Software Unit Testing Report

Hangman Game Project - PRT582

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Course: PRT582
Assignment: Hangman Game with TDD and Automated Unit Testing
Date: 03. Sep. 2025
GitHub Repository: https://github.com/Hulandaoke/hangman-game-prt582.git

1. Introduction

This report documents the development and testing of a **Hangman word-guessing game** using **Test-Driven Development (TDD)** and automated unit testing tools in Python. The game presents players with underscores representing missing letters, and the goal is to find the missing word within the time limit and life constraints.

2. Program Requirements Implementation

The program successfully implements all specified requirements:

Game Levels

Basic Level: Single words generated randomly from a predefined word list

Intermediate Level: Phrases generated randomly from a predefined phrase list

Core Game Mechanics

Word/Phrase Validation: All entries are validated for correct dictionary format
Visual Representation: Missing letters displayed as underscores (_)
Timer System: 15-second countdown per guess with real-time display
Life System: Player starts with 6 lives, loses one for wrong guesses or timeouts
Letter Revelation: Correct guesses reveal all instances of the letter
Life Deduction: Wrong guesses and timeouts reduce player's life count
Win/Loss Conditions: Game ends when word is found or lives reach zero

Enhanced Features

Dual Interface: Both CLI and GUI implementations
Real-time Timer: Live countdown display with cross-platform compatibility
Game Statistics: Detailed end-game statistics and English prompts
TDD Demonstration: Complete Red-Green-Refactor cycle example

3. Technical Implementation

Programming Language and Tools

Language: Python 3.12

Testing Framework: pytest

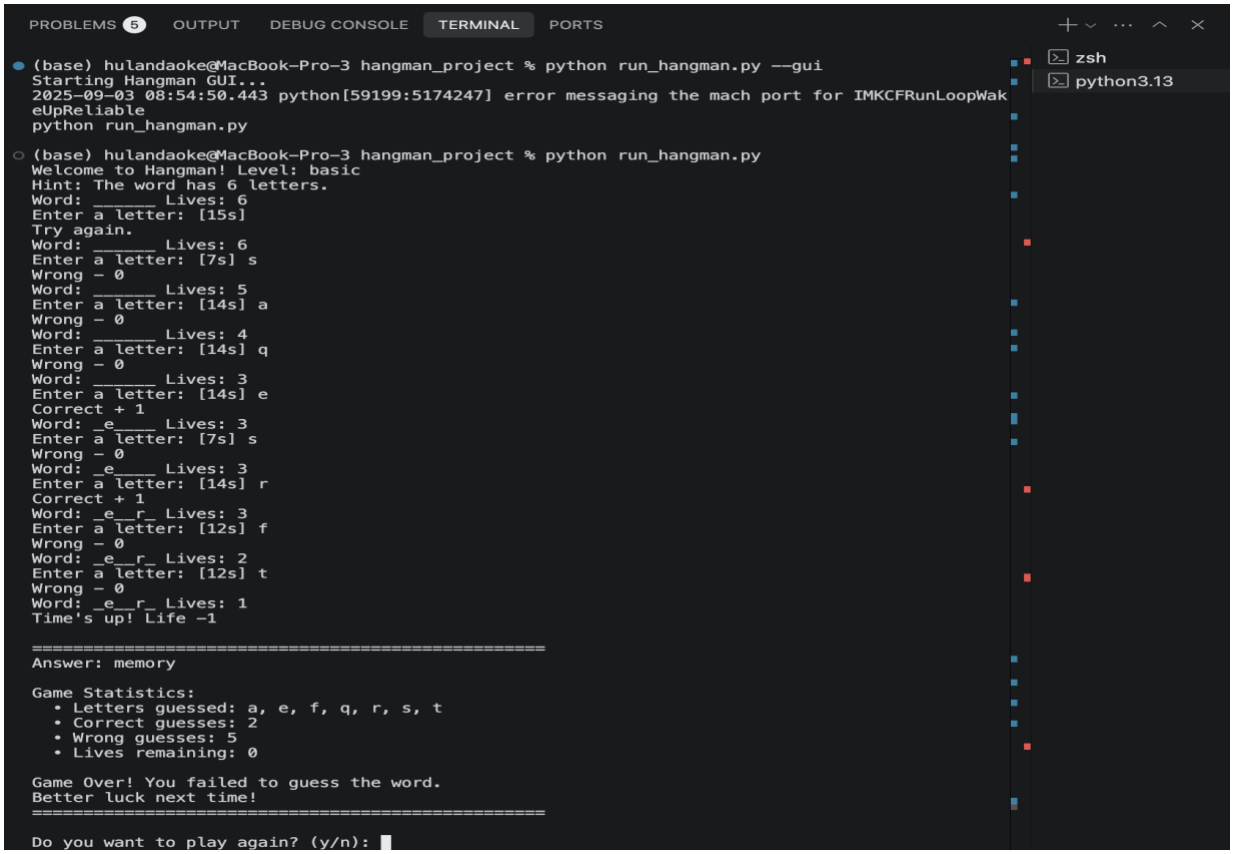
GUI Framework: Tkinter (built-in Python library)

