COMPUTER SCIENCE A
SECTION II
Time—1 hour and 45 minutes
Number of questions—4
Percent of total grade—50

Directions: SHOW ALL YOUR WORK. REMEMBER THAT PROGRAM SEGMENTS ARE TO BE WRITTEN IN JAVA.

Notes:

- Assume that the classes listed in the Quick Reference found in the Appendix 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 may not receive full credit.

1. A statistician is studying sequences of numbers obtained by repeatedly tossing a six-sided number cube. On each side of the number cube is a single number in the range of 1 to 6, inclusive, and no number is repeated on the cube. The statistician is particularly interested in runs of numbers. A run occurs when two or more consecutive tosses of the cube produce the same value. For example, in the following sequence of cube tosses, there are runs starting at positions 1, 6, 12, and 14.

Index	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Result	1	**5**	**5**	4	3	1	**2**	**2**	**2**	**2**	6	1	**3**	**3**	**5**	**5**	**5**	**5**

The number cube is represented by the following class.

```
public class NumberCube
{
  /** @return an integer value between 1 and 6, inclusive
   */
  public int toss()
  {  /* implementation not shown */  }

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

You will implement a method that collects the results of several tosses of a number cube and another method that calculates the longest run found in a sequence of tosses.

(a) Write the method `getCubeTosses` that takes a number cube and a number of tosses as parameters. The method should return an array of the values produced by tossing the number cube the given number of times.

Complete method `getCubeTosses` below.

```
/** Returns an array of the values obtained by tossing a number cube numTosses times.
 *  @param cube a NumberCube
 *  @param numTosses the number of tosses to be recorded
 *         Precondition: numTosses > 0
 *  @return an array of numTosses values
 */
public static int[] getCubeTosses(NumberCube cube, int numTosses)
```

(b) Write the method `getLongestRun` that takes as its parameter an array of integer values representing a series of number cube tosses. The method returns the starting index in the array of a run of maximum size. A run is defined as the repeated occurrence of the same value in two or more consecutive positions in the array.

For example, the following array contains two runs of length 4, one starting at index 6 and another starting at index 14. The method may return either of those starting indexes.

If there are no runs of any value, the method returns `-1`.

Index	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Result	1	**5**	**5**	4	3	1	**2**	**2**	**2**	**2**	6	1	**3**	**3**	**5**	**5**	**5**	**5**

Complete method `getLongestRun` below.

```
/** Returns the starting index of a longest run of two or more consecutive repeated values
 *  in the array values.
 *  @param values an array of integer values representing a series of number cube tosses
 *         Precondition: values.length > 0
 *  @return the starting index of a run of maximum size;
 *          -1 if there is no run
 */
public static int getLongestRun(int[] values)
```

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3. An electric car that runs on batteries must be periodically recharged for a certain number of hours. The battery technology in the car requires that the charge time not be interrupted.

The cost for charging is based on the hour(s) during which the charging occurs. A rate table lists the 24 one-hour periods, numbered from 0 to 23, and the corresponding hourly cost for each period. The same rate table is used for each day. Each hourly cost is a positive integer. A sample rate table is given below.

Hour	Cost
0	50
1	60
2	160
3	60
4	80
5	100
6	100
7	120

Hour	Cost
8	150
9	150
10	150
11	200
12	40
13	240
14	220
15	220

Hour	Cost
16	200
17	200
18	180
19	180
20	140
21	100
22	80
23	60

The class `BatteryCharger` below uses a rate table to determine the most economic time to charge the battery. You will write two of the methods for the `BatteryCharger` class.

```
public class BatteryCharger
{
  /** rateTable has 24 entries representing the charging costs for hours 0 through 23. */
  private int[] rateTable;

  /** Determines the total cost to charge the battery starting at the beginning of startHour.
   *  @param startHour the hour at which the charge period begins
   *         Precondition: 0 ≤ startHour ≤ 23
   *  @param chargeTime the number of hours the battery needs to be charged
   *         Precondition: chargeTime > 0
   *  @return the total cost to charge the battery
   */
  private int getChargingCost(int startHour, int chargeTime)
  {  /* to be implemented in part (a) */  }

  /** Determines start time to charge the battery at the lowest cost for the given charge time.
   *  @param chargeTime the number of hours the battery needs to be charged
   *         Precondition: chargeTime > 0
   *  @return an optimal start time, with 0 ≤ returned value ≤ 23
   */
  public int getChargeStartTime(int chargeTime)
  {  /* 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 `BatteryCharger` method `getChargingCost` that returns the total cost to charge a battery given the hour at which the charging process will start and the number of hours the battery needs to be charged.

For example, using the rate table given at the beginning of the question, the following table shows the resulting costs of several possible charges.

Start Hour of Charge	Hours of Charge Time	Last Hour of Charge	Total Cost
12	1	12	40
0	2	1	110
22	7	4 (the next day)	550
22	30	3 (two days later)	3,710

Note that a charge period consists of consecutive hours that may extend over more than one day.

