

1 Big-O

1. Consider an algorithm which sorts an array of numbers. Fill in the Big-O running time of each algorithm in the following scenarios:

	Insertion Sort	Selection Sort	MergeSort
Array sorted in ascending order			
Array sorted in descending order (backwards)			

2. Based on the previous question, consider which sorting algorithm choose if you knew your data was mostly sorted already? Which algorithm would you choose if you knew your data was mostly unsorted? Why?
3. If you knew nothing about the dataset (ie: you don't know if the array is mostly sorted or if it's totally unsorted), would you choose to write a Selection Sort or an Insertion Sort? Why?
4. In each situation, when would you choose to use a Binary Search instead of Sequential Search?
 - (a) If you only need to do one search and your data is unsorted, is it better to use Binary or Sequential Search?
 - (b) If you only need to do one search and your data is sorted, is it better to use Binary or Sequential Search?
 - (c) (Bonus) If you need to do a billion searches of your very large unsorted dataset, would it be better to do a billion Sequential Searches, or sort via MergeSort and then perform a billion Binary Searches?

2 Misc. Programming Questions

5. Write a program that reverses a String, *str*, and prints the result to the console:
 - (a) Using a loop.
 - (b) Using recursion.
6. Write a program that, given an array of Strings, does two passes of printing all of the strings (IE: if there are six strings, it will print all six strings once, and then print them all again). What is the Big-O running time of your algorithm?
7. Here is an implementation of fibonacci:

```
public int fibonacci(int n){  
    if(n == 0) return 1;  
    if(n == 1) return 1;  
    return fibonacci(n - 1) + fibonacci(n - 2);  
}
```

- (a) The running time of this algorithm is $O(2^n)$. Is that *better* or *worse* than an algorithm that runs in $O(n^2)$? Is $O(2^n)$ *better* or *worse* than an algorithm that runs in $O(n)$? How about one that runs in $O(\log_2(n))$ time? Rank them, from *fastest* to *slowest*:

-
- (b) Write a program that computes fibonacci of a given n , but without recursion:

```
public int fibonacci(int n){
```

```
}
```

- (c) What's the running time of the algorithm you wrote?

3 Object Oriented Programming

8. In this question, you will develop a class called *Racecar*. A Racecar has a fuel tank, which holds up to *capacity* gallons of gas. Racecars can accelerate if there is at least one gallon of gas in the tank, but this will consume a full gallon of gas, speeding the vehicle up by 10MPH. Your class should track the current speed, number of gallons of gas remaining in the tank, and the full capacity of the tank. With this information in mind, fill in the following class:

```
class Racecar{
    // Fields go here

    // In the beginning, the car has a full tank of gas and is going 0 MPH.
    public Racecar(int capacity){

    }

    // Gets the current speed of the car
    public int getCurrentSpeed(){

    }

    // Attempts to accelerate the car.
    // If there isn't enough fuel, this function should return false
    // If there is enough fuel, you should decrease the amount of fuel by 1 and increase the
    // speed by 10.
    public boolean accelerate(){

    }

    // This function should return true if the car is out of fuel, and false otherwise.
    public boolean isOutOfFuel(){

    }

    // This function is meant to refuel the car.
    // Given the costPerGallon, compute and return how much the total bill to refuel the tank
    // is, and then refill the tank to capacity.
    public double refuel(double costPerGallon){
```

```
}  
  
}
```

Consider the following example. Assume each line happens sequentially (ie: the state of the Racecar isn't reset between lines). Write out what will happen with each method call.

