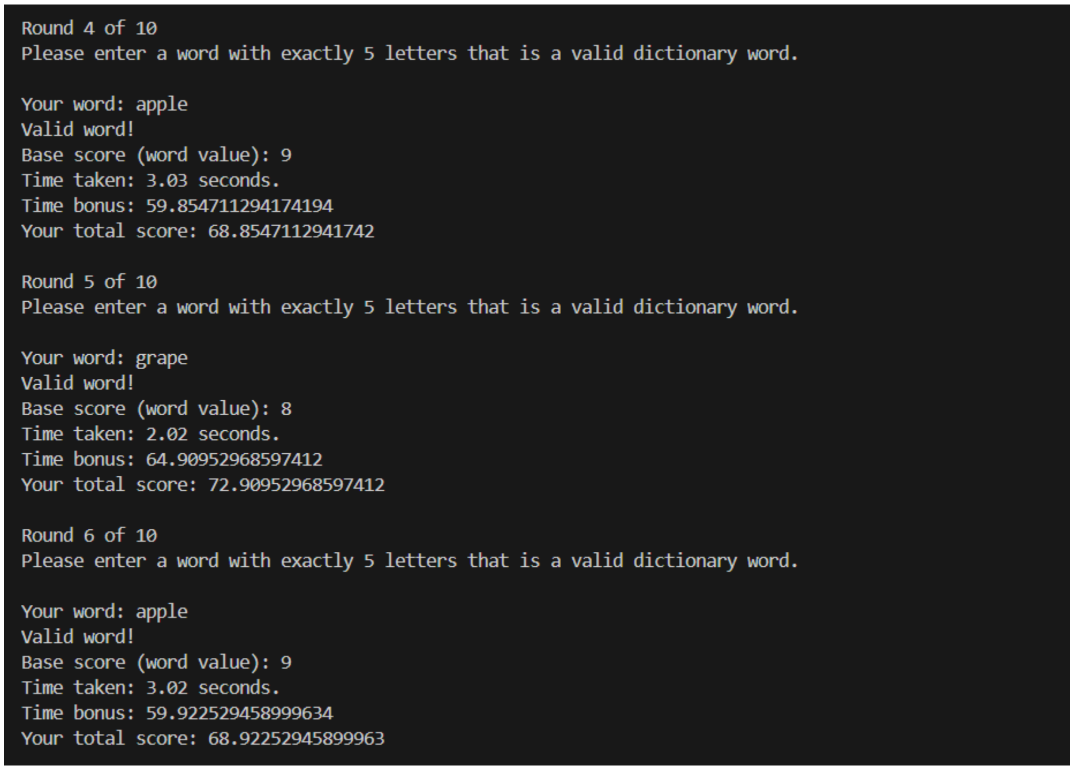


```python

scrabble = ScrabbleScore()
scrabble.play_game()

