Objectives

- Review the format and expectations for the final exam
- Review material needed to succeed on the final exam
- Set the material from the course in the context of the product realization process
- Answer questions

Importance of the Final

- The course grade is determined by
  - 40% term project
  - 30% final exam
  - 20% homework
  - 10% quizzes

Balance?

Dominates

- The final shows how you've learned over time
  - Did the home works and quizzes stick?

Format of the Final Exam

- 4 essay questions (10% each)
- 20 short answer questions (3% each)
- Which means its
  - 40% Essay
  - 60% Short answer
- 2 Hours -- I'd suggest
  - 10 minutes per essay
  - 3 minutes per short answer
  - 20 minute buffer / review

Final Exam Rules

- Open book
- Open notes
- Solutions to homework, quizzes -- OK
- Calculators -- probably helpful
- Laptop computers -- fine, but not needed

Essay Questions

- Emphasize the big picture and concepts
- Composed of several inter-related questions
- Example
  - What is a scaling factor?
  - What are the properties of a good scaling factor?
  - Provide an example of a scaling factor
  - If you found that there was no control factor with the desired properties, what would you do?
  - Tell me anything you know about scaling factors that you consider essential to practicing robust design.

Expectations on Essay Questions

- Answer the questions!
- Make your responses concise
  - About 3 sentences per question if possible
- Make the answer complete but avoid a shot gun approach
  - Points will be deducted for imprecise statements
- Examples should have engineering relevance
- Examples should preferably be from some area you know from experience rather than from a text

Short Answers

- Fairly similar to quizzes in format, difficulty, and sometimes in content
- No multiple choice or true / false
- Usually come in clusters of 3-5
- Relate to a scenario, data table, graphs …
- Usually have a "right answer"
- Often require estimation

Expectations on Short Answers

- Right answer ± 10% gets you full credit
  - So simplify and estimate when appropriate
- Right procedure gets you 2/3 credit
  - So show your work if you have time
- A reasonable attempt gets you 1/3 credit
  - So explain your assumptions

Short Answer -- Example

- The data below represent the results from an L_8 (2^7). The fifth and sixth columns were left unassigned.

	Control Factors							
Exp no.	A	B	C	D	e	e	F	η
1	1	1	1	1	1	1	1	14
2	1	1	1	2	2	2	2	18
3	1	2	2	1	1	2	2	19
4	1	2	2	2	2	1	1	10
5	2	1	2	1	2	1	2	18
6	2	1	2	2	1	2	1	12
7	2	2	1	1	2	2	1	13
8	2	2	1	2	1	1	2	19

- What is the factor effect f_1?
- Estimate the sum of squares due to the mean.
- You wish to study interaction between control factors A and D and also between factors F and B. Will this design allow you to determine the effect of these two interactions?

What is Fair Game

- Any concept or technique described in Phadke
- Any material in the lecture notes
- Any material in quizzes & home works
- Questions requiring original thought on subtle topics not explicitly discussed in class

High Probability Topics

- Ideal function
- Noise factors, control factors, signal factors, responses
- Design for additivity
- Interaction plots
- Selection of appropriate OAs
- Dummy levels

High Probability Topics

- Orthogonality
- The balancing property
- Estimating variance of responses
- Quality loss functions
- ANOVA (Taguchi style)
- ANOM
- Design of dynamic systems

High Probability Topics

- Compounding factors
- Noise strategies
- System integration & RD
- Counting DOF of a system
- Selecting an OA to suit a scenario
- Studying interactions in OAs
- Tolerance design (insofar Phadke covers it)

High Probability Topics

- Failure modes & RD
- Confirmation experiments
- Column merging
- Factor effect plots
- The additive model
- Prediction based on the additive model
- Sliding levels

High Probability Topics

- Pooling and F ratios
- Choosing a proper S/N ratio
- Interpreting S/N ratios
- Making engineering and economic judgements based on data
- Selecting quality characteristics
- Selecting control factors

Proactive Problem Solving

Example Essay

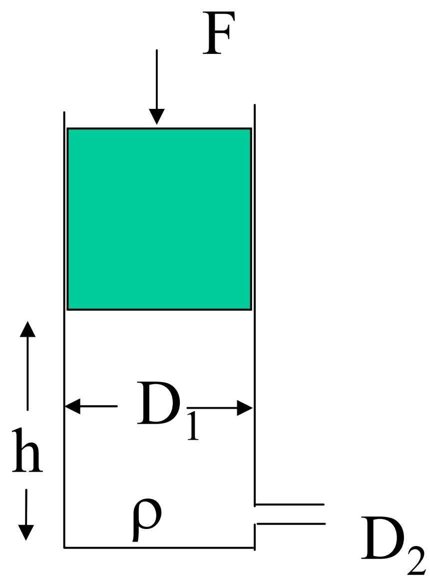
- You are the manager of a new product development program. 75% of the technology in the product is established and 25% is being fielded for the first time.
- What techniques from this class would you apply?
- At what stages would you apply them?
- How would your efforts differ between the new technology and the established technology?

Robust Design and Failure Modes
Example Essay

- When variance in a quality characteristic is too large, describe how adjustment of the mean can lead to chasing the problem from one failure mode to another (and often back again).
- Give an example of this phenomenon from an engineering context.
- If your product has multiple quality characteristics, how does this impact this phenomenon?
- How can the architecture of the system aggravate or ameliorate this problem?

Noise Factors
Example Short Answer Group

- Air Shock Absorber -- h and D vary by 1%
- Estimate the ratio of the contribution of h and D_2 to variance in t
- Estimate the ratio of σ_t to t



$$t = \frac{\pi h D_1^{\,3}}{D_2^{\,2}} \sqrt{\frac{2\rho}{\pi F}}$$

System Integration
Sample Essay

- Describe how lack of robustness in subsystems can lead to difficulties in system integration.
- Give an example of a system integration problem due to lack of robustness.
- If a robust design effort reduces the variance in all the subsystems, how will this effect the variance of the system?
- How is this effect a function of system scale and system architecture?

Noise Strategy
Sample Essay

- What is a compound noise factor?
- When would you use a compound noise factor?
- What is an outer orthogonal array?
- Compare the strategies of compounding noise factors with employing an outer array of noise with regard to:
  - Its effect on selection of control factor levels
  - Tolerance design decisions
  - Decision to field or not to field the system
- Discuss any alternate noise strategies you might consider

Parameter Design
Example Problem

- Given
  - Description of engineering scenario
  - Control factors and levels
- Questions
  - Which signal-to-noise ratio would you use?
  - How many experiments are required?
  - What is the smallest experiment that will allow you to resolve the main effects?
  - What is the gain in experimental efficiency by switching from one-factor-at-a-time to orthogonal array based experiments?
  - It is likely that there is a significant interaction between A and B. How will you ensure that your experimental plan can resolve this interaction effect?

Next Steps

- Final exam
  - 8AM (Sharp!) -10AM
- First off-campus session
  - 3:03-4:55
- Each student may resubmit up to three quizzes and/or home works by Monday 13 July (grades will be averaged with the original grades)