Part IV: Problem-Solving (30 points)

Answer the following problems in detail. Show all calculations and reasoning. Each question is worth 10 points.

1. **State Transition Analysis:**
   - A simple traffic light system operates with the following states: Red, Green, Yellow.
   - Events:
     - Timer Expired → Red to Green
     - Timer Expired → Green to Yellow
     - Timer Expired → Yellow to Red
2. **Tasks:**
   - Draw a state transition diagram for this system.
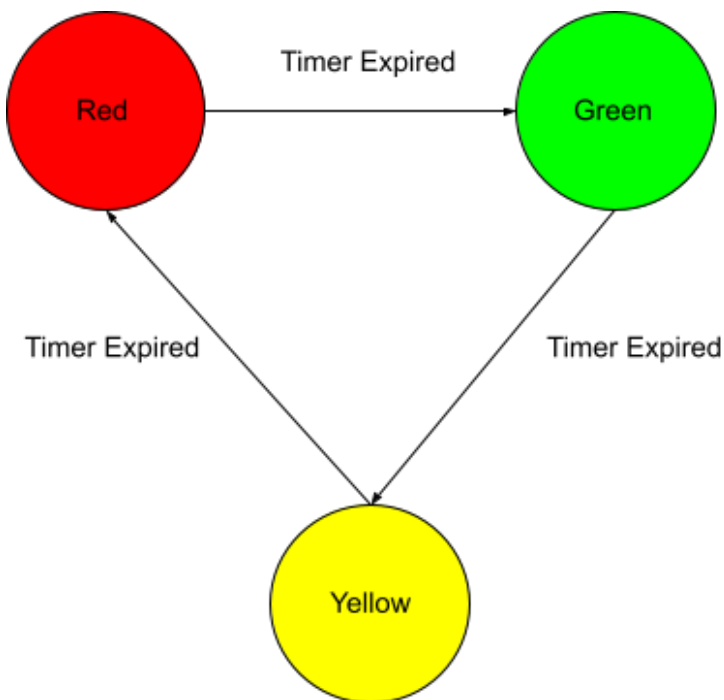
   - Create a state transition table for the system.

Current State	Event	New State
Red	Timer Expired	Green
Green	Timer Expired	Yellow

Yellow	Time Expired	Red

3. **Event Scheduling and Utilization Calculation:**
   - In a bank queue system, customers arrive at an average of 1 every 4 minutes. The service time for each customer is 3 minutes.
   Tasks:
   - Calculate the utilization of the teller.
   - Determine if a queue is likely to form and explain why, based on utilization.

Arrival rate (a) = 1 customer every 4 minutes = 0.25 customers per minute.

Service Rate (s) = 1 customer served every 3 minutes = 0.33 customers per minute.

P = Utilization of the teller

$P = a/s = 0.25/0.33 = \textbf{0.75}$

Utilization of teller = **75%**

4. **Application Analysis:**
   - Consider an ATM machine that operates with the states: Idle, Authenticating, Processing Transaction, Dispensing Cash, Returning to Idle.
   Tasks:
   - Identify the possible events in this system and describe their role in the simulation model.
   - Briefly outline how the ATM system can be effectively modeled using discrete-event simulation, including its events and state transitions.

List of possible events:

1. **Card Insertion:** Triggers the authentication process.
2. **PIN Entry:** Initiates the authentication process.
3. **Authentication Success:** Allows the user to proceed to the transaction menu.
4. **Authentication Failure:** Triggers card ejection and returns the ATM to the idle state.
5. **Transaction Selection:** User chooses a transaction type (withdraw, deposit, balance inquiry).
6. **Cash Withdrawal:** Initiates the cash dispensing process.
7. **Cash Dispensed:** Updates the account balance and returns to the idle state.
8. **Cash Dispensing Failure:** Notifies the user and returns to the idle state.
9. **Transaction Completion:** Returns the ATM to the idle state.
10. **Card Removal:** Triggers the return to the idle state.

Discrete-Event Simulation Model for an ATM:

➔ **States:**

◆ Idle
◆ Authenticating
◆ Processing Transaction
◆ Dispensing Cash
◆ Returning to Idle

➔ **Events:**
◆ As identified above, each event triggers a state transition.
◆ "Card Insertion" event transitions the ATM from the "Idle" state to the "Authenticating" state and schedules the "PIN Entry" event to occur after a certain time interval. Similarly, the "Authentication Success" event transitions the ATM to the "Processing Transaction" state and schedules the "Transaction Selection" event.

➔ **State Transitions:**

◆ Idle -> Authenticating (on Card Insertion)
◆ Authenticating -> Processing Transaction (on successful PIN entry)
◆ Authenticating -> Idle (on failed PIN entry)
◆ Processing Transaction -> Dispensing Cash (on cash withdrawal selection)
◆ Processing Transaction -> Returning to Idle (on other transaction types)
◆ Dispensing Cash -> Returning to Idle (on successful cash dispense)
◆ Dispensing Cash -> Idle (on failed cash dispense)
◆ Returning to Idle -> Idle (on card removal)