**Operating Systems – COC 3071L**

**SE 5th A – Fall 2025**

# Lab 5: Introduction to Threads

## 1. Introduction to Threads

**1.1 What is a Thread?**

A **thread** is the smallest unit of execution within a process.

A **process** can have multiple threads running concurrently

All threads within a process share:

Memory space (code, data, heap)

File descriptors

Process ID

Each thread has its own:

Thread ID (TID)

Stack

Program counter

Register set

**Real-world analogy:**

**Process** = A restaurant kitchen

**Threads** = Multiple cooks working together in the same kitchen, sharing ingredients and equipment

### 1.2 Threads vs Processes – Quick Comparison

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| --- | --- | --- |
| **Feature** | **Process** | **Thread** |
| Memory | Separate memory space | Shared memory space |
| Creation | Expensive (fork) | Lightweight (pthread\_create) |
| Communication | IPC needed (pipes, etc.) | Direct (shared variables) |
| Context Switch | Slower | Faster |
| Independence | Fully independent | Dependent on parent process |

**When to use threads?**

When tasks need to share data frequently

For parallel execution within the same application

When you need lightweight concurrency

## 2. POSIX Threads (pthreads) Library

In Linux, we use the **POSIX threads (pthreads)** library for thread programming.

### 2.1 Compilation Requirements

When compiling programs with threads, you **must** link the pthread library:

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## 3. C Programs with Threads

### Program 1: Creating a Simple Thread

**Objective:** Create a thread and print messages from both main thread and new thread.



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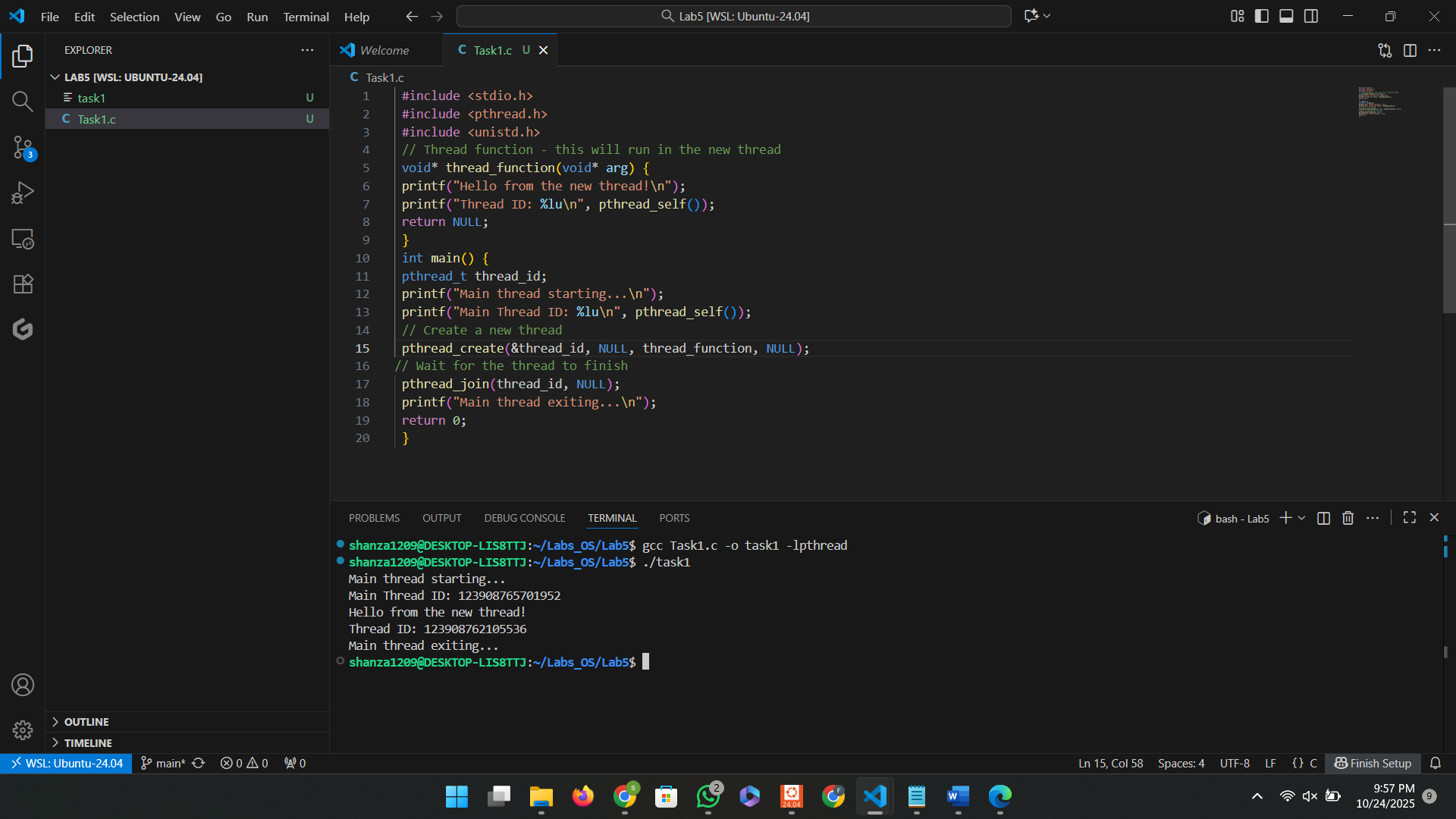
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**Explanation:**