Complete method `getChargingCost` below.

```
/** Determines the total cost to charge the battery starting at the beginning of startHour.
 *  @param startHour  the hour at which the charge period begins
 *          Precondition: 0 ≤ startHour ≤ 23
 *  @param chargeTime  the number of hours the battery needs to be charged
 *          Precondition: chargeTime > 0
 *  @return the total cost to charge the battery
 */
private int getChargingCost(int startHour, int chargeTime)
```

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(b) Write the `BatteryCharger` method `getChargeStartTime` that returns the start time that will allow the battery to be charged at minimal cost. If there is more than one possible start time that produces the minimal cost, any of those start times can be returned.

For example, using the rate table given at the beginning of the question, the following table shows the resulting minimal costs and optimal starting hour of several possible charges.

Hours of Charge Time	Minimum Cost	Start Hour of Charge	Last Hour of Charge
1	40	12	12
2	110	0 **or** 23	1 **or** 0 (the next day)
7	550	22	4 (the next day)
30	3,710	22	3 (two days later)

Assume that `getChargingCost` works as specified, regardless of what you wrote in part (a).

Complete method `getChargeStartTime` below.

```
/** Determines start time to charge the battery at the lowest cost for the given charge time.
 *  @param chargeTime the number of hours the battery needs to be charged
 *         Precondition: chargeTime > 0
 *  @return an optimal start time, with 0 ≤ returned value ≤ 23
 */
public int getChargeStartTime(int chargeTime)
```

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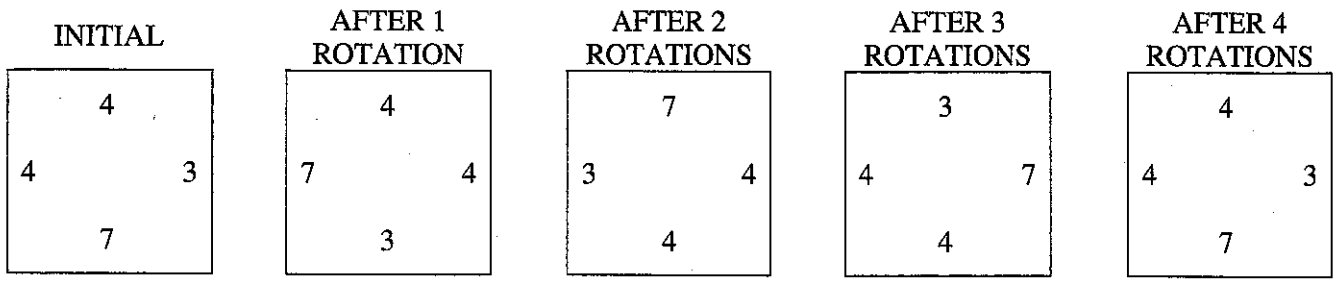
4. A game uses square tiles that have numbers on their sides. Each tile is labeled with a number on each of its four sides and may be rotated clockwise, as illustrated below.



The tiles are represented by the `NumberTile` class, as given below.

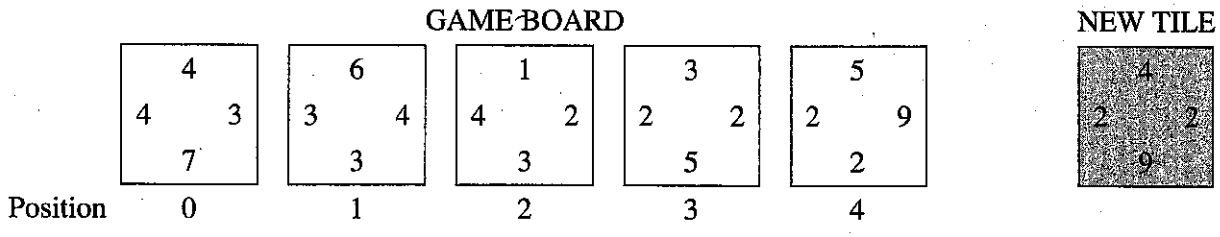
```
public class NumberTile
{
   /** Rotates the tile 90 degrees clockwise
    */
   public void rotate()
   {  /* implementation not shown */  }


   /** @return value at left edge of tile
    */
   public int getLeft()
   {  /* implementation not shown */  }


   /** @return value at right edge of tile
    */
   public int getRight()
   {  /* implementation not shown */  }

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

Tiles are placed on a game board so that the adjoining sides of adjacent tiles have the same number. The following figure illustrates an arrangement of tiles and shows a new tile that is to be placed on the game board.



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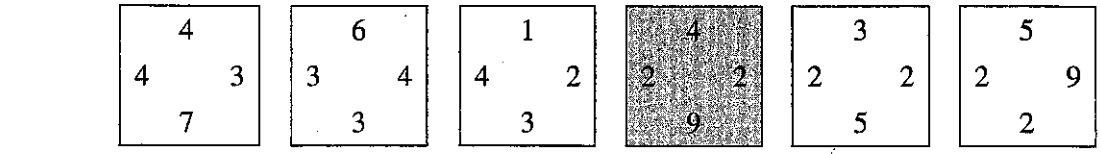
In its original orientation, the new tile can be inserted between the tiles at positions 2 and 3 or between the tiles at positions 3 and 4. If the new tile is rotated once, it can be inserted before the tile at position 0 (the first tile) or after the tile at position 4 (the last tile). Assume that the new tile, in its original orientation, is inserted between the tiles at positions 2 and 3. As a result of the insertion, the tiles at positions 3 and 4 are moved one location to the right, and the new tile is inserted at position 3, as shown below.

GAME BOARD AFTER INSERTING TILE



A partial definition of the `TileGame` class is given below.

