**Test-Driven Development Kata: Bowling Score Keeper (Version 3)**

The objective is to develop an application that can calculate the score of a single bowling game using TDD. There is no graphical user interface. You work only with objects and JUnit test cases in this assignment. You won’t need a main method.

The application’s requirements are divided into a set of user stories, which serve as your to-do list. You should be able to incrementally develop a complete solution without an upfront comprehension of all the game’s rules. For this exercise, don’t read ahead, and handle the requirements one at a time in the order provided. Solve the problem using TDD, starting with the first story’s requirement. Remember to always lead with a test case, taking hints from the examples provided. Only when a story is done, move on to the next one. A story is done when you are confident your program correctly implements the functionality stipulated by the story’s requirement. This implies *all* of your test cases for that story and *all* of the test cases for the previous stories pass. You may need to tweak your solution as you progress towards more advanced stories.

**1. Frame**

*Each turn of a bowling game is called a* ***frame****. 10 pins are arranged in each frame. The goal of the player is to knock down as many pins as possible in each frame. The player has two chances, or* ***throws****, to do so. The value of a throw is given by the number of pins knocked down in that throw.*

**Story:** As the scorekeeper, I want to be able to record a frame as composed of two throws. The first and second throws should be distinguishable.

**Example:** [2, 4] is a frame with two throws, in which two pins were knocked down in the first throw and four pins were knocked down in the second.

**2. Frame Score**

*An ordinary frame’s score is the sum of its throws.*

**Story:** As the scorekeeper, I want to be able to compute the score of an ordinary frame after a player has rolled both throws.

**Examples:** The score of the frame [2, 6] is 8. The score of the frame [0, 9] is 9.

**3. Game**

*A single game consists of 10 frames.*

**Story:** As the scorekeeper, I want to define a game as a sequence of 10 frames.

**Example:** The sequence of frames [1, 5] [3, 6] [7, 2] [3, 6] [4, 4] [5, 3] [3, 3] [4, 5] [8, 1] [2, 6] represents a game. You may reuse this game from now on to represent and test different scenarios, modifying only a few frames each time.

**4. Partial Game**

*When the player rolls a throw, the throw is automatically recorded in the correct frame.*

**Story:** As the scorekeeper, when the a player rolls throws, I want the game to keep track of the frames and figure out in which frame to place the next throw depending on the past throws. You think this is easy. Maybe for now. We’ll see.

**Example:** If the game currently consists of the frames [1, 5] [3, 6] [7, 2] [3, ?] and the player rolls a throw with a value of 4, the game becomes [1, 5] [3, 6] [7, 2] [3, 4]. Another roll with a value of 5 transforms the game to [1, 5] [3, 6] [7, 2] [3, 4][5, ?].

**5. Game Score**

*The score of a bowling game is the sum of the individual scores of its frames.*

**Story:** As the scorekeeper, I want to know a player’s game’s current score at all times.

**Example:** The score of the game [1, 5] [3, 6] [7, 2] [3, 6] [4, 4] [5, 3] [3, 3] [4, 5] [8, 1] [2, 6] is 81. Partial scores are possible for an incomplete game if the frame scores are known up to the last complete frame. The score of the game [1, 5] [3, 6] [7, ?] is 15. The frame [7, ?] is not yet complete.

**6. Strike**

*A frame is called a* ***strike*** *if all 10 pins are knocked down in the first throw. In this case, there is no second throw. A strike frame can be written as [10, 0]. The score of a strike equals 10 plus the sum of the next two throws of the subsequent frame.*

**Story:** As the scorekeeper, I want to be able to recognize a strike frame, compute its score after the next frame has been completed, and compute the game’s score.

**Examples:** Suppose [10, 0] and [3, 6] are consecutive frames. Then the first frame is a strike and its score equals 10 + 3 + 6 = 19. The game [10, 0] [3, 6] [7, 2] [3, 6] [4, 4] [5, 3] [3, 3] [4, 5] [8, 1] [2, 6] has a score of 94. The partial game [10, 0] [3, 6] has a score of 28.

**7. Spare**

*A frame is called a* ***spare*** *when all 10 pins are knocked down in two throws*. *The score of a spare frame is 10 plus the value of the first throw from the subsequent frame.*

**Story:** As the scorekeeper, I want to be able to recognize a spare frame, compute the score of a game containing a spare frame after the first throw of the next frame has been rolled, and compute the game’s score.

**Examples:** [1, 9], [4, 6], [7, 3] are all spares. If you have two frames [1, 9] and [3, 6] in a row, the spare frame’s score is 10 + 3 = 13. The game [1, 9] [3, 6] [7, 2] [3, 6] [4, 4] [5, 3] [3, 3] [4, 5] [8, 1] [2, 6] has a score of 88. The partial game [1, 9] [3, 6] has a score of 22.