**pthread\_t thread\_id**

This creates a **variable** to hold the thread’s ID (like a file descriptor or process ID).

It’s just a handle the OS uses to manage the thread.

**pthread\_create(&thread\_id, NULL, thread\_function, NULL)**

Let’s decode the four parameters:

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| --- | --- | --- |
| **Parameter** | **Type** | **Meaning** |
| &thread | pthread\_t\* | Where the new thread ID will be stored |
| NULL | pthread\_attr\_t\* | Thread attributes (priority, stack size, etc.)  — NULL means default |
| myThread | void\* (\*start\_routine) (void\*) | Function to run in the new thread |
| NULL | void\* | Pointer passed to the function for data |

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→ Returns the thread ID of calling thread

### Program 2: Passing Arguments to Threads

**Objective:** Pass data to a thread function.

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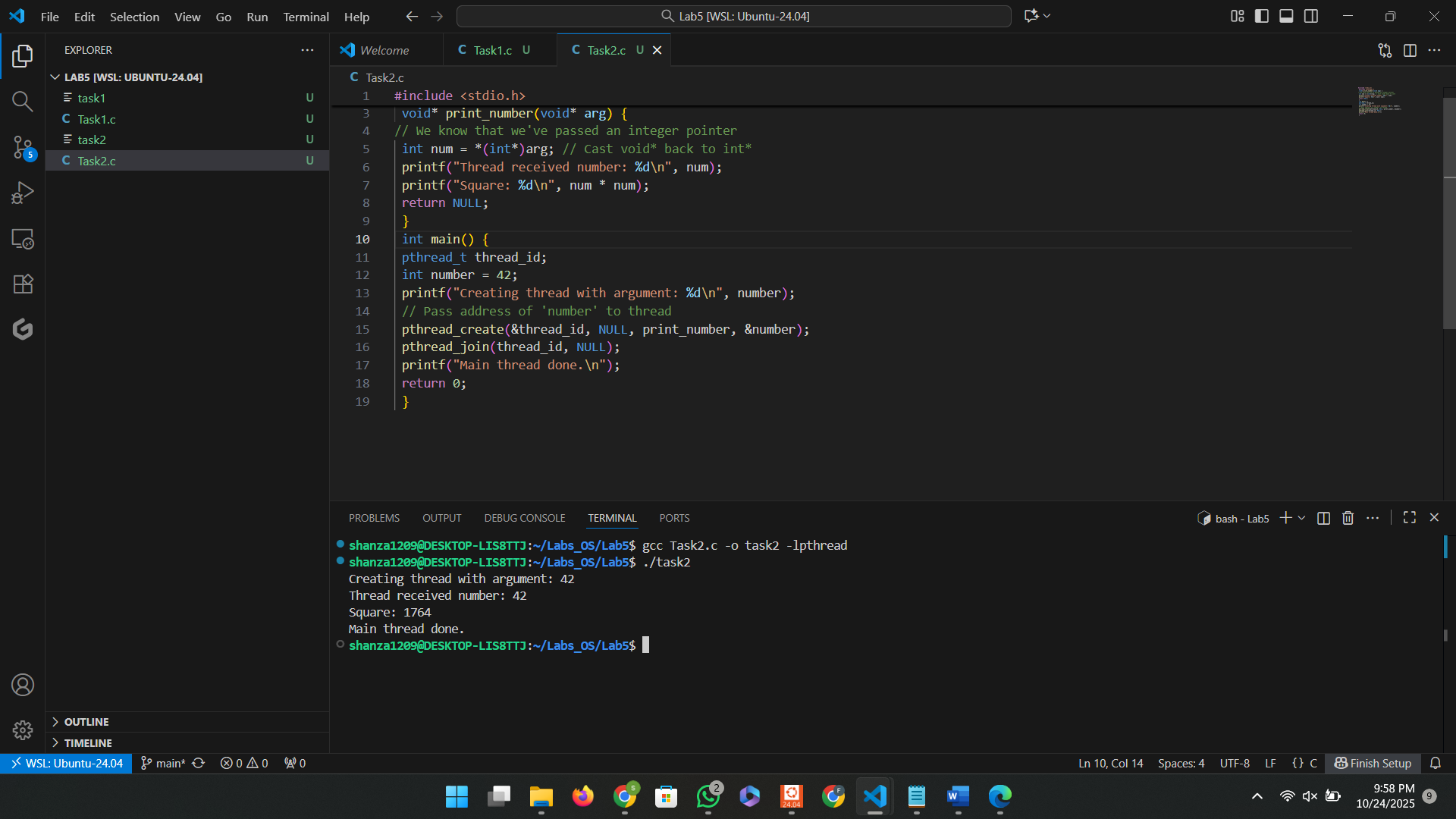
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**Important Notes:**

The 4th argument of pthread\_create() is passed to the thread function

It's a void\* pointer, so you can pass any data type

Remember to cast it properly inside the thread function Here’s what happens step by step:

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That’s because threads can accept *any* data type — integers, structs, arrays, etc.

void\* acts like a universal pointer type.

If you need to pass multiple variables, you wrap them in a

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and pass a pointer to it.

