Production and Operations Management

Regular Period Exam

June 15, 2022, noon – 2h30 p.m. | Wednesday

Solutions

SECTION I

1. (0.5 points). The seven basic TQM tools are grouped in the following three categories:

(a) Tools for generating ideas; tools for organizing the data; tools for identifying problems.

(b) Tools for generating ideas; tools for organizing information; tools for eliminating problems.

(c) Tools to manage professional training; tools for organizing problems; tools for detecting the data.

(d) Tools for maximizing ideas; tools to map mindsets; tools for dropping problems.

2. (0.5 points). One of the following is not a process strategy. Circle it:

(a) Repetitive process.

(b) Product focus.

(c) Mass customization.

(d) Environment focus.

3. (0.5 points) Johnson's rule:

(a) Designed to schedule n/1 problems.

(b) Minimize average job lateness.

(c) Minimize total processing time.

(d) None of the above.

4. (0.5 points) One of the following statements is FALSE. Circle it:

(a) The simplest queuing model is made up of one waiting line and one server.

(b) The simplest queuing model is made up of 1 sever, only.

(c) Average time a customer spends in a queuing system is the sum of average waiting time and average service time.

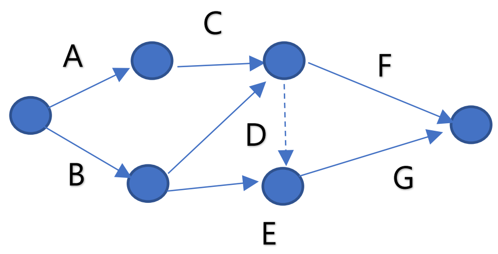
(d) On average, 4 customers arrive at M/M/1 every 30 minutes, therefore, the average time between arrivals is 7,5 minutes.

SECTION II

Consider the following online Marketplace project (time durations in days):

Activity	A	B	C	D	E	F	G
Predecessor	-	-	A	B	B	C, D	E, C, D
Optimistic time	1	1	2	2	1	1	1
Most probable time	2	1	4	3	2	3	5
Pessimistic time	3	1	6	4	3	5	9

1. **(1.5 points)** Draw the network and find the total slack for activity E.



Ativ.	t	ES	EF	LF	LS	Folga
A	2	0	2	2	0	0
B	1	0	1	3	2	2
C	4	2	6	6	2	0
D	3	1	4	6	3	2
E	2	1	3	6	4	3
F	3	6	9	11	9	3
G	5	6	11	11	6	0

Slack of activity E is 3 days

2. **(1.5 points)** Find the probability the project is completed 2 or more days prior the estimated date.

Activity	A	B	C	D	E	F	G
Optimistic time	**1**	**1**	**2**	**2**	**1**	**1**	**1**
Most probable time	**2**	**1**	**4**	**3**	**2**	**3**	**5**
Pessimistic time	**3**	**1**	**6**	**4**	**3**	**5**	**9**
Variance	**0.11**	**0**	**0.44**	**0.11**	**0.11**	**0.44**	**1.77**

[3]

Critical path A,C,G = 11 days

Variance of the critical path = 2.32

Syandard deviation = 1.523

X - v.a. that describes the project duration

X ~ N (11;1.523)

P(X< 9) = P(Z< ((9-11)/1.523)) = P(Z < -0.1313) = 1-P(Z<0.1313)

= 1-0.9049 = 0.0951

Aproximately 9.5%

SECTION III

(3 points) DRONE.TECH is a Japanese company that produces drones, among them the DRONE 4DRC F11 6K, which has an annual demand of 55,200 drones. At its manufacturing plant in Osaka the company produces drones DRONE 4DRC F11 6K at a rate of 1,600 drones per week. The holding cost per drone per year is 50 euros, and the setup cost is 150 euros per production run. The company currently produces lots of 11,040 drones in each production run. Assume that the company works 250 days per year, 50 weeks.

1. a) Taking into account the lot size used by DRONE.TECH:

1.1 (1 point) **Determine the annual holding cost.**

Annual holding cost = (Q/2)(1-d/p)*H = (11040/2)*(1-1104/1600)*50= 85560 euros/year

1.2. (1 point) What is the stock level 8 weeks after the beginning of a production run?

