Discussion 7: Exam Prep

Links to practice exams

https://www.swamiiyer.net/cs210/cs210_written_exam1.pdf

https://www.swamiiyer.net/cs210/cs210_programming_exam1.pdf

We are going to go through the two pdfs and do as many practice problems as we can.

We'll go over how to do them and either you can try and walk me through each one, or you can come up to the board.

Written Section

Problem 1. Consider the following function:

```
public static int mystery(int[][] a) {
    int x = 0;
    for (int i = 0; i < a.length; i++) {
        for (int j = 0; j < a[0].length; j++) {
            x += (i == j) ? a[i][j] * a[i][j] : 0;
        }
    }
    return x;
}
```

What does `mystery(a)` return, where `a = {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}}`?

Ⓐ 126

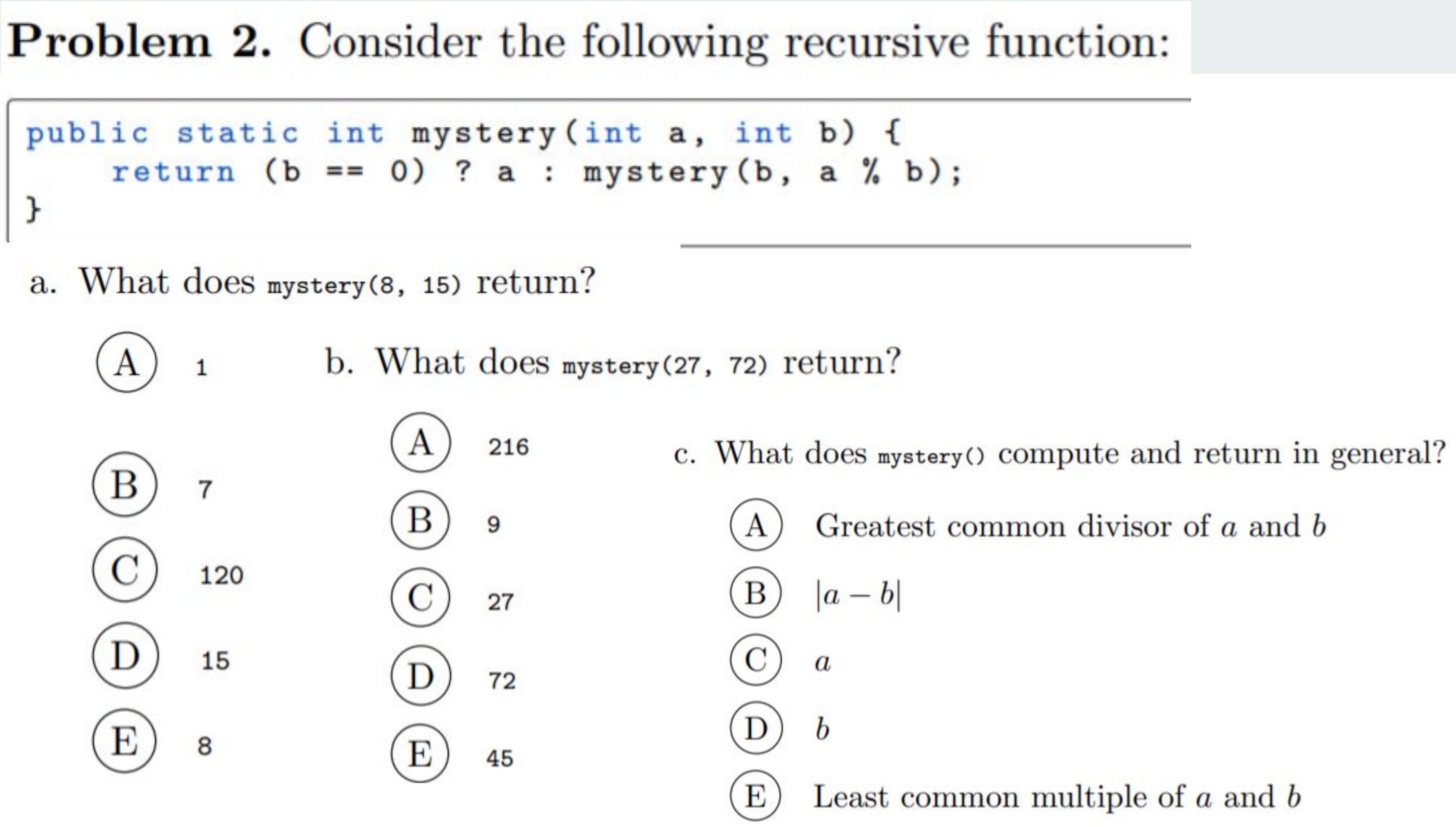
Ⓑ 107

Ⓒ 66

Ⓓ 45

Ⓔ 83

Problem 1. B



Problem 2. Consider the following recursive function:

```java
public static int mystery(int a, int b) {
    return (b == 0) ? a : mystery(b, a % b);
}
```

a. What does `mystery(8, 15)` return?

