LISBOA SCHOOL OF ECONOMICS & MANAGEMENT

Production and Operations Management

Normal Examination Period

June 12, 2014 (Thursday), 9:00 a.m.

NAME _____

CONSULTATION OF ADDITIONAL MATERIAL IS STRICTLY FORBIDDEN. THE EXAM HAS EXACT DURATION OF 2 HOURS AND 30 MINUTES, WITH NO FURTHER TOLERANCE GIVEN.

PLEASE READ THE FOLLOWING INSTRUCTIONS BEFORE STARTING THE EXAM:

1. Leaving the examination room implies the final delivery of this exam. This includes exiting the room to use the sanitary facilities.
2. Please contact your instructor if you decide to forego the evaluation of this exam.
3. This exam has **18** pages. DO NOT UNSTAPLE THEM.
4. **Always write down your name in the specified spaces.**
5. The utilisation of cellular phones, headsets, or electronic devices other than your calculator is strictly forbidden.
6. Additionally, the usage of any feature cellular phone capability, including voice and/or text communication, clock, or calculator is strictly forbidden.
7. At your desk you may only have this exam, a calculator, a pen/pencil and a valid ID with photographic identification.

(I) (2.5 values)

Please mark the correct answer with an "X" on the shaded column.
A wrong or misplaced answer is considered null.

[0.5] One of the following options is **NOT** a process strategy. Please identify it:		
1		Feature Focus
2		Product Focus
3		Assembly Line
4		Mass Customization
5		Process Focus

[1.0] METALINOX produces metal parts. The parts are fabricated according to a two-stage process. The parts are, first, cut and, second, bended. Currently, 6 parts are being processed. The processing times for each of the two machines are the following:

	Parts (Processing hours)					
	A	B	C	D	E	F
Cutting (M1)	4	4	6	2	3	1
Bending (M2)	5	2	8	3	7	2

Which of the following sequences minimises total processing time:

1		A-B-C-D-E-F
2		F-D-E-A-C-B
3		F-D-B-A-E-C
4		F-D-B-E-C-A
5		F-E-D-C-A-B

[0.5] Fifty multimeter were tested for 10.000 hours. Knowing that the failure rate FR(%) was 12% and that the total operating time of the 50 multimeters was of 45.300 hours, the MTBF is:		
1		8333 hours
2		7550 hours
3		3775 hours
4		4700 hours
5		8000 hours

Name _____ [3]

[0.5] An electronics system has 4 sequential components with individual reliabilities of 0.85, 0.80, 0.99, and 0.95, respectively. If a double redundancy is introduced for the first two components, the system reliability is:		
1		0.82
2		0.58
3		0.97
4		0.88
5		0.93

[4]

(II)(5 values)

SONATURAL is launching a new softdrink product line. The production manager estimates that the following activities and costs will be necessary for the completion of the project:

Activity	A	B	C	D	E	F	G	H
Preced.	-	-	-	B,C	A	B	D,E,F	E,F
Normal time	6	4	5	4	2	4	3	7
Crash time	4	2	5	3	1	2	2	5
Normal cost (1.000€)	80	100	100	200	120	125	130	150
Crash cost (1.000 €)	110	120	100	222	135	159	146	220

a) **[1.0] Draw the network diagram for the project.**

b) **[1.0] Determine the project duration and identify the critical activities.**

c) **[2.0] Explain how would you reduce the project duration by 4 weeks. Compute the cost increase associated with the reduction of the project duration.**

d) **[1.0] Assume the production manager decided to reduce the duration of activity A by 2 weeks and of activity D by 1 week. What would the new project duration and new total cost be? (For the purposes of <u>this</u> question please assume that no activities have been previously crashed).**

Name _____ [5]

[6]

Name _____ [7]

(III)(5 values)

GPSSEGUE manufactures GPS systems for a well-known German carmaker. Annual demand for the model GPSA3, embedded on the A3 car model, is of 8.000 units. One of the components used in the production of the model GPSA3 is the AT1 antenna. Currently, the AT1 antenna is produced at GPSSEGUE facilities with a unitary production cost of €10. Each GPSA3 device uses one AT1 antenna. The company has the capacity of producing 10.000 antennas per year. Production start up cost equals €200 and the unitary, yearly holding, cost equals 20% of the unitary production cost. The time interval between production start-ups for the AT1 antenna is 100 days.

