

Operations Management

Midterm 2

SOLUTIONS

04/6/2012

Duration 3h00m

Remember the following tips:

- Budget your time. Skim through the exam before starting.
- Show all your work to allow us to give you partial credit if appropriate.
- Answer groups in separate pages and please write down your name in all pages.

Good Luck!

Group 1 (55 points)

a) Classify the following statements as True (T), False (F), or Undetermined (U). Justify briefly your answer (max 3 lines). Most of the grade will be based on the justification.

a1) (5 pts) An 82% learning curve means that, for every doubling of output, the new output takes 18% less time than the previous output (e.g., unit 46 will take 18% less time than unit 23)

a2) (5 pts) Using the terminology of statistical control, the variation outside the control limits on an X-bar or range chart, is assumed to have been caused by special or assignable causes.

a3) (5 pts) Using the terminology of statistical control, if we observed that the variation of the average is all within the control limits on an X-bar chart we know the process is under control.

a4) (5 pts) A company that uses control charts to continuously verify the evolution of some process quality metrics (e.g. averages, ranges, etc) is not taking into account its immediate customer needs.

a5) (5 pts) The bullwhip effect enables different stages of the supply chain to have a consistent estimate of what demand looks like.

a6) (5 pts) The bullwhip effect negatively impacts performance at every stage and thus hurts the relationships between different stages of the supply chain.

a7) (5 pts) One of the advantages of user innovation over producer innovation is that the user knows his/her needs well so when he/she develops a new product or service, he /she is simultaneously showing that there is a market for that specific good or service.

a8) (5 pts) User innovators who become producer innovators are create a firm to commercialize their innovations, are typically called “user entrepreneurs”

a9) (5 pts) 3D printing is a process of producing three dimensional solid objects from a digital file. 3D printing is achieved using additive processes, where an object is created by laying down successive layers of material.

b) (10 points) Tony at the bicycle shop has made a list of bikes that wait for repair. After he is done with disassembly and repair, Johny takes over for cleaning and reassembly. The table below provides Tony’s and Johny’s estimated processing times in minutes. What is the optimal sequencing for completing these six units?

	A	B	C	D	E	F
Tony	44	36	20	24	30	64
Johny	28	38	26	56	42	22

Group 2 (25 points)

Good-old-san, a popular medication for hang-overs, is produced by Java pharmaceuticals. One of its active ingredients is ascorbid acid, more specifically 500 mg per pill. There are some suspicions that recent batches might not be following the same specifications. They have gathered the following data and hired you to get some answers.

Sample	Pill 1	Pill 2	Pill 3
1	501	499	497
2	503	498	497
3	502	496	499
4	501	494	501
5	502	493	503
6	503	492	498
7	504	490	498
8	506	488	501

Values in mg / pill

- a. Calculate the 3-sigma control limits for X-bar and R charts based on the three analyses from the first 5 batches.

Sample	Pill 1	Pill 2	Pill 3	X-bar	R
1	501	499	497	499,0	4
2	503	498	497	499,3	6
3	502	496	499	499,0	6
4	501	494	501	498,7	7
5	502	493	503	499,3	10
6	503	492	498	497,7	11
7	504	490	498	497,3	14
8	506	488	501	498,3	18
				499,1 X-2bars	6,6 R-bar

Mean

UCL = 505,8

LCL = 492,3

Range

UCL = 17,0

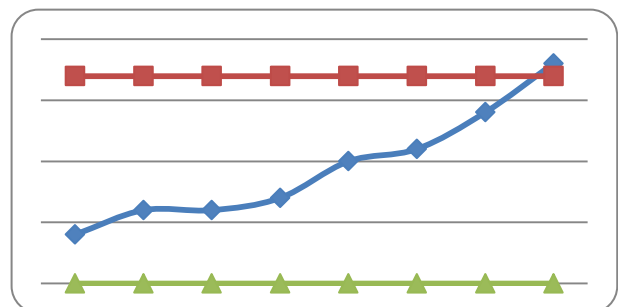
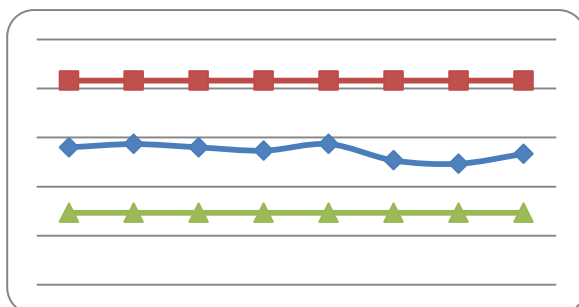
LCL = 0

A2 = 1,02

D3 = 0

D4 = 2,57

- b. Plot X-bar and R charts labeling the data points and upper and lower control limits. Plot the means/ranges of all 8 samples, but use the control limits and centre lines calculated for the first 5 samples.



