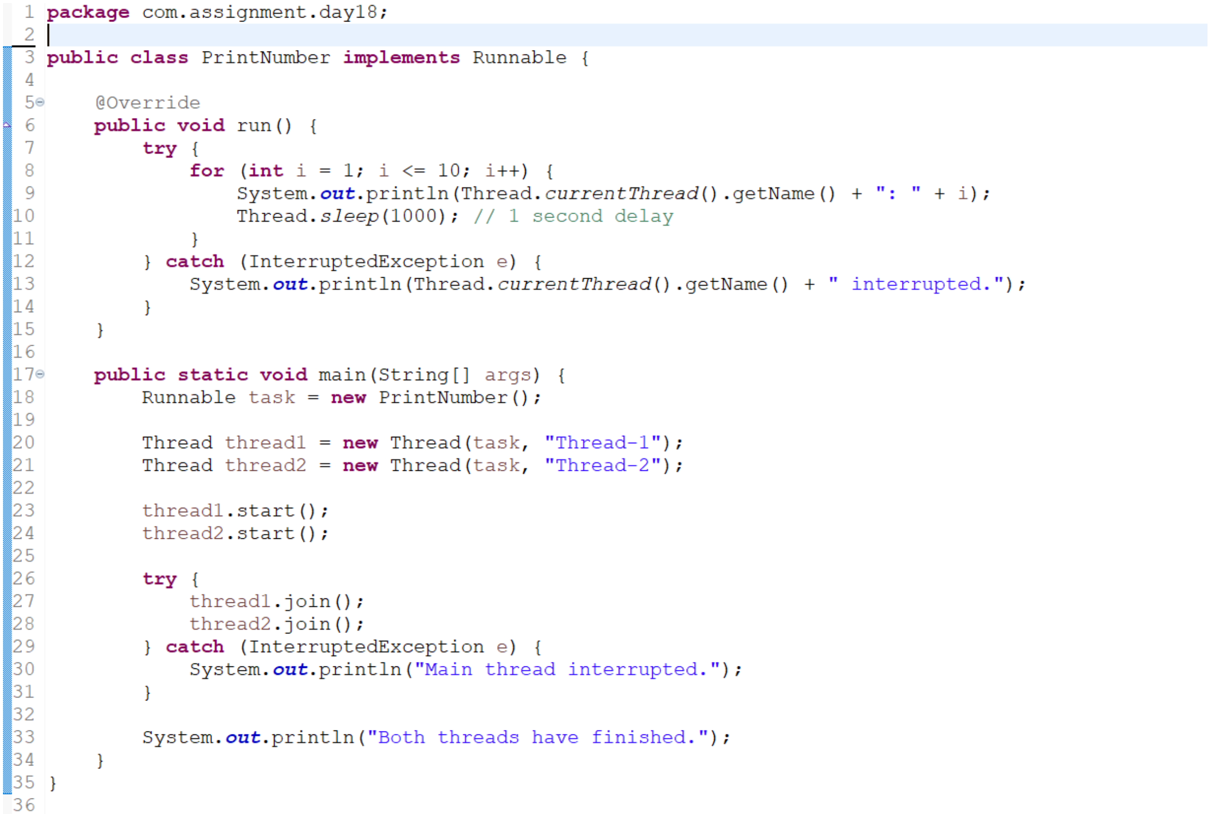
Day 18:

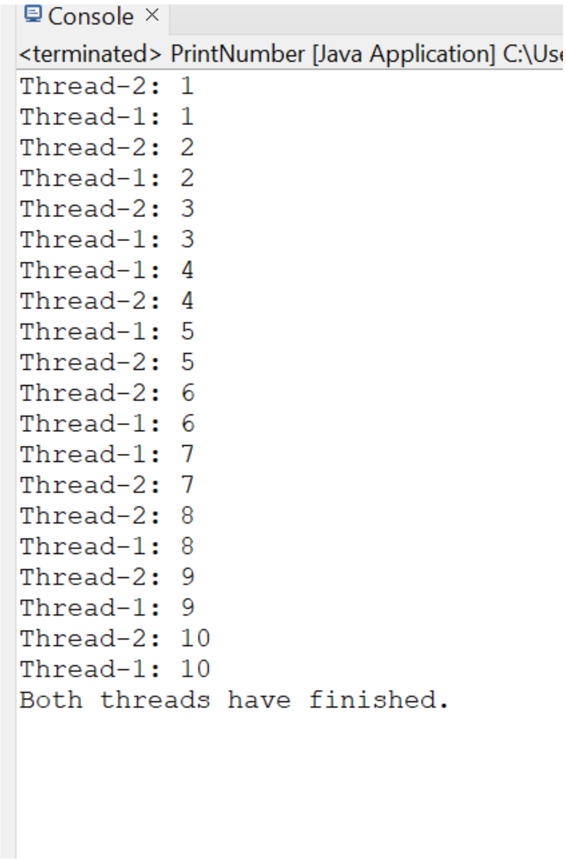
Task 1: Creating and Managing Threads

Write a program that starts two threads, where each thread prints numbers from 1 to 10 with a 1-second delay between each number.



```java
package com.assignment.day18;

public class PrintNumber implements Runnable {

    @Override
    public void run() {
        try {
            for (int i = 1; i <= 10; i++) {
                System.out.println(Thread.currentThread().getName() + ": " + i);
                Thread.sleep(1000); // 1 second delay
            }
        } catch (InterruptedException e) {
            System.out.println(Thread.currentThread().getName() + " interrupted.");
        }
    }

    public static void main(String[] args) {
        Runnable task = new PrintNumber();

        Thread thread1 = new Thread(task, "Thread-1");
        Thread thread2 = new Thread(task, "Thread-2");

        thread1.start();
        thread2.start();

        try {
            thread1.join();
            thread2.join();
        } catch (InterruptedException e) {
            System.out.println("Main thread interrupted.");
        }

        System.out.println("Both threads have finished.");
    }
}
```

OUTPUT:



```
<terminated> PrintNumber [Java Application] C:\Us
Thread-2: 1
Thread-1: 1
Thread-2: 2
Thread-1: 2
Thread-2: 3
Thread-1: 3
Thread-1: 4
Thread-2: 4
Thread-1: 5
Thread-2: 5
Thread-2: 6
Thread-1: 6
Thread-1: 7
Thread-2: 7
Thread-2: 8
Thread-1: 8
Thread-2: 9
Thread-1: 9
Thread-2: 10
Thread-1: 10
Both threads have finished.
```

Task 2: States and Transitions

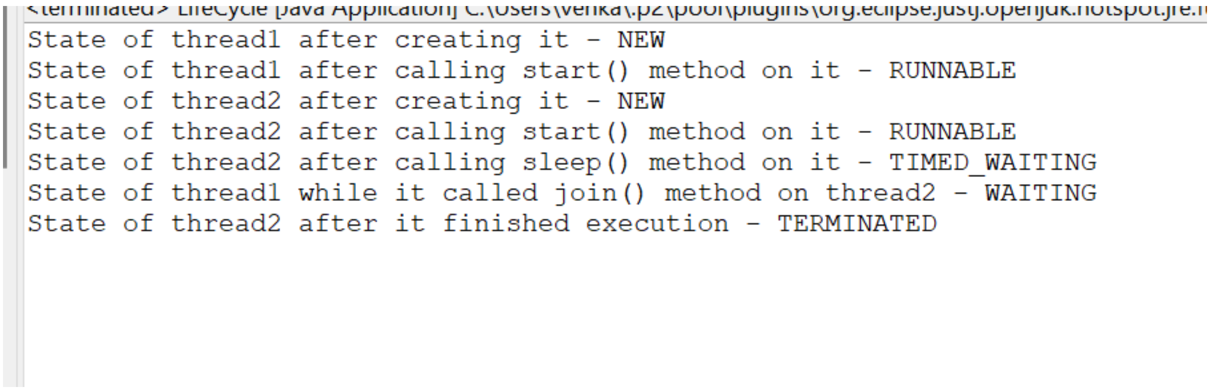
Create a Java class that simulates a thread going through different lifecycle states: NEW, RUNNABLE, WAITING, TIMED_WAITING, BLOCKED, and TERMINATED. Use methods like sleep(), wait(), notify(), and join() to demonstrate these states..

