UNIT 7

ArrayList

2.5–7.5%
AP EXAM WEIGHTING

~10–12
CLASS PERIODS

AP

Remember to go to **AP Classroom** to assign students the online **Personal Progress Check** for this unit.

Whether assigned as homework or completed in class, the **Personal Progress Check** provides each student with immediate feedback related to this unit's topics and skills.

Personal Progress Check 7

Multiple-choice: ~15 questions
Free-response: 1 question

- Array and `ArrayList` (`ArrayList` focus)

ArrayList

← → Developing Understanding

As students learned in Unit 6, data structures are helpful when storing multiple related data values. Arrays have a static size, which causes limitations related to the number of elements stored, and it can be challenging to reorder elements stored in arrays. The `ArrayList` object has a dynamic size, and the class contains methods for insertion and deletion of elements, making reordering and shifting items easier. Deciding which data structure to select becomes increasingly important as the size of the data set grows, such as when using a large real-world data set.

In this unit, students will also learn about privacy concerns related to storing large amounts of personal data and about what can happen if such information is compromised.

BIG IDEA 1
Variables **VAR**

▪ Why is an `ArrayList` more appropriate for storing your music playlist, while an array might be more appropriate for storing your class schedule?

BIG IDEA 2
Control **CON**

▪ How can we use statement execution counts to choose appropriate algorithms?

BIG IDEA 3
Impact of Computing **IOC**

▪ What personal data is currently being collected, and how?

Building Computational Thinking Practices

2.C **2.D** **3.D** **5.C**

Students need to consider the impact using `ArrayList` rather than an array has on the structure of their program code. This includes considering the use of `ArrayList` methods and the flexibility of a structure with a dynamic size. For instance, the use of an `ArrayList` will require students to analyze program code that uses method calls.

Providing students with practice writing programs for data sets of undetermined sized—or at least larger than they would be able to analyze easily by hand—presents a more relevant and realistic experience with data. Additionally, this requires students to focus more on the algorithm and ensuring that it will work in all situations rather than on an individual result.

With larger data sets, programmers become concerned with the amount of time it will take for their program code to run. Students should have practice determining the number of times a code segment executes; this can help them gain an idea of how long it will take to run a program on a data set of a given size.

Preparing for the AP Exam

When writing solutions to free-response questions that involve the use of an `ArrayList`, students are often asked to insert or delete elements from the `ArrayList`. In these cases, adjustments will need to be made to the loop counter to account for skipping an element or attempting to access elements that no longer exist.

Students may also be asked to traverse multiple data structures simultaneously. These data structures may be a mixture of array and `ArrayList` objects. As such, it is very easy for students to become confused about how elements are accessed and manipulated within each structure. Additionally, the size of the data structures may not be the same. In these situations, it is best to have different index variables and bounds checks for each structure to avoid accessing elements that are out-of-bounds.

UNIT
7
ArrayList

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skills	Class Periods ~10–12 CLASS PERIODS
VAR-2	**7.1** Introduction to `ArrayList`	**1.B** Determine code that would be used to complete code segments.	
		3.D Write program code to create, traverse, and manipulate elements in 1D array or `ArrayList` objects.	
	7.2 `ArrayList` Methods	**2.C** Determine the result or output based on the statement execution order in a code segment containing method calls.	
		3.D Write program code to create, traverse, and manipulate elements in 1D array or `ArrayList` objects.	
	7.3 Traversing ArrayLists	**2.C** Determine the result or output based on the statement execution order in a code segment containing method calls.	
		3.D Write program code to create, traverse, and manipulate elements in 1D array or `ArrayList` objects.	
CON-2	**7.4** Developing Algorithms Using ArrayLists	**3.D** Write program code to create, traverse, and manipulate elements in 1D array or `ArrayList` objects.	
		4.A Use test-cases to find errors or validate results.	
	7.5 Searching	**3.D** Write program code to create, traverse, and manipulate elements in 1D array or `ArrayList` objects.	
		5.C Explain how the result of program code changes, given a change to the initial code.	
	7.6 Sorting	**2.D** Determine the number of times a code segment will execute.	
IOC-1	**7.7** Ethical Issues Around Data Collection	Curricular requirement, not assessed on the AP Exam	

AP Go to **AP Classroom** to assign the **Personal Progress Check** for Unit 7.
Review the results in class to identify and address any student misunderstandings.

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional and are offered to provide possible ways to incorporate instructional approaches into the classroom. They were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 159 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	7.2	**Predict and compare** Have students look at the code they wrote to solve the free-response question in Unit 6 (or other code from Unit 6) on paper, and have them rewrite it using an `ArrayList`. Have them highlight the parts that need to be changed and determine how to change them. Then, have students type up the changes in an IDE and confirm that the program still works as expected.
2	7.1–7.5	**Identify a subtask** Have students read through an `ArrayList`-based free-response question in groups, and have them identify all subtasks. These subtasks could be conditional statements, iteration, or even other methods. Once the subtasks have been identified, divide the subtasks among the group members, and have students implement their given subtask. When all students are finished, have them combine the subtasks into a single solution.
3	7.5	**Discussion group** Discuss the algorithm necessary to search for the smallest value in an `ArrayList`. Without explaining what you are doing, change the Boolean expression so that it will find the largest value, and ask students to describe what the resulting algorithm will do. Then, change the algorithm to store and return the location of the largest value, and discuss the change.

✎ Unit Planning Notes

Use the space below to plan your approach to the unit. Consider how you want to pace your course and where you will incorporate writing and analyzing program code that uses real-world data sets.

TOPIC 7.1
Introduction to ArrayList

Required Course Content

ENDURING UNDERSTANDING

VAR-2

To manage large amounts of data or complex relationships in data, programmers write code that groups the data together into a single data structure without creating individual variables for each value.

LEARNING OBJECTIVE

VAR-2.D

Represent collections of related object reference data using `ArrayList` objects.

ESSENTIAL KNOWLEDGE

VAR-2.D.1

An `ArrayList` object is mutable and contains object references.

VAR-2.D.2

The `ArrayList` constructor `ArrayList()` constructs an empty list.

VAR-2.D.3

Java allows the generic type `ArrayList<E>`, where the generic type E specifies the type of the elements.

VAR-2.D.4

When `ArrayList<E>` is specified, the types of the reference parameters and return type when using the methods are type E.

VAR-2.D.5

`ArrayList<E>` is preferred over `ArrayList` because it allows the compiler to find errors that would otherwise be found at run-time.

TOPIC 7.2
ArrayList Methods

Required Course Content

ENDURING UNDERSTANDING

VAR-2

To manage large amounts of data or complex relationships in data, programmers write code that groups the data together into a single data structure without creating individual variables for each value.

LEARNING OBJECTIVE

VAR-2.D

Represent collections of related object reference data using `ArrayList` objects.

ESSENTIAL KNOWLEDGE

VAR-2.D.6

The `ArrayList` class is part of the `java.util` package. An import statement can be used to make this class available for use in the program.

VAR-2.D.7

The following `ArrayList` methods— including what they do and when they are used—are part of the Java Quick Reference:

- `int size()` – Returns the number of elements in the list
- `boolean add(E obj)` – Appends `obj` to end of list; returns `true`
- `void add(int index, E obj)` – Inserts `obj` at position `index` (`0 <= index <= size`), moving elements at position `index` and higher to the right (adds 1 to their indices) and adds 1 to size
- `E get(int index)` – Returns the element at position `index` in the list
- `E set(int index, E obj)` — Replaces the element at position `index` with `obj`; returns the element formerly at position `index`

LEARNING OBJECTIVE

VAR-2.D

Represent collections of related object reference data using `ArrayList` objects.

ESSENTIAL KNOWLEDGE

- `E remove(int index)`—Removes element from position `index`, moving elements at position `index + 1` and higher to the left (subtracts 1 from their indices) and subtracts 1 from size; returns the element formerly at position `index`

TOPIC 7.3
Traversing ArrayLists

Required Course Content

ENDURING UNDERSTANDING

VAR-2

To manage large amounts of data or complex relationships in data, programmers write code that groups the data together into a single data structure without creating individual variables for each value.

LEARNING OBJECTIVE

VAR-2.E

For `ArrayList` objects:
a. Traverse using a `for` or `while` loop
b. Traverse using an enhanced `for` loop

ESSENTIAL KNOWLEDGE

VAR-2.E.1

Iteration statements can be used to access all the elements in an `ArrayList`. This is called traversing the `ArrayList`.

VAR-2.E.2

Deleting elements during a traversal of an `ArrayList` requires using special techniques to avoid skipping elements.

VAR-2.E.3

Since the indices for an `ArrayList` start at 0 and end at the number of elements − 1, accessing an index value outside of this range will result in an `ArrayIndexOutOfBoundsException` being thrown.

VAR-2.E.4

Changing the size of an `ArrayList` while traversing it using an enhanced `for` loop can result in a `ConcurrentModificationException` being thrown. Therefore, when using an enhanced `for` loop to traverse an `ArrayList`, you should not add or remove elements.

SUGGESTED SKILLS

3.D

Write program code to create, traverse, and manipulate elements in 1D array or `ArrayList` objects.

4.A

Use test-cases to find errors or validate results.

AVAILABLE LAB

- Classroom Resources > **AP Computer Science A: Data Lab**

AVAILABLE RESOURCES

- **Runestone Academy: AP CSA—Java Review: 9.13—Removing an Object at an Index**
- **Practice-It!: BJP4 Chapter 10: ArrayLists—Exercises 10.2–10.17**
- The Exam >
  - **2017 AP Computer Science A Exam Free-Response Question 31, Part B (Digits)**
  - Past AP Free-Response Exam Questions on Array/ `ArrayList` on AP Question Bank

TOPIC 7.4

Developing Algorithms Using ArrayLists

Required Course Content

ENDURING UNDERSTANDING

CON-2

Programmers incorporate iteration and selection into code as a way of providing instructions for the computer to process each of the many possible input values.

LEARNING OBJECTIVE

CON-2.J

For algorithms in the context of a particular specification that requires the use of `ArrayList` traversals:

- Identify standard algorithms.
- Modify standard algorithms.
- Develop an algorithm.

ESSENTIAL KNOWLEDGE

CON-2.J.1

There are standard `ArrayList` algorithms that utilize traversals to:

- Insert elements
- Delete elements
- Apply the same standard algorithms that are used with 1D arrays

CON-2.J.2

Some algorithms require multiple `String`, array, or `ArrayList` objects to be traversed simultaneously.

TOPIC 7.5
Searching

Required Course Content

ENDURING UNDERSTANDING

CON-2

Programmers incorporate iteration and selection into code as a way of providing instructions for the computer to process each of the many possible input values.

LEARNING OBJECTIVE

CON-2.K

Apply sequential/linear search algorithms to search for specific information in array or `ArrayList` objects.

ESSENTIAL KNOWLEDGE

CON-2.K.1

There are standard algorithms for searching.

CON-2.K.2

Sequential/linear search algorithms check each element in order until the desired value is found or all elements in the array or `ArrayList` have been checked.

AVAILABLE LAB

- Classroom Resources > **AP Computer Science A: Data Lab**

AVAILABLE RESOURCES

- **Runestone Academy: AP CSA—Java Review: 13—Searching and Sorting**
- **Practice-It!: BJP4 Chapter 13: Searching and Sorting—Self-Check 13.29 and 13.30**
- **Visualgo.net: Sorting**
- **Sorting.at**

TOPIC 7.6
Sorting

Required Course Content

ENDURING UNDERSTANDING

CON-2

Programmers incorporate iteration and selection into code as a way of providing instructions for the computer to process each of the many possible input values.

LEARNING OBJECTIVE

CON-2.L

Apply selection sort and insertion sort algorithms to sort the elements of array or `ArrayList` objects.

ESSENTIAL KNOWLEDGE

CON-2.L.1

Selection sort and insertion sort are iterative sorting algorithms that can be used to sort elements in an array or `ArrayList`.

CON-2.M

Compute statement execution counts and informal run-time comparison of sorting algorithms.

CON-2.M.1

Informal run-time comparisons of program code segments can be made using statement execution counts.

TOPIC 7.7
Ethical Issues Around Data Collection

Required Course Content

ENDURING UNDERSTANDING

`IOC-1`

While programs are typically designed to achieve a specific purpose, they may have unintended consequences.

LEARNING OBJECTIVE

`IOC-1.B`

Explain the risks to privacy from collecting and storing personal data on computer systems.

ESSENTIAL KNOWLEDGE

`IOC-1.B.1`

When using the computer, personal privacy is at risk. Programmers should attempt to safeguard personal privacy.

`IOC-1.B.2`

Computer use and the creation of programs have an impact on personal security. These impacts can be beneficial and/or harmful.

AVAILABLE RESOURCES
- Classroom Resources >
  - **Ethical Use of the Computer**
  - **Ethical Issues: Internet Content Providers and Internet Service Providers**