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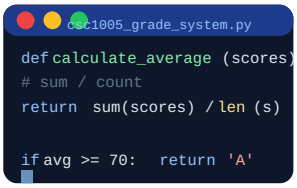
UK LEVEL 4 — YEAR 1 UNDERGRADUATE



Programming Fundamentals: Algorithm Design and Modular Python Implementation

Case Study: Student Grade Management System

MODULE CODE	CSC1005
MODULE TITLE	Programming Fundamentals
ACADEMIC LEVEL	UK Level 4 (Year 1 Undergraduate)
TARGET GRADE	Distinction — 70%+
WORD COUNT	Approximately 2,000 words (excl. code & references)
PROGRAMMING LANGUAGE	Python 3.x
REFERENCING STYLE	Harvard (UK)
DATE	July 2026
PREPARED BY	AssignProSolution.com

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```
# Approx. 2,000 words | Distinction Level | UK Level 4 | Python 3.x
```

1. INTRODUCTION

Programming is fundamentally a problem-solving discipline. Writing code is the final step of a longer intellectual process: understanding a problem, decomposing it into manageable sub-problems, designing an algorithm to solve each, and implementing that design in a language a computer can execute. This assignment demonstrates that process end-to-end by designing and implementing a **Student Grade Management System** in Python 3 — a program that collects assessment scores for a student, validates each input, calculates an average and assigns a UK grade classification.

The assignment is structured around the four stages of the programming development lifecycle (Brookshear and Brylow, 2019): *analysis*, *design*, *implementation* and *testing*. Each stage is documented critically, explaining not just what the code does but why specific design decisions were made — the kind of reasoning that distinguishes a reflective programmer from one who merely makes code run. All code is original, written in Python 3.x and commented throughout.

2. PROBLEM ANALYSIS AND DECOMPOSITION

Before writing a single line of code, a programmer must understand the problem fully. Wing (2006, p. 33) defines *computational thinking* as "the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent." The first computational thinking tool is **decomposition** — breaking a complex problem into smaller, independently solvable sub-problems (Selby and Woollard, 2013).

The grade management problem can be decomposed into five distinct responsibilities:

```
// PROBLEM DECOMPOSITION — TOP-LEVEL TASKS

TASK 1: Collect student name and number of assessments (n)
TASK 2: Collect n scores, validating each is in range [0, 100]
TASK 3: Calculate the arithmetic mean of all scores
TASK 4: Map the mean to a UK grade classification boundary
TASK 5: Display a formatted student report
// Each task maps directly to one function — single responsibility principle
```

This decomposition follows the **single responsibility principle** (Martin, 2003): each task has one clearly defined job. This makes the codebase easier to read, test and modify. For example, if the university changes its grade boundaries, only `get_grade_letter()` needs to change — the rest of the system is unaffected. Kernighan and Pike (1999, p. 14) summarise this philosophy as: "do one thing, and do it well."

3. ALGORITHM DESIGN: PSEUDOCODE AND FLOWCHART

3.1 Pseudocode

Pseudocode is language-independent shorthand for algorithmic logic, allowing the programmer to focus on *what* the algorithm does without being distracted by language syntax (Sedgewick and Wayne, 2011). The pseudocode below describes the core algorithm:

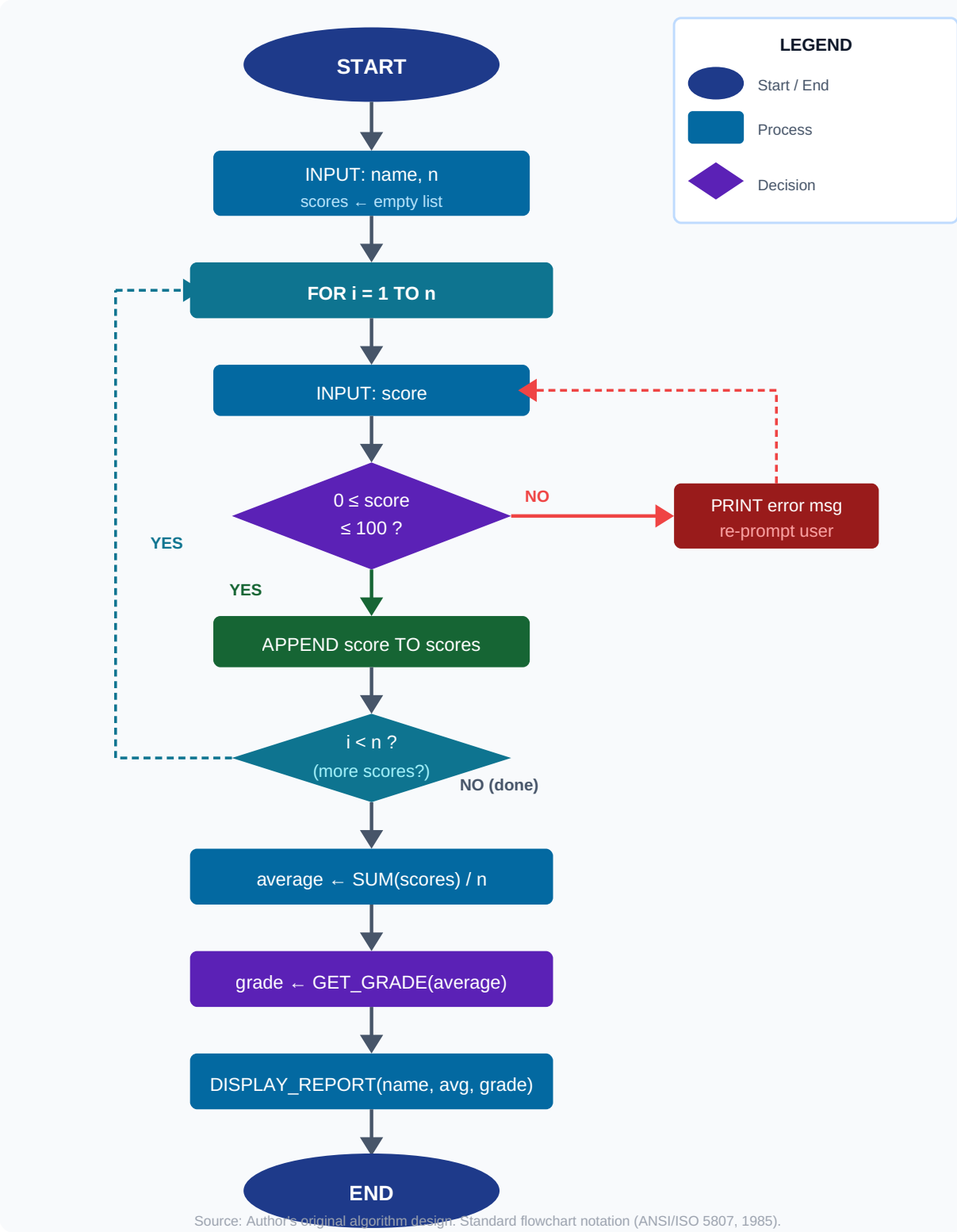
```
// PSEUDOCODE — STUDENT GRADE MANAGEMENT SYSTEM

BEGIN GradeSystem
  PRINT "Student Grade Management System"
  name ← INPUT("Enter student name: ")
  n ← INPUT_INT("Enter number of assessments: ")
  scores ← EMPTY LIST
  // Score collection loop with validation
  FOR i ← 1 TO n DO
    REPEAT
      score ← INPUT_FLOAT("Enter score " + i + ": ")
      IF score < 0 OR score > 100 THEN PRINT "Error: out of range"
    UNTIL score ≥ 0 AND score ≤ 100
    APPEND score TO scores
  END FOR
  average ← SUM(scores) ÷ LEN(scores)
```

