STATISTICAL MODELING AND DESIGN OF EXPERIMENTS (SMDE) -MIRI- (FIB- UPC)
COURSE 2018-2019 Term 1 –FINAL TEST
(Date: 17/01/2018 at 10:00-12:00)

Name:	
DNI or PASSPORT:	
Professors:	Pau Fonseca i Casas
Marks on Racó:	22 of January
Revision:	on C5218

1 Statistics (2.5 points)

Determine whether the following amount of insects (*Epilachna varivestis* by bean plants) can be represented by a Poisson distribution (the Expected value for the Poisson distribution is on Ei column).

Frequency table

Y	fy (=Oi)	Ei
0	12	23.03
1	56	36.01
2	23	28.15
3	10	14.67
4	5	5.73
5	4	2.39
total	**110**	**110**

Chi-square table critical values

df	0,1	0,05	0,025	0,01	0,005
1	3	4	5	7	7,8794
2	5	6	7	9	10,5965
3	6	8	9	11	12,8381
4	8	9	11	13	14,8602
5	9	11	13	15	16,7496
6	11	13	14	17	18,5475
7	12	14	16	18	20,2777
8	13	16	18	20	21,9549
9	15	17	19	22	23,5893
10	16	18	20	23	25,1881
11	17	19,6	22	25	26,7569
12	19	21	23	26	28,2997
13	20	22	25	28	29,8193
14	21	24	26	29	31,3194
15	22	25	27	31	32,8015
16	24	26	29	32	34,2671
17	25	28	30	33	35,7184
18	26	29	32	35	37,1564
19	27	30	33	36	38,5821
20	28	31	34	38	39,9969

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2 DOE (4 points)

An injection modeler wanted to gain better control of part shrinkage. The experimenter set aside two parallel production lines for a study of those seven factors. The objective of the test is to identify the important factors.

For this example, the seven factors are:

Table 5.11 Factors for molding case

	Factor	*Units*	*Low (–)*	*High (+)*
A.	Mold temperature	degrees F	130	180
B.	Cycle time	seconds	25	30
C.	Booster pressure	psig	1500	1800
D.	Moisture	percent	0.05	0.15
E.	Screw speed	inches/sec	1.5	4.0
F.	Holding pressure	psig	1200	1500
G.	Gate size	inches (10^{-3})	30	50

Compare the alternative of a full factorial design with other two less costly alternatives. Discuss the pros and the cons of the considered alternatives.

What is the method that will be used to calculate the replications considering that each piece that enters in the injection modeler is independent from the previous one? . Discuss the answer.

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Revision:	on C5209

3 Queueing theory (3.5 points)

[10p] A container unloading platform may allocate two containers, carrying each one of them two machines. An operator is responsible for extracting from each of the containers the two machines inside and it always does it sequentially (first one machine and then the other). The containers are attended by the order of arrival at the platform and the two machines inside must be always removed before proceeding with a second container that has arrived later on the platform. If at any given time there are two containers on the platform (one from which the machines are removed and another closed waiting), a third container that arrives is diverted to another facility. On average, every hour there is the arrival of a full container with the time between arrivals exponentially distributed. The time to extract a machine from a container is an hour on average (time also exponentially distributed)

1- [4p] State the Continuous Parameter Markov Chain that models the evolution of the number of machines in the platform calculate the probabilities in steady state that there are 0,1,2,3,4 machines.

2- [2.5p] Calculate the probability that a container can find a place on the platform and the average number of containers that are admitted per unit of time.

3- [3.5p] Calculate the average number of machines on the platform (average temporary occupation) and the mean sojourn time of a machine in the platform.

4 Statistics (2.5 points) Solution

Y	fy=(Oi)	Pi	Ei	(Oi-Ei)^2/Ei
0	12	0,10909091	23,03	5,28
1	56	0,50909091	36,01	11,10
2	23	0,20909091	28,15	0,94
3	10	0,09090909	14,67	1,49
4	5	0,04545455	5,73	0,09
5	4	0,03636364	2,39	1,08
total	110	1	109,98	19,99

Looking the table we have:

Df 5 al 0.05 →11, but we have 19.99. We reject null hypothesis. The Epilachna varivestis **can not** be represented by the proposed Poisson distribution.

Chi-square table

df	0,1	0,05	0,025	0,01	0,005
1	3	4	5	7	7,8794
2	5	6	7	9	10,5965
3	6	8	9	11	12,8381
4	8	9	11	13	14,8602
5	9	11	13	15	16,7496
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5 DOE (4 points) Solution

A two-level full factorial design will require 2^7 = 128 runs. It will be time-consuming and costly. Defining the table for this experimental full factorial 2^7 design we obtain:

Exp.	A	B	C	D	E	F	G	H
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	+
3	-	-	-	-	-	-	+	-
4	-	-	-	-	-	-	+	+
..	..	..	..	..	..	..	..	..
127	+	+	+	+	+	+	+	-
128	+	+	+	+	+	+	+	+

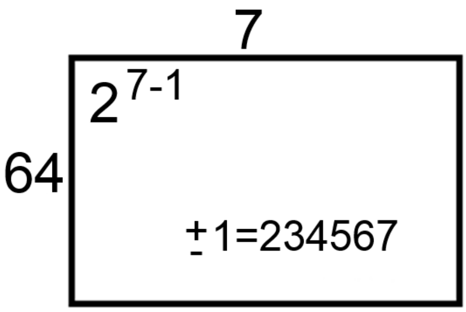
For each one of the different experiments it is needed to calculate the number of replications, and depending on the resources needed for each replication this can be unfeasible.