```

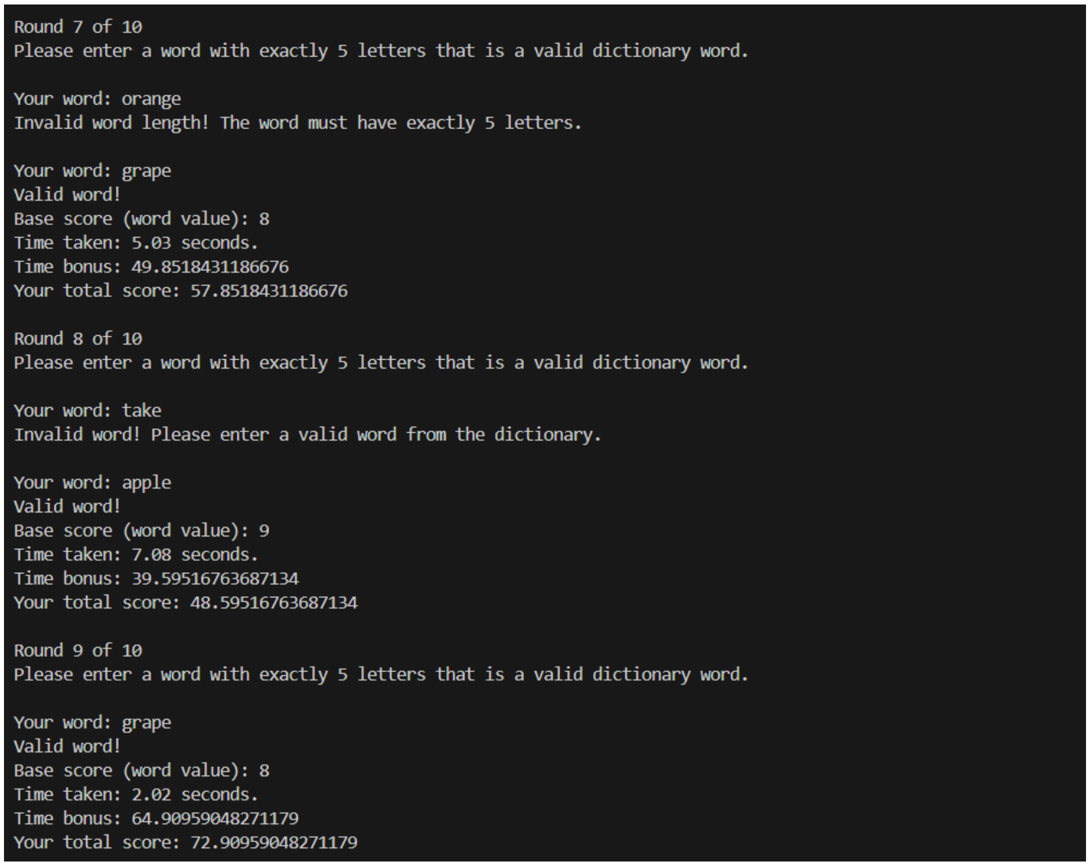
Result:



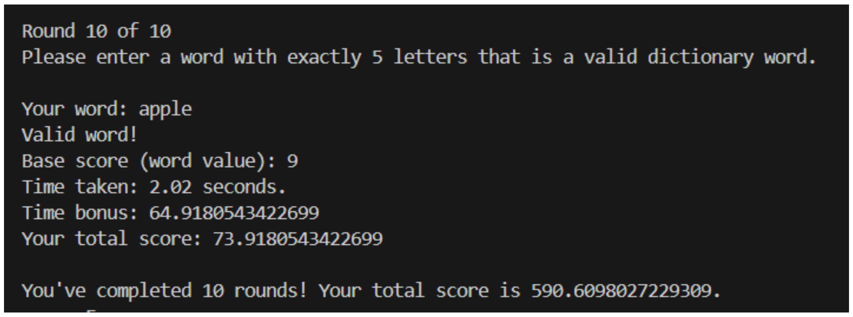
```
Round 1 of 10
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: app
Invalid word! Please enter a valid word from the dictionary.

Your word: app
Invalid word! Please enter a valid word from the dictionary.

Your word:
Time's up!Please Enter to proceed

Invalid word! Please enter a valid word from the dictionary.

Time's up! You took too long.
Time taken: 16.97 seconds.
Your score: 0

Round 2 of 10
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: apple
Valid word!
Base score (word value): 9
Time taken: 5.04 seconds.
Time bonus: 49.816380739212036
Your total score: 58.816380739212036

Round 3 of 10
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: grape
Valid word!
Base score (word value): 8
Time taken: 3.03 seconds.
Time bonus: 59.83199596405029
Your total score: 67.8319959640503
```



```
Round 4 of 10
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: apple
Valid word!
Base score (word value): 9
Time taken: 3.03 seconds.
Time bonus: 59.854711294174194
Your total score: 68.8547112941742

Round 5 of 10
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: grape
Valid word!
Base score (word value): 8
Time taken: 2.02 seconds.
Time bonus: 64.90952968597412
Your total score: 72.90952968597412

Round 6 of 10
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: apple
Valid word!
Base score (word value): 9
Time taken: 3.02 seconds.
Time bonus: 59.922529458999634
Your total score: 68.92252945899963
```



```
Round 7 of 10
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: orange
Invalid word length! The word must have exactly 5 letters.

Your word: grape
Valid word!
Base score (word value): 8
Time taken: 5.03 seconds.
Time bonus: 49.8518431186676
Your total score: 57.8518431186676

Round 8 of 10
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: take
Invalid word! Please enter a valid word from the dictionary.

Your word: apple
Valid word!
Base score (word value): 9
Time taken: 7.08 seconds.
Time bonus: 39.59516763687134
Your total score: 48.59516763687134

Round 9 of 10
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: grape
Valid word!
Base score (word value): 8
Time taken: 2.02 seconds.
Time bonus: 64.90959048271179
Your total score: 72.90959048271179
```



