Week 13

AP Computer Science A

Homework bundle for this week

本周作业合集

exercises.lol

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3. Class Creation

Starter Quiz · 课前小测

AP Computer Science A Name: _____ Score: _____

1. Abstraction is best described as...
   - ☐ hiding details to focus on the main idea
   - ☐ writing more code
   - ☐ deleting comments
   - ☐ a run-time error
2. A modular design (independent, well-named pieces) is mainly easier to...
   - ☐ test, maintain, and reuse
   - ☐ compile only once
   - ☐ run without a computer
   - ☐ hide from users
3. Which are the three kinds of members in a class?
   - ☐ instance variables, constructors, methods
   - ☐ loops, ifs, casts
   - ☐ int, double, boolean
   - ☐ public, private, static
4. A constructor has...
   - ☐ the class's name and no return type
   - ☐ a void return type
   - ☐ any name you like
   - ☐ an int return type
5. A method that returns information without changing the object is a(n)...
   - ☐ accessor (getter)
   - ☐ mutator (setter)
   - ☐ constructor
   - ☐ cast
6. Most code is read and changed far more often than it is first written.

   ☐ True ☐ False

7. A method can change the caller's int variable by modifying its parameter.

   ☐ True ☐ False

8. Breaking a big problem into smaller named behaviors (methods) is called method ____ (one word).

   _____

9. Bias in a program's data or logic can produce unfair results at scale.

   ☐ True ☐ False

10. Keeping data private and exposing it only through methods is called ____ (one word).

    _____

3. Class Creation

Answers · 答案

AP Computer Science A

1. **hiding details to focus on the main idea**

   Abstraction hides how something works so you can use what it does.

2. **test, maintain, and reuse**

   Modularity makes changes safer and pieces reusable.

3. **instance variables, constructors, methods**

   State (instance variables), setup (constructors), behavior (methods).

4. **the class's name and no return type**

   Same name as the class, no return type — not even void.

5. **accessor (getter)**

   Accessors read and return; mutators change state.

6. **True**

   So maintainable design pays off repeatedly.

7. **False**

   Primitives are copied — the caller's int is untouched.

8. **decomposition**

   Method decomposition splits work into focused methods.

9. **True**

   Design choices affect real people — consider who is impacted.

10. **encapsulation**

    Encapsulation protects an object's data.

AP COMPUTER SCIENCE A • EXERCISE SHEET

3.1 Abstraction and Program Design

Name: _____ Class: _____ Date: _____ **Total: 8 marks**

KEY WORDS abstraction 抽象 • method decomposition 方法分解 • procedural abstraction 过程抽象 • overloading 重载

Objective

Build the skills to answer exam questions on **abstraction and program design**.

You must be able to:

- describe **abstraction** 抽象 as hiding details to focus on the main idea
- explain how **procedural abstraction** 过程抽象 lets code use a method by what it does
- break a large problem into smaller behaviours using **method decomposition** 方法分解

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Abstraction

Abstraction hides details so you can focus on the main idea of a problem.

■ Procedural abstraction

Lets you use a method by **what it does**, not **how** it does it — you can call `Math.sqrt` without knowing its internal algorithm.

■ Method decomposition

Break a large problem into smaller, well-named methods, each handling one behaviour.

2 Practice

2.1 Define abstraction. [1]

2.2 State what procedural abstraction lets you do. [1]

2.3 State what method decomposition means. [1]

3 Exam-style questions

3.1 Abstraction means [1]

- **A** adding more detail
- **B** hiding detail to focus on the main idea
- **C** running faster
- **D** a syntax error

3.2 Using a method by what it does, not how, is [1]

- **A** overloading
- **B** procedural abstraction
- **C** casting
- **D** recursion

3.3 A large program is split into small methods, each doing one task.

(a) Name this approach. [1]

(b) State one benefit. [1]

(c) Name the idea of hiding detail. [1]

Solutions

2.1 hiding details to focus on the main idea of a problem.

2.2 use a method by what it does, without knowing how it works inside.

2.3 breaking a large problem into smaller methods, each handling one behaviour.

3.1 B.

3.2 B.

3.3 (a) method decomposition. (b) easier to read, reuse, or test (any one). (c) abstraction.

4. This question involves the design of an interface, writing a class that implements the interface, and writing a method that uses the interface.

   (a) A *number group* represents a group of integers defined in some way. It could be empty, or it could contain one or more integers.

   Write an interface named `NumberGroup` that represents a group of integers. The interface should have a single `contains` method that determines if a given integer is in the group. For example, if `group1` is of type `NumberGroup`, and it contains only the two numbers `-5` and `3`, then `group1.contains(-5)` would return `true`, and `group1.contains(2)` would return `false`.

   Write the complete `NumberGroup` interface. It must have exactly one method.

Part (b) begins on page 17.

(b) A *range* represents a number group that contains all (and only) the integers between a minimum value and a maximum value, inclusive.

Write the `Range` class, which is a `NumberGroup`. The `Range` class represents the group of `int` values that range from a given minimum value up through a given maximum value, inclusive. For example, the declaration

```
NumberGroup range1 = new Range(-3, 2);
```

represents the group of integer values -3, -2, -1, 0, 1, 2.

Write the complete `Range` class. Include all necessary instance variables and methods as well as a constructor that takes two `int` parameters. The first parameter represents the minimum value, and the second parameter represents the maximum value of the range. You may assume that the minimum is less than or equal to the maximum.

Part (c) begins on page 18.

(c) The `MultipleGroups` class (not shown) represents a collection of `NumberGroup` objects and is a `NumberGroup`. The `MultipleGroups` class stores the number groups in the instance variable `groupList` (shown below), which is initialized in the constructor.

```
private List<NumberGroup> groupList;
```

Write the `MultipleGroups` method `contains`. The method takes an integer and returns `true` if and only if the integer is contained in one or more of the number groups in `groupList`.

For example, suppose `multiple1` has been declared as an instance of `MultipleGroups` and consists of the three ranges created by the calls `new Range(5, 8)`, `new Range(10, 12)`, and `new Range(1, 6)`. The following table shows the results of several calls to `contains`.

Call	Result
`multiple1.contains(2)`	`true`
`multiple1.contains(9)`	`false`
`multiple1.contains(6)`	`true`

Complete method `contains` below.

```
/** Returns true if at least one of the number groups in this multiple group contains num;
 *          false otherwise.
 */
public boolean contains(int num)
```

STOP

END OF EXAM

AP COMPUTER SCIENCE A • EXERCISE SHEET

3.2 Impact of Program Design

Name: _____ Class: _____ Date: _____ **Total: 8 marks**

KEY WORDS maintainable 可维护 • reliable 可靠

Objective

Build the skills to answer exam questions on **the impact of program design**.

You must be able to:

- explain that design choices affect how **reliable** 可靠 and **maintainable** 可维护 a program is
- describe how a program can have unintended consequences for users
- understand the value of testing with a wide range of inputs

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Why design matters

Good design makes a program more **reliable** (it works correctly) and **maintainable** (it is easy to change). Poor design can cause **unintended consequences** for its users.

■ Testing widely

Testing with a **wide range of inputs**, including edge cases, reveals defects that a few simple tests would miss.

2 Practice

2.1 State one quality that good program design improves. [1]

2.2 State why you should test with a wide range of inputs. [1]

2.3 State what it means for a program to be “maintainable”. [1]

3 Exam-style questions

3.1 Good program design improves a program’s [1]

- **A** speed only
- **B** reliability and maintainability
- **C** file size
- **D** colour

3.2 Testing with a wide range of inputs helps to [1]

- **A** slow the program down
- **B** find defects
- **C** add bias
- **D** compress data

3.3 A poorly designed program is hard to change and often breaks.

(a) State one quality it lacks. [1]

(b) State one way to catch its bugs. [1]

(c) State one risk that poor design poses to users. [1]

Solutions

2.1 reliability or maintainability (any one).

2.2 to find defects that only appear on some inputs.

2.3 it is easy to understand and change.

3.1 B.

3.2 B.

3.3 (a) reliability (or maintainability). (b) test it with many varied inputs. (c) unintended consequences.

AP COMPUTER SCIENCE A • EXERCISE SHEET

3.3 Anatomy of a Class

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS class 类 • constructor 构造函数 • instance variables 实例变量 • encapsulation 封装

Objective

Build the skills to answer exam questions on **the anatomy of a class**.

You must be able to:

- identify the parts of a **class** 类: instance variables, constructors, and methods
- declare **instance variables** 实例变量 to hold each object's state
- use `private` and `public` to control **encapsulation** 封装

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Parts of a class

- **Instance variables** — hold the object's **state** (data).
- **Constructors** — set up a new object.
- **Methods** — the object's behaviour.

■ Encapsulation

Declaring instance variables `private` **hides** them, so they can only be changed through `public` methods — this is **encapsulation**, which protects an object's data.

2 Practice

2.1 Name the three parts of a class. [2]

2.2 State what instance variables hold. [1]

2.3 State the access modifier used to hide data. [1]

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3 Exam-style questions

3.1 The state of an object is held in its [1]

- **A** methods
- **B** instance variables
- **C** constructors
- **D** comments

3.2 To hide a class's data, declare it [1]

- **A** `public`
- **B** `private`
- **C** `static`
- **D** `void`

3.3 A `BankAccount` class stores a balance.

(a) Name what the balance is (which part of the class). [1]

(b) State the modifier to keep it hidden. [1]

(c) Name the idea of hiding data behind methods. [1]

Solutions

2.1 instance variables, constructors, methods.

2.2 the state (data) of each object.

2.3 `private`.

3.1 B.

3.2 B.

3.3 (a) an instance variable. (b) `private`. (c) encapsulation.

2. The `Bottle` class, which you will write, represents a bottle that contains liquid.

`Bottle` objects are created by calls to a constructor with a `double` parameter that represents the bottle's capacity, in milliliters (mL), which is the maximum amount of liquid in the bottle. Assume that this value will be greater than or equal to 0. When `Bottle` objects are constructed, each is filled to its capacity.

The `Bottle` class contains an `updateAmount` method, which updates the amount of liquid in the bottle. This method has a `double` parameter that represents the amount of liquid, in mL, to be removed from the bottle, with a precondition that the parameter is always greater than zero and less than or equal to the amount of liquid remaining in the bottle. If updating the amount of liquid in the bottle would cause it to be less than 25% of the capacity, the bottle is filled and reset to the capacity. The `updateAmount` method returns a `double` that represents the amount remaining in the bottle, in mL, after the amount has been updated.

The following table contains a sample code execution sequence and the corresponding results. The code execution sequence appears in a class other than `Bottle`.

Statement	Return Value (blank if no value)	Explanation
`double amt;`		
`Bottle water = new Bottle(1000.0);`		A `Bottle` object named `water` is constructed with a capacity of 1,000 mL of liquid.
`amt = water.updateAmount(400.0);`	`600.0`	400 mL are used, so 600 mL remain in the bottle.
`amt = water.updateAmount(100.0);`	`500.0`	100 mL are used, so 500 mL remain in the bottle.
`amt = water.updateAmount(300.0);`	`1000.0`	300 mL are used, so 200 mL remain in the bottle. Since this amount is less than 250 mL (25% of the capacity of 1,000 mL), the bottle is immediately filled and reset to the initial amount of 1,000 mL.
`Bottle shampoo = new Bottle(40.0);`		A `Bottle` object named `shampoo` is constructed with a capacity of 40 mL of liquid.
`amt = shampoo.updateAmount(30.0);`	`10.0`	30 mL are used, so 10 mL remain in the bottle.
`amt = shampoo.updateAmount(1.0);`	`40.0`	1 mL is used, so 9 mL remain in the bottle. Since this amount is less than 10 mL (25% of the capacity of 40 mL), the bottle is immediately filled and reset to the initial amount of 40 mL.

Write the complete `Bottle` class. Your implementation must meet all specifications and conform to the examples shown in the table.

2. This question involves the `SignedText` class, which contains methods that are used to include a signature as part of a string of text. You will write the complete `SignedText` class, which contains a constructor and two methods.

The `SignedText` constructor takes two `String` parameters. The first parameter is a first name and the second parameter is a last name. The length of the second parameter is always greater than or equal to 1.

The `getSignature` method takes no parameters and returns a formatted signature string constructed from the first and last names according to the following rules.

- If the first name is an empty string, the returned signature string contains just the last name.
- If the first name is not an empty string, the returned signature string is the first letter of the first name, a dash (`"-"`), and the last name, in that order.

The `addSignature` method returns a possibly revised copy of its `String` parameter. The parameter will contain at most one occurrence of the object's signature, at either the beginning or the end of the parameter. The returned string is created from the parameter according to the following rules.

- If the object's signature does not occur in the `String` parameter of the method, the returned `String` is the value of the parameter with the signature added to the end.
- If the object's signature occurs at the end of the `String` parameter, the returned `String` is the unchanged value of the parameter.
- If the object's signature occurs at the beginning of the `String` parameter, the returned `String` is the value of the original parameter with the signature removed from the beginning and appended to the end of the parameter.

The following table contains a sample code execution sequence and the corresponding results. The code execution sequence appears in a class other than `SignedText`.

Statement	Method Call Return Value (blank if none)	Explanation
`SignedText st1 = new SignedText("", "Wong");`		The `SignedText` object `st1` has an empty first name and last name `"Wong"`.
`String temp = st1.getSignature();`	`"Wong"`	
`SignedText st2 = new SignedText("henri", "dubois");`		The `SignedText` object `st2` has first name `"henri"` and last name `"dubois"`.
`temp = st2.getSignature();`	`"h-dubois"`	
`SignedText st3 = new SignedText("GRACE", "LOPEZ");`		The `SignedText` object `st3` has first name `"GRACE"` and last name `"LOPEZ"`.
`temp = st3.getSignature();`	`"G-LOPEZ"`	
`SignedText st4 = new SignedText("", "FOX");`		The `SignedText` object `st4` has an empty first name and last name `"FOX"`.
`String text = "Dear";`		
`temp = st4.addSignature(text);`	`"DearFOX"`	The signature does not occur in the `addSignature` parameter, so the returned string is the value of the parameter with the signature appended.
`text = "Best wishesFOX";`		
`temp = st4.addSignature(text);`	`"Best wishesFOX"`	The signature occurs at the end of the `addSignature` parameter, so the returned string is the unchanged value of the parameter.

Statement	Method Call Return Value (blank if none)	Explanation
`text = "FOXThanks";`		
`temp = st4.addSignature(text);`	`"ThanksFOX"`	The signature occurs at the beginning of the `addSignature` parameter, so the returned string is the value of the original parameter with the signature removed from the beginning and appended to the end of the parameter.
`text = "G-LOPEZHello";`		
`temp = st3.addSignature(text);`	`"HelloG-LOPEZ"`	The signature occurs at the beginning of the `addSignature` parameter, so the returned string is the value of the original parameter with the signature removed from the beginning and appended to the end of the parameter.

Write the complete `SignedText` class. Your implementation must meet all specifications and conform to the examples in the table.

AP Computer Science A: **2024**

2. This question involves a scoreboard for a game. The game is played between two teams who alternate turns so that at any given time, one team is active and the other team is inactive. During a turn, a team makes one or more plays. Each play can score one or more points and the team's turn continues, or the play can fail, in which case no points are scored and the team's turn ends. The `Scoreboard` class, which you will write, is used to keep track of the score in a game.

   The `Scoreboard` class contains a constructor and two methods.

   - The constructor has two parameters. The first parameter is a `String` containing the name of team 1, and the second parameter is a `String` containing the name of team 2. The game always begins with team 1 as the active team.
   - The `recordPlay` method has a single nonnegative integer parameter that is equal to the number of points scored on a play or `0` if the play failed. If the play results in one or more points scored, the active team's score is updated and that team remains active. If the value of the parameter is `0`, the active team's turn ends and the inactive team becomes the active team. The `recordPlay` method does not return a value.
   - The `getScore` method has no parameters. The method returns a `String` containing information about the current state of the game. The returned string begins with the score of team 1, followed by a hyphen (`"-"`), followed by the score of team 2, followed by a hyphen, followed by the name of the team that is currently active.