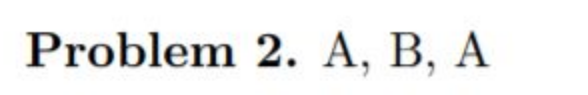
- Ⓐ 1
- Ⓑ 7
- Ⓒ 120
- Ⓓ 15
- Ⓔ 8

b. What does `mystery(27, 72)` return?

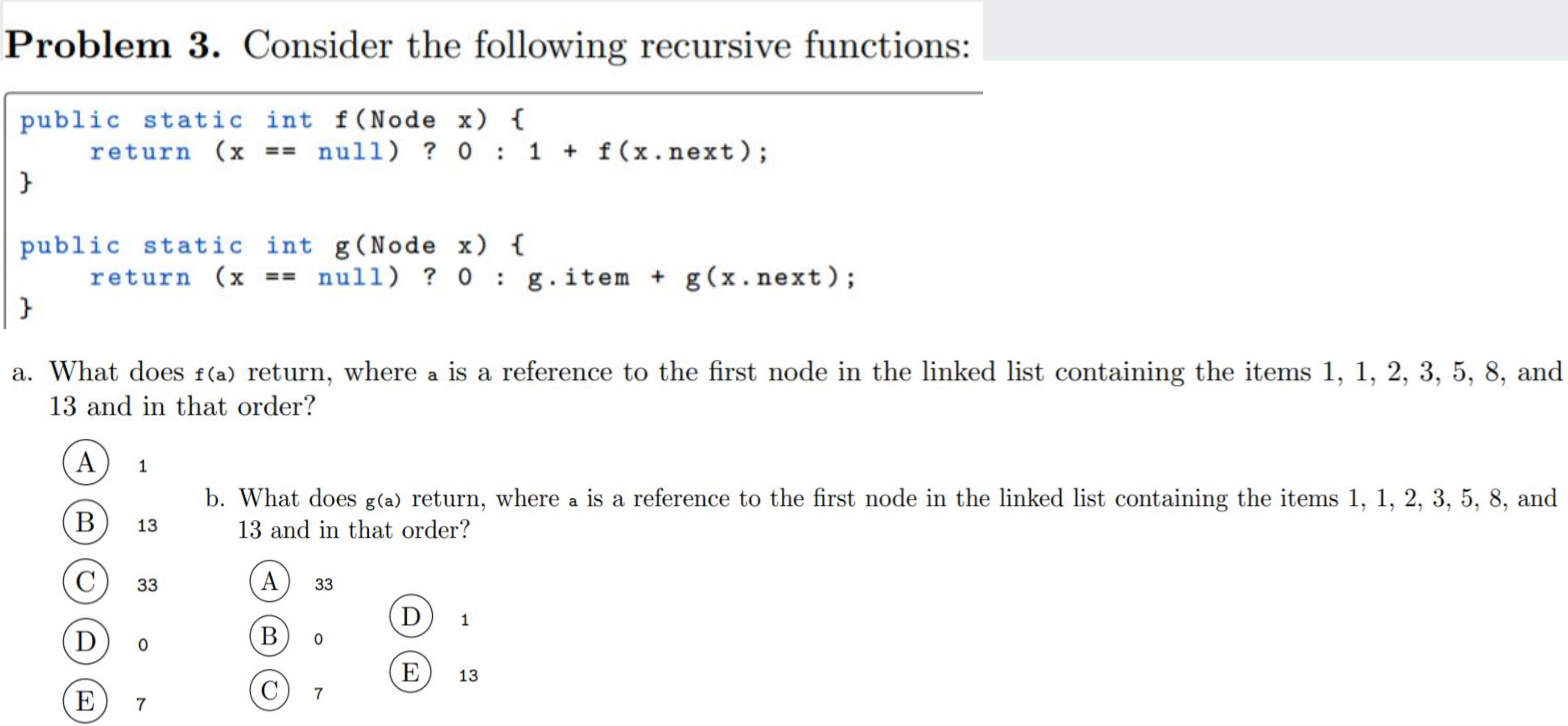
- Ⓐ 216
- Ⓑ 9
- Ⓒ 27
- Ⓓ 72
- Ⓔ 45

c. What does `mystery()` compute and return in general?

- Ⓐ Greatest common divisor of a and b
- Ⓑ $|a - b|$
- Ⓒ a
- Ⓓ b
- Ⓔ Least common multiple of a and b



Problem 2. A, B, A



Problem 3. Consider the following recursive functions:

```
public static int f(Node x) {
    return (x == null) ? 0 : 1 + f(x.next);
}

public static int g(Node x) {
    return (x == null) ? 0 : g.item + g(x.next);
}
```

a. What does `f(a)` return, where `a` is a reference to the first node in the linked list containing the items 1, 1, 2, 3, 5, 8, and 13 and in that order?

Ⓐ 1

Ⓑ 13

Ⓒ 33

Ⓓ 0

Ⓔ 7

b. What does `g(a)` return, where `a` is a reference to the first node in the linked list containing the items 1, 1, 2, 3, 5, 8, and 13 and in that order?

