

## **Problem 1.**

### **● Iced tea Coffee Problem**

Two Peoples meet regularly at a cozy coffee shop to catch up on their lives. However, they tend to interrupt each other while speaking, leading to confusion and frustration. Both of them (Person 1 and Person 2) enjoy iced coffee, but Person 2 frequently misspells it as "iced tea," leading to mix-ups and misunderstandings.

Design a C program that utilizes semaphores, threads, and processes to allow the two friends to communicate effectively and minimize the chances of confusion and mix-ups.

Requirements:

1. The program should simulate a conversation between the two friends, with each speaking in turn.
2. Use semaphores to ensure that only one person speaks at a time, and the other listens. Implement a turn-taking mechanism to ensure that each person has an equal opportunity to speak.
3. Implement error detection and correction for Person 2's tendency to misspell "iced coffee" as "iced tea." Whenever Person 2 mentions "iced tea," the program should automatically correct it to "iced coffee."
4. Use threads or processes to simulate the conversation and error detection/correction mechanisms.
5. The program should output the corrected conversation, including the number of errors detected and corrected.

Your program should demonstrate efficient and accurate communication between the two friends, minimizing confusion and errors, using semaphores, threads, and processes, while they discuss their mutual love for iced coffee.

*After solving the problem, enjoy a cold iced coffee and chat about your life's enthusiasm with someone.*

## **● Problem 2:**

### **Acrylic Painting Problem**

Someone loves acrylic painting and is working on a collaborative project with multiple other artists. Each artist is responsible for painting different parts of the artwork, and they must work sequentially to ensure that each part is completed before the next artist can start. To keep track of progress and not lose hope, the artists decide to use a multi-threaded C program with semaphores, processes, threads, and mutex locks to coordinate and monitor the painting process.

The shared artwork has several sections, and each section must be painted in a specific order. The artists also need to wait for the paint to dry before the next artist can begin their part. They require a system to manage this coordination and keep track of progress efficiently.

To address this problem, the artists will create a C program that uses multiple threads to represent the artists working on different parts of the painting. Semaphores will be used to synchronize the order in which the artists' work on their sections, allowing time for the paint to dry and ensuring that no two artists work on the same section simultaneously.

Additionally, the artists will use a mutex lock to protect access to a shared progress report that logs the completion of each section. This progress report will help Alice and her fellow artists stay motivated by giving them a clear view of the overall progress of the project. The program will also include processes to handle different stages of the painting, such as preparation, painting, and finishing touches.

By implementing this solution, Alice and her fellow artists will be able to maintain their motivation and complete their collaborative acrylic painting project efficiently and in a well-coordinated manner.

### ● **Problem 3:**

#### ● **Two book enthusiasts**

In a small town, there is a charming and cozy bookshop named “Whispering Pages,” which also serves as a café. Every Saturday, two book enthusiasts meet there to discuss and analyze various books they’ve read, such as “Heart Bones,” “The Alchemist,” and “Kafka on the Shore.” The bookshop frequently hosts multiple book clubs and reading groups that gather simultaneously, leading to lively discussions and debates throughout the shop.

Due to the increasing number of book clubs and reading groups, the bookshop owner realizes that managing the schedules, room allocations, and resources for each group has become quite challenging. The owner wants to implement a multi-threaded C program with semaphores, processes, threads, and mutex locks to efficiently coordinate the activities and ensure a smooth experience for all visitors.

The problem that needs to be addressed involves managing the following aspects:

- Scheduling and coordination of book club and reading group meetings, ensuring that no two groups are assigned the same room at the same time.
- Resource allocation, including books, tables, chairs, and audio-visual equipment, while avoiding conflicts and double bookings.
- Maintaining a shared digital catalog of the bookshop's inventory and keeping it up-to-date, even as multiple visitors and staff access and modify it concurrently.

The C program will need to create multiple threads to represent the different book clubs and reading groups and use mutex locks to protect access to shared resources such as the room allocation and resource booking systems. Semaphores will be employed to synchronize the activities of the groups and prevent any overlaps in their schedules.

By implementing such a system, the owner of Whispering Pages can ensure that the bookshop continues to operate smoothly and provide a welcoming environment for visitors who come together every Saturday to share their love for literature.

## ● **Problem 4:**

### ● **Bookshelf management problem**

Someone living in an apartment decides to create a cozy and well-organized bookshelf in their living room. This person is an avid reader with an extensive book collection and wants to sort and arrange their books efficiently. They decide to use a multi-threaded C program with semaphores, processes, threads, and mutex locks to coordinate the book organization process and ensure the books are correctly sorted and placed on the bookshelf.

