CNT 4714 – Project 2 – Summer 2017

Title: "Project 2: An Application Using Cooperating and Synchronized Multiple Threads In Java Using Locks"
Points: 100 points
Due Date: Sunday June 18, 2017 by 11:59 pm (WebCourses time)

Objectives: To practice programming cooperating, synchronized multiple threads of execution.

Description: In this programming assignment you will simulate the deposits and withdrawals made to a fictitious bank account (I'll let you use my real bank account if you promise to make only deposits! ☺). In this case the deposits and withdrawals will be made by synchronized threads. Synchronization is required for two reasons – (1) mutual exclusion (updates cannot be lost) and (2) because a withdrawal cannot occur if the amount of the withdrawal request is greater than the current balance in the account. This means that access to the account (the shared object) must be synchronized. This application requires cooperation and communication amongst the various threads (cooperating synchronized threads). (In other words, this problem is similar to the producer/consumer problem where there is more than one producer and more than one consumer process active simultaneously.) If a withdrawal thread attempts to withdraw an amount greater than the current balance in the account – then it must block itself and wait until a deposit has occurred before it can try again. As we covered in the lecture notes, this will require that the deposit threads signal all waiting withdrawal threads whenever a deposit is completed.

1. To keep things relatively simple as well as to see immediate results from a series of transactions (deposits and withdrawals) assume that deposits are made in amounts ranging from $1 to $200 (even dollars only) and withdrawals are made in amounts ranging from $1 to $50 (again, even dollars only).

2. You should have four deposit threads and six withdrawal threads executing simultaneously.

3. Once a deposit thread has executed, put it to sleep for few milliseconds or so (depends a little bit on the speed of your system as to how long you will want to sleep the depositor threads - basically we want to ensure a lot more withdrawals than deposits) to allow other threads to execute. This is the only situation in which a deposit thread will block.

4. For withdrawal threads, things will be a bit different depending on whether you are working on a single or multi-core processor.

    a. For single core processors, once a withdrawal thread has executed, have it yield to another thread. Since the thread is giving up the processor voluntarily, it will be unlikely to run again (attempt a second withdrawal in a row), before another thread runs. Note however, that it does not prevent it from running again, if all other withdrawal threads are blocked and all depositors are sleeping, it will run again.
    b. For multi-core processors, once a withdrawal thread has executed, have it sleep for some random period of time (again, a few milliseconds should be fine). Depending on which core a thread is executing, yielding the CPU won't ensure that the same thread will not run again immediately. While, sleeping the thread will also not ensure that it will not run two or more times in succession, it is less likely to do so in the multi-core environment.
    c. What we don't want to happen is either a single withdrawal thread or a group of withdrawal threads gaining the CPU and then executing a long sequence of withdrawal operations. Recall though that withdrawal threads block if they attempt to withdraw more than the current balance in the account.
    d. Similarly, we don't want depositor threads monopolizing the CPU either and causing the balance in the account to grow continuously. See page 7 for an illustration of this.

5. Assume all threads have the same priority.

6. The output from your program must look reasonably similar to the sample output shown below.

7. **Do not put the threads into a counted loop for your simulation.** In other words, the `run()` method should be an infinite loop.

8. **Do not use the Java synchronized statement.** I want you to handle the locking and signaling yourself. No monitors!

References:

Notes: Lecture Notes for Multithreaded Applications.

Restrictions:
Your source files shall begin with comments containing the following information:

```
/*  Name:
    Course: CNT 4714 Summer 2017
    Assignment title: Project 2 – Synchronized, Cooperating Threads Under Locking
    Due Date: June 18, 2017
*/
```

Input Specification: Internal to the program.

Output Specification: Console based. Your output should appear reasonably similar to the output shown below.

