

PRT582 Software Engineering: Process and Tools

Software Unit Testing Report

Hangman Game using TDD and Automated Unit Testing in Python

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Introduction

This project implements a compact Hangman game in Python and documents its development using a test-first mindset and automated unit testing. The repository contains: (i) a console game (`hangman.py`) built on a UI-agnostic Hangman model, (ii) a Tkinter GUI (`hangman_gui.py`) that adds a 15-second per-guess countdown, (iii) a standard-library unittest suite (`test_hangman.py`) that verifies the core rules, (iv) a short README.md, and (v) this report (PDF).

The required functionality is:

1. Two levels: *Basic* (random word) and *Intermediate* (random phrase).
2. Valid dictionary: selections come from curated lists of words/phrases.
3. Masked display: underscores for letters; spaces preserved.
4. Timer: player has 15 seconds per guess, visible in the GUI; when time expires, one life is deducted.
5. Reveal rule: a correct guess reveals all positions of that letter.
6. Penalty rule: a wrong first-time guess deducts one life; repeated guesses are ignored.
7. Termination: the player must guess the word/phrase before lives reach zero.
8. Game flow: play continues until Quit, Win, or Lives=0; on loss, reveal the answer.

Python as the language & unittest as the testing method

Python was chosen for readability, battery-included libraries, and ease of GUI prototyping (Van Rossum & Drake, 2009). For testing, the built-in **unittest** framework provides discovery, assertions, and structured fixtures without external dependencies (Python Software Foundation, 2024). The GUI uses **Tkinter**, which ships with CPython on most platforms, avoiding extra runtime dependencies (Van Rossum & Drake, 2009). In parallel, code quality tooling - **flake8** for style and **pylint** for static analysis – facilitated immediate feedback on naming, complexity, and stylistic issues,

Test-Driven Development (TDD)

TDD was selected as the governing process model. In TDD, developers iterate in short cycles: write a failing test (red), implement the minimal code to pass (green), then refactor to improve design without changing behaviour (Beck, 2002). Empirical studies have associated TDD with improved internal software quality and fewer defects (Erdogmus, Morisio & Torchiano, 2005; Janzen & Saiedian, 2005). In line with those findings, this project emphasised incrementalism, quick feedback, and continuous design attention, using small, verifiable steps from requirement to code.

Process

Architecture and design

The project adopts a layered structure:

- **Core model (Hangman in hangman.py):** Encapsulates all game rules and state: word, lives, guessed letters, masked representation (hidden_word), guess(), and predicates is_won()/is_over(). The model has no UI or timing code, which makes it easy to test and reuse.
- **Console UI (hangman.py):** A minimal play() loop demonstrating the rules in a terminal. It asks for mode, prints masked state, accepts letters, and reports outcomes.
- **GUI (hangman_gui.py):** A Tkinter front end that adds a visible countdown and Reset/Quit buttons. Radio buttons select Basic (word) vs Intermediate (phrase). The timer is implemented with after(1000, ...), which ticks every second and deducts a life when it reaches 0, then resets to 15s for the next guess. At the end of each guess (right or wrong), the timer is also reset to 15s. The GUI never duplicates rules; it delegates to the model.
- **Tests (test_hangman.py):** A unittest file capturing the required behaviours deterministically. Tests drive the model only (no GUI automation or timers) to remain fast and stable.

This separation adheres to single-responsibility and promotes sustainability: the model can be extended (e.g., loading dictionaries from files) without changing UIs; the GUI can evolve (art, sounds, accessibility) without touching rules.

TDD workflow

The development followed short, repeatable cycles:

1. **Red** – Write a failing test for a precise behaviour: e.g., “masking preserves spaces” or “wrong first-time guess deducts one life”.
2. **Green** – Add the minimal code to pass the test: e.g., compute hidden_word by replacing alphabetic characters with underscores, or decrement lives only on first-time wrong guesses.
3. **Refactor** – Improve names, remove duplication, and keep logic in the model class. Keep tests green after each refactor (Beck, 2002; Meszaros, 2007).

This cycle repeated until all requirements were covered by tests or GUI demonstrations (for timer visuals).