The following table contains a sample code execution sequence and the corresponding results. The code execution sequence appears in a class other than `Scoreboard`.

Statement	Value Returned (blank if none)	Explanation
`String info;`		
`Scoreboard game = new Scoreboard("Red", "Blue");`		`game` is a new `Scoreboard` for a game played between team 1, whose name is `"Red"`, and team 2, whose name is `"Blue"`. The active team is set to team 1.
`info = game.getScore();`	`"0-0-Red"`	
`game.recordPlay(1);`		Team 1 earns 1 point because the game always begins with team 1 as the active team.
`info = game.getScore();`	`"1-0-Red"`	
`game.recordPlay(0);`		Team 1's play failed, so team 2 is now active.
`info = game.getScore();`	`"1-0-Blue"`	
`info = game.getScore();`	`"1-0-Blue"`	The score and state of the game are unchanged since the last call to `getScore`.
`game.recordPlay(3);`		Team 2 earns 3 points.
`info = game.getScore();`	`"1-3-Blue"`	
`game.recordPlay(1);`		Team 2 earns 1 point.
`game.recordPlay(0);`		Team 2's play failed, so team 1 is now active.
`info = game.getScore();`	`"1-4-Red"`	
`game.recordPlay(0);`		Team 1's play failed, so team 2 is now active.
`game.recordPlay(4);`		Team 2 earns 4 points.
`game.recordPlay(0);`		Team 2's play failed, so team 1 is now active.
`info = game.getScore();`	`"1-8-Red"`	
`Scoreboard match = new Scoreboard("Lions", "Tigers");`		`match` is a new and independent `Scoreboard` object.
`info = match.getScore();`	`"0-0-Lions"`	
`info = game.getScore();`	`"1-8-Red"`	

Write the complete `Scoreboard` class. Your implementation must meet all specifications and conform to the examples shown in the preceding table.

Begin your response at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number. If there are multiple parts to this question, write the part letter with your response.

2. This question involves methods that distribute text across lines of an electronic sign. The electronic sign and the text to be displayed on it are represented by the `Sign` class. You will write the complete `Sign` class, which contains a constructor and two methods.

   The `Sign` class constructor has two parameters. The first parameter is a `String` that contains the message to be displayed on the sign. The second parameter is an `int` that contains the *width* of each line of the sign. The width is the positive maximum number of characters that can be displayed on a single line of the sign.

   A sign contains as many lines as are necessary to display the entire message. The message is split among the lines of the sign without regard to spaces or punctuation. Only the last line of the sign may contain fewer characters than the width indicated by the constructor parameter.

   The following are examples of a message displayed on signs of different widths. Assume that in each example, the sign is declared with the width specified in the first column of the table and with the message `"Everything on sale, please come in"`, which contains 34 characters.

Width of the Sign	Sign Display

15	`Everything on s`
	`ale, please com`
	`e in`

17	`Everything on sal` `e, please come in`
40	`Everything on sale, please come in`

   In addition to the constructor, the `Sign` class contains two methods.

   The `numberOfLines` method returns an `int` representing the number of lines needed to display the text on the sign. In the previous examples, `numberOfLines` would return `3`, `2`, and `1`, respectively, for the sign widths shown in the table.

   The `getLines` method returns a `String` containing the message broken into lines separated by semicolons `(;)` or returns `null` if the message is the empty string. The constructor parameter that contains the message to be displayed will not include any semicolons. As an example, in the first row of the preceding table, `getLines` would return `"Everything on s;ale, please com;e in"`. No semicolon should appear at the end of the `String` returned by `getLines`.

The following table contains a sample code execution sequence and the corresponding results. The code execution sequence appears in a class other than `Sign`.

Statement	Method Call Return Value (blank if none)	Explanation
`String str;`		
`int x;`		
`Sign sign1 = new Sign("ABC222DE", 3);`		The message for `sign1` contains 8 characters, and the sign has lines of width 3.
`x = sign1.numberOfLines();`	`3`	The sign needs three lines to display the 8-character message on a sign with lines of width 3.
`str = sign1.getLines();`	`"ABC;222;DE"`	Semicolons separate the text displayed on the first, second, and third lines of the sign.
`str = sign1.getLines();`	`"ABC;222;DE"`	Successive calls to `getLines` return the same value.
`Sign sign2 = new Sign("ABCD", 10);`		The message for `sign2` contains 4 characters, and the sign has lines of width 10.
`x = sign2.numberOfLines();`	`1`	The sign needs one line to display the 4-character message on a sign with lines of width 10.
`str = sign2.getLines();`	`"ABCD"`	No semicolon appears, since the text to be displayed fits on the first line of the sign.
`Sign sign3 = new Sign("ABCDEF", 6);`		The message for `sign3` contains 6 characters, and the sign has lines of width 6.
`x = sign3.numberOfLines();`	`1`	The sign needs one line to display the 6-character message on a sign with lines of width 6.
`str = sign3.getLines();`	`"ABCDEF"`	No semicolon appears, since the text to be displayed fits on the first line of the sign.
`Sign sign4 = new Sign("", 4);`		The message for `sign4` is an empty string.
`x = sign4.numberOfLines();`	`0`	There is no text to display.
`str = sign4.getLines();`	`null`	There is no text to display.
`Sign sign5 = new Sign("AB_CD_EF", 2);`		The message for `sign5` contains 8 characters, and the sign has lines of width 2.
`x = sign5.numberOfLines();`	`4`	The sign needs four lines to display the 8-character message on a sign with lines of width 2.
`str = sign5.getLines();`	`"AB;_C;D_;EF"`	Semicolons separate the text displayed on the four lines of the sign.

Write the complete `Sign` class. Your implementation must meet all specifications and conform to the examples shown in the preceding table.

Begin your response at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number. If there are multiple parts to this question, write the part letter with your response.

2. This question involves the implementation of a fitness tracking system that is represented by the `StepTracker` class. A `StepTracker` object is created with a parameter that defines the minimum number of steps that must be taken for a day to be considered *active*.

   The `StepTracker` class provides a constructor and the following methods.

   - `addDailySteps`, which accumulates information about steps, in readings taken once per day
   - `activeDays`, which returns the number of active days
   - `averageSteps`, which returns the average number of steps per day, calculated by dividing the total number of steps taken by the number of days tracked

   The following table contains a sample code execution sequence and the corresponding results.

Statements and Expressions	Value Returned (blank if no value)	Comment
`StepTracker tr = new StepTracker(10000);`		Days with at least 10,000 steps are considered active. Assume that the parameter is positive.
`tr.activeDays();`	`0`	No data have been recorded yet.
`tr.averageSteps();`	`0.0`	When no step data have been recorded, the `averageSteps` method returns `0.0`.
`tr.addDailySteps(9000);`		This is too few steps for the day to be considered active.
`tr.addDailySteps(5000);`		This is too few steps for the day to be considered active.
`tr.activeDays();`	`0`	No day had at least 10,000 steps.
`tr.averageSteps();`	`7000.0`	The average number of steps per day is (14000 / 2).
`tr.addDailySteps(13000);`		This represents an active day.
`tr.activeDays();`	`1`	Of the three days for which step data were entered, one day had at least 10,000 steps.
`tr.averageSteps();`	`9000.0`	The average number of steps per day is (27000 / 3).
`tr.addDailySteps(23000);`		This represents an active day.
`tr.addDailySteps(1111);`		This is too few steps for the day to be considered active.
`tr.activeDays();`	`2`	Of the five days for which step data were entered, two days had at least 10,000 steps.
`tr.averageSteps();`	`10222.2`	The average number of steps per day is (51111 / 5).

Write the complete `StepTracker` class, including the constructor and any required instance variables and methods. Your implementation must meet all specifications and conform to the example.

3. The `StringChecker` interface describes classes that check if strings are valid, according to some criterion.

```
public interface StringChecker
{
    /** Returns true if str is valid. */
    boolean isValid(String str);
}
```

A `CodeWordChecker` is a `StringChecker`. A `CodeWordChecker` object can be constructed with three parameters: two integers and a string. The first two parameters specify the minimum and maximum code word lengths, respectively, and the third parameter specifies a string that must not occur in the code word. A `CodeWordChecker` object can also be constructed with a single parameter that specifies a string that must not occur in the code word; in this case the minimum and maximum lengths will default to 6 and 20, respectively.

The following examples illustrate the behavior of `CodeWordChecker` objects.

Example 1

```
StringChecker sc1 = new CodeWordChecker(5, 8, "$");
```

Valid code words have 5 to 8 characters and must not include the string `"$"`.

Method call	Return value	Explanation
`sc1.isValid("happy")`	`true`	The code word is valid.
`sc1.isValid("happy$")`	`false`	The code word contains `"$"`.
`sc1.isValid("Code")`	`false`	The code word is too short.
`sc1.isValid("happyCode")`	`false`	The code word is too long.

Example 2

```
StringChecker sc2 = new CodeWordChecker("pass");
```

Valid code words must not include the string `"pass"`. Because the bounds are not specified, the length bounds are 6 and 20, inclusive.

Method call	Return value	Explanation
`sc2.isValid("MyPass")`	`true`	The code word is valid.
`sc2.isValid("Mypassport")`	`false`	The code word contains `"pass"`.
`sc2.isValid("happy")`	`false`	The code word is too short.
`sc2.isValid("1,000,000,000,000,000")`	`false`	The code word is too long.

Write the complete `CodeWordChecker` class. Your implementation must meet all specifications and conform to all examples.

2. This question involves the design of a class that will be used to produce practice problems. The following `StudyPractice` interface represents practice problems that can be used to study some subject.

```
public interface StudyPractice
{
    /** Returns the current practice problem. */
    String getProblem();

    /** Changes to the next practice problem. */
    void nextProblem();
}
```

The `MultPractice` class is a `StudyPractice` that produces multiplication practice problems. A `MultPractice` object is constructed with two integer values: *first integer* and *initial second integer*. The first integer is a value that remains constant and is used as the first integer in every practice problem. The initial second integer is used as the starting value for the second integer in the practice problems. This second value is incremented for each additional practice problem that is produced by the class.

For example, a `MultPractice` object created with the call `new MultPractice(7, 3)` would be used to create the practice problems `"7 TIMES 3"`, `"7 TIMES 4"`, `"7 TIMES 5"`, and so on.

In the `MultPractice` class, the `getProblem` method returns a string in the format of `"`*first integer* `TIMES` *second integer*`"`. The `nextProblem` method updates the state of the `MultPractice` object to represent the next practice problem.

The following examples illustrate the behavior of the `MultPractice` class. Each table shows a code segment and the output that would be produced as the code is executed.

Example 1

Code segment	Output produced
`StudyPractice p1 = new MultPractice(7, 3);` `System.out.println(p1.getProblem());`	`7 TIMES 3`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 4`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 5`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 6`

Example 2

Code segment	Output produced

`StudyPractice p2 = new MultPractice(4, 12);`
`p2.nextProblem();`
`System.out.println(p2.getProblem());`
`System.out.println(p2.getProblem());`
	`4 TIMES 13`
	`4 TIMES 13`

`p2.nextProblem();`
`p2.nextProblem();`
`System.out.println(p2.getProblem());`
	`4 TIMES 15`

`p2.nextProblem();` `System.out.println(p2.getProblem());`	`4 TIMES 16`

Question 2 continues on page 10.

Interface information for this question

```
public interface StudyPractice

String getProblem()
void nextProblem()
```

Write the complete `MultPractice` class. Your implementation must be consistent with the specifications and the given examples.

COMPUTER SCIENCE A
SECTION II
Time—1 hour and 30 minutes
Number of questions—4
Percent of total score—50

Directions: SHOW ALL YOUR WORK. REMEMBER THAT PROGRAM SEGMENTS ARE TO BE WRITTEN IN JAVA.

Notes:
- Assume that the classes listed in the Java Quick Reference have been imported where appropriate.
- Unless otherwise noted in the question, assume that parameters in method calls are not `null` and that methods are called only when their preconditions are satisfied.
- In writing solutions for each question, you may use any of the accessible methods that are listed in classes defined in that question. Writing significant amounts of code that can be replaced by a call to one of these methods will not receive full credit.

1. This question involves the implementation and extension of a `RandomStringChooser` class.

   (a) A `RandomStringChooser` object is constructed from an array of non-`null` `String` values. When the object is first constructed, all of the strings are considered available. The `RandomStringChooser` class has a `getNext` method, which has the following behavior. A call to `getNext` returns a randomly chosen string from the available strings in the object. Once a particular string has been returned from a call to `getNext`, it is no longer available to be returned from subsequent calls to `getNext`. If no strings are available to be returned, `getNext` returns `"NONE"`.

   The following code segment shows an example of the behavior of `RandomStringChooser`.

```
String[] wordArray = {"wheels", "on", "the", "bus"};
RandomStringChooser sChooser = new RandomStringChooser(wordArray);
for (int k = 0; k < 6; k++)
{
   System.out.print(sChooser.getNext() + " ");
}
```

   One possible output is shown below. Because `sChooser` has only four strings, the string `"NONE"` is printed twice.

```
bus the wheels on NONE NONE
```

WRITE YOUR SOLUTION ON THE NEXT PAGE.

Write the entire `RandomStringChooser` class. Your implementation must include an appropriate constructor and any necessary methods. Any instance variables must be `private`. The code segment in the example above should have the indicated behavior (that is, it must compile and produce a result like the possible output shown). Neither the constructor nor any of the methods should alter the parameter passed to the constructor, but your implementation may copy the contents of the array.

Part (b) begins on page 4.

(b) The following partially completed `RandomLetterChooser` class is a subclass of the `RandomStringChooser` class. You will write the constructor for the `RandomLetterChooser` class.

```
public class RandomLetterChooser extends RandomStringChooser
{
    /** Constructs a random letter chooser using the given string str.
     *  Precondition: str contains only letters.
     */
    public RandomLetterChooser(String str)
    {  /* to be implemented in part (b) */  }

    /** Returns an array of single-letter strings.
     *  Each of these strings consists of a single letter from str. Element k
     *  of the returned array contains the single letter at position k of str.
     *  For example, getSingleLetters("cat") returns the
     *  array { "c", "a", "t" }.
     */
    public static String[] getSingleLetters(String str)
    {  /* implementation not shown */  }
}
```

The following code segment shows an example of using `RandomLetterChooser`.

```
RandomLetterChooser letterChooser = new RandomLetterChooser("cat");
for (int k = 0; k < 4; k++)
{
   System.out.print(letterChooser.getNext());
}
```

The code segment will print the three letters in `"cat"` in one of the possible orders. Because there are only three letters in the original string, the code segment prints `"NONE"` the fourth time through the loop. One possible output is shown below.

```
actNONE
```

Assume that the `RandomStringChooser` class that you wrote in part (a) has been implemented correctly and that `getSingleLetters` works as specified. You must use `getSingleLetters` appropriately to receive full credit.

Complete the `RandomLetterChooser` constructor below.

```
/** Constructs a random letter chooser using the given string str.
 *  Precondition: str contains only letters.
 */
public RandomLetterChooser(String str)
```

2. Consider a guessing game in which a player tries to guess a hidden word. The hidden word contains only capital letters and has a length known to the player. A guess contains only capital letters and has the same length as the hidden word.

   After a guess is made, the player is given a hint that is based on a comparison between the hidden word and the guess. Each position in the hint contains a character that corresponds to the letter in the same position in the guess. The following rules determine the characters that appear in the hint.

If the letter in the guess is …	**the corresponding character in the hint is**
also in the same position in the hidden word,	the matching letter
also in the hidden word, but in a different position,	`"+"`
not in the hidden word,	`"*"`

The `HiddenWord` class will be used to represent the hidden word in the game. The hidden word is passed to the constructor. The class contains a method, `getHint`, that takes a guess and produces a hint.

For example, suppose the variable `puzzle` is declared as follows.

```
HiddenWord puzzle = new HiddenWord("HARPS");
```

The following table shows several guesses and the hints that would be produced.