In order to reduce the amount of experiments to be considered two alternatives can be done, a fractional design or a Plackett and Burman (PB) design.

For a fractional design it is needed to define the "fraction" of the experiments that are going to be executed, and the confounding factors. Depending on the desired "resolution" of the experiment we are losing information related to the interaction between the different factors. This example needs 64 experiments and could be defined as follows:

Number of factors	Fraction	Resolution	Experiments	
7	2	VII	64	I=ABCDEFG

Hence:



PRO: we can reduce the number of experiments depending on the desired resolution.

CONS: we lose some interactions information.

For the PB design the table that we obtain is:

Config	Input Parameters (factors)							Response
	A	B	C	D	E	F	G	
1	+1	+1	+1	-1	+1	-1	-1	
2	-1	+1	+1	+1	-1	+1	-1	
3	-1	-1	+1	+1	+1	-1	+1	
4	+1	-1	-1	+1	+1	+1	-1	
5	-1	+1	-1	-1	+1	+1	+1	
6	+1	-1	+1	-1	-1	+1	+1	
7	+1	+1	-1	+1	-1	-1	+1	
8	-1	-1	-1	-1	-1	-1	-1	
Effect								

PRO: less experiments to be analyzed that in the previous alternative.

CONS: only the main effects are analyzed.

Since we are focused on the **method** to perform the replications we must analyze if the system can be represented by a finite simulation (or not) and if the loading period is needed (or not). In that case, each piece can be considered independent from the previous one, and for sure that the loading period analysis is needed, hence we must use **Independent repetitions**, it is clear that each different piece is going to start a completely new cycle.

If the question (not the case) ask regarding the **number** of replications, one can use the formula:

$$n^* = n\left(\frac{h}{h^*}\right)^2$$

where:

n = initial number of replications.

n* = total replications needed.

h = half-range of the confidence interval for the initial number of replications.

h* = half-range of the confidence interval for all the replications (the desired half-range).

6 Queueing theory (3.5 points) Solution

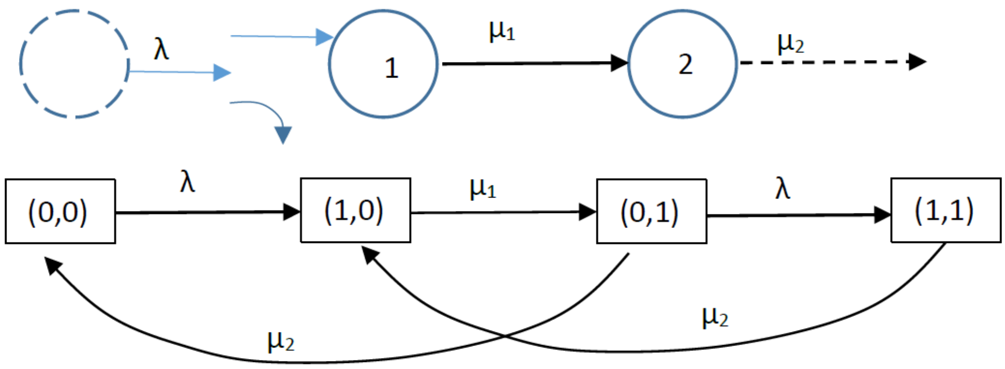


Figura 2: Transitions Diagram.

$$Q^\top = \begin{array}{c} (0,0) \\ (0,1) \\ (1,0) \\ (1,1) \end{array} \begin{pmatrix} -\lambda & \mu_2 & 0 & 0 \\ 0 & -\mu_2 - \lambda & \mu_1 & 0 \\ \lambda & 0 & -\mu_1 & \mu_2 \\ 0 & \lambda & 0 & -\mu_1 \end{pmatrix}$$

$$Q^\top \pi = 0, \ \sum_\ell \pi_\ell = 1 \text{ para } \lambda = \mu_2 = \mu_1 = 1h^{-1}$$

$$\begin{aligned} \pi_{00} &= 1/5 \\ \pi_{01} &= 1/5 \\ \pi_{10} &= 2/5 \\ \pi_{11} &= 1/5 \end{aligned}$$

$\pi_0(0) = \pi_{00} + \pi_{01}$, $\pi_0(1) = \pi_{10} + \pi_{11}$, $\pi_1(0) = \pi_{10} + \pi_{00} = 3/5$,

$$\pi_1(1) = 2/5$$

$L_0 = \pi_0(1) = 3/5$
$L_1 = 1\pi_1(1) = 2/5$
$L = 0\pi_{00} + 1(\pi_{01} + \pi_{10}) + 2\pi_{11} = 1$
$\bar{\lambda} = \lambda\pi_0(0) = 2/5$
$W = L/\bar{\lambda} = 5/2$