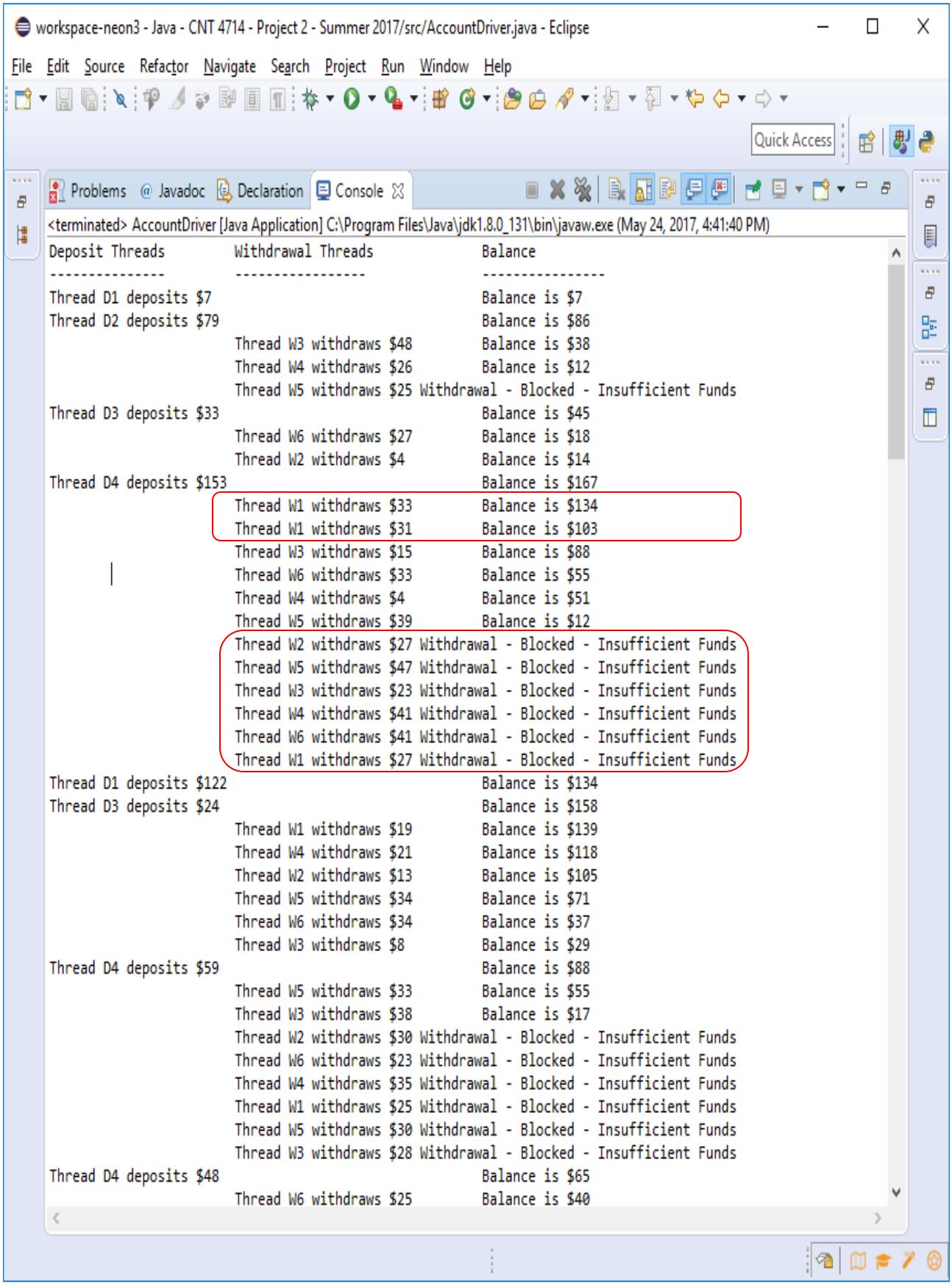
Deliverables:

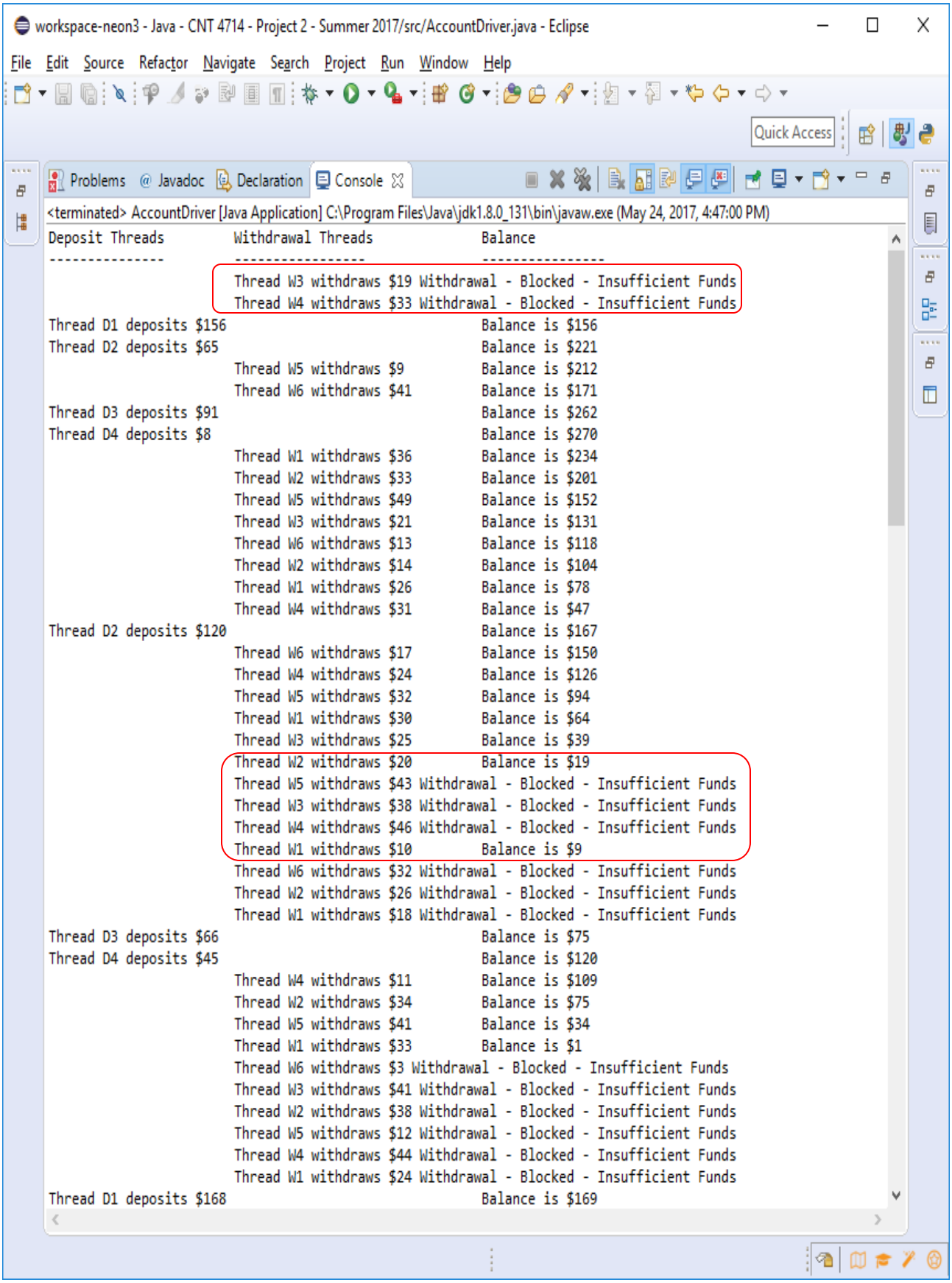
(1) Zip up all of your .java files and submit them via WebCourses no later than 11:59pm Sunday June 18, 2017.

