ENGINEERING CONFIDENCE

Using Objects & Methods

Solution Guide with Metacognitive Scaffolding

AP COMPUTER SCIENCE A · UNIT 1 · EFFECTIVE FALL 2025 · 15–25% OF MCQ

Variables & expressions · Integer division & casting · String objects & methods · The reference model

A reference for the whole unit — not a single session's homework, but built the way my session guides are built: tool selection first, every step shown, commentary where the thinking usually goes wrong.

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BEFORE YOU COMPUTE

About this guide. Java meets you with a wall of small rules — integer division throws away remainders, `substring` counts from zero and excludes its endpoint, `==` answers a different question than `.equals` — and the students who struggle are rarely the ones who "can't code." They're the ones who read code like prose instead of tracing it like a machine. This guide covers Unit 1 of the revised AP Computer Science A framework (effective Fall 2025): *Using Objects and Methods*, all 15 current topics, and a 15–25% weighting in the multiple-choice section. It is the unit every later unit stands on.

You will not find an `if` statement or a loop anywhere in these pages, and that is not an oversight. In the revised framework, selection and iteration belong to Unit 2. What is left here is the part almost everyone races past on the way to the "real" programming: what a value *is*, what a variable *holds*, and what each operator does with what it was actually handed — not what you meant to hand it. Many later confusions that start with the words "but I thought this variable was…" trace back to a Unit 1 rule that needs another pass.

The pages that follow are your **concept reference**: a diagnostic decision tree and a Master Toolbox. Use them on demand rather than reading every card before you begin. Pick a problem from the route below, attempt it first, consult only the named card when you stall, and return to the full tree for a mixed trace. Work each problem *before* reading its solution — the "Before you compute" notes are there to catch a likely wrong turn while it is still visible.

If the symptom is about …	Start here
division, casts, overflow, precision	Problems 1–3, 9 and the numeric cards
String indices, output, exact assembly	Problems 3, 4, 7–9
objects, aliases, constructors, method calls	Problems 5, 6, 9
APIs, comments, signatures, `null`	Problem 9 and the contracts card
designing and checking a method	Problems 7–9

Problem 1's negative-remainder part is labeled Java enrichment because the current AP framework excludes a negative dividend for remainder questions. Reference identity in Problem 5 and numeric equality in Problem 9(f) anticipate Unit 2. The method implementations in Problems 7–8 and parameter reassignment in Problem 9(e) anticipate Unit 3. Those bridges make the Unit 1 object, signature, and finite-storage rules useful.

One habit runs through all of it: **write the state down**. Use a variable table for running code, an index ruler for Strings, and boxes and arrows for objects. Tracing in your head can silently skip a step; these tools make the state visible and give you an independent check.

Diagnostic Decision Tree

HOW TO READ A CODE SEGMENT

Run through these questions in two passes. On the first pass, use the first "yes" to choose a primary workspace: a variable table, index ruler, or object diagram. On the second, apply every relevant check to the expressions inside that workspace. A single line can contain a cast, method call, division, and concatenation, so one match never cancels the others.

1. Am I asked what the code prints or returns? Don't read it like a paragraph — run it like the machine: a variable table, one line at a time, values updated in the order written. Predicting from the general shape of the code is where wrong answers come from, because the general shape is exactly what the distractors are built to match. *Problems 3, 5, 7.*

2. Is there a `/` or a `%` anywhere? Name the type of *each operand* before evaluating anything. After confirming that the divisor is nonzero, `int / int` throws the remainder away, truncating toward zero; `%` takes its sign from the left operand. Integer division or remainder by zero instead throws `ArithmeticException` at run time. One `double` anywhere in that one operation changes everything about it. Note the phrase "that one operation" — a `double` elsewhere in the line does not help. *Problems 1, 2, 3, 7.*

3. Is there a cast? Decide exactly what it applies to before you evaluate anything. `(int)` and `(double)` grab only the *very next value* unless parentheses hand them more. `(double) a / b` and `(double)(a / b)` are different programs with different answers. *Problems 2, 3, 6, 7.*

4. Is it a String index question? Write the string out and number the characters from 0 *before* touching `substring` or `indexOf`. `substring(a, b)` includes index `a`, excludes index `b`, and has length `b − a`. Spaces count, and they are the character everyone forgets to number. *Problems 4, 7–9.*

