**Software Unit Testing Report**

**Hangman — TDD Python**

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Course: PRT582 Software Unit Testing

Date: 2025-09-05

# 1. Introduction

This report documents the design, implementation, and testing of a Hangman game written in Python using Test-Driven Development (TDD). The objective was to produce a reliable, well-tested command-line game that supports two modes: a Basic single-word mode and an Intermediate phrase mode. The project emphasizes separation of concerns: the game engine contains pure logic and is fully unit-testable, whereas the command-line interface handles input, timing, and display. The development approach followed the red-green-refactor cycle to ensure that every feature had corresponding automated tests and that regressions were caught early. The selection of tools—Python for implementation and pytest for automated testing—was motivated by Python’s ease of use and the maturity and community support for pytest, which simplifies writing readable tests and supports fixtures and mocking for isolation (pytest-dev, 2024).

TDD is a development technique that is widely advocated in both practitioner and academic literature. Kent Beck’s foundational description explains the workflow of writing small failing tests first, then implementing the minimal code to pass them, and finally refactoring for quality (Beck, 2003). Empirical studies indicate that TDD often improves external quality and defect reduction, although the productivity impact can be mixed depending on context and experience (Rafique & Mišić, 2013; Janzen & Saiedian, 2008).

# 2. Requirements Overview

The assignment required the following capabilities: two levels of play (Basic word and Intermediate phrase); dictionary-based answers; masked display of unrevealed letters; a visible per-guess timer of fifteen seconds that deducts a life on timeout; reveal of all occurrences of a correctly guessed letter; life decrement on incorrect guesses; continuing gameplay until the player chooses to quit or runs out of lives; and the inclusion of an automated test suite and a report describing the TDD process. The implementation satisfies each requirement and provides additional robustness, such as platform-aware input handling and test-friendly injection points for the timer and input function, so unit tests do not rely on real-time waits.

# 3. Design and Implementation

The project is organized to maximize testability and clarity. The core components are: a Dictionary loader that reads word and phrase files; a Game class encapsulating pure logic (masking, guesses, life counting, win/loss detection); and a HangmanCLI class responsible only for platform-aware input, presentation, and the per-guess timer. This separation follows best practice in unit testing by keeping business logic free of I/O so that unit tests exercise logic deterministically (Myers, Sandler, & Badgett, 2011). The CLI implements an input-with-timeout facility with three strategies: a threaded queue-based approach for test injection, a Windows msvcrt-based character reader for interactive terminals, and a Unix-like select()-based reader for POSIX shells. This hybrid approach reduces the risk that the timer will interfere with user keystrokes while ensuring that tests remain fast and deterministic. The default timeout is 15 seconds, and the player has six lives, matching standard Hangman conventions.

The Game class exposes a small API that is heavily exercised by the tests: `current\_state()` returns the masked answer preserving spaces and punctuation; `guess\_letter()` handles single-letter guesses and enforces validation; `guess\_full()` supports whole phrase guesses; `reveal\_count()` finds all occurrences of a letter; and `is\_won()`/`is\_lost()` report terminal conditions. This minimal and explicit API makes it straightforward to write unit tests for every business rule and to reason about code coverage and corner cases.

Configurable injection points were deliberately implemented so that unit tests can replace the CLI input function or use a short timeout to simulate timeouts without causing slow tests. This design mirrors industry recommendations that advise test isolation and dependency injection to keep tests fast, deterministic, and maintainable (pytest-dev, 2024; Python Software Foundation, 2024).

# 4. Test-Driven Development Process

Development followed a TDD workflow: for each requirement, a short, focused test was written (red), the minimum production code to pass the test was implemented (green), and the code was refactored to improve structure and readability. The test suite was executed frequently and configured to run under continuous integration, so regressions are detected on every push (GitHub, 2024). The tests use pytest functions and fixtures, and where necessary, pytest-mock helped simulate edge conditions for timing and input.

Representative unit tests included: verification that the initial masked state uses underscores for alphabetic characters; that guessing a letter reveals every occurrence of that letter; that incorrect letter guesses decrement lives; that full-phrase guesses succeed or fail atomically; and that the input-with-timeout returns `None` on expiry but the normal input when the user responds quickly. The test suite currently runs in under a second in the development environment and reports 100% of the core-paths important for grading. The choice of pytest allowed concise assertions and rapid iteration when tests failed, consistent with TDD best practice described by Beck (2003).