### Program 3: Passing Multiple Data



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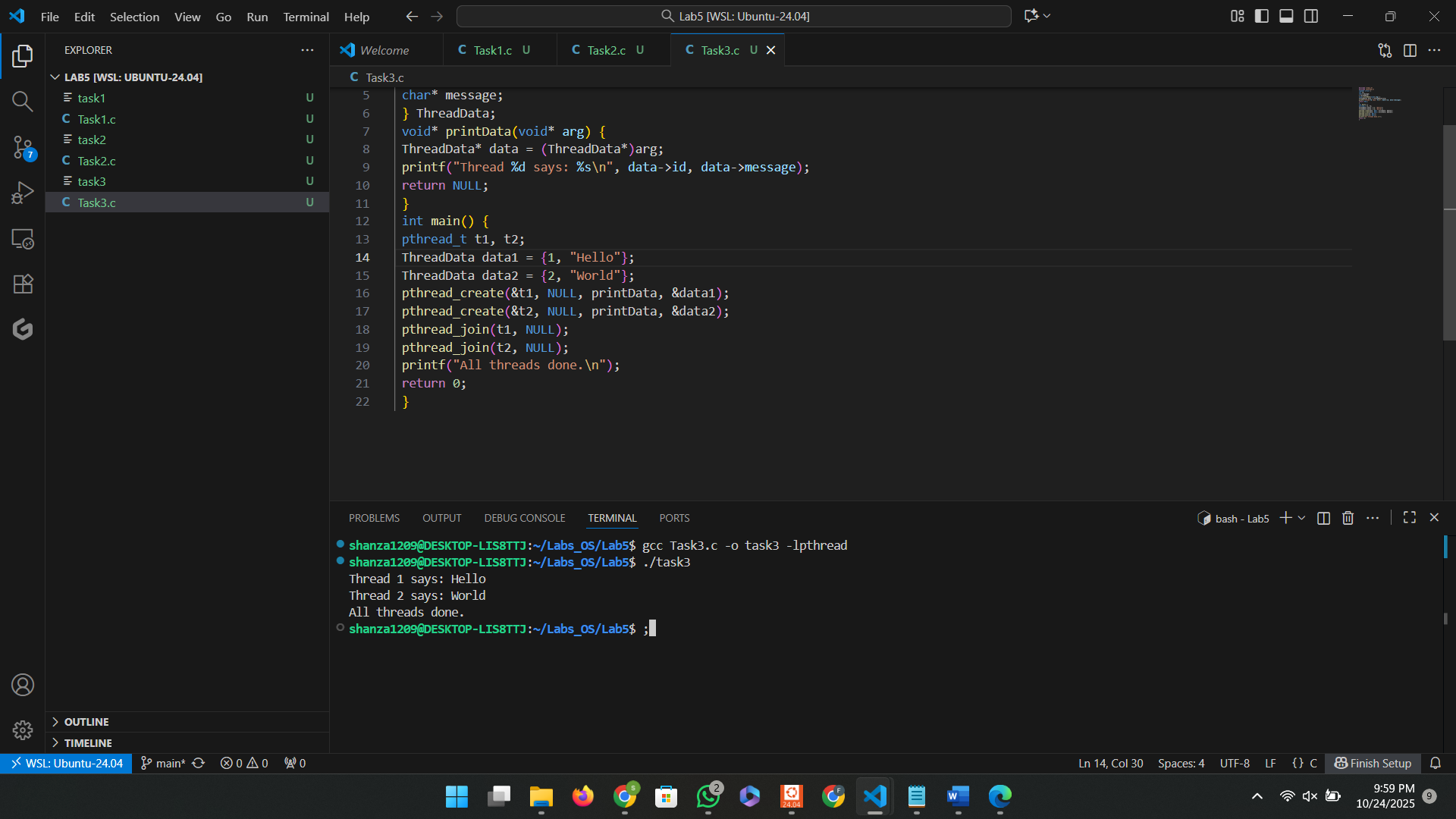
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### Program 4: Thread Return Values

