SAMPLE FINAL EXAM SOLUTIONS

Question 1

In 2002, Baja Fresh was the leading chain in the quick-service, "Fresh-Mex" restaurant segment, which emphasizes freshly prepared meals. By 2005, it had lost that position to Chipotle Mexican Grill. Today, it lags behind both Chipotle and Qdoba Mexican Grill. Many industry observers claim that the breadth of Baja Fresh's menu is partially to blame. The chain has always offered a wide variety of items while Chipotle's menu features less than 20 choices. Why would the range of offerings be a problem for a quick-service restaurant?

Firms face trade offs in process design. One such trade off is between variety and speed. Holding cost and quality constant, it will difficult for Baja Fresh to match Chipotle in terms of speed with its wider variety. Alternatively, Baja Fresh's variety may force it to sacrifice quality or cost.

Question 2

When a Palu Gear store manages its inventory of jackets by ordering 520 jackets when inventory hits the reorder point of 188 jackets, it is using a pull system.

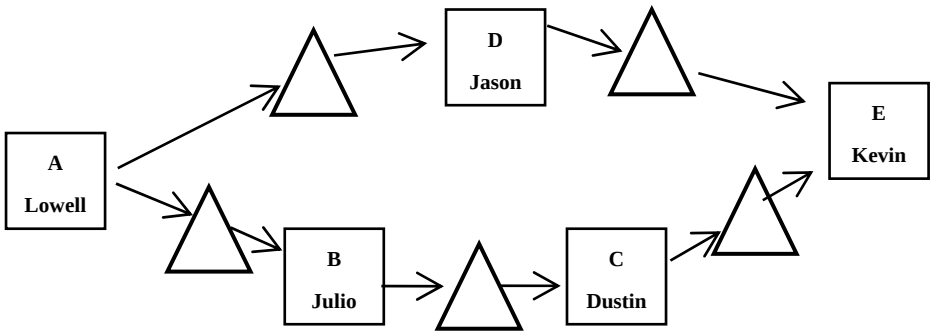
Circle one: **True** **False**

Explain:

The action (i.e., ordering) is driven demand (which is what drops the inventory below the reorder point). Hence, it is a pull system.

Question 3

Consider the following process:



Each activity is performed by a separate resource (activity A is performed by Lowell; Activity B is by Julio and so on). Activity A takes 8 minutes, Activity B takes 4 minutes, Activity D takes 9 minutes, and Activity E takes 10 minutes. Further, Dustin can process 10 units per hour. Note that Activity E cannot begin until a flow unit has completed both Activities C and D.

a) What is the bottleneck of the process? What is the capacity of the process (in units per hour)?

The bottleneck is _____Kevin_____.

The process capacity is ____6_____ units per hour.

If Dustin's capacity is 10/hr, his unit load must be 6 min/unit. We then have the following:

Resource	Unit Load (time/job)	Resource Capacity		
		Unit Capacity	# of units	Total
Lowell	*8 min/unit*	*7.5 units/hour*	*1*	*7.5 units/hour*
Jason	*9 min/unit*	*6.67*	*1*	*6.67*
Julio	*4 min/bag*	*15*	*1*	*15*
Dustin	*6 min/unit*	*10*	*1*	*10*
Kevin	*10min/unit*	*6*		*6*

b) What is the theoretical flow time of the process (in minutes)?

The theoretical flow time is _____28_____minutes.

The longer path through the process goes through activities B and C.

Thus TFT is 8min+4min+6min+10min=28mins

c) If the process runs at 75% of capacity and there are on average 9 jobs in the system, what is the average flow time for a job (in hours)?

The average flow time is ____2_____hours.

*R= 0.75*6=4.5 units/hour*

I=9 jobs

T=I/R=9/4.5=2hours

Question 4

Companies like Motorola aim for six-sigma, which theoretically corresponds to just 2 defective parts per billion produced. Give **two** practical reasons why six-sigma would be a reasonable goal for a process.

Reason 1:

Production process with multiple stages. When there is a chance that each stage of the process might fail, the total yield can be much less than the yield at any one stage. Hence, increasing the sigma capability assures high yields for the whole process.

Reason 2.

Processes may be subject to mean shifts. When the mean shifts, the rate of non-conforming product goes up. However, if the standard deviation is very small (i.e., the sigma capability is high), the rate of good product is still high.

Question 5

At SPC Incorporated a key process often goes out control. Further, it often takes several samples before the operator realizes that the process is out of control. Management would like to increase the chance that the operator determines that the process is out of control on the first sample. This must be done quickly and there is no time to implement process improvements that would change the mean or standard deviation of process output. Give two suggestions and the state the pros and cons of each.

