Pilot Program Goals

First Year MS-AMS Program

Foundation Modules
Real World Connection
Active Learning
Soft Skills
Life Cycle
Student Cohorts
Interdisciplinary
Industry Partnerships
Modules
Skills Based Learning
Subjects for the Pilot Course

“Polymers and Composites for Materials Scientists”
# Course Structure and Timeline

- Dr. Robert Carlson (Polymers)
- Dr. Gireesh Menta (Composites)

<table>
<thead>
<tr>
<th>Week</th>
<th>1</th>
<th>2</th>
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<th>14</th>
<th>15</th>
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<tbody>
<tr>
<td><strong>Subject</strong></td>
<td><strong>Short Course on Polymers</strong></td>
<td><strong>Materials</strong></td>
<td><strong>Design &amp; Analysis</strong></td>
<td><strong>Manufacturing</strong></td>
<td><strong>Testing, Repair and Recycling</strong></td>
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<tr>
<td><strong>Labs</strong></td>
<td><strong>Computer Labs</strong></td>
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Developing Course Content

IUB Backward Course Design Model

- How will I know they have changed?
- What must students be able to think and do to successfully complete the assessment?
- How will my students be different?
- What do students need to complete the Student Learning Outcomes?

Learning Outcomes:
- Lectures, Class Activities, Readings, Homework
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- Lectures, Class Activities, Readings, Homework
Course Goals

After completing the course, students will be able to:

- Demonstrate similar level of understanding irrespective of their background or department
- Demonstrate understanding of materials, manufacturing and design of FRP composites
- Apply the knowledge and tools learned in the class to design and manufacture composites for a given application
- Express confidence in communicating and working with students from different backgrounds
Targeted Tools and Skills

- Knowledge of available fibers, forms and matrices
- Material selection based on customer and product specifications
- Manufacturing using hand lay-up, VARTM, Autoclave and Out of Autoclave
- Excel sheets to design layup configuration, composite thickness and estimating the resulting load capacity, strength and stiffness of the composite product
Goals and Final Assessment

**Goals**

- Demonstrate same level of understanding irrespective of their background
- Industry readiness
- Demonstrate interdisciplinary skills
- Improved soft skills (presentation, team work etc.)

**Assessment**

- When the final results are compared, Chemistry students perform as good as engineering students, and vice versa
- Know how to handle prepregs, read data sheet and heat according to cure cycle
- Chemistry students comfortable in communicating with engineering students and vice versa
- Practice group work and short presentations

**Goals**

- Demonstrate understanding of materials, manufacturing and design of FRP composites

**Assessment**

- For a given application, students can select proper fibers, matrix and specific manufacturing process
- Reasonably ready to manufacture a part using hand lay-up, VARTM, OOA or Filament Winding Process
- For a given application, students can produce optimum fiber lay-up configuration using excel sheet
Specific Learning Outcomes

For a given application, students can select proper fibers, matrix and specific manufacturing process.

- Define composites (what are composites?)
- Identify the benefits of composite materials
- Why are composites? (when we have other materials?)
- Identify the applications of composites in different fields
- Describe the differences between isotropic and anisotropic materials
- Explain the roles/functions of fiber and matrix
- What are the mechanisms that provide composites their benefits?
- Explain failure mechanisms in composites and their tolerances
- What is the mechanism that provides composites such their benefits?
- List commonly used fibers and matrices
- Identify main aspects of different fibers and matrices
- List different forms in which fibers are available
- List different manufacturing techniques of thermost and thermoplastic composites
- Identify the fundamental physics behind composite manufacturing process
- Identify common terminology in composite manufacturing process
- Describe typical defects found in composite manufacturing process and explain how these can be minimized

