Concurrency and Multi-threading - Assignment

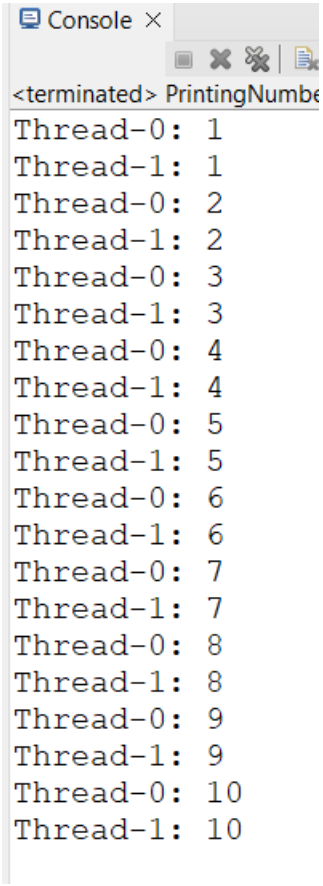
Task 1: Creating and Managing Threads

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

Code:

```
package creatingmanagingthreads;

public class PrintingNumbersThreads implements Runnable {
public static void main(String[] args) {
Runnable rTask = new PrintingNumbersThreads();
Thread t1 = new Thread(rTask);
Thread t2 = new Thread(rTask);
t1.start();
t2.start();
}

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

Output:



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..

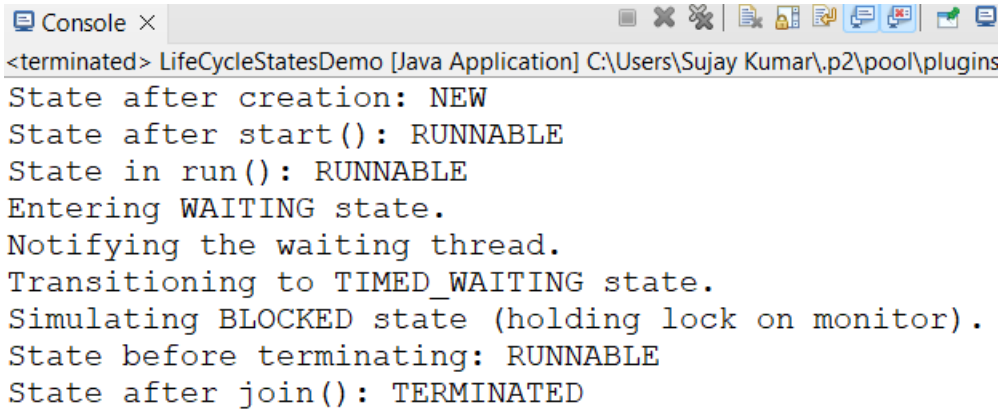
Code:

```
package lifecyclestates;

public class LifeCycleStatesDemo {
private static final Object monitor = new Object();

public static void main(String[] args) {
Thread thread = new Thread(new DemoRunnable());
```

```
System.out.println("State after creation: " + thread.getState());

thread.start();
System.out.println("State after start(): " + thread.getState());

sleep(100);
synchronized (monitor) {
System.out.println("Notifying the waiting thread.");
monitor.notify();
}
sleep(100);
try {
thread.join();
} catch (InterruptedException e) {
e.printStackTrace();
}

System.out.println("State after join(): " + thread.getState());
}

static class DemoRunnable implements Runnable {
@Override
public void run() {
try {
System.out.println("State in run(): " + Thread.currentThread().getState());

synchronized (monitor) {
System.out.println("Entering WAITING state.");
monitor.wait();
}

System.out.println("Transitioning to TIMED_WAITING state.");
Thread.sleep(1000);
```

```
synchronized (monitor) {
System.out.println("Simulating BLOCKED state (holding lock on monitor).");
}

System.out.println("State before terminating: " + Thread.currentThread().getState());
} catch (InterruptedException e) {
e.printStackTrace();
}
}
}

