ESD.33 Systems Engineering

Assignment 6
Design of Experiments

Due Date: 13 July, 8:30AM EST

Deliverable: Team written report (about five pages)

Time allotment: You should expect to spend 5 hours all together on this homework.

Grading: 5% of your final course grade. Every team member earns the same grade.

Assignment:
Self select into teams of 2 to 5 people. In this case, I think it is best to have a heterogeneous team.

1) Short answer questions

a. Stephan Thomke lists three properties of a good prototype. List and briefly describe these properties.

b. Give an example (from the team's personal experience) of effective use of a prototype in the early stages of the systems engineering process.

c. In hospital (A), 45 babies are born each day (on average) and in the smaller hospital (B) about 15 babies are born each day (on average). For a period of a year, each hospital recorded the days on which more than 60% of the babies were boys. Which of the following statements is true? Why?

1) Hospital A probably recorded more days with >60% boys
2) Hospital B probably recorded more days with >60% boys
3) Hospital A and B are probably about the same

d. In George Box's paper "Statistics as a catalyst to Learning by the Scientific Method: Part I" he describes the use of a resolution IV design as a screening experiment. What is a screening experiment? What role does it play in designing a system? What is the rationale for using a Resolution IV experiment for this purpose?

e. In George Box's paper "Statistics as a catalyst to Learning by the Scientific Method: Part I" he describes the use of a central composite design. What is the purpose of a central composite design (CCD)? How does the arrangement of sample points in the CCD make sense in light of its purpose?

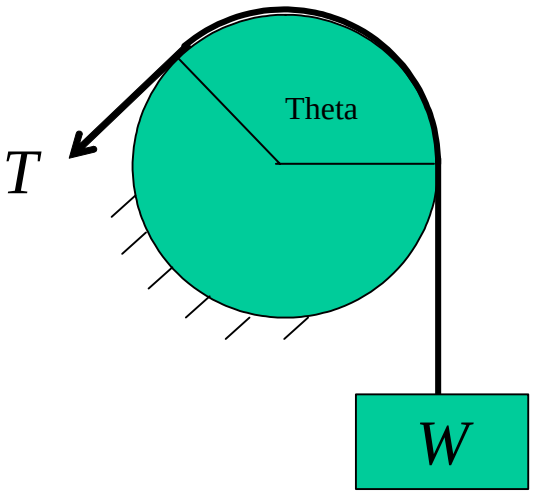
2) The two sub-problems below concern regression

a. The data below come from an experiment on a prosthesis in which cable tension was varied systematically and grip force was measured. Perform linear regression on this data. What is the equation relating the two variables? What is the R squared value? What does it mean? What is the F ratio? What does it mean? What is the p-value for the slope of the regression line? What conclusion do you draw? Plot the residuals.

Cable Tension (lbs)	Prosthetic Grip Force (lbs)
12	2.010771454
12	3.098565848
12	2.406333052
12	2.274479186
12	2.406333052
21	3.988579442
21	4.252287174
21	3.988579442
21	4.515994905
21	4.450067973
15	4.186360241
15	2.670040784
15	3.131529314
15	2.966711982
15	3.329310113
27	5.504898899
27	6.296022095
27	6.098241296
27	6.361949027
27	6.658620226
6	2.14262532
6	0.955940527
6	0.988903994
6	1.153721326

continued	
6	0.955940527
24	4.515994905
24	4.812666104
24	5.471935433
24	5.175264235
24	5.274154634
9	2.637077317
9	2.076698387
9	1.549282924
9	1.450392524
9	1.58224639
18	4.186360241
18	3.560054378
18	4.153396774
18	3.82376211
18	3.856725576
3	1.186684793
3	0.494451997
3	0.527415463
3	0.824086662
3	0.725196262
30	5.669716232
30	6.790474091
30	6.856401024
30	5.933423963
30	6.856401024

b. The data below come from an experiment in which the wrap angle over a capstan is varied and the ratio of tension to weight is measured. Perform linear regression on this data. What is the equation relating the two variables? What is the R squared value? What does it mean? Plot the residuals. How do your conclusions differ from those in sub-problem (a)? What do you suggest doing to further analyze this data?