5. Is something being compared? For primitives, `==` compares exact stored values. That is the intended tool for `int` and `boolean`; computed `double` values that are only approximately expected may need a tolerance instead. For references, `==` asks whether both variables hold the same reference. For String content, use `.equals`; for another class, read its API because its equality behavior may differ. *Problems 5, 9.*

6. Is a method being called? Match the call to its documented header. A class-qualified call (`ClassName.method(...)`) is **static** — it has no receiving instance, although it may use class state. A call documented as an instance method runs on its receiving object; it is conventionally written `variable.method(...)`. Then ask the second question: does it *return* a value you must catch, or is it `void`? *Problems 5, 6, 7, 9.*

7. Is + touching a String? Evaluate left to right. From the first String onward, + stops adding and starts gluing — and everything after it gets glued, including numbers that were about to be added. *Problems 3, 7–9.*

Every question is also a **secondary check**. A trace can have a cast buried inside it; a String question can hide an integer division, and a method call can return the value that a later + consumes. When that happens, run the tree again on the smaller question, settle it, and come back to where you were.

Master Toolbox — Core Tools

ALGORITHMS, INPUT, AND THE WRITE–COMPILE–RUN LOOP

An **algorithm** is a finite, sequenced set of steps for completing a task or solving a problem. It can be represented in ordinary written language or with a diagram.

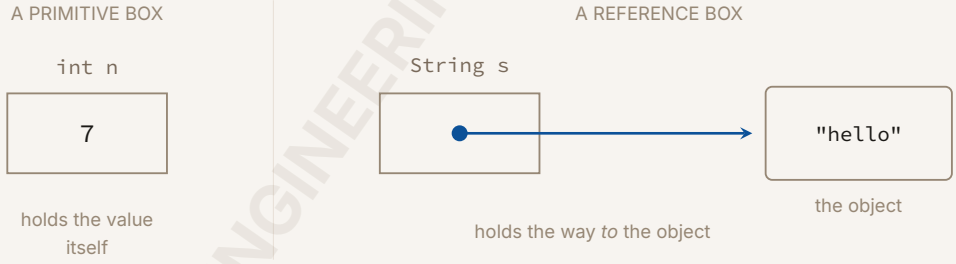
Before it becomes code, sequencing matters: each step completes one at a time, in the stated order. A trace is simply an algorithm executed on paper.

An integrated development environment, or **IDE**, can help write, compile, and run a program. The compiler checks syntax and type rules; code containing a detected compile-time error must be repaired before it can run. Passing the compiler does not establish correctness. Test with specific data to expose logic errors, and distinguish those from a run-time error or exception that interrupts execution.

Input may be tactile, audio, visual, or text. Java's `Scanner` class is one way to obtain keyboard text, but the current AP exam does not require a particular user-input form or a particular Scanner call. Whatever the source, input becomes values stored in variables; for example, `boolean confirmed = true;` stores one Boolean value that later code can use.

THE ONE IDEA UNDER EVERYTHING: TWO KINDS OF BOX

Every variable is a labeled box, and there are exactly two kinds. A **primitive** box (`int`, `double`, `boolean`) holds the value itself. A **reference** box (`String`, or any class type) holds either an *arrow* to an object that lives somewhere else or the special value `null` — never the object itself.



The dot is the arrow's tail, and it lives inside the variable. The object is not in the box and never was.

Three consequences follow, and they organize much of the unit:

- **Assignment copies what's in the box** — a value, an arrow, or `null`. `int m = n;` copies the number 7 and the two variables are then strangers. `String t = s;` copies the *arrow*, and now two variables point at one object.
- **== compares what's in the boxes.** For primitives that is the exact stored value. It directly fits `int` and `boolean`; a computed `double` that is only approximately expected may need a tolerance. For objects that's the arrows: `true` only when both variables hold the *same reference*; two `null` references also compare `true`. For Strings, `.equals` reads the characters. Other classes define their own documented equality behavior, or inherit identity-based `equals` from `Object`.

- **A method called through a non-null reference travels down the arrow** and acts on whatever it finds there — which may be an object that other variables also point at. Calling an instance method through `null` instead throws a `NullPointerException`.