Call to `getHint`	**String returned**
`puzzle.getHint("AAAAA")`	`"+A+++"`
`puzzle.getHint("HELLO")`	`"H****"`
`puzzle.getHint("HEART")`	`"H*++*"`
`puzzle.getHint("HARMS")`	`"HAR*S"`
`puzzle.getHint("HARPS")`	`"HARPS"`

Write the complete `HiddenWord` class, including any necessary instance variables, its constructor, and the method, `getHint`, described above. You may assume that the length of the guess is the same as the length of the hidden word.

4. This question involves the design of an interface, writing a class that implements the interface, and writing a method that uses the interface.

   (a) A *number group* represents a group of integers defined in some way. It could be empty, or it could contain one or more integers.

   Write an interface named `NumberGroup` that represents a group of integers. The interface should have a single `contains` method that determines if a given integer is in the group. For example, if `group1` is of type `NumberGroup`, and it contains only the two numbers `-5` and `3`, then `group1.contains(-5)` would return `true`, and `group1.contains(2)` would return `false`.

   Write the complete `NumberGroup` interface. It must have exactly one method.

Part (b) begins on page 17.

(b) A *range* represents a number group that contains all (and only) the integers between a minimum value and a maximum value, inclusive.

Write the `Range` class, which is a `NumberGroup`. The `Range` class represents the group of `int` values that range from a given minimum value up through a given maximum value, inclusive. For example, the declaration

```
NumberGroup range1 = new Range(-3, 2);
```

represents the group of integer values -3, -2, -1, 0, 1, 2.

Write the complete `Range` class. Include all necessary instance variables and methods as well as a constructor that takes two `int` parameters. The first parameter represents the minimum value, and the second parameter represents the maximum value of the range. You may assume that the minimum is less than or equal to the maximum.

Part (c) begins on page 18.

(c) The `MultipleGroups` class (not shown) represents a collection of `NumberGroup` objects and is a `NumberGroup`. The `MultipleGroups` class stores the number groups in the instance variable `groupList` (shown below), which is initialized in the constructor.

```
private List<NumberGroup> groupList;
```

Write the `MultipleGroups` method `contains`. The method takes an integer and returns `true` if and only if the integer is contained in one or more of the number groups in `groupList`.

For example, suppose `multiple1` has been declared as an instance of `MultipleGroups` and consists of the three ranges created by the calls `new Range(5, 8)`, `new Range(10, 12)`, and `new Range(1, 6)`. The following table shows the results of several calls to `contains`.

Call	Result
`multiple1.contains(2)`	`true`
`multiple1.contains(9)`	`false`
`multiple1.contains(6)`	`true`

Complete method `contains` below.

```
/** Returns true if at least one of the number groups in this multiple group contains num;
 *          false otherwise.
 */
public boolean contains(int num)
```

STOP

END OF EXAM

2. This question involves reasoning about the GridWorld case study. Reference materials are provided in the appendixes.

   A `Director` is a type of `Rock` that has the following characteristics.
   - A `Director` has an initial color of `Color.RED` and alternates between `Color.RED` and `Color.GREEN` each time it acts.
   - If the color of a `Director` is `Color.GREEN` when it begins to act, it will cause any `Actor` objects in its neighboring cells to turn 90 degrees to their right.

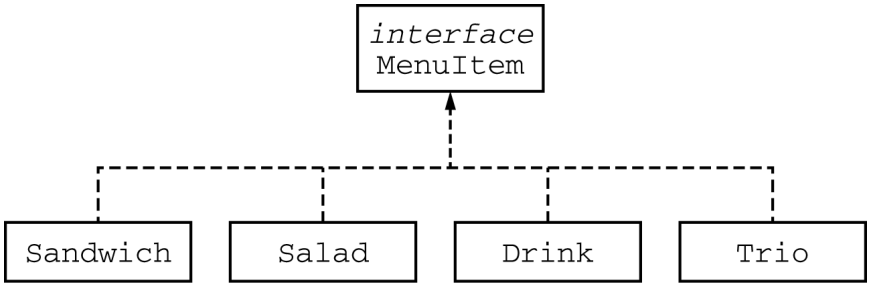
   Write the complete `Director` class, including the zero-parameter constructor and any necessary instance variables and methods. Assume that the `Color` class has been imported.

4. The menu at a lunch counter includes a variety of sandwiches, salads, and drinks. The menu also allows a customer to create a "trio," which consists of three menu items: a sandwich, a salad, and a drink. The price of the trio is the sum of the two highest-priced menu items in the trio; one item with the lowest price is free.

Each menu item has a name and a price. The four types of menu items are represented by the four classes `Sandwich`, `Salad`, `Drink`, and `Trio`. All four classes implement the following `MenuItem` interface.

```
public interface MenuItem
{
  /** @return the name of the menu item */
  String getName();

  /** @return the price of the menu item */
  double getPrice();
}
```

The following diagram shows the relationship between the `MenuItem` interface and the `Sandwich`, `Salad`, `Drink`, and `Trio` classes.



For example, assume that the menu includes the following items. The objects listed under each heading are instances of the class indicated by the heading.

Sandwich	Salad	Drink
"Cheeseburger" 2.75	"Spinach Salad" 1.25	"Orange Soda" 1.25
"Club Sandwich" 2.75	"Coleslaw" 1.25	"Cappuccino" 3.50

Question 4 continues on page 13

The menu allows customers to create `Trio` menu items, each of which includes a sandwich, a salad, and a drink. The name of the `Trio` consists of the names of the sandwich, salad, and drink, in that order, each separated by `"/"` and followed by a space and then `"Trio"`. The price of the `Trio` is the sum of the two highest-priced items in the `Trio`; one item with the lowest price is free.

A trio consisting of a cheeseburger, spinach salad, and an orange soda would have the name `"Cheeseburger/Spinach Salad/Orange Soda Trio"` and a price of $4.00 (the two highest prices are $2.75 and $1.25). Similarly, a trio consisting of a club sandwich, coleslaw, and a cappuccino would have the name `"Club Sandwich/Coleslaw/Cappuccino Trio"` and a price of $6.25 (the two highest prices are $2.75 and $3.50).

Write the `Trio` class that implements the `MenuItem` interface. Your implementation must include a constructor that takes three parameters representing a sandwich, salad, and drink. The following code segment should have the indicated behavior.

```
Sandwich sandwich;
Salad salad;
Drink drink;
/* Code that initializes sandwich, salad, and drink */

Trio trio = new Trio(sandwich, salad, drink);  // Compiles without error

Trio trio1 = new Trio(salad, sandwich, drink); // Compile-time error
Trio trio2 = new Trio(sandwich, salad, salad); // Compile-time error
```

WRITE YOUR SOLUTION ON THE NEXT PAGE.

Write the complete `Trio` class below.

STOP

END OF EXAM

AP COMPUTER SCIENCE A • EXERCISE SHEET

3.4 Constructors

Name: _____ Class: _____ Date: _____ **Total: 8 marks**

KEY WORDS constructor 构造方法

Objective

Build the skills to answer exam questions on **constructors**.

You must be able to:

- write a **constructor** 构造方法 that sets the initial state of a new object
- use **parameters** to give each object its starting values
- understand that a constructor runs when an object is created with `new`

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Constructors

A **constructor** sets a new object's **initial state**. It has the class's name, takes parameters, and runs when you use `new`:

```
public Dog(String n) {
    name = n;   // set the starting value
}
```

`new Dog("Rex")` runs this constructor and stores `"Rex"` as the dog's name.

■ A no-argument constructor

A class may have more than one constructor. A **no-argument** constructor sets defaults:

```
public Dog() {
    name = "Unknown";
}
```

`new Dog()` uses this one; `new Dog("Rex")` uses the parameterised one. Java chooses by the arguments you pass.

2 Practice

2.1 State what a constructor does. [1]

2.2 State when a constructor runs. [1]

2.3 State how a constructor gives each object different starting values. [1]

3 Exam-style questions

3.1 A constructor runs when an object is [1]

- **A** printed
- **B** created with `new`
- **C** deleted
- **D** compared

3.2 A constructor sets an object's [1]

- **A** final value
- **B** initial state
- **C** return type
- **D** superclass

3.3 The statement `new Student("Ana", 16)` is run.

(a) State what runs as a result. [1]

(b) Name `"Ana"` and `16` in this call. [1]

(c) State what the constructor sets up. [1]

Solutions

2.1 it sets the initial state of a new object.

2.2 when an object is created with `new`.

2.3 through its parameters, which supply each object's starting values.

3.1 B.

3.2 B.

3.3 (a) the constructor. (b) arguments. (c) the object's initial state.

1. This question involves the `Account` class, which is used to represent user accounts for a website. The `Account` class contains a helper method, `isAvailable`, which determines whether a username is available. You will write a constructor and a method in the `Account` class.

```
public class Account
{
   private String username; // To be initialized in part (a)

   /**
    *  Creates a username based on the parameter requestedName. If the
    *  username is unavailable, appends successive integers, beginning
    *  with 1, to requestedName until an available username is found,
    *  as described in part (a).
    */
   public Account(String requestedName)
   { /* to be implemented in part (a) */ }

   /**
    *  Returns true if the parameter str is an available username;
    *  returns false otherwise.
    */
   public static boolean isAvailable(String str)
   { /* implementation not shown */ }

   /**
    *  Returns a shortened version of username with each hyphen ("-")
    *  and the character before it removed, as described in part (b)
    *  Preconditions: username does not start or end with a hyphen.
    *                 username does not contain consecutive hyphens.
    *                 username.length() >= 2
    *  Postcondition: username is unchanged.
    */
   public String getShortenedName()
   { /* to be implemented in part (b) */ }

   /* There may be instance variables, constructors, and methods
      that are not shown. */
}
```

The following information applies to part A.

In part A, you will write the `Account` constructor, which creates a username based on the parameter `requestedName`.

A helper method, `isAvailable`, has been provided to determine whether a username is available. The `isAvailable` method returns `true` if its parameter is an available username and returns `false` otherwise.

If `requestedName` is an available username, the `Account` constructor will assign `requestedName` to the instance variable `username`. If not, the constructor will try different variations of `requestedName` until an available username is found and assigned to the instance variable `username`. The variations consist of `requestedName` followed by an integer, as in the following example.

- If `requestedName` is `"Luis-Cruz"` and this username is not available, then the constructor will check the availability of `"Luis-Cruz1"`, `"Luis-Cruz2"`, `"Luis-Cruz3"`, and so on, until an available username is found. The first available username found is assigned to `username`.
- If `requestedName` is `"PSmith"` and this username is available, then `"PSmith"` is assigned to `username`.

The following information applies to part B.

In part B, you will write the `getShortenedName` method, which returns a shortened version of the instance variable `username` with each hyphen (`"-"`) and the character immediately before it removed. If no hyphens appear in `username`, the value of `username` is returned.

For example, if `username` is `"Amy-Marie-Lin"`, `getShortenedName` should return `"AmMariLin"`.

As another example, if `username` is `"SammyB3"`, `getShortenedName` should return `"SammyB3"`.

Part A

Complete the `Account` constructor. You must use `isAvailable` appropriately in order to receive full credit.

```
/**
 *  Creates a username based on the parameter requestedName. If the
 *  username is unavailable, appends successive integers, beginning
 *  with 1, to requestedName until an available username is found,
 *  as described in part (a).
 */
public Account(String requestedName)
```

Part B

Complete method `getShortenedName`.

```
/**
 *  Returns a shortened version of username with each hyphen ("-")
 *  and the character before it removed, as described in part (b)
 *  Preconditions: username does not start or end with a hyphen.
 *                 username does not contain consecutive hyphens.
 *                 username.length() >= 2
 *  Postcondition: username is unchanged.
 */
public String getShortenedName()
```


3. This question involves pairing competitors in a tournament into one-on-one matches for one round of the tournament. For example, in a chess tournament, the competitors are the individual chess players. A game of chess involving two players is a match. The winner of each match goes on to a match in the next round of the tournament. Since half of the players are eliminated in each round of the tournament, there is eventually a final round consisting of one match and two competitors. The winner of that match is considered the winner of the tournament.

Competitors, matches, and rounds of the tournament are represented by the `Competitor`, `Match`, and `Round` classes. You will write the constructor and one method of the `Round` class.

```
/** A single competitor in the tournament */
public class Competitor
{
  /** The competitor's name and rank */
  private String name;
  private int rank;

  /**
   * Assigns n to name and initialRank to rank
   * Precondition: initialRank >= 1
   */
  public Competitor(String n, int initialRank)
  { /* implementation not shown */ }

  /* There may be instance variables, constructors,
     and methods that are not shown. */
}
```

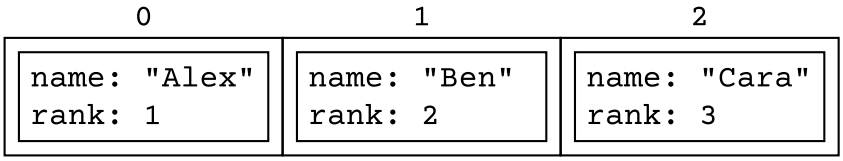
```
/** A match between two competitors */
public class Match
{
  public Match(Competitor one, Competitor two)
  { /* implementation not shown */ }

  /* There may be instance variables, constructors,
     and methods that are not shown. */
}


/** A single round of the tournament */
public class Round
{
  /** The list of competitors participating in this round */
  private ArrayList<Competitor> competitorList;

  /** Initializes competitorList, as described in part (a) */
  public Round(String[] names)
  { /* to be implemented in part (a) */ }

  /**
   * Creates an ArrayList of Match objects for the next round
   * of the tournament, as described in part (b)
   * Preconditions: competitorList contains at least one element.
   *                competitorList is ordered from best to worst rank.
   * Postcondition: competitorList is unchanged.
   */
  public ArrayList<Match> buildMatches()
  { /* to be implemented in part (b) */ }

  /* There may be instance variables, constructors,
     and methods that are not shown. */
}
```

A. Write the constructor for the `Round` class. The constructor should initialize `competitorList` to contain one `Competitor` object for each name in the `String[] names`. The order in which `Competitor` objects appear in `competitorList` should be the same as the order in which they appear in `names`, and the rank of each competitor is based on the competitor's position in `names`. Names are listed in `names` in order from the best-ranked competitor with rank `1` to the worst-ranked competitor with rank *n*, where *n* is the number of elements in `names`.

For example, assume the following code segment is executed.

```
String[] players = {"Alex", "Ben", "Cara"};
Round r = new Round(players);
```

The following shows the contents of `competitorList` in `r` after the constructor has finished executing.



Complete the `Round` constructor.

```
/** Initializes competitorList, as described in part (a) */
public Round(String[] names)
```

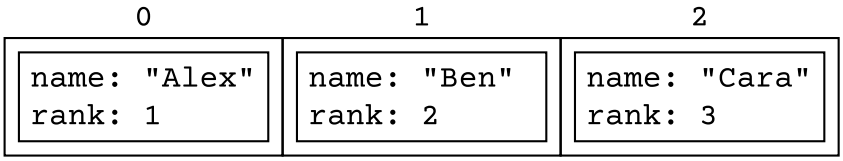
B. Write the `Round` method `buildMatches`. This method should return a new `ArrayList<Match>` object by pairing competitors from `competitorList` according to the following rules.

- If the number of competitors in `competitorList` is even, the best-ranked competitor is paired with the worst-ranked competitor, the second-best-ranked competitor is paired with the second-worst-ranked competitor, etc.
- If the number of competitors in `competitorList` is odd, the competitor with the best rank is ignored and the remaining competitors are paired according to the rule for an even number of competitors.

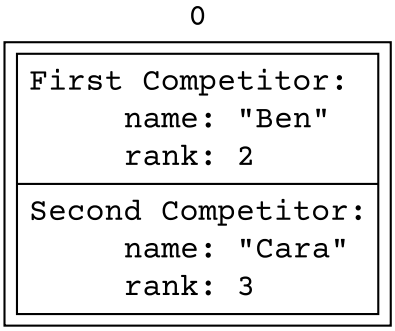
Each pair of competitors is used to create a `Match` object that should be added to the `ArrayList` to return. Competitors may appear in either order in a `Match` object, and matches may appear in any order in the returned `ArrayList`.

The following example shows the contents of `competitorList` in a `Round` object `r1` containing an odd number of competitors and the `ArrayList` of `Match` objects that should be returned by the call `r1.buildMatches()`.