Automated unit testing (unittest)

The test_hangman.py suite focuses on the core rules to keep execution deterministic:

- **Level selection & dictionary validity:**
test_basic_level_selects_word_from_dictionary() ensures Basic mode draws from WORDS. test_intermediate_level_selects_phrase_from_dictionary() ensures Intermediate draws from PHRASES and includes a space.
- **Masked display:**
test_initial_masking_uses_underscores_and_preserves_spaces() asserts "hello world" becomes "____ _".
- **Reveal rule:**
test_correct_guess_reveals_all_matching_positions() checks that guessing 'p' in "apple" yields "_pp_" and returns True.
- **Penalty rule:**
test_wrong_guess_deducts_one_life() verifies that a wrong first-time guess reduces lives by exactly one.
- **End conditions:**
test_win_condition_when_all_letters_revealed() and
test_lose_condition_when_lives_reach_zero() verify is_won()/is_over() for both paths.

No unit-test on the GUI timer was run as time-based UIs are better demonstrated with screenshots and validated indirectly through the model's live behaviour. If a test hook like timeout() were added to the model, the countdown could be exercised deterministically (Meszaros, 2007). For now, the timer is verified empirically in the GUI (see screenshots).

Coding style and quality

The code is formatted for readability (PEP 8-style naming, ≤ 100 -character lines, small functions, and docstrings in tests). The model exposes a minimal API that maps directly to requirements; the UIs hold no business logic. This clarity supports the rubric's emphasis on "elegant, modular and sustainable" design.

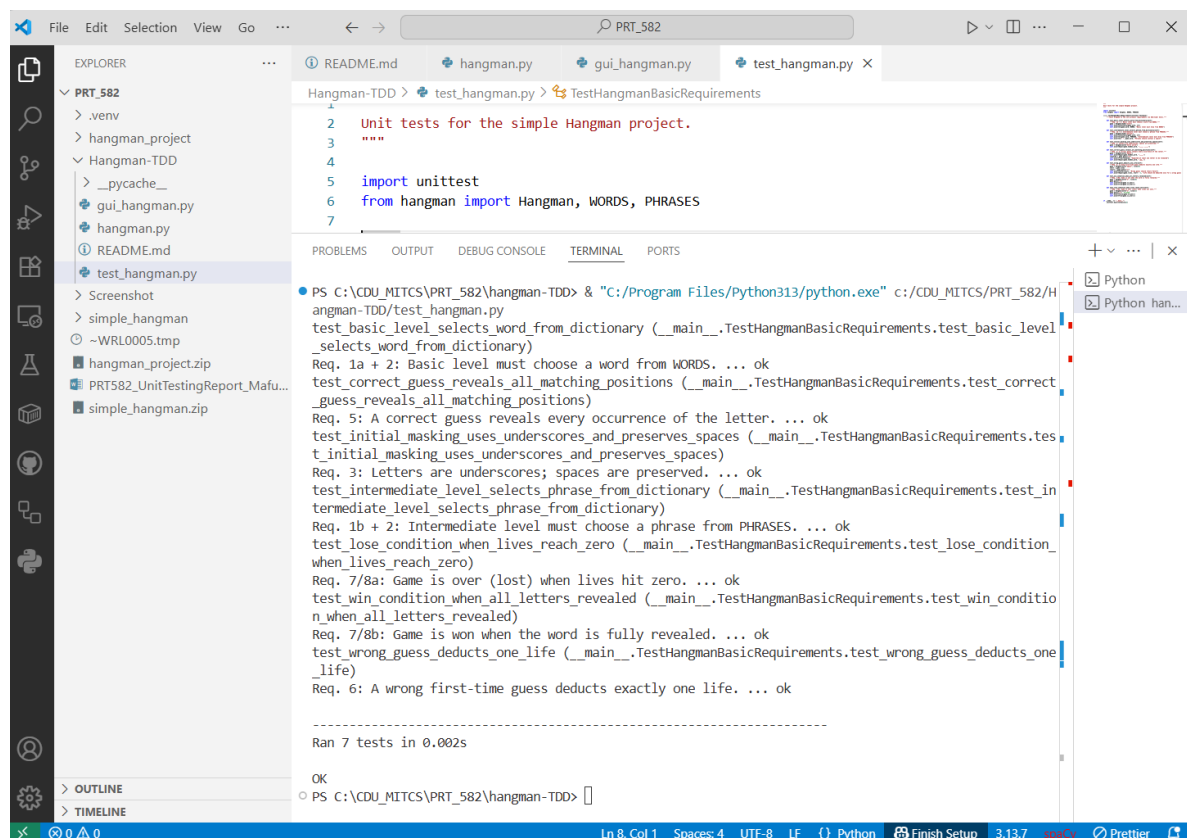
The files are written to pass typical defaults for flake8 and pylint (e.g., clear names, docstrings where helpful, controlled line length).