- c. Do you feel that the Good-old-san production process is in control? Do you think the quality control team should have acted earlier? Why?

No, the production process is not in control. Given the growing tendency showed by R chart, they could identify the problem earlier.

Group 3 (30 points)

The summer is coming and with it the summer festivals! A group of Católica students are planning to organize the 'Friend's Festival' with Portuguese bands. After selecting the bands, they are now dealing with operations issues, and need your advice for the tickets sales, as an Operations Management expert.

The 3 ticket offices, located in different places of Lisbon (Baixa, Católica and Colombo), will be open one month before the festival. They expect to sell 90 tickets per hour (each person buys on average 3 (three) tickets). Each ticket seller will take 4 minutes per customer. Assume a Poisson distribution for customer's arrival and a negative exponential distribution for tickets office service.

- a. Considering that each ticket office will have the same affluence, how long a customer will wait before buying the tickets? Please show your calculations with 2 decimal places and explain how you calculated the arrival rate.

$$\frac{1}{\mu} = 4 \text{ min} \rightarrow \mu = 15$$

$$\lambda = 10 \text{ (90 tickets per hour / 3 tickets offices / 3 tickets per person)}$$

$$Wq = \frac{10}{15(15 - 10)} = \frac{10}{75} = 0,1(3) \text{ hours} = 8 \text{ min}$$

- b. During the 3 days of the festival, the ticket offices will be placed in the festival location (near the entrances) and they expect to sell 130 tickets per hour (2 per person). If the police will help to organize the buyers in one single queue, how many ticket offices do they need, assuming that each customer is expecting to wait no more than 8 minutes before entering in the festival?

$$\lambda = \frac{130}{2} = 65 \text{ and } \mu = 15$$

$$Ws \leq 8 \text{ min} \wedge Wq = Ws - \frac{1}{\mu} = 8 - 4 = 4$$

$$Wq \leq 4 \Rightarrow Lq \leq \lambda \cdot Wq \wedge \rho < 1$$

$$Lq \leq 65 * \frac{4}{60} \wedge \frac{\lambda}{s \cdot \mu} < 1$$

$$Lq \leq 4, (3) \wedge s \geq 4, (3) \approx 5$$

$$s = 5 \Rightarrow \rho = 0,8(6) \approx 0,87 \Rightarrow Lq = \frac{4,15 + 5,27}{2} = 4,71 \Rightarrow Wq = 0,073 = 4,38 \text{ min}$$

$$s = 6 \Rightarrow \rho = 0,72 \Rightarrow Lq = 0,95 \Rightarrow Wq = 0,015 = 52 \text{ sec}$$

- c. Hiring more skilled sellers will decrease the selling time to 2 minutes. However, these sellers will cost 57€/hour instead of 28€/hour (regular sellers in b.). Considering the same waiting time per customer and a cost of 10€ per ticket office per hour (structure and communications), which is the best choice for selling the tickets (b. or c.)?

$$\lambda = 65 \text{ and } \mu = 30$$

$$Wq \leq 4 \Rightarrow Lq \leq \lambda \cdot Wq \wedge \rho < 1$$

$$Lq \leq 65 * \frac{4}{60} \wedge \frac{\lambda}{s \cdot \mu} < 1$$

$$Lq \leq 4, (3) \wedge s \geq 2,1(6) \approx 3$$

$$s = 3 \Rightarrow \rho = 0,7(2) \approx 0,72 \Rightarrow Lq = 1,34 \Rightarrow Wq = 0,02 = 1,23 \text{ min}$$

b. costs / hour:

$$6 * 28\text{€} = 168\text{€}$$

$$6 * 10\text{€} = \underline{60\text{€}}$$

$$228\text{€}$$

c. costs /hour:

$$3 * 57\text{€} = 171\text{€}$$

$$3 * 10\text{€} = \underline{30\text{€}}$$

$$201\text{€}$$

Group 4 (40 points)

As a young entrepreneur and a Microsoft maniac, you just had what you think is a brilliant idea: you want to manufacture a floating cover for the soon-to-be-released Windows8 tablets, that will allow users to enjoy their devices while having a bath or even drinking a piña colada in the pool. The device will be highly customizable and you expect several brands to buy your product in mass to then place it in the market. In the first year, you would like to produce 3200 covers per week. You also think that you'll probably run a crowdfunding campaign to raise the seed investment, but you'll plan that later.