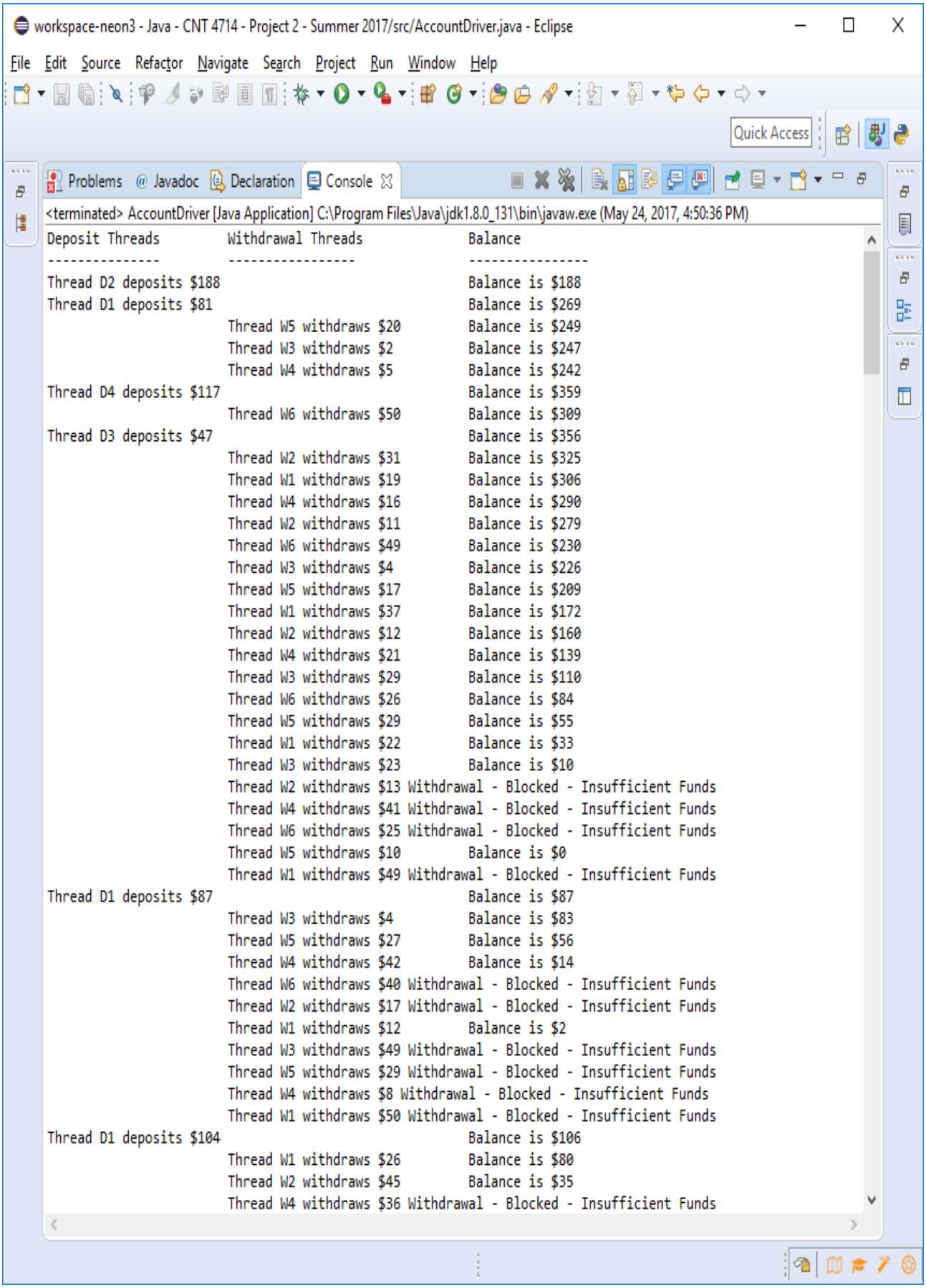
(2) Include at least one screen shot which illustrates the execution of your synchronized threaded application. See below for some representative examples. You can either do a screen shot of the console window like I did below or redirect your output to a file and take a screen shot from an editor.