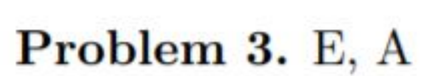
Ⓐ 33

Ⓑ 0

Ⓒ 7

Ⓓ 1

Ⓔ 13



Problem 3. E, A

Problem 4. Consider the following program `Mystery.java`:

```java
public class Mystery {
    public static void main(String[] args) {
        String x = StdIn.readString();
        String y = StdIn.readString();
        StdOut.print(x + y);
        StdOut.print(" ");
        StdOut.print(y + x);
        StdOut.println();
    }
}
```

Next, suppose that the file `input.txt` contains the two strings `AB` and `BA` separated by a space. What does the following command output?

```
$ java Mystery < input.txt | java Mystery | java Mystery
```

(A) `ABBABAABBAABABBABAABABBAABBABAAB BAABABBAABBABAABABBABAABBAABABBA`

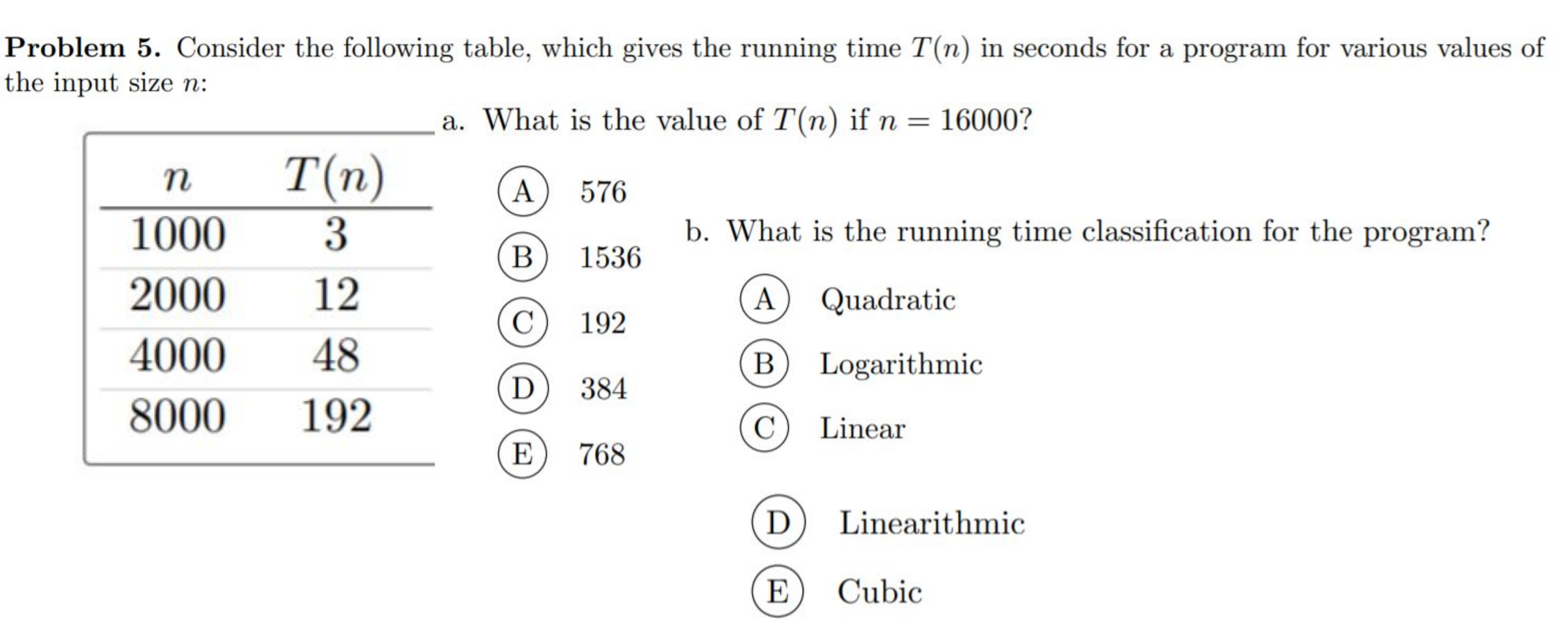
(B) `ABBABAAB BAABABBA`

(C) `AB BA`

(D) `ABBABAABBAABABBA BAABABBAABBABAAB`

(E) `ABBA BAAB`

D



Problem 5. Consider the following table, which gives the running time $T(n)$ in seconds for a program for various values of the input size n:

n	$T(n)$
1000	3
2000	12
4000	48
8000	192

a. What is the value of $T(n)$ if $n = 16000$?

(A) 576

(B) 1536

(C) 192

(D) 384

(E) 768

b. What is the running time classification for the program?

