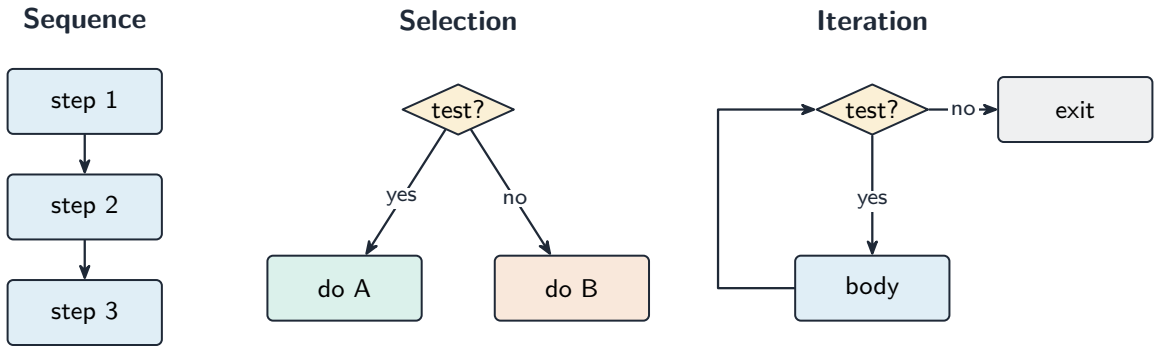
Selection and Iteration

AP Computer Science A

Selection and Repetition in Algorithms

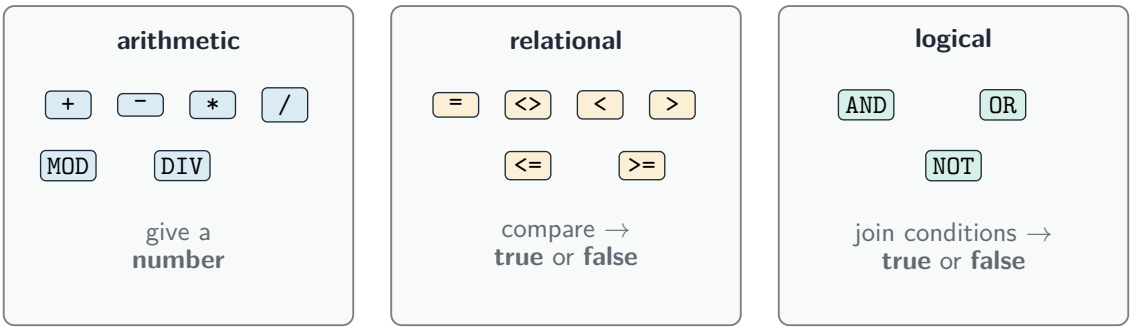
Algorithms are built from three **control structures** 控制结构: **sequence** (steps in order), **selection** 选择 (choosing a path), and **iteration** 迭代 (repeating steps). This topic covers selection and iteration –the tools that let a program make decisions and loop.



The three control structures: sequence, selection, and iteration

Boolean Expressions

A **boolean expression** 布尔表达式 evaluates to `true` or `false`, using **relational operators** 关系运算符: `==` (equal), `!=` (not equal), `<`, `>`, `<=`, `>=`. Note `==` compares primitive values but **object references** for objects, so use `.equals` for `String`s.



The three families of operators: arithmetic, relational, and logical

The if Statement

An **if statement** 条件语句 runs a block only when its condition is true; an optional `else` gives an alternative:

```java
if (score >= 60) {
    System.out.println("Pass");
} else {
    System.out.println("Fail");
}
```

Nested if Statements

Placing an `if` inside another, or chaining with `else if`, tests several cases in order. Only the **first** matching branch runs:

```java
if (g >= 90) grade = 'A';
else if (g >= 80) grade = 'B';
else grade = 'C';
```

Compound Boolean Expressions

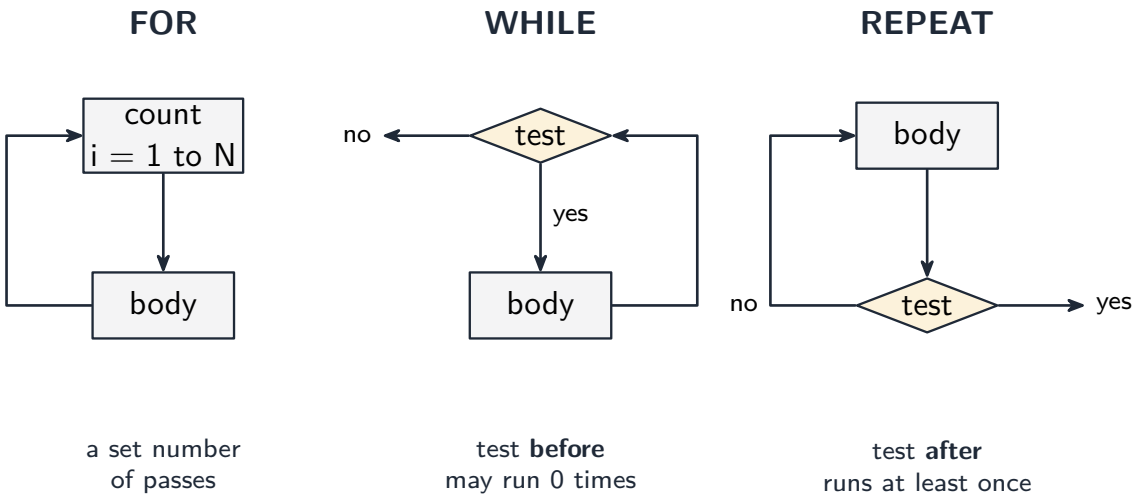
Logical operators 逻辑运算符 combine conditions: `&&` (**and** –both true), `||` (**or** –at least one true), `!` (**not** –reverse). Java uses **short-circuit evaluation** 短路求值: `&&` stops if the left side is false, and `||` stops if the left side is true –useful to guard against errors, e.g. `if (n != 0 && total / n > 5)`.

Comparing Boolean Expressions

De Morgan's laws 德摩根定律 rewrite negations: `!(a && b)` equals `!a || !b`, and `!(a || b)` equals `!a && !b`. Two boolean expressions are **equivalent** if they give the same result for every input –a truth table proves it. Simplifying conditions this way is a common exam task.

while Loops

A **while loop** 循环 repeats **while** its condition stays true, testing **before** each pass. You must change something inside so the loop eventually stops, or it becomes an **infinite loop** 无限循环:



The three loop types differ in where the condition is tested

```
int i = 0;
while (i < 5) {
    System.out.println(i);
    i++;
}
```

for Loops

A **for loop** packs initialization, condition, and update into one line –best when you know the count:

```
for (int i = 0; i < n; i++) {
    // runs n times, i = 0..n-1
}
```

A `for` and an equivalent `while` do the same work; be able to convert between them.

Building Complete Selection and Iteration Algorithms

Combine loops and conditions to solve real problems –count, sum, find a maximum, or test a property:

```
int max = arr[0];
for (int k = 1; k < arr.length; k++) {
    if (arr[k] > max) max = arr[k];
}
```

Standard patterns like a running total, a counter, or a **flag** 标志 (a boolean that records whether something happened) recur throughout the course.

String Algorithms

Loop through a string by index to process each character:

```
for (int i = 0; i < s.length(); i++) {
    char c = s.charAt(i);
    // count vowels, reverse, check for a substring, ...
}
```

