



School of Aerospace Engineering
AE3051

**THE NATURE OF EXPERIMENTS
AND EXPERIMENTAL PLANNING**

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(With excerpts from Planning Experimental Programs
by R.J.Moffat, ©1978)

Why Experiments?

Engineering Problem Solving Tools

- **Inspiration**
 - creativity and physical intuition
 - not methodical (but can be “taught”)
- **Analysis** (theory/computer)
 - **based on deduction**
 - model manipulation
 - given a set of postulates, what is the outcome
- **Experiments**
 - **based on induction**
 - given a set of input and corresponding output data (w/ uncertainty), try to infer model function
 - experimental techniques: measurement and inference

Types of Data Taking

- **Experiments**

- Exploratory, trend identifiers (“easy”, what happens if....)
- Data acquisition over a range of parameters/screening
- Testing of hypotheses

- **Tests**

- Demonstration of system performance
- Performance testing against a know standard (“easy”, spelled out what you have to compare)
- Quality assurance sampling (“easy”, repetitive procedure, measuring relative deviations)

The Experimental Program

1. Problem Assignment
2. Determination of specific objectives
3. Selection of experimental approach
4. Parametric design of apparatus
5. Hardware design
6. Construction and installation
7. Shakedown, debugging and qualification runs
8. Data taking
9. Data reduction and analysis
10. Reporting

Planning
Iterative

Execution
Iterative



Selection of Objectives

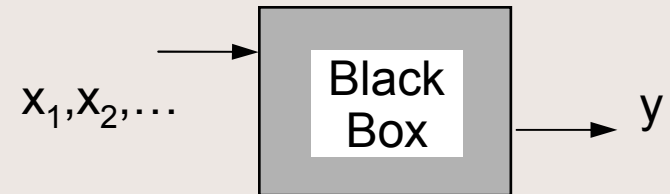
- **Motivating question**
 - not usually your choice, person who “pays the bill” chooses
- **Experimenters responsibility**
 - formulate several alternative statements of motivating question that include definite objectives
 - ask “which of these questions, if it alone is answered, will justify the cost of the experiment?”

The Right Question

- Good choice can be based on method of “strong inference”
- **Strong inference method**
 1. formulation of more than one alternative hypothesis concerning major question
 2. identification of *crucial* experiment(s) which would *disprove* each hypothesis
 3. carrying out experiment so as to get “clean” results
 4. iterating on procedure: making sub- or sequential hypotheses based on new information/data

The Experimental Problem

- Gathering enough **meaningful** input-output data
 - to infer form of **useful** model
 - to resolve question
- **Issues**
 - choosing input values, x_i
 - accuracy of data (inputs & outputs)
 - picking important independent variables $y=f(x_1, x_2, x_3, \dots)$
 - scalar data
 - hard to order some things, e.g., shape
 - identify quantifiable parameters



x	Y	sin (x)
0.000	0.000	0.000
0.786	0.707	0.707
1.571	1.000	1.000
2.357	0.707	0.707
3.142	0.001	0.000
3.928	-0.706	-0.707
4.713	-0.998	-1.000
5.499	-0.704	-0.707
6.284	0.005	0.001
7.070	0.713	0.708
7.855	1.006	1.000

Summary

- Experimental method different from analysis (class work)
 - heavy emphasis on induction
 - used to provide models for or tests of “reality”
- Experimental planning crucial
 - redefining the problem statement
 - identification of crucial experiments
- Experimental processes is iterative
 - experimenter required to constantly redefine physical model to ask new questions

Problem Statement #1

A manufacturer of human-powered vehicles wants to have their newest vehicle certified for operation on interstate freeways. They are concerned with what will happen when their vehicle is passed by large trailer trucks. Specifically, they are worried about “flows of air” from the truck “disrupting” their vehicle. You have been asked to design an experiment to determine the safe operating conditions for their vehicle in this regard.

Problem Statement #2

A significant problem in aircraft engines is compressor surge, which can be induced by flow distortions in the incoming air. NASUH has designed and built a facility that can create (hopefully) repeatable flow distortions by using "small" air jets surrounding the engine inlet, with the flowrate from each jet "programmable." As a NASUH engineer, you have been asked to characterize the various flow distortions caused by the jets.