Group Assignment 2 (100 points)

1. **Newsvendor Game Simulation (35 points)**
In the in-class Newsvendor game, we played it twice. In the first time, you have not learned Newsvendor model, the orders you put shows strong demand chasing patterns; in the second time, your behavior is more rational and shows smaller demand chasing patterns. Many of you input constant decisions.

    a. Write the formula respectively for sales quantity (S), Salvage quantity (Sa), and Lost sales (L) as functions of order quantity Q and Demand D. (6 points)

    b. What is the relationship between salvage quantity (Sa) and Lost sales (L) in each round? (3 points)

    c. The objective of the game is to maximize the long-run cumulative profit, which is equivalent to maximize the expected profit for one round. Suppose the demand density function is $f(x)$, if demand x is less than order quantity Q, the profit is $px - cQ + v(Q - x)$; if demand x is large than order quantity Q, the profit is $pQ - cQ$. We can write the objective (maximize the expected profit):
    $$\max_{Q} \int_{0}^{Q} \big(px - cQ + v(Q - x)\big) f(x)dx + \int_{Q}^{\infty} (pQ - cQ)\, f(x)dx$$
    We have defined the overage cost $C_o = c - v$, the underage cost $C_u = p - c$. Write an equivalent objective that minimizes the expected total costs. (5 points)

For now on, the price per unit is $p = 4$, the cost per unit is $c = 2$, the salvage value per unit is $v = 1$. The demand distribution is uniform [1,100].

d. Caculate the optimal order. (4 points)

e. Suppose after each round, the demand of that round is shown. There are 4 students. Student 1 constantly orders the average demand in each round; Student 2 constantly orders optimal quality in each round; Student 3 orders the average demand in the first round, and then constantly chases the demand (order the last round demand); Student 4 puts random i.i.d orders uniform [1,100]. The related code is available at Moodle. Use your student ID (one of your group member) as the seed and play 100 rounds. Rank the profit performance of the four students. (5 points)

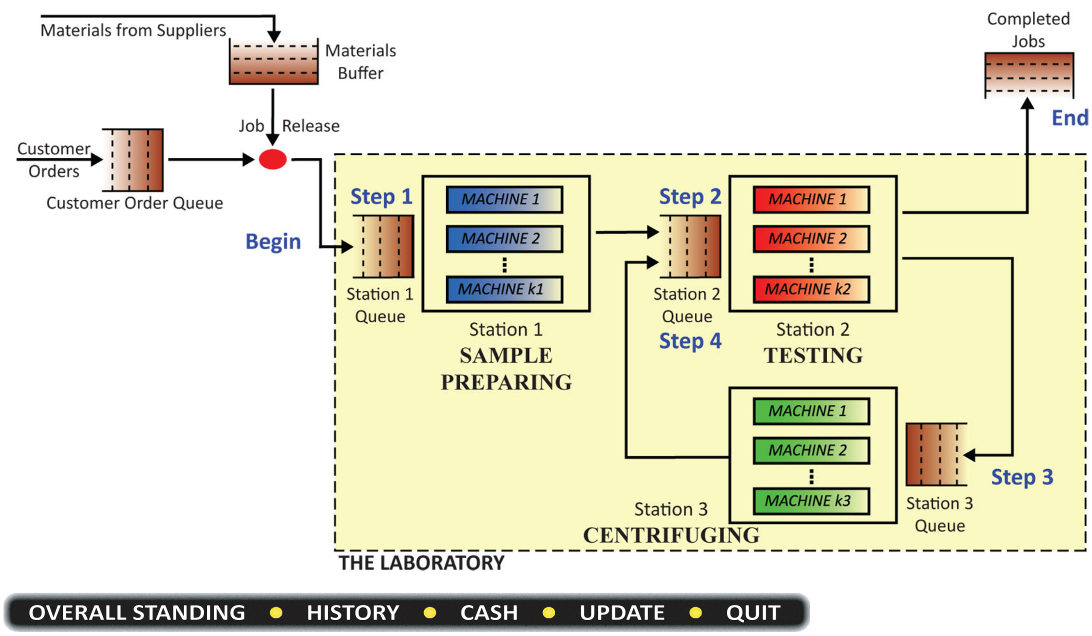
f. In reality, the manager may not have demand distribution. If you plan to play for 100 rounds and the objective is to maximize the total cumulative profit. You know the upper bound of demand is 100. Here is your plan: For the first several rounds (maybe 10-30 rounds), you put larger orders to learn the demand (learning periods); then you update the demand distribution and calculate the newsvendor optimal order quantity based on normal distribution assumption, and then place the order accordingly (earning periods). Use your student ID as the seed. Try and compare different length of learning periods. Provide a reasonably good plan. (12 points)