- Define lamina vs. laminate
- List elastic constants in a 2D lamina
- Apply Hooke's law to unidirectional composite
- Predict the properties of unidirectional composite using micromechanical approach
- List commonly used approaches for prediction of elastic constants
- Predict the properties using three approaches
- Outline stress-strain relations of uni. composite subjected to mechanical, thermal and moisture loads
- Explain bending/stretching, coupling and stretching shear coupling in composite products
- Apply Hooke's law to laminate
- Apply Different failure criteria
- Demonstrate your knowledge by designing composite laminate for different applications
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Specific Learning Targets</th>
<th>Quizzes</th>
<th>In-class Discussions</th>
<th>Assignments</th>
<th>Projects</th>
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<tbody>
<tr>
<td>1</td>
<td>Define composites (what are composites?)</td>
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<td>2</td>
<td>Identify the benefits of composite materials</td>
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<td>3</td>
<td>Why use composites? (when we have other materials?)</td>
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<td>4</td>
<td>Identify the applications of composites in different fields</td>
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<td>5</td>
<td>Describe the differences between isotropic and anisotropic materials</td>
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<td>6</td>
<td>In what aspects are composites different from metals?</td>
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<td>7</td>
<td>Explain the roles/functions of fiber and matrix</td>
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<td>8</td>
<td>What are the mechanisms that provide composites their benefits?</td>
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<td>9</td>
<td>Explain failure mechanisms in composites and their tolerances</td>
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<td>10</td>
<td>What is the mechanism that provides composites with their benefits?</td>
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<td>11</td>
<td>List commonly used fibers and matrices</td>
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<td>Identify the fundamental physics behind composite manufacturing process</td>
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<td>16</td>
<td>Describe typical defects found in composite manufacturing process and explain how these can be minimized</td>
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<td>17</td>
<td>Define lamina vs. laminate</td>
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<td>18</td>
<td>List elastic constants in a 2D lamina</td>
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<td>19</td>
<td>Apply Hooke's law to unidirectional composite</td>
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<td>20</td>
<td>Predict the properties of uni-composite using micromechanical approach</td>
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<td>21</td>
<td>List commonly used approaches for prediction of elastic constants</td>
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<td>24</td>
<td>Explain bending/stretching, coupling and stretching shear coupling in composite products</td>
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<td>25</td>
<td>Apply Hooke's law to laminate</td>
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<td>Apply Different failure criteria</td>
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<td>27</td>
<td>Demonstrate your knowledge by designing composite laminate for different applications</td>
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<td>28</td>
<td>Demonstrate by manufacturing 4 in. x 4 in. flat composite part using hand lay-up</td>
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<tr>
<td>29</td>
<td>Demonstrate by manufacturing 4 in. x 4 in. flat panel using VARTM Process</td>
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<td>30</td>
<td>Demonstrate by manufacturing 6 in. long composite cylinder using filament winding process</td>
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<tr>
<td>31</td>
<td>Demonstrate by manufacturing a dog bone shaped part using injection molding process</td>
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<tr>
<td>32</td>
<td>Demonstrate by manufacturing a dog bone shaped part using injection molding process</td>
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<tr>
<td>33</td>
<td>Demonstrate by manufacturing a dog bone shaped part using injection molding process</td>
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Student Enrollment
Class
Labs
Examples of Assignments

Building Block Approach to Final Product Delivery

Assignment 3

Name: ___________________________ Due Date: 2/21/18

Each group has been assigned a specific part from a specific industry. For the assigned part, each group should suggest their top choices for fibers and resins. A group of three will suggest three fiber materials and three resin systems whereas a group of two will suggest two material systems. All three suggested options can be of the same material (e.g., Carbon or epoxy, but of different types/forms or from different suppliers etc.). Should also include the rationale behind the selection (like properties, cost etc.) and the details of the suppliers (e.g. Website links etc.). Since you neither have the product specification nor yet covered the manufacturing aspects, you can only make a best guess.

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Part</th>
<th>Industry</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Truck bed</td>
<td>Automotive</td>
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<tr>
<td>2</td>
<td>Oxidizer tank for rockets</td>
<td>Space</td>
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<tr>
<td>3</td>
<td>Handle bars for dirt bikes</td>
<td>Racing</td>
</tr>
<tr>
<td>4</td>
<td>Small UAV</td>
<td>Aerospace</td>
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<tr>
<td>5</td>
<td>Combat helmet</td>
<td>Defense</td>
</tr>
<tr>
<td>6</td>
<td>Wind Turbine blades</td>
<td>Energy</td>
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</tbody>
</table>