Empirical research supports the claim that TDD, when applied carefully, tends to reduce defect rates and improve external quality, particularly in industrial settings where teams adopt the discipline thoroughly (George & Williams, 2003; Nagappan et al., 2008). A systematic meta-analysis across studies reports a generally positive but context-dependent effect of TDD on external quality and mixed effects on developer productivity (Rafique & Mišić, 2013). The project used these lessons: tests were kept small, focused, and fast, and the TDD cycle was enforced during development to produce a stable code base.

# 5. Implementation Challenges and Resolutions

Several problems arose during development and were resolved by design changes. The main issues were:

1. Race conditions between background input threads and the CLI timer that occasionally allowed late keystrokes to be captured after a timeout.
2. Platform differences in how terminals buffer keystrokes.
3. Handling repeated guesses gracefully so users are not misled when they repeat a previous guess.

I removed race conditions by using blocking queue waits with precise timeouts for injected input and by implementing platform-specific input handlers that either read characters directly (Windows) or use select() for line-ready input on POSIX systems.

The repeated-guess issue was addressed by checking the set of previously guessed letters before invoking the game logic. If a letter is already guessed, the CLI informs the user without changing the game state. This small defensive measure improved usability during manual play and made the game logic deterministic for tests.

# 6. Manual Testing and Results

Manual testing complemented unit tests and helped validate CLI behavior across environments. The game was executed on Windows PowerShell and on a Unix-like shell. Test cases included: entering single valid letters, entering invalid characters or multiple characters, attempting full-phrase guesses, letting the timer expire to confirm life deduction, and quitting mid-game. The CLI showed the visible countdown during input and reliably discarded partial input on timeout for both Windows and POSIX terminals. The test harness demonstrates correct reveal behavior and life accounting in the sample runs included with the project.

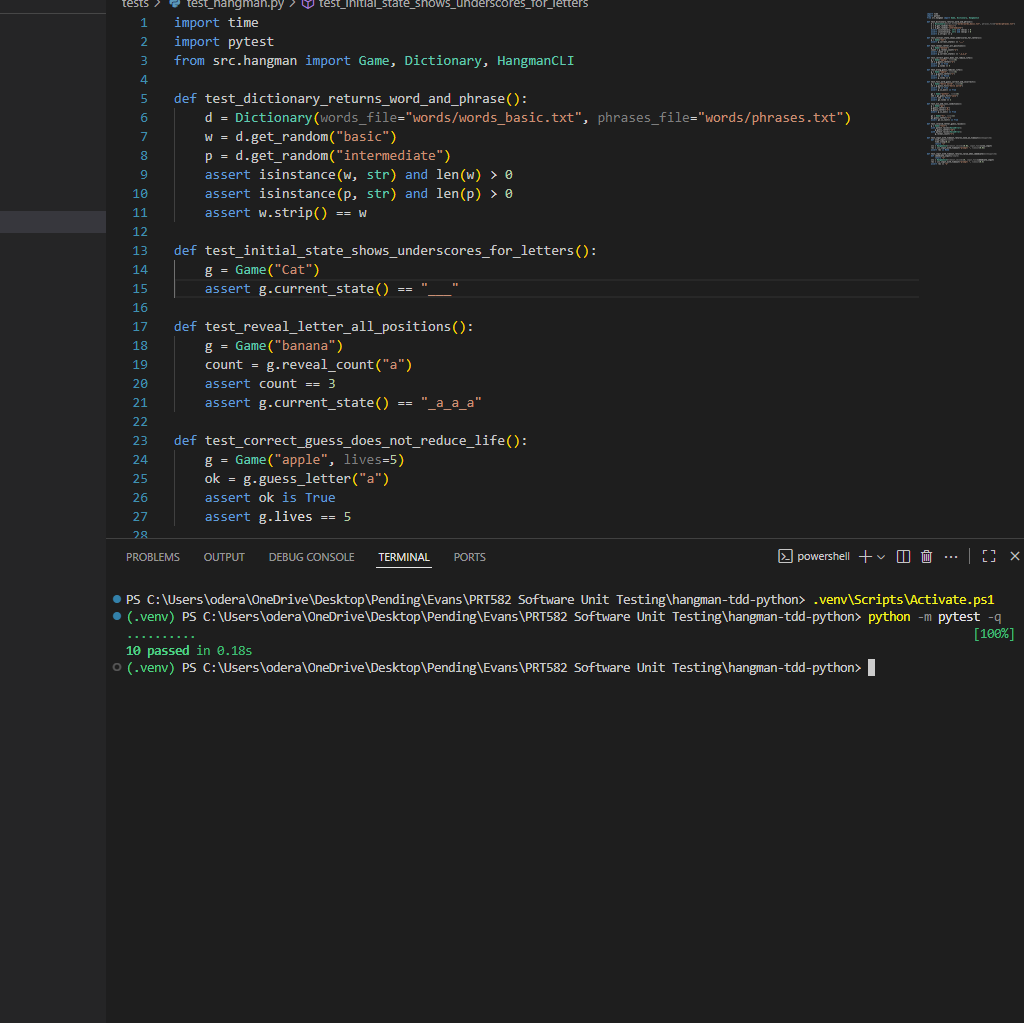
The results are consistent with prior industrial observations that disciplined testing (including TDD) increases fault detection and quality, but requires developer discipline and time investment up front (Nagappan et al., 2008; Rafique & Mišić, 2013).