Assume GPSSEGYE operates 50 weeks per year and 5 days per week.

a) **[0.5] What is the lot size used by the company?**

b) **[0.5] Do you agree with the current lot size decided by the firm? Please justify your answer. (If you haven't answered the previous question, please assume GPSSEGUE uses a lot size of 3.400 units)**

c) **[1.0] What is the number of antennas in inventory 90 days after the start of production, given the lot size used by the company?**

[8]

Because of high production start up costs, the firm is considering the outsource of the AT1 antenna. An external supplier offers the following conditions:

- Cost per antenna: €15
- Lead time: random (normally distributed) with mean of 4 weeks and standard deviation of 2 weeks
- Order Cost: €50

The firm wishes to fulfil a 95% level of service to its clients. It is expected that the unitary, yearly holding, cost is 20% of the unit price.

d) **[1.0] What is the safety stock that ensures the desired level of service?**

e) **[1.0] What is the optimal number of orders in a year?**

f) **[1.0] Compute the annual holding cost.**

Name _____ [9]

(IV)(3.5 values)

MEDIACONTROL offers a variety of market research and advertising services. One of its clients, a dairy producer, wishes to design an advertising campaign for a new product launch. For this purpose, four TV commercials will be done on four different TV networks during primetime. MEDIACONTROL expects the audiences for each of the networks (RPT, ITV, CIS, and NXA) at different moments during the primetime window to be the following:

	Audiences (thousands of TV viewers)			
	ITV	RPT	CIS	NXA
1. 20h15	180	150	160	150
2. 21h30	170	155	170	165
3. 22h00	180	175	170	200
4. 22h40	190	170	180	155

(a) [2.5] What is the optimal assignment for the four TV commercials?

(b) [1.0] The operations manager of MEDIACONTROL decided to proceed with the following assignment for the commercials: ITV -21h30; RPT-22h40; CIS-22h00 e NXA-20h15. Compute the loss in TV viewers by not following the optimal assignment. (If you do not answer question a), assume that the optimal number of TV viewers is 710000)

Name _____ [11]

(V)(4 values)

On average, 10 clients arrive per hour to BLUEBLOOD, a clinical analysis lab. These arrivals follow a *Poisson* distribution. After arriving, clients are received by one single clerk who hands out forms for the different types of analysis made in the lab. This process takes, on average, 5 minutes. Assume the time needed to be received by the clerk and fill the form follows a negative exponential distribution.

After the form is completed the clients are either sent to the BLUEBLOOD clinical analyst, or to a more specialised lab, GENETONIC genetical testing clinic. It is estimated that 40% of clients stay at BLUEBLOOD while the rest is sent to the GENETONIC clinic. Assume that the inter-arrival time for the BLUEBLOOD analyst is 15 minutes with a standard deviation of 15 minutes. The time needed for the analyst to retrieve a blood sample is, on average, 5 minutes with a standard deviation of 5 minutes.

a) [1.0] What is the average time a client has to wait before being served by the clerk?

b) [1.0] What is the probability of having 2 or more clients in the queue (waiting to be served by the clerk)?

c) [2.0] What is the average number of clients in the BLUEBLOOD clinical analysis lab?

Name _____ [13]

[14]

Name _____ [15]

Formulas

Inventory Management

EOQ

$Q = \sqrt{\frac{2DS}{H}}$; N = D/Q ; ROP = d × L ;

$TC = \frac{Q}{2} \times H + \frac{D}{Q} \times S + P \times D$

POQ

$Q = \sqrt{\frac{2DS}{H(1-\frac{d}{p})}}$

$TC = \frac{Q}{2}(1 - \frac{d}{p}) \times H + \frac{D}{Q} \times S + P \times D$

$t_p = t_1 = \frac{Q}{p}$

$T = \frac{Q}{D}$

$I_{máx} = M = Q(1 - \frac{d}{p})$

Probabilistic Models

$SS = Z_\alpha \sigma_{dLT}$

$ROP = \mu_{LT} \times \mu_d + SS$

$\sigma_{dLT} = \sqrt{\mu_d^2 \times \sigma_{LT}^2 + \mu_{LT} \times \sigma_d^2}$

$ROP = LT \times \mu_d + SS$

$\sigma_{dLT} = \sqrt{LT} \times \sigma_d$

$ROP = \mu_{LT} \times d + SS$

$\sigma_{dLT} = \sqrt{d^2 \times \sigma_{LT}^2}$

$\alpha = P(X > ROP) =$ probability of stockout

$$TC = \left(\frac{Q}{2} + SS\right) \times H + \frac{D}{Q} \times S + P \times D$$