```
public class TileGame
{
  /** represents the game board; guaranteed never to be null */
  private ArrayList<NumberTile> board;

  public TileGame()
  { board = new ArrayList<NumberTile>(); }

  /** Determines where to insert tile, in its current orientation, into game board
   *  @param tile the tile to be placed on the game board
   *  @return the position of tile where tile is to be inserted:
   *            0 if the board is empty;
   *           -1 if tile does not fit in front, at end, or between any existing tiles;
   *           otherwise, 0 ≤ position returned ≤ board.size()
   */
  private int getIndexForFit(NumberTile tile)
  {  /* to be implemented in part (a) */  }

  /** Places tile on the game board if it fits (checking all possible tile orientations if necessary).
   *  If there are no tiles on the game board, the tile is placed at position 0.
   *  The tile should be placed at most 1 time.
   *  Precondition: board is not null
   *  @param tile the tile to be placed on the game board
   *  @return true if tile is placed successfully; false otherwise
   *  Postcondition: the orientations of the other tiles on the board are not changed
   *  Postcondition: the order of the other tiles on the board relative to each other is not changed
   */
  public boolean insertTile(NumberTile tile)
  {  /* to be implemented in part (b) */  }

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

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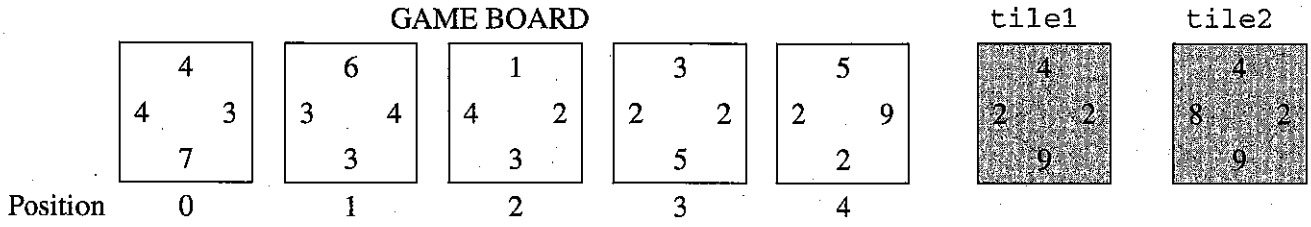
(a) Write the `TileGame` method `getIndexForFit` that determines where a given tile, in its current orientation, fits on the game board. A tile can be inserted at either end of a game board or between two existing tiles if the side(s) of the new tile match the adjacent side(s) of the tile(s) currently on the game board. If there are no tiles on the game board, the position for the insert is 0. The method returns the position that the new tile will occupy on the game board after it has been inserted. If there are multiple possible positions for the tile, the method will return any one of them. If the given tile does not fit anywhere on the game board, the method returns `-1`.

For example, the following diagram shows a game board and two potential tiles to be placed. The call `getIndexForFit(tile1)` can return either 3 or 4 because `tile1` can be inserted between the tiles at positions 2 and 3, or between the tiles at positions 3 and 4. The call `getIndexForFit(tile2)` returns `-1` because `tile2`, in its current orientation, does not fit anywhere on the game board.



Complete method `getIndexForFit` below.

```
/** Determines where to insert tile, in its current orientation, into game board
 *  @param tile the tile to be placed on the game board
 *  @return the position of tile where tile is to be inserted:
 *              0 if the board is empty;
 *             -1 if tile does not fit in front, at end, or between any existing tiles;
 *             otherwise, 0 ≤ position returned ≤ board.size()
 */
private int getIndexForFit(NumberTile tile)
```

(b) Write the `TileGame` method `insertTile` that attempts to insert the given tile on the game board. The method returns `true` if the tile is inserted successfully and `false` only if the tile cannot be placed on the board in any orientation.

Assume that `getIndexForFit` works as specified, regardless of what you wrote in part (a).

Complete method `insertTile` below.

```
/** Places tile on the game board if it fits (checking all possible tile orientations if necessary).
 *  If there are no tiles on the game board, the tile is placed at position 0.
 *  The tile should be placed at most 1 time.
 *  Precondition: board is not null
 *  @param tile the tile to be placed on the game board
 *  @return true if tile is placed successfully; false otherwise
 *  Postcondition: the orientations of the other tiles on the board are not changed
 *  Postcondition: the order of the other tiles on the board relative to each other is not changed
 */
public boolean insertTile(NumberTile tile)
```

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