

QUALITY MANAGEMENT 444

Tutorial 9 Week 10

Prof Imke de Kock

imkedk@sun.ac.za





Tutorial 9



Practical exposure to a full factorial 3-factor DOE
Optimizing the design of paper helicopters.

You will need:

- Scissors
- Ruler
- Pencil
- A4 paper (at least 8 pages)
- Laptop capable of running Excel





Paper helicopters

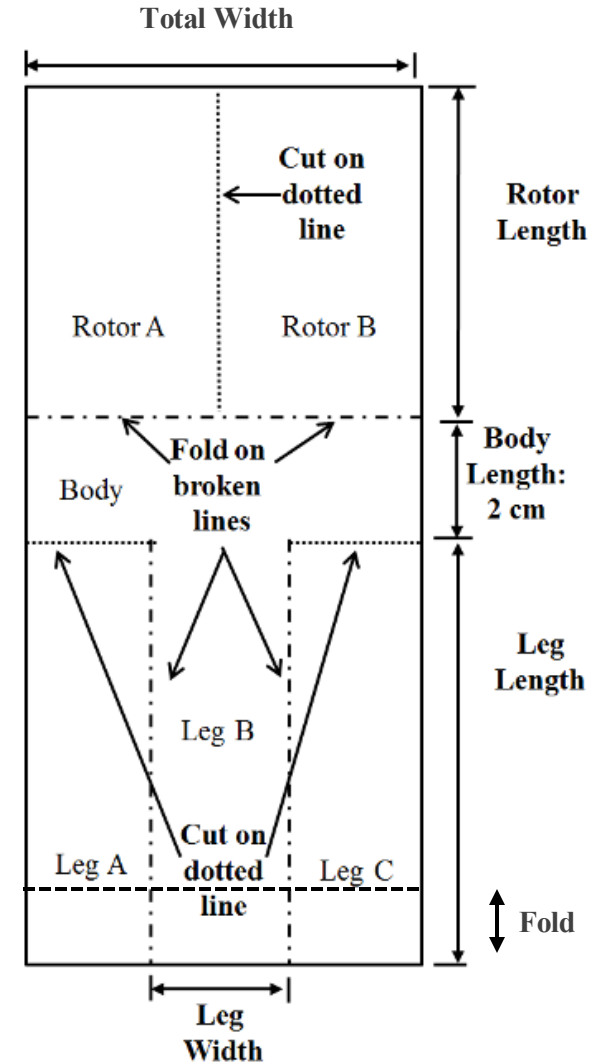




Decide on 3 factors, and two levels



- Full factorial DOE using 3 factors
 - $2^3 = 8$ runs (Excel template)
- Assume:
 - Rotor width = $1/2$ total width
 - Leg Width = $1/3$ total width
- Choose
 - 2 x rotor lengths
 - 2 x leg lengths
- Third = your choice
 - Total width
 - Bottom fold (yes/no or height)
 - Thickness of paper
 - Paper clip
 - Body Length





Making the helicopters



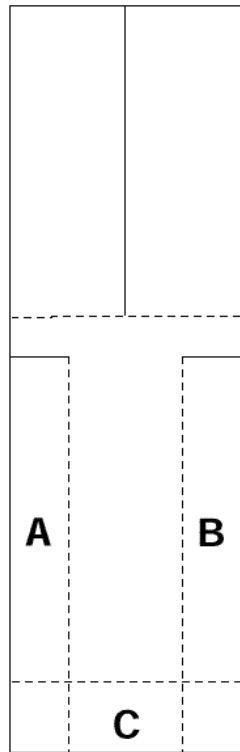
1. Cut on solid black lines.
Fold on dashed lines.