(A) Quadratic

(B) Logarithmic

(C) Linear

(D) Linearithmic

(E) Cubic

E A

Problem 6. What is the running time classification for following code fragment?

```
int sum = 0;
for (int i = 0; i < N; i++) {
    for (int j = 0; j < 100; j++) {
        for (int k = 0; k < 1000; k++) {
            sum++;
        }
    }
}
```

Ⓐ Linearithmic

Ⓑ Cubic

Ⓒ Quadratic

Ⓓ Exponential

Ⓔ Linear

E

Problem 7. Consider a data type `T` with two instance variables: `int x` and `double y`. Ignoring array and object overheads, what is the memory footprint (in bytes) of the array `a[]` created and initialized as follows?

```
T[] a = new T[100];
for (int i = 0; i < 100; i++) {
    T[i] = new T();
}
```

Ⓐ 1200

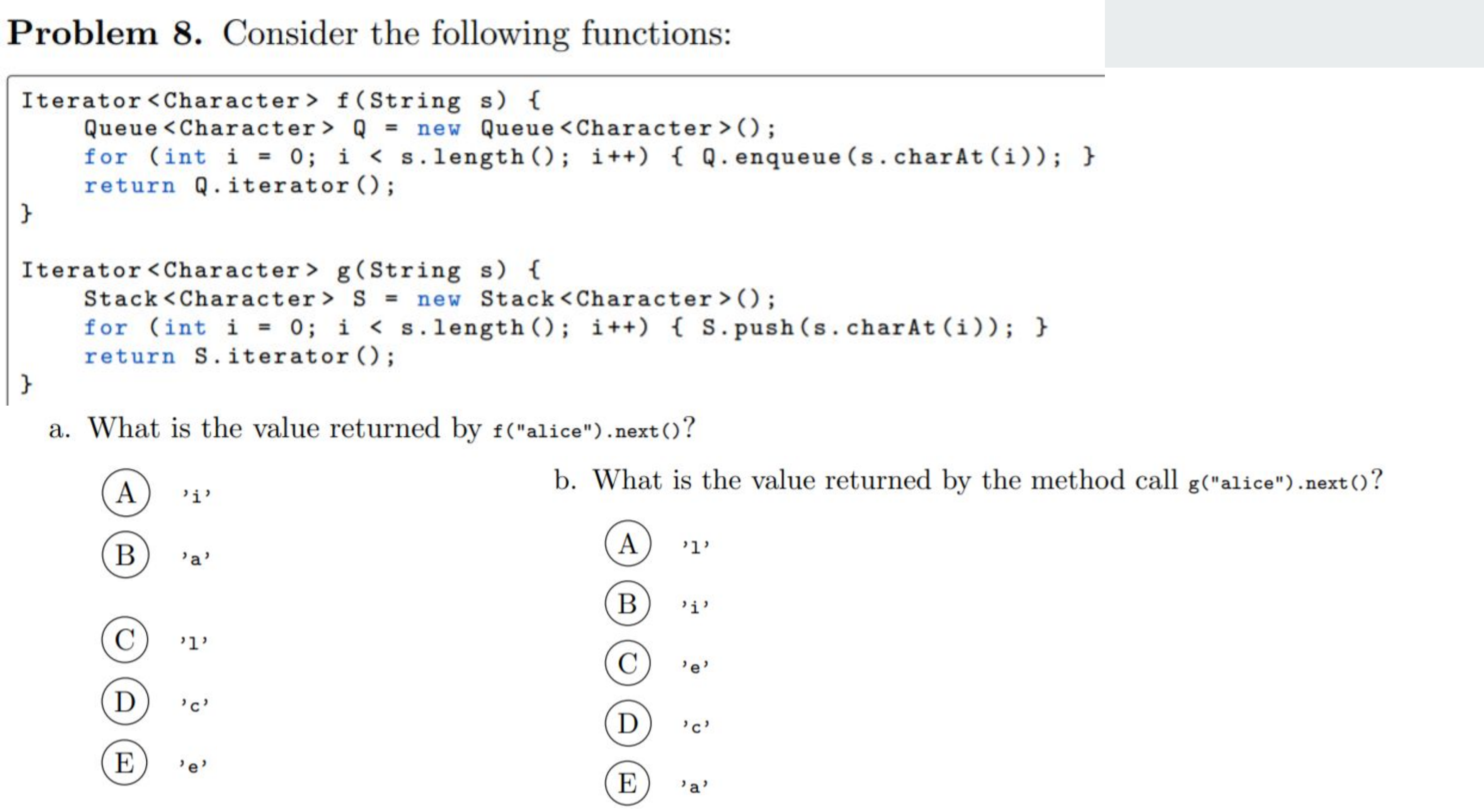
Ⓑ 800

Ⓒ 12

Ⓓ 400

Ⓔ 100

A



Problem 8. Consider the following functions:

```
Iterator<Character> f(String s) {
    Queue<Character> Q = new Queue<Character>();
    for (int i = 0; i < s.length(); i++) { Q.enqueue(s.charAt(i)); }
    return Q.iterator();
}

Iterator<Character> g(String s) {
    Stack<Character> S = new Stack<Character>();
    for (int i = 0; i < s.length(); i++) { S.push(s.charAt(i)); }
    return S.iterator();
}
```

a. What is the value returned by `f("alice").next()`?

Ⓐ ’i’

Ⓑ ’a’

Ⓒ ’l’

Ⓓ ’c’

Ⓔ ’e’

b. What is the value returned by the method call `g("alice").next()`?