Requirement-to-implementation mapping

- 1. Levels:** Model constructor selects from WORDS or PHRASES based on mode; GUI radio buttons.
- 2. Valid dictionary:** Curated lists in the model; easy to extend or replace with file I/O.
- 3. Masked display:** `_display` list built from the answer: letters → “_”, non-letters preserved; `hidden_word` joins it.
- 4. A 15-second timer with visible countdown:** In `hangman_gui.py`, after drives a 1-second tick. On reaching **0**, one life is deducted and the timer resets; after each guess, the timer resets to **15**.
- 5. Reveal all positions:** `guess()` iterates over the answer and opens every matching index.
- 6. Penalty for wrong guess:** First-time wrong guesses decrement lives; repeated guesses are ignored (no double penalty).
- 7. Termination rule:** `is_won()` is true when `hidden_word == word`; `is_over()` if `is_won()` or `lives <= 0`.
- 8. Game flow:** CLI prints outcomes; GUI disables inputs and shows a message box. On loss, GUI/CLI reveal the correct answer.

Screenshots as evidence for the Process

- 1. Unit tests passing (unittest):** Terminal running `python -m unittest -v`.



```
File Edit Selection View Go ... PRT_582
EXPLORER
PRT_582
  .venv
  hangman_project
  Hangman-TDD
    __pycache__
    gui_hangman.py
    hangman.py
    README.md
    test_hangman.py
  Screenshot
  simple_hangman
  ~WRL0005.tmp
  hangman_project.zip
  PRT582_UnitTestingReport_Mafu...
  simple_hangman.zip
  OUTLINE
  TIMELINE

PRT_582
hangman.py
gui_hangman.py
test_hangman.py

2 Unit tests for the simple Hangman project.
3 """
4
5 import unittest
6 from hangman import Hangman, WORDS, PHRASES
7

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS
Python
Python han...

PS C:\CDU_MITCS\PRT_582\hangman-TDD> & "C:/Program Files/Python313/python.exe" c:/CDU_MITCS/PRT_582/H
angman-TDD/test_hangman.py
test_basic_level_selects_word_from_dictionary (__main__.TestHangmanBasicRequirements.test_basic_level
_selects_word_from_dictionary)
Req. 1a + 2: Basic level must choose a word from WORDS. ... ok
test_correct_guess_reveals_all_matching_positions (__main__.TestHangmanBasicRequirements.test_correct
_guess_reveals_all_matching_positions)
Req. 5: A correct guess reveals every occurrence of the letter. ... ok
test_initial_masking_uses_underscores_and_preserves_spaces (__main__.TestHangmanBasicRequirements.tes
t_initial_masking_uses_underscores_and_preserves_spaces)
Req. 3: Letters are underscores; spaces are preserved. ... ok
test_intermediate_level_selects_phrase_from_dictionary (__main__.TestHangmanBasicRequirements.test_in
termediate_level_selects_phrase_from_dictionary)
Req. 1b + 2: Intermediate level must choose a phrase from PHRASES. ... ok
test_lose_condition_when_lives_reach_zero (__main__.TestHangmanBasicRequirements.test_lose_conditio
n_when_lives_reach_zero)
Req. 7/8a: Game is over (lost) when lives hit zero. ... ok
test_win_condition_when_all_letters_revealed (__main__.TestHangmanBasicRequirements.test_win_conditio
n_when_all_letters_revealed)
Req. 7/8b: Game is won when the word is fully revealed. ... ok
test_wrong_guess_deducts_one_life (__main__.TestHangmanBasicRequirements.test_wrong_guess_deducts_one
_life)
Req. 6: A wrong first-time guess deducts exactly one life. ... ok

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Ran 7 tests in 0.002s

OK
PS C:\CDU_MITCS\PRT_582\hangman-TDD>
```

Figure 1 — Unit tests (unittest) covering core behaviours pass.

2. **GUI at game start (underscores visible):** Basic or Intermediate with masked word/phrase: underscores for letters, spaces preserved, timer at 15s.