You have designed the manufacturing process and done a little research on the machines available to accomplish what you want. The plant will work 8 hours per day, five days a week. First you'll need to produce the front and back covers. These will be produced in separate steps, A and B. Then the front cover will go through a special chemical process in step C, while the back cover gets a different treatment in step D. In step E, both components are wrapped with a special material that will make the whole device floatable. After that, the front and back covers are put in separate trays. The front part goes through a paint job in step F and then to step G, where the LabelGluer machine glues the label (previously printed in step H) to the cover. The component then goes through the drier in step I while the back cover is dried in step J, and finally the two components are screwed together in step K. You have come up with the table below.

Step	Time (seconds)	Immediate Predecessors
A	30	-
B	25	-
C	13	A
D	17	B
E	36	C,D
F	8	E
G	45	F, H
H	10	-
I	5	G
J	28	E
K	15	I,J

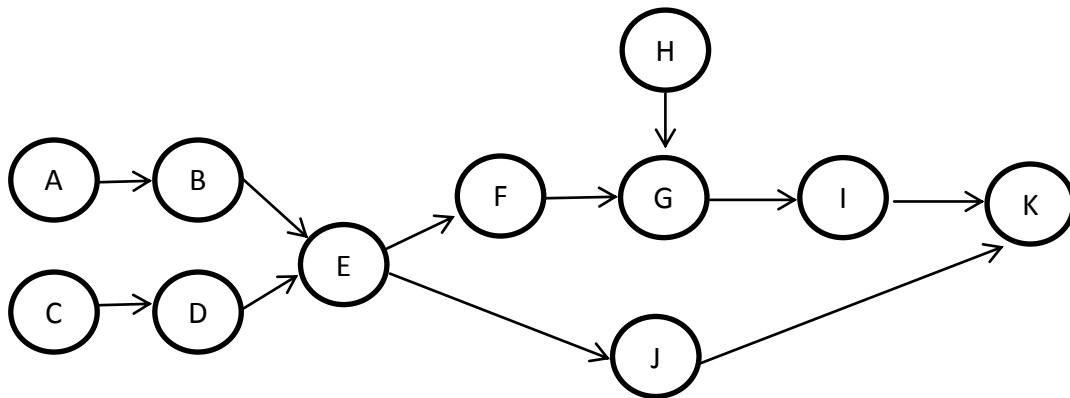
- a) How many items must be produced per hour (production rate)?

$3200/40 = 80$ covers / hour

- b) What is the desired cycle time (in seconds)?

$3600/80 = 45$ seconds

- c) Draw the precedence diagram.



- d) Balance the production line.

Station	Candidates	Chosen	Time	Cumulated time	Remaining time	Station Idle time
1	A, C, H	A	30	30	15	2
	B, C, H	C	13	43	2	
2	B, D, H	B	25	25	20	3
	H, D	D	17	42	3	
3	H, E	E	36	36	9	1
	F, J, H	F	8	44	1	
4	J, H	J	28	28	17	7
	H	H	10	38	7	
5	G	G	45	45	0	0
6	I	I	5	5	40	25
	K	K	15	20	25	

- e) Calculate the efficiency (or balance delay) for this line.

Balance delay: $38/(45 \cdot 6) = 14.07$

Efficiency: 85.93%

- f) At some point, some technological modifications are made to the LabelGluer machine (in step G), which make it more precise but also a little slower: they increase its processing time per item from 45 to 60 seconds. What are the implications of such a change?

The consequence is that we will be unable to meet the desired production, or have to work more hours per day to meet it.

- g) After an intensive research conducted by a crowdsourcing company, you find out that you have three options to replace the LabelGluer machine. Which option would you choose and why?

Option	Machine name	Time (seconds)	Price (thousands of Euros)	Observations
A	LabelPrintex3000	45	10	Has a yearly maintenance cost of 2,000 Euros
B	Printarama	20	30	Will last forever, no maintenance required!
C	Labelukit	35	14	Will only last for two years

Not a single right answer (but some more than others). Could choose the least expensive for now as it meets the demand, even if it has a yearly cost. Option C is a short-term option, but cannot be used nor sold after two years, while option A is still operational. Still, 2 years might be enough before having to adapt to new trends. Option B seems too expensive and given the technology life cycle, it is very unlikely that we need this machine for a very long period. But it also depends on the possibility of adapting the machine for other formants (new tablets or mobile devices in the future). As a startup, and given the information and expectations you have, it might be wiser to refrain from big investments.