`competitorList`:

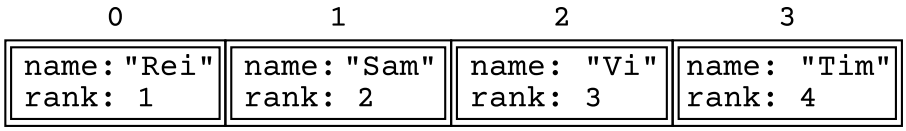


The `ArrayList` to be returned contains a single match between Ben and Cara, the second and third-ranked competitors:

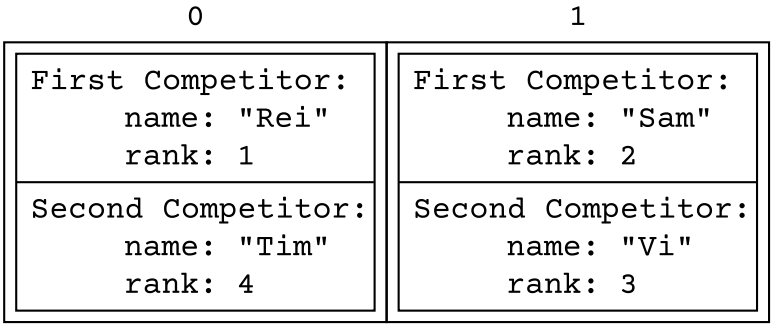


The next example shows the contents of `competitorList` in a `Round` object `r2` containing an even number of competitors and the `ArrayList` of `Match` objects that should be returned by the call `r2.buildMatches()`.

`competitorList`:



The `ArrayList` to be returned contains two matches: one match between the first- and last-ranked competitors Rei and Tim, and a second match between the second- and third-ranked competitors Sam and Vi:



Complete the `buildMatches` method.

```
/**
 * Creates an ArrayList of Match objects for the next round
 * of the tournament, as described in part (b)
 * Preconditions: competitorList contains at least one element.
 *                competitorList is ordered from best to worst rank.
 * Postcondition: competitorList is unchanged.
 */
public ArrayList<Match> buildMatches()
```

2. This question involves a scoreboard for a game. The game is played between two teams who alternate turns so that at any given time, one team is active and the other team is inactive. During a turn, a team makes one or more plays. Each play can score one or more points and the team's turn continues, or the play can fail, in which case no points are scored and the team's turn ends. The `Scoreboard` class, which you will write, is used to keep track of the score in a game.

   The `Scoreboard` class contains a constructor and two methods.

   - The constructor has two parameters. The first parameter is a `String` containing the name of team 1, and the second parameter is a `String` containing the name of team 2. The game always begins with team 1 as the active team.
   - The `recordPlay` method has a single nonnegative integer parameter that is equal to the number of points scored on a play or `0` if the play failed. If the play results in one or more points scored, the active team's score is updated and that team remains active. If the value of the parameter is `0`, the active team's turn ends and the inactive team becomes the active team. The `recordPlay` method does not return a value.
   - The `getScore` method has no parameters. The method returns a `String` containing information about the current state of the game. The returned string begins with the score of team 1, followed by a hyphen (`"-"`), followed by the score of team 2, followed by a hyphen, followed by the name of the team that is currently active.

The following table contains a sample code execution sequence and the corresponding results. The code execution sequence appears in a class other than `Scoreboard`.

Statement	Value Returned (blank if none)	Explanation
`String info;`		
`Scoreboard game = new Scoreboard("Red", "Blue");`		`game` is a new `Scoreboard` for a game played between team 1, whose name is `"Red"`, and team 2, whose name is `"Blue"`. The active team is set to team 1.
`info = game.getScore();`	`"0-0-Red"`	
`game.recordPlay(1);`		Team 1 earns 1 point because the game always begins with team 1 as the active team.
`info = game.getScore();`	`"1-0-Red"`	
`game.recordPlay(0);`		Team 1's play failed, so team 2 is now active.
`info = game.getScore();`	`"1-0-Blue"`	
`info = game.getScore();`	`"1-0-Blue"`	The score and state of the game are unchanged since the last call to `getScore`.
`game.recordPlay(3);`		Team 2 earns 3 points.
`info = game.getScore();`	`"1-3-Blue"`	
`game.recordPlay(1);`		Team 2 earns 1 point.
`game.recordPlay(0);`		Team 2's play failed, so team 1 is now active.
`info = game.getScore();`	`"1-4-Red"`	
`game.recordPlay(0);`		Team 1's play failed, so team 2 is now active.
`game.recordPlay(4);`		Team 2 earns 4 points.
`game.recordPlay(0);`		Team 2's play failed, so team 1 is now active.
`info = game.getScore();`	`"1-8-Red"`	
`Scoreboard match = new Scoreboard("Lions", "Tigers");`		`match` is a new and independent `Scoreboard` object.
`info = match.getScore();`	`"0-0-Lions"`	
`info = game.getScore();`	`"1-8-Red"`	

Write the complete `Scoreboard` class. Your implementation must meet all specifications and conform to the examples shown in the preceding table.

Begin your response at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number. If there are multiple parts to this question, write the part letter with your response.

2. This question involves methods that distribute text across lines of an electronic sign. The electronic sign and the text to be displayed on it are represented by the `Sign` class. You will write the complete `Sign` class, which contains a constructor and two methods.

   The `Sign` class constructor has two parameters. The first parameter is a `String` that contains the message to be displayed on the sign. The second parameter is an `int` that contains the *width* of each line of the sign. The width is the positive maximum number of characters that can be displayed on a single line of the sign.

   A sign contains as many lines as are necessary to display the entire message. The message is split among the lines of the sign without regard to spaces or punctuation. Only the last line of the sign may contain fewer characters than the width indicated by the constructor parameter.

   The following are examples of a message displayed on signs of different widths. Assume that in each example, the sign is declared with the width specified in the first column of the table and with the message `"Everything on sale, please come in"`, which contains 34 characters.

Width of the Sign	Sign Display
15	**Everything on s ale, please com e in**
17	**Everything on sal e, please come in**
40	**Everything on sale, please come in**

   In addition to the constructor, the `Sign` class contains two methods.

   The `numberOfLines` method returns an `int` representing the number of lines needed to display the text on the sign. In the previous examples, `numberOfLines` would return `3`, `2`, and `1`, respectively, for the sign widths shown in the table.

   The `getLines` method returns a `String` containing the message broken into lines separated by semicolons `(;)` or returns `null` if the message is the empty string. The constructor parameter that contains the message to be displayed will not include any semicolons. As an example, in the first row of the preceding table, `getLines` would return `"Everything on s;ale, please com;e in"`. No semicolon should appear at the end of the `String` returned by `getLines`.

The following table contains a sample code execution sequence and the corresponding results. The code execution sequence appears in a class other than `Sign`.

Statement	Method Call Return Value (blank if none)	Explanation
`String str;`		
`int x;`		
`Sign sign1 = new Sign("ABC222DE", 3);`		The message for `sign1` contains 8 characters, and the sign has lines of width 3.
`x = sign1.numberOfLines();`	`3`	The sign needs three lines to display the 8-character message on a sign with lines of width 3.
`str = sign1.getLines();`	`"ABC;222;DE"`	Semicolons separate the text displayed on the first, second, and third lines of the sign.
`str = sign1.getLines();`	`"ABC;222;DE"`	Successive calls to `getLines` return the same value.
`Sign sign2 = new Sign("ABCD", 10);`		The message for `sign2` contains 4 characters, and the sign has lines of width 10.
`x = sign2.numberOfLines();`	`1`	The sign needs one line to display the 4-character message on a sign with lines of width 10.
`str = sign2.getLines();`	`"ABCD"`	No semicolon appears, since the text to be displayed fits on the first line of the sign.
`Sign sign3 = new Sign("ABCDEF", 6);`		The message for `sign3` contains 6 characters, and the sign has lines of width 6.
`x = sign3.numberOfLines();`	`1`	The sign needs one line to display the 6-character message on a sign with lines of width 6.
`str = sign3.getLines();`	`"ABCDEF"`	No semicolon appears, since the text to be displayed fits on the first line of the sign.
`Sign sign4 = new Sign("", 4);`		The message for `sign4` is an empty string.
`x = sign4.numberOfLines();`	`0`	There is no text to display.
`str = sign4.getLines();`	`null`	There is no text to display.
`Sign sign5 = new Sign("AB_CD_EF", 2);`		The message for `sign5` contains 8 characters, and the sign has lines of width 2.
`x = sign5.numberOfLines();`	`4`	The sign needs four lines to display the 8-character message on a sign with lines of width 2.
`str = sign5.getLines();`	`"AB;_C;D_;EF"`	Semicolons separate the text displayed on the four lines of the sign.

Write the complete `Sign` class. Your implementation must meet all specifications and conform to the examples shown in the preceding table.

Begin your response at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number. If there are multiple parts to this question, write the part letter with your response.

2. The `Book` class is used to store information about a book. A partial `Book` class definition is shown.

```
public class Book
{
   /** The title of the book */
   private String title;

   /** The price of the book */
   private double price;

   /** Creates a new Book with given title and price */
   public Book(String bookTitle, double bookPrice)
   {  /* implementation not shown */  }

   /** Returns the title of the book */
   public String getTitle()
   {  return title;  }

   /** Returns a string containing the title and price of the Book */
   public String getBookInfo()
   {
      return title + "-" + price;
   }

   // There may be instance variables, constructors, and methods that are not shown.
}
```

You will write a class `Textbook`, which is a subclass of `Book`.

A `Textbook` has an edition number, which is a positive integer used to identify different versions of the book. The `getBookInfo` method, when called on a `Textbook`, returns a string that also includes the edition information, as shown in the example.

Information about the book title and price must be maintained in the `Book` class. Information about the edition must be maintained in the `Textbook` class.

The `Textbook` class contains an additional method, `canSubstituteFor`, which returns `true` if a `Textbook` is a valid substitute for another `Textbook` and returns `false` otherwise. The current `Textbook` is a valid substitute for the `Textbook` referenced by the parameter of the `canSubstituteFor` method if the two `Textbook` objects have the same title and if the edition of the current `Textbook` is greater than or equal to the edition of the parameter.

GO ON TO THE NEXT PAGE.

The following table contains a sample code execution sequence and the corresponding results. The code execution sequence appears in a class other than `Book` or `Textbook`.

Statement	Value Returned (blank if no value)	Class Specification
`Textbook bio2015 = new Textbook("Biology", 49.75, 2);`		`bio2015` is a `Textbook` with a title of `"Biology"`, a price of `49.75`, and an edition of `2`.
`Textbook bio2019 = new Textbook("Biology", 39.75, 3);`		`bio2019` is a `Textbook` with a title of `"Biology"`, a price of `39.75`, and an edition of `3`.
`bio2019.getEdition();`	`3`	The edition is returned.
`bio2019.getBookInfo();`	`"Biology-39.75-3"`	The formatted string containing the title, price, and edition of `bio2019` is returned.
`bio2019.canSubstituteFor(bio2015);`	`true`	`bio2019` is a valid substitute for `bio2015`, since their titles are the same and the edition of `bio2019` is greater than or equal to the edition of `bio2015`.
`bio2015.canSubstituteFor(bio2019);`	`false`	`bio2015` is not a valid substitute for `bio2019`, since the edition of `bio2015` is less than the edition of `bio2019`.
`Textbook math = new Textbook("Calculus", 45.25, 1);`		`math` is a `Textbook` with a title of `"Calculus"`, a price of `45.25`, and an edition of `1`.
`bio2015.canSubstituteFor(math);`	`false`	`bio2015` is not a valid substitute for `math`, since the title of `bio2015` is not the same as the title of `math`.

Write the complete `Textbook` class. Your implementation must meet all specifications and conform to the examples shown in the preceding table.

Begin your response at the top of a new page in the Free Response booklet and fill in the appropriate circle indicating the question number.
If there are multiple parts to this question, write the part letter with your response.

GO ON TO THE NEXT PAGE.

2. The class `SingleTable` represents a table at a restaurant.

```
public class SingleTable
{
    /** Returns the number of seats at this table. The value is always greater than or equal to 4. */
    public int getNumSeats()
    {  /* implementation not shown */  }

    /** Returns the height of this table in centimeters. */
    public int getHeight()
    {  /* implementation not shown */  }

    /** Returns the quality of the view from this table. */
    public double getViewQuality()
    {  /* implementation not shown */  }

    /** Sets the quality of the view from this table to value. */
    public void setViewQuality(double value)
    {  /* implementation not shown */  }

    // There may be instance variables, constructors, and methods that are not shown.
}
```

At the restaurant, customers can sit at tables that are composed of two single tables pushed together. You will write a class `CombinedTable` to represent the result of combining two `SingleTable` objects, based on the following rules and the examples in the chart that follows.

- A `CombinedTable` can seat a number of customers that is two fewer than the total number of seats in its two `SingleTable` objects (to account for seats lost when the tables are pushed together).
- A `CombinedTable` has a desirability that depends on the views and heights of the two single tables. If the two single tables of a `CombinedTable` object are the same height, the desirability of the `CombinedTable` object is the average of the view qualities of the two single tables.
- If the two single tables of a `CombinedTable` object are not the same height, the desirability of the `CombinedTable` object is 10 units less than the average of the view qualities of the two single tables.

Assume `SingleTable` objects `t1`, `t2`, and `t3` have been created as follows.

- `SingleTable t1` has 4 seats, a view quality of 60.0, and a height of 74 centimeters.
- `SingleTable t2` has 8 seats, a view quality of 70.0, and a height of 74 centimeters.
- `SingleTable t3` has 12 seats, a view quality of 75.0, and a height of 76 centimeters.

The chart contains a sample code execution sequence and the corresponding results.

Statement	Value Returned (blank if no value)	Class Specification
`CombinedTable c1 = new CombinedTable(t1, t2);`		A `CombinedTable` is composed of two `SingleTable` objects.
`c1.canSeat(9);`	`true`	Since its two single tables have a total of 12 seats, `c1` can seat 10 or fewer people.
`c1.canSeat(11);`	`false`	`c1` cannot seat 11 people.
`c1.getDesirability();`	`65.0`	Because `c1`'s two single tables are the same height, its desirability is the average of `60.0` and `70.0`.
`CombinedTable c2 = new CombinedTable(t2, t3);`		A `CombinedTable` is composed of two `SingleTable` objects.
`c2.canSeat(18);`	`true`	Since its two single tables have a total of 20 seats, `c2` can seat 18 or fewer people.
`c2.getDesirability();`	`62.5`	Because `c2`'s two single tables are not the same height, its desirability is 10 units less than the average of `70.0` and `75.0`.
`t2.setViewQuality(80);`		Changing the view quality of one of the tables that makes up `c2` changes the desirability of `c2`, as illustrated in the next line of the chart. Since `setViewQuality` is a `SingleTable` method, you do not need to write it.
`c2.getDesirability();`	`67.5`	Because the view quality of `t2` changed, the desirability of `c2` has also changed.

The last line of the chart illustrates that when the characteristics of a `SingleTable` change, so do those of the `CombinedTable` that contains it.

Write the complete `CombinedTable` class. Your implementation must meet all specifications and conform to the examples shown in the preceding chart.

Begin your response at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number. If there are multiple parts to this question, write the part letter with your response.

2. This question involves the implementation of a fitness tracking system that is represented by the `StepTracker` class. A `StepTracker` object is created with a parameter that defines the minimum number of steps that must be taken for a day to be considered *active*.

   The `StepTracker` class provides a constructor and the following methods.

   - `addDailySteps`, which accumulates information about steps, in readings taken once per day
   - `activeDays`, which returns the number of active days
   - `averageSteps`, which returns the average number of steps per day, calculated by dividing the total number of steps taken by the number of days tracked

   The following table contains a sample code execution sequence and the corresponding results.