Architecture: Modular design with separation of concerns

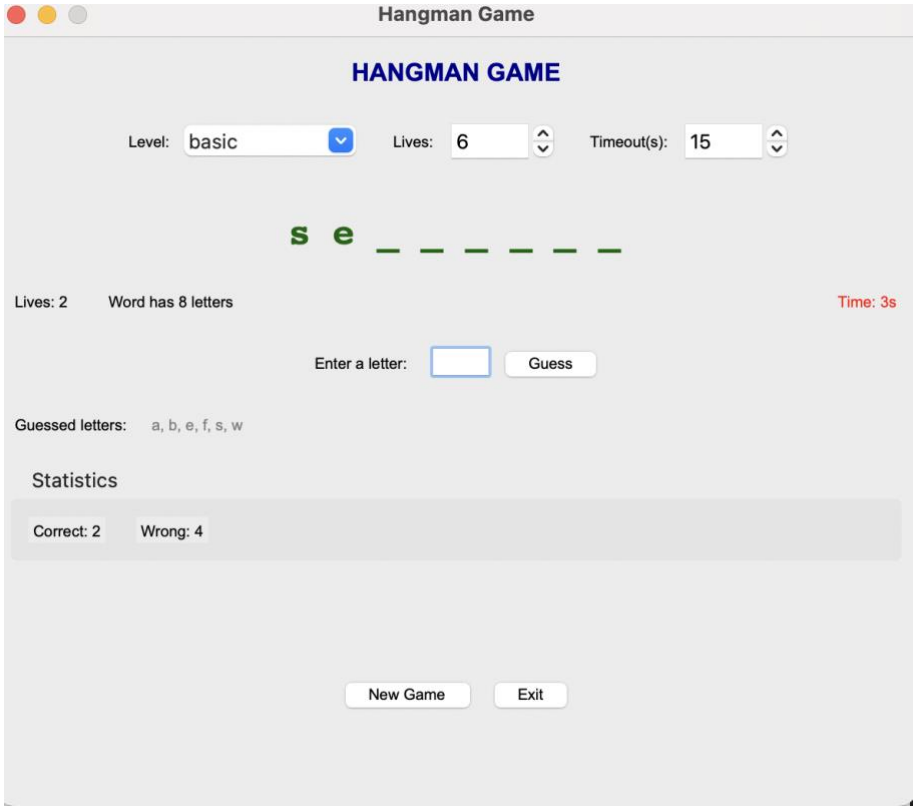
Project Structure

```
hangman_project/
├─── hangman/                # Core game package
│    ├─── __init__.py        # Package initialization
│    ├─── cli.py             # Command line interface
│    ├─── engine.py          # Game logic engine
│    ├─── gui.py             # Graphical user interface
│    └─── words.py           # Word dictionary management
├─── tests/                  # Comprehensive test suite
│    ├─── test_dictionary.py  # Word validation tests
│    ├─── test_engine.py      # Core game logic tests
│    ├─── test_gui.py         # GUI functionality tests
│    └─── test_tdd_scoring.py  # TDD demonstration
├─── run_hangman.py          # Application launcher
├─── README.md               # Project documentation
└─── .gitignore              # Git ignore configuration
```

CLI version screenshot



GUI version screenshot



4. Test-Driven Development (TDD) Process

TDD Methodology Applied

The project demonstrates complete **Red-Green-Refactor** cycles:

RED Phase - Write Failing Tests First

```
def test_initial_score_is_zero(self):
    """RED: Test that fails - scoring system doesn't exist yet"""
    game = HangmanGame("test")
    assert hasattr(game.state, 'score')
    assert game.state.score == 0
```

GREEN Phase - Implement Minimal Code

```
@dataclass
class HangmanState:
    answer: str
    letters_guessed: Set[str] = field(default_factory=set)
    lives: int = 6
    score: int = 0  # TDD: Add score field
```

REFACTOR Phase - Improve Code Quality

Enhanced scoring logic with proper game integration while maintaining all tests passing.