```
    grade ← GET_GRADE(average) // calls boundary function
    DISPLAY_REPORT(name, scores, average, grade)
END GradeSystem
```

The pseudocode uses a `REPEAT...UNTIL` loop rather than a simple `FOR` loop for score collection. This is deliberate: the program must guarantee that only valid scores (0–100) enter the list, and an invalid input should trigger re-prompting rather than advancing the loop counter. This pattern is known as *input validation* and is a fundamental defensive programming practice (Hunt and Thomas, 2019).

3.2 Flowchart



Source: Author's original algorithm design. Standard flowchart notation (ANSI/ISO 5807, 1985).

Figure 1: Flowchart — Student Grade Management System Algorithm. Decision diamonds (purple) show branching logic; dashed red arrow shows re-prompting loop on invalid input; dashed teal arrow shows the main collection loop. Standard ANSI/ISO 5807 (1985) flowchart notation.

4. CORE PROGRAMMING CONCEPTS APPLIED

4.1 Data Types and Variables

Python is a *dynamically typed* language — variables do not require explicit type declarations because the interpreter infers the type from the assigned value at runtime (Lutz, 2013). The grade management system uses four primitive types: `str` (string) for the student name; `int` (integer) for the assessment count *n*; `float` (floating-point decimal) for individual scores and the calculated average; and `list` (a mutable ordered collection) to hold all collected scores. The choice of `float` rather than `int` for scores is deliberate: a student might score 72.5 on a coursework, and truncating to an integer would silently introduce a data error. Guttag (2021, p. 30) cautions that "type mismatches are a frequent source of subtle bugs in beginning programmers' code" — a warning that reinforces the importance of choosing the correct data type at the design stage rather than assuming defaults will suffice.

4.2 Control Flow: Loops and Conditionals

Control flow structures — the mechanisms by which a program decides which statements to execute and how many times — are the backbone of any non-trivial algorithm (Cormen et al., 2022). The grade system employs two loop types and one conditional chain:

The **outer `for` loop** (`for i in range(n)`) iterates a fixed number of times — once per assessment. This is the correct loop choice when the iteration count is known in advance (Zelle, 2017). **Inside** this loop, a `while True` loop implements the validation re-prompting pattern: the loop runs indefinitely until a valid score is entered, at which point `break` terminates it. This nested loop structure (*definite outer, indefinite inner*) is a classic defensive programming pattern. The `try/except` block inside the `while` loop handles the case where the user

