

Consider a software system that models a horse barn. Classes that represent horses implement the following interface.

```
public interface Horse
{
    /** @return the horse's name */
    String getName();

    /** @return the horse's weight */
    int getWeight();

    // There may be methods that are not shown.
}
```

A horse barn consists of  $N$  numbered spaces. Each space can hold at most one horse. The spaces are indexed starting from 0; the index of the last space is  $N - 1$ . No two horses in the barn have the same name.

The declaration of the `HorseBarn` class is shown below. You will write two unrelated methods of the `HorseBarn` class.

```
public class HorseBarn
{
    /** The spaces in the barn. Each array element holds a reference to the horse
     *   that is currently occupying the space. A null value indicates an empty space.
     */
    private Horse[] spaces;

    /** Returns the index of the space that contains the horse with the specified name.
     *   Precondition: No two horses in the barn have the same name.
     *   @param name the name of the horse to find
     *   @return the index of the space containing the horse with the specified name;
     *           -1 if no horse with the specified name is in the barn.
     */
    public int findHorseSpace(String name)
    { /* to be implemented in part (a) */ }

    /** Consolidates the barn by moving horses so that the horses are in adjacent spaces,
     *   starting at index 0, with no empty space between any two horses.
     *   Postcondition: The order of the horses is the same as before the consolidation.
     */
    public void consolidate()
    { /* to be implemented in part (b) */ }

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

- (a) Write the `HorseBarn` method `findHorseSpace`. This method returns the index of the space in which the horse with the specified name is located. If there is no horse with the specified name in the barn, the method returns -1.

For example, assume a `HorseBarn` object called `sweetHome` has horses in the following spaces.

0	1	2	3	4	5	6
"Trigger" 1340	null	"Silver" 1210	"Lady" 1575	null	"Patches" 1350	"Duke" 1410

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

Method Call	Value Returned	Reason
<code>sweetHome.findHorseSpace("Trigger")</code>	0	A horse named Trigger is in space 0.
<code>sweetHome.findHorseSpace("Silver")</code>	2	A horse named Silver is in space 2.
<code>sweetHome.findHorseSpace("Coco")</code>	-1	A horse named Coco is not in the barn.

Information repeated from the beginning of the question

```
public interface Horse

String getName()
int getWeight()

public class HorseBarn

private Horse[] spaces
public int findHorseSpace(String name)
public void consolidate()
```

Complete method `findHorseSpace` below.

```
/** Returns the index of the space that contains the horse with the specified name.
 * Precondition: No two horses in the barn have the same name.
 * @param name the name of the horse to find
 * @return the index of the space containing the horse with the specified name;
 *         -1 if no horse with the specified name is in the barn.
 */
public int findHorseSpace(String name)
```

- (b) Write the `HorseBarn` method `consolidate`. This method consolidates the barn by moving horses so that the horses are in adjacent spaces, starting at index 0, with no empty spaces between any two horses. After the barn is consolidated, the horses are in the same order as they were before the consolidation.

For example, assume a barn has horses in the following spaces.

0	1	2	3	4	5	6
"Trigger" 1340	null	"Silver" 1210	null	null	"Patches" 1350	"Duke" 1410

The following table shows the arrangement of the horses after `consolidate` is called.

0	1	2	3	4	5	6
"Trigger" 1340	"Silver" 1210	"Patches" 1350	"Duke" 1410	null	null	null

Information repeated from the beginning of the question

```
public interface Horse
```

```
String getName()
```

```
int getWeight()
```

```
public class HorseBarn
```

```
private Horse[] spaces
```

```
public int findHorseSpace(String name)
```

```
public void consolidate()
```

Complete method `consolidate` below.

```
/** Consolidates the barn by moving horses so that the horses are in adjacent spaces,  
 * starting at index 0, with no empty space between any two horses.  
 * Postcondition: The order of the horses is the same as before the consolidation.  
 */  
public void consolidate()
```

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 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.



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)
```

This question involves reasoning about one-dimensional and two-dimensional arrays of integers. You will write three static methods, all of which are in a single enclosing class, named `DiverseArray` (not shown). The first method returns the sum of the values of a one-dimensional array; the second method returns an array that represents the sums of the rows of a two-dimensional array; and the third method analyzes row sums.

- (a) Write a static method `arraySum` that calculates and returns the sum of the entries in a specified one-dimensional array. The following example shows an array `arr1` and the value returned by a call to `arraySum`.

<u>arr1</u>					Value returned by <u>arraySum(arr1)</u>
0	1	2	3	4	
1	3	2	7	3	16

Complete method `arraySum` below.

```
/** Returns the sum of the entries in the one-dimensional array arr.
 */
public static int arraySum(int[] arr)
```

- (b) Write a static method `rowSums` that calculates the sums of each of the rows in a given two-dimensional array and returns these sums in a one-dimensional array. The method has one parameter, a two-dimensional array `arr2D` of `int` values. The array is in row-major order: `arr2D[r][c]` is the entry at row `r` and column `c`. The method returns a one-dimensional array with one entry for each row of `arr2D` such that each entry is the sum of the corresponding row in `arr2D`. As a reminder, each row of a two-dimensional array is a one-dimensional array.

For example, if `mat1` is the array represented by the following table, the call `rowSums(mat1)` returns the array `{16, 32, 28, 20}`.

<u>mat1</u>					
	0	1	2	3	4
0	1	3	2	7	3
1	10	10	4	6	2
2	5	3	5	9	6
3	7	6	4	2	1

Methods written in this question

```
public static int arraySum(int[] arr)
public static int[] rowSums(int[][] arr2D)
public static boolean isDiverse(int[][] arr2D)
```

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

Complete method `rowSums` below.

```
/** Returns a one-dimensional array in which the entry at index k is the sum of
 * the entries of row k of the two-dimensional array arr2D.
 */
public static int[] rowSums(int[][] arr2D)
```

- (c) A two-dimensional array is *diverse* if no two of its rows have entries that sum to the same value. In the following examples, the array `mat1` is diverse because each row sum is different, but the array `mat2` is not diverse because the first and last rows have the same sum.

mat1

	0	1	2	3	4	Row sums
0	1	3	2	7	3	16
1	10	10	4	6	2	32
2	5	3	5	9	6	28
3	7	6	4	2	1	20

mat2

	0	1	2	3	4	Row sums
0	1	1	5	3	4	14
1	12	7	6	1	9	35
2	8	11	10	2	5	36
3	3	2	3	0	6	14

Write a static method `isDiverse` that determines whether or not a given two-dimensional array is diverse. The method has one parameter: a two-dimensional array `arr2D` of `int` values. The method should return `true` if all the row sums in the given array are unique; otherwise, it should return `false`. In the arrays shown above, the call `isDiverse(mat1)` returns `true` and the call `isDiverse(mat2)` returns `false`.

Methods written in this question

```
public static int arraySum(int[] arr)
public static int[] rowSums(int[][] arr2D)
public static boolean isDiverse(int[][] arr2D)
```



Assume that `arraySum` and `rowSums` work as specified, regardless of what you wrote in parts (a) and (b). You must use `rowSums` appropriately to receive full credit.

Complete method `isDiverse` below.

```
/** Returns true if all rows in arr2D have different row sums;
 *     false otherwise.
 */
public static boolean isDiverse(int[][] arr2D)
```