Lab Sheet 01 - Multi-threaded Java Application

Part 1: Introduction to Threads in Java

1. Create a Simple Thread Class

Steps:

I. create a new project named MultiThreadApp.
II. Inside the project, create a new class called SimpleThread.java.

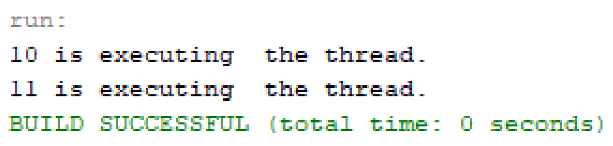
Code:

```
 public class SimpleThread extends Thread {
@Override
public void run () {
System.out.println(Thread.currentThread().getId() + " is executing  the thread.");
}

public static void main(String[] args) {
SimpleThread thread1 = new SimpleThread();
SimpleThread thread2 = new SimpleThread();

thread1.start(); // Starts thread1
thread2.start(); // Starts thread2
}
}
```

Explanation:

1. SimpleThread extends Thread
   - Creates a custom thread class.
2. run() method
   - Contains the code that runs when the thread starts.
3. Thread.currentThread().getId()
   - Gets the ID of the running thread.
4. main() method
   - Creates two threads and starts them with start(), so they run at the same time.

Output:



```
run:
10 is executing  the thread.
11 is executing  the thread.
BUILD SUCCESSFUL (total time: 0 seconds)
```

Part 2: Using Runnable Interface

2. Create a Runnable Class

Steps:

I. Create a new class called RunnableTask.java.

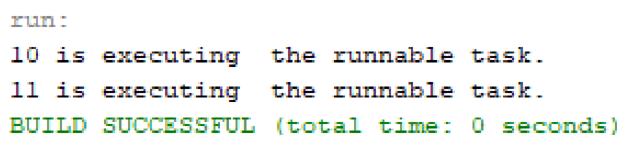
Code:

```
public class RunnableTask implements Runnable {
 @Override
 public void run() {
 System.out.println(Thread.currentThread().getId() + " is executing  the runnable task.");
 }

 public static void main(String[] args) {
 RunnableTask task1 = new RunnableTask();
 RunnableTask task2 = new RunnableTask();

 Thread thread1 = new Thread(task1);
 Thread thread2 = new Thread(task2);

 thread1.start(); // Starts thread1
 thread2.start(); // Starts thread2
 }
}
```

Explanation:

1. implements Runnable
   - Defines a class that can be executed by a thread.
2. run() method
   - Contains the task to run in a thread.
3. Thread.currentThread().getId()
   - Prints the ID of the thread running the task.
4. main() method
   - Creates two RunnableTask objects.
   - Wraps them in Thread objects.
   - Starts both threads to run concurrently.

Output:



```
run:
10 is executing  the runnable task.
11 is executing  the runnable task.
BUILD SUCCESSFUL (total time: 0 seconds)
```

Part 3: Synchronizing Threads

In a multi-threaded environment, synchronization is used to control access to shared resources like variables or files. It prevents data inconsistency caused by multiple threads accessing or modifying the resource at the same time.

3. Synchronizing Shared Resources

   Steps:

   I. Create a new class called Counter.java to demonstrate synchronization with shared resources.

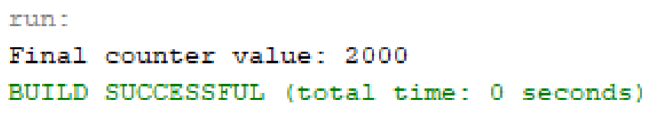
   Code:

```
    // Enter class Counter.java
      class Counter {
        private int count = 0;
// Synchronized method to ensure thread-safe access to the counter
     public synchronized void increment() {
          count++;
    }
     public int getCount() {
        return count;
}
}



//Enter  class SynchronizedExample.java
    public class SynchronizedExample extends Thread  {
        private Counter counter;
    public SynchronizedExample(Counter counter) {
        this.counter = counter;
 }
 @Override
   public void run() {
    for (int i = 0; i < 1000; i++) {
    counter.increment();
   }
  }
 public static void main(String[] args) throws InterruptedException {
    Counter counter = new Counter();
  // Create and start multiple threads
  Thread thread1 = new SynchronizedExample(counter);
  Thread thread2 = new SynchronizedExample(counter);
  thread1.start();
  thread2.start();
  // Wait for threads to finish
  thread1.join();
  thread2.join();
  System.out.println("Final counter value: " + counter.getCount());
 }
}
```

Explanation:

1. Shared Object:
   - Both threads use the same Counter object.
2. Thread Safety:
   - increment() is synchronized, so only one thread can modify count at a time.
3. join():
   - Waits for both threads to finish before printing the final result.

