

## Operations Management

### Midterm 1

05/04/2013

Duration 2h30m

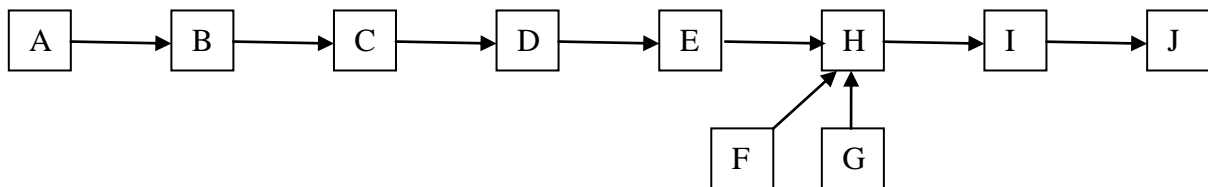
Remember the following tips:

- 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 (35 points)

São Tomé and Príncipe's main production is cocoa which represents 95% of the exportations of this African country. A manufacturer in Portugal is importing cocoa in order to produce the finest chocolate to sell in gourmet stores. The process of transforming the cocoa beans in one type of chocolate bars (70% dark chocolate) uses the following scheme (the local capacity of each phase is provided in the next table):



Phase	Phase description	Resources	Capacity per resource / day
A	Select the finest beans	10 men	100 kg
B	Clean and roast the better beans	2 machines	225 Kg
C	Crack (but not crush) the beans to remove the shell	1 machine	250 Kg
D	Grind and refine the beans (to create the cocoa liquor)	1 machine	220 Kg
E	Refine the cocoa liquor	1 container	200 kg
F	Prepare the sugar and the vanilla	2 containers	60 Kg
G	Prepare the secret spice	1 container	30 Kg
H	Stir the paste	3 containers	150 kg
I	Mould the chocolate into bars	1 machine	1.600 bars of 200 gr
J	Wrap-up and pack the bars	2 machines	750 packs of 200 gr

Additional information:

- From phase A to B only 50% of the beads are good for producing chocolate;
  - From phase B to C, 20% of the weight is lost;
  - On phase H, 2 portions of 'Vanilla + Sugar' and 1 portion of the secret spice are added to 7 portions of the cocoa liquor.
- a) Find the bottleneck and the capacity of the process (and show your calculations)
  - b) Calculate the slack of each phase in terms of final product (and show your calculations)
  - c) Knowing the demand of the product is 1.500 chocolate bars per day, suggest 3 or 4 main improvements for the process.
  - d) Why can we say that a process with no slacks in any phase could create problems to production?

**Group 2 (35 points)**

There are two types of planes that depart from Lx Airport: planes with a European destination, which have a capacity of 150 passengers per plane, and planes with an intercontinental destination, with a capacity of 300 passengers per plane. Once a plane is scheduled for departure it first needs to go through a process of boarding of passengers that takes 45 minutes per plane. The pilot then contacts Air Traffic Control (ATC) and requests a pushback from the gate. On average 4 planes are communicating with ATC at the same time. Also, on average, 8 planes are waiting for the pushback car before they can taxi (=drive) to the runway. Intercontinental flights taxi to runway A, European flights taxi to runway B. Taxing to Runway A takes 20 min.; while to Runway B it takes only 5 minutes, because it is closer to the terminal. When they arrive to the runway, they initiate the take-off sequence, which takes both types of planes about 3 minutes. On average 9,000 passengers per hour leave from Lx airport; 40% of them take planes to intercontinental destinations and 60% go to European destinations.

- Draw a process flow diagram for the departure process at Lx Airport.
- On average, how many planes are taxiing to runway A and B (give answers for both)? AND how many planes are in the entire departure sequence in Lx Airport?
- On average, how long does a plane (not a passenger!) take for the entire departure process (from boarding to take-off) on average?

**Group 3 (30 points)**

Corks & Bottles Company (CBC) is a leading cork stoppers manufacturer from Alentejo. Since there is an annual demand of 12000 packages, CBC has just invested in a new machine that can produce 3000 cork stoppers packages per month. CBC estimates that each package costs 10€ per year to store. There are no backorders but lead time to suppliers is 4 weeks, on average.