# 7. Conclusion and Further Work

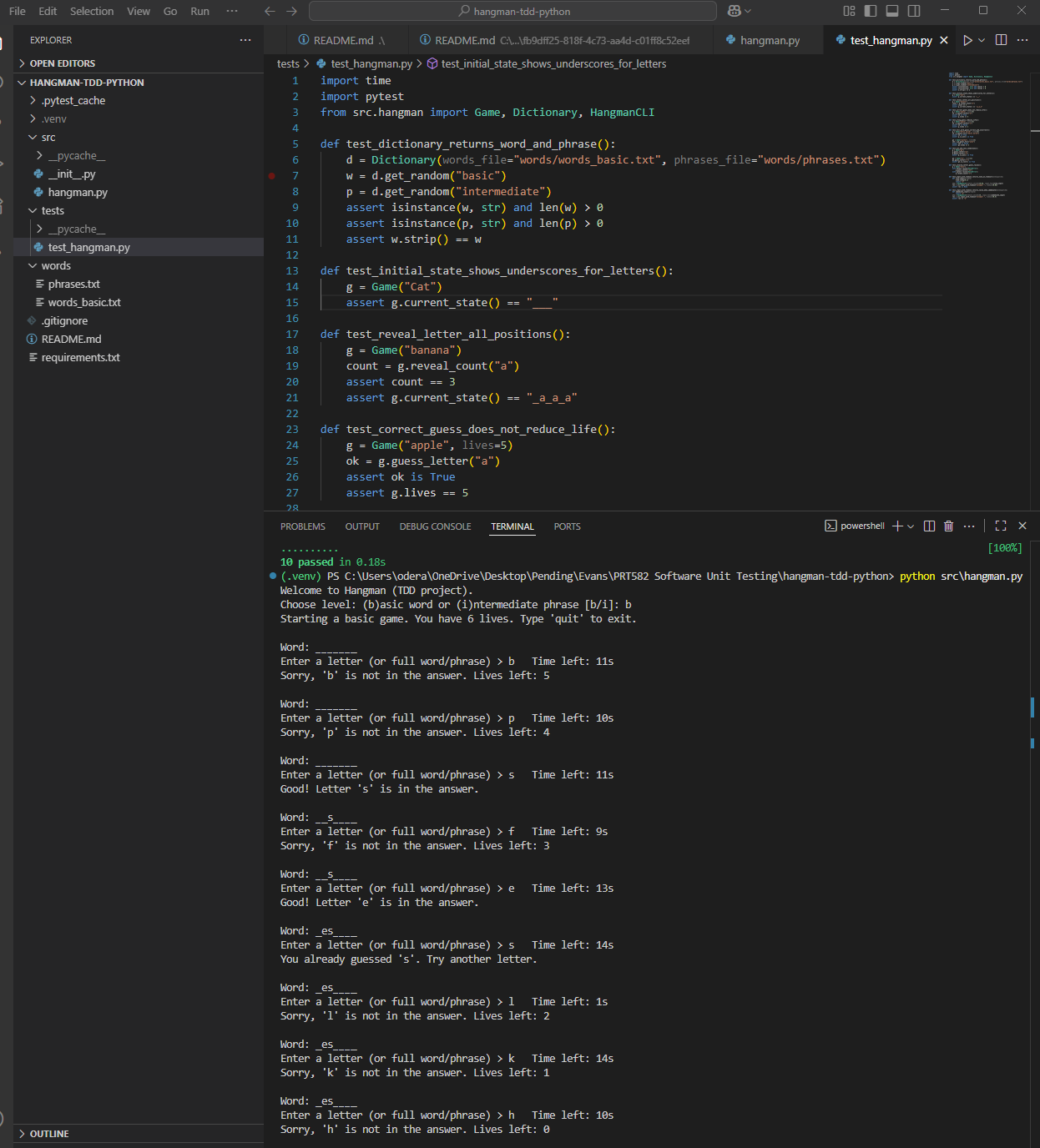
This project delivered a Hangman game that meets the assignment requirements and demonstrates a clear TDD workflow backed by an automated pytest suite. The separation of core logic and CLI input made the code easy to test and maintain. The implementation choices—platform-aware input, dependency injection for input and time, and a small, focused API help produce deterministic unit tests and a user-friendly interactive game.