Ⓐ ’l’

Ⓑ ’i’

Ⓒ ’e’

Ⓓ ’c’

Ⓔ ’a’

B C

Problem 9. Suppose we use the `QuickUnionUF` data structure to solve the dynamic connectivity problem with 10 sites and input pairs (8, 1), (7, 6), (9, 2), (7, 8), (4, 6), (6, 0), and (4, 1), arriving in that order; the code for the `union()` method in `QuickUnionUF` is shown below.

```
public void union(int p, int q) {
    int rootP = find(p);
    int rootQ = find(q);
    if (rootP == rootQ) {
        return;
    }
    parent[rootP] = rootQ;
    count--;
}
```

a. What are the values in the `parent` array after all the pairs are processed?

(A) `parent = {2, 0, 2, 0, 0, 0, 6, 0, 8, 0}`

(B) `parent = {0, 1, 0, 2, 0, 0, 0, 2, 8, 0}`

(C) `parent = {0, 0, 2, 0, 0, 2, 6, 0, 8, 0}`

(D) `parent = {0, 0, 0, 3, 2, 2, 0, 0, 0, 9}`

2}

b. What is the size of the largest component?

(A) 7

(B) 4

(C) 3

(D) 6

(E) 5

c. What is the identifier of the largest component?

(A) 1

(B) 4

(C) 2

(D) 3

(E) 0

EDE

Problem 10. Consider sorting an array `a[]` containing the following strings, using selection sort (shown below):

```
C   G   H   Y   V   T   S   M   Z   N
```

```java
public static void sort(Comparable[] a) {
    int n = a.length;
    for (int i = 0; i < n; i++) {
        int min = i;
        for (int j = i + 1; j < n; j++) {
            if (less(a[j], a[min])) {
                min = j;
            }
        }
        exchange(a, i, min);
    }
}
```

a. What is the value that `H` is exchanged with?

(A) `N`

(B) `H`

(C) `M`

(D) `S`

(E) `Z`

b. What is the value that `Y` is exchanged with?

