

# Statistical Process Control and Design of Experiments Class Steve Brainerd

- Course Description
- Over the past 30 years design of experiments (DOE) has proven to be an extremely value tool allowing USA manufacturing to re-gain it's lead as the highest quality producer in the world.
- Course is geared for engineers in any industry/discipline seeking a practical understanding of design of experiments. Class will cover a review of **basic statistical techniques, distributions, Control charts, T-test, F-Test, ANOVA, full factorial designs, block designs, Latin squares, and fractional factorial designs..** Emphasis will be on practical applications of techniques to real world problems and how to avoid some of the typical errors made in designing, executing and analyzing an experiment. Actual industrial examples will be used throughout the class to allow the student to see the value of these techniques. Professor Brainerd brings over 25 years of engineering experience using experimental designs to solve many problems associated with the semiconductor manufacturing processes. Class project will involve the student actually running a DOE on a topic of interest.

# Statistical Process Control and Design of Experiments Class Steve Brainerd

- Syllabus

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- **Text Design and Analysis of Experiments, 5th Edition**


- Author Douglas C. Montgomery, John Wiley & Sons ISBN 0-471-31649-0; 5th ed. 2001

- Software Design Expert Version 6.03 Stat-Ease Inc.

- Student version Distributed by John Wiley and Sons ISBN 0 471-39411-4

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### – Good REFERENCES

- **World Class Quality**  **We will reference this text a few times!**  
Keki R. Bhote  
AMACOM ISBN 0-8144-5053-9; 1991
- **Statistics for Experimenters An Introduction to Design, Data Analysis, and Model Building**  
George E. P. Box, William G. Hunter, J. Stuart Hunter  
ISBN 0-471-09315-7; 1978
- **Practical Experiment Designs for Engineers and Scientists, 3rd Edition**  
William J. Diamond  
ISBN 0-471-39054-2; 1981
- **Experiments Planning, Analysis, and Parameter Design Optimization**
- Wu and Hamada  
John Wiley & Sons ISBN 0-471-25511-4;. 2000

## **Statistical Process Control and Design of Experiments Class Steve Brainerd**

- Statistical Process Control SPC and Design of Experiments DOE
- Class has 2 basic sections
- I Basic concepts, distributions, control charts, establishment of an effective measurement system, Cause generating techniques
- II. Inductive statistics Comparisons, ANOVA's, factorials, and fractional factorials.
- There will be many examples, diagrams, and graphics so you get a good sense of the planning, mechanics, and value of SPC and DOE!

## **Statistical Process Control and Design of Experiments Class Steve Brainerd**

- Section I Statistical Process Control SPC items and “clue generating techniques”.
- Tests for normal data
- Normal Probability plots
- Control Charts and rules
- Process Capability Cp CpK
- Sampling plan and OC curves
- Isoplot Shainin
- Multi-Vari plots
- B Vs C Shainin

## **Statistical Process Control and Design of Experiments Class Steve Brainerd**

- Section II Statistical Designed experiments
- T test
- F test
- ANOVA
- Factorial designed experiment
- Blocked designs
- Fractional factorials

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## *Class Schedule rev 1.0 weeks 1-3*

<i>Week</i>	<i>Class</i>	<b>WEEKLY GOAL</b>	<i>Lecture Topics</i>	<i>Professor -Student Presentation</i>	<i>Student Presentation</i>	<b>Text reference sections</b>	<i>Homework Assignment due</i>	<b>Text Reading</b>	<b>Lecture Notes Website</b>
1	1	<b>OVERVIEW PROBABILITY DISTRIBUTIONS</b>	Introduction Basic ideas Plot the data and Distributions	TEST Review project organization datasets		<b>Chapter 1</b>			<b>Overview;Normal tests; Chap 1</b>
	2		Normalcy test	Industrial example I	Student discussion on plans/goals for SPC DOE	<b>section 2-1; 2-2; 2-3</b>		<b>Chapter 1; "DOE Requires Careful</b>	<b>Distributions</b>
2	3	<b>DISTRIBUTIONS SPC CpK OC</b>	SPC Control Charts Cpk OC curves	Industrial example II		<b>lecture notes</b>	<b>HOMEWORK 1: Discuss Articles Create a Normal probability plot</b>	<b>Woodall Article</b>	<b>Distribution ; Control charts CpK</b>
	4		Measurement Systems Isolplot	Design Expert software	Explain Nomal Probability plots	<b>lecture notes</b>			<b>OC Curves Guage and Isoplot</b>
3	5	<b>Z and T Tests</b>	Z test and T test		Student Presentations on Selected projects	<b>lecture notes</b>	<b>Project Report 1 Proposal 5 pages</b>		<b>Z Score</b>
	6		B Vs C test	Industrial example III		<b>section 2-4</b>		<b>Chapter 2</b>	<b>Chap 2</b>

# Statistical Process Control and Design of Experiments Class Steve Brainerd

## *Class Schedule rev 1.0 weeks 4-6*

<i>Week</i>	<i>Class</i>	<i>WEEKLY GOAL</i>	<i>Lecture Topics</i>	<i>Professor -Student Presentation</i>	<i>Student Presentation</i>	<i>Text reference sections</i>	<i>Homework Assignment due</i>	<i>Reading</i>	<i>Lecture Notes Website</i>
4	7	<b>Non-Parametric tests and Paired Comparison F-Test</b>	Paired comparison and Sample size p 40 F-test	Industrial example IV	Explain 1 Homework example on board	<b>section 2-5</b>	HOMEWORK 2 : 2-5 2-12	<b>Summary table 46-47</b>	<b>Non-normal; Montgomery page 61</b>
	8		ANOVA Single factor	Anova example page 61		<b>Section 2.6 ;3-1</b>		<b>Chapter 2-6 to 3-2</b>	<b>Chapter 3; F test Logic</b>
5	9	<b>ANOVA</b>	Experimental planning	Industrial example V	Explain 1 Homework example on board	<b>section: 3-2;3-3</b>	HOMEWORK 3 : 3-6 3-9	<b>Chapter 3-3 to 3-7</b>	<b>Anova Logic</b>
	10		ANOVA	Example text page 70		<b>section 3-4;3-5;3-6</b>		<b>Design Expert example</b>	<b>Anova 1 and 2</b>
6	11	<b>ANOVA Randomized Blocks</b>	ANOVA	Design Expert example		<b>Section 3-7; 4-1</b>			<b>Anova 3</b>
	12		Blocks RCBD	Industrial example VI	Student Presentations on Selected projects	<b>Section 4-1</b>	Project Report 25 pages	<b>Chapter 4: 4--1</b>	<b>Chapter 4; Blocking Basics</b>

# Statistical Process Control and Design of Experiments Class Steve Brainerd

## *Class Schedule rev 1.0 weeks 7 -10*

<i>Week</i>	<i>Class</i>	<b>WEEKLY GOAL</b>	<i>Lecture Topics</i>	<i>Professor -Student Presentation</i>	<i>Student Presentation</i>	<b>Text reference sections</b>	<i>Homework Assignment due</i>	<b>Reading</b>	<b>Lecture Notes Website</b>
7	13	<b>Factorial Design</b>	Blocks Latin squares		Explain 1 Homework example on board	<b>Section 4-2</b>	HOMEWORK 4: 4-6 4-15	<b>Chapter 4: 4-2</b>	<b>Chapter 5</b>
	14		Factorial design	Industrial exampleVII		<b>Section 5-1 5-2 5-3</b>		<b>Chapter 5: 5-1 5-2 5-3</b>	<b>Basic Factorial Design Chap 5</b>
8	15	<b>Factorial Design</b>	Factorial design		Explain 1 Homework example on board	<b>Section 5-3 5-5</b>	HOMEWORK 5: 5-5 5-17	<b>Chapter 5: 5-3 5-5</b>	<b>Chap 5 example</b>
	16		Factorial design	Industrial example VIII		<b>Section 6-1 6-2</b>		<b>Chapter 6: 6-1 6-2</b>	<b>Chapter 6</b>
9	17	<b>2k Factorials</b>	2k Designs		Explain 1 Homework example on board	<b>Section 6-3 6-4</b>	Homework 6: 6-1	<b>Chapter 6: 6-3 6-4</b>	<b>Chapter 6</b>
	18		2k designs	Industrial example IX		<b>Chapter 7</b>		<b>Chapter 7: 7-1 7-3</b>	<b>Chapter 7</b>
10	19	<b>Fractional Factorials</b>	Fractional Factorials		Final Student Presentations	<b>Section 8-1</b>	Homework 7: 7-2; 8-25	<b>Chapter 8 8-1</b>	<b>Chapter 8</b>
	20		Fractional Factorials		Final Student Presentations	<b>Section 8-2 8-3</b>	Final Project Report 15 pages	<b>Chapter 8: 8-3</b>	<b>Chapter 8</b>



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**Homeworks Week 1-5 >> 5.7% each x 7 = 40% of your grade**

<i>Week</i>	<i>Class</i>	<i>WEEKLY GOAL</i>	<i>Lecture Topics</i>	<i>Professor -Student Presentation</i>	<i>Student Presentation</i>	<i>Homework Assignment due</i>
1	1	<b>OVERVIEW PROBABILITY DISTRIBUTIONS</b>	Introduction Basic ideas Plot the data and Distributions	TEST Review project organization datasets		
	2		Normalcy test	Industrial example I	Student discussion on plans/goals for SPC DOE	
2	3	<b>DISTRIBUTIONS SPC CpK OC</b>	SPC Control Charts Cpk OC curves	Industrial example II	Discussion on Articles	<b>HOMEWORK 1: Discuss Articles Create a Normal probability plot</b>
	4		Measurement Systems Isolplot	Design Expert software	Explain Nomal Probability plots	
3	5	<b>Z and T Tests</b>	Z test and T test		Student Presentations on Selected projects	<b>Project Report 1 Proposal 5 pages</b>
	6		B Vs C test	Industrial example III		
4	7	<b>Non-Parametric tests and Paired Comparison F-Test</b>	Paired comparison and Sample size p 40 F-test	Industrial example IV	Explain 1 Homework example on board	<b>HOMEWORK 2 : 2-5 2-12</b>
	8		ANOVA Single factor	Anova example page 61		
5	9	<b>ANOVA</b>	Experimental planning	Industrial example V	Explain 1 Homework example on board	<b>HOMEWORK 3 : 3-6 3-9</b>
	10		ANOVA	Example text page 70		

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**Homeworks Week 6-10 >> 5.7% each x 7 = 40% of your grade**

<i>Week</i>	<i>Class</i>	<i>WEEKLY GOAL</i>	<i>Lecture Topics</i>	<i>Professor -Student Presentation</i>	<i>Student Presentation</i>	<i>Homework Assignment due</i>
6	11	ANOVA Randomized Blocks	ANOVA	Design Expert example		
	12		Blocks RCBD	Industrial example VI	Student Presentations on Selected projects	Project Report 2 5 pages
7	13	Factorial Design	Blocks Latin squares		Explain 1 Homework example on board	HOMEWORK 4: 4-6 4-15
	14		Factorial design	Industrial exampleVII		
8	15	Factorial Design	Factorial design		Explain 1 Homework example on board	HOMEWORK 5: 5-5 5-17
	16		Factorial design	Industrial example VIII		
9	17	2k Factorials	2k Designs		Explain 1 Homework example on board	Homework 6: 6-1
	18		2k designs	Industrial example IX		
10	19	Fractional Factorials	Fractional Factorials		Final Student Presentations	Homework 7: 7-2; 8-25
	20		Fractional Factorials		Final Student Presentations	Final Project Report 15 pages

Text      **Design and Analysis of Experiments, 5th Edition**

Author Douglas C. Montgomery, John Wiley & Sons ISBN 0-471-31649-0; 5th ed. 2001

• **Term Project**                      **60% of grade**

Term Project

- The term project is performed in teams of up to three people. The project consists of planning, designing, conducting and analyzing an experiment, using appropriate DOX principles. Two written interim project reports are required, along with a final written project report. The dates these items are due is on the course outline above.

The context of the project experiment is limited only by your imagination. In previous classes, students have conducted experiments directly connected to their own research projects. This is a nice way to get extra-mileage from this course; it can help you finish your research sooner. For industrial participants or those with an internship in industry, a project that they are involved with at work is a good possibility. If all else fails, you could conduct a “household” experiment (such as how does varying factors such as type of cooking oil, amount of oil, cooking temperature, pan type, brand of popcorn, etc. affect the yield and taste of popcorn). However, I’ve seen just about all the possible popcorn experiments than can be run, and I’m looking for a little variety in my life, so let’s be creative.

The major requirement is that the experiment must involve at least three design factors. Each of the interim reports requires information about the problem, the factors, the responses that will be observed, and the specific details of the design that will be used. You will be given feedback on these reports that should help you in completing the final experiment and the analysis, and preparing the final report. Several of these projects will be selected for class presentation.

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## – Internet sites

- [http //www.psychology.uni-duesseldorf.de/aap/projects/gpower/reference/reference\\_manual\\_07.html](http://www.psychology.uni-duesseldorf.de/aap/projects/gpower/reference/reference_manual_07.html) < **good**
- [http //www.animatedsoftware.com/statglos/sgdegree.htm](http://www.animatedsoftware.com/statglos/sgdegree.htm) << **Definitions**
- [http //www.sportsci.org/resource/stats/contents.html](http://www.sportsci.org/resource/stats/contents.html) << **Very good**
- [http //www.itl.nist.gov/div898/handbook/index.htm](http://www.itl.nist.gov/div898/handbook/index.htm) **SEMATECH HANDBOOK**
- [http //ubmail.ubalt.edu/~harsham/stat-data/opre330.htm#rwi](http://ubmail.ubalt.edu/~harsham/stat-data/opre330.htm#rwi)
- [http //www.mathworks.com/access/helpdesk/help/toolbox/stats/stats.shtml](http://www.mathworks.com/access/helpdesk/help/toolbox/stats/stats.shtml)
- [http //curiouscat.com/bill/](http://curiouscat.com/bill/)
- [http //www.stat.wisc.edu/departments/handouts/technical413/technical413.html](http://www.stat.wisc.edu/departments/handouts/technical413/technical413.html)
- [http //curiouscat.com/guides/stats.cfm](http://curiouscat.com/guides/stats.cfm)
- [http //www.stat.wisc.edu/statistics/](http://www.stat.wisc.edu/statistics/)
- [http //www.isixsigma.com/tt/doe/](http://www.isixsigma.com/tt/doe/)
- [http //spsp.clarion.edu/mm/RDE3/C6/C6MainMenu.html](http://spsp.clarion.edu/mm/RDE3/C6/C6MainMenu.html) <<<< **Looks good!!**
- [http //trochim.human.cornell.edu/kb/expfact.htm](http://trochim.human.cornell.edu/kb/expfact.htm) < **good**
- [http //www.public.asu.edu/~pythagor/interactions.htm](http://www.public.asu.edu/~pythagor/interactions.htm) << **good**
- [http //stat.rutgers.edu/~buyske/591/](http://stat.rutgers.edu/~buyske/591/) << **Good class notes**
- [http //www-ist.massey.ac.nz/61325/sg/chap2-5.htm](http://www-ist.massey.ac.nz/61325/sg/chap2-5.htm) <<
- [http //www.ndt.net/article/ecndt98/reliabil/321/321.htm](http://www.ndt.net/article/ecndt98/reliabil/321/321.htm) <<
- [http //methods.fullerton.edu/chapter8.html](http://methods.fullerton.edu/chapter8.html)

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### – Internet sites

- [http //www.tufts.edu/%7Egdallal/LHSP.HTM](http://www.tufts.edu/%7Egdallal/LHSP.HTM)     **good site for basics t-test**
- [http //davidmlane.com/hyperstat/](http://davidmlane.com/hyperstat/)     **On line text**
- [http //members.aol.com/johnp71/javasta2.html#General](http://members.aol.com/johnp71/javasta2.html#General)     **Free Statistical software**