Suggestion 1: Increase the sample size.

Pros and cons: Increasing sample size will reduce the standard deviation around the sample mean and thus tighten the control limits. It will reduce the number of sample required to detect that the process has gone out of control. This benefit must be traded off against the increased cost of measuring additional units.

Suggestion 2: Deviate from standard industry practice and set the control limits less than 3 standard deviations from the mean.

Pros and cons: This will increase the chance of detecting that the process has gone out of control and does require measuring additional units. However, it will increase the chance of a "false positive." That is, there is a higher likelihood of the process being declared out of control when in fact there is no assignable cause.

Question 6

Pumping Iron, Inc. produces pistons used in various industrial pumps. A customer places a large order for pistons of diameter 10 cm. The customer says he will only accept pistons within a 0.2 cm tolerance (i.e., pistons between 9.8 cm and 10.2 cm are acceptable to the customer). Pumping Iron, Inc. sets the mean of its piston-production process at 10 cm. The standard deviation of process output is 0.08 centimeters.

a. What is the sigma capability of the process? What fraction of output will conform to the customer's specification?

The sigma capability is ____2.5_____ and ___98.76_____ % of output will be within the customer's specifications.

σ capability = (USL-mean)/σ = (10.2-10)/0.08 = 2.5

Normdist(10.2, 10, 0.08, True) - Normdist(9.8, 10, 0.08, True)= 0.9876

b. Pumping Iron wants to introduce statistical process control. It tells the machine operator to use a sample size of 16. If Pumping Iron follows standard industry practice, how should it set its control limits?

UCL ___10.06_____ cm LCL ____9.94_____ cm

UCL = Sample Mean + 3 σ_{Xbar} = 10 + 3 σ/Sqrt(N) = 10 + 3×0.08/Sqrt(16) = 10 + 3×0.02 = 10.06

LCL = Sample Mean – 3 σ_{Xbar} = 10 - 3 σ/Sqrt(N) = 10 - 3×0.08/Sqrt(16) = 10 - 3×0.02 = 9.94

Question 7

The gym facilities at Western University have recently been renovated with a significant amount of new workout equipment. The four new elliptical trainers have proven particularly popular. Indeed, they have been so popular that gym patrons have been complaining to gym manager Evan North about the difficulty of getting on the machines. Currently, there is a sign up board for each machine that can hold up to three names. Gym users are only allowed to sign up for one machine and must come to the gym to do so. Gym patrons frequently complain that they aren't even able to sign up for a machine. Gym users also complain about long waits once they get on the sign up board. Once a patron gets on a machine, he or she works out for any where between 15 and 70 minutes. The average user does a 30 minute work out on the machine. Users have suggested adding additional elliptical trainers. North would love to do this but doubts that Western would be willing to spend additional money on the gym so shortly after a major renovation. He wonders what else he could do improve the situation.

Provide North with three suggestions. For each one, say what impact you expect your suggestion to have on the ability to sign up for an elliptical trainer and on the wait to begin a work out. Explain why your proposal will deliver the expected results.

Option 1: *Have a common waiting list. Pooling the machines will reduce the average waiting time and line length. This reduces the average wait and makes it easier to get on the sign up list.* ***NOTE: To receive full credit an answer must include this option.***

Option 2: *Reduce the utilization of the machines – at least during peak times. This can be done in a number of ways:*

- ✓ *Limit the time on the machines. Imposing a maximum of time on the machines of, say, 30 minutes will reduce the utilization of the machines and potentially limit the variability in the service time.*
- ✓ *Encourage users to come at off-peak hours. This spreads arrivals out over more of the day and both lowers the utilization during peak hours and reduce the variability of arrivals.*
- ✓ *Educate customers on the use of other machines. This shifts work from the elliptical trainers to other (presumably less utilized) machines.*

Option 3: *Increase the length of the sign up queue. Allowing more people to join the queue will make it easier to sign up but will increase the waiting time for those who wait.* ***NOTE: To receive full credit a discussion of this option must include the observation that average waits will go up with increasing the length of the sign up list.***

Option 4: *Take reservations for the machines. Queuing is driven by variability in arrivals or services. Taking reservations will reduce variability in arrivals.*

Question 8

The Bedford Clinic is a large medical center affiliated with a regional heath maintenance organization. In order to keep costs down, the clinic has experimented with a number of programs to reduce the number of clinic visits per patient. In the pediatrics practice, for example, a system has been established to determine over the telephone whether a child with a cold or fever needs to see a doctor or whether the child can simply be treated at home. The process works as follows. All arriving calls to a pediatrics help line are answered by a single clerk who calls up the patient's computer record and then forwards the call along with the relevant patient information to a team of nurses. Thus, when a nurse from the team answers the forwarded call, information such as the patient's age and recent medical history simultaneously appears on the nurse's computer screen.