Group 5 (35 points)

In the interest of promoting relevant alternatives to finance for entrepreneurs and also important investment opportunities to anyone, PPL Crowdfunder company has decided to do a Joint Venture with an international partner to move Crowdfunding to another level, in Portugal and in Europe. The deal means setting up a new company, jointly owned, and making it operational. You, executive director of the board, and your staff, have identified 11 major tasks to this project. Your team has also determined the immediate predecessors. The results are as follows:

Activity	Description	Immediate predecessor	Time (hours)
A	Determine high level terms to negotiate	-	120
B	Select new office site and do site survey	-	90
C	Involve lawyer teams to jointly define model	A	100
D	Negotiate site rental	B	100
E	Bring furniture to the site	B	240
F	Interview applicants and fill positions required	A	100
G	Negotiate legal terms	C	350
H	Re-paint and re-decorate site	D	400
I	Develop the information system	A	150
J	Close all financial terms, costs and revenues	E, G, H	40
K	Launch operation and Press Release	F, I, J	60

- a. What is its length of your project (in hours)?

After having developed the project plan you understand that every hour and day is critical. The project is too long and needs to be completed in 630 hours. You have the data below to help in determining how to shorten the project duration.

Activity	Normal time	Normal cost	Crash time	Crash cost
A	120	120	110	130
B	90	500	70	640
C	100	40	50	70
D	100	160	80	200
E	240	1,200	140	2,000
F	100	100	60	160
G	350	5,000	250	5,300
H	400	12,000	350	12,600
I	150	400	100	525
J	40	100	10	130
K	60	300	50	340

- Which activities did you crash to achieve the 630 hours?
- What will it cost to decrease the schedule to 620 hours from 630 hours?

a. What is its length of your project (in hours)?

It is recommended that the activity diagram is drawn, to reveal the correct precedence and sequence of all tasks. In this way, the critical path will become evident.

Critical Path: B, D, H, J, K

The total time for the tasks in the critical path to complete is: $90 + 100 + 400 + 40 + 60 = 690$ hours

b. Which activities did you crash to achieve the 630 hours?

Steps:

determine the cost to crash each activity on the critical path
determine which activities are cheapest to crash and until what limit
determine if any other path becomes critical after crashing on the original critical path
and would so also require crashing of activities to attain 630 hours

On completion of the 3 steps, it become evident that the activities to crash are D, J and K and that no other path will become critical, so the entire project duration can be reduced to 630 hours.

c. What will it cost to decrease the schedule to 620 hours from 630 hours?

We will require to reduce 10 hours from the current critical path, and the next cheapest and available task for crashing is task B. Task B has a cost of $(640 - 500) / 20 = 7$ per hour.

However, path A, C, G, J, K is now impacted and becomes critical, and will also require reduction of one or more tasks in 10 hours.

Analyzing this second critical path and the cost of crashing per task, we realize task C requires crashing of 10 hours at a cost of $(70 - 40) / (100 - 50) = 0.6$ per hour.

In TOTAL, to decrease the schedule from 630 hours to 620 hours, we would need to crash 10 hours of task B at a unit cost of 7 and 10 hours of task C at a unit cost of 0.6.

In all, it would cost 76 to decrease the entire schedule from 630 hours to 620 hours.

Group 6 (15 points)

Your Crowdfunding company, prior to any joint venture, reviews and approves any application for a project in a quite efficient manner. At the start, naturally, your due diligence process took longer as you and your team adapted to this Startup's operations. However, you were glad to understand that the team progressed rapidly to turn the application review and approval into an efficient process. The following report shows how long it took you to review and approve each of the first 5 applications.

Application	1	2	3	4	5
Review and Approval Time (in hours)	10.0	9.5	9.2	9.0	8.8

You've estimated that the learning curve effect is roughly 95%. How many hours will it take to finish the 160th application given your good progress (show your answer to one decimal place)?

SOLUTION

$T_{160} = 10 \times \text{Learning Factor}$ (NOTE: use table of UNIT values, NOT cumulative)

$T_{160} = 10 \times 0.6869 = 6.8$ hours