The dependable rule is question-specific: use `.equals` for String content and `compareTo` for String order. Use `==` only when reference identity is actually the question. Problem 5 shows why `==` cannot stand in for String-content equality.

TYPES, DECLARATIONS, AND THE COMPOUND ASSIGNMENTS

The three primitive types this unit uses. `int` — whole numbers, no fractional part, ever. `double` — real-number values represented with finite precision. `boolean` — `true` or `false`, nothing else. Their names are lowercase because they are built into the language. Class types — `String`, `Counter`, anything you or somebody else wrote — are capitalized by convention, and they are reference types.

A declaration builds the box; an assignment fills it. `int a = 8;` does both at once: make a box named `a` that can hold an `int`, and put `8` in it. The type is chosen once and never changes — an `int` box cannot later hold `3.5`, and the compiler will refuse rather than round.

A literal has a type of its own, before any variable sees it. `5` is an `int`. `5.0` is a `double`. `"5"` is a String. Those are three different things, and the difference between the first two is what decides whether a division keeps its remainder. When you write `2.0` instead of `2` in a division, you are not decorating — you are changing which operation runs.

`=` is not equality. `a = a + 1;` is not a false statement about numbers; it is an instruction with two halves: evaluate the right side using the values that exist right now, then store the result in the box on the left, discarding whatever was there. Read every assignment right side first.

Compound assignment performs, converts, then stores.

You write	AP-level reading	Watch for
`a += c`	add, convert to a's type, store	if either side is a String, this glues
`a -= c`	subtract, convert, store	
`a *= c`	multiply, convert, store	
`a /= c`	divide, convert, store	operand types still choose the division
`a %= c`	remainder, convert, store	
`a++`	`a = a + 1`	
`a--`	`a = a - 1`	

For the same-type examples in this guide, the result matches the familiar long form. In full Java, however, compound assignment also converts the result back to the left variable's type. Thus `int a = 5; a /= 2.0;` compiles and stores `2`, while `a = a / 2.0;` does not compile without a cast. The left-hand location is also evaluated once, a distinction that matters for more complex expressions later in the course.

PRECEDENCE AND ORDER OF EVALUATION

Two separate questions, and mixing them up is its own error. Precedence says *which operator claims which operands*. Order says *which one fires first* among equals.

Tier	Operators
1 (tightest)	anything inside `( )`; a cast `(int) (double)`; unary `-`
2	`*` `/` `%`
3	`+` `-` (including + used as String glue)
4	`==` `!=`
5 (loosest)	`=` `+=` `-=` `*=` `/=` `%=`

The binary arithmetic and concatenation operators shown here evaluate left to right within a tier. That rule decides `17 / 5 * 5.0` (the division goes first, on two `int`s) and `"total: " + a + b` (the left + makes a String, so the right one can only glue). Both look like they should come out otherwise, and neither does.

Assignment comes after the right-side expression. The entire right side finishes before anything is stored — so the type of the variable on the left cannot reach backwards and change how the arithmetic ran.

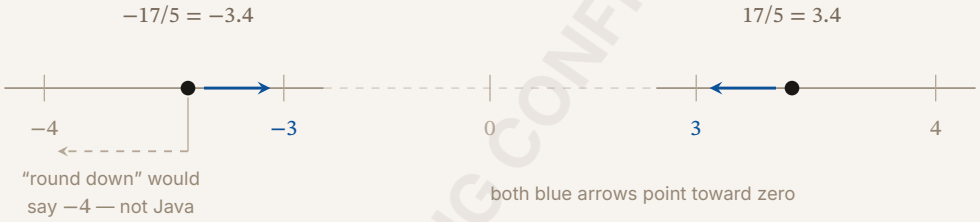
Assignment expressions themselves associate right to left, but chained assignment expressions are outside the AP CSA scope.

INTEGER ARITHMETIC: / AND %

When both operands are `int` and the divisor is nonzero, the answer is an `int` — and an `int` has nowhere to put a fraction. So Java splits the result in two: `/` hands you the whole part and `%` hands you what was left over. Neither one is broken. Between them they lose nothing; take only one and you have thrown half the answer away.

```
17 / 5 → 3   17 % 5 → 2   -17 / 5 → -3   -17 % 5 → -2
```

The negative cases are the ones that surprise people, and the reason is one word: truncation is toward *zero*, not downward.



