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AP<sup>®</sup>

 CollegeBoard

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# AP<sup>®</sup> Computer Science A

## Free-Response Questions

**COMPUTER SCIENCE A**

**SECTION II**

**Time—1 hour and 30 minutes**

**4 Questions**

**Directions: SHOW ALL YOUR WORK. REMEMBER THAT PROGRAM SEGMENTS ARE TO BE WRITTEN IN JAVA.** You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

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.

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1. This question involves simulation of the play and scoring of a single-player video game. In the game, a player attempts to complete three levels. A level in the game is represented by the `Level` class.

```
public class Level
{
    /** Returns true if the player reached the goal on this level and returns false otherwise */
    public boolean goalReached()
    { /* implementation not shown */ }

    /** Returns the number of points (a positive integer) recorded for this level */
    public int getPoints()
    { /* implementation not shown */ }

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

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Play of the game is represented by the `Game` class. You will write two methods of the `Game` class.

```
public class Game
{
    private Level levelOne;
    private Level levelTwo;
    private Level levelThree;

    /** Postcondition: All instance variables have been initialized. */
    public Game()
    { /* implementation not shown */ }

    /** Returns true if this game is a bonus game and returns false otherwise */
    public boolean isBonus()
    { /* implementation not shown */ }

    /** Simulates the play of this Game (consisting of three levels) and updates all relevant
     * game data
     */
    public void play()
    { /* implementation not shown */ }

    /** Returns the score earned in the most recently played game, as described in part (a) */
    public int getScore()
    { /* to be implemented in part (a) */ }

    /** Simulates the play of num games and returns the highest score earned, as
     * described in part (b)
     * Precondition: num > 0
     */
    public int playManyTimes(int num)
    { /* to be implemented in part (b) */ }

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

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- (a) Write the `getScore` method, which returns the score for the most recently played game. Each game consists of three levels. The score for the game is computed using the following helper methods.
- The `isBonus` method of the `Game` class returns `true` if this is a bonus game and returns `false` otherwise.
  - The `goalReached` method of the `Level` class returns `true` if the goal has been reached on a particular level and returns `false` otherwise.
  - The `getPoints` method of the `Level` class returns the number of points recorded on a particular level. Whether or not recorded points are earned (included in the game score) depends on the rules of the game, which follow.

The score for the game is computed according to the following rules.

- Level one points are earned only if the level one goal is reached. Level two points are earned only if both the level one and level two goals are reached. Level three points are earned only if the goals of all three levels are reached.
- The score for the game is the sum of the points earned for levels one, two, and three.
- If the game is a bonus game, the score for the game is tripled.

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The following table shows some examples of game score calculations.

	Level One Results	Level Two Results	Level Three Results	isBonus Return Value	Score Calculation
goalReached Return Value:  getPoints Return Value:	true  200	true  100	true  500	true	$(200 + 100 + 500) \times 3 = 2,400$ The recorded points for levels one, two, and three are earned because the goals were reached in all three levels. The earned points are multiplied by 3 because isBonus returns true.
goalReached Return Value:  getPoints Return Value:	true  200	true  100	false  500	false	$200 + 100 = 300$ The recorded points for level one and level two are earned because the goal was reached in levels one and two. The recorded points for level three are not earned because the goal was not reached in level three.
goalReached Return Value:  getPoints Return Value:	true  200	false  100	true  500	true	$200 \times 3 = 600$ The recorded points for only level one are earned because the goal was not reached in level two. The earned points are multiplied by 3 because isBonus returns true.
goalReached Return Value:  getPoints Return Value:	false  200	true  100	true  500	false	0 Because the goal in level one was not reached, no points are earned for any level.

Complete the `getScore` method.

```
/** Returns the score earned in the most recently played game, as described in part (a) */
public int getScore()
```

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**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.**

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- (b) Write the `playManyTimes` method, which simulates the play of `num` games and returns the highest game score earned. For example, if the four plays of the game that are simulated as a result of the method call `playManyTimes(4)` earn scores of 75, 50, 90, and 20, then the method should return 90.

Play of the game is simulated by calling the helper method `play`. Note that if `play` is called only one time followed by multiple consecutive calls to `getScore`, each call to `getScore` will return the score earned in the single simulated play of the game.

Complete the `playManyTimes` method. Assume that `getScore` works as intended, regardless of what you wrote in part (a). You must call `play` and `getScore` appropriately in order to receive full credit.

```
/** Simulates the play of num games and returns the highest score earned, as
 * described in part (b)
 * Precondition: num > 0
 */
public int playManyTimes(int num)
```

---

**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.**

Class information for this question

```
public class Level
public boolean goalReached()
public int getPoints()

public class Game
private Level levelOne
private Level levelTwo
private Level levelThree

public Game()
public boolean isBonus()
public void play()
public int getScore()
public int playManyTimes(int num)
```

**GO ON TO THE NEXT PAGE.**

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.

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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
<code>Textbook bio2015 = new Textbook("Biology", 49.75, 2);</code>		bio2015 is a <code>Textbook</code> with a title of "Biology", a price of 49.75, and an edition of 2.
<code>Textbook bio2019 = new Textbook("Biology", 39.75, 3);</code>		bio2019 is a <code>Textbook</code> with a title of "Biology", a price of 39.75, and an edition of 3.
<code>bio2019.getEdition();</code>	3	The edition is returned.
<code>bio2019.getBookInfo();</code>	"Biology-39.75-3"	The formatted string containing the title, price, and edition of bio2019 is returned.
<code>bio2019. canSubstituteFor(bio2015);</code>	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.
<code>bio2015. canSubstituteFor(bio2019);</code>	false	bio2015 is not a valid substitute for bio2019, since the edition of bio2015 is less than the edition of bio2019.
<code>Textbook math = new Textbook("Calculus", 45.25, 1);</code>		math is a <code>Textbook</code> with a title of "Calculus", a price of 45.25, and an edition of 1.
<code>bio2015. canSubstituteFor(math);</code>	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.

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**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.**

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3. Users of a website are asked to provide a review of the website at the end of each visit. Each review, represented by an object of the `Review` class, consists of an integer indicating the user's rating of the website and an optional `String` comment field. The comment field in a `Review` object ends with a period (". "), exclamation point ("!"), or letter, or is a `String` of length 0 if the user did not enter a comment.

```
public class Review
{
    private int rating;
    private String comment;

    /** Precondition: r >= 0
     *     c is not null.
     */
    public Review(int r, String c)
    {
        rating = r;
        comment = c;
    }

    public int getRating()
    {
        return rating;
    }

    public String getComment()
    {
        return comment;
    }

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

**GO ON TO THE NEXT PAGE.**

The `ReviewAnalysis` class contains methods used to analyze the reviews provided by users. You will write two methods of the `ReviewAnalysis` class.

```
public class ReviewAnalysis
{
    /** All user reviews to be included in this analysis */
    private Review[] allReviews;

    /** Initializes allReviews to contain all the Review objects to be analyzed */
    public ReviewAnalysis()
    { /* implementation not shown */ }

    /** Returns a double representing the average rating of all the Review objects to be
     * analyzed, as described in part (a)
     * Precondition: allReviews contains at least one Review.
     * No element of allReviews is null.
     */
    public double getAverageRating()
    { /* to be implemented in part (a) */ }

    /** Returns an ArrayList of String objects containing formatted versions of
     * selected user comments, as described in part (b)
     * Precondition: allReviews contains at least one Review.
     * No element of allReviews is null.
     * Postcondition: allReviews is unchanged.
     */
    public ArrayList<String> collectComments()
    { /* to be implemented in part (b) */ }
}
```

**GO ON TO THE NEXT PAGE.**

- (a) Write the `ReviewAnalysis` method `getAverageRating`, which returns the average rating (arithmetic mean) of all elements of `allReviews`. For example, `getAverageRating` would return 3.4 if `allReviews` contained the following `Review` objects.

0	1	2	3	4
4 "Good! Thx"	3 "OK site"	5 "Great!"	2 "Poor! Bad."	3 ""

Complete method `getAverageRating`.

```
/** Returns a double representing the average rating of all the Review objects to be
 * analyzed, as described in part (a)
 * Precondition: allReviews contains at least one Review.
 * No element of allReviews is null.
 */
public double getAverageRating()
```

---

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

Class information for this question

```
public class Review
private int rating
private String comment

public Review(int r, String c)
public int getRating()
public String getComment()

public class ReviewAnalysis
private Review[] allReviews

public ReviewAnalysis()
public double getAverageRating()
public ArrayList<String> collectComments()
```

**GO ON TO THE NEXT PAGE.**

- (b) Write the `ReviewAnalysis` method `collectComments`, which collects and formats only comments that contain an exclamation point. The method returns an `ArrayList` of `String` objects containing copies of user comments from `allReviews` that contain an exclamation point, formatted as follows. An empty `ArrayList` is returned if no comment in `allReviews` contains an exclamation point.
- The `String` inserted into the `ArrayList` to be returned begins with the index of the `Review` in `allReviews`.
  - The index is immediately followed by a hyphen (" - ").
  - The hyphen is followed by a copy of the original comment.
  - The `String` must end with either a period or an exclamation point. If the original comment from `allReviews` does not end in either a period or an exclamation point, a period is added.

The following example of `allReviews` is repeated from part (a).

0	1	2	3	4
4 "Good! Thx"	3 "OK site"	5 "Great!"	2 "Poor! Bad."	3 ""

The following `ArrayList` would be returned by a call to `collectComments` with the given contents of `allReviews`. The reviews at index 1 and index 4 in `allReviews` are not included in the `ArrayList` to return since neither review contains an exclamation point.

"0-Good! Thx."	"2-Great!"	"3-Poor! Bad."
----------------	------------	----------------

Complete method `collectComments`.

```

/** Returns an ArrayList of String objects containing formatted versions of
 * selected user comments, as described in part (b)
 * Precondition: allReviews contains at least one Review.
 * No element of allReviews is null.
 * Postcondition: allReviews is unchanged.
 */
public ArrayList<String> collectComments()

```

**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.**

4. This question involves a two-dimensional array of integers that represents a collection of randomly generated data. A partial declaration of the `Data` class is shown. You will write two methods of the `Data` class.

```
public class Data
{
    public static final int MAX = /* value not shown */;
    private int[][] grid;

    /** Fills all elements of grid with randomly generated values, as described in part (a)
     * Precondition: grid is not null.
     * grid has at least one element.
     */
    public void repopulate()
    { /* to be implemented in part (a) */ }

    /** Returns the number of columns in grid that are in increasing order, as described
     * in part (b)
     * Precondition: grid is not null.
     * grid has at least one element.
     */
    public int countIncreasingCols()
    { /* to be implemented in part (b) */ }

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

**GO ON TO THE NEXT PAGE.**

- (a) Write the `repopulate` method, which assigns a newly generated random value to each element of `grid`. Each value is computed to meet all of the following criteria, and all valid values must have an equal chance of being generated.
- The value is between 1 and `MAX`, inclusive.
  - The value is divisible by 10.
  - The value is not divisible by 100.

Complete the `repopulate` method.

```
/** Fills all elements of grid with randomly generated values, as described in part (a)
 * Precondition: grid is not null.
 *     grid has at least one element.
 */
public void repopulate()
```

---

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

**GO ON TO THE NEXT PAGE.**

- (b) Write the `countIncreasingCols` method, which returns the number of columns in `grid` that are in increasing order. A column is considered to be in increasing order if the element in each row after the first row is greater than or equal to the element in the previous row. A column with only one row is considered to be in increasing order.

The following examples show the `countIncreasingCols` return values for possible contents of `grid`.

The return value for the following contents of `grid` is 1, since the first column is in increasing order but the second and third columns are not.

10	50	40
20	40	20
30	50	30

The return value for the following contents of `grid` is 2, since the first and third columns are in increasing order but the second and fourth columns are not.

10	540	440	440
220	450	440	190

Complete the `countIncreasingCols` method.

```
/** Returns the number of columns in grid that are in increasing order, as described
 *   in part (b)
 *   Precondition: grid is not null.
 *   grid has at least one element.
 */
public int countIncreasingCols()
```

---

**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.**

Class information for this question

```
public class Data
public static final int MAX = /* value not shown */
private int[][] grid
public void repopulate()
public int countIncreasingCols()
```

**GO ON TO THE NEXT PAGE.**

**STOP**

**END OF EXAM**