SOLUTION:

```java
package com.assignment.day18;

class ThreadExample implements Runnable {

@Override

public void run() {

try {

Thread.sleep(1500);
} catch (InterruptedException e) {
e.printStackTrace();
}
System.out.println(
"State of thread1 while it called join() method on thread2 - " +
LifeCycle.thread1.getState()
);
try {
Thread.sleep(200);
} catch (InterruptedException e) {
e.printStackTrace();
}
}
}
public class LifeCycle implements Runnable {
public static Thread thread1;
public static LifeCycle obj;
public static void main(String[] args) {
obj = new LifeCycle();
thread1 = new Thread(obj);
System.out.println("State of thread1 after creating it - " +
thread1.getState());
thread1.start();
System.out.println("State of thread1 after calling start() method on it - "
+ thread1.getState());
}
@Override
public void run() {
ThreadExample myThread = new ThreadExample();
```

```
Thread thread2 = new Thread(myThread);

System.out.println("State of thread2 after creating it - " +
thread2.getState());

thread2.start();

System.out.println("State of thread2 after calling start() method on it - "
+ thread2.getState());

try {

Thread.sleep(200);

} catch (InterruptedException e) {

e.printStackTrace();

}

System.out.println("State of thread2 after calling sleep() method on it - "
+ thread2.getState());

try {

thread2.join();

} catch (InterruptedException e) {

e.printStackTrace();

}

System.out.println("State of thread2 after it finished execution - " +
thread2.getState());

}

}
```

OUTPUT:



```
<terminated> LifeCycle [Java Application] C:\Users\venka\.p2\pool\plugins\org.eclipse.justj.openjdk.hotspot.jre.f
State of thread1 after creating it - NEW
State of thread1 after calling start() method on it - RUNNABLE
State of thread2 after creating it - NEW
State of thread2 after calling start() method on it - RUNNABLE
State of thread2 after calling sleep() method on it - TIMED_WAITING
State of thread1 while it called join() method on thread2 - WAITING
State of thread2 after it finished execution - TERMINATED
```

Task 3: Synchronization and Inter-thread Communication

Implement a producer-consumer problem using wait() and notify() methods to handle the correct processing sequence between threads.

SOLUTION:

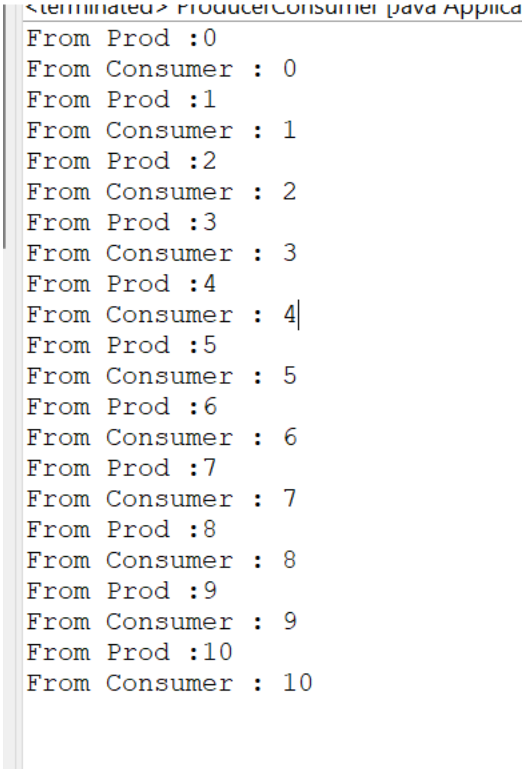
```
package com.assignment.day18;
class Common {
int num;
boolean available = false;
public synchronized int put(int num) {
synchronized (this) {
if (available)
try {
wait();
} catch (InterruptedException e) {
// TODO: handle exception
e.printStackTrace();
}
this.num = num;
System.out.println("From Prod :" + this.num);
try {
Thread.sleep(1000);
} catch (InterruptedException e) {
// TODO: handle exception
e.printStackTrace();
}
available = true;
notify();
}
```

```java
return num;

}

public synchronized int get() {

if (!available)

try {

wait();

} catch (InterruptedException e) {

e.printStackTrace();

}

System.out.println("From Consumer : " + this.num);

try {

Thread.sleep(1000);

} catch (InterruptedException e) {

// TODO Auto-generated catch block

e.printStackTrace();

}

available = false;

notify();

return num;

}

}

class Producer extends Thread {

Common c;

public Producer(Common c) {

this.c = c;

new Thread(this, "Producer :").start();

}

public void run() {
```

```java
int x = 0, i = 0;

while (x <= 10) {

c.put(i++);

x++;

}

}

}

class Consumer extends Thread {

Common c;

public Consumer(Common c) {

this.c = c;

new Thread(this, "Consumer :").start();

}

public void run() {

int x = 0;

while (x <= 10) {

c.get();

x++;

}

}

}

public class ProducerConsumer {

public static void main(String[] args) {

// TODO Auto-generated method stub

Common c = new Common();

new Producer(c);

new Consumer(c);

}
```

```
}
```

OUTPUT:



```
<terminated> ProducerConsumer [Java Applica
From Prod :0
From Consumer : 0
From Prod :1
From Consumer : 1
From Prod :2
From Consumer : 2
From Prod :3
From Consumer : 3
From Prod :4
From Consumer : 4
From Prod :5
From Consumer : 5
From Prod :6
From Consumer : 6
From Prod :7
From Consumer : 7
From Prod :8
From Consumer : 8
From Prod :9
From Consumer : 9
From Prod :10
From Consumer : 10
```

Task 4: Synchronized Blocks and Methods

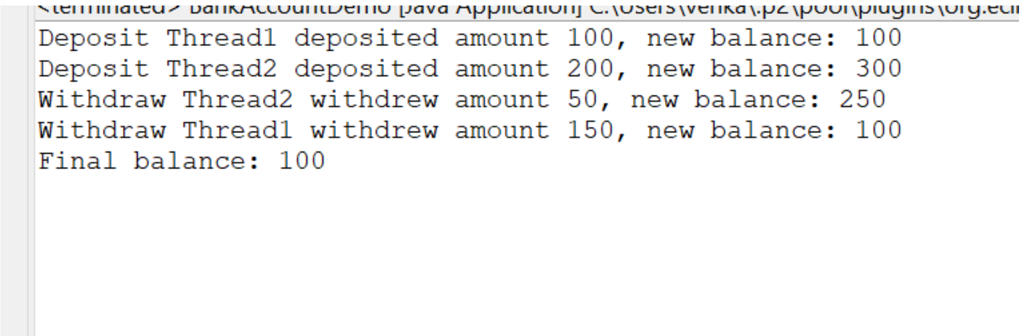
Write a program that simulates a bank account being accessed by multiple threads to perform deposits and withdrawals using synchronized methods to prevent race conditions.