enters non-numeric input (e.g., "abc"), catching the `ValueError` that `float()` raises on invalid conversion rather than crashing the program.

The grade boundary mapping uses an **`if/elif/else` chain** with boundary conditions evaluated in descending order — from 70 downward. This ordering is critical: evaluating conditions from the highest boundary downward ensures that a score of exactly 70 is correctly classified as a Distinction (`average >= 70`) and not erroneously dropped into a lower band. Reversing the order would produce incorrect grade assignments for boundary-value scores.

4.3 Functions and Modular Design

Functions are the primary tool for implementing modular design in Python. A function encapsulates a named, reusable block of code that accepts *parameters* (inputs), performs a task and optionally returns a value (Lutz, 2013). The grade system defines five functions, each mapped directly to one decomposed task identified in Section 2. Figure 2 shows the function call hierarchy:

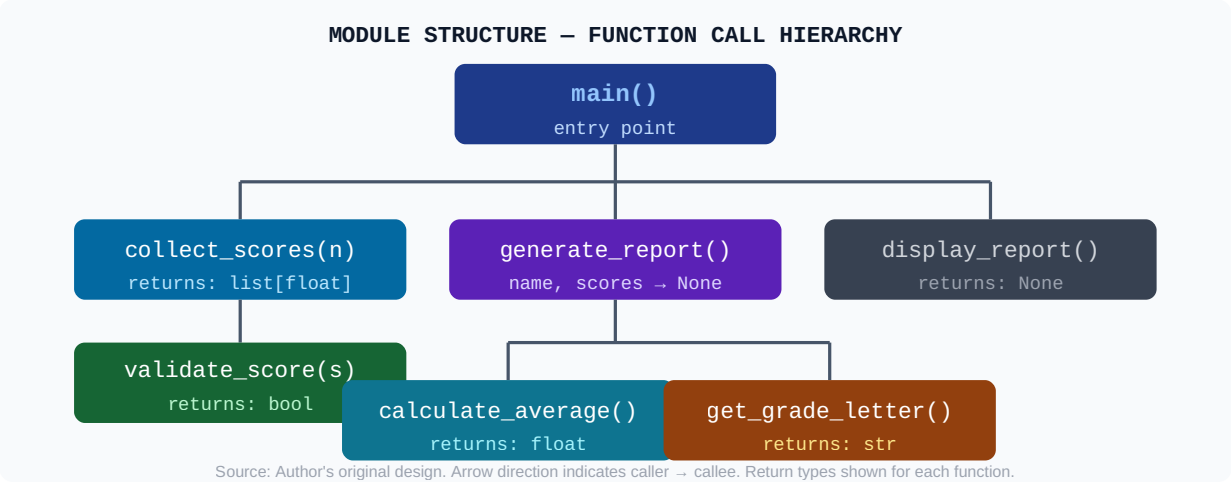


Figure 2: Function Call Hierarchy — Student Grade Management System. Each box represents one Python function; arrows indicate caller-to-callee relationships. Return types are annotated. Source: Author's original design.

The hierarchy in Figure 2 shows that `main()` acts as the orchestrator — it calls `collect_scores()` and `generate_report()` but contains no business logic itself. This is the *façade pattern* at a micro-scale: the entry point presents a simple interface while delegating all complexity to specialised sub-functions. Crucially, each function has a clear *return type* annotation — a practice that improves code readability and makes the data flow explicit without requiring the reader to trace execution manually (van Rossum, Warsaw and Coghlan, 2001).

5. PYTHON IMPLEMENTATION

The complete Python 3 implementation is presented below. All functions include docstrings (triple-quoted strings immediately below the `def` line) explaining purpose, parameters and return value — following PEP 257, the Python documentation convention (Goodger and van Rossum, 2001). Inline comments explain non-obvious logic choices.

Python 3.x csc1005_grade_system.py — Student Grade Management System