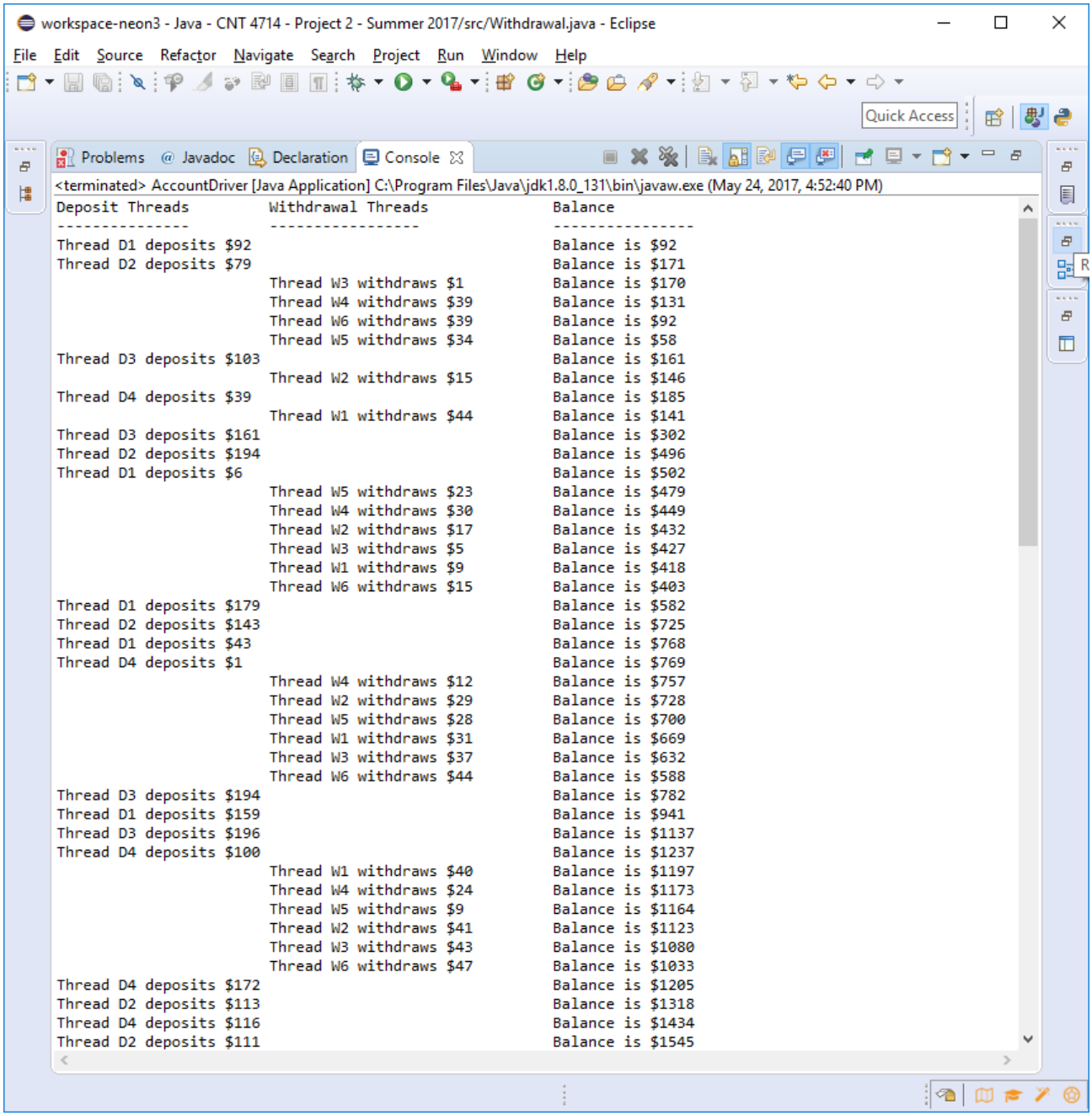
Additional Information:

Shown below are three example screen shots of the output from this program to help illustrate how your application is to operate and display the results. The last page illustrates execution runs that you do not want to produce.