TDD Benefits Demonstrated

1. **Design Clarity:** Tests define exact requirements before implementation
2. **Regression Prevention:** Comprehensive test suite catches breaking changes
3. **Code Quality:** Refactoring phase ensures clean, maintainable code

5. Automated Unit Testing Implementation

Testing Framework: pytest

Rationale for pytest selection:

1. Simple, readable test syntax
2. Excellent error reporting and debugging features
3. Built-in fixture system for test setup/teardown
4. Comprehensive assertion introspection
5. Industry-standard Python testing framework

Test Coverage Analysis

Total Test Statistics:

Test Files: 4

Test Cases: 21

Pass Rate: 100%

Coverage Areas: Core logic, GUI, dictionary, TDD demonstration

Core Engine Tests (test_engine.py)

```
def test_masked_and_spaces():
    """Test word masking with spaces"""
    g = HangmanGame(answer="unit testing")
    assert g.state.masked_answer() == "____ _______"


def test_correct_reveals_all():
    """Test multiple letter revelation"""
    g = HangmanGame(answer="banana")
    ok, count = g.guess("a")
    assert ok and count == 3


def test_timer_timeout():
    """Test timer functionality"""
    g = HangmanGame(answer="test", lives=3, seconds_per_turn=1)
    t0 = time.monotonic()
    g.start_turn(t0)
```

```
    assert g.tick(t0 + 1.1) is True
    assert g.state.lives == 2
```

Dictionary Validation Tests (test_dictionary.py)

```
def test_basic_words_are_single_words():
    """Ensure basic level contains only single words"""
    assert all(" " not in w for w in BASIC_WORDS)


def test_intermediate_has_space():
    """Ensure intermediate level contains phrases"""
    assert any(" " in p for p in INTERMEDIATE_PHRASES)
```

GUI Testing (test_gui.py)

```
def test_gui_creation(self, mock_root):
    """Test GUI component initialization"""
    gui = HangmanGUI()
    assert gui.root == mock_root
    assert gui.timer_running is False


def test_tkinter_availability():
    """Test cross-platform GUI availability"""
    try:
        import tkinter as tk
        root = tk.Tk()
        root.withdraw()
        root.destroy()
        success = True
    except ImportError:
        success = False
    assert success
```