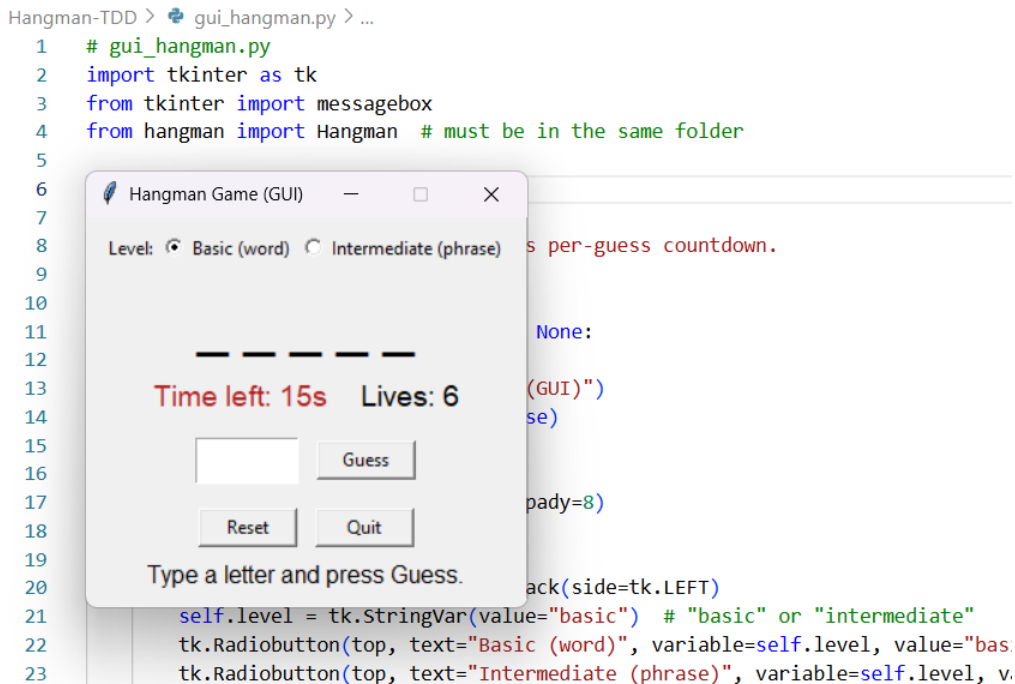


Figure 2 — GUI showing initial masked display and 15-second timer.

3. **GUI mid-round (countdown visible):** Show “Time left: Ns” decreasing and lives unchanged (before timeout).