Some useful resources:
1. https://www.compositesworld.com/suppliers
Mathematics Involved in Design

\[ \varepsilon_x = \frac{\partial u_0}{\partial x} - z \frac{\partial^2 w}{\partial x^2} \]
\[ \varepsilon_y = \frac{\partial v_0}{\partial y} - z \frac{\partial^2 w}{\partial y^2} \]
\[ \gamma_{xy} = \frac{\partial u_0}{\partial y} + \frac{\partial v_0}{\partial x} - 2z \frac{\partial^2 w}{\partial x \partial y} \]

\[ \begin{bmatrix} N_x \\ N_y \\ N_{xy} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{16} & B_{11} & B_{12} & B_{16} \\ A_{12} & A_{22} & A_{26} & B_{12} & B_{22} & B_{26} \\ A_{16} & A_{26} & A_{66} & B_{16} & B_{26} & B_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_x^0 \\ \varepsilon_y^0 \\ \gamma_{xy}^0 \end{bmatrix} \]

\[ \begin{bmatrix} \kappa_x \\ \kappa_y \end{bmatrix} = \begin{bmatrix} A' & C' \\ B' & D' \end{bmatrix} \begin{bmatrix} N \\ M \end{bmatrix} \]

where

\[ [A'] = [A^-1] - [B^*][D^*]^{-1}[C^*] \]
\[ [B'] = [B^*][D^*]^{-1} \]
\[ [C'] = -[D^*]^{-1}[C^*] \]
\[ [D'] = [D^*]^{-1} \]

and

\[ [A'] = [A]^{-1}, \quad [B'] = -[A]^{-1}[B] \]
\[ [C'] = [B][A]^{-1}, \quad [D'] = [D] - [B][A]^{-1}[B] \]
Student Performance

Chemistry, ChemE and MechE

- Quizzes
- Assignments
- Group Review
- Projects
- Exams
- Overall course

Chemistry
ChemE
MechE
Student Feedback

- **Overall Course Experience**: 80% Excellent, 20% Very Good
- **Recommend Course to a Friend**: 87% Excellent, 13% Very Good
- **Effectiveness of Instructor**: 53% Excellent, 47% Very Good
- **Style of Presentation**: 67% Excellent, 33% Very Good
- **Effectiveness in Imparting Knowledge**: 53% Excellent, 47% Very Good
- **Effectiveness of Labs**: 53% Excellent, 47% Very Good
- ** Pace of Course**: 53% Excellent, 47% Very Good
- **Reading Materials**: 53% Excellent, 47% Very Good
- **Topics and Course Content**: 80% Excellent, 20% Very Good
“I am confident to jump in and help with a composites project”

“I feel extremely Confident”

“Very effective. Applicable knowledge that is easily transferable to industry”

“I would feel very comfortable going into industry. I feel that I have the background to extend my knowledge quickly”

“I feel confident”

“I feel very confident”

“I feel confident that I have the background of design, analysis, manufacturing to be able to land a job in the field. I feel I have unique qualities (design spreadsheet) to help land the job and impress”

“I feel confident”

“I feel much confident for composites, resins and polymers”
Student Comments on Effectiveness of Course

“Very effective. Design section was extremely interesting and relevant”

“Very good, even the introduction of these topics and methods will help very much”

“Quite effective”

“This course did an excellent job instructing me as to how to design and manufacture composites”

“Very efficient”

“It was a very helpful course”

“Very effective. Throughout the course, the instructor would give examples of industry techniques or information”
After the Course

- Lightweight shoes
- Drones
- Composite bike
- Composite shelf
- 3D Printing
- Vacuum bagging for sensors (Research)
Conclusions

● Proposed framework is effective in bringing students from diverse background to relatively same level of knowledge
● Students demonstrated their tools and skills on selected industry problems/projects
● Significant progress was observed in student’s ability to communicate with those from other backgrounds
● Student cohorts created a strong sense of community
● Overall, students strongly supported the proposed framework
Acknowledgements

- Julia Williams, Ass. Pro. & Dir. of Grad. Studies, College of Education & Human Services Professions
- MIE Department Staff/Students
  - Tracy Shaw
  - Darrell Anderson
  - GTA’s
  - Senior Design Students (letting us use their makeshift oven)
- Participated students of the class
THANK YOU