The problem that needs to be addressed involves the following aspects:

- Sorting the books based on a predefined categorization system, such as alphabetical order, genre, or publication date. This task requires coordinating the different sorting methods and ensuring that the books are sorted correctly and efficiently without disrupting the overall organization of the bookshelf.
- Updating a shared digital inventory of the book collection to keep track of the books' locations on the bookshelf. The inventory system should allow the person to easily find and locate any book in the collection.
- Ensuring that the digital inventory system is protected from potential data inconsistencies and conflicts, especially if it is accessible from multiple devices or if the person is using an automation system to help with the organization process.

The C program will need to create multiple threads to represent each task involved in the bookshelf organization process. Mutex locks will be employed to protect access to shared resources, such as the digital inventory system, ensuring that it remains consistent and accurate.

Semaphores will be used to synchronize the different tasks, allowing them to work together effectively and avoid disrupting the book sorting and organization process.

By implementing such a system, the person can successfully create a cozy and well-organized bookshelf in their living room, providing an enjoyable space for reading and sharing their love for literature.

## ● **Problem 5:**

### ● "I sleep so that we can meet."

In a magical town, two lovebirds, Moon and Star, are trying to synchronize their naps to meet in their dreams at the enchanting "Dream Park." This park, filled with mystical landscapes and creatures, allows visitors to create beautiful memories together in their dreams. However, the park's magic only works when both individuals are asleep at the same time. To manage this, they use a unique semaphore called "SleepToMeet," a mutex lock, and a friendly owl named "Whisper" to coordinate their naps and protect their dreams from interruptions.

Each person is represented by a process, with their awake and sleep states managed by separate threads. The SleepToMeet semaphore has two components: MoonAsleep and StarAsleep, representing the sleep state of each person. A mutex lock ensures that only one person can update their sleep status within the SleepToMeet semaphore at a time, preventing race conditions and securing their shared dream world.

The Whisper message system, implemented as an additional thread, monitors the SleepToMeet semaphore and sends messages to Moon and Star when their counterpart is asleep. Whisper also alerts them if any potential dream disruptions, such as an incoming phone call or a noisy neighbor, are detected, allowing them to adjust their sleep schedules accordingly.

The C program will manage the sleep and awake schedules of Moon and Star, ensuring they can only meet in their dreams at the Dream Park when both components of the SleepToMeet semaphore are set to 1. The mutex lock prevents race conditions and secures their shared dream world, while the Whisper message system assists in coordinating their naps effectively and alerts them to potential disruptions. Through careful synchronization, Moon and Star can continue to create cherished memories together in the magical Dream Park.

## ● **Problem 6:**

### ● Market Visit Problem

Alice is a software engineer who loves to visit the local artisan market every weekend. One day, she goes to the market to look for unique, handcrafted items. As she walks through the stalls, she spots a beautiful hand-painted vase that would be perfect for her living room.

She spends some time admiring the vase but ultimately decides not to buy it due to its high price. However, after coming home, she starts to regret her decision. The vase had a one-of-a-kind design, and she knows it would be a great addition to her home decor. Alice decides to search for the vase online, hoping to find it on the artist's website or an e-commerce platform.

In this scenario, there are multiple factors and potential problems that need to be managed concurrently:

1. Alice's decision-making process.
2. The availability of the vase at the market and online.
3. The synchronization of the artist's inventory between the market and the online platform.
4. The competition among other potential customers who might also be interested in buying the vase.

To solve these problems, a C program can be developed using semaphores, processes, and thread mutex locks:

1. Semaphores can be used to manage the availability of the vase and ensure that it is not sold to multiple customers simultaneously.
2. Processes can represent the different actions Alice takes (e.g., visiting the market, searching online, and making a purchase) and can run concurrently.
3. Thread mutex locks can be used to synchronize the artist's inventory between the market and the online platform, ensuring that the vase's availability is accurately reflected on both platforms.

By using semaphores, processes, and thread mutex locks, the C program can effectively simulate Alice's experience of finding, deciding not to buy, regretting her decision, and searching for the vase online, while also addressing the potential challenges and concurrency issues that arise in this scenario.

## ● **Problem 7:**

### ● **Dentist Problem**

Dr. Smith, a recent dental school graduate, has just opened his own dental clinic. The clinic has one dentist (Dr. Smith), one dental chair for treatment, and  $n$  chairs in the waiting room for patients. There is also a receptionist who manages patient appointments and records. Initially, all the chairs are empty. When there are no patients, Dr. Smith takes a nap in his chair. If a patient arrives, they need to wake up Dr. Smith. If multiple patients arrive and Dr. Smith is attending to one patient, the remaining patients either wait in the available chairs or leave if no chairs are empty. Patients can also call the receptionist to make appointments and check the availability of Dr. Smith before arriving at the clinic.