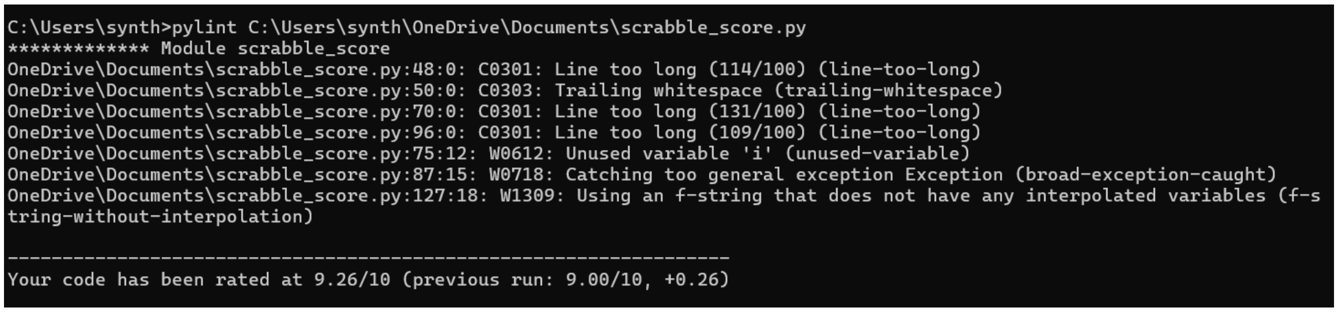
```
Round 10 of 10
Please enter a word with exactly 5 letters that is a valid dictionary word.

Your word: apple
Valid word!
Base score (word value): 9
Time taken: 2.02 seconds.
Time bonus: 64.9180543422699
Your total score: 73.9180543422699

You've completed 10 rounds! Your total score is 590.6098027229309.
```

After checking and conducting user acceptance tests several times, I have found that so far all the logic is working fine without any errors or exceptions, above is a sample game results/outputs given.

- **Analyzing code base for coding style and programming errors:**

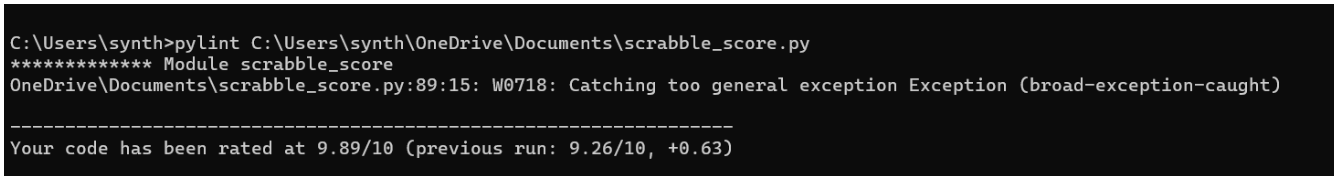
Now that development of my Scrabble game is done by following TDD, I am going to check my coding style for mistakes or programming errors that I may have made during my TDD process. So I have used the code analyzer Pylint and Flake8 libraries on my code base.

Pylint:



```
C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\scrabble_score.py
************* Module scrabble_score
OneDrive\Documents\scrabble_score.py:48:0: C0301: Line too long (114/100) (line-too-long)
OneDrive\Documents\scrabble_score.py:50:0: C0303: Trailing whitespace (trailing-whitespace)
OneDrive\Documents\scrabble_score.py:70:0: C0301: Line too long (131/100) (line-too-long)
OneDrive\Documents\scrabble_score.py:96:0: C0301: Line too long (109/100) (line-too-long)
OneDrive\Documents\scrabble_score.py:75:12: W0612: Unused variable 'i' (unused-variable)
OneDrive\Documents\scrabble_score.py:87:15: W0718: Catching too general exception Exception (broad-exception-caught)
OneDrive\Documents\scrabble_score.py:127:18: W1309: Using an f-string that does not have any interpolated variables (f-s
tring-without-interpolation)

------------------------------------------------------------------
Your code has been rated at 9.26/10 (previous run: 9.00/10, +0.26)
```

After running pylint against my functional code base, there are some minor improvements need to be fixed for some trailing whitespaces, long lines, using f-string, unused variables and catching too general exception. Let's fix that and run pylint again.