On the whole, the system has worked well but recently Joan Oates, the clinic's operations manager, has received a number of complaints. Primarily complaints have centered on long delays to speak with the clerk, the first step in the process. Patients see little value in this largely clerical step and resent waiting. There have also been a few complaints about getting busy signals when calling the pediatrics help line.

Two remedies have been suggested. The first requires re-programming the clinic's rather old phone system to increase the number of calls that can wait for the clerk from five to seven. The alternative is a modest change in the computerized form the clerk must complete before forwarding a call. This change would reduce the time of the clerk's task by 10%. Oates estimates that implementing either solution will cost roughly the same amount.

If only one of the proposals can be implemented, which would you recommend? Justify your answer.

Circle one: **Add Phone Lines** **Alter Form**

Because:

Adding phones line will increase the wait in the system, exacerbating the primary complaint. Altering the form reduces the wait in the system as well as reducing the number of busy signals.

Note: To receive full credit, an answer must clearly indicate that adding lines will increase the average wait in the system.

Question 9

Wildcat Walk-In Clinics (WWIC) is a chain of medical clinics that specialize in convenient treatment of a limited range of basic illnesses. A typical WWIC is located in a drug store and is staffed by nurse practitioners (NPs). The NPs are the only employees at a location. WWIC has an average revenue of $55 per patient visit. An NP spends on average 20 minutes to process a patient although there is significant variability in this time. (Assume the time is exponentially distributed.) NPs are paid $15 per hour plus $10 per patient seen.

a) A particular WWIC location is staffed with 2 NPs. Patients arrive at a rate of 3.9 per hour. (The time between patients is approximately exponentially distributed.) What is utilization of the NPs? What is the probability that a patient has to wait before being seen by a NP?

The utilization of the nurse practitioners is _____65____ %.

The probability a patient has to wait is _____51.21_____ %.

We use Queue.xls with the following:

Number of Servers, c =	**2**
Arrival Rate, R_i =	**3.9**
Service Rate Capacity of each server, R_p =	**3**

We get a utilization of 3.9/6 = 65%

To determine the chance of waiting, we have

T: Probability of more than 0 time-units waiting = 51.21%

b) WWIC is considering offering patients who wait more than 15 minutes before being seen a $10 discount on their visit. What would be the clinic's hourly margin if this plan were implemented?

The clinic's hourly margin would be $__133.69_____ per hour.

First, we determine the fraction of customer getting a discount:
T: Probability of more than 0.25 time-units waiting = 30.29%
The number of customers receiving the discount is 1.181/hour.
We then have

*Revenue 3.9*55 = $214.50/hour*
*Labor cost: 2*15 + 10*3.9 = 30 + 39 = $69/hour*
*Penalties: 10*1.18 = 11.81*

Margin: 214.5-69-11.81 = $133.69/hour

Question 10

For the next two statements consider the following scenario:

Superfast manufactures and sells a wide variety of motors to industrial customers. All motors cost about the same and are assembled on the same line. Switching over from assembling one motor to another requires about two hours regardless of the motors involved. Superfast assembles motors to be stocked in distribution center from where they are shipped as orders arrive. HP is the highest selling motor (in terms of units sold) and LP is the lowest selling.

Statement 1:

The average cycle inventory of HP motors will be

Circle One: **LOWER THAN** **HIGHER THAN** **THE SAME AS**

the average cycle inventory of LP motors.

Explain:

The average cycle inventory of HP motors will be higher because of higher demand. For the same setup and holding cost, HP will be produced in larger batches (i.e., larger EOQ natch size)..

Statement 2:

The average time spent in inventory by an HP motor will be

Circle One: **LESS THAN** **MORE THAN** **THE SAME AS**

the average time spent in inventory by LP motor.

Explain:

The average time spent by HP motors will be less. Cycle inventory is proportional to the square root of demand. Time=Inventory/demand. Suppose that demand for HP motors will be k times larger than demand for LP motors. Then. inventory for HP motors will be sqrt(k) times larger than for LP motor. However the average fime for HP motors will be sqrt(k)/k = 1/sqrt(k) times less than that for LP motors.