**Objective:** Get return values from threads.



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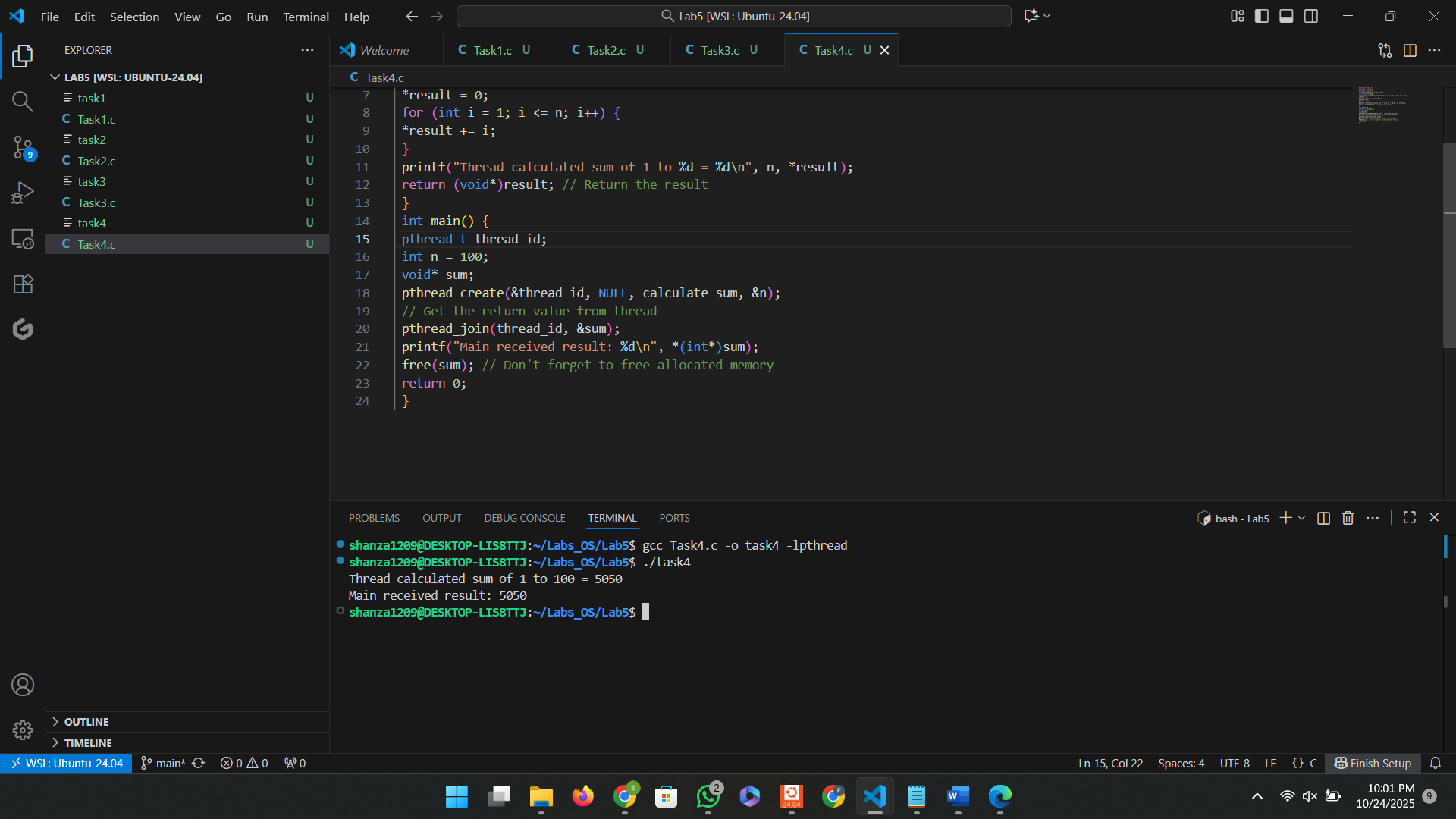
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**Key Points:**

Thread functions return void\*

Use pthread\_join() to retrieve the return value

Remember to free any dynamically allocated memory

## 4. Basic Multithreading

**4.1 What is Multithreading?**

**Multithreading** means running multiple threads *concurrently* to perform different tasks within the same process.

It allows:

Faster program execution on multi-core CPUs

Better resource utilization

Improved responsiveness (e.g., in GUIs or servers)

**Example use cases:**

A web server handling multiple client requests simultaneously

A program performing computation and I/O in parallel

### Program 1: Creating and Running Multiple Threads

**Objective:**

Create multiple threads that execute independently and print messages concurrently.