Theta	T/W
0	1
30	1.06708
60	1.13966
90	1.215042
120	1.296548
150	1.38352
180	1.436327
210	1.57536
240	1.701036
270	1.7938
300	1.914129
330	2.002529
360	2.179542

3) The template "paper_airplane.pdf" contains a template for a paper airplane. It has four variables that can be changed independently between three different levels each. The template also has a nine run orthogonal array printed on its side (Taguchi's L9 or Plackett Burman P-$B_{3,9}$). Carry out the experiment described. Preferably, your team should perform at least one true replicate with a different thrower. Preferably, your team should randomize the throw order of the 9 treatment conditions. You may need to mark off distances on the floor with tape or a tape measure.

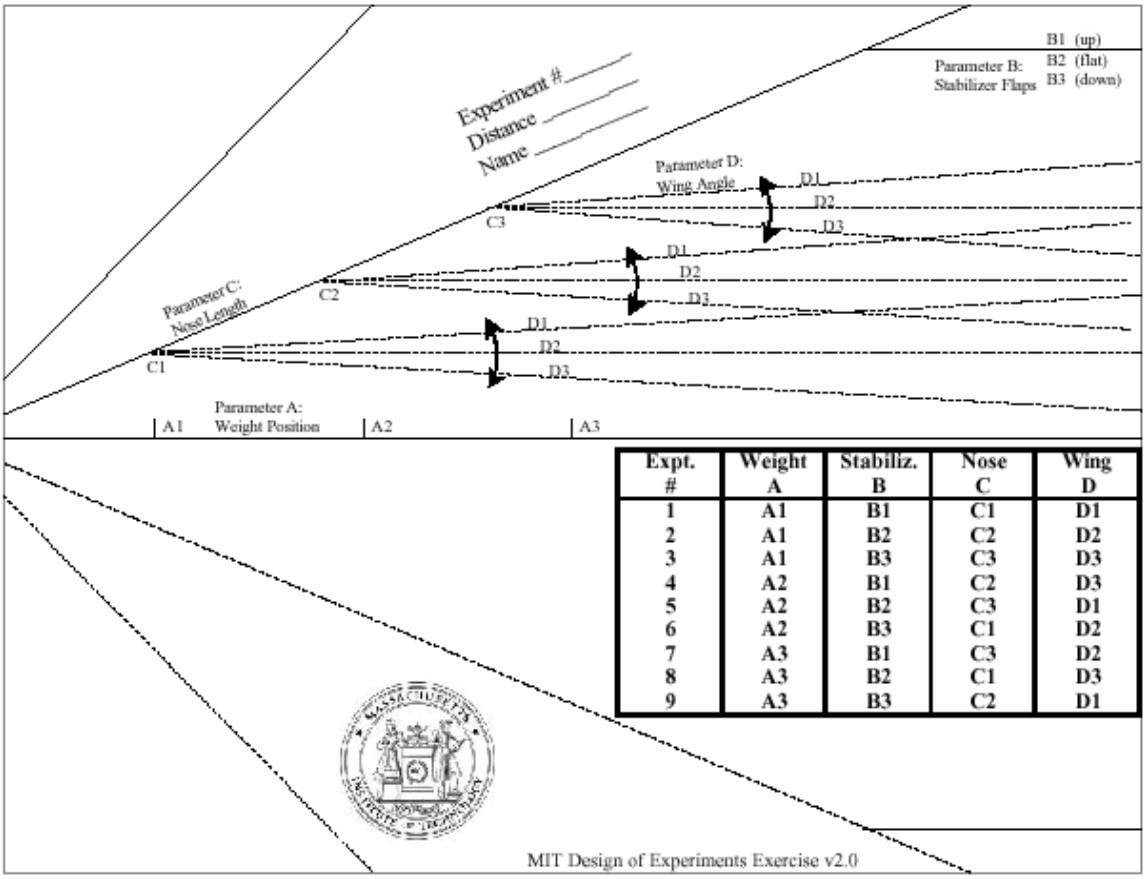
a) List the data along with any pertinent notes concerning the conduct of the experiment.

b) Create plots indicating the main effects of the factors.

c) Compute confidence intervals on the main effects.

d) Select the values of the variables that give the longest flight. Manufacture that plane and fly it at least three times. How does its flight compare to the predicted flight distance based on an additive model?

e) Select at least one two factor interaction of interest and use a full factorial design 2^2 to study it.



Expt. #	Weight A	Stabiliz. B	Nose C	Wing D
1	A1	B1	C1	D1
2	A1	B2	C2	D2
3	A1	B3	C3	D3
4	A2	B1	C2	D3
5	A2	B2	C3	D1
6	A2	B3	C1	D2
7	A3	B1	C3	D2
8	A3	B2	C1	D3
9	A3	B3	C2	D1