private static void sleep(int m) {
try {
Thread.sleep(m);
} catch (InterruptedException e) {
e.printStackTrace();
}
}
}
```

Output:



Task 3: Synchronization and Inter-thread Communication

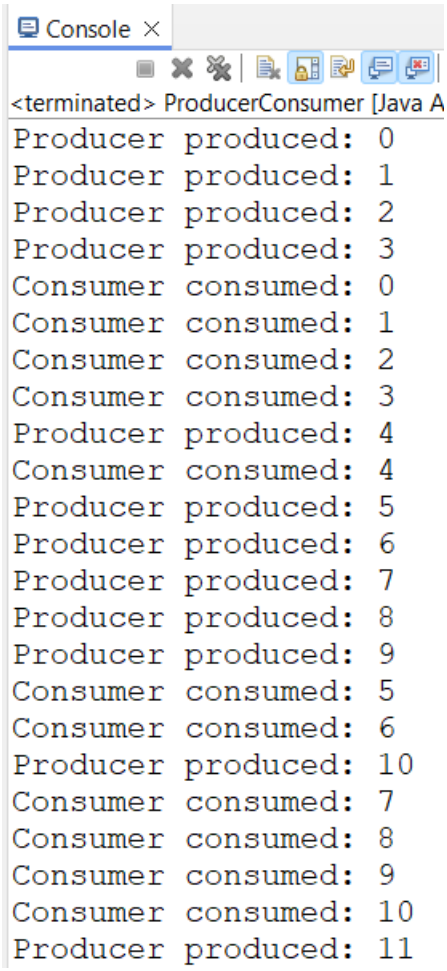
Implement a producer-consumer problem using wait() and notify() methods to handle the correct processing sequence between threads.

Code:

```
package producerconsumer;
import java.util.LinkedList;

public class ProducerConsumer {
private LinkedList<Integer> buffer = new LinkedList<>();
private final int CAPACITY = 5;

public void produce() throws InterruptedException {
int value = 0;
while (true) {
synchronized (this) {
while (buffer.size() == CAPACITY) {
wait();
}
System.out.println("Producer produced: " + value);
buffer.add(value++);
notify();
Thread.sleep(1000);
}
}
}

public void consume() throws InterruptedException {
while (true) {
synchronized (this) {
while (buffer.isEmpty()) {
wait();
}
int consumedValue = buffer.removeFirst();
System.out.println("Consumer consumed: " + consumedValue);
notify();
Thread.sleep(1000);
}
```

```
}
}

public static void main(String[] args) {
ProducerConsumer pc = new ProducerConsumer();

Thread pThread = new Thread(() -> {
try {
pc.produce();
} catch (InterruptedException e) {
e.printStackTrace();
}
});

Thread cThread = new Thread(() -> {
try {
pc.consume();
} catch (InterruptedException e) {
e.printStackTrace();
}
});

pThread.start();
cThread.start();
}
}
```

Output:



and output goes on……

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.

Code:

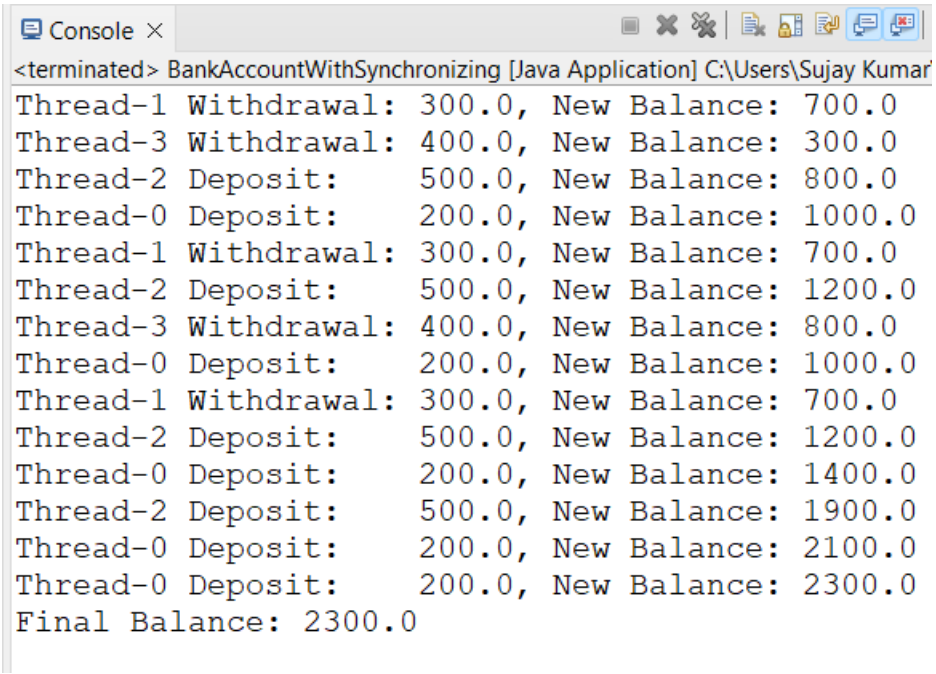
```
package synchronizedbacksystem;

public class BankAccountWithSynchronizing {
private double balance;

public BankAccountWithSynchronizing(double initialBalance) {
this.balance = initialBalance;
}
```

```
public synchronized void deposit(double amount) {
balance += amount;
System.out.println(Thread.currentThread().getName() + " Deposit: " + amount + ",
New Balance: " + balance);
}

public synchronized void withdraw(double amount) {
if (balance >= amount) {
balance -= amount;
System.out
.println(Thread.currentThread().getName() + " Withdrawal: " + amount + ", New
Balance: " + balance);
} else {
System.out.println("Insufficient funds for withdrawal: " + amount);
}
}

public static void main(String[] args) {
BankAccountWithSynchronizing account = new
BankAccountWithSynchronizing(1000);

