

## 2016 AP<sup>®</sup> COMPUTER SCIENCE A FREE-RESPONSE QUESTIONS

3. A crossword puzzle grid is a two-dimensional rectangular array of black and white squares. Some of the white squares are labeled with a positive number according to the *crossword labeling rule*.

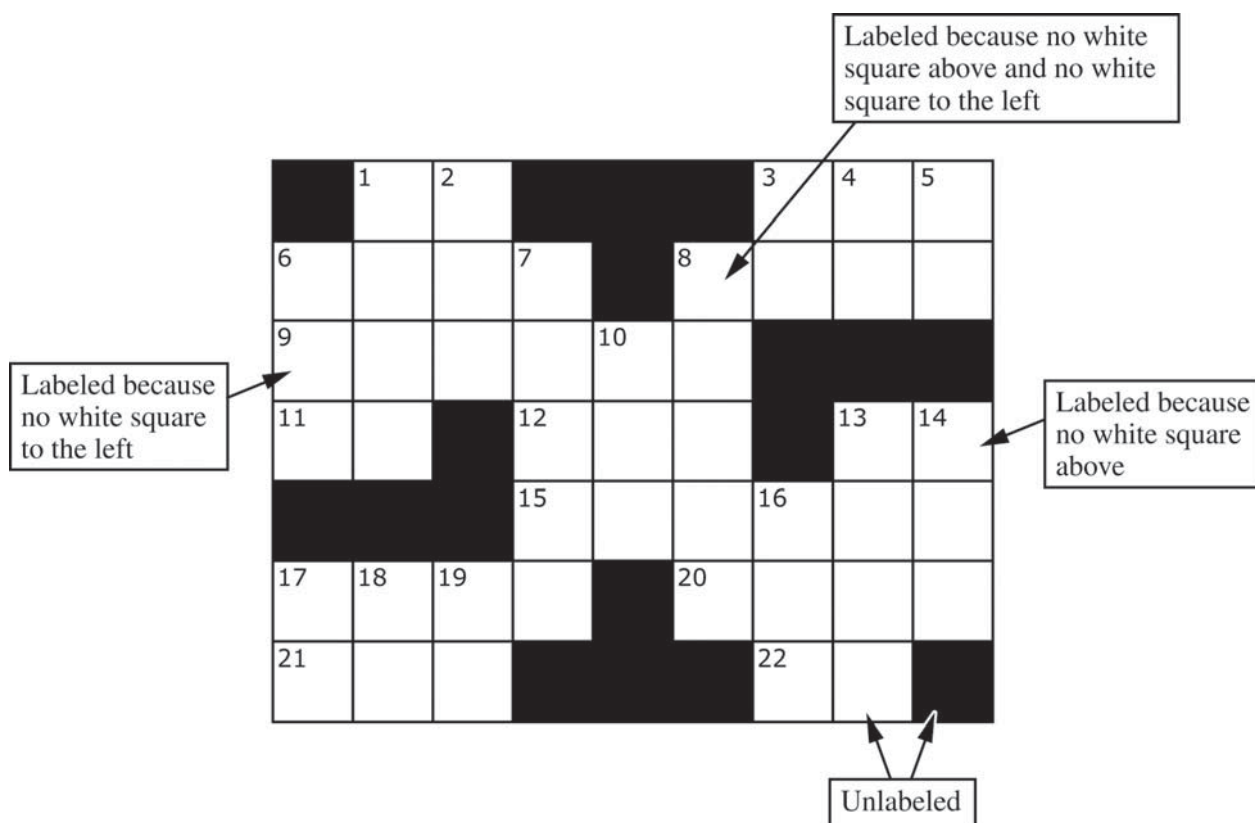
The crossword labeling rule identifies squares to be labeled with a positive number as follows.

A square is labeled with a positive number if and only if

- the square is white and
- the square does not have a white square immediately above it, or it does not have a white square immediately to its left, or both.

The squares identified by these criteria are labeled with consecutive numbers in row-major order, starting at 1.