Output:



```
run:
Final counter value: 2000
BUILD SUCCESSFUL (total time: 0 seconds)
```

Part 4: Thread Pooling

A thread pool is a collection of pre-created, reusable threads. Instead of creating a new thread for every task, tasks are submitted to the pool, and available threads pick them up.

4. Using ExecutorService for Thread Pooling

Steps:

1. Create a new class called ThreadPoolExample.java.

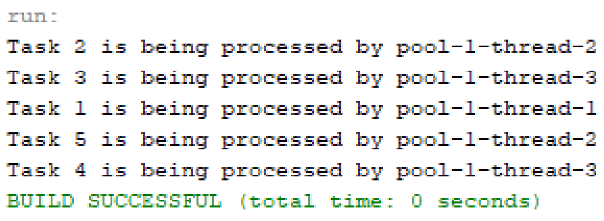
Code:

```
import java.util.concurrent.ExecutorService;
import java.util.concurrent.Executors;
class Task implements Runnable {
    private int taskId;
 public Task(int taskId) {
    this.taskId = taskId;
}
 @Override
 public void run() {
 System.out.println("Task " + taskId + " is being processed by " +
Thread.currentThread().getName());
 }
}
public class ThreadPoolExample {
  public static void main(String[] args) {
    // Create a thread pool with 3 threads
  ExecutorService executorService = Executors.newFixedThreadPool(3);
   // Submit tasks to the pool
 for (int i = 1; i <= 5; i++) {
 executorService.submit(new Task(i));
 }
 // Shutdown the thread pool
 executorService.shutdown();
 }
}
```

Explanation:

1. **Task class**:
    - A simple task that prints its ID and the thread name.
2. **ExecutorService**:
    - Manages a fixed pool of 3 threads.
3. **submit()**:
    - Sends 5 tasks to the thread pool.
4. **shutdown()**:
    - Closes the pool after tasks are done.

Output:



```
run:
Task 2 is being processed by pool-1-thread-2
Task 3 is being processed by pool-1-thread-3
Task 1 is being processed by pool-1-thread-1
Task 5 is being processed by pool-1-thread-2
Task 4 is being processed by pool-1-thread-3
BUILD SUCCESSFUL (total time: 0 seconds)
```

Part 5: Thread Lifecycle and States

In Java, threads can exist in several states during their lifecycle. These states include:

1. New: A thread is created but not yet started.
2. Runnable: A thread is ready to run, waiting for CPU time.
3. Blocked: A thread is blocked waiting for a resource.
4. Waiting: A thread is waiting indefinitely for another thread to perform particular action.
5. Terminated: A thread has finished execution.

5.Thread Lifecycle Example

Steps:

1. Create a new class called ThreadLifecycleExample**.**java

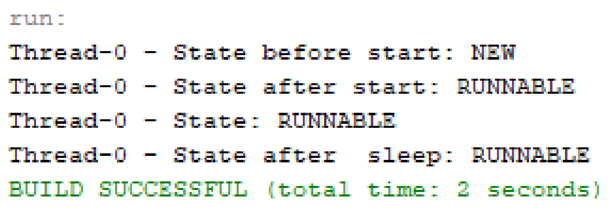
Code:

```
 public class ThreadLifecycleExample extends Thread {
   @Override
  public void run() {
    System.out.println(Thread.currentThread().getName() + " - State: " +
Thread.currentThread().getState());

 try {
 Thread.sleep(2000); // Simulate waiting state
 }
 catch (InterruptedException e) {
 e.printStackTrace();
 }
 System.out.println(Thread.currentThread().getName() + " - State after  sleep: " +
Thread.currentThread().getState());
 }

 public static void main(String[] args) {
 ThreadLifecycleExample thread = new ThreadLifecycleExample();
System.out.println(thread.getName() + " - State before start: " +  thread.getState());
 thread.start(); // Start the thread
 System.out.println(thread.getName() + " - State after start: " +  thread.getState());
 }
}
```

Explanation:

1. Before start()
   - Thread is in NEW state.
2. After start()
   - Thread moves to RUNNABLE, waiting to run.
3. Inside run()
   - When executing, it's in RUNNING state.
4. Thread.sleep(2000)
   - Thread enters TIMED_WAITING state for 2 seconds.
5. After sleep
   - Thread resumes and completes, ending in TERMINATED state.

Output:



```
run:
Thread-0 - State before start: NEW
Thread-0 - State after start: RUNNABLE
Thread-0 - State: RUNNABLE
Thread-0 - State after  sleep: RUNNABLE
BUILD SUCCESSFUL (total time: 2 seconds)
```