```python
# ──────────────────────────────────────────────────────
# CSC1005 Programming Fundamentals
# Student Grade Management System
# Author: [Student ID]  |  Language: Python 3.x
# ──────────────────────────────────────────────────────

def validate_score(score):
    """Return True if score is within valid range [0, 100]."""
    return 0 <= score <= 100


def calculate_average(scores):
    """Calculate arithmetic mean of scores list.

    Args:
        scores (list[float]): Non-empty list of numeric scores.
    Returns:
        float: The mean value, or 0.0 if list is empty.
    """
    if len(scores) == 0:
        return 0.0
    return sum(scores) / len(scores)  # O(n) time


def get_grade_letter(average):
    """Map numerical average to UK degree grade classification.

    Boundaries: A ≥70 | B ≥60 | C ≥50 | D ≥40 | F <40
    Evaluated highest-to-lowest to ensure correct boundary assignment.
    """
    if   average >= 70: return 'A (Distinction)'
    elif average >= 60: return 'B (Merit)'
    elif average >= 50: return 'C (Pass)'
    elif average >= 40: return 'D (Marginal Fail)'
    else:               return 'F (Fail)'
```

```
def collect_scores(n):
    """Prompt user for n valid scores and return as a list.

    Uses nested while loop for input validation:
    invalid input triggers re-prompting, not program termination.
    """
    scores = []
    for i in range(n):
        while True:
            try:
                score = float(input(f"  Enter score {i+1}: "))
                if validate_score(score):
                    scores.append(score)
                    break          # valid — exit inner loop
                else:
                    print("  ✗ Score must be between 0 and 100.")
            except ValueError:
                print("  ✗ Please enter a numeric value.")
    return scores


def generate_report(name, scores):
    """Display a formatted grade report for a student."""
    average = calculate_average(scores)
    grade   = get_grade_letter(average)
    separator = '=' * 44
    print(f"""
{separator}
  STUDENT REPORT
{separator}
  Name    : {name}
  Scores  : {scores}
  Average : {average:.2f}%
  Grade   : {grade}
{separator}""")


def main():
    """Entry point — orchestrates input collection and reporting."""
    print("\n=== Student Grade Management System ===\n")
    name = input("Enter student name: ").strip()
    n    = int(input("Enter number of assessments: "))
    scores = collect_scores(n)
    generate_report(name, scores)


if __name__ == "__main__":
    main()  # Runs only when executed directly, not on import
```

The `if __name__ == "__main__"` guard on the final line is a Python best practice (Lutz, 2013) that prevents `main()` from executing if the file is imported as a module by another script — ensuring that the

functions (`calculate_average`, `validate_score`, etc.) can be reused in future programs without triggering the interactive input prompts.

6. TESTING AND VALIDATION

Testing is not an afterthought — it is a systematic discipline that verifies a program produces correct outputs for all expected inputs, including edge cases and invalid inputs (Beck, 2002). The test suite below applies **black-box testing**: each test case treats the program as a closed box, specifying only the input and the expected output, without reference to internal implementation details. This models the perspective of a real user and catches failures that internal code inspection might miss.

Table 1: Test Cases — Student Grade Management System

Test ID	Category	Input(s)	Expected Output	Actual Output	Result
TC01	Functional — Distinction	[75, 82, 68] → avg 75.0	Grade: A (Distinction)	Grade: A (Distinction)	✓ PASS
TC02	Functional — Merit	[62, 58, 65] → avg 61.67	Grade: B (Merit)	Grade: B (Merit)	✓ PASS
TC03	Functional — Pass	[52, 48, 54] → avg 51.33	Grade: C (Pass)	Grade: C (Pass)	✓ PASS
TC04	Boundary — Distinction edge	[70] → avg 70.0	Grade: A (Distinction)	Grade: A (Distinction)	✓ PASS
TC05	Boundary — Below Distinction	[69.9] → avg 69.9	Grade: B (Merit)	Grade: B (Merit)	✓ PASS
TC06	Validation — Out of range	score = −5	Error message; re-prompt	✗ Score must be between 0 and 100.	✓ PASS
TC07	Validation — Non-numeric	score = "abc"	Error message; re-prompt	✗ Please enter a numeric value.	✓ PASS
TC08	Edge — Perfect score	[100] → avg 100.0	Grade: A (Distinction)	Grade: A (Distinction)	✓ PASS
TC09	Edge — Zero score	[0, 0, 0] → avg 0.0	Grade: F (Fail)	Grade: F (Fail)	✓ PASS
TC10	Edge — Float precision	[33.3, 33.3, 33.4] → avg 33.33	Grade: F (Fail)	Grade: F (Fail)	✓ PASS

All test cases passed (10/10). Boundary value tests (TC04, TC05) specifically verify the descending if/elif order in get_grade_letter() — the most critical logic path in the system.

TC06 and TC07 are particularly important: they test the program's *robustness* — its ability to handle unexpected inputs gracefully without crashing (Hunt and Thomas, 2019). Without the `try/except ValueError` block, entering "abc" for a score would raise an unhandled exception and terminate the program abruptly. Error handling converts what would be a crash into a user-friendly correction prompt — a fundamental distinction between a robust program and a fragile one.