2. **Littlefield Game Simulation**

The detailed description is given by kouvelis.pdf document. We will play this game in class by group and 20 points will be allocated based your performance. The team with the highest cash position gets all 20 points and set the bench. Each of other teams get a score proportional to their cash position relative to the best team. (20 points)

This following problems are based on the Littlefield game process. **The context and all the paratemeters are changed**.

Littlefield Laboratories is a state-of-the-art highly automated blood samples testing lab. Samples are tested using a test kit that is disposed after testing one sample. These kits are procured from a single supplier and stored in the materials buffer. The testing process consists of four steps carried out at 3 stations called sample preparing, testing and centrifuging. The blood samples arrive from hospitals and clinics as customer orders. The first step consists of matching each sample with one test kit from the buffer (the combination is referred to as a job), filling test tubes with blood and preparing for the testing process. This is done at the sample preparing station. The job then moves to the testing station where basic tests are conducted on the blood sample in step 2. In the third step, the sample is centrifuged to extract plasma and blood cells. Finally, the job moves back to the testing station for additional testing in step 4. All samples go through additional testing and then the results are sent to the customer.



We do not need to worry about the cash position. We just do theoretic calculations. We assume that step 1 takes 4.7 hours, step 2 takes 2.7 hours, step 3 takes 1.5 hours, and step 4 takes 1 hour.

We use the following contract:

price = \$240; quoted lead time = 1 day; maximum lead time = 3 days.

We assume the demand is a Poisson process with rate 1 job per hour. Therefore, everyday, the demand is an independent Poisson distribution with mean 24. For the testing kits, the order lead time is 4 days. Note that this lead time is different from the lead time (waiting time) of the blood testing. (45 points)

a) To satisfy all the demand, what is the minimal number of machines should you purchase for each station? With the minimal equipment, what are the average waiting times and number of jobs in the system? It is reasonable to use Possion arrivals for each station 1. You can use M/D/m queueing models to approximate stations 1 and 3. Since station 2 are handling two different steps, you shall use M/G/m to approximate it. (9 points)

b) If the waiting time (lead time) of jobs has a mean of x (based on your calculation in part (a)), and is uniformly distributed on [9.9, 2x-9.9]. What is the average revenue ($240 minus penalty if overdue) of each job? (5 points)

c) You may also change the way testing is scheduled. Currently, samples at the testing station are scheduled First-In-First-Out (FIFO), but you can give priority status either to the step 2 test or the step 4 test. Which schedule should you use? Why? (Hint: When jobs waiting before a server have different sizes (service times), Shortest Job First rule minimize the total waiting.) (4 points)

Test kits are purchased from a single supplier and cost $100 per kit. There is also a fixed cost of $1000 per shipment of test kits, independent of the shipment size. The revenue earned from filled orders increases the cash balance. The balance earns interest at rate of 10% per year. The supplier requires 4 days to ship any quantity of test kits.

d) Using EOQ model, what is the optimal order quantity for the raw materials? (6 points)

e) Based on the EOQ order cycle, calculate the target service level. (Hint: since the raw materials can be used in the next cycle, the overage cost is the interest cost of the unused raw materials. Meanwhile, the underage cost is the marginal expected profit loss from lost profit due to overdue penalty. Note that all jobs are served and no job is lost. Let us assume the waiting time of a job during out-of-stock time will be more than 72 hours.) (7 points)

f) Based on the target service level, find the optimal continuous review policy. (Hint: The daily demand is Poisson distribution with mean 24, and it can be approximated by Normal distribution with mean 24 and variance of 24.) (7 points)

g) If the manager cannot track the inventory in real time, and can only review periodically, what is the optimal Peridoical Revew Policy (Use EOQ model for the length of period)? (7 points)