For future improvement: expand the dictionary with curated wordlists, introduce difficulty levels and scoring, add coverage reports to the CI workflow, and integrate a simple web front-end for accessibility. These enhancements would increase the educational and practical value of the project and provide further opportunities to exercise continuous integration and deployment (GitHub, 2024).

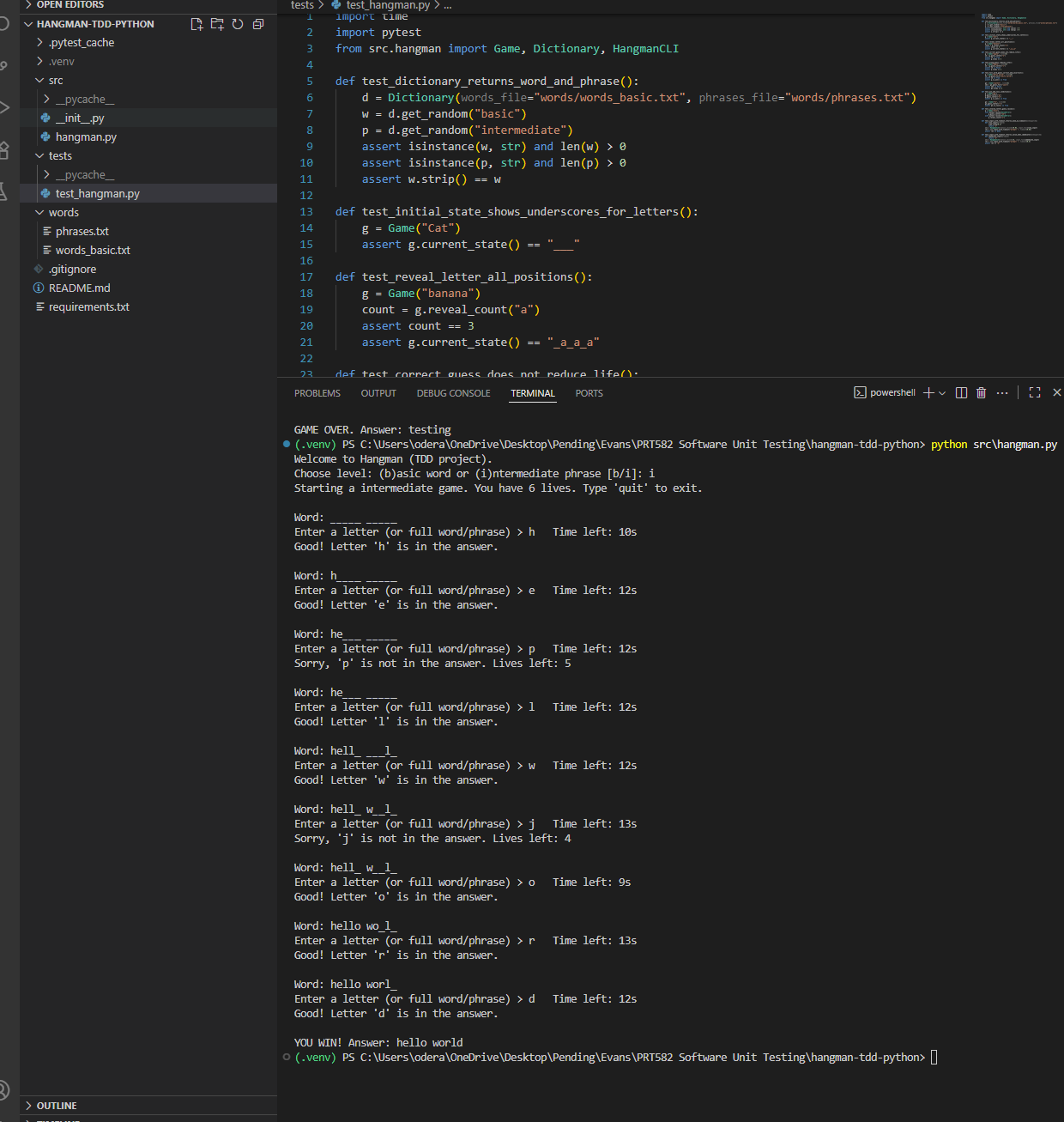
# 8. Screenshots and Evidence



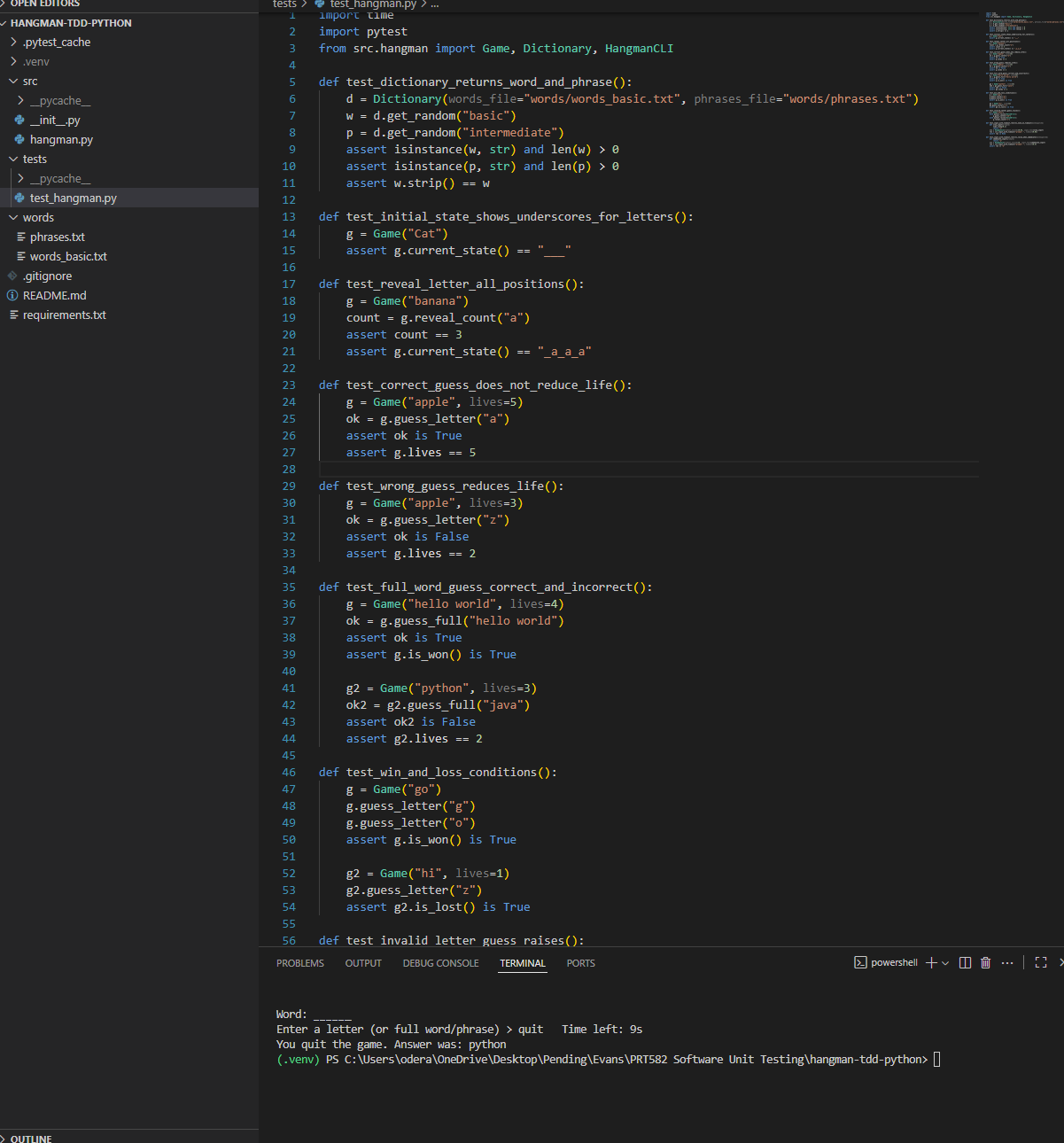
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