(A) `M`

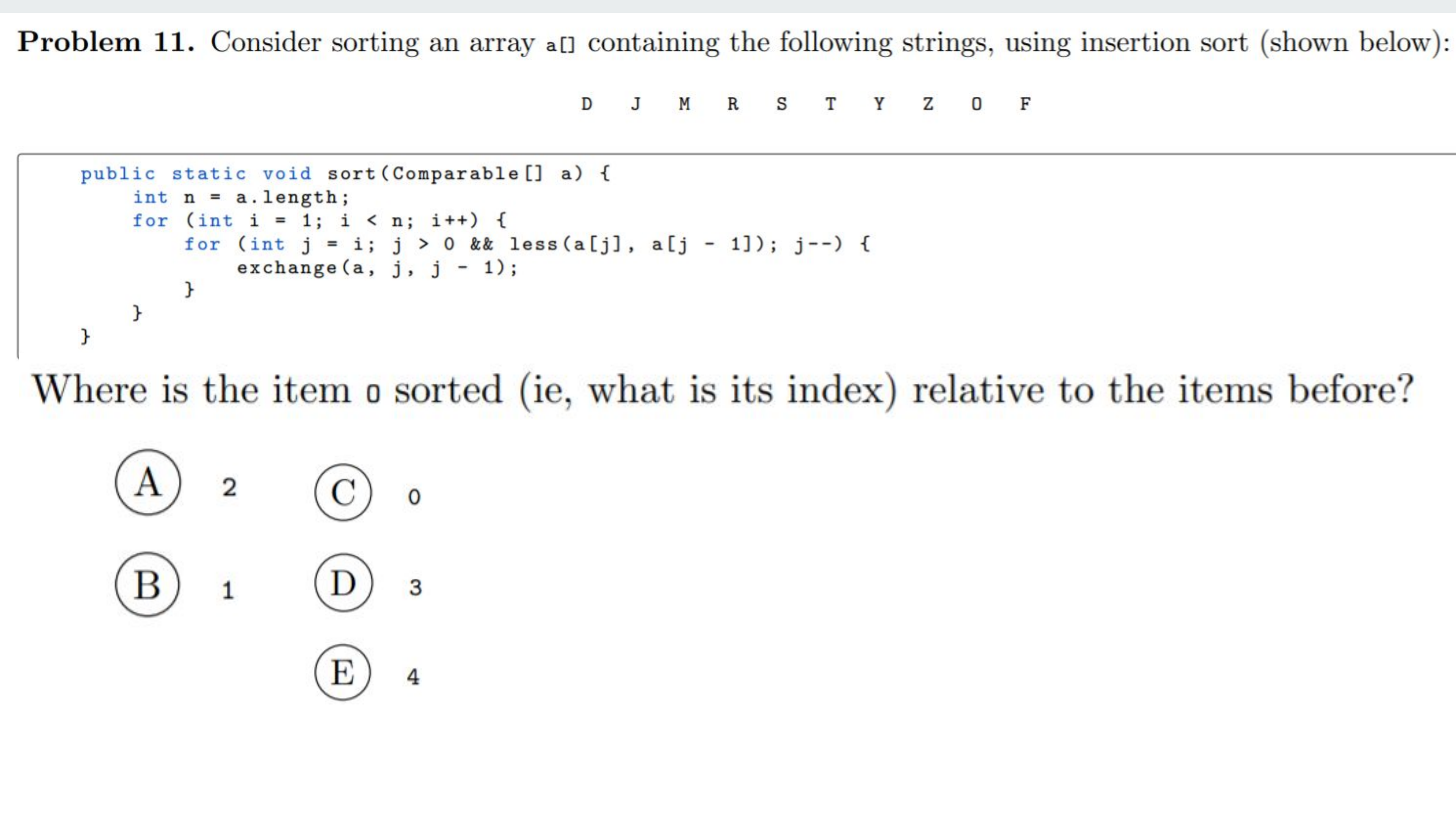
(B) `N`

(C) `H`

(D) `S`

(E) `Z`

B A



Problem 11. Consider sorting an array `a[]` containing the following strings, using insertion sort (shown below):

```
D   J   M   R   S   T   Y   Z   O   F
```

```
    public static void sort(Comparable[] a) {
        int n = a.length;
        for (int i = 1; i < n; i++) {
            for (int j = i; j > 0 && less(a[j], a[j - 1]); j--) {
                exchange(a, j, j - 1);
            }
        }
    }
```

Where is the item `O` sorted (ie, what is its index) relative to the items before?

Ⓐ 2

Ⓑ 1

Ⓒ 0

Ⓓ 3

Ⓔ 4

D

Problem 12. Consider sorting an array `a[]` containing the following strings (already shuffled), using quick sort (shown below):

```
V   U   Z   L   S   Y   R   E   I   J
```

a. What is the destination index of the pivot element after the first call to `partition()`?

(A) 7

(B) 6

(C) 8

(D) 5

(E) 9

b. What is the state of the array `a` after the first call to `partition()`?

(A) `E   J   I   S   R   U   L   V   Y   Z`

(B) `I   E   J   R   U   S   L   V   Z   Y`

(C) `I   S   U   R   J   L   E   V   Y   Z`

(D) `R   L   U   J   E   I   S   V   Z   Y`

(E) `E   U   J   L   S   I   R   V   Y   Z`

c. What is pivot element in the next call to `partition()`?

