Exercise 2: Smart Factory Control System (Mutex and Semaphore)

Scenario

In a smart factory, multiple conveyor belts transport products to a central inspection area. The system consists of:

- **Conveyor Control System**
  Operates conveyor belts, ensuring only one runs at a time to avoid product collisions. Each belt runs for a specified period before pausing to allow the next belt to operate.

- **Inspection System**
  Simulates product inspection. It processes products one at a time and signals when a product is inspected.

- **Logger System**
  Logs all operations (e.g., belt status, product inspection status) for monitoring purposes.

Requirements

- **Synchronization**
  - Ensure only one conveyor belt runs at a time using a mutex.
  - The inspection system must only process a product when signaled by a conveyor belt using a binary semaphore.

- **Task Priorities**
  - Conveyor belts should operate with medium priority.
  - The inspection system should have the highest priority to ensure timely product processing.
  - The logging system can run at the lowest priority to avoid interfering with critical operations.

- **Synchronization**
  - Use synchronization mechanisms like semaphores to handle critical sections or ensure tasks run in sequence when required.

- **Logging & logger Task**
  - Log every state change in the system (e.g., when a conveyor starts/stops, when a product is inspected).
  - Fault Handling (Optional)
    - If a conveyor belt fails to release the mutex (e.g., due to an error), the system must detect and handle the fault by restarting the conveyor task safely.

Hints for Implementation

1. Task Descriptions
    a. Conveyor Task
        i. Simulate a conveyor belt operating for a fixed duration.
        ii. After running, signal the inspection system that a product is ready for inspection.
    b. Inspection Task
        i. Wait for a signal from the conveyor task.
        ii. Simulate inspecting the product and log the result.
    c. Logger Task
        i. Continuously log operations like conveyor status, inspection completion, and faults.

2. Use a mutex to ensure only one conveyor operates at a time.
3. Use a binary semaphore to signal the inspection task.
4. Inspection task should preempt the conveyor task whenever a product is ready.
5. Use a watchdog timer or FreeRTOS task notifications to detect and recover from deadlocks.