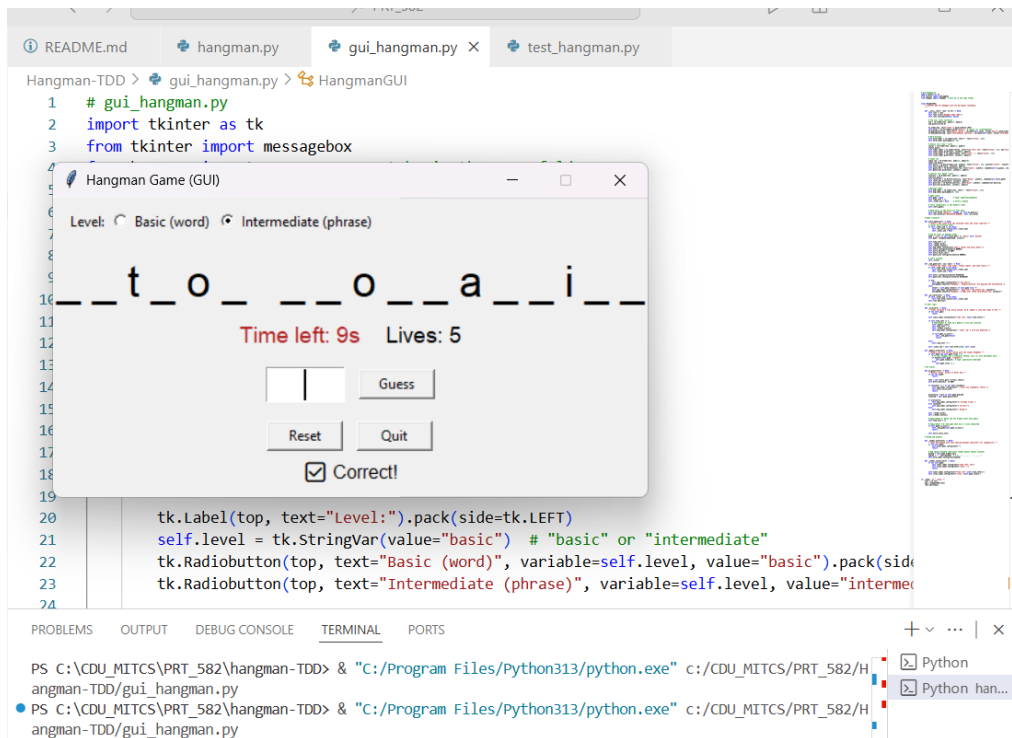


Figure 3 — Per-guess countdown in progress.

4. **GUI timeout (life deducted):** Allow the 15 seconds to expire without input; show lives decreased and timer reset to 15s.

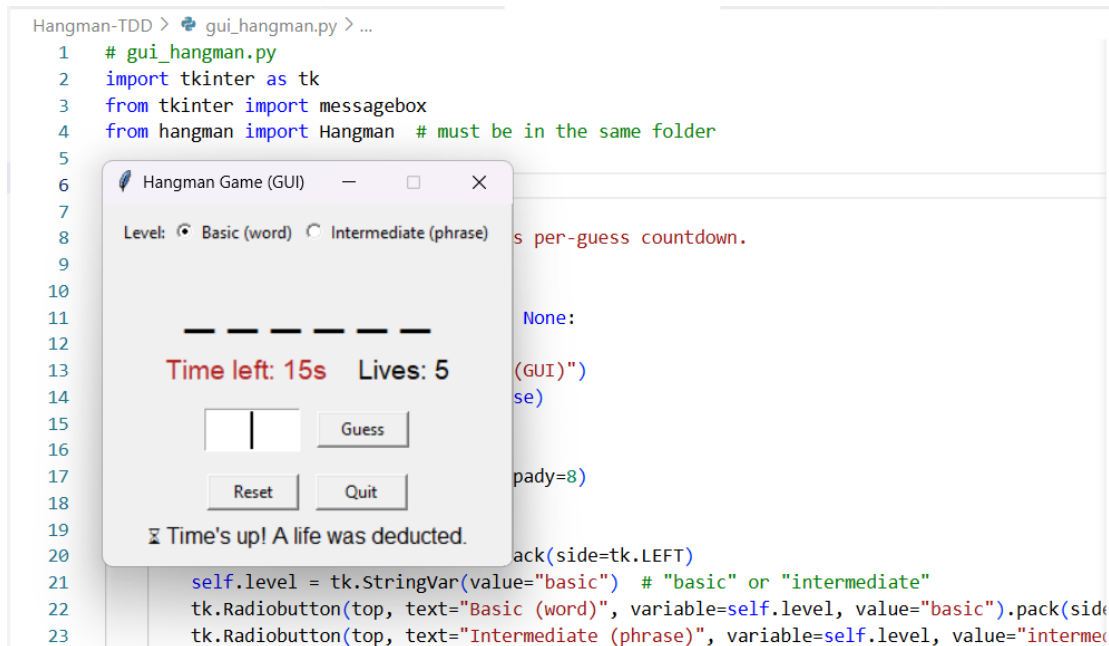


Figure 4 — Timeout deducted one life and reset the timer.

5. **GUI win or loss state:** Win: all letters revealed and success dialogue; or Loss: lives = 0, game over dialogue, and revealed answer.