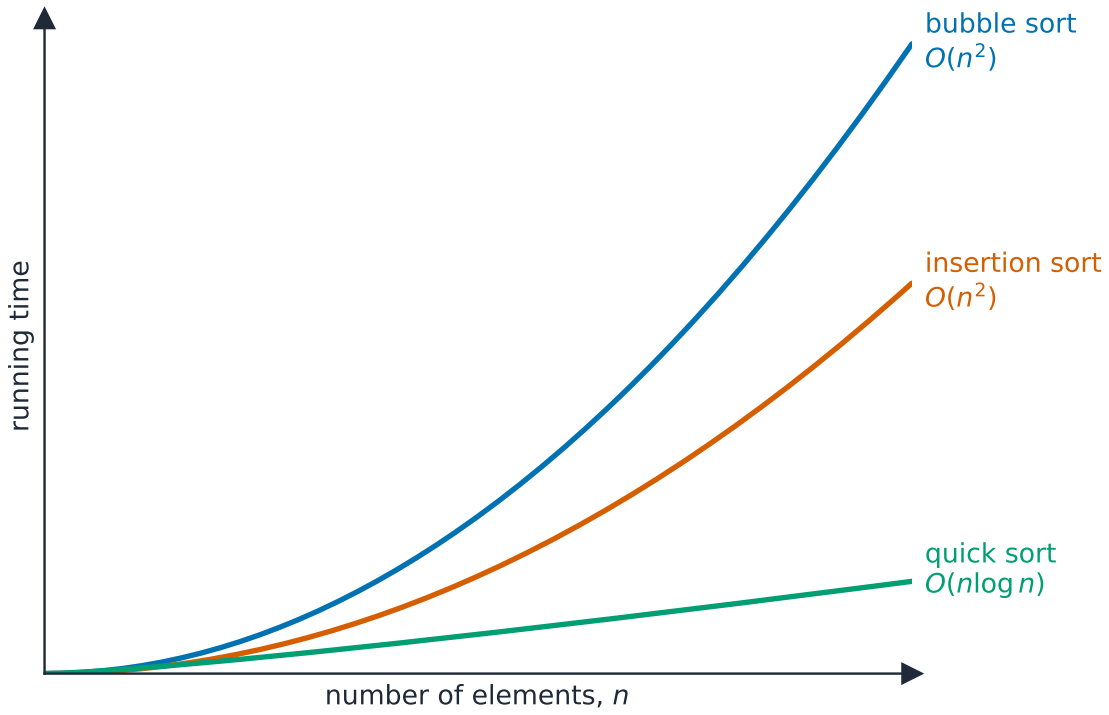
Typical tasks: count occurrences, build a reversed or filtered copy, or test whether one string contains another.

Nested Iteration

A **nested loop** 嵌套循环 puts one loop inside another; the inner loop completes fully for **each** pass of the outer. If the outer runs n times and the inner m times, the body runs $n \times m$ times –the basis for processing grids and comparing all pairs.

Informal Run-Time Analysis

Run-time analysis 运行时间分析 counts how many basic steps an algorithm takes as the input size n grows. Count the executions of the innermost statement: a single loop over n items is **linear** (n steps); two nested loops over n are **quadratic** (n^2). This informal counting lets you compare two algorithms' efficiency.



How the running time grows with the number of elements n

Exam skill: for a nested loop, be able to state how many times the inner statement runs in terms of the loop bounds –a frequent multiple-choice question.

Worked example. How many stars does this print?

```
for (int i = 0; i < 4; i++)
    for (int j = 0; j < i; j++)
        System.out.print("*");
```

The inner loop runs `i` times for each outer `i`: `0 + 1 + 2 + 3 = 6` stars. When the inner bound is the *outer* variable, the total is the triangular sum $0+1+\cdots+(n-1) = \dfrac{n(n-1)}{2}$ –here $\dfrac{4\times 3}{2} = 6$ –not the full $n^2 = 16$ of a rectangular nested loop.

Exam tips

- Get boundary conditions right: use `<` vs `<=` deliberately, and watch the first and last iteration of every loop (off-by-one is the classic bug).
- Build compound conditions with `&&`, `||`, `!` and remember **short-circuit** evaluation (put the null check first).
- Trace nested loops by counting how many times the **inner** body runs in total.
- Choose the right structure —`if/else if` for ranges, a loop for repetition —and avoid an infinite loop by updating the loop variable.
- Apply **De Morgan's laws** when you simplify or negate a boolean condition.