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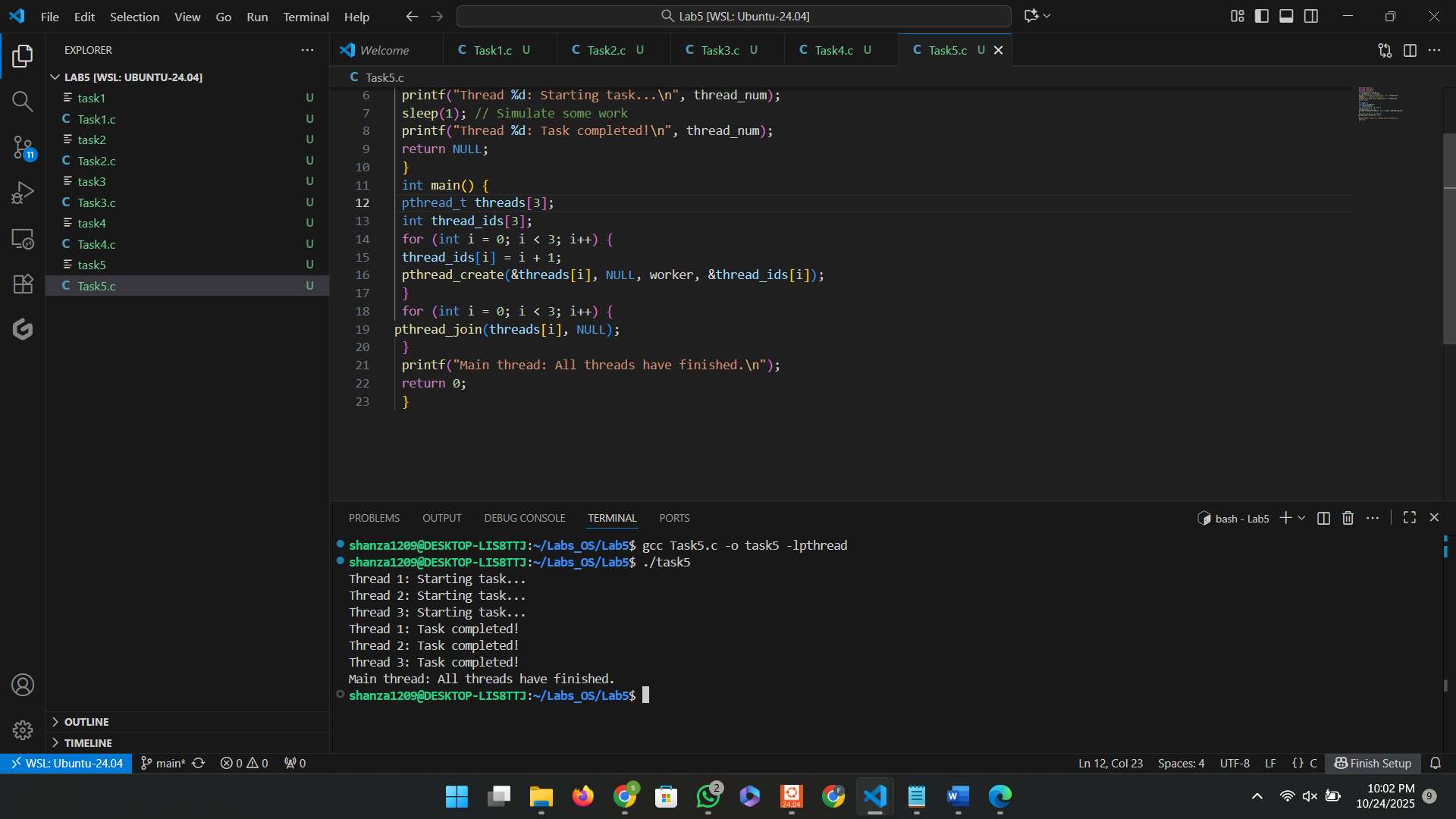
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**Explanation:**