Truncation deletes the fractional part where it stands. It never moves a number away from zero, in either direction.

And `%` takes its sign from the left operand, which is not an arbitrary decision either. Java guarantees that the quotient and the remainder fit back together:

$$(a \;/\; b) \cdot b + (a \;\%\; b) = a$$

Check it both ways: $3 \cdot 5 + 2 = 17$, and $(-3) \cdot 5 + (-2) = -17$. Once the quotient truncates toward zero, the remainder has no choice about its sign — it has to make up the difference back to a negative dividend, so it must be negative. This identity is also the fastest self-check you own: if your quotient and remainder don't rebuild the number you started with, one of them is wrong and you know it in five seconds.

Scope and zero. The signed examples above describe Java, but a negative dividend for `%` is outside the current AP CSA exam scope. Integer division by zero is required knowledge: an expression such as `17 / 0` throws an `ArithmeticException` at run time. The program does not receive a quotient.

Two idioms worth recognizing on sight, because they show up everywhere later: for a non-negative `n`, `n % 10` is its last digit and `n / 10` is `n` with that digit removed. Together they take a number apart one digit at a time. (Negative `n` gives a negative last digit, for exactly the reason above.)

CASTING: MOVING BETWEEN INT AND DOUBLE

Widening is automatic. An `int` can always be carried inside a `double` without losing anything, so Java promotes it for you the moment the two meet in one operation: `17 / 5.0` is real division, and the 17 becomes 17.0 on its way in. No cast needed, no permission asked.

Narrowing must be requested, and it truncates. Going the other way loses information, so Java refuses to do it silently — you have to write `(int)`, which is you signing for the loss. And it chops rather than rounds, toward zero from both sides: `(int) 7.9` is 7 and `(int)(-7.9)` is −7.

A cast grabs only the next value — it sits in the tightest precedence tier, alongside parentheses. This is where the two forms separate:

`(double) 7 / 2` → `7.0 / 2 → 3.5`

the cast takes only the 7

`(double) (7 / 2)` → `(double) 3 → 3.0`

the parentheses hand it all of it

Same three numbers, same two operators, one pair of parentheses of difference — and the information is gone before the cast arrives in the second line.

A cast produces a value; it does not change a variable. After `(int) x`, the variable `x` is still a `double` holding exactly what it held before. The cast made a temporary `int` for that one expression to use.

The rounding idiom. The AP reference sheet hands you `abs`, `pow`, `sqrt`, and `random` — and no rounding method at all. So you build one:

`x`	`x + 0.5`	`(int)(x + 0.5)`	**Why**
6.2	6.7	6	short of 7, so truncation lands on 6
6.5	7.0	7	exactly halfway — pushed over, rounds up
6.78	7.28	7	past the halfway mark, so it crosses
6.99	7.49	7	still short of 8, correctly

Adding `0.5` moves every value that deserves to round up across the next whole number, and leaves every value that doesn't below it. Truncation then does the rest. **For negative x, subtract instead:** `(int)(x - 0.5)`, because "round away from the fraction" now points the other way — `(int)(-6.78 + 0.5)` is −6, which is wrong, and `(int)(-6.78 - 0.5)` is −7, which is right.

FINITE STORAGE: INTEGER OVERFLOW AND DOUBLE ROUND-OFF

Java gives every `int` four bytes. Its inclusive endpoints are `Integer.MIN_VALUE` (−2,147,483,648) and `Integer.MAX_VALUE` (2,147,483,647). If an integer expression's mathematical result lies outside that range, an **integer overflow** occurs. Java still stores an allowed `int`, but it may not be the mathematical value you expected:

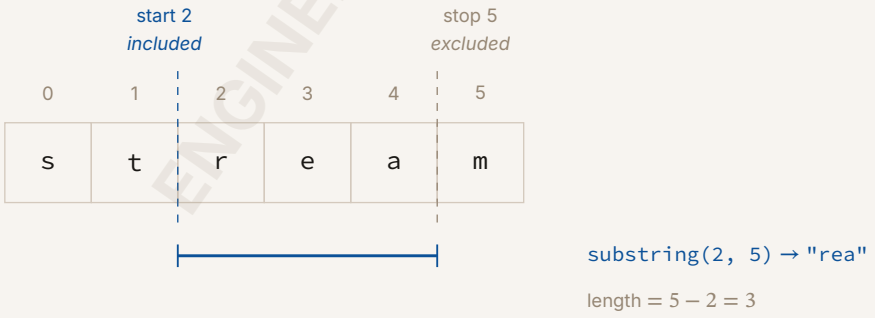
`Integer.MAX_VALUE + 1` ⟶ `Integer.MIN_VALUE`

No compiler message announces the overflow. Before adding or multiplying large whole-number quantities, compare the possible result with the two named limits.