2. Fold A and B
to middle.

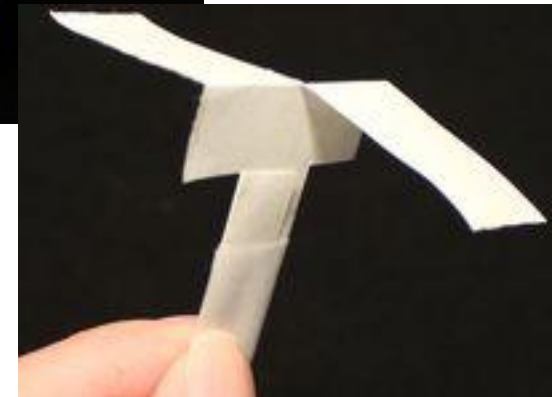
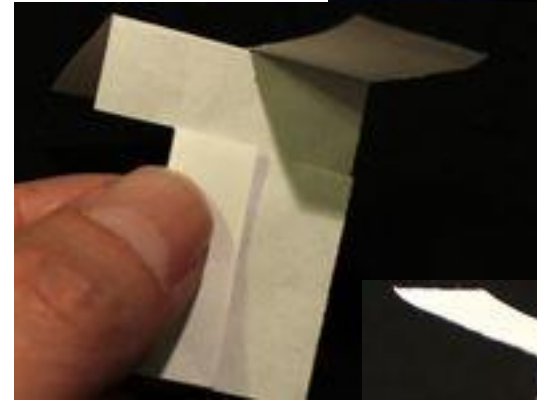
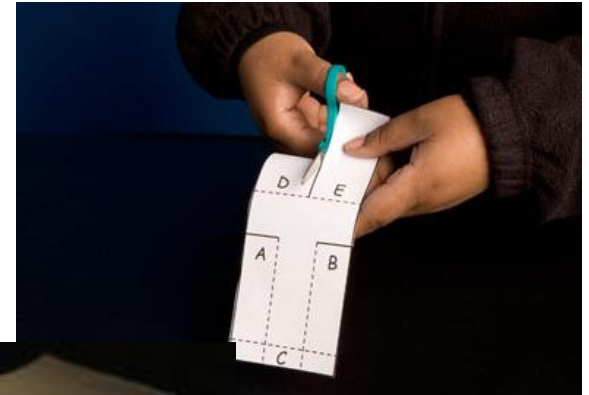
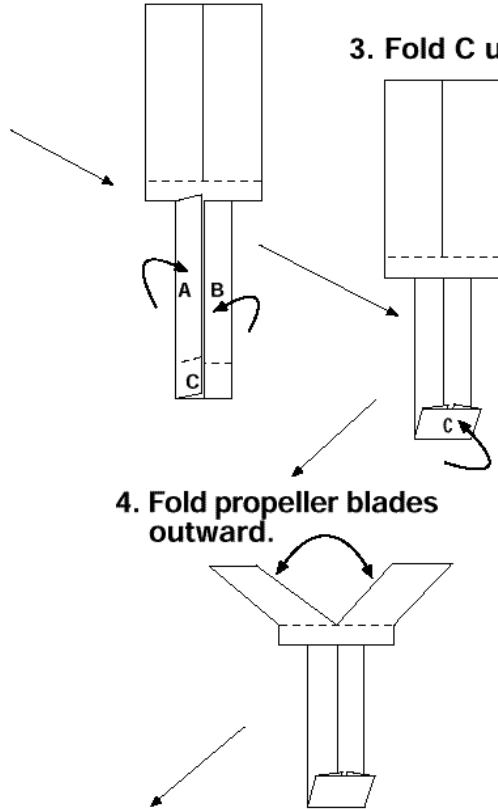
3. Fold C up.

4. Fold propeller blades
outward.

5. Test fly by dropping
from over your head.



Paper Helicopter
Pattern





3_Factor_DoE_Template



Step 1: Enter factor names

Enter Factor Names		
Rotor L	Leg L	Total W

☐ Samples are Replicates

Units
sec

Random Order	A	B	C	A X B	A X C	B X C	A X B X C	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Avg
1 # 6	75	80	75	1	1	1	-1	2.39	2.3	1.99			2.22667
2 # 8	75	105	105	1	-1	-1	1	2.07	2.11	1.94			2.04
3 # 1	75	105	105	-1	1	1	-1	2.03	2.1	2.17			2.1
4 # 4	75	105	105	1	1	-1	-1	1.91	2.04	1.9			1.95
5 # 2	90	105	105	1	1	1	1	2.75	2.65	2.6			2.66667
6 # 5	90	80	105	-1	1	-1	-1	2.48	2.47	2.77			2.57333
7 # 3	90	120	75	1	-1	-1	-1						2.32333
8 # 7	90	120	105	1	1	1	1						2.18667

Step 3: Do experiments according to run order

Step 4: Repeat measurements (not replicates)

Step 2: Enter hi/lo settings

ANOVA Table Using the Sum of Squares					
Factor	df	Sum of Sq.	Mean Sq.	F-Value	P-Value
A	1	0.2568056	0.2568056	321.00694	0.0354954
B	1	0.1120222	0.1120222	140.02778	0.0536713
A X B	1	0.0329389	0.0329389	41.173611	0.0984218
C	1	0.0401389	0.0401389	50.173611	0.0892857
A X C	1	0.0014222	0.0014222	1.7777778	0.4096655
B X C	1	5.556E-06	5.556E-06	0.0069444	0.9470706
A X B X C	*	*	*	*	*
Error	1	0.0008	0.0008		
Total	7	0.4441333			

Enter actual Hi and Low Settings			Use sliders to find best output		
Factor	Lo Setting	Hi Setting	Coded level, -2 to 2		Best
Rotor L	75	90	◀	2	97.5
Leg L	80	120	◀	-2	60
Total W	75	105	◀	-0.01	89.85
Y=					3.11003

Select what you would like to optimize

☒ Target Value

☐ Minimum Variation

Step X: ID significant factors

Step 5: Predict 'optimum' design

- Significant at 95% confidence



Tutorial / Assignment submission



- ⦿ 3 – 5 slide presentation
 - ⦿ Videos & photos
 - ⦿ Excel outputs
 - ⦿ Clear description of findings (...what could you not / did you not control that had / may have had an influence on outcome?)
 - ⦿ A brief reflection of the applicability and value of DoE for (i) industrial engineers, and (ii) within the context of quality management.
-
- Submit on SUNLearn by 15 October, 13h00