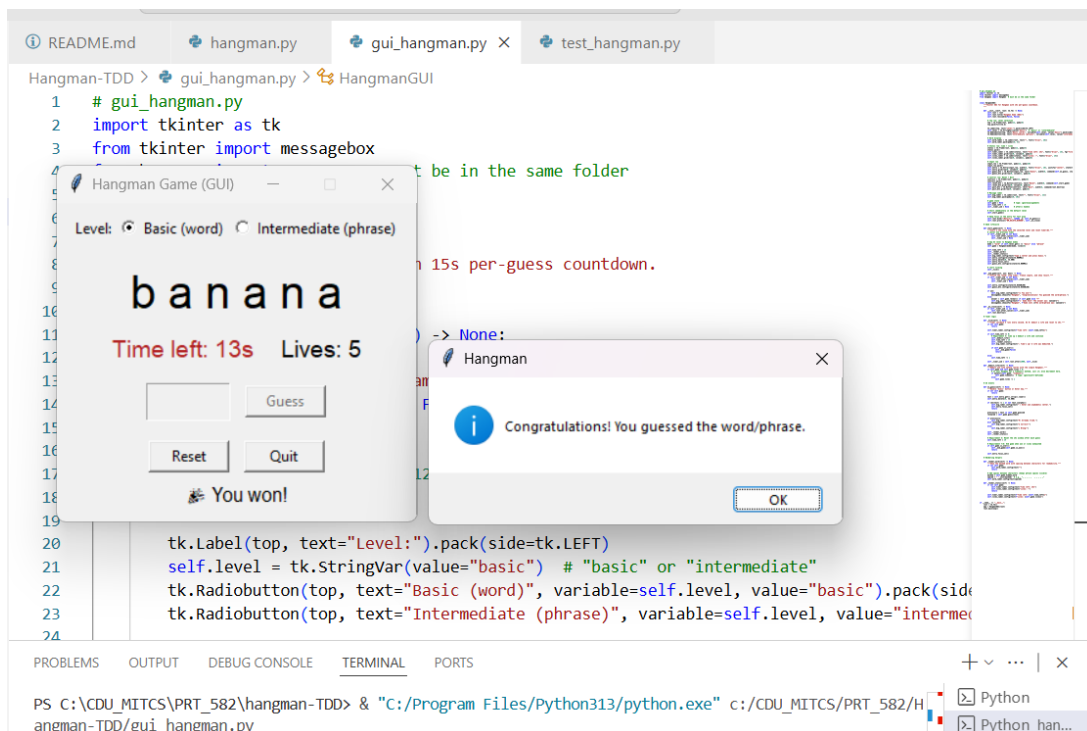


Figure 5 — End state with WIN message and revealed answer.

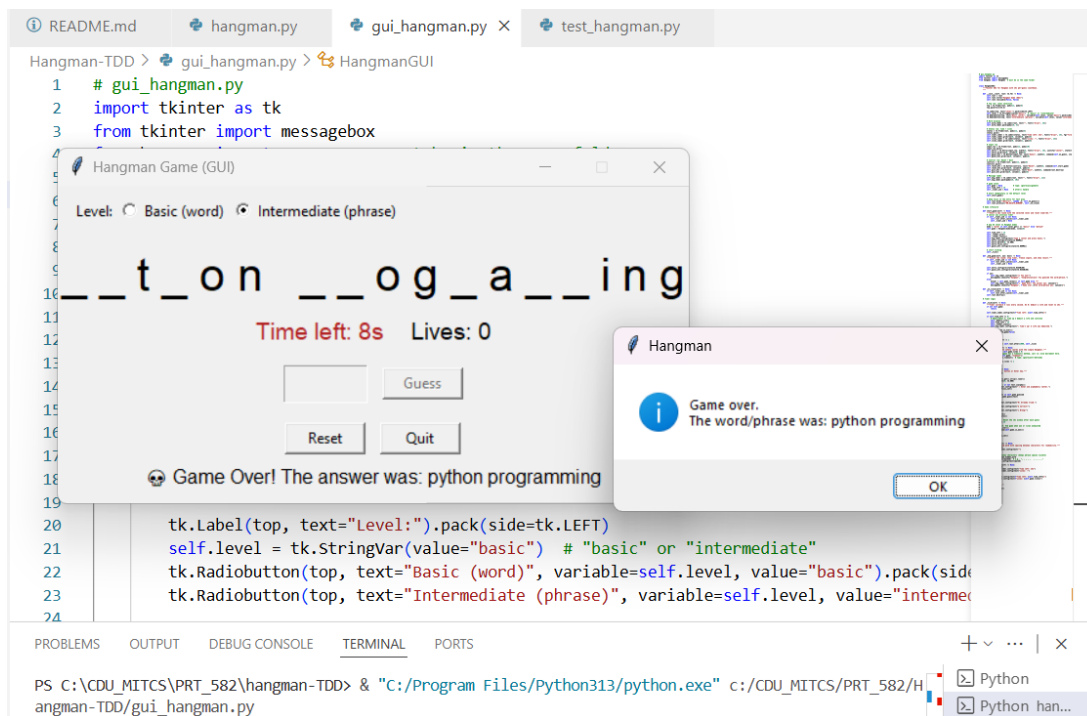


Figure 6 — End state with LOSS message and revealed answer.