A `double` also has finite storage. Many decimal fractions cannot be represented exactly in binary, so the stored result is the nearest representable value. That **round-off error** is why `0.1 + 0.2` can produce `0.30000000000000004` rather than exactly `0.3`. Use `int` when the quantity is inherently a whole-number count and must remain exact; for measured or fractional quantities, carry enough precision and round only as the task requires.

STRINGS: INDEXING, SUBSTRING, IMMUTABILITY

A String is an object, and its characters are numbered from **0**. Spaces are characters and get numbers like everything else. Every question in this family becomes reading rather than guessing the moment you draw the ruler.



Read the two arguments as *cut lines*, not as characters: cut before index a, cut before index b, keep what is between. That is why the second endpoint is excluded and why the length is the subtraction.

`word.length()`	number of characters (so the last index is `length() - 1`)
`word.substring(a, b)`	indices a through `b - 1` — length `b - a`
`word.substring(a)`	from index `a` to the end
`word.indexOf(s)`	index where the first occurrence of `s` *begins*; `-1` if absent
`word.equals(other)`	`true` if the contents match, character for character
`word.compareTo(other)`	a negative `int` if `word` comes first in dictionary order, `0` if the two are identical, a positive `int` if `word` comes second. Read the *sign*, nothing else

On `compareTo`, and what this guide does with it. It is on the AP Java Quick Reference, so the exam may hand it to you — and the reference sheet specifies only the sign, which means the sign is all you should ever reason from. The comparison runs left to right and stops at the first position where the two strings differ; if neither differs and one simply runs out, the shorter string comes first. Capital letters sort before lowercase ones, which is the result that surprises people: `"Zoe".compareTo("ada")` is negative. **No problem in this guide exercises it**, because every comparison here asks whether two things are equal — that is `.equals`'s job, not ordering. It is in the table so the reference sheet is not the first place you meet it.

Legal ranges, precisely. For `substring(a, b)` you need $0 \le a \le b \le$ `length()`. Note the last one: `b` is allowed to *equal* the length, one past the last valid character index — that is how you say "to the end," and it is legal precisely because `b` is a cut line rather than a character. An index outside that range is not a wrong answer, it is a crash: `StringIndexOutOfBoundsException`, at run time.

`indexOf` fails politely. It returns `-1` rather than crashing when the argument isn't there, and `-1` was chosen because it is not a valid index — there is no way to confuse it with a real answer. It also reports where the match *starts*, and it matches the *whole* argument, so a partial match at an earlier position does not count.

Strings are immutable, and this is the fact with consequences. A String object cannot be modified after it is built. A method that appears to transform text returns a String result while leaving the original unchanged; the API does not promise that every such result has a fresh identity.

- Ignoring a returned String has no persistent effect on the variable. `word.substring(0, 3);` drops the returned reference. Store it in another variable or assign it back to `word`; neither operation modifies the original object.
- You can hand a String to any method without defending it. Nobody can alter it. This is why Strings are safe in a way that mutable objects (Problem 5's `Counter`) are not.

The one-character idiom is `substring(i, i + 1)` — length $(i + 1) - i = 1$, by the same subtraction as everything else. **Escapes inside literals:** `\n` (new line), `\"` (a quote that doesn't end the string), `\\` (a backslash).

`String` is in `java.lang`. A literal is the usual way to create one, but `new String("hi")` also calls a String constructor and creates a distinct String object containing the same characters.

APIS, COMMENTS, CONTRACTS, AND SIGNATURES

A **library** is a collection of classes; related classes are grouped into a **package**. An application programming interface, or **API**, documents how clients may use those classes: their attributes, behaviors, constructors, methods, parameter types, return types, and stated conditions. The implementation may remain hidden. The `Math` and `String` classes belong to the `java.lang` package, which is available without an import.