The machine preparation, before each production run, costs 1000€ in materials and 2000€ in labor.

- How many packages of cork stoppers should CBC produce in each batch?
- The machine is only able to produce batches of 1000 packages. How many packages should CBC produce in order to minimize inventory costs?
- The brand new machine is also able to produce special Champagne stoppers and CBC has a commercial proposal to supply a large retail network. CBC estimates that will take them six months of annual production at current capacity to satisfy the forecasted demand. Do they need to invest in additional capacity or is the current system able to cope with the demand?

**Group 4 (35 points)**

Weekly demand for Pasteis de Belem in the most famous pastelaria of Lisbon/Belem “Casa Pasteis De Belem” (CPDB) is normally distributed with a mean of 84,000 pasteis per week, and a standard deviation of 15,000 pasteis. On average, two eggs are needed to make one pasteis. Currently, the store places orders for eggs via paper that is faxed to a supplier, and the supplier only sells eggs in “dúzia” (12 eggs package). Assume 52 working weeks in a year and the following data:

- Lead time for delivery of the order of eggs is 4 days
- Fixed cost (ordering and transportation) per order is \$300
- Each *duzia* costs \$1
- Holding cost is 20% of the inventory value of a *duzia*.

Present your results with two digits precision (two digits to the right of the decimal point).

- Which of the probabilistic inventory models would you use for this problem based on the information given in the text?

b) Assuming that CPDB wants the probability of stocking out in a cycle to be no more than 3%, recommend an optimal inventory policy (i.e. order quantity and safety stock). What is the level of safety stock? Under this policy, how long, on average, would a *duzia* of eggs spend in the storage? Would this method make sense for CPDB? Why?

c) CPDB uses only AA grade of eggs, and if kept properly the eggs are considered AA grade only for 2 weeks from the day of production. CPDB's manager suspects that existing inventory model (as described in b)) is not the best choice and that it may be improved. You are asked to propose another model, and you propose fixed P model. How would you recommend the manager to use the model to calculate order quantity? Show the manager an example, assuming that the inventory on hand is 4000 *duzias* and the service level is 97%. Calculate the level of safety stock.

d) Based on the result of your analysis, compare the two models for the manager, their advantages and disadvantages, and state your recommendation.

### Group 5 (30 points)

You are a manager at PortuSunny, a company that takes advantage of the country's sunny weather to sell country houses to rich people from Northern Europe. These people can proactively contact you, but you must do a huge marketing effort to be noticed in your target markets. When a potential customer contacts you, your sales team must do all it can to try and sell a house from your portfolio to that person.

You would like to know how many potential customers you will probably have in the near future, given the data of the previous months. Because the industry is very recent, the number of submissions is quite unpredictable, and you decide to use the 3-period simple moving average method.

a) Calculate the forecast for months 4 to 7, as well as the Mean Absolute Deviation (MAD) and Mean Square Error (MSE) for the same period, based on the data obtained from the initial 6 months of operation.

month	1	2	3	4	5	6
Potential customers	14	24	16	38	48	52

b) After one year, you decide to change your forecasting method. You are still using the 3-month moving average, but you think that the data from the last month is twice as meaningful as each of the other two months. Calculate the forecast for months 10-13 as well as the MAD and MSE for that period.

month	7	8	9	10	11	12
Potential customers	24	16	32	56	64	48

c) Three years have passed, and you finally realize that the number of customer contacts is cyclical. You have summarized the quarterly data as shown in the table below. You also have computed the least squares regression line function ( $y = 59,24 + 14,86 x$ ) and the seasonality indexes for each month. Find the forecast for each quarter of 2014 using seasonal indexes.