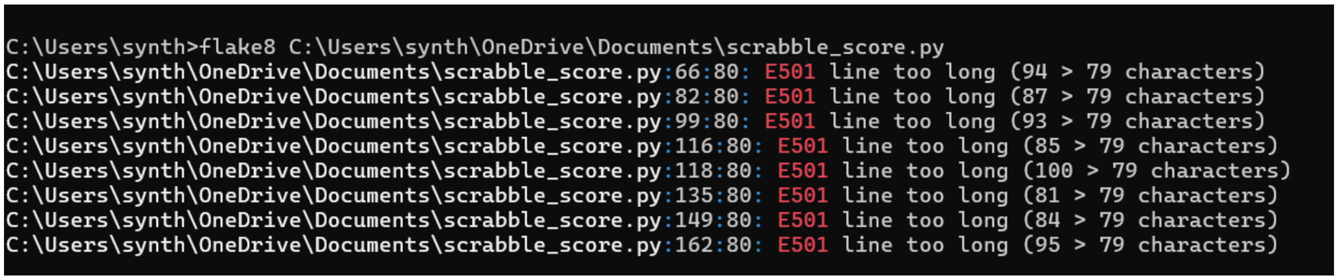


```
C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\scrabble_score.py
************* Module scrabble_score
OneDrive\Documents\scrabble_score.py:89:15: W0718: Catching too general exception Exception (broad-exception-caught)

------------------------------------------------------------------
Your code has been rated at 9.89/10 (previous run: 9.26/10, +0.63)
```

I can see that after fixing all these issues, the code base is rated at 9.89/10. But we cannot remove the warning of "Catching too general exception" while taking user input because if the exception is not pass, then code will be crashed, so rather it needs to be passed as invalid input when user will deliberately cancel the game. This is false positives after Pylint result. So, by keeping it, Pylint result is: 9.89/10, which is a very good result.

Next, I am going to run Flake8 to check the code base further.

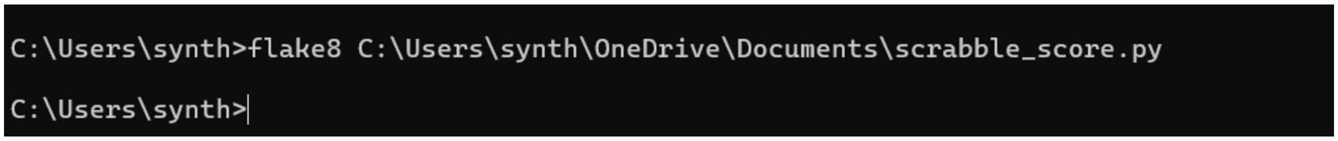
Flake8 output:



```
C:\Users\synth>flake8 C:\Users\synth\OneDrive\Documents\scrabble_score.py
C:\Users\synth\OneDrive\Documents\scrabble_score.py:66:80: E501 line too long (94 > 79 characters)
C:\Users\synth\OneDrive\Documents\scrabble_score.py:82:80: E501 line too long (87 > 79 characters)
C:\Users\synth\OneDrive\Documents\scrabble_score.py:99:80: E501 line too long (93 > 79 characters)
C:\Users\synth\OneDrive\Documents\scrabble_score.py:116:80: E501 line too long (85 > 79 characters)
C:\Users\synth\OneDrive\Documents\scrabble_score.py:118:80: E501 line too long (100 > 79 characters)
C:\Users\synth\OneDrive\Documents\scrabble_score.py:135:80: E501 line too long (81 > 79 characters)
C:\Users\synth\OneDrive\Documents\scrabble_score.py:149:80: E501 line too long (84 > 79 characters)
C:\Users\synth\OneDrive\Documents\scrabble_score.py:162:80: E501 line too long (95 > 79 characters)
```

Now, I am fixing the issues that flake8 captured.