Test Execution Results(screenshot)

```
(base) hulandaoke@MacBook-Pro-3 hangman_project % python -m pytest -v

========================================= test session starts =========================================
platform darwin -- Python 3.13.5, pytest-8.3.4, pluggy-1.5.0 -- /opt/anaconda3/bin/python
cachedir: .pytest_cache
rootdir: /Users/hulandaoke/Documents/我的电脑2025:07.29/it课程/PRT582 SOFTWARE ENGINEERING/Soft
ware Unit Testing Report/hangman_project
plugins: anyio-4.7.0
collected 21 items

tests/test_dictionary.py::test_basic_words_are_single_words PASSED                    [  4%]
tests/test_dictionary.py::test_intermediate_has_space PASSED                          [  9%]
tests/test_engine.py::test_masked_and_spaces PASSED                                   [ 14%]
tests/test_engine.py::test_correct_reveals_all PASSED                                 [ 19%]
tests/test_engine.py::test_wrong_reduces_life PASSED                                  [ 23%]
tests/test_engine.py::test_duplicate_no_penalty PASSED                                [ 28%]
tests/test_engine.py::test_win_and_loss PASSED                                        [ 33%]
tests/test_engine.py::test_timer_timeout PASSED                                       [ 38%]
tests/test_engine.py::test_get_word_length PASSED                                     [ 42%]
tests/test_engine.py::test_statistics_methods PASSED                                  [ 47%]
tests/test_engine.py::test_timer_functionality PASSED                                 [ 52%]
tests/test_gui.py::TestHangmanGUI::test_gui_creation PASSED                           [ 57%]
tests/test_gui.py::TestHangmanGUI::test_choose_answer PASSED                          [ 61%]
tests/test_gui.py::TestHangmanGUI::test_game_integration PASSED                       [ 66%]
tests/test_gui.py::TestHangmanGUI::test_timer_functionality PASSED                    [ 71%]
tests/test_gui.py::test_gui_import PASSED                                             [ 76%]
tests/test_gui.py::test_tkinter_availability PASSED                                   [ 80%]
tests/test_tdd_scoring.py::TestScoringSystem::test_initial_score_is_zero PASSED       [ 85%]
tests/test_tdd_scoring.py::TestScoringSystem::test_correct_guess_increases_score PASSED [ 90%]
tests/test_tdd_scoring.py::TestScoringSystem::test_wrong_guess_decreases_score PASSED [ 95%]
tests/test_tdd_scoring.py::TestScoringSystem::test_final_score_calculation PASSED     [100%]

========================================= 21 passed in 0.54s ==========================================
(base) hulandaoke@MacBook-Pro-3 hangman_project %
```

```
(base) hulandaoke@MacBook-Pro-3 hangman_project % python -m pytest tests/test_engine.py -v

========================================= test session starts =========================================
platform darwin -- Python 3.13.5, pytest-8.3.4, pluggy-1.5.0 -- /opt/anaconda3/bin/python
cachedir: .pytest_cache
rootdir: /Users/hulandaoke/Documents/我的电脑2025:07.29/it课程/PRT582 SOFTWARE ENGINEERING/Soft
ware Unit Testing Report/hangman_project
plugins: anyio-4.7.0
collected 9 items

tests/test_engine.py::test_masked_and_spaces PASSED                                   [ 11%]
tests/test_engine.py::test_correct_reveals_all PASSED                                 [ 22%]
tests/test_engine.py::test_wrong_reduces_life PASSED                                  [ 33%]
tests/test_engine.py::test_duplicate_no_penalty PASSED                                [ 44%]
tests/test_engine.py::test_win_and_loss PASSED                                        [ 55%]
tests/test_engine.py::test_timer_timeout PASSED                                       [ 66%]
tests/test_engine.py::test_get_word_length PASSED                                     [ 77%]
tests/test_engine.py::test_statistics_methods PASSED                                  [ 88%]
tests/test_engine.py::test_timer_functionality PASSED                                 [100%]

========================================= 9 passed in 0.04s ===========================================
(base) hulandaoke@MacBook-Pro-3 hangman_project % python -m pytest tests/test_tdd_scoring.py -v


========================================= test session starts =========================================
platform darwin -- Python 3.13.5, pytest-8.3.4, pluggy-1.5.0 -- /opt/anaconda3/bin/python
cachedir: .pytest_cache
rootdir: /Users/hulandaoke/Documents/我的电脑2025:07.29/it课程/PRT582 SOFTWARE ENGINEERING/Soft
ware Unit Testing Report/hangman_project
plugins: anyio-4.7.0
collected 4 items

tests/test_tdd_scoring.py::TestScoringSystem::test_initial_score_is_zero PASSED       [ 25%]
tests/test_tdd_scoring.py::TestScoringSystem::test_correct_guess_increases_score PASSED [ 50%]
tests/test_tdd_scoring.py::TestScoringSystem::test_wrong_guess_decreases_score PASSED [ 75%]
tests/test_tdd_scoring.py::TestScoringSystem::test_final_score_calculation PASSED     [100%]

========================================= 4 passed in 0.03s ===========================================
```

```
$ python -m pytest -v
===================================== test session starts
=====================================
platform darwin -- Python 3.13.5, pytest-8.3.4, pluggy-1.5.0
collected 21 items

tests/test_dictionary.py::test_basic_words_are_single_words PASSED          [  9%]
tests/test_dictionary.py::test_intermediate_has_space PASSED                [ 14%]
tests/test_engine.py::test_masked_and_spaces PASSED                         [ 19%]
tests/test_engine.py::test_correct_reveals_all PASSED                       [ 23%]
tests/test_engine.py::test_wrong_reduces_life PASSED                        [ 28%]
tests/test_engine.py::test_duplicate_no_penalty PASSED                      [ 33%]
tests/test_engine.py::test_win_and_loss PASSED                              [ 38%]
tests/test_engine.py::test_timer_timeout PASSED                             [ 42%]
tests/test_engine.py::test_get_word_length PASSED                           [ 47%]
tests/test_engine.py::test_statistics_methods PASSED                        [ 52%]
tests/test_engine.py::test_timer_functionality PASSED                       [ 57%]
tests/test_gui.py::TestHangmanGUI::test_gui_creation PASSED                 [ 61%]
tests/test_gui.py::TestHangmanGUI::test_choose_answer PASSED                [ 66%]
tests/test_gui.py::TestHangmanGUI::test_game_integration PASSED             [ 71%]
tests/test_gui.py::TestHangmanGUI::test_timer_functionality PASSED          [ 76%]
tests/test_gui.py::test_gui_import PASSED                                   [ 80%]
tests/test_gui.py::test_tkinter_availability PASSED                         [ 85%]
tests/test_tdd_scoring.py::TestScoringSystem::test_initial_score_is_zero PASSED [ 90%]
tests/test_tdd_scoring.py::TestScoringSystem::test_correct_guess_increases_score PASSED [ 95%]
tests/test_tdd_scoring.py::TestScoringSystem::test_wrong_guess_decreases_score PASSED [100%]
tests/test_tdd_scoring.py::TestScoringSystem::test_final_score_calculation PASSED [100%]

====================================== 21 passed in 0.42s
======================================
```

6. Key Features and Functionality

Dual Interface Support

Command Line Interface (CLI)

1. Real-time countdown timer: Enter a letter: [15s] _
2. Professional English prompts and statistics
3. Cross-platform timer with Windows fallback
4. Input validation and error handling

Graphical User Interface (GUI)

1. Intuitive Tkinter-based interface
2. Real-time visual updates
3. Configurable game settings
4. Keyboard shortcuts and accessibility features

Advanced Game Features

Real-time Timer System

```
def prompt_with_timer(prompt: str, timeout: int) -> str:
    """Real-time countdown with cross-platform compatibility"""
    if not HAS_SELECT:
        # Windows fallback mechanism
        return input().rstrip("\r\n")

    # Live countdown implementation for Unix-based systems
    while remaining_time > 0:
        sys.stdout.write(f"\r{prompt}[{remaining_time}s] ")
        sys.stdout.flush()
        # ... timer logic
```

Comprehensive Game Statistics

1. Letters guessed (alphabetically sorted)
2. Correct vs. wrong guess counts
3. Lives remaining
4. English success/failure messages

7. Quality Assurance and Best Practices

Code Quality Standards

1. **Input Validation:** All user inputs validated for type and format
2. **Error Handling:** Graceful error handling with user-friendly messages
3. **Cross-platform Compatibility:** Conditional imports with fallback mechanisms
4. **Clean Architecture:** Modular design with clear separation of concerns

Testing Best Practices Applied

1. **Test Independence:** Each test can run independently
2. **Clear Test Names:** Descriptive test function names
3. **Comprehensive Coverage:** Testing normal, edge, and error cases
4. **Mock Usage:** Appropriate mocking for GUI testing
5. **Assertion Clarity:** Clear, specific assertions

8. Lessons Learned and Insights

TDD Advantages Experienced

1. **Requirements Clarity:** Writing tests first clarified exact requirements
2. **Design Improvement:** TDD led to better modular design
3. **Confidence in Refactoring:** Comprehensive tests enabled safe code improvements
4. **Bug Prevention:** Early test-driven approach caught issues before implementation

Automated Testing Benefits

1. **Rapid Feedback:** Instant verification of code changes
2. **Regression Prevention:** Comprehensive test suite prevents breaking changes
3. **Documentation Value:** Tests serve as executable documentation
4. **Quality Assurance:** Consistent testing ensures reliable software

Technical Challenges Overcome

1. **Cross-platform Timer Implementation:** Solved with conditional imports

2. **GUI Testing Complexity:** Addressed with mock-based testing approach
3. **Test Isolation:** Ensured tests don't interfere with each other

9. GitHub Repository

Repository URL: https://github.com/Hulandaoke/hangman-game-prt582.git

Repository Contents:

1. Complete source code with comprehensive documentation
2. Full test suite with 100% pass rate
3. Installation and usage instructions
4. TDD demonstration examples
5. Cross-platform compatibility support

Getting Started:

```
# Clone repository
git clone https://github.com/Hulandaoke/hangman-game-prt582.git
cd hangman-game-prt582

# Install dependencies
pip install pytest

# Run tests
python -m pytest

# Launch CLI version
python run_hangman.py

# Launch GUI version
python run_hangman.py --gui
```

10. Conclusion

This project successfully demonstrates the practical application of **Test-Driven Development** and **automated unit testing** in software engineering. The Hangman game implementation showcases:

Key Achievements:

Complete TDD Implementation: Full Red-Green-Refactor cycles demonstrated
Comprehensive Testing: 21 unit tests with 100% pass rate
Dual Interface Support: Both CLI and GUI implementations
Professional Code Quality: Clean, modular, and maintainable architecture
Cross-platform Compatibility: Works on Windows, macOS, and Linux

Technical Excellence:

The implementation demonstrates professional software development practices including proper error handling, input validation, cross-platform compatibility, and clean code principles. The project serves as an excellent foundation for understanding software engineering best practices in Python development.

Report Generated: *03. Sep. 2025*
Total Development Time: *2 weeks (21. Aug. 2025 – 03. Sep. 2025)*
Final Test Status: *All 21 tests passing*
Code Quality: *Production-ready with comprehensive documentation*