Creative Development

AP Computer Science Principles

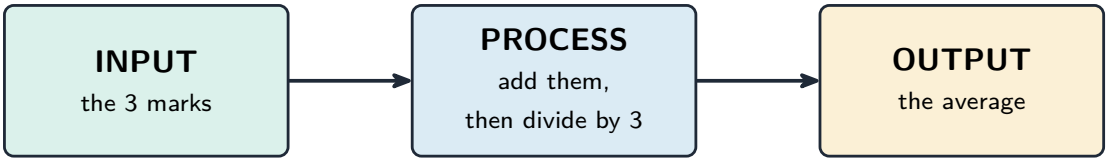
Collaboration

A jigsaw in progress: collaboration and modular design piece the solution together

Computing is a **collaborative** 协作 activity. Working in a team brings more perspectives, catches more errors, and produces better programs than working alone. Good collaboration uses **consensus building**, clear communication, and each member's strengths. **Pair programming** 结对编程 – two people at one computer, one typing and one reviewing – is a common practice. On the exam, you should be able to explain how collaboration improved a program (more ideas, fewer bugs, wider testing).

Program Function and Purpose

Every program is written for a **purpose** – it solves a problem or pursues an interest. A program takes **input** 输入, processes it, and produces **output** 输出. Inputs can come from a user, a device, a file, or another program; outputs can be visual, audible, textual, or a signal to a device. Being able to state a program's purpose, and describe its inputs and outputs clearly, is a core skill (and part of the Create performance task).



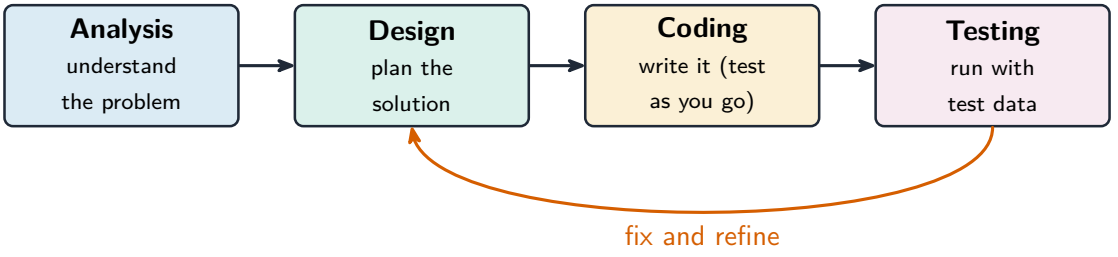
Every program decomposes into input, processing, and output

Every program follows the input-processing-output model

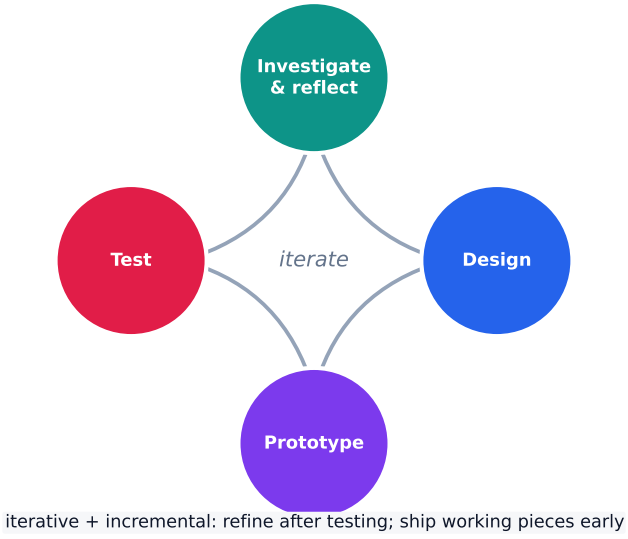
Program Design and Development

A programmer debugging at a multi-monitor workstation — iterative design and testing

Programs are built through an **iterative** 迭代 process, not in one straight line: investigate the problem and users, design (often with a **diagram** or written plan), implement in code, and test – then repeat. A large problem is broken into smaller pieces (**decomposition** 分解). **Comments** 注释 and clear naming document the design so others (and your future self) can understand it. Development is **incremental** – build and test a small piece, then add the next.



The stages of program development, with testing feeding back to fix and refine



Software is built by an iterative, incremental development process

Investigating what users actually need

Before any code is written, the developer investigates the problem and the people who will use the program. Three ways to do that:

- **surveys** 调查问卷 sent to potential users, which collect data from many people quickly;

- **interviews** and direct observation of users doing the task by hand;
- **studying existing solutions** to see what already works and what frustrates people.