Statements and Expressions	Value Returned (blank if no value)	Comment
`StepTracker tr = new StepTracker(10000);`		Days with at least 10,000 steps are considered active. Assume that the parameter is positive.
`tr.activeDays();`	`0`	No data have been recorded yet.
`tr.averageSteps();`	`0.0`	When no step data have been recorded, the `averageSteps` method returns `0.0`.
`tr.addDailySteps(9000);`		This is too few steps for the day to be considered active.
`tr.addDailySteps(5000);`		This is too few steps for the day to be considered active.
`tr.activeDays();`	`0`	No day had at least 10,000 steps.
`tr.averageSteps();`	`7000.0`	The average number of steps per day is (14000 / 2).
`tr.addDailySteps(13000);`		This represents an active day.
`tr.activeDays();`	`1`	Of the three days for which step data were entered, one day had at least 10,000 steps.
`tr.averageSteps();`	`9000.0`	The average number of steps per day is (27000 / 3).
`tr.addDailySteps(23000);`		This represents an active day.
`tr.addDailySteps(1111);`		This is too few steps for the day to be considered active.
`tr.activeDays();`	`2`	Of the five days for which step data were entered, two days had at least 10,000 steps.
`tr.averageSteps();`	`10222.2`	The average number of steps per day is (51111 / 5).

Write the complete `StepTracker` class, including the constructor and any required instance variables and methods. Your implementation must meet all specifications and conform to the example.

3. The `StringChecker` interface describes classes that check if strings are valid, according to some criterion.

```
public interface StringChecker
{
    /** Returns true if str is valid. */
    boolean isValid(String str);
}
```

A `CodeWordChecker` is a `StringChecker`. A `CodeWordChecker` object can be constructed with three parameters: two integers and a string. The first two parameters specify the minimum and maximum code word lengths, respectively, and the third parameter specifies a string that must not occur in the code word. A `CodeWordChecker` object can also be constructed with a single parameter that specifies a string that must not occur in the code word; in this case the minimum and maximum lengths will default to 6 and 20, respectively.

The following examples illustrate the behavior of `CodeWordChecker` objects.

Example 1

```
StringChecker sc1 = new CodeWordChecker(5, 8, "$");
```

Valid code words have 5 to 8 characters and must not include the string `"$"`.

Method call	Return value	Explanation
`sc1.isValid("happy")`	`true`	The code word is valid.
`sc1.isValid("happy$")`	`false`	The code word contains `"$"`.
`sc1.isValid("Code")`	`false`	The code word is too short.
`sc1.isValid("happyCode")`	`false`	The code word is too long.

Example 2

```
StringChecker sc2 = new CodeWordChecker("pass");
```

Valid code words must not include the string `"pass"`. Because the bounds are not specified, the length bounds are 6 and 20, inclusive.

Method call	Return value	Explanation
`sc2.isValid("MyPass")`	`true`	The code word is valid.
`sc2.isValid("Mypassport")`	`false`	The code word contains `"pass"`.
`sc2.isValid("happy")`	`false`	The code word is too short.
`sc2.isValid("1,000,000,000,000,000")`	`false`	The code word is too long.

Write the complete `CodeWordChecker` class. Your implementation must meet all specifications and conform to all examples.

1. This question involves identifying and processing the digits of a non-negative integer. The declaration of the `Digits` class is shown below. You will write the constructor and one method for the `Digits` class.

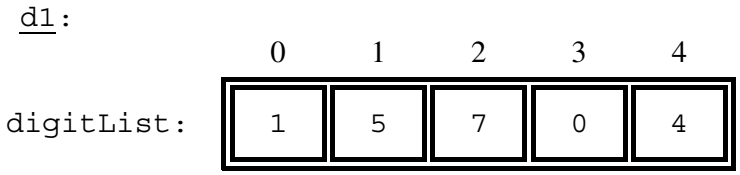
```
public class Digits
{
    /** The list of digits from the number used to construct this object.
     *  The digits appear in the list in the same order in which they appear in the original number.
     */
    private ArrayList<Integer> digitList;

    /** Constructs a Digits object that represents num.
     *  Precondition: num >= 0
     */
    public Digits(int num)
    {  /* to be implemented in part (a) */  }

    /** Returns true if the digits in this Digits object are in strictly increasing order;
     *          false otherwise.
     */
    public boolean isStrictlyIncreasing()
    {  /* to be implemented in part (b) */  }
}
```

Part (a) begins on page 4.

(a) Write the constructor for the `Digits` class. The constructor initializes and fills `digitList` with the digits from the non-negative integer `num`. The elements in `digitList` must be `Integer` objects representing single digits, and appear in the same order as the digits in `num`. Each of the following examples shows the declaration of a `Digits` object and the contents of `digitList` as initialized by the constructor.

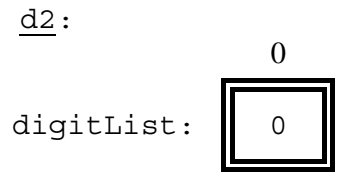
Example 1

```
Digits d1 = new Digits(15704);
```



Example 2

```
Digits d2 = new Digits(0);
```



WRITE YOUR SOLUTION ON THE NEXT PAGE.

Complete the `Digits` constructor below.

```
/** Constructs a Digits object that represents num.
 *  Precondition: num >= 0
 */
public Digits(int num)
```

Part (b) begins on page 6.

(b) Write the `Digits` method `isStrictlyIncreasing`. The method returns `true` if the elements of `digitList` appear in strictly increasing order; otherwise, it returns `false`. A list is considered strictly increasing if each element after the first is greater than (but not equal to) the preceding element.

The following table shows the results of several calls to `isStrictlyIncreasing`.

Method call	Value returned
`new Digits(7).isStrictlyIncreasing()`	`true`
`new Digits(1356).isStrictlyIncreasing()`	`true`
`new Digits(1336).isStrictlyIncreasing()`	`false`
`new Digits(1536).isStrictlyIncreasing()`	`false`
`new Digits(65310).isStrictlyIncreasing()`	`false`

WRITE YOUR SOLUTION ON THE NEXT PAGE.

Complete method `isStrictlyIncreasing` below.

```
/** Returns true if the digits in this Digits object are in strictly increasing order;
 *          false otherwise.
 */
```

2. This question involves the design of a class that will be used to produce practice problems. The following `StudyPractice` interface represents practice problems that can be used to study some subject.

```
public interface StudyPractice
{
    /** Returns the current practice problem. */
    String getProblem();

    /** Changes to the next practice problem. */
    void nextProblem();
}
```

The `MultPractice` class is a `StudyPractice` that produces multiplication practice problems. A `MultPractice` object is constructed with two integer values: *first integer* and *initial second integer*. The first integer is a value that remains constant and is used as the first integer in every practice problem. The initial second integer is used as the starting value for the second integer in the practice problems. This second value is incremented for each additional practice problem that is produced by the class.

For example, a `MultPractice` object created with the call `new MultPractice(7, 3)` would be used to create the practice problems `"7 TIMES 3"`, `"7 TIMES 4"`, `"7 TIMES 5"`, and so on.

In the `MultPractice` class, the `getProblem` method returns a string in the format of `"`*first integer* `TIMES` *second integer*`"`. The `nextProblem` method updates the state of the `MultPractice` object to represent the next practice problem.

The following examples illustrate the behavior of the `MultPractice` class. Each table shows a code segment and the output that would be produced as the code is executed.

Example 1

Code segment	Output produced
`StudyPractice p1 = new MultPractice(7, 3);` `System.out.println(p1.getProblem());`	`7 TIMES 3`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 4`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 5`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 6`

Example 2

Code segment	Output produced

`StudyPractice p2 = new MultPractice(4, 12);`
`p2.nextProblem();`
`System.out.println(p2.getProblem());`
`System.out.println(p2.getProblem());`
	`4 TIMES 13`
	`4 TIMES 13`

`p2.nextProblem();`
`p2.nextProblem();`
`System.out.println(p2.getProblem());`
	`4 TIMES 15`

`p2.nextProblem();` `System.out.println(p2.getProblem());`	`4 TIMES 16`

Question 2 continues on page 10.

Interface information for this question

```
public interface StudyPractice

String getProblem()
void nextProblem()
```

Write the complete `MultPractice` class. Your implementation must be consistent with the specifications and the given examples.

COMPUTER SCIENCE A
SECTION II
Time—1 hour and 30 minutes
Number of questions—4
Percent of total score—50

Directions: SHOW ALL YOUR WORK. REMEMBER THAT PROGRAM SEGMENTS ARE TO BE WRITTEN IN JAVA.

Notes:
- Assume that the classes listed in the Java Quick Reference have been imported where appropriate.
- Unless otherwise noted in the question, assume that parameters in method calls are not `null` and that methods are called only when their preconditions are satisfied.
- In writing solutions for each question, you may use any of the accessible methods that are listed in classes defined in that question. Writing significant amounts of code that can be replaced by a call to one of these methods will not receive full credit.

1. This question involves the implementation and extension of a `RandomStringChooser` class.

   (a) A `RandomStringChooser` object is constructed from an array of non-`null` `String` values. When the object is first constructed, all of the strings are considered available. The `RandomStringChooser` class has a `getNext` method, which has the following behavior. A call to `getNext` returns a randomly chosen string from the available strings in the object. Once a particular string has been returned from a call to `getNext`, it is no longer available to be returned from subsequent calls to `getNext`. If no strings are available to be returned, `getNext` returns `"NONE"`.

   The following code segment shows an example of the behavior of `RandomStringChooser`.

```
String[] wordArray = {"wheels", "on", "the", "bus"};
RandomStringChooser sChooser = new RandomStringChooser(wordArray);
for (int k = 0; k < 6; k++)
{
   System.out.print(sChooser.getNext() + " ");
}
```

   One possible output is shown below. Because `sChooser` has only four strings, the string `"NONE"` is printed twice.

```
bus the wheels on NONE NONE
```

WRITE YOUR SOLUTION ON THE NEXT PAGE.

Write the entire `RandomStringChooser` class. Your implementation must include an appropriate constructor and any necessary methods. Any instance variables must be `private`. The code segment in the example above should have the indicated behavior (that is, it must compile and produce a result like the possible output shown). Neither the constructor nor any of the methods should alter the parameter passed to the constructor, but your implementation may copy the contents of the array.

Part (b) begins on page 4.

(b) The following partially completed `RandomLetterChooser` class is a subclass of the `RandomStringChooser` class. You will write the constructor for the `RandomLetterChooser` class.

```
public class RandomLetterChooser extends RandomStringChooser
{
    /** Constructs a random letter chooser using the given string str.
     *  Precondition: str contains only letters.
     */
    public RandomLetterChooser(String str)
    {  /* to be implemented in part (b) */  }

    /** Returns an array of single-letter strings.
     *  Each of these strings consists of a single letter from str. Element k
     *  of the returned array contains the single letter at position k of str.
     *  For example, getSingleLetters("cat") returns the
     *  array { "c", "a", "t" }.
     */
    public static String[] getSingleLetters(String str)
    {  /* implementation not shown */  }
}
```

The following code segment shows an example of using `RandomLetterChooser`.

```
RandomLetterChooser letterChooser = new RandomLetterChooser("cat");
for (int k = 0; k < 4; k++)
{
   System.out.print(letterChooser.getNext());
}
```

The code segment will print the three letters in `"cat"` in one of the possible orders. Because there are only three letters in the original string, the code segment prints `"NONE"` the fourth time through the loop. One possible output is shown below.

```
actNONE
```

Assume that the `RandomStringChooser` class that you wrote in part (a) has been implemented correctly and that `getSingleLetters` works as specified. You must use `getSingleLetters` appropriately to receive full credit.

Complete the `RandomLetterChooser` constructor below.

```
/** Constructs a random letter chooser using the given string str.
 *  Precondition: str contains only letters.
 */
public RandomLetterChooser(String str)
```

2. This question involves two classes that are used to process log messages. A list of sample log messages is given below.

```
CLIENT3:security alert – repeated login failures
Webserver:disk offline
SERVER1:file not found
SERVER2:read error on disk DSK1
SERVER1:write error on disk DSK2
Webserver:error on /dev/disk
```

Log messages have the format *machineId*:*description*, where *machineId* identifies the computer and *description* describes the event being logged. Exactly one colon (":") appears in a log message. There are no blanks either immediately before or immediately after the colon.

The following `LogMessage` class is used to represent a log message.

```
public class LogMessage
{
   private String machineId;
   private String description;

   /** Precondition: message is a valid log message. */
   public LogMessage(String message)
   {  /* to be implemented in part (a) */  }

   /** Returns true if the description in this log message properly contains keyword;
    *          false otherwise.
    */
   public boolean containsWord(String keyword)
   {  /* to be implemented in part (b) */  }

   public String getMachineId()
   {  return machineId;  }

   public String getDescription()
   {  return description;  }

   // There may be instance variables, constructors, and methods that are not shown.
}
```

(a) Write the constructor for the `LogMessage` class. It must initialize the private data of the object so that `getMachineId` returns the *machineId* part of the message and `getDescription` returns the *description* part of the message.

Complete the `LogMessage` constructor below.

```
/** Precondition: message is a valid log message. */
public LogMessage(String message)
```

Part (b) begins on page 8.

(b) Write the `LogMessage` method `containsWord`, which returns `true` if the description in the log message *properly contains* a given keyword and returns `false` otherwise.

A description *properly contains* a keyword if all three of the following conditions are true.

- the keyword is a substring of the description;
- the keyword is either at the beginning of the description or it is immediately preceded by a space;
- the keyword is either at the end of the description or it is immediately followed by a space.

The following tables show several examples. The descriptions in the left table properly contain the keyword `"disk"`. The descriptions in the right table do not properly contain the keyword `"disk"`.

Descriptions that properly contain `"disk"`

`"disk"`
`"error on disk"`
`"error on /dev/disk disk"`
`"error on disk DSK1"`

Descriptions that do not properly contain `"disk"`

`"DISK"`
`"error on disk3"`
`"error on /dev/disk"`
`"diskette"`

WRITE YOUR SOLUTION ON THE NEXT PAGE.

Assume that the `LogMessage` constructor works as specified, regardless of what you wrote in part (a).

Complete method `containsWord` below.

```
/** Returns true if the description in this log message properly contains keyword;
 *          false otherwise.
 */
public boolean containsWord(String keyword)
```

Part (c) begins on page 10.

(c) The `SystemLog` class represents a list of `LogMessage` objects and provides a method that removes and returns a list of all log messages (if any) that properly contain a given keyword. The messages in the returned list appear in the same order in which they originally appeared in the system log. If no message properly contains the keyword, an empty list is returned. The declaration of the `SystemLog` class is shown below.

```
public class SystemLog
{
    /** Contains all the entries in this system log.
     *  Guaranteed not to be null and to contain only non-null entries.
     */
    private List<LogMessage> messageList;

    /** Removes from the system log all entries whose descriptions properly contain keyword,
     *  and returns a list (possibly empty) containing the removed entries.
     *  Postcondition:
     *    – Entries in the returned list properly contain keyword and
     *      are in the order in which they appeared in the system log.
     *    – The remaining entries in the system log do not properly contain keyword and
     *      are in their original order.
     *    – The returned list is empty if no messages properly contain keyword.
     */
    public List<LogMessage> removeMessages(String keyword)
    {  /* to be implemented in part (c) */  }

    // There may be instance variables, constructors, and methods that are not shown.
}
```

Write the `SystemLog` method `removeMessages`, which removes from the system log all entries whose descriptions properly contain `keyword` and returns a list of the removed entries in their original order. For example, assume that `theLog` is a `SystemLog` object initially containing six `LogMessage` objects representing the following list of log messages.

```
CLIENT3:security alert – repeated login failures
Webserver:disk offline
SERVER1:file not found
SERVER2:read error on disk DSK1
SERVER1:write error on disk DSK2
Webserver:error on /dev/disk
```

The call `theLog.removeMessages("disk")` would return a list containing the `LogMessage` objects representing the following log messages.

```
Webserver:disk offline
SERVER2:read error on disk DSK1
SERVER1:write error on disk DSK2
```

After the call, `theLog` would contain the following log messages.

```
CLIENT3:security alert – repeated login failures
SERVER1:file not found
Webserver:error on /dev/disk
```

Assume that the `LogMessage` class works as specified, regardless of what you wrote in parts (a) and (b). You must use `containsWord` appropriately to receive full credit.