Thread t1 = new Thread(() -> {
for (int i = 0; i < 5; i++) {
account.deposit(200);
try {
Thread.sleep(1000);
} catch (InterruptedException e) {
e.printStackTrace();
}
}
});

Thread t2 = new Thread(() -> {
for (int i = 0; i < 3; i++) {
```

```
account.withdraw(300);
try {
Thread.sleep(1000);
} catch (InterruptedException e) {
e.printStackTrace();
}
}
});

Thread t3 = new Thread(() -> {
for (int i = 0; i < 4; i++) {
account.deposit(500);
try {
Thread.sleep(1000);
} catch (InterruptedException e) {
e.printStackTrace();
}
}
});

Thread t4 = new Thread(() -> {
for (int i = 0; i < 2; i++) {
account.withdraw(400);
try {
Thread.sleep(1000);
} catch (InterruptedException e) {
e.printStackTrace();
}
}
});

t1.start();
t2.start();
t3.start();
```

```
t4.start();

try {
t1.join();
t2.join();
t3.join();
t4.join();
} catch (InterruptedException e) {
e.printStackTrace();
}

System.out.println("Final Balance: " + account.balance);
}
}
```

Output:



Task 5: Thread Pools and Concurrency Utilities

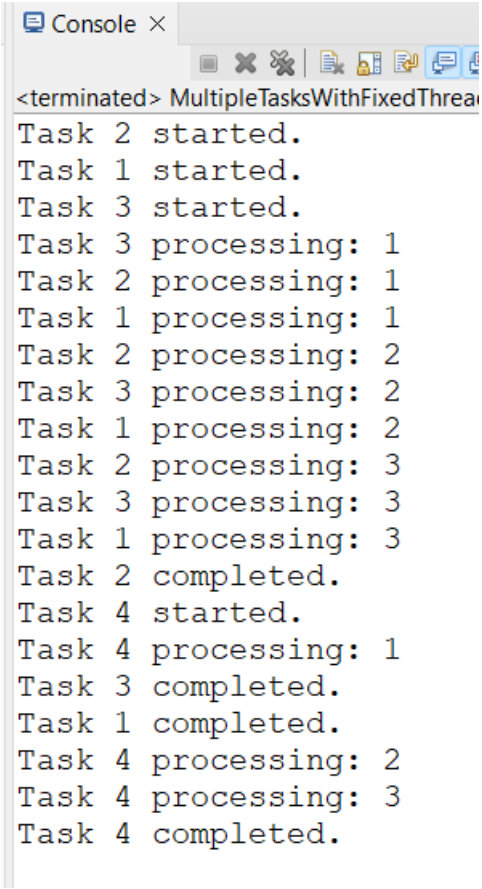
Create a fixed-size thread pool and submit multiple tasks that perform complex calculations or I/O operations and observe the execution.

Code:

```
package threadpool;
import java.util.concurrent.ExecutorService;
import java.util.concurrent.Executors;

class ComplexTask implements Runnable {
private int taskId;

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

@Override
public void run() {
System.out.println("Task " + taskId + " started.");
for (int i = 1; i < 4; i++) {
System.out.println("Task " + taskId + " processing: " + i);
try {
Thread.sleep(500);
} catch (InterruptedException e) {
e.printStackTrace();
}
}
System.out.println("Task " + taskId + " completed.");
}
}

public class MultipleTasksWithFixedThreadPool {
public static void main(String[] args) {

ExecutorService executor = Executors.newFixedThreadPool(3);