The following diagram shows a crossword puzzle grid and the labeling of the squares according to the crossword labeling rule.



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This question uses two classes, a `Square` class that represents an individual square in the puzzle and a `Crossword` class that represents a crossword puzzle grid. A partial declaration of the `Square` class is shown below.

```
public class Square
{
    /** Constructs one square of a crossword puzzle grid.
     * Postcondition:
     *     - The square is black if and only if isBlack is true.
     *     - The square has number num.
     */
    public Square(boolean isBlack, int num)
    { /* implementation not shown */ }

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

A partial declaration of the `Crossword` class is shown below. You will implement one method and the constructor in the `Crossword` class.

```
public class Crossword
{
    /** Each element is a Square object with a color (black or white) and a number.
     * puzzle[r][c] represents the square in row r, column c.
     * There is at least one row in the puzzle.
     */
    private Square[][] puzzle;

    /** Constructs a crossword puzzle grid.
     * Precondition: There is at least one row in blackSquares.
     * Postcondition:
     *     - The crossword puzzle grid has the same dimensions as blackSquares.
     *     - The Square object at row r, column c in the crossword puzzle grid is black
     *       if and only if blackSquares[r][c] is true.
     *     - The squares in the puzzle are labeled according to the crossword labeling rule.
     */
    public Crossword(boolean[][] blackSquares)
    { /* to be implemented in part (b) */ }

    /** Returns true if the square at row r, column c should be labeled with a positive number;
     *     false otherwise.
     * The square at row r, column c is black if and only if blackSquares[r][c] is true.
     * Precondition: r and c are valid indexes in blackSquares.
     */
    private boolean toBeLabeled(int r, int c, boolean[][] blackSquares)
    { /* to be implemented in part (a) */ }

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

Part (a) begins on page 14.

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- (a) Write the `Crossword` method `toBeLabeled`. The method returns `true` if the square indexed by row `r`, column `c` in a crossword puzzle grid should be labeled with a positive number according to the crossword labeling rule; otherwise it returns `false`. The parameter `blackSquares` indicates which squares in the crossword puzzle grid are black.

Class information for this question

```
public class Square
```

```
public Square(boolean isBlack, int num)
```

```
public class Crossword
```

```
private Square[][] puzzle
```

```
public Crossword(boolean[][] blackSquares)
```

```
private boolean toBeLabeled(int r, int c, boolean[][] blackSquares)
```

**WRITE YOUR SOLUTION ON THE NEXT PAGE.**

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Complete method `toBeLabeled` below.

```
/** Returns true if the square at row r, column c should be labeled with a positive number;
 *     false otherwise.
 *     The square at row r, column c is black if and only if blackSquares[r][c] is true.
 *     Precondition: r and c are valid indexes in blackSquares.
 */
private boolean toBeLabeled(int r, int c, boolean[][] blackSquares)
```

Part (b) begins on page 16.

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- (b) Write the `Crossword` constructor. The constructor should initialize the crossword puzzle grid to have the same dimensions as the parameter `blackSquares`. Each element of the puzzle grid should be initialized with a reference to a `Square` object with the appropriate color and number. The number is positive if the square is labeled and 0 if the square is not labeled.

Class information for this question

```
public class Square
```

```
public Square(boolean isBlack, int num)
```

```
public class Crossword
```

```
private Square[][] puzzle
```

```
public Crossword(boolean[][] blackSquares)
```

```
private boolean toBeLabeled(int r, int c, boolean[][] blackSquares)
```

**WRITE YOUR SOLUTION ON THE NEXT PAGE.**

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

Complete the `Crossword` constructor below.

```
/** Constructs a crossword puzzle grid.
 * Precondition: There is at least one row in blackSquares.
 * Postcondition:
 *   - The crossword puzzle grid has the same dimensions as blackSquares.
 *   - The Square object at row r, column c in the crossword puzzle grid is black
 *     if and only if blackSquares[r][c] is true.
 *   - The squares in the puzzle are labeled according to the crossword labeling rule.
 */
public Crossword(boolean[][] blackSquares)
```