workspace-neon3 - Java - CNT 4714 - Project 2 - Summer 2017/src/AccountDriver.java - Eclipse
File Edit Source Refactor Navigate Search Project Run Window Help
Quick Access
Problems Javadoc Declaration Console
<terminated> AccountDriver [Java Application] C:\Program Files\Java\jdk1.8.0_131\bin\javaw.exe (May 24, 2017, 4:41:40 PM)
Deposit Threads Withdrawal Threads Balance
Thread D1 deposits $7 Balance is $7
Thread D2 deposits $79 Balance is $86
Thread W3 withdraws $48 Balance is $38
Thread W4 withdraws $26 Balance is $12
Thread W5 withdraws $25 Withdrawal - Blocked - Insufficient Funds
Thread D3 deposits $33 Balance is $45
Thread W6 withdraws $27 Balance is $18
Thread W2 withdraws $4 Balance is $14
Thread D4 deposits $153 Balance is $167
Thread W1 withdraws $33 Balance is $134
Thread W1 withdraws $31 Balance is $103
Thread W3 withdraws $15 Balance is $88
Thread W6 withdraws $33 Balance is $55
Thread W4 withdraws $4 Balance is $51
Thread W5 withdraws $39 Balance is $12
Thread W2 withdraws $27 Withdrawal - Blocked - Insufficient Funds
Thread W5 withdraws $47 Withdrawal - Blocked - Insufficient Funds
Thread W3 withdraws $23 Withdrawal - Blocked - Insufficient Funds
Thread W4 withdraws $41 Withdrawal - Blocked - Insufficient Funds
Thread W6 withdraws $41 Withdrawal - Blocked - Insufficient Funds
Thread W1 withdraws $27 Withdrawal - Blocked - Insufficient Funds
Thread D1 deposits $122 Balance is $134
Thread D3 deposits $24 Balance is $158
Thread W1 withdraws $19 Balance is $139
Thread W4 withdraws $21 Balance is $118
Thread W2 withdraws $13 Balance is $105
Thread W5 withdraws $34 Balance is $71
Thread W6 withdraws $34 Balance is $37
Thread W3 withdraws $8 Balance is $29
Thread D4 deposits $59 Balance is $88
Thread W5 withdraws $33 Balance is $55
Thread W3 withdraws $38 Balance is $17
Thread W2 withdraws $30 Withdrawal - Blocked - Insufficient Funds
Thread W6 withdraws $23 Withdrawal - Blocked - Insufficient Funds
Thread W4 withdraws $35 Withdrawal - Blocked - Insufficient Funds
Thread W1 withdraws $25 Withdrawal - Blocked - Insufficient Funds
Thread W5 withdraws $30 Withdrawal - Blocked - Insufficient Funds
Thread W3 withdraws $28 Withdrawal - Blocked - Insufficient Funds
Thread D4 deposits $48 Balance is $65
Thread W6 withdraws $25 Balance is $40


workspace-neon3 - Java - CNT 4714 - Project 2 - Summer 2017/src/AccountDriver.java - Eclipse
File Edit Source Refactor Navigate Search Project Run Window Help
Quick Access
Problems Javadoc Declaration Console
<terminated> AccountDriver [Java Application] C:\Program Files\Java\jdk1.8.0_131\bin\javaw.exe (May 24, 2017, 4:47:00 PM)
Deposit Threads Withdrawal Threads Balance
Thread W3 withdraws $19 Withdrawal - Blocked - Insufficient Funds
Thread W4 withdraws $33 Withdrawal - Blocked - Insufficient Funds
Thread D1 deposits $156 Balance is $156
Thread D2 deposits $65 Balance is $221
Thread W5 withdraws $9 Balance is $212
Thread W6 withdraws $41 Balance is $171
Thread D3 deposits $91 Balance is $262
Thread D4 deposits $8 Balance is $270
Thread W1 withdraws $36 Balance is $234
Thread W2 withdraws $33 Balance is $201
Thread W5 withdraws $49 Balance is $152
Thread W3 withdraws $21 Balance is $131
Thread W6 withdraws $13 Balance is $118
Thread W2 withdraws $14 Balance is $104
Thread W1 withdraws $26 Balance is $78
Thread W4 withdraws $31 Balance is $47
Thread D2 deposits $120 Balance is $167
Thread W6 withdraws $17 Balance is $150
Thread W4 withdraws $24 Balance is $126
Thread W5 withdraws $32 Balance is $94
Thread W1 withdraws $30 Balance is $64
Thread W3 withdraws $25 Balance is $39
Thread W2 withdraws $20 Balance is $19
Thread W5 withdraws $43 Withdrawal - Blocked - Insufficient Funds
Thread W3 withdraws $38 Withdrawal - Blocked - Insufficient Funds
Thread W4 withdraws $46 Withdrawal - Blocked - Insufficient Funds
Thread W1 withdraws $10 Balance is $9
Thread W6 withdraws $32 Withdrawal - Blocked - Insufficient Funds
Thread W2 withdraws $26 Withdrawal - Blocked - Insufficient Funds
Thread W1 withdraws $18 Withdrawal - Blocked - Insufficient Funds
Thread D3 deposits $66 Balance is $75
Thread D4 deposits $45 Balance is $120
Thread W4 withdraws $11 Balance is $109
Thread W2 withdraws $34 Balance is $75
Thread W5 withdraws $41 Balance is $34
Thread W1 withdraws $33 Balance is $1
Thread W6 withdraws $3 Withdrawal - Blocked - Insufficient Funds
Thread W3 withdraws $41 Withdrawal - Blocked - Insufficient Funds
Thread W2 withdraws $38 Withdrawal - Blocked - Insufficient Funds
Thread W5 withdraws $12 Withdrawal - Blocked - Insufficient Funds
Thread W4 withdraws $44 Withdrawal - Blocked - Insufficient Funds
Thread W1 withdraws $24 Withdrawal - Blocked - Insufficient Funds
Thread D1 deposits $168 Balance is $169