SOLUTION:

```
package com.assignment.day18;

public class BankAccountDemo {

public static void main(String[] args) {

BankAccount account = new BankAccount();

Thread depositThread1 = new Thread(new DepositTask(account, 100), "Deposit
Thread1");

Thread depositThread2 = new Thread(new DepositTask(account, 200), "Deposit
Thread2");

Thread withdrawThread1 = new Thread(new WithdrawTask(account, 150),
"Withdraw Thread1");
```

```
Thread withdrawThread2 = new Thread(new WithdrawTask(account, 50), "Withdraw Thread2");
depositThread1.start();
depositThread2.start();
withdrawThread1.start();
withdrawThread2.start();
try {
depositThread1.join();
depositThread2.join();
withdrawThread1.join();
withdrawThread2.join();
} catch (InterruptedException e) {
e.printStackTrace();
}
System.out.println("Final balance: " + account.getBalance());
}
}
class BankAccount {
private int balance = 0;
public synchronized void deposit(int amount) {
balance += amount;
System.out.println(
Thread.currentThread().getName() + " deposited amount " + amount + ", new balance: " + balance);
}
public synchronized void withdraw(int amount) {
if (balance >= amount) {
balance -= amount;
System.out.println(
Thread.currentThread().getName() + " withdrew amount " + amount + ", new
balance: " + balance);

} else {

System.out.println(Thread.currentThread().getName() + " attempted to
withdraw " + amount

+ ", but insufficient funds. Balance: " + balance);

}

}

public int getBalance() {

return balance;

}

}

class DepositTask implements Runnable {

private final BankAccount account;

private final int amount;

public DepositTask(BankAccount account, int amount) {

this.account = account;

this.amount = amount;

}

@Override

public void run() {

account.deposit(amount);

}

}

class WithdrawTask implements Runnable {

private final BankAccount account;

private final int amount;

public WithdrawTask(BankAccount account, int amount) {

this.account = account;
this.amount = amount;

}

@Override

public void run() {

account.withdraw(amount);

}

}
```

OUTPUT:



```
<terminated> BankAccountDemo [Java Application] C:\Users\venka\.p2\pool\plugins\org.ecli
Deposit Thread1 deposited amount 100, new balance: 100
Deposit Thread2 deposited amount 200, new balance: 300
Withdraw Thread2 withdrew amount 50, new balance: 250
Withdraw Thread1 withdrew amount 150, new balance: 100
Final balance: 100
```

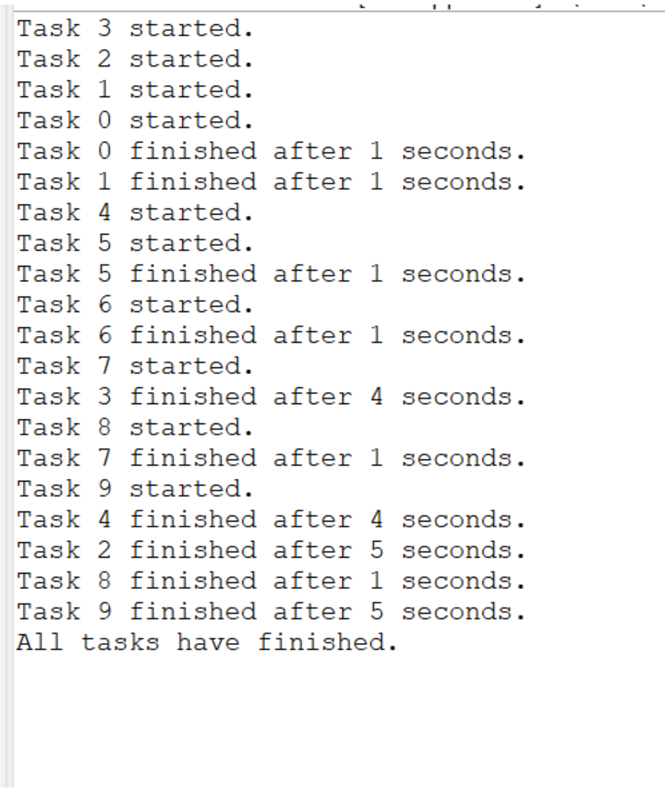
Task 5: Thread Pools and Concurrency Utilities

Create a fixed-size thread pool and submit multiple tasks that perform complex calculations or I/O operations and observe the execution.