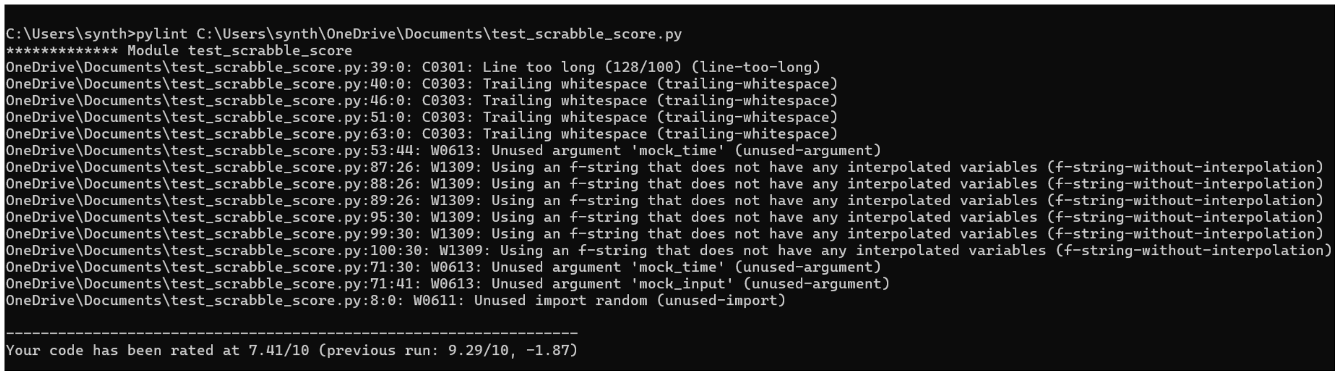
After fixing code flake8 output:



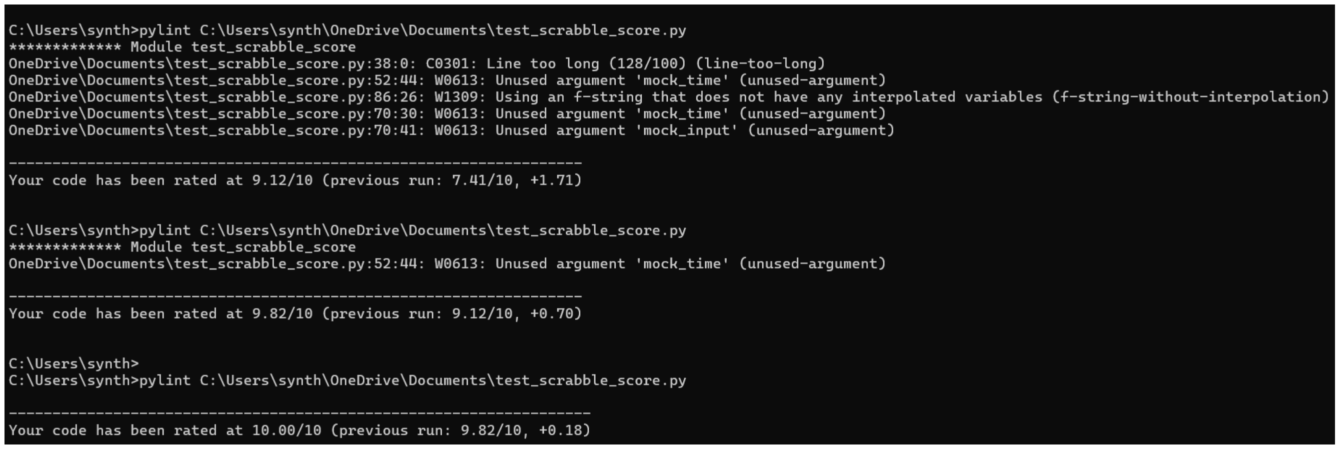
```
C:\Users\synth>flake8 C:\Users\synth\OneDrive\Documents\scrabble_score.py

C:\Users\synth>
```

- **Analyzing Unit Test Code Using Pylint and Flake8:**
  Now, I am going to check for the standard coding style and programming errors of my unittest code as well. So I did so and below are the results of pylint and flake8.

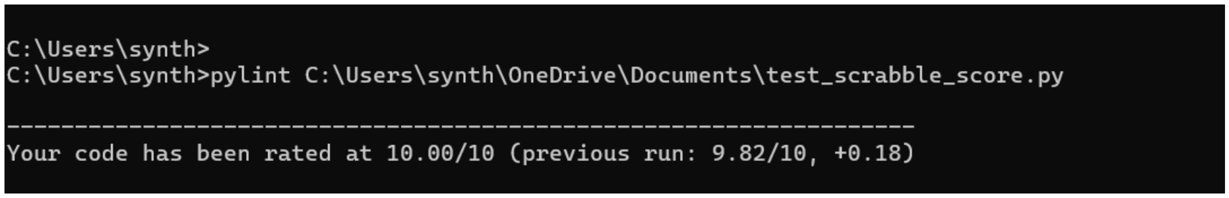
Pylint:



```
C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\test_scrabble_score.py
************* Module test_scrabble_score
OneDrive\Documents\test_scrabble_score.py:39:0: C0301: Line too long (128/100) (line-too-long)
OneDrive\Documents\test_scrabble_score.py:40:0: C0303: Trailing whitespace (trailing-whitespace)
OneDrive\Documents\test_scrabble_score.py:46:0: C0303: Trailing whitespace (trailing-whitespace)
OneDrive\Documents\test_scrabble_score.py:51:0: C0303: Trailing whitespace (trailing-whitespace)
OneDrive\Documents\test_scrabble_score.py:63:0: C0303: Trailing whitespace (trailing-whitespace)
OneDrive\Documents\test_scrabble_score.py:53:44: W0613: Unused argument 'mock_time' (unused-argument)
OneDrive\Documents\test_scrabble_score.py:87:26: W1309: Using an f-string that does not have any interpolated variables (f-string-without-interpolation)
OneDrive\Documents\test_scrabble_score.py:88:26: W1309: Using an f-string that does not have any interpolated variables (f-string-without-interpolation)
OneDrive\Documents\test_scrabble_score.py:89:26: W1309: Using an f-string that does not have any interpolated variables (f-string-without-interpolation)
OneDrive\Documents\test_scrabble_score.py:95:30: W1309: Using an f-string that does not have any interpolated variables (f-string-without-interpolation)
OneDrive\Documents\test_scrabble_score.py:99:30: W1309: Using an f-string that does not have any interpolated variables (f-string-without-interpolation)
OneDrive\Documents\test_scrabble_score.py:100:30: W1309: Using an f-string that does not have any interpolated variables (f-string-without-interpolation)
OneDrive\Documents\test_scrabble_score.py:71:30: W0613: Unused argument 'mock_time' (unused-argument)
OneDrive\Documents\test_scrabble_score.py:71:41: W0613: Unused argument 'mock_input' (unused-argument)
OneDrive\Documents\test_scrabble_score.py:8:0: W0611: Unused import random (unused-import)

------------------------------------------------------------------
Your code has been rated at 7.41/10 (previous run: 9.29/10, -1.87)
```

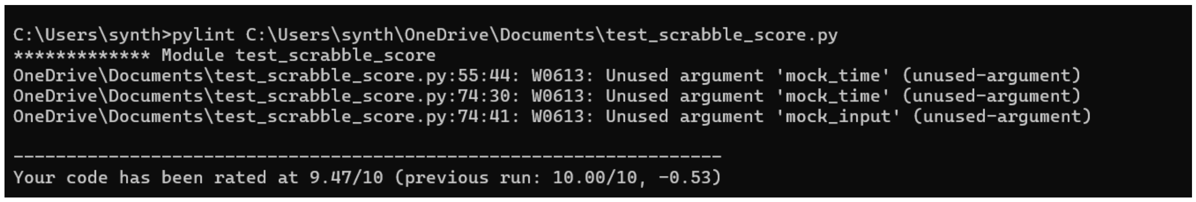


```
C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\test_scrabble_score.py
************* Module test_scrabble_score
OneDrive\Documents\test_scrabble_score.py:38:0: C0301: Line too long (128/100) (line-too-long)
OneDrive\Documents\test_scrabble_score.py:52:44: W0613: Unused argument 'mock_time' (unused-argument)
OneDrive\Documents\test_scrabble_score.py:86:26: W1309: Using an f-string that does not have any interpolated variables (f-string-without-interpolation)
OneDrive\Documents\test_scrabble_score.py:70:30: W0613: Unused argument 'mock_time' (unused-argument)
OneDrive\Documents\test_scrabble_score.py:70:41: W0613: Unused argument 'mock_input' (unused-argument)

------------------------------------------------------------------
Your code has been rated at 9.12/10 (previous run: 7.41/10, +1.71)


C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\test_scrabble_score.py
************* Module test_scrabble_score
OneDrive\Documents\test_scrabble_score.py:52:44: W0613: Unused argument 'mock_time' (unused-argument)

------------------------------------------------------------------
Your code has been rated at 9.82/10 (previous run: 9.12/10, +0.70)


C:\Users\synth>
C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\test_scrabble_score.py

-------------------------------------------------------------------
Your code has been rated at 10.00/10 (previous run: 9.82/10, +0.18)
```



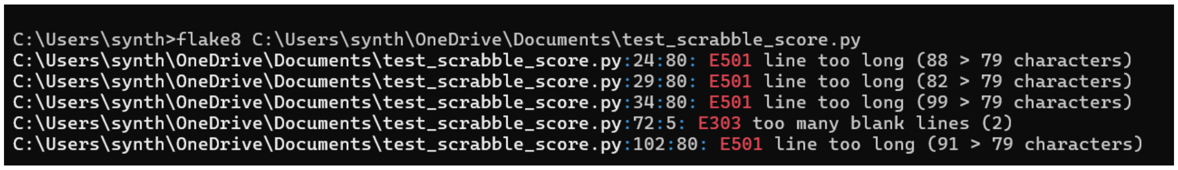
```
C:\Users\synth>
C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\test_scrabble_score.py

-------------------------------------------------------------------
Your code has been rated at 10.00/10 (previous run: 9.82/10, +0.18)
```

But If we remove “mock_time” and “mock_input”, test case will not be run properly as they are internally used. It seems these Pylint warnings are false positives due to mock test limitation. So, by keeping these, the pylint result is 9.47/10, which is a very good result:



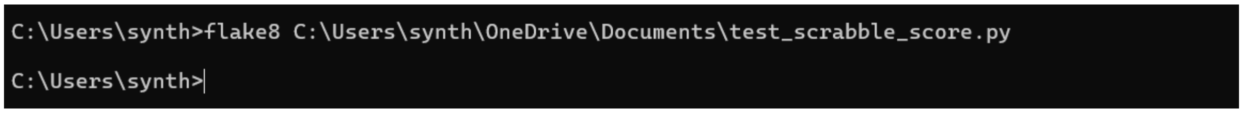
```
C:\Users\synth>pylint C:\Users\synth\OneDrive\Documents\test_scrabble_score.py
************* Module test_scrabble_score
OneDrive\Documents\test_scrabble_score.py:55:44: W0613: Unused argument 'mock_time' (unused-argument)
OneDrive\Documents\test_scrabble_score.py:74:30: W0613: Unused argument 'mock_time' (unused-argument)
OneDrive\Documents\test_scrabble_score.py:74:41: W0613: Unused argument 'mock_input' (unused-argument)

-------------------------------------------------------------------
Your code has been rated at 9.47/10 (previous run: 10.00/10, -0.53)
```

flake8:



```
C:\Users\synth>flake8 C:\Users\synth\OneDrive\Documents\test_scrabble_score.py
C:\Users\synth\OneDrive\Documents\test_scrabble_score.py:24:80: E501 line too long (88 > 79 characters)
C:\Users\synth\OneDrive\Documents\test_scrabble_score.py:29:80: E501 line too long (82 > 79 characters)
C:\Users\synth\OneDrive\Documents\test_scrabble_score.py:34:80: E501 line too long (99 > 79 characters)
C:\Users\synth\OneDrive\Documents\test_scrabble_score.py:72:5: E303 too many blank lines (2)
C:\Users\synth\OneDrive\Documents\test_scrabble_score.py:102:80: E501 line too long (91 > 79 characters)
```

After fixing flake8 issues, the result is:



```
C:\Users\synth>flake8 C:\Users\synth\OneDrive\Documents\test_scrabble_score.py

C:\Users\synth>
```

Conclusion:

The main benefit of the TDD approach that I experienced during my development process is fewer bugs, defects and errors in my code because testing first enabled me to evaluate my system and its components with the intent to find whether it satisfies the specified requirements or not. So, at the end of the development of my software, my code has fewer bugs, and as a result, I spent less time fixing them than other programming methodologies that are not test-driven. Finally, TDD allowed me to produce a higher overall test coverage, and therefore, I was able to develop a better-quality final product.

GitHub link: https://github.com/synthia26/PRT582-Software-Process