Comments are ignored during execution but communicate intent: `//` begins a one-line comment, `/* ... */` encloses a block comment, and `/** ... */` is a Javadoc comment used to generate API documentation. A **precondition** must be true just before a method runs for its promised behavior to apply; the method is not required to check it. A **postcondition** states what must be true after a successful call, in terms of a return value or object state.

A method **signature** is its name plus its ordered list of parameter types; the return type is not part of the signature. A constructor signature uses the class name plus ordered parameter types. Methods or constructors are **overloaded** when one class supplies the same name with different signatures. Documentation tells you which one matches the number, order, and compatible types of the arguments.

A **parameter** is the local variable declared in a header; an **argument** is the value supplied at a call. Java uses **call by value**: a primitive argument copies its value, while an object argument copies its reference. The method can therefore mutate a shared object, but reassigning the parameter cannot retarget the caller's variable. Control enters at the call and returns after `return` or the end of a `void` method.

OBJECTS: NEW, CONSTRUCTORS, AND READING A CLASS

A class is a description — what one object of that kind *knows*, and what it can *do*. Reading one is a four-line skill:

You see	It means
`private int count;`	An **instance variable**: every object of this class gets its own separate `count`. Two objects, two counts, no connection. `private` means code within the declaring class can access it directly
`public Counter(int s)`	A **constructor** — same name as the class, no return type written, ever. It runs once, during `new`, and its job is to put the new object's instance variables into a sensible starting state
`public void increment()`	A **mutator**: `void` means it hands nothing back, and what it does instead is change the object it was called on
`public int getCount()`	An **accessor**: it changes nothing and hands back a value. A standard public route through which a client can learn about private state

What `new Counter(3)` actually does, in order: builds a new object with its own set of instance variables; runs the constructor with the argument 3; and hands back *an arrow to that object*, which is what gets stored in your variable. In a trace of explicit constructor calls such as Problem 5, each successful `new Counter(...)` creates one Counter object. Other expressions and library code can allocate objects without a visible `new`, so do not turn that local counting tool into a rule about every object in a program.

`void` has no value, so it cannot be used as one. `System.out.println(b.increment());` does not compile — not sometimes, not depending on anything else in the program. The message is `'void' type not allowed here`, and it is exactly right: there is nothing there to print. A `void` method is a command; a returning method is a question.

NULL, INHERITANCE, AND OBJECT TEXT

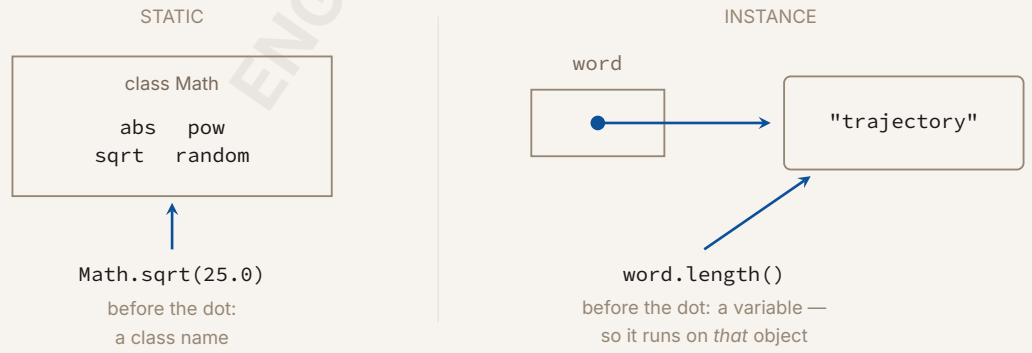
A reference variable may hold an object reference or the special literal `null`, meaning it currently refers to no object. The assignment `Counter c = null;` is legal. Calling an instance method through that reference, such as `c.getCount()`, throws a `NullPointerException` at run time because there is no receiving object. Merely declaring or assigning the null reference does not throw.

Related classes can share attributes and behaviors through **inheritance**: a subclass draws on a superclass. Every Java class ultimately inherits from the `Object` class. Designing and implementing inheritance relationships is outside the current AP CSA scope, but recognizing the relationship is not.