T = Q/D = 11 040/55 200 = 0,2 years = 10 weeks

t1 = Q/p = 11 040/1600 = 6,9 weeks

I (8 weeks) = 2 × 1104 = 2208 ou 11040*(1-1104/1600)* –(8-6,9)*1104 =2208 drones

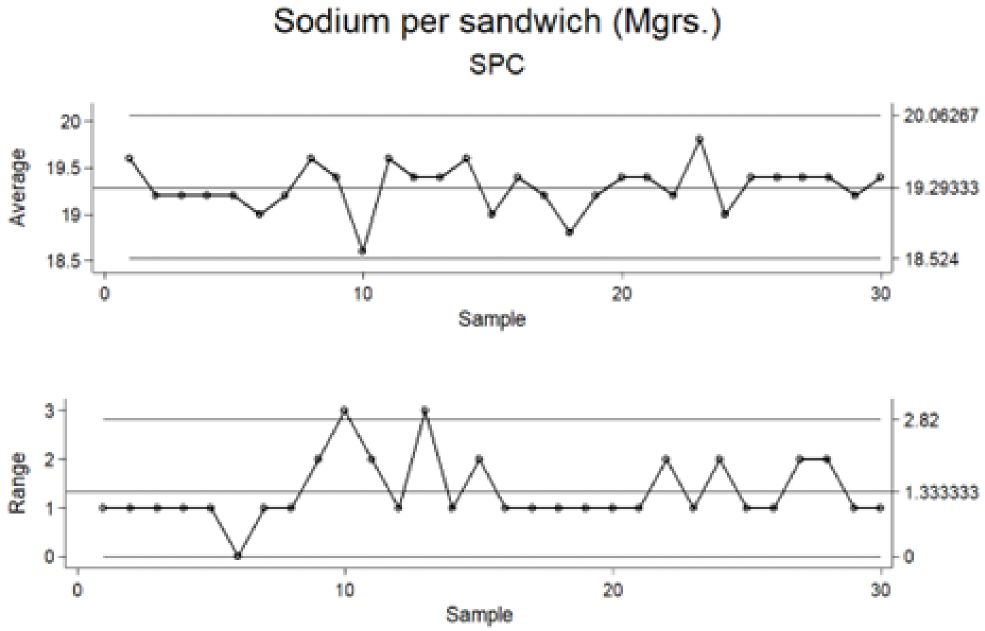
2. (1 point) In order to reduce the annual holding cost, the production manager decided to change the lot size. Knowing that the annual setup cost for the new lot size is 4,140 euros per year, what is the lot size defined by the production manager?

Annual Setup Cost = (D/Q) × S = 4140 euros/year

(55200/Q) × 150 = 4140 euros/year ⇒ Q = (55200×150)/4140 = 2000 drones

SECTION IV

1. The level of sodium in a Big Kahuna sandwich has been controlled by the quality compliance technician for the last 30 days. During this period, the technician gathered a daily sample of five sandwiches and summarized the information on sodium levels using the charts depicted below. The charts provide information for the sampled average and range of sodium levels, respectively.



1.1. (1 point) Identify the statistical process control charts employed by the technician and explain whether they are variable or attribute control charts.

The depicted charts correspond to the means ($\bar{x}$) and range (R) variable charts. These charts should be employed in conjunction and here controls the level of sodium, a continuous variable. The $\bar{x}$-chart assesses whether changes have occurred in the central tendency (the mean, equal to 19.293) of the process and the R-chart its dispersion (the range).

1.2. (1 point) Is this process under statistical control? Carefully justify your answer.

This specific process shows evidence of loss of statistical control in both charts. On the $\bar{x}$-chart, there is one instance of five data points consecutively below average (days 2-7) and, on the R-chart, two instances of samples with range above the upper control limit (days 10 and 13).

2. The production of 180 gr. vinyl records at the Léaud pressing plant is meticulously controlled by Mr. Doinel, its quality assurance technician. During the last 26 days, Mr. Doinel controlled a daily sample of 100 vinyl records. After examining each sampled record, he decided whether they would be approved for shipping, or rejected and recycled. The daily number of rejected records is reproduced below:

Day	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	**Average**
No. Reject	1	5	1	4	5	5	4	3	3	5	2	4	4	**3.538**
Day	***14***	***15***	***16***	***17***	***18***	***19***	***20***	***21***	***22***	***23***	***24***	***25***	***26***	**Average**
No. Reject	3	5	5	4	2	5	4	5	4	5	0	5	4	**3.923**

2.1. (1 point) Identify the adequate control chart(s) to assess this process and calculate its upper and lower control limits (at the 3σ level). Is this process under statistical control?