**8. Strike and Spare**

*A strike can be followed by a spare. The strike’s score is not affected when this happens.*

**Story:** As the scorekeeper, I want to make sure that the score of a strike is computed right when it’s followed by a spare.

**Examples:** In the sequence [10, 0] [4, 6] [7, 2], a strike is followed by a spare. In this case, the score of the strike is 10 + 4 + 6 = 20, and the score of the spare is 4 + 6 + 7 = 17. The game [10, 0] [4, 6] [7, 2] [3, 6] [4, 4] [5, 3] [3, 3] [4, 5] [8, 1] [2, 6] has a score of 103.

**9. Multiple Strikes**

*Two strikes in a row are possible. You must take care when this happens for the computation of the first strike’s score requires the values of throws from two subsequent frames.*

**Story:** As the scorekeeper, I want to make sure that I can record two consecutive strikes correctly in the game, and correctly compute the score of the first strike after the next two throws have been rolled.

**Examples:** In the sequence [10, 0] [10, 0] [7, 2], the score of the first strike is 10 + 10 + 7 = 27. The score of the second strike is 10 + 7 + 2 = 19. The game [10, 0] [10, 0] [7, 2] [3, 6] [4, 4] [5, 3] [3, 3] [4, 5] [8, 1] [2, 6] has a score of 112. The score of the partial game [10, 0] [10, 0] [7, ?] is 27 (we can’t yet compute the scores of the last two frames).

**10. Multiple Spares**

*Two spares in a row are possible. The first spare’s score is not affected when this happens.*

**Story:** As the scorekeeper, I want to be able to compute the score of a game with two spares in a row, and the scores of the first spare after the next spare has been completed.

**Example:** The game [8, 2] [5, 5] [7, 2] [3, 6] [4, 4] [5, 3] [3, 3] [4, 5] [8, 1] [2, 6] has a score of 98.

**11. Spare as the Last Frame**

*When a game’s last frame is a spare, the player will be given a bonus throw. However, this bonus throw does not belong to a regular frame. It is only used to calculate the score of the last spare.*

**Story:** As the scorekeeper, I hate it when the last frame is a spare: let the game please figure out that the next roll is a bonus throw and compute the score of the last frame and the whole game based on the value of that bonus throw.

**Example:** The last frame in the game [1, 5] [3, 6] [7, 2] [3, 6] [4, 4] [5, 3] [3, 3] [4, 5] [8, 1] [2, 8] is a spare. If the bonus throw is [7], the last frame has a score of 2 + 8 + 7 = 17. The game has a score of 90.

**12. Strike as the Last Frame**

*When a game’s last frame is a strike, the player will be given two bonus throws. However, these two bonus throws do not belong to a regular frame. They are only used to calculate score of the last strike frame.*

**Story:** As the scorekeeper, I hate it even more when the last frame of a game is a strike: let the game please figure out that the next rolls are bonus throws and compute the score of the last frame and the whole game based on the value of those bonus throws.

**Example:** The last frame in the game [1, 5] [3, 6] [7, 2] [3, 6] [4, 4] [5, 3] [3, 3] [4, 5] [8, 1] [10, 0] is a strike. If the bonus throws are [7, 2], the last frame’s score is 10 + 7 + 2 = 19. The game’s score is 92.

**13. Bonus is a Strike**

*Further bonus throws are not granted when a game’s last frame is a spare and the bonus throw is a strike.*

**Story:** As the scorekeeper, I hate it most when the last frame is spare and the bonus throw is a strike: please God, let the game figure this scenario out correctly.

**Example:** In the game [1, 5] [3, 6] [7, 2] [3, 6] [4, 4] [5, 3] [3, 3] [4, 5] [8, 1] [2, 8], the last frame is a spare. If the bonus throw is [10], the game’s score is 93.

**14. Best Score**

*A perfect game consists of all strikes (a total of 12 of them including the bonus throws), and has a score of 300.*

**Story:** As the scorekeeper, I love it when the game is just a sequence of strikes, including the bonus throws, because I know that the player then deserves a perfect score of 300.

**Example:** A perfect game looks like [10, 0] [10, 0] [10, 0] [10, 0] [10, 0] [10, 0] [10, 0] [10, 0] [10, 0] [10, 0] with bonus throws [10, 10]. Its score is 300.

**15. Random Game**

**Story:** As the scorekeeper, I want to make sure that the game [6, 3] [7, 1] [8, 2] [7, 2] [10, 0] [6, 2] [7, 3] [10, 0] [8, 0] [7, 3] [10] has a score of 135.

Congratulations, you are done!