Complete method `removeMessages` below.

```
/** Removes from the system log all entries whose descriptions properly contain keyword,
 *  and returns a list (possibly empty) containing the removed entries.
 *  Postcondition:
 *    – Entries in the returned list properly contain keyword and
 *      are in the order in which they appeared in the system log.
 *    – The remaining entries in the system log do not properly contain keyword and
 *      are in their original order.
 *    – The returned list is empty if no messages properly contain keyword.
 */
public List<LogMessage> removeMessages(String keyword)
```

AP COMPUTER SCIENCE A • EXERCISE SHEET

3.5 Methods: How to Write Them

Name: _____ Class: _____ Date: _____ **Total: 8 marks**

KEY WORDS accessor 访问器 • mutator 修改器 • return type 返回类型 • constructor 构造函数

Objective

Build the skills to answer exam questions on **writing methods**.

You must be able to:

- write an **accessor** 访问器 (getter) that returns an instance variable
- write a **mutator** 修改器 (setter) that changes an instance variable
- give a method a **return type** 返回类型 and use `return`

1 Worked examples

Study these first. Each one shows the method for a question type used later.

Accessor and mutator

- An **accessor** (getter) **returns** the value of an instance variable.
- A **mutator** (setter) **changes** it.

```
public int getAge()      { return age; }   // accessor
public void setAge(int a) { age = a; }      // mutator
```

Return type

Every method states a **return type**; `return` sends back a result. A `void` method returns nothing.

2 Practice

2.1 State what an accessor method does. [1]

2.2 State what a mutator method does. [1]

2.3 State what the keyword `return` does. [1]

---

3 Exam-style questions

3.1 A getter (accessor) method [1]

- **A** changes a variable
- **B** returns a variable's value
- **C** prints output
- **D** deletes a variable

3.2 A method that changes an instance variable is a [1]

- **A** getter
- **B** setter (mutator)
- **C** constructor
- **D** void loop

3.3 `public int getScore() { return score; }`.

(a) Name this kind of method. [1]

(b) State its return type. [1]

(c) State what a matching setter would do. [1]

Solutions

2.1 it returns the value of an instance variable.

2.2 it changes the value of an instance variable.

2.3 it sends a result back to the caller.

3.1 B.

3.2 B.

3.3 (a) an accessor (getter). (b) `int`. (c) change (set) the score.

2. This question involves a scoreboard for a game. The game is played between two teams who alternate turns so that at any given time, one team is active and the other team is inactive. During a turn, a team makes one or more plays. Each play can score one or more points and the team's turn continues, or the play can fail, in which case no points are scored and the team's turn ends. The `Scoreboard` class, which you will write, is used to keep track of the score in a game.

   The `Scoreboard` class contains a constructor and two methods.

   - The constructor has two parameters. The first parameter is a `String` containing the name of team 1, and the second parameter is a `String` containing the name of team 2. The game always begins with team 1 as the active team.
   - The `recordPlay` method has a single nonnegative integer parameter that is equal to the number of points scored on a play or `0` if the play failed. If the play results in one or more points scored, the active team's score is updated and that team remains active. If the value of the parameter is `0`, the active team's turn ends and the inactive team becomes the active team. The `recordPlay` method does not return a value.
   - The `getScore` method has no parameters. The method returns a `String` containing information about the current state of the game. The returned string begins with the score of team 1, followed by a hyphen (`"-"`), followed by the score of team 2, followed by a hyphen, followed by the name of the team that is currently active.

The following table contains a sample code execution sequence and the corresponding results. The code execution sequence appears in a class other than `Scoreboard`.

Statement	Value Returned (blank if none)	Explanation
`String info;`		
`Scoreboard game = new Scoreboard("Red", "Blue");`		`game` is a new `Scoreboard` for a game played between team 1, whose name is `"Red"`, and team 2, whose name is `"Blue"`. The active team is set to team 1.
`info = game.getScore();`	`"0-0-Red"`	
`game.recordPlay(1);`		Team 1 earns 1 point because the game always begins with team 1 as the active team.
`info = game.getScore();`	`"1-0-Red"`	
`game.recordPlay(0);`		Team 1's play failed, so team 2 is now active.
`info = game.getScore();`	`"1-0-Blue"`	
`info = game.getScore();`	`"1-0-Blue"`	The score and state of the game are unchanged since the last call to `getScore`.
`game.recordPlay(3);`		Team 2 earns 3 points.
`info = game.getScore();`	`"1-3-Blue"`	
`game.recordPlay(1);`		Team 2 earns 1 point.
`game.recordPlay(0);`		Team 2's play failed, so team 1 is now active.
`info = game.getScore();`	`"1-4-Red"`	
`game.recordPlay(0);`		Team 1's play failed, so team 2 is now active.
`game.recordPlay(4);`		Team 2 earns 4 points.
`game.recordPlay(0);`		Team 2's play failed, so team 1 is now active.
`info = game.getScore();`	`"1-8-Red"`	
`Scoreboard match = new Scoreboard("Lions", "Tigers");`		`match` is a new and independent `Scoreboard` object.
`info = match.getScore();`	`"0-0-Lions"`	
`info = game.getScore();`	`"1-8-Red"`	

Write the complete `Scoreboard` class. Your implementation must meet all specifications and conform to the examples shown in the preceding table.

Begin your response at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number. If there are multiple parts to this question, write the part letter with your response.

1. This question involves the `AppointmentBook` class, which provides methods for students to schedule appointments with their teacher. Appointments can be scheduled during one of eight class periods during the school day, numbered 1 through 8. A requested appointment has a duration, which is the number of minutes the appointment will last. The 60 minutes within a period are numbered 0 through 59. In order for an appointment to be scheduled, the teacher must have a block of consecutive, available minutes that contains at least the requested number of minutes in a requested period. Scheduled appointments must start and end within the same period.

The `AppointmentBook` class contains two helper methods, `isMinuteFree` and `reserveBlock`. You will write two additional methods of the `AppointmentBook` class.

```
public class AppointmentBook
{
   /**
    *  Returns true if minute in period is available for an appointment and returns
    *  false otherwise
    *  Preconditions: 1 <= period <= 8;  0 <= minute <= 59
    */
   private boolean isMinuteFree(int period, int minute)
   {  /* implementation not shown */  }

   /**
    *  Marks the block of minutes that starts at startMinute in period and
    *  is duration minutes long as reserved for an appointment
    *  Preconditions: 1 <= period <= 8; 0 <= startMinute <= 59;
    *      1 <= duration <= 60
    */
   private void reserveBlock(int period, int startMinute, int duration)
   {  /* implementation not shown */  }

   /**
    *  Searches for the first block of duration free minutes during period, as described in
    *  part (a). Returns the first minute in the block if such a block is found or returns -1 if no
    *  such block is found.
    *  Preconditions: 1 <= period <= 8; 1 <= duration <= 60
    */
   public int findFreeBlock(int period, int duration)
   {  /* to be implemented in part (a) */  }

   /**
    *  Searches periods from startPeriod to endPeriod, inclusive, for a block
    *  of duration free minutes, as described in part (b). If such a block is found,
    *  calls reserveBlock to reserve the block of minutes and returns true; otherwise
    *  returns false.
    *  Preconditions: 1 <= startPeriod <= endPeriod <= 8; 1 <= duration <= 60
    */
   public boolean makeAppointment(int startPeriod, int endPeriod,
                                  int duration)
   {  /* to be implemented in part (b) */  }

   // There may be instance variables, constructors, and methods that are not shown.
}
```

(a) Write the `findFreeBlock` method, which searches `period` for the first block of free minutes that is `duration` minutes long. If such a block is found, `findFreeBlock` returns the first minute in the block. Otherwise, `findFreeBlock` returns `-1`. The `findFreeBlock` method uses the helper method `isMinuteFree`, which returns `true` if a particular minute is available to be included in a new appointment and returns `false` if the minute is unavailable.

Consider the following list of unavailable and available minutes in period 2.

Minutes in Period 2	Available?
0–9 (10 minutes)	No
10–14 (5 minutes)	Yes
15–29 (15 minutes)	No
30–44 (15 minutes)	Yes
45–49 (5 minutes)	No
50–59 (10 minutes)	Yes

The method call `findFreeBlock(2, 15)` would return `30` to indicate that a 15-minute block starting with minute `30` is available. No steps should be taken as a result of the call to `findFreeBlock` to mark those 15 minutes as unavailable.

The method call `findFreeBlock(2, 9)` would also return `30`. Whenever there are multiple blocks that satisfy the requirement, the earliest starting minute is returned.

The method call `findFreeBlock(2, 20)` would return `-1`, since no 20-minute block of available minutes exists in period 2.

Complete method `findFreeBlock`. You must use `isMinuteFree` appropriately in order to receive full credit.

```
/**
 *  Searches for the first block of duration free minutes during period, as described in
 *  part (a). Returns the first minute in the block if such a block is found or returns -1 if no
 *  such block is found.
 *  Preconditions: 1 <= period <= 8; 1 <= duration <= 60
 */
public int findFreeBlock(int period, int duration)
```

Begin your response at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number. If there are multiple parts to this question, write the part letter with your response.

(b) Write the `makeAppointment` method, which searches the periods from `startPeriod` to `endPeriod`, inclusive, for the earliest block of `duration` available minutes in the lowest-numbered period. If such a block is found, the `makeAppointment` method calls the helper method `reserveBlock` to mark the minutes in the block as unavailable and returns `true`. If no such block is found, the `makeAppointment` method returns `false`.

Consider the following list of unavailable and available minutes in periods 2, 3, and 4 and three successive calls to `makeAppointment`.

Period	Minutes	Available?
2	0–24 (25 minutes)	No
2	25–29 (5 minutes)	Yes
2	30–59 (30 minutes)	No
3	0–14 (15 minutes)	Yes
3	15–40 (26 minutes)	No
3	41–59 (19 minutes)	Yes
4	0–4 (5 minutes)	No
4	5–29 (25 minutes)	Yes
4	30–43 (14 minutes)	No
4	44–59 (16 minutes)	Yes

The method call `makeAppointment(2, 4, 22)` returns `true` and results in the minutes 5 through 26, inclusive, in period 4 being marked as unavailable.

The method call `makeAppointment(3, 4, 3)` returns `true` and results in the minutes 0 through 2, inclusive, in period 3 being marked as unavailable.

The method call `makeAppointment(2, 4, 30)` returns `false`, since there is no block of 30 available minutes in periods 2, 3, or 4.

The following shows the updated list of unavailable and available minutes in periods 2, 3, and 4 after the three example method calls are complete.

Period	Minutes	Available?
2	0–24 (25 minutes)	No
2	25–29 (5 minutes)	Yes
2	30–59 (30 minutes)	No
3	0–2 (3 minutes)	No
3	3–14 (12 minutes)	Yes
3	15–40 (26 minutes)	No
3	41–59 (19 minutes)	Yes
4	0–26 (27 minutes)	No
4	27–29 (3 minutes)	Yes
4	30–43 (14 minutes)	No
4	44–59 (16 minutes)	Yes

Complete method `makeAppointment`. Assume that `findFreeBlock` works as intended, regardless of what you wrote in part (a). You must use `findFreeBlock` and `reserveBlock` appropriately in order to receive full credit.

```
/**
 *  Searches periods from startPeriod to endPeriod, inclusive, for a block
 *  of duration free minutes, as described in part (b). If such a block is found,
 *  calls reserveBlock to reserve the block of minutes and returns true; otherwise
 *  returns false.
 *  Preconditions: 1 <= startPeriod <= endPeriod <= 8; 1 <= duration <= 60
 */
public boolean makeAppointment(int startPeriod, int endPeriod,
                               int duration)
```

Begin your response at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number. If there are multiple parts to this question, write the part letter with your response.

Class information for this question

```
public class AppointmentBook

private boolean isMinuteFree(int period, int minute)
private void reserveBlock(int period, int startMinute,
   int duration)
public int findFreeBlock(int period, int duration)
public boolean makeAppointment(int startPeriod, int endPeriod,
   int duration)
```

2. The `Book` class is used to store information about a book. A partial `Book` class definition is shown.

```
public class Book
{
   /** The title of the book */
   private String title;

   /** The price of the book */
   private double price;

   /** Creates a new Book with given title and price */
   public Book(String bookTitle, double bookPrice)
   {  /* implementation not shown */  }

   /** Returns the title of the book */
   public String getTitle()
   {  return title;  }

   /** Returns a string containing the title and price of the Book */
   public String getBookInfo()
   {
      return title + "-" + price;
   }

   // There may be instance variables, constructors, and methods that are not shown.
}
```

You will write a class `Textbook`, which is a subclass of `Book`.

A `Textbook` has an edition number, which is a positive integer used to identify different versions of the book. The `getBookInfo` method, when called on a `Textbook`, returns a string that also includes the edition information, as shown in the example.

Information about the book title and price must be maintained in the `Book` class. Information about the edition must be maintained in the `Textbook` class.

The `Textbook` class contains an additional method, `canSubstituteFor`, which returns `true` if a `Textbook` is a valid substitute for another `Textbook` and returns `false` otherwise. The current `Textbook` is a valid substitute for the `Textbook` referenced by the parameter of the `canSubstituteFor` method if the two `Textbook` objects have the same title and if the edition of the current `Textbook` is greater than or equal to the edition of the parameter.

GO ON TO THE NEXT PAGE.

The following table contains a sample code execution sequence and the corresponding results. The code execution sequence appears in a class other than `Book` or `Textbook`.

Statement	Value Returned (blank if no value)	Class Specification
`Textbook bio2015 = new Textbook("Biology", 49.75, 2);`		`bio2015` is a `Textbook` with a title of `"Biology"`, a price of `49.75`, and an edition of `2`.
`Textbook bio2019 = new Textbook("Biology", 39.75, 3);`		`bio2019` is a `Textbook` with a title of `"Biology"`, a price of `39.75`, and an edition of `3`.
`bio2019.getEdition();`	`3`	The edition is returned.
`bio2019.getBookInfo();`	`"Biology-39.75-3"`	The formatted string containing the title, price, and edition of `bio2019` is returned.
`bio2019.canSubstituteFor(bio2015);`	`true`	`bio2019` is a valid substitute for `bio2015`, since their titles are the same and the edition of `bio2019` is greater than or equal to the edition of `bio2015`.
`bio2015.canSubstituteFor(bio2019);`	`false`	`bio2015` is not a valid substitute for `bio2019`, since the edition of `bio2015` is less than the edition of `bio2019`.
`Textbook math = new Textbook("Calculus", 45.25, 1);`		`math` is a `Textbook` with a title of `"Calculus"`, a price of `45.25`, and an edition of `1`.
`bio2015.canSubstituteFor(math);`	`false`	`bio2015` is not a valid substitute for `math`, since the title of `bio2015` is not the same as the title of `math`.

Write the complete `Textbook` class. Your implementation must meet all specifications and conform to the examples shown in the preceding table.

Begin your response at the top of a new page in the Free Response booklet and fill in the appropriate circle indicating the question number.
If there are multiple parts to this question, write the part letter with your response.

GO ON TO THE NEXT PAGE.

1. The `APCalendar` class contains methods used to calculate information about a calendar. You will write two methods of the class.

```
public class APCalendar
{

   /** Returns true if year is a leap year and false otherwise. */
   private static boolean isLeapYear(int year)
   {  /* implementation not shown */  }

   /** Returns the number of leap years between year1 and year2, inclusive.
    *  Precondition: 0 <= year1 <= year2
    */
   public static int numberOfLeapYears(int year1, int year2)
   {  /* to be implemented in part (a) */  }

   /** Returns the value representing the day of the week for the first day of year,
    *  where 0 denotes Sunday, 1 denotes Monday, ..., and 6 denotes Saturday.
    */
   private static int firstDayOfYear(int year)
   {  /* implementation not shown */  }

   /** Returns n, where month, day, and year specify the nth day of the year.
    *  Returns 1 for January 1 (month = 1, day = 1) of any year.
    *  Precondition: The date represented by month, day, year is a valid date.
    */
   private static int dayOfYear(int month, int day, int year)
   {  /* implementation not shown */  }

   /** Returns the value representing the day of the week for the given date
    *  (month, day, year), where 0 denotes Sunday, 1 denotes Monday, ...,
    *  and 6 denotes Saturday.
    *  Precondition: The date represented by month, day, year is a valid date.
    */
   public static int dayOfWeek(int month, int day, int year)
   {  /* to be implemented in part (b) */  }

   // There may be instance variables, constructors, and other methods not shown.

}
```

(a) Write the static method `numberOfLeapYears`, which returns the number of leap years between `year1` and `year2`, inclusive.