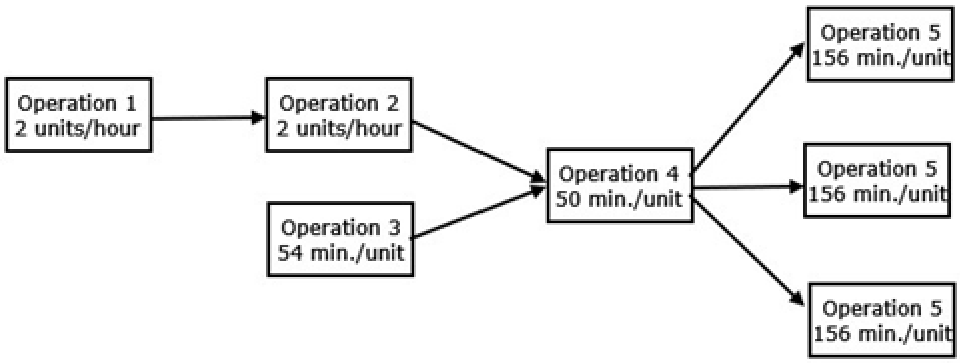
The portrayed example controls a binary state of the finished product. The most suitable control chart in such instances is a p-chart. Limits below:

UPCp = 0.0373 + 3 × 0.0189 = 0.094 or 9.4%

LPCp = 0.0373 - 3 × 0.0189 = -0.0194 → cannot be negative, so = 0.

SECTION V

GPO-POM is a company that has the process (with 5 operations) displayed below:



The Operation 3 occurs separately from, and simultaneously with, the Operation 1 and Operation 2. The product only needs to go through one of the three final operations (Operation 5), since they are in parallel. Assume that the company works 8 hours per day, the yield in each phase is 100%, there are no stoppages, and stock cannot be accumulated between the different operations of the process.

1. **(1 point).** Which operation is the bottleneck?

Operation 1: 30 min/unit
Operation 2: 30 min/unit
Operation 3: 54 min/unit
Operation 4: 50 min/unit
Operation 5: 156 min/3 machines = 52 min/unit
Therefore, the bottleneck is the slowest operation, which is Operation 3, at 54 min/unit.

2. **(1 point).** What is the throughput time (in minutes) for the overall system?

System throughput time is the maximum of (30 + 30 + 50 + 156) = 266, or (54 + 50 + 156) = 260 is Maximum of (266 or 260) = **266 min**

3. **(1 point).** Suppose that a second 'Operation 3' machine is added, and it takes the same time as the original 'Operation 3' machine. What is the new bottleneck time of the system and how long is it?

Operation 1: 30 min/unit
Operation 2: 30 min/unit
Operation 3: 54 min/2 machines = 27 min/unit
Operation 4: 50 min/unit
Operation 5: 156 min/3 machines = 52 min/unit
Therefore, the bottleneck shifts to **Operation 5, at 52 min/unit**.

SECTION VI

The operations manager of AUTOREP, a truck repair shop, has six trucks to schedule for repair. Each truck requires body work prior to painting. The processing times to the body and paint work are as follows:

Table 1						
	Truck 1	Truck 2	Truck 3	Truck 4	Truck 5	Truck 6
Body work (hours)	4	8	10	6	9	5
Paint (hours)	12	16	4	8	6	10

The processing and idle costs for each workstation are presented in Table 2:

Table 2	Processing cost (euros/hora)	Idle cost (euros/hora)
Body work (hours)	10	12
Paint (hours)	25	12

