Mechanical Design Engineering

Design Related Engineering Problem Solving

MAE 495 – 005
MAE 589 – 005, 604
Spring 2015
Logistical Information

Instructor:
Carl F. Zorowski “Dr Z”
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On Campus     Tues. – Thurs.
              (~9:00 – ~2:00)

Class:
On Campus:    Tues., Thurs.   331 Daniels
              10:15 – 11:30
Distance Ed   Internet Delivery
Course Objective

Help students and practitioners develop the skills of synthesis, inventiveness, operational analysis and decision making to successfully use the engineering design practice process through the presentation and application of the methodologies of engineering problem solving together with personal experience in their use in solving design related engineering problems.
Course Justification

• Early engineering education was based on engineering practice and empirical knowledge, (ME program at NCSU began as “Mechanic Arts” – wood working, metal fabrication and drafting).

• For the first half of the 20th century engineering design, practice and education involved the use of handbooks, slide rules and the drafting table.

• Laboratory experience involved learning to operate and make performance measurements on actual industrial machinery and equipment.
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• Laboratory experience involved learning to operate and make performance measurements on actual industrial machinery and equipment.
• Engineering science began replacing practice and empiricism in engineering curricula as a result of WWII, early 50’s, and Sputnik in 1957

• Some educators recognized that development of skills needed for design practice required a different approach. (synthesis vs. analysis) (middle 50’s through 60’s)

• Analysis dominated over synthesis and effective education in design received minimal attention. (easier to teach analysis and conduct engineering science research) (late 60 through early 80’s)
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- Industry brought oversight and lack of design skill development to the attention of academia in late 1980’s. (industry found it had to educate it own designers)

- Some meaningful design instruction reintroduced through requirements for program accreditation. (ABET Criteria changes in 1990s)

- Today globalization of product development and production is occurring at an unprecedented rate in both developing and industrialized countries. (India, China, Taiwan, etc.).
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• Multinational firms around the world are conducting high tech engineering and research on a 24/7 basis. (result of global wide-band communication and inter net)

• To maintain technological leadership in this “Flattening World” (Tom Freidman -2007) we must become the source of new products, service ideas and technical innovations.

• There is a real need for engineering students and practitioners to develop their creative design and problem solving skills to meet this challenge.
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Hope to accomplish in this course!
A Fact of Life

I **cannot teach you** how to be a successful engineer/designer

(there is no simple formula or silver bullet)

but

You **can be helped** to develop your own creative and innovative engineering/design skills.
But How ??

Through the presentation and application of problem solving practices so that you can learn through your own experience by solving real engineering problems using these methodologies
Generic Practice Process

- Problem definition
- Solution synthesis
- Model formulation
- Application of engineering principles
- Analytic manipulation and/or experimentation
- Evaluate results
- Establish reasonableness
- Extract generalizations
- Draw conclusions and communicate
An Operational Conundrum!

Positives +

- There exists a ubiquitous availability of personal computers together with all types of sophisticated math, statistics and engineering design software (CAD, CAM, FEA, JMP, etc. systems).

- Applications of these devices with their many computational capabilities together with existing software permits the generation of numerical and graphical results rapidly and with great detail to problems with high degrees of complexity.
Conundrum (cont.)

Negatives –

• Interpretation and understanding of generated results can be difficult, misunderstood or improperly interpreted because of lack of understanding of solution process and underlying assumptions.

• Specific numerical solutions provide limited insight into how results can be generalized or the effect of changes in problem parameters on outcomes.
Conundrum (cont.)

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Example: How meaningful is the following FEA calculated stress number?