(A) R

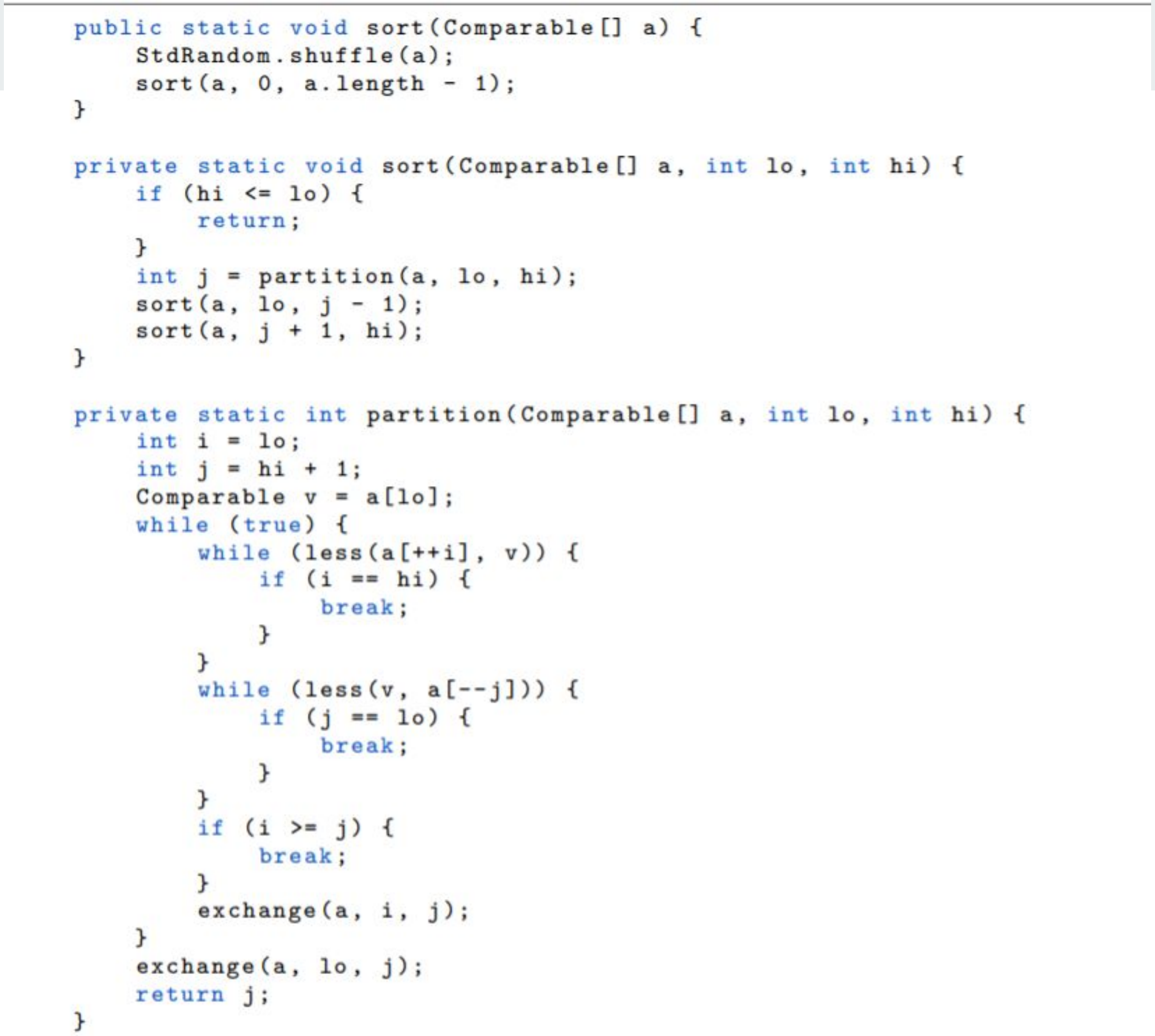
(B) Y

(C) E

(D) Z

(E) I

Quick Sort



```
public static void sort(Comparable[] a) {
    StdRandom.shuffle(a);
    sort(a, 0, a.length - 1);
}

private static void sort(Comparable[] a, int lo, int hi) {
    if (hi <= lo) {
        return;
    }
    int j = partition(a, lo, hi);
    sort(a, lo, j - 1);
    sort(a, j + 1, hi);
}

private static int partition(Comparable[] a, int lo, int hi) {
    int i = lo;
    int j = hi + 1;
    Comparable v = a[lo];
    while (true) {
        while (less(a[++i], v)) {
            if (i == hi) {
                break;
            }
        }
        while (less(v, a[--j])) {
            if (j == lo) {
                break;
            }
        }
        if (i >= j) {
            break;
        }
        exchange(a, i, j);
    }
    exchange(a, lo, j);
    return j;
}
```

AEC

Problem 13. Insert the following keys in that order into a max-heap:

```
B   Z   Q   K   V   F   S   N   I
```

a. What is the index of the key B?

- (A) 5
- (B) 4
- (C) 7
- (D) 6
- (E) 8

b. What is the key with index 6?

- (A) F
- (B) Q
- (C) S
- (D) K
- (E) N

c. If we perform a delMax() operation on the tree, what is the key that will replace the current maximum before it is sunk down?

- (A) F
- (B) I
- (C) Q
- (D) K
- (E) B

EAB

Programming Section

How it'll Work

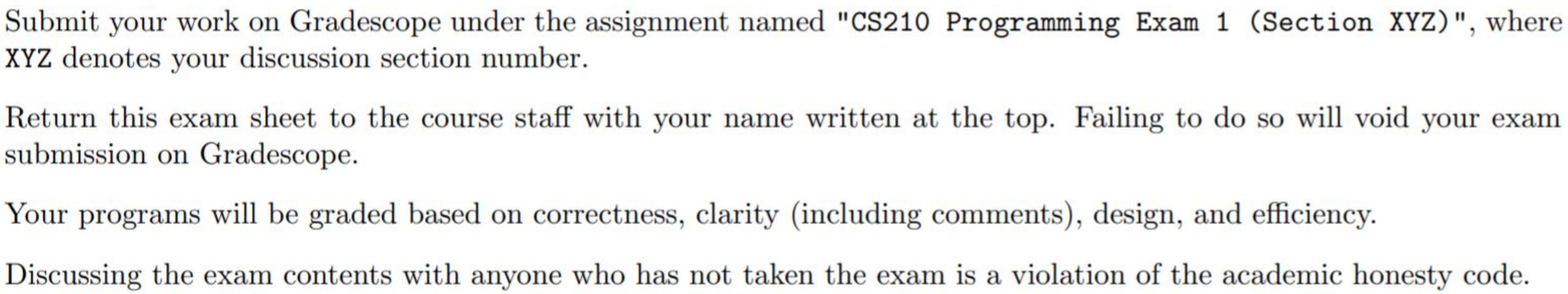
75 Min

When instructed to start, download the following IntelliJ project containing the starter files for the exam problems (use student for username and enigma for password)