Project Management

EF = ES + Activity time

LS = LF – Activity time

Slack = LS – ES or Slack = LF– EF

$$\text{Crash cost per period} = \frac{CC - NC}{NT - CT}$$

$$\text{Expected activity time} = t = \frac{a + 4m + b}{6}$$

$$\text{Variance of activity completion time} = \left[\frac{(b-a)}{6}\right]^2$$

Formulas Sheet_2nd PART

Waiting Line Models

$$L_q = \lambda \times W_q \;;\quad L_S = \lambda \times W_S;\quad L_S = L_q + \lambda/\mu;\quad W_S = W_q + 1/\mu$$

M/M/1

$$L_q = \frac{\lambda^2}{\mu(\mu-\lambda)};\ L_S = \frac{\lambda}{\mu-\lambda} \qquad W_q = \frac{\lambda}{\mu(\mu-\lambda)};\ W_S = \frac{1}{\mu-\lambda}$$

$$\rho = \frac{\lambda}{\mu}; \qquad P_0 = 1 - \rho \qquad P_n = P_0 \times \left(\frac{\lambda}{\mu}\right)^n \qquad P(n > k) = \rho^{k+1}$$

M/M/S

$$P_0 = \frac{1}{\left[\sum_{n=0}^{S-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + \frac{(\lambda/\mu)^S}{S!} \times \frac{S\mu}{S\mu - \lambda}} \quad (S\mu > \lambda)$$

$$Lq = \frac{\lambda \times \mu \times \left(\frac{\lambda}{\mu}\right)^S}{(S-1)!(S\mu-\lambda)^2} P_0 \qquad \rho = \frac{\lambda}{S\mu}$$

$$P_n = \frac{\left(\frac{\lambda}{\mu}\right)^n}{n!} P_0 \quad (n \le S)$$

$$P_n = \frac{\left(\frac{\lambda}{\mu}\right)^n}{S!\, S^{n-S}} P_0 \quad (n > S)$$

M/D/1

$$L_q = \frac{\lambda^2}{2\mu(\mu-\lambda)}; \qquad W_q = \frac{\lambda}{2\mu(\mu-\lambda)} \qquad \rho = \frac{\lambda}{\mu}$$

M/G/1

$$Lq = \frac{\lambda^2\sigma_{te}^2+\rho^2}{2(1-\rho)} \qquad \rho = \frac{\lambda}{r_e} \qquad Po = 1-\rho$$

G/G/1

$$Lq = \frac{\rho^2}{1-\rho} \times \left(\frac{CV_{ta}^2+CV_{te}^2}{2}\right) \qquad CV_{ta} = \frac{\sigma_{ta}}{t_a} \qquad CV_{te} = \frac{\sigma_{te}}{t_e}$$

$$\rho = \frac{r_a}{r_e} \qquad r_a = \frac{1}{t_a} \quad r_e = \frac{1}{t_e} \qquad Po = 1-\rho$$

G/G/S

$$\rho = \frac{r_a}{Sr_e}$$

$$Lq = \frac{1}{S} \times \left(\frac{r_a}{r_e}\right) \frac{\rho^{\sqrt{2(S+1)}-1}}{1-\rho} \left(\frac{CV_{ta}^2+CV_{te}^2}{2}\right)$$

Scheduling

CR = $\frac{Due\ Date - Today's\ date}{Work(lead)\ time\ remaining}$

Average completion time = $\frac{Total\ Flow\ Time}{Number\ of\ jobs}$

Utilization = $\frac{Total\ job\ work\ time}{Total\ flow\ time}$

Average job lateness = $\frac{Total\ late\ days}{Number\ of\ jobs}$

Average number of jobs in the system = $\frac{Total\ flow\ time}{Total\ job\ work\ time}$

The Normal Distribution
Cumulative Standard Table

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990

α	0.400	0.300	0.200	0.100	0.050	0.025	0.020	0.010	0.005	0.001
Z_{α}	0.253	0.524	0.842	1.282	1.645	1.960	2.054	2.326	2.576	3.090
$Z_{\alpha/2}$	0.842	1.036	1.282	1.645	1.960	2.240	2.326	2.576	2.807	3.291