The main challenges in this extended scenario are:

- Synchronizing the arrival of patients, appointment scheduling, and the availability of the dentist.
- Managing the waiting room chairs.
- Ensuring that once a patient receives treatment, they leave the clinic.
- Handling appointment scheduling and record-keeping with the receptionist.
- Terminating the dentist thread, receptionist thread, and the main program when all patient threads have been treated and terminated.

To solve this problem, a program can be created using POSIX threads, mutex locks, and semaphores. This program will effectively simulate and manage the concurrent activities of Dr. Smith, the receptionist, and his patients, including the treatment process, appointment scheduling, waiting room chair availability, and termination of threads once all patients have been treated. The program will dynamically allocate memory for data structures based on the input parameters (total number of patients, number of chairs, and the maximum number of appointments the receptionist can handle).

## ● **Problem 8:**

### ● **Sweet Harmony.**

In the small, picturesque town of Pastelville, there is a lovely bakery called "Sweet Harmony." This bakery is famous for its scrumptious pastries and charming atmosphere. The bakery has a limited number of tables for customers to sit and enjoy their treats. To maintain the pleasant ambiance, they have a unique rule: at any given time, there can only be an equal number of customers wearing red and blue outfits inside the bakery.

Sweet Harmony's staff must manage the following aspects:

1. Allowing customers to enter the bakery while maintaining the equal number of red and blue outfits rule.
2. Ensuring customers can find a table to sit at or wait for a table to become available.
3. Managing the queue of customers waiting outside the bakery when the equal outfit rule cannot be maintained.
4. Handling customers leaving the bakery, freeing up tables, and allowing new customers to enter.

A C program can be developed using semaphores, processes, and thread mutex locks to address the above challenges:

1. Semaphores can be used to manage the equal outfit rule, allowing only customers with matching outfits to enter.

2. Processes can represent individual customers and their actions (entering the bakery, finding a table, waiting, and leaving).
3. Thread mutex locks can be used to synchronize the available tables, ensuring customers can only sit at a free table.
4. Additional semaphores can be used to manage the waiting queue outside the bakery.

By utilizing semaphores, processes, and thread mutex locks, the C program can effectively simulate the charming environment at Sweet Harmony bakery, while addressing the concurrency issues and unique outfit rule that arise in this scenario.

## ● **Problem 9:**

### ● **Will & Lou's Café Problem**

In the quaint village where "Me Before You" by Jojo Moyes is set, a lovely little café called "Will & Lou's" has opened. This charming café is inspired by the beautiful marriage between Will Traynor and Louisa Clark and is adorned with bumblebee tights and quirky decorations. The café has a limited number of tables, and they offer a unique service: customers can borrow books to read while enjoying their coffee and treats.

To maintain the serene atmosphere of the café and ensure a smooth borrowing experience for customers, the following aspects need to be managed:

1. Allowing customers to enter the café while making sure there is a table available for them to sit.
2. Managing the borrowing and returning process of books, ensuring customers only take available books.
3. Ensuring customers leave a table once they finish reading and enjoying their treats, making room for new customers.
4. Synchronizing the book inventory, so the availability status of each book is accurate.

A C program can be developed using semaphores, processes, and thread mutex locks to address these challenges:

1. Semaphores can be used to manage the available tables, allowing customers to enter only when there is a free table.
2. Processes can represent individual customers and their actions (entering the café, borrowing a book, reading, and leaving).
3. Thread mutex locks can be used to synchronize the book inventory, ensuring customers can only borrow available books.

4. Additional semaphores can be used to manage the queue of customers waiting outside the café.

By utilizing semaphores, processes, and thread mutex locks, the C program can effectively simulate the endearing atmosphere of the "Will & Lou's" café, while addressing the concurrency issues related to table availability and book inventory management that arise in this scenario.

## ● **Problem 10:**

### ● **Being Ted Mosby's**

Inspired by Ted Mosby's character, a captivating and imaginative event planning company called "Ted's Stories" has emerged in New York City. Ted, the founder of the company, is passionate about bringing people's love stories to life through meticulously planned events, such as weddings. The company has a limited number of event planners who work together to create the most romantic and memorable events.

Ted, known for his romantic gestures, believes in the power of serendipity. He wants to encourage his event planners to embrace spontaneous ideas and collaborate with each other. However, to ensure that the events are well-organized, certain aspects need to be managed:

1. Coordinating the availability of event planners to avoid overbooking.
2. Managing shared resources, such as proposal spots, decorations, and audiovisual equipment.
3. Ensuring that each event is executed seamlessly and on schedule.
4. Synchronizing the use of shared resources and communication among event planners to prevent conflicts.

A C program can be developed using semaphores, processes, and thread mutex locks to address these challenges:

1. Semaphores can be used to manage the availability of event planners, ensuring they take on new events only when they have the capacity.
2. Processes can represent individual event planners and their actions (planning events, using shared resources, and coordinating with other planners).
3. Thread mutex locks can be used to synchronize the use of shared resources like proposal spots, decorations, and audiovisual equipment, ensuring they are used for one event at a time.
4. Additional semaphores can be used to manage the communication and collaboration between event planners, enabling spontaneous ideas and teamwork.