SOLUTION:

```
package com.assignment.day18;


import java.util.concurrent.ExecutorService;

import java.util.concurrent.Executors;

import java.util.concurrent.TimeUnit;

import java.util.Random;


public class ThreadPoolDemo {
    public static void main(String[] args) {
        // Create a fixed-size thread pool with 4 threads
        ExecutorService executor = Executors.newFixedThreadPool(4);

        // Submit multiple tasks to the thread pool
        for (int i = 0; i < 10; i++) {
            executor.submit(new CalculationTask(i));
        }

        // Shutdown the executor service
        executor.shutdown();

        try {
            // Wait for all tasks to complete or timeout after 1 hour
            if (!executor.awaitTermination(1, TimeUnit.HOURS)) {
                executor.shutdownNow();
            }
        } catch (InterruptedException e) {
            executor.shutdownNow();
        }

        System.out.println("All tasks have finished.");
    }
}

class CalculationTask implements Runnable {
    private final int taskId;
    private final Random random = new Random();

    public CalculationTask(int taskId) {
        this.taskId = taskId;
    }

    @Override
    public void run() {
        System.out.println("Task " + taskId + " started.");

        // Simulate a complex calculation or I/O operation
        long duration = random.nextInt(5) + 1; // Random duration between 1 and 5 seconds
        try {
            TimeUnit.SECONDS.sleep(duration);
        } catch (InterruptedException e) {
            System.out.println("Task " + taskId + " was interrupted.");
        }

        System.out.println("Task " + taskId + " finished after " + duration + " seconds.");
    }
}
```

OUTPUT :



```
Task 3 started.
Task 2 started.
Task 1 started.
Task 0 started.
Task 0 finished after 1 seconds.
Task 1 finished after 1 seconds.
Task 4 started.
Task 5 started.
Task 5 finished after 1 seconds.
Task 6 started.
Task 6 finished after 1 seconds.
Task 7 started.
Task 3 finished after 4 seconds.
Task 8 started.
Task 7 finished after 1 seconds.
Task 9 started.
Task 4 finished after 4 seconds.
Task 2 finished after 5 seconds.
Task 8 finished after 1 seconds.
Task 9 finished after 5 seconds.
All tasks have finished.
```

Task 6: Executors, Concurrent Collections, CompletableFuture

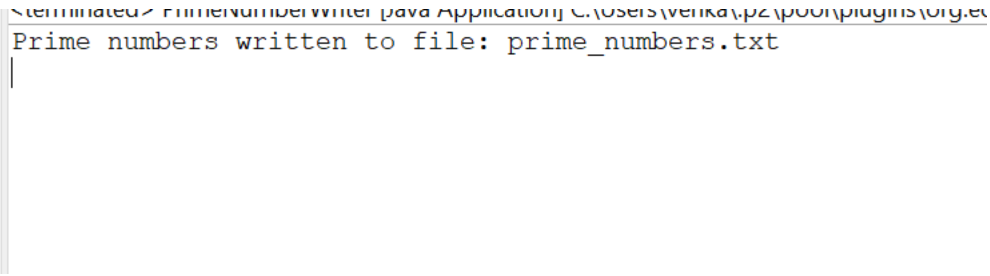
Use an ExecutorService to parallelize a task that calculates prime numbers up to a given number and then use CompletableFuture to write the results to a file asynchronously.