In order to calculate this value, a helper method is provided for you.

- `isLeapYear(year)` returns `true` if `year` is a leap year and `false` otherwise.

Complete method `numberOfLeapYears` below. You must use `isLeapYear` appropriately to receive full credit.

```
/** Returns the number of leap years between year1 and year2, inclusive.
 *  Precondition: 0 <= year1 <= year2
 */
public static int numberOfLeapYears(int year1, int year2)
```

(b) Write the static method `dayOfWeek`, which returns the integer value representing the day of the week for the given date (`month`, `day`, `year`), where `0` denotes Sunday, `1` denotes Monday, ..., and `6` denotes Saturday. For example, 2019 began on a Tuesday, and January 5 is the fifth day of 2019. As a result, January 5, 2019, fell on a Saturday, and the method call `dayOfWeek(1, 5, 2019)` returns `6`.

As another example, January 10 is the tenth day of 2019. As a result, January 10, 2019, fell on a Thursday, and the method call `dayOfWeek(1, 10, 2019)` returns `4`.

In order to calculate this value, two helper methods are provided for you.

- `firstDayOfYear(year)` returns the integer value representing the day of the week for the first day of `year`, where `0` denotes Sunday, `1` denotes Monday, ..., and `6` denotes Saturday. For example, since 2019 began on a Tuesday, `firstDayOfYear(2019)` returns `2`.
- `dayOfYear(month, day, year)` returns *n*, where `month`, `day`, and `year` specify the *n*th day of the year. For the first day of the year, January 1 (`month = 1, day = 1`), the value `1` is returned. This method accounts for whether `year` is a leap year. For example, `dayOfYear(3, 1, 2017)` returns `60`, since 2017 is not a leap year, while `dayOfYear(3, 1, 2016)` returns `61`, since 2016 is a leap year.

Class information for this question

```
public class APCalendar

private static boolean isLeapYear(int year)
public static int numberOfLeapYears(int year1, int year2)
private static int firstDayOfYear(int year)
private static int dayOfYear(int month, int day, int year)
public static int dayOfWeek(int month, int day, int year)
```

Complete method `dayOfWeek` below. You must use `firstDayOfYear` and `dayOfYear` appropriately to receive full credit.

```
/** Returns the value representing the day of the week for the given date
 *  (month, day, year), where 0 denotes Sunday, 1 denotes Monday, ...,
 *  and 6 denotes Saturday.
 *  Precondition: The date represented by month, day, year is a valid date.
 */
public static int dayOfWeek(int month, int day, int year)
```

2. This question involves the design of a class that will be used to produce practice problems. The following `StudyPractice` interface represents practice problems that can be used to study some subject.

```
public interface StudyPractice
{
    /** Returns the current practice problem. */
    String getProblem();

    /** Changes to the next practice problem. */
    void nextProblem();
}
```

The `MultPractice` class is a `StudyPractice` that produces multiplication practice problems. A `MultPractice` object is constructed with two integer values: *first integer* and *initial second integer*. The first integer is a value that remains constant and is used as the first integer in every practice problem. The initial second integer is used as the starting value for the second integer in the practice problems. This second value is incremented for each additional practice problem that is produced by the class.

For example, a `MultPractice` object created with the call `new MultPractice(7, 3)` would be used to create the practice problems `"7 TIMES 3"`, `"7 TIMES 4"`, `"7 TIMES 5"`, and so on.

In the `MultPractice` class, the `getProblem` method returns a string in the format of `"`*first integer* `TIMES` *second integer*`"`. The `nextProblem` method updates the state of the `MultPractice` object to represent the next practice problem.

The following examples illustrate the behavior of the `MultPractice` class. Each table shows a code segment and the output that would be produced as the code is executed.

Example 1

Code segment	Output produced
`StudyPractice p1 = new MultPractice(7, 3);` `System.out.println(p1.getProblem());`	`7 TIMES 3`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 4`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 5`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 6`

Example 2

Code segment	Output produced
`StudyPractice p2 = new MultPractice(4, 12);`	
`p2.nextProblem();` `System.out.println(p2.getProblem());`	`4 TIMES 13`
`System.out.println(p2.getProblem());`	`4 TIMES 13`

`p2.nextProblem();`
`p2.nextProblem();`
`System.out.println(p2.getProblem());`
	`4 TIMES 15`

`p2.nextProblem();` `System.out.println(p2.getProblem());`	`4 TIMES 16`

Question 2 continues on page 10.

Interface information for this question

```
public interface StudyPractice

String getProblem()
void nextProblem()
```

Write the complete `MultPractice` class. Your implementation must be consistent with the specifications and the given examples.

2. This question involves two classes that are used to process log messages. A list of sample log messages is given below.

```
CLIENT3:security alert – repeated login failures
Webserver:disk offline
SERVER1:file not found
SERVER2:read error on disk DSK1
SERVER1:write error on disk DSK2
Webserver:error on /dev/disk
```

Log messages have the format *machineId*:*description*, where *machineId* identifies the computer and *description* describes the event being logged. Exactly one colon (":") appears in a log message. There are no blanks either immediately before or immediately after the colon.

The following `LogMessage` class is used to represent a log message.

```
public class LogMessage
{
   private String machineId;
   private String description;

   /** Precondition: message is a valid log message. */
   public LogMessage(String message)
   {  /* to be implemented in part (a) */  }

   /** Returns true if the description in this log message properly contains keyword;
    *          false otherwise.
    */
   public boolean containsWord(String keyword)
   {  /* to be implemented in part (b) */  }

   public String getMachineId()
   {  return machineId;  }

   public String getDescription()
   {  return description;  }

   // There may be instance variables, constructors, and methods that are not shown.
}
```

(a) Write the constructor for the `LogMessage` class. It must initialize the private data of the object so that `getMachineId` returns the *machineId* part of the message and `getDescription` returns the *description* part of the message.

Complete the `LogMessage` constructor below.

```
/** Precondition: message is a valid log message. */
public LogMessage(String message)
```

Part (b) begins on page 8.

(b) Write the `LogMessage` method `containsWord`, which returns `true` if the description in the log message *properly contains* a given keyword and returns `false` otherwise.

A description *properly contains* a keyword if all three of the following conditions are true.

- the keyword is a substring of the description;
- the keyword is either at the beginning of the description or it is immediately preceded by a space;
- the keyword is either at the end of the description or it is immediately followed by a space.

The following tables show several examples. The descriptions in the left table properly contain the keyword `"disk"`. The descriptions in the right table do not properly contain the keyword `"disk"`.

Descriptions that properly contain `"disk"`

`"disk"`
`"error on disk"`
`"error on /dev/disk disk"`
`"error on disk DSK1"`

Descriptions that do not properly contain `"disk"`

`"DISK"`
`"error on disk3"`
`"error on /dev/disk"`
`"diskette"`

WRITE YOUR SOLUTION ON THE NEXT PAGE.

Assume that the `LogMessage` constructor works as specified, regardless of what you wrote in part (a).

Complete method `containsWord` below.

```
/** Returns true if the description in this log message properly contains keyword;
 *         false otherwise.
 */
public boolean containsWord(String keyword)
```

Part (c) begins on page 10.

(c) The `SystemLog` class represents a list of `LogMessage` objects and provides a method that removes and returns a list of all log messages (if any) that properly contain a given keyword. The messages in the returned list appear in the same order in which they originally appeared in the system log. If no message properly contains the keyword, an empty list is returned. The declaration of the `SystemLog` class is shown below.

```
public class SystemLog
{
    /** Contains all the entries in this system log.
     *  Guaranteed not to be null and to contain only non-null entries.
     */
    private List<LogMessage> messageList;

    /** Removes from the system log all entries whose descriptions properly contain keyword,
     *  and returns a list (possibly empty) containing the removed entries.
     *  Postcondition:
     *    – Entries in the returned list properly contain keyword and
     *      are in the order in which they appeared in the system log.
     *    – The remaining entries in the system log do not properly contain keyword and
     *      are in their original order.
     *    – The returned list is empty if no messages properly contain keyword.
     */
    public List<LogMessage> removeMessages(String keyword)
    {  /* to be implemented in part (c) */  }

    // There may be instance variables, constructors, and methods that are not shown.
}
```

Write the `SystemLog` method `removeMessages`, which removes from the system log all entries whose descriptions properly contain `keyword` and returns a list of the removed entries in their original order. For example, assume that `theLog` is a `SystemLog` object initially containing six `LogMessage` objects representing the following list of log messages.

```
CLIENT3:security alert – repeated login failures
Webserver:disk offline
SERVER1:file not found
SERVER2:read error on disk DSK1
SERVER1:write error on disk DSK2
Webserver:error on /dev/disk
```

The call `theLog.removeMessages("disk")` would return a list containing the `LogMessage` objects representing the following log messages.

```
Webserver:disk offline
SERVER2:read error on disk DSK1
SERVER1:write error on disk DSK2
```

After the call, `theLog` would contain the following log messages.

```
CLIENT3:security alert – repeated login failures
SERVER1:file not found
Webserver:error on /dev/disk
```

Assume that the `LogMessage` class works as specified, regardless of what you wrote in parts (a) and (b). You must use `containsWord` appropriately to receive full credit.

Complete method `removeMessages` below.

```
/** Removes from the system log all entries whose descriptions properly contain keyword,
 *  and returns a list (possibly empty) containing the removed entries.
 *  Postcondition:
 *    – Entries in the returned list properly contain keyword and
 *      are in the order in which they appeared in the system log.
 *    – The remaining entries in the system log do not properly contain keyword and
 *      are in their original order.
 *    – The returned list is empty if no messages properly contain keyword.
 */
public List<LogMessage> removeMessages(String keyword)
```

4. This question involves the process of taking a list of words, called `wordList`, and producing a formatted string of a specified length. The list `wordList` contains at least two words, consisting of letters only.

   When the formatted string is constructed, spaces are placed in the gaps between words so that as many spaces as possible are evenly distributed to each gap. The equal number of spaces inserted into each gap is referred to as the *basic gap width.* Any *leftover spaces* are inserted one at a time into the gaps from left to right until there are no more leftover spaces.

   The following three examples illustrate these concepts. In each example, the list of words is to be placed into a formatted string of length 20.

   Example 1: `wordList: ["AP", "COMP", "SCI", "ROCKS"]`

   Total number of letters in words: 14
   Number of gaps between words: 3
   Basic gap width: 2
   Leftover spaces: 0

   Formatted string:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
A	P			C	O	M	P			S	C	I			R	O	C	K	S

   Example 2: `wordList: ["GREEN", "EGGS", "AND", "HAM"]`

   Total number of letters in words: 15
   Number of gaps between words: 3
   Basic gap width: 1
   Leftover spaces: 2

   The leftover spaces are inserted one at a time between the words from left to right until there are no more leftover spaces. In this example, the first two gaps get an extra space.

   Formatted string:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
G	R	E	E	N			E	G	G	S			A	N	D		H	A	M

   Example 3: `wordList: ["BEACH", "BALL"]`

   Total number of letters in words: 9
   Number of gaps between words: 1
   Basic gap width: 11
   Leftover spaces: 0

   Formatted string:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
B	E	A	C	H												B	A	L	L

   You will implement three `static` methods in a class named `StringFormatter` that is not shown.

(a) Write the `StringFormatter` method `totalLetters`, which returns the total number of letters in the words in its parameter `wordList`. For example, if the variable `List<String> words` is `["A", "frog", "is"]`, then the call `StringFormatter.totalLetters(words)` returns `7`. You may assume that all words in `wordList` consist of one or more letters.

Complete method `totalLetters` below.

```
/** Returns the total number of letters in wordList.
 *  Precondition: wordList contains at least two words, consisting of letters only.
 */
public static int totalLetters(List<String> wordList)
```

Part (b) begins on page 20.

(b) Write the `StringFormatter` method `basicGapWidth`, which returns the basic gap width as defined earlier.

Class information for this question

```
public class StringFormatter

public static int totalLetters(List<String> wordList)
public static int basicGapWidth(List<String> wordList,
                                int formattedLen)
public static int leftoverSpaces(List<String> wordList,
                                 int formattedLen)
public static String format(List<String> wordList, int formattedLen)
```

WRITE YOUR SOLUTION ON THE NEXT PAGE.

Assume that `totalLetters` works as specified regardless of what you wrote in part (a). You must use `totalLetters` appropriately to receive full credit.

Complete method `basicGapWidth` below.

```
/** Returns the basic gap width when wordList is used to produce
 *  a formatted string of formattedLen characters.
 *  Precondition: wordList contains at least two words, consisting of letters only.
 *                formattedLen is large enough for all the words and gaps.
 */
public static int basicGapWidth(List<String> wordList,
                                int formattedLen)
```

Part (c) begins on page 22.

(c) Write the `StringFormatter` method `format`, which returns the formatted string as defined earlier. The `StringFormatter` class also contains a method called `leftoverSpaces`, which has already been implemented. This method returns the number of leftover spaces as defined earlier and is shown below.

```
/** Returns the number of leftover spaces when wordList is used to produce
 *  a formatted string of formattedLen characters.
 *  Precondition: wordList contains at least two words, consisting of letters only.
 *                formattedLen is large enough for all the words and gaps.
 */
public static int leftoverSpaces(List<String> wordList,
                                 int formattedLen)
{  /* implementation not shown */  }
```

Class information for this question

```
public class StringFormatter

public static int totalLetters(List<String> wordList)
public static int basicGapWidth(List<String> wordList,
                                int formattedLen)
public static int leftoverSpaces(List<String> wordList,
                                 int formattedLen)
public static String format(List<String> wordList, int formattedLen)
```

WRITE YOUR SOLUTION ON THE NEXT PAGE.

Assume that `basicGapWidth` works as specified, regardless of what you wrote in part (b). You must use `basicGapWidth` and `leftoverSpaces` appropriately to receive full credit.

Complete method `format` below.

```
/** Returns a formatted string consisting of the words in wordList separated by spaces.
 *  Precondition: The wordList contains at least two words, consisting of letters only.
 *                formattedLen is large enough for all the words and gaps.
 *  Postcondition: All words in wordList appear in the formatted string.
 *    - The words appear in the same order as in wordList.
 *    - The number of spaces between words is determined by basicGapWidth and the
 *      distribution of leftoverSpaces from left to right, as described in the question.
 */
public static String format(List<String> wordList, int formattedLen)
```

STOP

END OF EXAM

4. This question involves the design of an interface, writing a class that implements the interface, and writing a method that uses the interface.

   (a) A *number group* represents a group of integers defined in some way. It could be empty, or it could contain one or more integers.

   Write an interface named `NumberGroup` that represents a group of integers. The interface should have a single `contains` method that determines if a given integer is in the group. For example, if `group1` is of type `NumberGroup`, and it contains only the two numbers `-5` and `3`, then `group1.contains(-5)` would return `true`, and `group1.contains(2)` would return `false`.

   Write the complete `NumberGroup` interface. It must have exactly one method.

Part (b) begins on page 17.

(b) A *range* represents a number group that contains all (and only) the integers between a minimum value and a maximum value, inclusive.

Write the `Range` class, which is a `NumberGroup`. The `Range` class represents the group of `int` values that range from a given minimum value up through a given maximum value, inclusive. For example, the declaration

```
NumberGroup range1 = new Range(-3, 2);
```

represents the group of integer values -3, -2, -1, 0, 1, 2.

Write the complete `Range` class. Include all necessary instance variables and methods as well as a constructor that takes two `int` parameters. The first parameter represents the minimum value, and the second parameter represents the maximum value of the range. You may assume that the minimum is less than or equal to the maximum.

Part (c) begins on page 18.

