ISyE 3104: Introduction to Supply Chain Modeling:
Manufacturing and Warehousing
Instructor: Spyros Reveliotis
Spring 2013
Homework #4
Due Date: 4/16/13

Reading Assignment:

This homework covers the modeling, analysis and design of (discrete-part) high-volume production systems. Reading material for this part of the course is provided in:

a) The two sets of Powerpoint slides that are items #2 and #3 in the list of "Course Materials" that is posted at the course website (http://www2.isye.gatech.edu/~spyros/courses/IE3104/Spring13/course_materials.html)
b) The material on Assembly Line Balancing that has been posted on the course electronic reserves.
c) I also recommend that you read the material on KANBAN and CONWIP systems from Chapter 7 of your textbook that was indicated in my earlier email, i.e., Section 7.1, Section 7.2 with emphasis on 7.2.1, 7.2.2, 7.2.5, 7.2.6, 7.2.7.1, 7.2.7.2, 7.2.8, 7.2.11 and the introductory part of Section 7.3. For this part, the emphasis should be primarily on the concepts instead of the computational techniques.

Finally, remember that in order to access the electronic reserves for our course, you will need the following password: he4mo45g

Problem Set:

1. Solve Problems 27 and 29 from the posted material on the ALB problem at the library electronic reserves.

2. Consider a production line consisting of two single-machine stations. The processing times at these two stations (in particular, the first two moments of the distributions of these processing times) are characterized by the following information:

Attribute	**Station 1**	**Station 2**
t_0	11min	11min
c_0	0.5	0.5

Parts are released in this line at a deterministic pace with a part inter-release time of 12 min.

Answer the following questions:

i. Argue that the above operational regime is stable.
ii. What is the line throughput in the considered operational regime?
iii. What is the expected cycle time for a part going through the entire line?
iv. What is the average WIP waiting to be processed at each of the two stations? Which station has the highest WIP level? Why?
v. What is the maximum production rate that can be supported by this line in a stable mode? Please, state your answer in parts per hour.
vi. Can we effect a decrease of the part cycle time by 10% by reducing the variability at the two line stations (not necessarily in a uniform manner)? Please, justify your answer.

3. Consider a single-server processing station where jobs arrive according to a Poisson process with rate of 5 jobs per hour. The arriving stream of jobs is classified into two types, A and B, and it is processed on a first-come-first-serve basis. An arriving part will be type A with probability $p = 0.3$. Processing times for part type A are normally distributed with a mean of 10 min and a st. dev. of 2 min. Processing times for part type B are normally distributed with a mean of 12 min and a st. dev. of 4 min.
   i. Show that the station operation is stable.
   ii. What is the expected cycle time for jobs going through the station?
   iii. Determine the condition that must be satisfied by the type-defining probability p in order to guarantee the stability of the line. Can you provide a natural interpretation for this condition?

4. Consider a workstation that produces a final product by fastening together two major sub-assemblies. Jobs arriving at this workstation consist of kits containing one unit from each of the two sub-assemblies, and if both parts are in good order, the fastening operation can be performed at an average time of t=2min. However, each of the two parts in a kit can also be defective, with corresponding probabilities p1=0.3 and p2=0.2. A defective part must go through some additional rework that occurs locally and requires an exponentially distributed time; the corresponding processing rates are r1=0.2min-1 and r2=0.1min-1. Part failures are independent from each other, and in the case that both parts in a kit are defective, the necessary reworks take place simultaneously. Use the above information in order to determine the effective processing capacity of this station. Express your result in product units per hour.

   Hint: Remember that the minimum of two exponential random variables X and Y with rates r_X and r_Y is another exponential random variable Z with rate $r_Z = r_X+r_Y$. Also, the probability that $Z = \min\{X,Y\} = X$ is equal to r_X/r_Z.