for (int i = 0; i < 4; i++) {
executor.submit(new ComplexTask(i + 1));
```

```
}
executor.shutdown();
}
}
```

Output:



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.

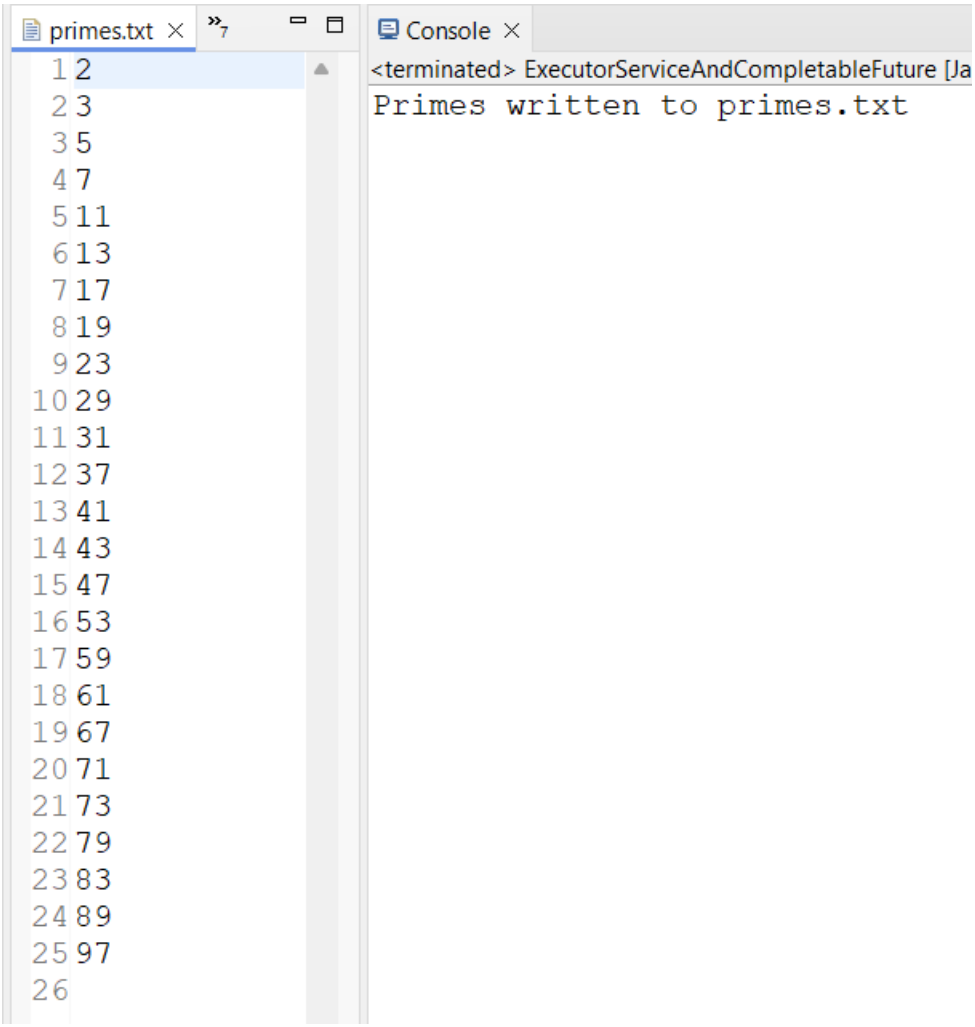
Code:

```
package concurrencyutilities;
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;

class PrimeCalculator {
public List<Integer> calculatePrimes(int n) {
List<Integer> primes = new ArrayList<>();
for (int i = 2; i <= n; i++) {
if (isPrime(i)) {
primes.add(i);
}
}
return primes;
}

private boolean isPrime(int number) {
if (number <= 1)
return false;
if (number <= 3)
return true;
if (number % 2 == 0 || number % 3 == 0)
return false;
for (int i = 5; i * i <= number; i += 6) {
if (number % i == 0 || number % (i + 2) == 0)
return false;
}
return true;
}
}

public class ExecutorServiceAndCompletableFuture {
public static void main(String[] args) throws IOException {
```

```
int n = 100;
String outputFile = "primes.txt";

ExecutorService executor = Executors.newFixedThreadPool(4);

CompletableFuture<List<Integer>> future = CompletableFuture.supplyAsync(() -> {
PrimeCalculator calculator = new PrimeCalculator();
return calculator.calculatePrimes(n);
}, executor);

CompletableFuture<Void> writeFuture = future.thenAcceptAsync(primes -> {
try (BufferedWriter writer = new BufferedWriter(new FileWriter(outputFile))) {
for (int prime : primes) {
writer.write(String.valueOf(prime));
writer.newLine();
}
System.out.println("Primes written to " + outputFile);
} catch (IOException e) {
e.printStackTrace();
}
}, executor);

executor.shutdown();
writeFuture.join();
}
}
```

Output:



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.

Counter.java Code:

```
package threadsafe;

public class Counter {
private int count;

public Counter() {
this.count = 0;
}
```

```
public synchronized void increment() {
count++;
}

public synchronized void decrement() {
count--;
}

public synchronized int getCount() {
return count;
}
public static void main(String[] args) {
Counter counter = new Counter();
Thread[] threads = new Thread[5];
for (int i = 0; i < threads.length; i++) {
threads[i] = new Thread(() -> {
for (int j = 0; j < 1000; j++) {
counter.increment();
counter.decrement();
}
});
threads[i].start();
}

for (Thread thread : threads) {
try {
thread.join();
} catch (InterruptedException e) {
e.printStackTrace();
}
}
System.out.println("Final count: " + counter.getCount());
}
```

```
}
```

CounterSnapshot.java Code:

```
package threadsafe;

class CounterSnapshot {
private final int count;

public CounterSnapshot(int count) {
this.count = count;
}

public int getCount() {
return count;
}
}
```

Output: