Learning Objectives:

1. Students will be able to identify defining components of a composite material
2. Students will be able to understand strengths and weaknesses of composite material design given various inputs
3. Students will be able to apply knowledge of composite materials from lecture to design a composite plaster brick to withstand the most weight before fracture subject to a cost constraint.
4. Students will be able to evaluate the performance of their brick versus a plaster-only brick using knowledge of composite materials from lecture.

Topics covered:

- Lecture
    1. Mechanical properties of composites
    2. How composite microstructure affects overall properties
    3. Failure mechanisms of composites
- Lab
    1. Design of composites
    2. Cost/design balance
    3. Three-point bend testing
    4. Evaluation of final design compared to a control

Estimated Time for Activity:
Lecture:
–30 minutes max
Lab:
–Day 1: 45 min - 1 hour
–Day 2: 45 min - 1 hour

Supplies Needed:

- Lecture
    - Computer with Powerpoint
    - Projector
    - Optional: iClicker/Polling software

- Lab
  - Gloves and safety glasses for each student
  - Brick Assembly
    - Silicon mold–brick shaped (see example here)
    - Composite filler materials
      - Popsicle sticks
      - Rubber bands
      - Pipe cleaners
      - Pennies
      - Dry spaghetti
    - Plaster of Paris (roughly 8 lbs. for four bricks)
    - Disposable cups
    - Stirring implements (ex: tongue depressors)
    - Play money
  - Brick Testing
    - 2 wooden boards
    - 5 gallon bucket with weights (bags of sand, etc.)
    - A file to notch the bricks (triangular file, nail file, etc.)

Recommended Prior Knowledge for Instructor:

- Familiarity with basic mechanical properties
  - Stress and strain equations and curves
  - Tensile testing
- Basic understanding of material fracture
  - The difference between ductile and brittle materials

Recommended Prior Knowledge for Students:

- Bonding types
- Basic understanding of material classes

Discussion Points for Instructors:
Lecture:

- Common uses of composites
  - Why are composites chosen for these specific applications?

- Fiber orientation vs. final application loading/material behavior
  - If fibers are oriented vertically, what happens if force is applied in the fiber direction? Perpendicular to the fibers?

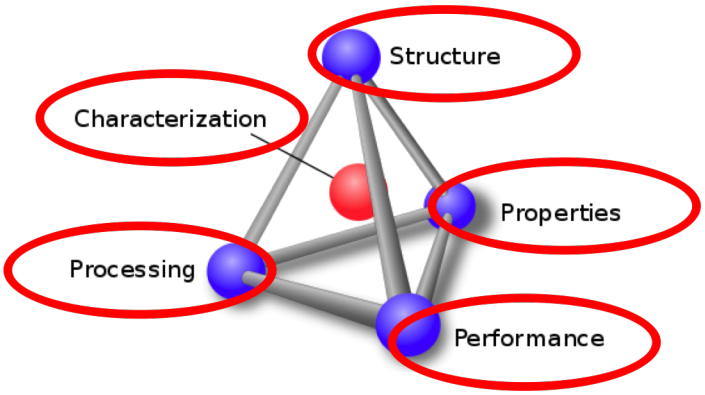
Lab Day 1:

- Cost benefit analysis during design of materials/products
  - Why aren't composites used for everything?
  - How will you use your budget to design the best composite brick?
  - If you had no budget constraints, what would your design look like?

Lab Day 2:

- How much force did your composite withstand?
- What does the fracture surface look like?
- What filler/design did the strongest brick use?

Aspects of Materials Science Tetrahedron Covered in Module:



Complimentary Modules

- Casting
- Fracture

Files Needed

- Composites Lecture (PPT or pdf)
- Composites Instructor Lab Handout
- Composites Student Lab Handout

For K-12 Instructors:

Assessment Ideas

- Lecture
  - Utilize a word cloud through PollEverywhere – ask "What was the most interesting thing you learned?"
  - Use Think, Pair, Share for critical discussion questions regarding composite properties (ex: What will break first– fibers oriented with the direction of the force or perpendicular?)
- Lab
  - Design check question discussion
  - Think, Pair, Share in groups regarding fatal design choice in their brick after testing
  - Written homework assignment discussing brick design choices and possible redesign rationale