**National University of Computer and Emerging Sciences, Lahore Campus**

**Course**

**Name:**

**Program:**

**Duration:**

**Paper Date:**

**Section:**

**Exam:**

**Data Structures**

**BS(CS)**

**1**

**Hours**

**18**

**-**

**Oct**

**-**

**23**

**BCS**

**-**

**H**

**3**

**Quiz**

**-**

**2**

**Course Code:**

**Semester:**

**Total Marks:**

**Weight:**

**Pages:**

**CL2001**

**Fall 2023**

**50**

**2**

**Student**

**:**

**Name:**

**Roll No.**

**Section:**

**Instruction/Notes:**



**Problem: Library System with Queue**

You are tasked with designing a sophisticated library system in C++ that utilizes a queue to handle various library operations. The system should be capable of managing books, patrons, reservations, and a waiting list for popular books. To make it challenging, you need to implement the following tasks:

1. **Managing Books: (5)**

* Create a class Book with attributes such as an ISBN, title, author, and availability status.
* Implement a queue-based system for handling book reservations, allowing patrons to reserve books.
* When a reserved book becomes available, notify the patron who reserved it via a message.

1. **Managing Patrons: (5)**

* Create a class Patron with attributes like a unique patron ID, name, and a list of reserved books.
* Ensure that a patron can only reserve one book at a time.

1. **Handling Reservations: (5)**

* Implement a mechanism for tracking reservations in a way that efficiently processes reservations when a book becomes available.
* Ensure that patrons are informed of the availability of a reserved book without delays.

1. **Waiting List: (5)**

* Create a waiting list for books that are currently unavailable because they are reserved by others.
* Patrons can choose to be added to the waiting list for a specific book.

1. **Complex Reservation Logic: (5)**

* Implement a rule where a patron can only reserve a book if they have borrowed fewer than three books and are not on the waiting list for any book.
* Patrons on the waiting list for a book should receive a reservation opportunity when a copy becomes available.

1. **Handling Book Returns: (5)**

* Implement the book return process, updating the book's availability and informing patrons on the waiting list if a book becomes available.

1. **Display and Notifications: (5)**

* Develop a comprehensive display system that allows librarians to view all books, their availability, and waiting lists.
* Implement a notification system that sends messages to patrons about their reservations.

1. **Error Handling and Synchronization: (5)**

* Address potential race conditions and ensure that the system handles exceptions and concurrent operations gracefully.

**Challenge: (10)**

Design the system with maximum efficiency, considering performance and scalability. Optimize the handling of reservations and waiting lists to minimize delays and notify patrons promptly.

Your solution should provide a user-friendly interface for librarians to manage books and patrons, and for patrons to interact with the library system efficiently.