:https://www.swamiiyer.net/teaching/restricted/cs210_programming_exam1.zip

Open notes, but no collaboration of any kind

Either Discussion 05 or 06

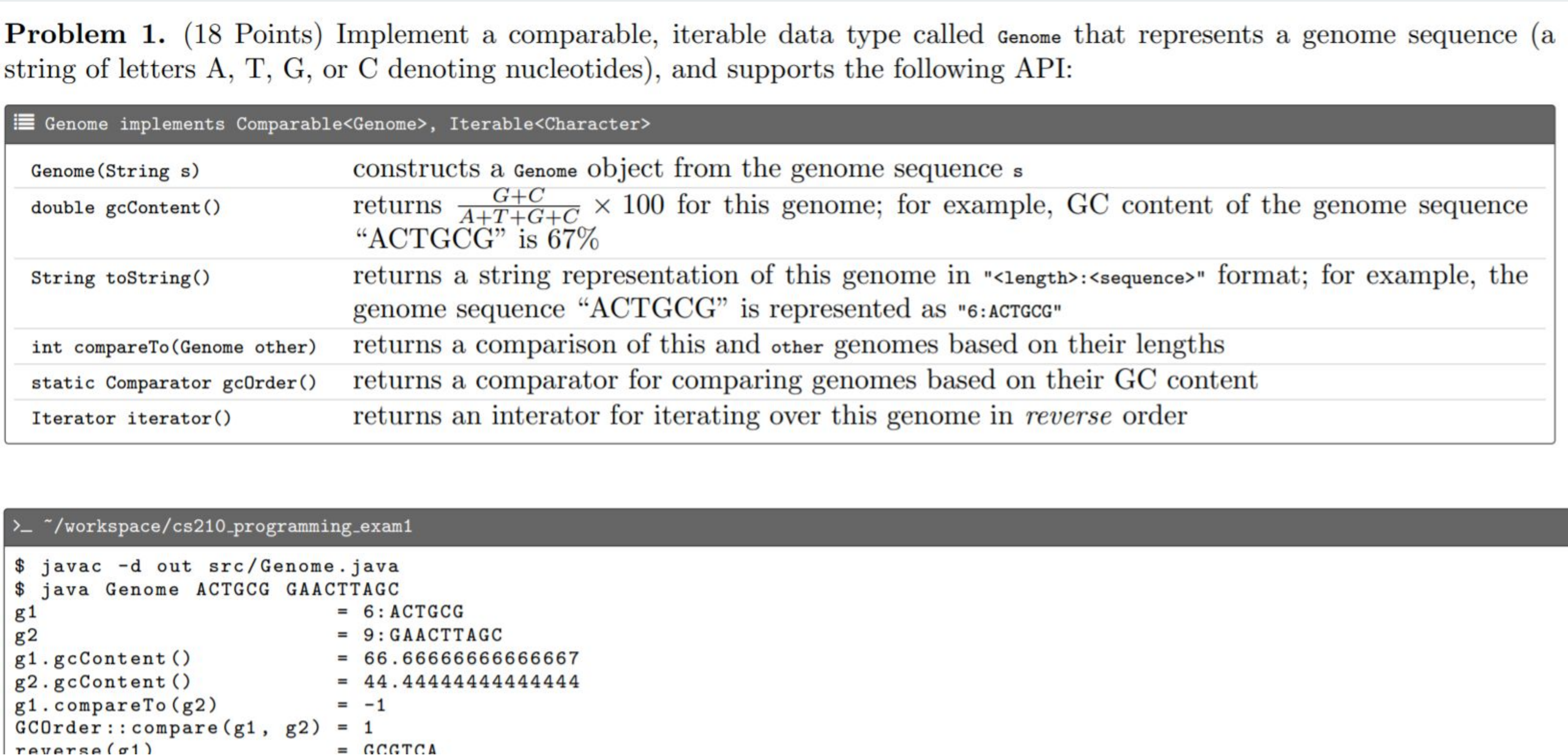


Submit your work on Gradescope under the assignment named `"CS210 Programming Exam 1 (Section XYZ)"`, where `XYZ` denotes your discussion section number.

Return this exam sheet to the course staff with your name written at the top. Failing to do so will void your exam submission on Gradescope.

Your programs will be graded based on correctness, clarity (including comments), design, and efficiency.

Discussing the exam contents with anyone who has not taken the exam is a violation of the academic honesty code.



Problem 1. (18 Points) Implement a comparable, iterable data type called `Genome` that represents a genome sequence (a string of letters A, T, G, or C denoting nucleotides), and supports the following API:

☰ `Genome implements Comparable<Genome>, Iterable<Character>`

`Genome(String s)`	constructs a `Genome` object from the genome sequence `s`
`double gcContent()`	returns $\frac{G+C}{A+T+G+C} \times 100$ for this genome; for example, GC content of the genome sequence “ACTGCG” is 67%
`String toString()`	returns a string representation of this genome in `"<length>:<sequence>"` format; for example, the genome sequence “ACTGCG” is represented as `"6:ACTGCG"`
`int compareTo(Genome other)`	returns a comparison of this and `other` genomes based on their lengths
`static Comparator gcOrder()`	returns a comparator for comparing genomes based on their GC content
`Iterator iterator()`	returns an interator for iterating over this genome in *reverse* order

>_ ~/workspace/cs210_programming_exam1

```
$ javac -d out src/Genome.java
$ java Genome ACTGCG GAACTTAGC
g1                         = 6:ACTGCG
g2                         = 9:GAACTTAGC
g1.gcContent()             = 66.66666666666667
g2.gcContent()             = 44.44444444444444
g1.compareTo(g2)           = -1
GCOrder::compare(g1, g2) = 1
reverse(g1)                = GCGTCA
```

Problem 2. (7 Points) Implement the function `private static void closestPair(int[] a)` in `CloestPair.java` such that it prints the closest pair of integers in `a`, separated by a space.

```
>_ ~/workspace/cs210_programming_exam1
```

```
$ javac -d out src/ClosestPair.java
$ java ClosestPair
4 9 3 -1 6
<ctrl-d>
3 4
```

https://www.swamiiyer.net/cs210/cs210_programming_exam1.pdf

For this section brush up on your previous projects and concepts you used in them

- Comparators
- Iterators
- Data Structures
- Logic
- Java Syntax
- Constructors
- More