IST, Technical University of Lisbon
*Department of Chemical and Biological Engineering*

**“Athens” 1.st semester course** 20.th of March, 2009

# OPERATIONAL RESEARCH

## *Exam (simulated)*

*Duration:* 02 hours 30 minutes. *Type:* “open book” exam with computer.
*Author:* Miguel Casquilho [mobile ph., (+351) 91 919 2021]

**Instructions**
**(1)** Give your answers in an Excel file and or other, as needed. In the end: if you have not used any paper, at least leave a **sheet with your name**; and **send your file(s)** to ***mcasquilho@ist.utl.pt***, and, for security, to ***yourself*** and to the course e-mail account, ***athenslisbon@yahoo.co.uk*** (empty message with your *name* as subject). You may go to Yahoo to send the messages. **(2)** Below, references may be made to the ***c***ourse ***w***eb***p***age (CWP), which is at *web.ist.utl.pt/mcasquilho/acad/or/*. **(3)** If other Internet pages or sources are used, cite them.

**1)** *(Short answers)*

***a)*** How can an LP program work with free sign variables ?

***b)*** Who discovered the simplex method for LP ?

***c)*** Is the following true or false ? “In the Monte Carlo ‘inversion’ method, the only function (of the random variable to be simulated) that is needed is the density.”

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**3)** Company XYZ, with maximum profit as the objective, can manufacture certain products, with known *unit profits*, $P_i$, in *quantities*, $X_i$, to be determined, $i = 1..4$. It is assumed that $P = (5, 5, 5, 5)$. The technological or other conditions to be met are: 1) for safety, the total of 1 and 2 is *less than* or equal to the total of 3 and 4; 2) for fiscal reasons, the total of 3 and 4 is *greater than* or equal to 80 % of the whole production; 3) the market absorbs *up to* 300 units of the total of products 3 and 4.

***a)*** Formulate the problem (show the convenient mathematical formulas).

***b)*** Solve the problem (by any means) “as is” (only with its structural variables).

***c)*** Put the problem in the *standard form* and solve it again. Is the solution compatible with the previous one ?

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**4)** Cylindrical cans are filled with exactly 1 L (litre) of a liquid, i.e., $V = 1000\ \text{cm}^3$. The diameter of the cans, $D$, varies randomly with a *triangular* density in the interval $9.0 \pm 0.2$ cm. Find the probability that the height of the liquid exceeds 15.9 cm (which might hinder closing the can) in the following steps.

***a***) Simulate the filling of 100 cans.

***b***) Classify the values of $d$ in (say) 7 classes. Determine their accumulated values. With the classified values: make a histogram; and from the accumulated values, find the probability as mentioned.

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**5)** A queue, when working with one server, shows an average length of $L_q = 8.4$ and causes an average wait of $W_q = 20$ min.

***a)*** Calculate its parameters.

***b)*** For the same arrival rate, calculate the service rate that reduces $W_q$ to half the previous value.

***c)*** Determine the minimum service rate for the same arrival rate.

***d)*** Compare the cost of the system with *one* and *two* servers for costs of $C_s$ = 66 € / server / day, with 1 day = 12 h, and $C_w$ = 8 € / hour.

***e)*** Calculate $L_q$ for a new number of two servers.

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| Marks: | **1)** | | 1.5 | (3 × 0,5) | 30 % |
| | **2)** | | 7 | (1+2+2+2) | 35 % |
| | **3)** | | 5 | (2+3) | 25 % |
| | **4)** | | 8 | (4+4) | 40 % |
| | | Total | ***26*** | | ***130*** % |

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