45.326798 kpsi
"IT JUST SEEMED LOGICAL TO HAVE A SCREEN FOR EACH DIMENSION"
Course Content

1. Introduction
   Engineering in Context
   Design Engineering as a Discipline
   The Engineering Design Process
   Skills of Engineering Design
   Synthesis vs. Analysis

2. Personal traits and Preferences
   Myers Briggs Indicators
   Left brain/ right brain
   Learning styles

3. Creativity
   Creative Process
   Formal techniques
Course Content (cont.)

4. Operational Analysis
   Engineering Analysis Methodology
   Problem Definition and Model Formulation
   Analytical and/or Experimental Analysis
   Computation and Checking
   Evaluation and Communication
   Case Study

5. Design of Power Transmissions
   Definitions and Properties
   Kinematics of Gear Trains
   Principles of Power Transmission
   Constant Speed Devices
   Fluid Couplings and Torque Converters
Course Content (cont.)

6. Design for Dynamic Response
   Harmonic Systems
   Forced Vibration and Resonance
   Design for Isolation
   Impact Loading Considerations

7. Design for Deflection
   Comparative Solution Methods
   Mechanical Strain Energy
   Strain Energy in Slender Members
   Castiglione's Theorem
   Indeterminate Structures
Course Content (cont.)

8. Design of Complex Mechanical Sections
   Unsymmetrical Cross Section Beams
   Non Circular Cross Section Shafts
   Simple Reinforced Composites
   Buckling and Stability Considerations

9. Design for Assembly
   Process Definition
   Product and Part Design Guidelines
   Redesign for improvement

10. Design for Strength and Endurance
    Static Failure Criteria
    Fatigue Failure Prediction
Conduct of Course

Class Meetings and Lectures -
   Present relevant content materials
   Work sample problems
   Solve and discuss assigned problems
   Engage in interactive learning exercises

Out of Class Activity -
   Solve assigned engineering problems
   Work in teams on real redesign problem

Grading -
   No exams are scheduled
   Grade based on problem solutions
Problem Assignments

• Eight problems beginning with 2nd week of class
• Solutions due one week after assignment (except Prob. 1)
• Submission in formal report format
• All problems will be “graded” and discussed
• Redesign problem after spring break
• Solutions will be presented orally

Course grade is based on problem and project performance
Problem Grading Process

- Students submit formal solution
- Instructor solution presented in class session
- Students self-grade their own problem submission
- Self-assigned grades submitted and recorded
- Some selected solutions reviewed by the instructor weekly
- Each student will have one solution instructor graded
- Grading guidelines and metrics will be provided
## Activity Calendar

<table>
<thead>
<tr>
<th>Wks</th>
<th>Dates</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Assignment Made on Tues</th>
<th>Solution Due Due on Tues</th>
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<tbody>
<tr>
<td>1</td>
<td>Jan 5 - 9</td>
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<td>First Day</td>
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<td>Session -1</td>
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<td>Jan 12 - 16</td>
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<td>Session -3</td>
<td>Problem - 1</td>
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<td>3</td>
<td>Jan 19 - 23</td>
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<td>Session -5</td>
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<td>Session -7</td>
<td>Problem - 2</td>
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<td>Feb 9 - 13</td>
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<td>Session -11</td>
<td>Problem - 4</td>
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<td>Mar 23 - 27</td>
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<td>Session -21</td>
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<td>Mar 30 - Apr 3</td>
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<td>Project Due</td>
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<td>Apr 27 - May 1</td>
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Course Web Sites

- Recorded lectures available through “Real Media” on EOL established course page.
- Course moodle site will be set up with MAE 589-604 as “parent” and MAE 589-005 as “child.
- All materials presented in class will be posted – feel free to print any materials
- Lectures notes will be available by class session
- Problem solutions will be posted following presentation and discussion
Relevant References

• Ver Planck and Teare, Engineering Analysis, An Introduction to Professional Method, John Wiley & Sons, 1954


• Weinstein and Angrist, An Introduction to the Art of Engineering, Allyn and Bacon, Inc., 1970

• Pink, A Whole New Mind, Moving from the Information Age to the Conceptual Age, Riverhead Books, 2005

• Friedman, The World is Flat, Farrar, Straus and Giroux, 2007