By utilizing semaphores, processes, and thread mutex locks, the C program can effectively simulate the romantic and imaginative environment of "Ted's Stories" event planning



company, while addressing the concurrency issues related to event planner availability, shared resource management, and collaboration that arise in this scenario.

*If you're feeling down about solving this problem, I have something to remind you:*

*"Whenever I'm sad, I stop being sad and become awesome instead."*

## ● **Problem 11:**

### ● **The Garden Watering Dilemma**

To honor her mother, who has a passion for gardening, Jane decides to create an automated garden watering system. This system needs to cater to various plants in the garden, each with different water requirements. She has a limited water supply and several sprinklers that need to be used efficiently. The garden has expanded, and now there are five sections: flowers, vegetables, fruits, herbs, and a small greenhouse.

Each section has a designated sprinkler, and the water supply can only cater to one sprinkler at a time. To make things more challenging, the following conditions must be met:

- The flowers need to be watered three times a day, vegetables and fruits twice a day, herbs once a day, and the greenhouse's watering frequency depends on the current humidity level, requiring water either once or twice a day.
- No two sections can be watered simultaneously.
- The water supply must be used efficiently to ensure that all sections are watered according to their needs.
- The watering process should start at 6 AM and finish no later than 10 PM, with a minimum one-hour gap between watering sessions for each section.
- Each section has a sensor to monitor soil moisture levels. If the moisture level is above a threshold, that section should not be watered.

Jane decides to use C programming to solve this problem. She will implement a solution using semaphores, process threads, and mutex locks to ensure that the sprinklers are used effectively without any conflicts, while adhering to the watering requirements of each garden section. The program should also incorporate the sensor data to avoid overwatering and efficiently manage the water supply.

*I wanted to remind you of something: "I saw a girl with a golden heart, and by the way, she is my mother."*

## ● **Problem 12:**

### ● **IELTS and GRE exams Problem**

A school is organizing a mock IELTS and GRE exam for its students. The exam hall has several rooms, and each room can accommodate up to 30 students. There are a total of 300 students who have registered for the exam. The exam will last for three hours, and each student will be assigned to a specific room for the duration of the exam. The school administration wants to ensure that the exam runs smoothly without any disruptions. Therefore, they have decided to implement a program that will manage the allocation of students to rooms.

The program should be able to do the following:

1. Assign a unique ID to each student.
2. Assign each student to a specific room.
3. Ensure that each room is not over capacity.
4. Ensure that each student is assigned to only one room.
5. Allow students to enter their designated room only when the exam starts.
6. Ensure that no student leaves the exam hall before the exam ends.
7. Provide a summary of the exam attendance at the end of the exam.

To achieve this, you need to write a C program that uses the following concepts:

1. Semaphore: To control the access of students to the exam hall and rooms.
2. Process: To handle the allocation of students to rooms.
3. Thread: To allow students to enter their designated room only when the exam starts.
4. Mutex Lock: To ensure that no student leaves the exam hall before the exam ends.

Your program should be able to allocate the students to rooms and allow them to enter their designated room at the start of the exam. It should also ensure that no student leaves the exam hall before the end of the exam. At the end of the exam, the program should provide a summary of the attendance for the exam.

Good luck!

## ● **Problem 13:**

### ● **The Whimsical Widget Workshop**

In a quaint little town, there is a cute, aesthetic, and lovely software engineering company named "Whimsical Widget Workshop." They specialize in creating custom widgets for various clients. These

widgets include colorful buttons, sliders, and interactive elements that bring life to otherwise dull applications.

The company has a team of three software engineers, Alice, Bob, and Carol, who work on multiple client projects simultaneously. Each widget requires a different combination of resources, such as design assets, coding templates, and testing tools. These resources are limited and shared among the engineers.

To efficiently manage the resource allocation and avoid conflicts between the engineers, the company needs to develop a resource management system using C programming. The system should implement semaphores, process threads, and mutex locks to ensure that the engineers can work smoothly without any resource conflicts.

The following conditions must be met:

1. Each engineer can work on only one widget at a time.
2. An engineer can only use a resource if it is not currently in use by another engineer.
3. When a resource is available, it should be allocated to the engineer who has been waiting the longest.
4. An engineer must release a resource after completing their work on a widget.

This resource management system should be efficient and fair, ensuring that all engineers can work on their widgets without delays or conflicts, while maintaining the cute, aesthetic, and lovely standards of the Whimsical Widget Workshop.

*I hope you can solve this problem in dark more because “Why do programmers prefer dark mode? Because light attracts bugs.”*