	2011				2012				2013			
Quarter	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Potential customers	58	138	72	168	86	184	100	224	124	268	140	308
Seasonal index	0,78	1,55	0,69	1,42	0,64	1,24	0,61	1,26	0,64	1,29	0,63	1,30

**Group 6 (35 points)**

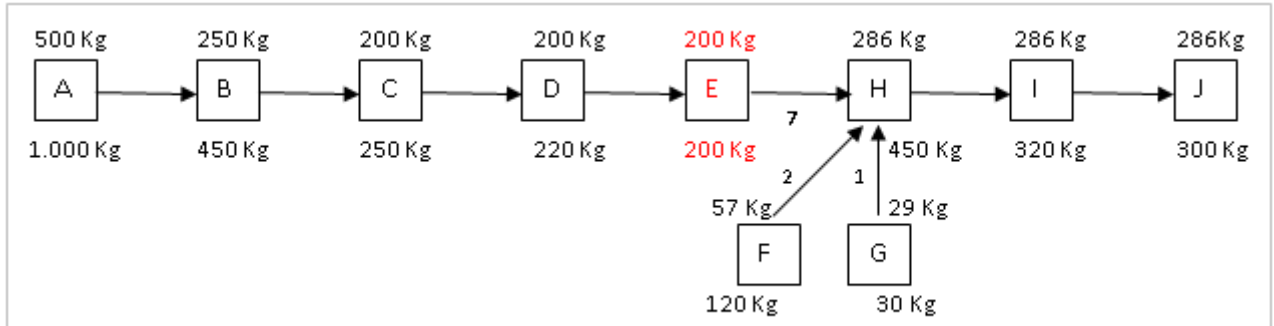
Classify the following sentences as True (T), False (F), or Undetermined (U). Briefly explain your choice (2 lines maximum). Most of grade refers to the explanation.

- 1) (7pts) In a product/process matrix, as we move from 'continuous process' to 'project', we typically will encounter lower volumes, less vertical integration, more resource flexibility, more customer involvement and less capital intensity.
- 2) (7pts) A company that uses control charts to control the production process is not taking into account its immediate customer needs.
- 3) (7pts) The process capability ratio is good enough to conclude if a given production process is producing according to the customer specifications.
- 4) (7pts) Exponential smoothing is a special type of weighted moving average.
- 5) (7pts) In a service with an average utilization rate lower than 5%, a queue should never form over time.

## SOLUTIONS

### GROUP 1

#### 1. Bottleneck E | Process capacity 286 Kg



2.

Phase A:  $50\% \times 1000 \times 80\% + \frac{3}{7} \times 400 = 400 + 171 = 571$

$571 - 286 = 285$

Phase B:  $80\% \times 450 + \frac{3}{7} \times 360 = 360 + 154 = 514$

$514 - 286 = 228$

Phase C:  $250 + \frac{3}{7} \times 250 = 250 + 107 = 357$

$357 - 286 = 71$

Phase D:  $220 + \frac{3}{7} \times 220 = 220 + 94 = 314$

$314 - 286 = 28$

Phase E:  $200 + \frac{3}{7} \times 200 = 200 + 86 = 286$

$286 - 286 = 0$

Phase F:  $120 + \frac{8}{2} \times 120 = 120 + 480 = 600$

$600 - 286 = 314$

Phase G:  $30 + 9 \times 30 = 30 + 270 = 300$

$300 - 286 = 14$

Phase H: 450

$450 - 286 = 164$

Phase I: 320

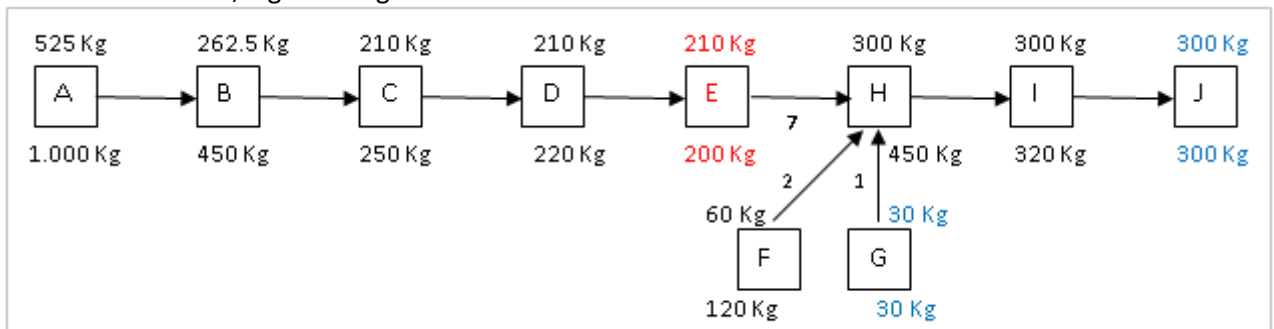
$320 - 286 = 34$

Phase J: 300

$300 - 286 = 14$

3.