The findings are turned into a design. Two artefacts do that: a **program requirements** list saying exactly what the program must do, and **diagrams representing the layout of the user interface** 用户界面 — sketches showing which controls appear where, and what each one does when used. Designing the interface on paper first is cheaper than discovering after coding that the buttons are in the wrong place.

Events, and programs that wait

Not every program runs straight through from top to bottom. An **event** 事件 is generated when a key is pressed, a mouse is clicked, a program is started, or any other defined action occurs — and an event changes the **flow of execution**: the program pauses what it was doing and runs the code attached to that event, called an **event handler** 事件处理程序.

This is why a program with a graphical interface can appear to be doing nothing: it is waiting for the next event. The order in which those events arrive is decided by the user, not by the programmer, so the same program can run its blocks in a different order each time it is used.

Identifying and Correcting Errors

A **bug** is an error in a program; **debugging** 调试 is finding and fixing it. Three kinds:

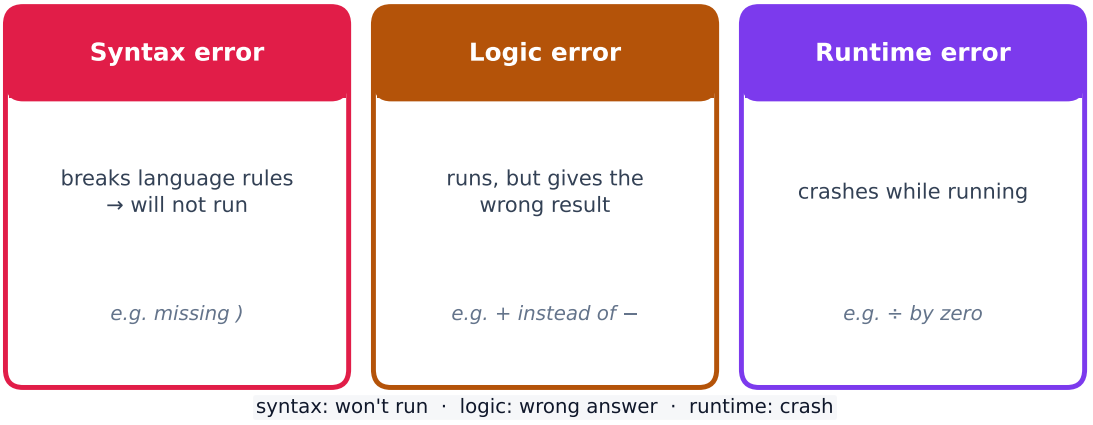
count	total	output
1	5	
2	12	
3	20	20

A trace table records each variable's value as the program runs, to find bugs

- a **syntax error** 语法错误 breaks the language's rules, so the program will not run;
- a **runtime error** 运行时错误 crashes the program while it runs (e.g. dividing by zero);
- a **logic error** 逻辑错误 lets it run but gives the wrong result.

Find bugs by **testing** with different inputs, adding **print statements** to see values, and hand-tracing the code. Choose the test inputs deliberately: they should demonstrate the different expected outcomes **at or just beyond the extremes** — the minimum and maximum values the program should accept, and a value just outside each of them. A program that works on ordinary data very often fails on an empty list, a zero, or a value one past the end of a range, so those are the inputs worth trying first. Fixing one bug at a time and re-testing is the reliable method.

Exam skill: be able to name the type of an error and describe a testing strategy that would catch it – a recurring multiple-choice and Create-task theme.



Three kinds of programming error: syntax, logic, and runtime

Worked example. A program meant to print the average of two numbers instead runs `avg = a + b / 2`. Tracing the order of operations, `/` runs before `+`, so it computes $a + \frac{b}{2}$ rather than the average. Add parentheses to fix it: `avg = (a + b) / 2`. Testing with $a = 4$, $b = 6$ confirms the fix — the buggy line gives $4 + 3 = 7$, the corrected line gives $\frac{10}{2} = 5$. Testing with known inputs is exactly how you find and confirm a **logic error**.

Exam tips

- Much of CSP is assessed through the **Create** and written performance tasks — explain your reasoning clearly, not just your result.
- Know the benefits of collaboration and how diverse perspectives reduce bias in a program.
- Use precise vocabulary (iterative development, program requirements) when you describe a design process.
- Give and take feedback constructively; credit collaborators and sources.
- Break a large problem into smaller modules that a team can build in parallel.