Question 11

For the next two statements consider the following scenario:

Your store sells personal radios that come in two versions – jogger and biker. The products currently have different plastic casings (one each for jogger and biker) and different microchips (the jogger micro-chip handles more vibrations). Currently, the supplier assembles both models and ships them to retailers. However, the supplier is redesigning the product so that a generic casing will be used for both models. Retailers will get an inventory of radio kits (the casing and other common components but not the micro-chip) and of two types of microchips. The retail store will assemble the appropriate radio upon the customer's request. (This takes just a few minutes.) The lead-time to acquire kits or chips will be the same as the current lead times for radios.

Statement 1:

Following this change, the inventory of *casings* will

Circle One: **LESS THAN** **MORE THAN** **THE SAME AS**

the total number radios you currently hold.

Explain:

The inventory of casing will go down to pooling. Letting σ_j and σ_b be respectively the standard deviations of jogger and biker demand, the standard deviation of demand for the casings will be Sqrt(σ_j + σ_b). Safety stock will now be proportional to Sqrt(σ_j^2 + σ_b^2). Previously, safety for joggers would proportional to σ_j while safety for bikers was proportional to σ_b. However, Sqrt(σ_j^2 + σ_b^2)< σ_j + σ_b.

Statement 2:

Following this change, the inventory of *chips* will be

Circle One: **LESS THAN** **MORE THAN** **THE SAME AS**

the total number radios you currently hold.

Explain

The inventory of chips will remain the same since the store must still carry two variants of chips.

Question 12

The village board of SnowCity, must contract for plowing services. Weekly snowfall during is normally distributed with a mean of 10 inches and a standard deviation of 3 inches. The board is considering a long term contract with a snow removal company which charges $1000 per truck per week contracted. Thus, if the board signs a long-term contract for 3 trucks, they pay $3,000 per week whether the trucks are used or not. Each truck is capable of clearing 2 inches of snow per week. If snowfall in a week exceeds the quantity that can be handled by the trucks included in the long term contract, the board must make emergency arrangements at a cost of $2,500 for each additional truck brought in. For how many trucks should the board sign a long term contract? (For simplicity, you may assume that a fractional number of trucks can be obtained, i.e., 3.5 trucks is an acceptable answer.)

They should contract for ____5.38_____ trucks.

Cost of understocking, MB = $2500 – 1000 = $1500
Cost of overstocking Mc = $1000
Nesvendor fractile = MB/(MB+MC) = 1500/2500 = 0.6
Thus a long term contract should be entered into with enough trucks such that snow is cleared by these trucks with 60% probability.
*Snow cleaned by long term trucks = 10 + normsinv(.6)*3 = 10.76 inches*
Number of trucks = 10.76/2 = 5.38
SnowCity should thus enter into a long term contract for 5.38 trucks

Question 13

The Home and Garden (HG) chain of superstores imports decorative planters from Italy. Weekly demand for planters averages 1,500. Each planter costs $10. HG incurs a holding cost of 25% per year to carry inventory. HG has an opportunity to set up a superstore in the Phoenix region. Each order shipped from Italy incurs a fixed transportation and delivery cost of $10,000. Consider 52 weeks in the year.

a. What is the optimal order quantity of planters for HG? What are its resulting annual holding and ordering costs?

Optimal order quantity = ___24,980__. Holding and ordering costs are $__62,450___ per year.

R = 1,500/week = 78,000/year
H = rC = 0.25×10 = $2.50 per planter per year.
S = $10,000

Q = Sqrt(2SR/H) = Sqrt(2 ×10,000×78,000/2.5) = Sqrt(624,000,000) = 24,980

Annual Holding Costs = H Q/2 = 2.5 × 24,980/2 = $31,225/year
Annual Ordering Costs = S R/Q = 10,000×78,000/24,980 = $31,225/year
Total $62,450/year

b. Demand is not constant week to week. The standard deviation of weekly demand is 800 planters. If the delivery lead time from Italy is 4 weeks and HG wants to provide its customers a cycle service level of 90%, how much safety stock should it carry? By how much does this change costs?

The optimal safety stock is ___2050___.

This (circle one) INCREASES DECREASES annual costs by $ ___5,125___ per year.

*I_S = NORMSINV(.9)*sqrt(4)*800 = 2050*

Added costs are H I_S = 2.50×2050 = $5,125/year

c. Fastship is a new shipping company that promises to reduce the delivery lead time for planters from 4 to 1 week using a faster ship and expedited customs clearance. Using fast ship will add $0.2 to the cost of each planter compared to the current approach. Should HG go with Fastship? Why?

HG (circle one) SHOULD SHOULD NOT go with Fastship.

Explain

We first observe that any savings from this program will come from reducing safety stock. Thus to be worthwhile the program has to cost less than $5,125/year. However, it adds 20¢ to every planter. That costs 0.2 × 78,000 = $15,600/year.