1500 bars =  $1500 \times 0,2\text{kg} = 300 \text{ Kg}$



Bottlenecks (assuming one more container in Phase E): Phase G and Phase J

Suggestions:

Phase A: use 6 men (instead of 10)

Phase E: add more 10Kg of capacity (1 more container)

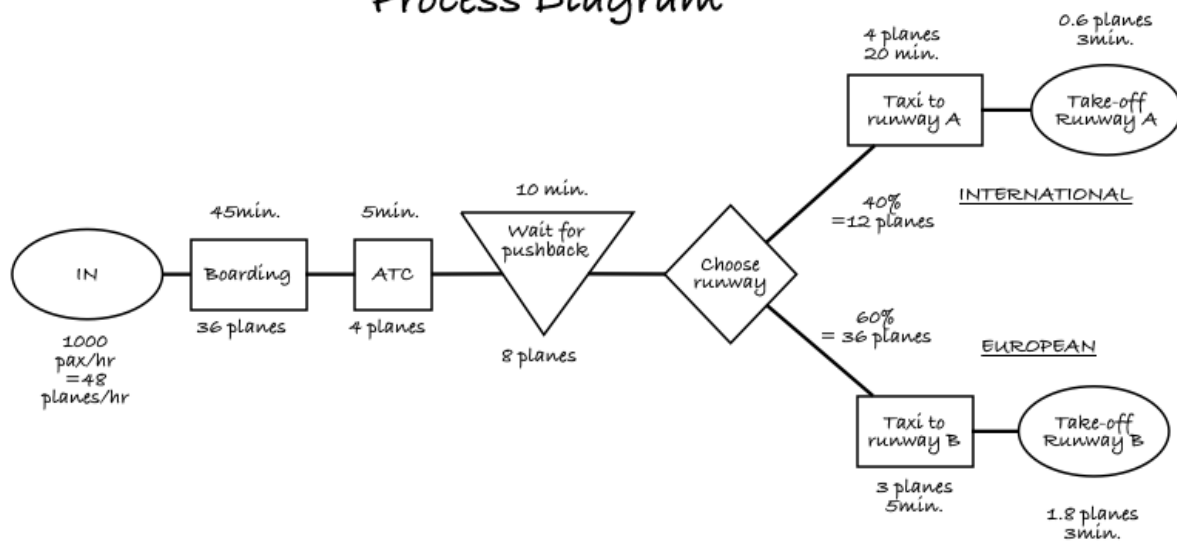
Phase F: use one container =  $1 \times 6 \text{ Kg} = 60 \text{ Kg}$  (instead of 2) – in this case, will be also a bottleneck

Phase H: use 2 containers =  $2 \times 150 \text{ Kg} = 300 \text{ Kg}$  (instead of 3) – in this case, will be also a bottleneck

## GROUP 2

1. + 2.

### Process Diagram



3.  $(83 \times 12 + 68 \times 36) / 48 = 71,75$  mins

## GROUP 3

1.  $Q^* = 3286$

2.

$Q = 3000 \Rightarrow TC = 12000 + 10000 = 22000$  €

$Q = 4000 \Rightarrow TC = 9000 + 13333 = 22333$  €

Ans: Batches of 3000 packages

3. Current demand takes 4 months of production. With additional 6 months for new product, there is still slack within a single year. No need to invest in new capacity.

