1.7 Decomposition, testing and debugging

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

KEY WORDS decomposition • testing • debugging • boundary case

Objective

Decompose a problem into single-job functions, write boundary tests the moment a function exists, and debug by bisecting the gap between what you believe and what the code does.

1 Key knowledge and worked examples

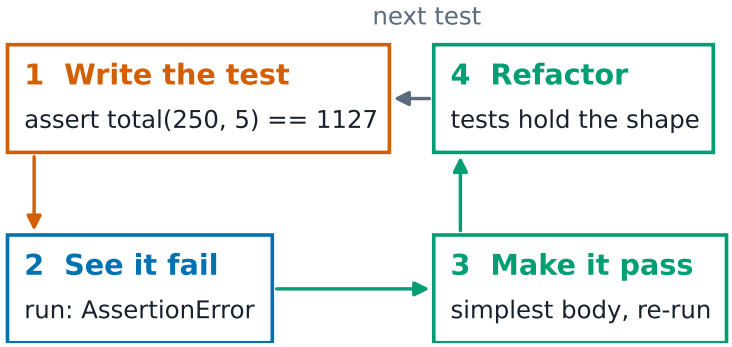
■ Decomposition: one job per function

Decomposition splits a problem until each piece does one thing – small enough to hold in your head, and to test alone. The functions from unit 1.4 compose:

```
def add_fee(amount):
    """Return amount plus a fixed 3 pence fee."""
    return amount + 3

def order_total(unit_pence, quantity):
    """Return the order total: subtotal plus the fixed fee."""
    return add_fee(unit_pence * quantity)
```

Each has a stated contract in its docstring: inputs, output, units. A function that prints instead of returning cannot be composed – printing is for the edges of the program, returning is for its middle.



■ Worked example: tests at the boundaries

Testing compares actual with expected. The boundary cases find the bugs: zero, one, empty, and one awkward case.

```
assert order_total(250, 4) == 1003   # a normal case
assert order_total(250, 0) == 3      # zero quantity - fee still applies
assert order_total(0, 4) == 3        # zero unit price
```

Silence is a pass: an `assert` that never fires is a green test. Write tests before the body when you can – the tests are the contract made executable, and a function written to pass them rarely needs its logic re-examined.

■ Debugging by bisection

Debugging is locating the difference between belief and behaviour. The method: (1) reproduce with the smallest failing input; (2) inspect values at the boundary between the code you trust and the code you suspect; (3) fix one thing; (4) re-run all the tests.

For a 100-line pipeline, one well-placed `print` halves the search each run – three runs locate a fault among eight stages. Remove the prints (or turn them into tests) when done.

2 Practice

2.1 Name the three boundary cases every new function should get, according to this course's habit, and apply them to `def repeat(text, times)` returning the text repeated `times` times. [3]

2.2 A function's tests all pass, but the program's output is still wrong. Give the two most likely locations of the fault, given the tests pass. [2]

2.3 Write the boundary tests for `def clip(value, low, high)` that returns `value` limited to the range `low..high`. [4]

3 Exam-style questions

3.1 A café report needs: the day's takings from a list of sale amounts, the count of sales, and a line `n sales, total t, average a` with the average at two decimals (0.00 when there are no sales).

Decompose this into functions of one job each (names, parameters, return values – docstrings optional), then write the boundary tests for the empty-sales case and one normal case. [7]

3.2 A student's `tally` function passes its tests, but the program printing `"Most popular: {winner}"` shows the wrong drink. The program reads orders from a file into a list, tallies with the function, then picks `max(counts, key=counts.get)`.

Set out a bisection debugging plan: the three inspection points you would add and what each would confirm, and name the most likely fault given the tests pass. [6]

Solutions

2.1

- Zero, one, and one awkward case.
- `repeat("ha", 0)` → `""`; `repeat("ha", 1)` → `"ha"`; awkward: `repeat("", 5)` → `""` (or a negative times → `""`).

2.2

- The wiring between functions – arguments passed in the wrong order or a result discarded.
- The output edge – formatting or printing the right value wrongly.

2.3

- `clip(5, 0, 10)` → 5 (inside, unchanged).
- `clip(-3, 0, 10)` → 0 (below low).
- `clip(13, 0, 10)` → 10 (above high).
- Boundary: `clip(10, 0, 10)` → 10 (at the limit – inclusive).

3.1

```
def takings(sales):
    """Return the sum of sale amounts."""
    return sum(sales)

def count_sales(sales):
    """Return the number of sales."""
    return len(sales)

def report(sales):
    """Return the report line for the sales list."""
    total = takings(sales)
    n = count_sales(sales)
    average = total / n if n else 0
    return f"{n} sales, total {total:.2f}, average {average:.2f}"
```

- Decomposition: summing, counting and formatting as separate jobs.
- The guard for no sales (average 0.00, no division by zero).
- Formatting at two decimals in the report function.
- Tests: `assert report([]) == "0 sales, total 0.00, average 0.00"`.
- `assert report([2.5, 1.5]) == "2 sales, total 4.00, average 2.00"`.

3.2

- Inspection 1: print the list read from the file – confirms the input is complete and correctly stripped.
- Inspection 2: print the tallied dictionary – confirms the tested function's ACTUAL output on this input.
- Inspection 3: print `max(counts, key=counts.get)` with `counts` – confirms the winner choice given that dictionary.
- Most likely fault given the tests pass: the input – lines not stripped, so `"tea"` and `"tea\n"` tally as different drinks (a file-specific case the tests, which used a clean list, never exercised).
- The fix lands at the reading edge (`line.strip()`), not in the tested function.