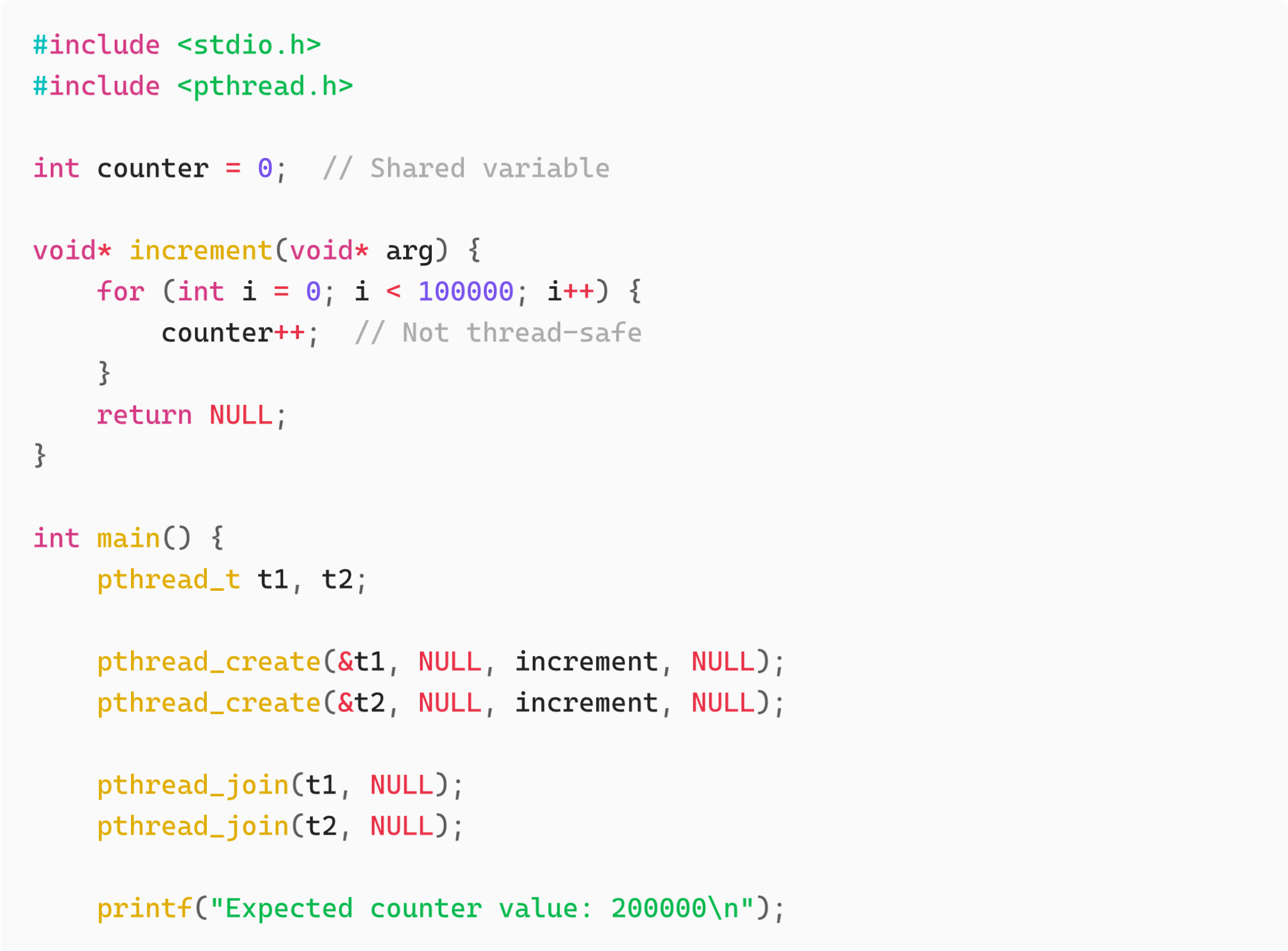
Three threads execute the same function concurrently.

Output order may vary because threads run in parallel.

Demonstrates *basic multithreading behavior* and *non-deterministic execution order*.