(c) The `MultipleGroups` class (not shown) represents a collection of `NumberGroup` objects and is a `NumberGroup`. The `MultipleGroups` class stores the number groups in the instance variable `groupList` (shown below), which is initialized in the constructor.

```
private List<NumberGroup> groupList;
```

Write the `MultipleGroups` method `contains`. The method takes an integer and returns `true` if and only if the integer is contained in one or more of the number groups in `groupList`.

For example, suppose `multiple1` has been declared as an instance of `MultipleGroups` and consists of the three ranges created by the calls `new Range(5, 8)`, `new Range(10, 12)`, and `new Range(1, 6)`. The following table shows the results of several calls to `contains`.

Call	Result
`multiple1.contains(2)`	`true`
`multiple1.contains(9)`	`false`
`multiple1.contains(6)`	`true`

Complete method `contains` below.

```
/** Returns true if at least one of the number groups in this multiple group contains num;
 *          false otherwise.
 */
public boolean contains(int num)
```

STOP

END OF EXAM

AP COMPUTER SCIENCE A • EXERCISE SHEET

3.6 Methods: Passing and Returning References of an Object

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS references 引用

Objective

Build the skills to answer exam questions on **passing and returning references of an object**.

You must be able to:

- understand that object **references** 引用 are passed to and returned from methods
- explain that changing an object through a reference affects the **original** object
- distinguish passing a **primitive value** from passing an object reference

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Passing references

When an object is passed to a method, the method receives a **reference** to it — not a copy. So if the method **changes the object** through that reference, the **original** object changes too.

■ Primitives vs references

A **primitive** (`int`, `double`, `boolean`) is passed **by value** — the method gets a copy, so changing the parameter does **not** affect the original.

2 Practice

2.1 State what a method receives when an object is passed to it. [1]

2.2 State what happens if a method changes an object through its reference. [1]

2.3 State the difference between passing a primitive and passing an object reference. [2]

3 Exam-style questions

3.1 When an object is passed to a method, the method receives [1]

- **A** a full copy of the object
- **B** a reference to the object
- **C** nothing
- **D** the class

3.2 Changing a primitive parameter inside a method [1]

- **A** changes the original value outside
- **B** does not change the original value outside
- **C** is illegal
- **D** deletes the value

3.3 A method sorts an array object passed to it.

(a) State whether the original array is changed. [1]

(b) State what was passed to the method. [1]

(c) State whether an `int` passed the same way would change outside. [1]

Solutions

2.1 a reference to the object.

2.2 the original object is changed too.

2.3 a primitive is passed by value (a copy), so changes do not affect the original; an object reference lets the method change the actual object.

3.1 B.

3.2 B.

3.3 (a) yes. (b) a reference to the array. (c) no.

2. The class `SingleTable` represents a table at a restaurant.

```
public class SingleTable
{
    /** Returns the number of seats at this table. The value is always greater than or equal to 4. */
    public int getNumSeats()
    {  /* implementation not shown */  }

    /** Returns the height of this table in centimeters. */
    public int getHeight()
    {  /* implementation not shown */  }

    /** Returns the quality of the view from this table. */
    public double getViewQuality()
    {  /* implementation not shown */  }

    /** Sets the quality of the view from this table to value. */
    public void setViewQuality(double value)
    {  /* implementation not shown */  }

    // There may be instance variables, constructors, and methods that are not shown.
}
```

At the restaurant, customers can sit at tables that are composed of two single tables pushed together. You will write a class `CombinedTable` to represent the result of combining two `SingleTable` objects, based on the following rules and the examples in the chart that follows.

- A `CombinedTable` can seat a number of customers that is two fewer than the total number of seats in its two `SingleTable` objects (to account for seats lost when the tables are pushed together).
- A `CombinedTable` has a desirability that depends on the views and heights of the two single tables. If the two single tables of a `CombinedTable` object are the same height, the desirability of the `CombinedTable` object is the average of the view qualities of the two single tables.
- If the two single tables of a `CombinedTable` object are not the same height, the desirability of the `CombinedTable` object is 10 units less than the average of the view qualities of the two single tables.

Assume `SingleTable` objects `t1`, `t2`, and `t3` have been created as follows.

- `SingleTable t1` has 4 seats, a view quality of 60.0, and a height of 74 centimeters.
- `SingleTable t2` has 8 seats, a view quality of 70.0, and a height of 74 centimeters.
- `SingleTable t3` has 12 seats, a view quality of 75.0, and a height of 76 centimeters.

The chart contains a sample code execution sequence and the corresponding results.

Statement	Value Returned (blank if no value)	Class Specification
`CombinedTable c1 = new CombinedTable(t1, t2);`		A `CombinedTable` is composed of two `SingleTable` objects.
`c1.canSeat(9);`	`true`	Since its two single tables have a total of 12 seats, `c1` can seat 10 or fewer people.
`c1.canSeat(11);`	`false`	`c1` cannot seat 11 people.
`c1.getDesirability();`	`65.0`	Because `c1`'s two single tables are the same height, its desirability is the average of `60.0` and `70.0`.
`CombinedTable c2 = new CombinedTable(t2, t3);`		A `CombinedTable` is composed of two `SingleTable` objects.
`c2.canSeat(18);`	`true`	Since its two single tables have a total of 20 seats, `c2` can seat 18 or fewer people.
`c2.getDesirability();`	`62.5`	Because `c2`'s two single tables are not the same height, its desirability is 10 units less than the average of `70.0` and `75.0`.
`t2.setViewQuality(80);`		Changing the view quality of one of the tables that makes up `c2` changes the desirability of `c2`, as illustrated in the next line of the chart. Since `setViewQuality` is a `SingleTable` method, you do not need to write it.
`c2.getDesirability();`	`67.5`	Because the view quality of `t2` changed, the desirability of `c2` has also changed.

The last line of the chart illustrates that when the characteristics of a `SingleTable` change, so do those of the `CombinedTable` that contains it.

Write the complete `CombinedTable` class. Your implementation must meet all specifications and conform to the examples shown in the preceding chart.

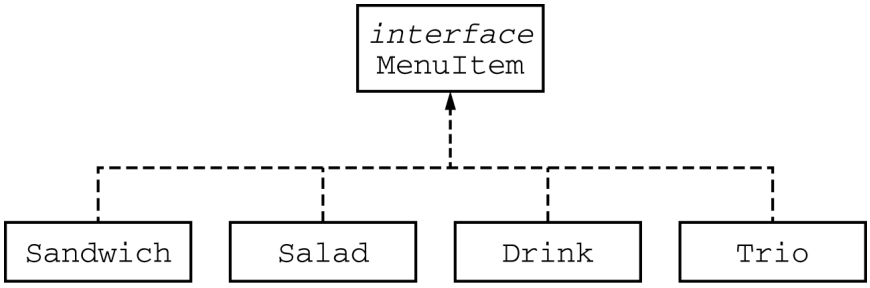
Begin your response at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number. If there are multiple parts to this question, write the part letter with your response.

4. The menu at a lunch counter includes a variety of sandwiches, salads, and drinks. The menu also allows a customer to create a "trio," which consists of three menu items: a sandwich, a salad, and a drink. The price of the trio is the sum of the two highest-priced menu items in the trio; one item with the lowest price is free.

Each menu item has a name and a price. The four types of menu items are represented by the four classes `Sandwich`, `Salad`, `Drink`, and `Trio`. All four classes implement the following `MenuItem` interface.

```
public interface MenuItem
{
  /** @return the name of the menu item */
  String getName();

  /** @return the price of the menu item */
  double getPrice();
}
```

The following diagram shows the relationship between the `MenuItem` interface and the `Sandwich`, `Salad`, `Drink`, and `Trio` classes.



For example, assume that the menu includes the following items. The objects listed under each heading are instances of the class indicated by the heading.

Sandwich	Salad	Drink
"Cheeseburger" 2.75	"Spinach Salad" 1.25	"Orange Soda" 1.25
"Club Sandwich" 2.75	"Coleslaw" 1.25	"Cappuccino" 3.50

Question 4 continues on page 13

The menu allows customers to create `Trio` menu items, each of which includes a sandwich, a salad, and a drink. The name of the `Trio` consists of the names of the sandwich, salad, and drink, in that order, each separated by `"/"` and followed by a space and then `"Trio"`. The price of the `Trio` is the sum of the two highest-priced items in the `Trio`; one item with the lowest price is free.

A trio consisting of a cheeseburger, spinach salad, and an orange soda would have the name `"Cheeseburger/Spinach Salad/Orange Soda Trio"` and a price of $4.00 (the two highest prices are $2.75 and $1.25). Similarly, a trio consisting of a club sandwich, coleslaw, and a cappuccino would have the name `"Club Sandwich/Coleslaw/Cappuccino Trio"` and a price of $6.25 (the two highest prices are $2.75 and $3.50).

Write the `Trio` class that implements the `MenuItem` interface. Your implementation must include a constructor that takes three parameters representing a sandwich, salad, and drink. The following code segment should have the indicated behavior.

```
Sandwich sandwich;
Salad salad;
Drink drink;
/* Code that initializes sandwich, salad, and drink */

Trio trio = new Trio(sandwich, salad, drink);  // Compiles without error

Trio trio1 = new Trio(salad, sandwich, drink); // Compile-time error
Trio trio2 = new Trio(sandwich, salad, salad); // Compile-time error
```

WRITE YOUR SOLUTION ON THE NEXT PAGE.

Write the complete `Trio` class below.

STOP

END OF EXAM

AP COMPUTER SCIENCE A • EXERCISE SHEET

3.7 Class Variables and Methods

Name: _____ Class: _____ Date: _____ **Total: 8 marks**

KEY WORDS static variable 静态变量 • static (class) variable 类变量 • instance variables 实例变量 • constructor 构造函数

Objective

Build the skills to answer exam questions on **class variables and methods**.

You must be able to:

- declare a **static variable** 静态变量 shared by every object of a class
- understand that a static variable belongs to the **class**, not any single object
- write a **static method** that does not act on an individual object's state

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Static (class) variables

A **static variable** is shared by **every** object of the class — there is only **one** copy, belonging to the class itself. It is useful for a shared count or a constant.

■ Static methods

A **static method** belongs to the class and does **not** act on an individual object's state (so it uses no instance variables directly).

2 Practice

2.1 State what a static variable is shared by. [1]

2.2 State whether a static variable belongs to the class or to each object. [1]

2.3 State one use of a static variable. [1]

3 Exam-style questions

3.1 A static variable is [1]

- **A** unique to each object
- **B** shared by all objects of the class
- **C** a local variable
- **D** a parameter

3.2 A static method [1]

- **A** acts on one object's state
- **B** does not act on an individual object
- **C** requires `new`
- **D** is a constructor

3.3 A class counts how many objects have been created, using a shared count.

(a) Name the kind of variable used for the count. [1]

(b) State what it belongs to. [1]

(c) State whether each object has its own copy of it. [1]

Solutions

2.1 every object of the class.

2.2 the class.

2.3 a shared count, or a class constant (any one).

3.1 B.

3.2 B.

3.3 (a) a static variable. (b) the class. (c) no — there is one shared copy.

2. This question involves the implementation of a fitness tracking system that is represented by the `StepTracker` class. A `StepTracker` object is created with a parameter that defines the minimum number of steps that must be taken for a day to be considered *active*.

   The `StepTracker` class provides a constructor and the following methods.

   - `addDailySteps`, which accumulates information about steps, in readings taken once per day
   - `activeDays`, which returns the number of active days
   - `averageSteps`, which returns the average number of steps per day, calculated by dividing the total number of steps taken by the number of days tracked

   The following table contains a sample code execution sequence and the corresponding results.

Statements and Expressions	Value Returned (blank if no value)	Comment
`StepTracker tr = new StepTracker(10000);`		Days with at least 10,000 steps are considered active. Assume that the parameter is positive.
`tr.activeDays();`	`0`	No data have been recorded yet.
`tr.averageSteps();`	`0.0`	When no step data have been recorded, the `averageSteps` method returns `0.0`.
`tr.addDailySteps(9000);`		This is too few steps for the day to be considered active.
`tr.addDailySteps(5000);`		This is too few steps for the day to be considered active.
`tr.activeDays();`	`0`	No day had at least 10,000 steps.
`tr.averageSteps();`	`7000.0`	The average number of steps per day is (14000 / 2).
`tr.addDailySteps(13000);`		This represents an active day.
`tr.activeDays();`	`1`	Of the three days for which step data were entered, one day had at least 10,000 steps.
`tr.averageSteps();`	`9000.0`	The average number of steps per day is (27000 / 3).
`tr.addDailySteps(23000);`		This represents an active day.
`tr.addDailySteps(1111);`		This is too few steps for the day to be considered active.
`tr.activeDays();`	`2`	Of the five days for which step data were entered, two days had at least 10,000 steps.
`tr.averageSteps();`	`10222.2`	The average number of steps per day is (51111 / 5).

Write the complete `StepTracker` class, including the constructor and any required instance variables and methods. Your implementation must meet all specifications and conform to the example.

AP COMPUTER SCIENCE A • EXERCISE SHEET

3.8 Scope and Access

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS local variable 局部变量 • instance variable 实例变量 • scope 作用域

Objective

Build the skills to answer exam questions on **scope and access**.

You must be able to:

- describe the **scope** 作用域 of a variable
- distinguish a **local variable** 局部变量 from an **instance variable** 实例变量
- understand that a local variable exists only while its method runs

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Scope

The **scope** of a variable is the region of code where it can be used.

■ Local vs instance variables

- A **local variable** is declared inside a method and exists **only while that method runs**.
- An **instance variable** belongs to the object and lasts as long as the object exists.

2 Practice

2.1 Define the scope of a variable. [1]

2.2 State the difference between a local variable and an instance variable. [2]

2.3 State how long a local variable exists. [1]

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3 Exam-style questions

3.1 The scope of a variable is [1]

- **A** its value
- **B** the region of code where it can be used
- **C** its type
- **D** its name

3.2 A local variable exists [1]

- **A** forever
- **B** only while its method runs
- **C** in every method
- **D** as a static variable

3.3 A variable is declared inside a method.

(a) Name this kind of variable. [1]

(b) State when it exists. [1]

(c) Name a variable that belongs to the object instead. [1]

Solutions

2.1 the region of code where the variable can be used.

2.2 a local variable is declared in a method and exists only while it runs; an instance variable belongs to the object and lasts as long as the object.

2.3 only while its method is running.

3.1 B.

3.2 B.

3.3 (a) a local variable. (b) only while the method runs. (c) an instance variable.

AP COMPUTER SCIENCE A • EXERCISE SHEET

3.9 this Keyword

Name: _____ Class: _____ Date: _____ **Total: 8 marks**

KEY WORDS constructor 构造函数

Objective

Build the skills to answer exam questions on **the this keyword**.

You must be able to:

- understand that **this** refers to the current object
- use `this` to distinguish an instance variable from a parameter of the same name
- explain how `this` gives a method access to its object

1 Worked examples

Study these first. Each one shows the method for a question type used later.

The `this` keyword

`this` refers to the **current object** — the one the method was called on.

Telling apart same-named variables

When a parameter has the **same name** as an instance variable, `this.` picks out the instance variable:

```
public void setName(String name) {
    this.name = name;   // instance variable = parameter
}
```

Here `this.name` is the object's field and `name` (on the right) is the parameter.

2 Practice

2.1 State what `this` refers to. [1]

2.2 State one use of `this`. [1]

2.3 In `this.age = age;`, state which `age` is the instance variable. [1]

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3 Exam-style questions

3.1 The keyword `this` refers to [1]

- **A** the class
- **B** the current object
- **C** a parameter
- **D** a static variable

3.2 `this` is used to distinguish an instance variable from a [1]

- **A** method
- **B** parameter of the same name
- **C** class
- **D** constructor

3.3 `public void setSpeed(int speed) { this.speed = speed; }`.

(a) State what `this.speed` refers to. [1]

(b) State what `speed` (on the right) refers to. [1]

(c) State what `this` refers to. [1]

Solutions

2.1 the current object.

2.2 to distinguish an instance variable from a same-named parameter.

2.3 `this.age` (the left side).

3.1 B.

3.2 B.

3.3 (a) the instance variable. (b) the parameter. (c) the current object.