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

• 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 shotgun 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.

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- 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 $\sigma_t$ 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)