- Console win or loss state:** Win: all letters revealed and success dialogue; or Loss: lives = 0, game over dialogue, and revealed answer.

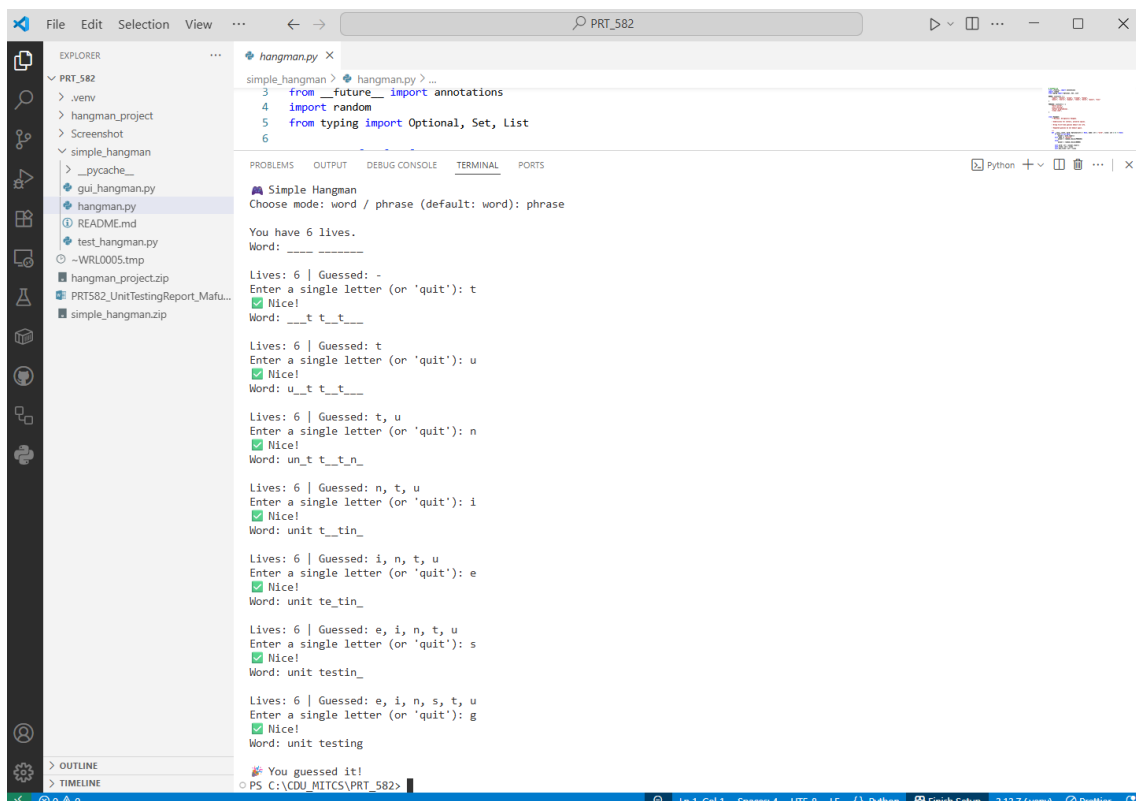


Figure 7 — End state with WIN message and revealed answer.

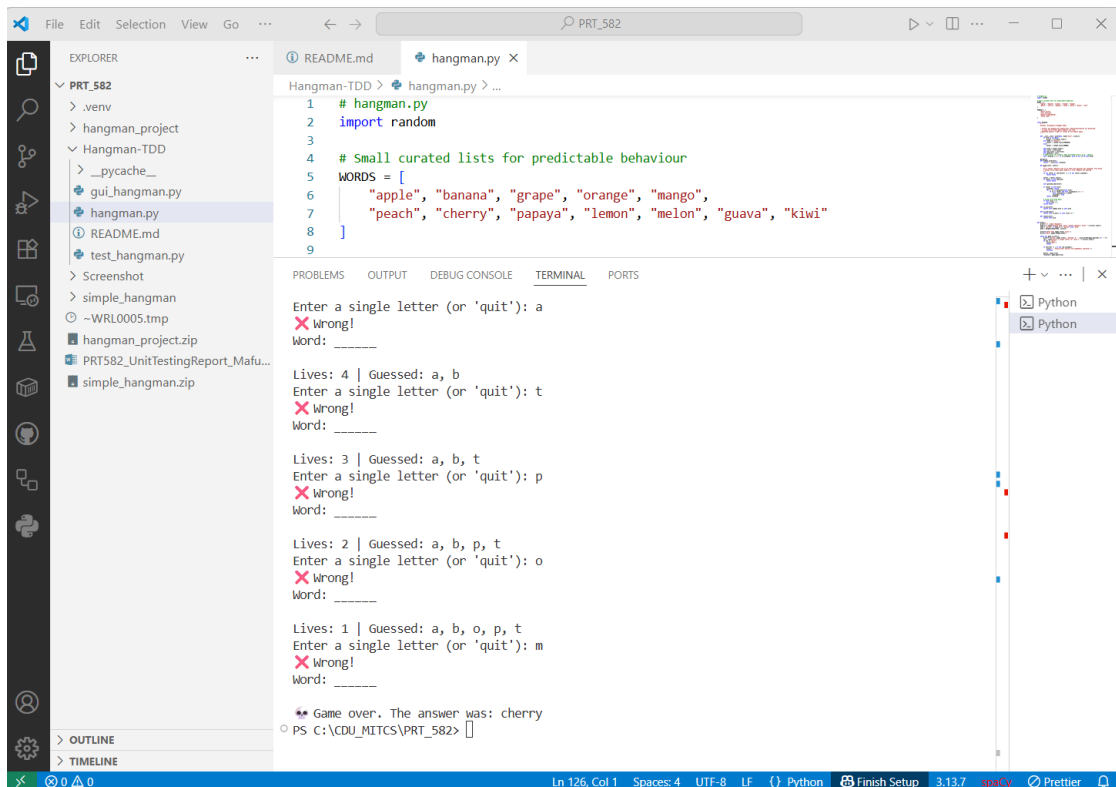


Figure 8 — End state with LOSS message and revealed answer.

This set demonstrates each requirement and the automated tests.

Sustainability and extension

The model's isolation makes enhancement straightforward:

- **Bigger dictionaries:** replace the lists with file loads (e.g., words.txt, phrases.txt).
- **CI and linters:** add a GitHub Actions workflow to run unittest, flake8, and pylint on every push.

Constraints and rationale

- **No GUI automation:** To keep tests deterministic and avoid flakiness, the suite targets the model only. The timer is validated visually through screenshots; a future hook like `timeout()` would allow clean timer tests without sleeping.
- **Simplicity over feature breadth:** The aim is to produce a small, inspectable codebase that clearly evidences TDD and automated testing. Extra features can be layered without re-architecting the model.

Conclusion

This project demonstrates how a test-first, model-centric approach produces a clean, maintainable solution for Hangman. The Hangman class encapsulates all rules and remains free of UI concerns; the CLI and Tkinter GUI reuse this model without duplication. The GUI implements a visible 15-second countdown that deducts a life on expiry and resets each turn, satisfying the timing requirement. The unittest suite verifies the core behaviours: dictionary selection for both levels, masking, reveal/penalty rules, and end conditions.

Lessons learned

- **TDD guides design:** Writing tests first focuses effort on observable behaviour and encourages small, composable functions (Beck, 2002).
- **Keep time-based logic at the UI boundary:** The timer is best exercised in the GUI while the model remains deterministic; introducing a small `timeout()` hook would support automated timer tests if required (Meszaros, 2007).
- **Sustainability via separation:** Isolating the model reduces coupling and makes both UIs thin and easy to modify.
- **Tooling matters:** Even with a small project, running **linters** and **unit tests** early catches defects and style issues inexpensively (Van Rossum & Drake, 2009).

Future improvements

- Load larger, configurable dictionaries from files; optionally validate words against an external wordlist.
- Add a `timeout()` method to the model and write deterministic timer tests.
- Introduce CI (GitHub Actions) to run unittest, flake8, and pylint on every push.
- Optional accessibility: larger fonts, keyboard-only play, and high-contrast themes.

Repository link

<https://github.com/MafujaA/Hangman-TDD>

References

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