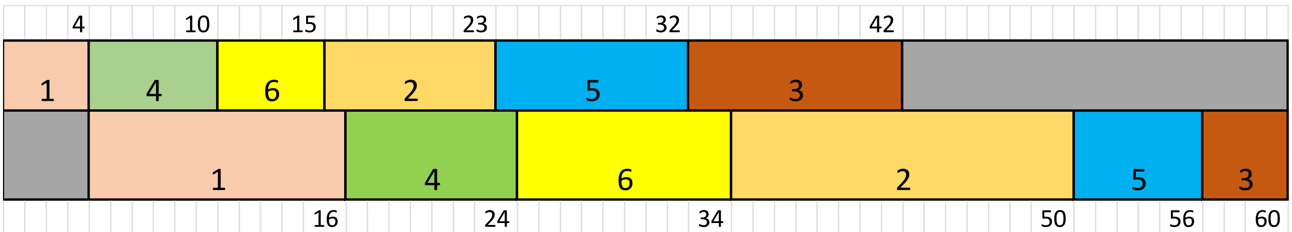
The shop works 8 hours per day (from 8 a.m. to 12 and 1 p.m. to 5 p.m.), from Monday thru Friday. The operations manager decided to start the repair of these trucks today, June 15 (Wednesday) at 8 a.m. The total cost of idle time for body work and paint is allocated to each truck proportionally to their respective total processing time.

1. **(1 point)** The processing sequence followed by the operations manager was 1-4-6-2-5-3, do you agree with this sequence? Justify your answer.

No. The sequence that minimize the total processing time is given by the Johnson's Rule:

1	**6**	**4**	**2**	**5**	**3**

2. **(1 point)** Assuming that the sequence followed was 1-4-6-2-5-3, how many trucks are repaired on June 17 at the end of the day?



July 17 → 8 hours/day × 3 days = 24 hours

On July 17 two trucks are repaired (truck 1 and truck 4).

3. **(1 point)** Determine the total cost allocated to the repair (body work and paint) of truck 3.

Total idle cost

Body work : 12 euros/hour × (60-42) hours = 216 euros
Paint: 12 euros/hour × 4 hours = 48 euros

Total cost allocated to the repair (body work and paint) of truck 3 =10 euros/hour × 10 hours + 25 euros/hour × 4 hours + 216 euros × (10 hours/42 hours) + 48 euros × (4 hours/56 hours) = 254.86 euros

SECTION VII

1. **(1 point)** The cost (C), in euros, of a M/M/1 system is C=50+15W (W in hours). On average, 1 customer arrives every 20 minutes according to a Poisson distribution. Currently, the utilization factor is 60%. Find the system cost.

$1/\lambda = 1/20 \Rightarrow \lambda = 3$ customers/hour, Poisson distribution
$\rho = 0.6 \Rightarrow 3/\mu = 0.6 \Rightarrow \mu = 5$ customers/hour, exponential distribution

$$W = \frac{1}{(\mu - \lambda)} = \frac{1}{(5-3)} = 0.5\ hours$$

C=50+15W = 50+15×0.5 = 57.5 euros

2. **(1 point)** On average, cars arrive at *CleanWash* at a rate of 6 per hour according to a Poisson distribution. The washing team spends on average 7,5 minutes to wash 1 car manually. The manager is concerned about the time customers wait to be served as well as with the number of cars waiting within the limited parking space available. She is considering purchasing a state-of-the-art automatic car wash system that washes at a constant rate of 4 minutes each car. Would you recommend purchasing the state-of-the-art automatic car wash system? Show all calculations supporting your recommendation.

M/M/1	M/D/1
λ = 6 customers/hour, μ = 8 customers/hour W_q = 6/16 horas = 22.5 minutes L_q =36/16 =2.25 cars	λ = 6 customers/hour, μ = 15 customers/hour W_q = 6/270 horas = 1.33 minutes L_q =36/270 =0.133 cars

Yes, I recommend it since the performance measures, Wq and Lq, improve substantially with M/D/1.

3. **(1 point)** *(Work out this problem regardless of what you have recommended in the previous problem).* Consider the management is operating an automatic carwash system which washes 15 cars per hour at a constant rate. Cars arrive at a rate of 6 per hour according to a Poisson distribution. Management greets customers waiting 4 or more minutes with a free of charge wash. Find the estimated annual number of customers receiving the free of charge wash (the automatic line works 8 hours daily over 250 days per year).

M/D/1
λ = 6 customers/hour, μ = 15 customers/hour W_q = 6/270 hours = 1.33 minutes

A newly arrived customer that finds 3 on hold (4 in the system) will wait (3×1.33), thus:
$P(n \geq 4) = (6/15)^4 = 0.0256$ → 0,0256 × 6 customers/h × 8h/day × 250 days/year = 307.2 customers/year