SOLUTION :

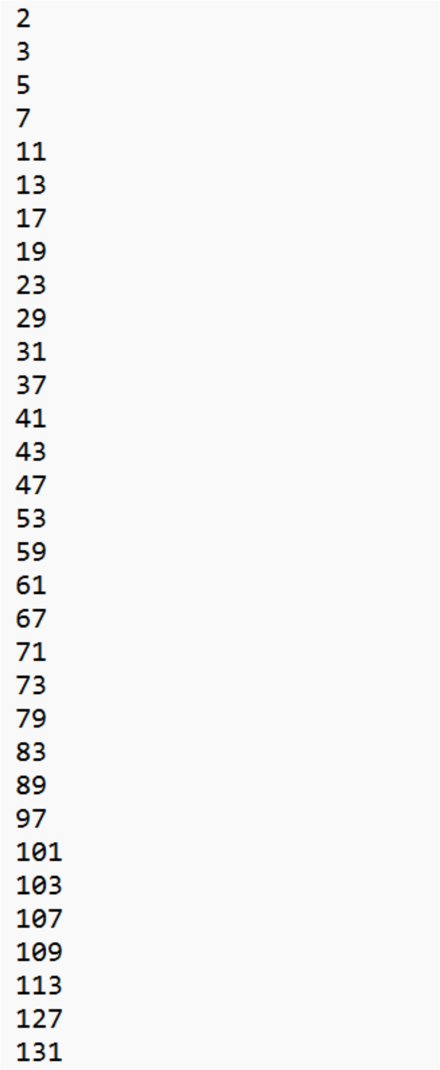
```
package com.assignment.day18;


import java.io.BufferedWriter;

import java.io.FileWriter;

import java.io.IOException;

import java.util.ArrayList;

import java.util.List;

import java.util.concurrent.CompletableFuture;

import java.util.concurrent.ExecutorService;

import java.util.concurrent.Executors;
import java.util.concurrent.Future;
import java.util.concurrent.TimeUnit;

public class PrimeNumberWriter {

    private static final int NUM_THREADS = 4;
    private static final String FILE_NAME = "prime_numbers.txt";

    public static void main(String[] args) throws Exception {
        int upperLimit = 1000;

        List<Future<List<Integer>>> primeNumberFutures = calculatePrimes(upperLimit);
        List<Integer> allPrimes = new ArrayList<>();

        for (Future<List<Integer>> future : primeNumberFutures) {
            allPrimes.addAll(future.get());
        }

        writePrimesToFileAsync(allPrimes);

        System.out.println("Prime numbers written to file: " + FILE_NAME);
    }

    private static List<Future<List<Integer>>> calculatePrimes(int upperLimit) throws Exception {
        ExecutorService executor = Executors.newFixedThreadPool(NUM_THREADS);
        List<Future<List<Integer>>> futures = new ArrayList<>();
        int chunkSize = upperLimit / NUM_THREADS;

        for (int i = 0; i < upperLimit; i += chunkSize) {
            int start = i + 1;
            int end = Math.min(i + chunkSize, upperLimit);
            futures.add(executor.submit(() -> findPrimesInRange(start, end)));
        }

        executor.shutdown();
        executor.awaitTermination(10, TimeUnit.SECONDS);

        return futures;
    }

    private static List<Integer> findPrimesInRange(int start, int end) {
        List<Integer> primes = new ArrayList<>();
        for (int num = start; num <= end; num++) {
            if (isPrime(num)) {
                primes.add(num);
            }
        }
        return primes;
    }

    private static boolean isPrime(int num) {
        if (num < 2) {
            return false;
        }
        for (int i = 2; i <= Math.sqrt(num); i++) {
            if (num % i == 0) {
                return false;
            }
        }
        return true;
    }
```

```
    private static void writePrimesToFileAsync(List<Integer> primes) throws Exception {
        CompletableFuture<Void> writeFuture = CompletableFuture.runAsync(() -> {
            try (BufferedWriter writer = new BufferedWriter(new FileWriter(FILE_NAME))) {
                for (int prime : primes) {
                    writer.write(prime + "\n");
                }
            } catch (IOException e) {
                e.printStackTrace();
            }
        });

        writeFuture.get();
    }
}
```