One inherited behavior explains object concatenation. When a String is concatenated with an object, Java uses that object's `toString` method to obtain text. Every class has such a method through `Object`; a class may supply a more useful class-specific result. Implementing a `toString` override is outside the current exam scope, but using the documented result is required Unit 1 reasoning.

CALLING METHODS: STATIC, INSTANCE, AND THE MATH CLASS

The calls emphasized in this unit normally advertise their kind before the dot. A class method is typically called with the class name; inside its own class, that qualifier may be omitted. An instance method is called on an object expression. Java also permits the discouraged syntax of calling a static method through an instance, so the method's documented header — not punctuation alone — is the final authority.



A static call has no receiving object, though it may use class state. An instance call has a hidden extra input — the receiving object itself.

- **Constructor:** `new ClassName(args)` — builds the object, runs the constructor, hands back the arrow.

- **A returned value you don't capture evaporates.** The method still ran; the answer just went nowhere. Store it, print it, or use it inside a larger expression.
- **The class-name rule is about the method, not the class.** `String` does have static methods — `String.valueOf(7)` is one — so "String methods are instance methods" is not the rule. The rule is that `length` is a fact *about a particular String*, and a fact about a particular object needs that object.

The `Math` methods this unit leans on, with the return type that catches people:

Call	Returns	Note
`Math.abs(x)`	same type as `x`	`int` in, `int` out
`Math.pow(a, b)`	`double` *always*	`Math.pow(3, 2)` is `9.0`, not `9`
`Math.sqrt(x)`	`double` always	
`Math.random()`	`double` in [0.0, 1.0)	0.0 is possible; 1.0 is not

Build the random range rather than memorizing it, in three moves — *scale, truncate, shift*. For a positive integer `range`, `(int)(Math.random() * range) + min` produces the integers `min` through `min + range - 1`. Every time you use it, check the two ends by hand; the half-open interval [0.0, 1.0) is what makes the top end come out one lower than it looks.

THE + OPERATOR, AND HOW VALUES PRINT

+ has two entirely different jobs, and which one runs is decided operand by operand, at the moment that particular + fires:

Left	Right	What + does
number	number	arithmetic; the result is a number
String	anything	concatenation; the result is a String
anything	String	concatenation; the result is a String

Because + runs left to right, and because the result of a concatenation is itself a String, **the first String in a chain converts every + after it**. Nothing downstream can turn the gluing back off — but parentheses can protect arithmetic by making it happen first.

How the printed characters get chosen. An `int` prints as its digits and nothing else. A `double` *always* prints with a decimal point, even when the value is whole: the number 4 stored in a `double` prints as `4.0`, and that `.0` is part of the exact output. Otherwise Java prints the shortest run of digits that could only mean the value it is holding, which is why `12.75` prints as `12.75` and not `12.750000`.

`System.out.println` versus `System.out.print`: `println` ends the line, so the next output starts below; `print` leaves the cursor where it is. Count your line breaks when the question asks for exact output — they are graded too.

THREE KINDS OF ERROR, AND WHICH ONE YOU ARE LOOKING AT

Naming the kind is most of the diagnosis, because each kind is found a different way.

Kind	When it appears	What it means
Compile-time	Before the program ever runs	The grammar or the types don't work. `missing return statement`, `incompatible types`, `cannot find symbol`. The program does not exist yet
Run time	Mid-run, and it stops there	The code was legal but asked for something impossible with the actual values. `StringIndexOutOfBounds-Exception` is this unit's example
Logic	Never announced	It compiles, it runs, it finishes — and the answer is wrong. Examples are unintended integer division and an in-range wrong index

The compiler checks grammar and types. It has no access to your intentions, so it cannot catch a mismatch between a legal computation and the intended algorithm. Integer division or an in-range off-by-one index is a logic error only when it produces unintended behavior; an out-of-range String index instead throws a run-time exception. Problem 7 contains one compile-time error and two logic errors, while Problem 4's out-of-range case illustrates a run-time exception.