### Program 2: Demonstrating a Race Condition

**Objective:** What happens when multiple threads modify a shared variable **without synchronization**.



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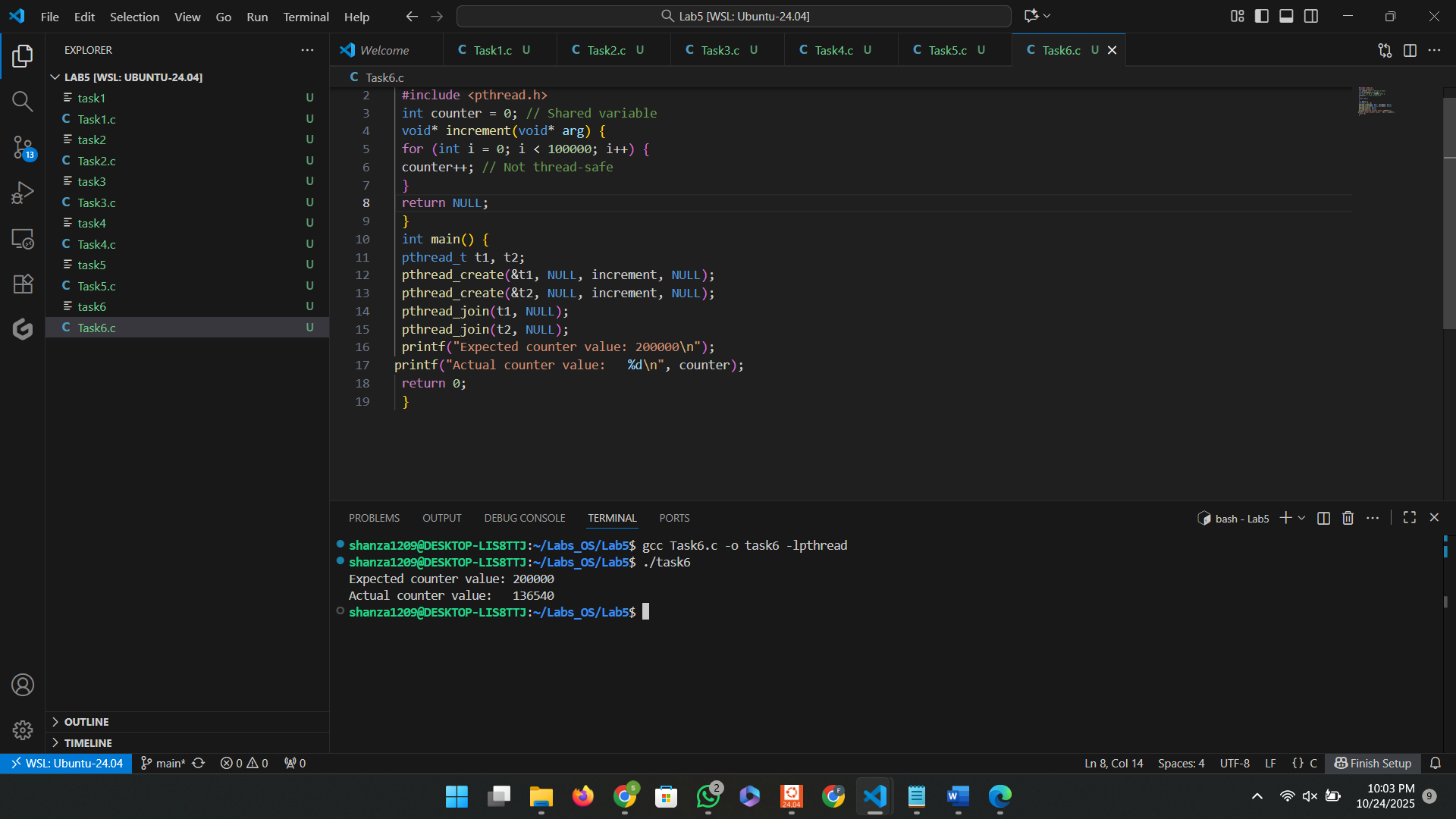
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**Observation:**

The final counter is often **less than 200000**.

This happens because both threads read and write counter simultaneously — a **race condition**.

**Concept introduced:**

When multiple threads access shared data without control, results become

unpredictable.

Synchronization will be used to solve this.