- (a) `Racecar r = new Racecar(2);`
- (b) `r.isOutOfFuel();`
- (c) `r.accelerate();`
- (d) `r.refuel(3.10);`
- (e) `r.getCurrentSpeed();`
- (f) `r.accelerate();`
- (g) `r.getCurrentSpeed();`
- (h) `r.accelerate();`
- (i) `r.getCurrentSpeed();`
- (j) `r.accelerate();`
- (k) `r.getCurrentSpeed();`
- (l) `r.isOutOfFuel();`
- (m) `r.refuel(3.20);`

4 String Manipulation

9. Write a program that determines if a String is a palindrome (a palindrome is a word that is the same forwards and backwards, e.g: racecar).
 - (a) Using loops.
 - (b) Using recursion.
10. Write a method that, given, a String *needle* and a String *haystack*, determines whether or not *needle* occurs in *haystack*. As an example, if *haystack* = "Hello World" and *needle* = "lo W", it should return true. If *haystack* = "Hello World!" and *needle* = "World?", it should return false.

```
public static boolean substringExists(String needle, String haystack){
```

11. Write a method, *dollarsToWords*, which accepts an integer argument *dollars* (such that $0 \leq \textit{dollars} \leq 999$, and prints the words that represent this number of dollars. Here are some examples:

dollars	Output
999	Nine hundred ninety nine dollars
84	Eighty four dollars
115	One hundred fifteen dollars
1	One dollar
100	One hundred dollars

Note: This question is more difficult than it may appear on the surface. You may benefit from helper methods.

12. Write a program that reverses a String.
 - (a) Using loops.
 - (b) Using recursion.
13. Write a program that determines if a String contains only digits.
 - (a) Using loops.
 - (b) Using recursion.
14. Write a program that calculates how many vowels are in a String.
 - (a) Using loops.
 - (b) Using recursion.

15. Write a method, *bizarre*, which takes a String *str* as a parameter, and modifies the input string and returns it. The input string will contain words separated by spaces. If the word is of an even length, your resulting string should contain the word, but backwards. If the length is odd, you should add the word to your result as it appears. Here are some examples:

str	result
"the old home"	"the old emoh"
"pig fish dog kitten"	"pig hsif dog nettik"
"hello world"	"hello world"
" "	" "

16. Without using `Integer.parseInt(String)`, write a program that converts a String into an integer. You may assume that the number in the string will actually fit inside of an integer.
Hint: You should use loops and start at the one's place in the String.

5 Arrays and Matrices

17. Consider a 2D array of strings:

```
String[] [] strMatrix = new String[8][8];
```

You are to write a program that fills in each cell in the matrix with a String in the format "row, column". That is, it should look roughly like:

"0, 0"	"0, 1"	"0, 2"	...
"1, 0"	"1, 1"	"1, 2"	...
"2, 0"	"2, 1"	"2, 2"	...
...

18. You are to write a program that iterates through a 2D array in an "S" shape and print each element it encounters. That is, you should go through the first row left→right, the second row right→left, the third row left→right, and so on. That is, if your array looks like:

0	1	2	3
4	5	6	7
8	9	10	11
12	13	14	15

Your program should print: 0 1 2 3 7 6 5 4 8 9 10 11 15 14 13 12.

19. Write a method, *getCol*, which takes a 2-dimensional integer array *arr* and an integer *i*, and returns the *i*th column of *arr*. For example, in the 2D array in the question seen above, and *i* = 2, you should return {2, 6, 10, 14}.
20. Write a program that finds the number of unique numbers in an integer array. As an example, the array {1, 5, 2, 1, 5, 6, 8, 5} should return 3.
21. For each of the following, assume we have declared the following:

```
int[] arr = {1, 2, 3, 18};
int[] arr2 = new int[8];
int[] [] arr3 = { {1, 2}, {3, 4}, {5, 6}, {7, 8}, {9, 10} };
String s = "Hello World";
```

Identify what the result will be, or write *Compile-time* or *Run-time* if there is a Compile-time or Run-time error:

- (a) arr[0];
- (b) arr[arr2.length - 5];
- (c) s.charAt(arr.length);
- (d) s.charAt(arr[3]);
- (e) s.charAt(arr[5]);
- (f) s.charAt(arr[1]);
- (g) arr3[arr.length];
- (h) arr3[arr.length][1];
- (i) arr3.length;