PROBLEM 1

One slash, two arithmetics: diagnosing division and remainder

A classmate insists Java "gets division wrong." Evaluate each expression by hand — exact value and *type.*

(a) `17 / 5` *(b)* `17 % 5` *(c)* `17.0 / 5` *(d)* `17 / 5.0`

(e) `-17 / 5` *(f)* `-17 % 5` *(g)* `1 + 17 / 5` *(h)* `17 / 5 * 5.0`

JAVA ENRICHMENT IN PARTS (E)–(F)

The signed results are real Java behavior and useful for debugging. The current AP CSA framework excludes a negative dividend in remainder questions, so part (f) extends beyond required exam recall.

> BEFORE YOU COMPUTE
>
> The whole problem begins with two checks: the divisor must be nonzero, then the operand types choose the arithmetic. Classify each operand: the operator behaves according to what the operands *are*, not what you meant them to be. With a nonzero divisor, two `int`s mean integer arithmetic, and one `double` in the pair means real division. Parts (g) and (h) add the second question, which is *in what order*, and that is a precedence question rather than an arithmetic one. Answer it before you compute, not while you compute.

WORKING

Do the classification first, in a table, and the answers fall out of the last two columns:

Expression	Operand types	Which arithmetic	Result
(a) `17 / 5`	`int`, `int`	integer division	`3` (`int`)
(b) `17 % 5`	`int`, `int`	integer remainder	`2` (`int`)
(c) `17.0 / 5`	`double`, `int`	the `int` is promoted; real	`3.4` (`double`)
(d) `17 / 5.0`	`int`, `double`	the `int` is promoted; real	`3.4` (`double`)
(e) `-17 / 5`	`int`, `int`	integer division	`-3` (`int`)
(f) `-17 % 5`	`int`, `int`	integer remainder	`-2` (`int`)

(a), (b) — the pair that loses nothing. 17 ÷ 5 is 3 with 2 left over. `/` keeps the 3 and `%` keeps the 2, and between them nothing was lost — it was only split. Rebuild it as a check: $3 \cdot 5 + 2 = 17$. That check costs five seconds and catches a mismatch between the quotient, remainder, and original dividend.

(c), (d) — one `double` is enough, on either side. Java widens the `int` to a `double` before dividing, so both expressions run the same real division and both give `3.4`. Which side the decimal point sits on is irrelevant. What matters is that it is *inside this operation* — a point that (h) exists to make.

(e), (f) — the surprises, and why they are not surprising. The exact quotient is −3.4. Truncation deletes the fractional part where it stands, which moves the value toward zero, giving `-3`. "Rounding down" would give −4, and that is the trap: it is what a math class means by the floor, and what several other languages do. Java does not. Then the remainder has no freedom left — it must satisfy `(a / b) * b + (a % b) = a`, so from (−3) · 5 = −15 we need −2 more to reach −17. Hence `-2`, negative, taking its sign from the left operand. The sign rule is not a separate fact to memorize; it is a consequence of the truncation rule.

(g) — precedence. `/` sits a tier above `+`, so the division claims the 17 and the 5 before the addition sees anything: 1 + (17/5) = 1 + 3 = 4, an `int`. It is not (1 + 17)/5.

(h) — same tier, left to right, and the decimal arrives too late. `*` and `/` share a tier, so the leftmost fires first. At that instant `17 / 5` is a division between two `int`s and returns `3` — the `.4` is gone, permanently, and the `5.0` sitting to the right had no vote. *Then* the multiplication runs, `int` against `double`, promoting the 3: `3 * 5.0 = 15.0`, a `double`. Compare that with what you might have expected, 17 ÷ 5 × 5 = 17, and you can see exactly where the 2 went.

ANSWER

(a) `3`, int (b) `2`, int (c) `3.4`, double (d) `3.4`, double (e) `-3`, int (f) `-2`, int (g) `4`, int (h) `15.0`, double

WATCH OUT

Two traps here outlive the unit. First: truncation is *toward zero*, so negative quotients come out looking one "too big" to anyone expecting a floor. Second, and worse because it hides: an expression is not rescued by a `double` that arrives *later* in the line, as (h) shows — by the time `5.0` joined in, the remainder had already been discarded. The habit that catches both: quotient times divisor plus remainder must recreate the dividend, signs and all.

ABOUT THIS EXCERPT

This excerpt contains the diagnostic tree, full Master Toolbox, and Problem 1 from the 43-page guide. The complete guide adds 8 worked problems and is shared during the fit conversation.