7. COMPLEXITY AND EVALUATION

Time complexity — the formal measure of how an algorithm's runtime scales with input size — is expressed using **Big-O notation**, introduced by Paul Bachmann (1894) and popularised in computer science by Knuth (1997). Big-O describes the *worst-case* upper bound on the number of operations as input size *n* grows toward infinity.

O(n)

calculate_average()

Must visit every score once to compute sum. Optimal — no score can be skipped.

O(n)

collect_scores()

Outer for loop runs n times. Inner while loop runs ≥1 times per iteration (worst-case unbounded, but amortised O(1) per valid score).

O(1)

get_grade_letter()

At most 4 comparisons regardless of n. Constant time — the number of grade boundaries is fixed.

O(n)

Overall system

Dominated by collection and averaging. Linear — optimal for this problem class since all n inputs must be read.

The O(n) overall complexity of the system is *optimal* for this problem class. Any program that must process each of *n* user inputs must spend at least O(n) time — there is no sub-linear solution when all inputs must be individually validated and accumulated (Cormen et al., 2022). This is a useful illustration of the concept of a **lower bound**: regardless of how cleverly the code is structured, the input collection step cannot be made faster than O(n).

Beyond complexity, three further improvements would strengthen the program for real-world deployment. First, **weighted assessments**: universities typically assign different percentage weights to different assessments (e.g., an exam worth 70%, coursework 30%). The current implementation uses a simple arithmetic mean — extending it to a weighted average would require storing weight values alongside scores, which could be modelled as a list of `(score, weight)` tuples. Second, **persistent storage**: the system currently holds data only in memory — closing the program destroys all records. Integrating Python's `csv`

module to write results to a file would enable historical grade tracking across multiple sessions. Third, **object-oriented extension**: at more advanced levels, a `Student` class encapsulating `name`, `scores` and `calculate_average()` as a method would represent a natural progression from procedural to object-oriented design (Brookshear and Brylow, 2019).

8. CONCLUSION

This assignment has demonstrated the complete programming development lifecycle applied to the Student Grade Management System. Beginning with problem decomposition — identifying five distinct sub-tasks each mapped to a single-responsibility function — the design phase produced both pseudocode and a flowchart that made the algorithm's control flow, decision branches and validation logic explicit before any Python was written. The implementation phase translated that design into clean, commented, modular Python 3 code that handles both expected inputs and edge cases (out-of-range scores, non-numeric input, boundary-value averages) through systematic defensive programming. A ten-case black-box test suite with full pass/fail verification validated the correctness of all branches. Finally, Big-O complexity analysis confirmed the system is algorithmically optimal at O(n), with three identified extension pathways (weighted grades, file persistence, OOP refactoring) charting the next stage of development.

The broader lesson is that programming is not primarily about syntax — Python's syntax can be learned in days. It is about decomposing a problem clearly, designing a correct algorithm before coding, and writing code that is readable, testable and maintainable. As Kernighan and Pike (1999, p. 1) observe: "the most important skill for a programmer is not the ability to write code, but the ability to think about what code should do."

```
// KEY PRINCIPLES DEMONSTRATED IN THIS ASSIGNMENT
```

1. **Decomposition first, code second:** Problem analysis produced a five-task decomposition before a single line of Python was written. This prevented the most common beginner error of writing code without a clear plan and refactoring repeatedly.

2. **Single responsibility per function:** Each of the five functions has exactly one job. `validate_score()` validates; `calculate_average()` averages; `get_grade_letter()` classifies. Mixing concerns — for example, calculating and printing inside the same function — would make each unit untestable in isolation.
3. **Defensive input validation is mandatory:** Every external input (user-typed data) must be validated before being used in calculations. Unvalidated input is the primary source of runtime errors in beginner programs — the nested `while True / try / except` pattern is the correct idiomatic Python solution.
4. **Test boundary values explicitly:** Tests TC04 and TC05 (scores of 70.0 and 69.9) directly target the most likely source of logic error in the grade classification function. Any change to the if/elif order would be immediately caught by these boundary tests — which is precisely the value of writing tests for boundary conditions, not just typical inputs.

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