OUTPUT :



```
<terminated> PrimeNumberWriter [Java Application] C:\Users\venka\.p2\pool\plugins\org.ec
Prime numbers written to file: prime_numbers.txt
```



```
2
3
5
7
11
13
17
19
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31
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41
43
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59
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71
73
79
83
89
97
101
103
107
109
113
127
131
```

Task 7: Writing Thread-Safe Code, Immutable Objects

Design a thread-safe Counter class with increment and decrement methods. Then demonstrate its usage from multiple threads. Also, implement and use an immutable class to share data between threads.

SOLUTION :

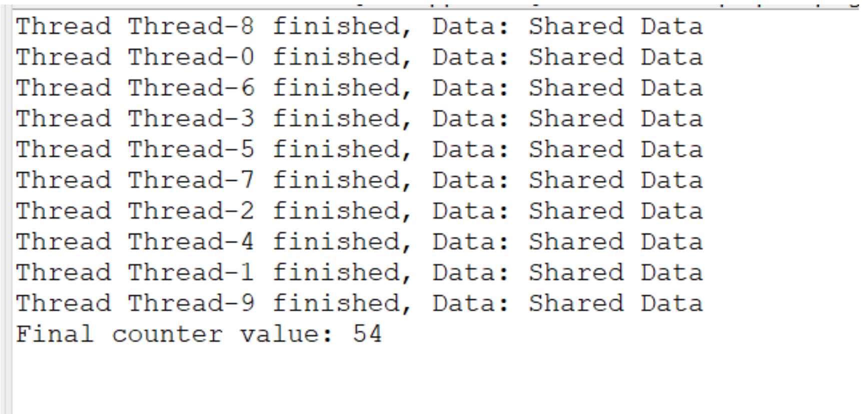
```
package com.assignment.day18;


import java.util.concurrent.atomic.AtomicInteger;
```

```
class ThreadSafeCounter {
    private final AtomicInteger count;

    public ThreadSafeCounter() {
        this.count = new AtomicInteger(0);
    }

    public void increment() {
        count.incrementAndGet();
    }

    public void decrement() {
        count.decrementAndGet();
    }

    public int get() {
        return count.get();
    }
}

class ImmutableData {
    private final String data;

    public ImmutableData(String data) {
        this.data = data;
    }

    public String getData() {
        return data;
    }
}
```

```
public class ThreadSafeDemo {
  public static void main(String[] args) {
    ThreadSafeCounter counter = new ThreadSafeCounter();
    ImmutableData data = new ImmutableData("Shared Data");

    int numThreads = 10;

    for (int i = 0; i < numThreads; i++) {
      Thread thread = new Thread(() -> {
        for (int j = 0; j < 1000; j++) {
          if (Math.random() > 0.5) {
            counter.increment();
          } else {
            counter.decrement();
          }
        }
        System.out.println("Thread " + Thread.currentThread().getName() + " finished, Data: " + data.getData());
      });
      thread.start();
    }

    for (int i = 0; i < numThreads; i++) {
      try {
        Thread.sleep(1000);
      } catch (InterruptedException e) {
        e.printStackTrace();
      }
    }
```

```
        System.out.println("Final counter value: " + counter.get());
    }
}
```

OUTPUT :



```
Thread Thread-8 finished, Data: Shared Data
Thread Thread-0 finished, Data: Shared Data
Thread Thread-6 finished, Data: Shared Data
Thread Thread-3 finished, Data: Shared Data
Thread Thread-5 finished, Data: Shared Data
Thread Thread-7 finished, Data: Shared Data
Thread Thread-2 finished, Data: Shared Data
Thread Thread-4 finished, Data: Shared Data
Thread Thread-1 finished, Data: Shared Data
Thread Thread-9 finished, Data: Shared Data
Final counter value: 54
```