## GROUP 4

1. Fixed quantity – or Q system

2. Optimal quantity, based on the information about:

Annual demand:  $D = 84000 \text{ pasteis/week} \times 2 \text{ eggs/pastel} \times 52 \text{ weeks} / 12 \text{ eggs/duzia} = 728\,000$  duzias/year

Average holding cost:  $C_H = 0.20 \times \$1 = \$0.20$

$$Q^* = \sqrt{\frac{2 \cdot D \cdot C_0}{C_H}} = \sqrt{\frac{2 \times (728\,000 \text{ duzia/year}) \times \$300}{\$0.20}} = 46\,733.29 \text{ duzias}$$

Service Level = 97%;  $(100 - 3\%)$ ;  $Z \approx 1.85$

Standard deviation of duzias' daily demand:  $\sigma_d = 357.14$

$$\sigma_L = \sqrt{L_T} \cdot \sigma_d = \sqrt{4} \times 357.14 = 714.29 \text{ duzias}$$

$$SS = Z * \sigma_L = 1.85 \times 714.29 \text{ duzias} = 1\,321.43 \text{ duzias}$$

$$\bar{I} = \frac{Q^*}{2} + SS = \frac{46\,733.29}{2} + 1\,321.43 = 24\,688.07 \text{ duzias}$$

On average, a duzia of eggs would spend in the storage

$$t_{\text{stock}} = \frac{\bar{I}}{\bar{d}} = \frac{24\,688.07 \text{ duzias}}{14\,000 \frac{\text{duzias}}{\text{week}}} = 1.76 \text{ weeks}$$

CPDB orders the specified quantity every:

$$t_{\text{order}} = \frac{Q^*}{\bar{d}} = \frac{46\,733.29 \text{ duzias}}{14\,000 \frac{\text{duzias}}{\text{week}}} = 3.34 \text{ weeks}$$

Note: Compare  $t_{\text{order}}$  and  $t_{\text{stock}}$  and take into consideration information that becomes available in c). You may find this useful to provide the answer for this problem's part d).

3.  $T+L = 2 \text{ weeks} = 14 \text{ days}$

$$q = \bar{d} * (T + L) + z * \sigma_{T+L} - I = \bar{d} * (T + L) + z * \sqrt{T + L} * \sigma_d - I$$

The example of using the formula to calculate the quantity to order, with an information of the existing level of inventory:

Average daily demand in duzias:  $\bar{d} = 2\,000 \text{ duzias}$

On-hand inventory:  $I = 4\,000 \text{ duzias}$

$$q = 2\,000 \text{ duzias} * (14) + 1.85 * \sqrt{14} * 357.14 - 4\,000 \text{ duzias} = 26\,472.17 \text{ duzias}$$

$$SS = Z * \sigma_{T+L} = 1.85 \times \sqrt{14} * 357.14 \text{ duzias} = 2\,472.17 \text{ duzias}$$

4. You can consider the comparison in two ways: qualitatively, and quantitatively.

Qualitatively, follow the instructions on slide 9 of the theoretical class presentation (OM class#4, Spring 2013), and also consider what is specific to holding eggs (freshness, quality, etc.) in perspective of the results obtain in previous steps.

Quantitatively, calculate total cost for both cases, and compare.

Both are accepted as correct, either provided separately, or together.

## GROUP 5

1.

month	1	2	3	4	5	6	7
submitted projects	14	24	16	38	48	52	
Forecast				18	26	34	46
Error				20	22	18	
Abs Error				20	22	18	
SQ Error				400	484	324	

MAD	20
MSE	402,7

## 2. 3 month moving weighted average

month	7	8	9	10	11	12	13
submitted projects	24	16	32	56	64	48	
Forecast				26	40	54	54
Error				30	24	-6	
Abs Error				30	24	6	
SQ Error				900	576	36	

MAD	20	w1	0,5
MSE	504,0	w2	0,25
		w3	0,25

## 3.

First use the linear regression formula to calculate the Forecast without seasonal index for each of the periods of 2014

$$y = 59,24 + 14,86 x$$

Then calculate the average seasonal index for each of the quarters:

St Q1 0,69

St Q2 1,36

St Q3 0,64

St Q4 1,32

Finally, calculate the forecast with the seasonal index for year 2014.

2014			
Q1	Q2	Q3	Q4
13	14	15	16
252,42	267,28	282,14	297,00
0,69	1,36	0,64	1,32
174,11	363,55	181,95	392,99