workspace-neon3 - Java - CNT 4714 - Project 2 - Summer 2017/src/AccountDriver.java - Eclipse
File Edit Source Refactor Navigate Search Project Run Window Help
Quick Access
Problems Javadoc Declaration Console
<terminated> AccountDriver [Java Application] C:\Program Files\Java\jdk1.8.0_131\bin\javaw.exe (May 24, 2017, 4:50:36 PM)
Deposit Threads Withdrawal Threads Balance
Thread D2 deposits $188 Balance is $188
Thread D1 deposits $81 Balance is $269
Thread W5 withdraws $20 Balance is $249
Thread W3 withdraws $2 Balance is $247
Thread W4 withdraws $5 Balance is $242
Thread D4 deposits $117 Balance is $359
Thread W6 withdraws $50 Balance is $309
Thread D3 deposits $47 Balance is $356
Thread W2 withdraws $31 Balance is $325
Thread W1 withdraws $19 Balance is $306
Thread W4 withdraws $16 Balance is $290
Thread W2 withdraws $11 Balance is $279
Thread W6 withdraws $49 Balance is $230
Thread W3 withdraws $4 Balance is $226
Thread W5 withdraws $17 Balance is $209
Thread W1 withdraws $37 Balance is $172
Thread W2 withdraws $12 Balance is $160
Thread W4 withdraws $21 Balance is $139
Thread W3 withdraws $29 Balance is $110
Thread W6 withdraws $26 Balance is $84
Thread W5 withdraws $29 Balance is $55
Thread W1 withdraws $22 Balance is $33
Thread W3 withdraws $23 Balance is $10
Thread W2 withdraws $13 Withdrawal - Blocked - Insufficient Funds
Thread W4 withdraws $41 Withdrawal - Blocked - Insufficient Funds
Thread W6 withdraws $25 Withdrawal - Blocked - Insufficient Funds
Thread W5 withdraws $10 Balance is $0
Thread W1 withdraws $49 Withdrawal - Blocked - Insufficient Funds
Thread D1 deposits $87 Balance is $87
Thread W3 withdraws $4 Balance is $83
Thread W5 withdraws $27 Balance is $56
Thread W4 withdraws $42 Balance is $14
Thread W6 withdraws $40 Withdrawal - Blocked - Insufficient Funds
Thread W2 withdraws $17 Withdrawal - Blocked - Insufficient Funds
Thread W1 withdraws $12 Balance is $2
Thread W3 withdraws $49 Withdrawal - Blocked - Insufficient Funds
Thread W5 withdraws $29 Withdrawal - Blocked - Insufficient Funds
Thread W4 withdraws $8 Withdrawal - Blocked - Insufficient Funds
Thread W1 withdraws $50 Withdrawal - Blocked - Insufficient Funds
Thread D1 deposits $104 Balance is $106
Thread W1 withdraws $26 Balance is $80
Thread W2 withdraws $45 Balance is $35
Thread W4 withdraws $36 Withdrawal - Blocked - Insufficient Funds



We don’t want to see this sort of scenario where the depositors are monopolizing the account. Indication is the depositor threads aren’t sleeping long enough.