- (j) `arr3[0].length;`
- (k) `arr3[1].length();`
- (l) `s.length;`
- (m) `s.charAt(s.indexOf('H'));`
- (n) `s.charAt(s.indexOf('Q'));`
- (o) `s.indexOf('Q');`
- (p) `arr2[0];`
- (q) `arr2 = arr;`
- (r) `arr[0] = arr3[2][0] + arr3[3][0];`
- (s) `arr[0] = (int) s.charAt(6);`
- (t) `arr[0] = s.charAt(6);`
- (u) `int j = 6.0;`
- (v) `double d = 7;`
- (w) `s += 'q';`
- (x) `(s + "Goodbye!").length();`
- (y) `s == ("Hello " + "World");`
- (z) `s.equals("Hello " + "World");`

6 Programming Project Question

22. In Milestones 2 and 3, we asked you to write a `MovieApp` class that had the following methods:

```
public MovieApp();
public MovieApp(int capacity);
public void addMovie(Movie m);
public boolean removeMovie(Movie m);
public Movie[] getMovies();
public int getNumberOfItems();
public boolean updateRating(Movie m, int ratings);
public void print();
public Movie[] getMoviesByDirector(String director);
public Movie[] getMoviesByYear(int year);
public Movie[] getMoviesWithRatingsGreaterThanOrEqualTo(int ratings);
public Movie searchMovieByName(String name);
public void sortByYear();
public void sortByName();
```

23. Imagine a `MovieApp` now that also tracks how many times you've viewed each `Movie`. To accomplish this, you are to add a private integer array field to your app, which will keep track of how many times a `Movie` at a given index has been viewed. That is, if the `Movie` "The Cat in the Hat" is at index 2 in the `items` array and has been viewed 4 times, `views[2]` should be 4. To implement this, you are to:

- (a) Implement a method, `int getNumberViews(String movieName)`
- (b) Change the method `addMovie(Movie m)` to, when inserting the `Movie m` at position `i`, also set `views[i]` to 0.
- (c) Implement a method, `void watch(String movieName)`, that will increment the number of views the `movieName` has by 1.

Hint: You should use other methods from the `MovieApp` to do some of these tasks, particularly using your search functions.

```
public void addMovie(Movie m){
```

```
}
```

```
// Should return the number of times a movie with the name movieName has been viewed.  
public int getNumberOfViews(String movieName){
```

```
}
```

```
// Should increment the movie that has the name movieName by 1.  
public void watch(String movieName){
```

```
}
```

24. What are the Big-O running times of your algorithms?

addMovie	
watch	
getNumberOfViews	

7 Searching and Sorting

25. Trace a MergeSort of the following dataset, showing the number of comparisons in each pass:

$\{7, 12, 100, 18, 23, 8, 1, 3, 4, 0, 19, 6, 4, 1, 20, 12\}$

26. Trace an Insertion Sort of the following dataset, showing the number of comparisons in each pass:

$\{8, 1, 3, 4, 0, 19\}$

27. Trace a Binary Search of the following dataset, where we are attempting to find the number 8.

$\{1, 3, 5, 6, 12, 19, 20, 25, 28, 33\}$

28. Here is an implementation of binary search. It has a number of bugs. Try to fix them to make the code work correctly.

```
public static int binarySearch(int[] arr, int target){
    double left, right, middle;
    left = 1
    right = arr.length - 1;
    while(left > right){
        middle = (left + right) / 3; // Find the middle index.
        int middleElement = arr[middle];
        if(middleElement == target){
            return middle;
        }else if(middleElement > target){
            left = middle + 1;
        }else if(middleElement < target){
            right = middle;
        }
    }

    return -1;
}
```

To help test your solution, ensure it works on the array: {1, 2, 4, 12, 18, 23, 54, 56, 60, 89, 91, 102, 148, 176, 192} for the targets:

Target	Expected Result
1	0
192	14
56	7
176	13
200	-1
0	-1
24	-1