

## Building a Stronger (Sweeter) New Orleans Activity — Rebuilding New Orleans Composite Materials Lab

### Purpose

- To design a strong, lightweight material.
- To construct and analyze a graph of stress vs. strain for the composite material.
- To compare the different composite materials and determine which is the best building material based on its strength and density.

### Materials (each group)

Marshmallows	Butter
Rice Krispies®	Small Chocolate Chips
Small Cupcake Wrappers	Spoon
Balance	Microwave-safe container
Weights	Microwave
Ruler	Wooden block
Flexi Force Sensor (optional)	Computer with Microsoft Excel (or similar)
Microcontroller (optional)	Microwave-safe bowl

### Procedure

#### Part 1 – Design

Create a composite material with the greatest ratio of strength to density using Rice Krispies, chocolate chips (optional), butter and marshmallows. The Rice Krispies are hollow and will serve to strengthen the marshmallows, which will serve as the matrix.

1. Determine the amount of marshmallows, butter, Rice Krispies and chocolate chips (optional) you will add to make each of your three composites. List your “recipe” in Table 1.

**Table 1. Composite Recipes**

	Mass of each Ingredient (g)			
	Rice Krispies	Marshmallows	Butter	Chocolate Chips
Composite Material 1				
Composite Material 2				
Composite Material 3				

2. Measure and record the mass of each of the components that you are adding. Remember your goal is to create a material with the greatest strength that is also lightweight.
3. Describe in words the measurement of each of your components. (Are you adding **a lot** or **a little** of each of the ingredients?)
4. Label each cupcake wrapper with your initials and the number of your composite sample.
5. Measure out the specified amount of butter and marshmallows, based on your recipe Table 1, and put them in a bowl.

Name: \_\_\_\_\_ Date: \_\_\_\_\_

6. Place the bowl in the microwave for 30 seconds. Stir immediately.
7. Add Rice Krispies and/or chocolate chips. Stir until it is well-mixed.
8. Pour the mixture in the cupcake wrapper and wait for it to cool.
9. Repeat steps 2-5 and for each composite mixture.

### Part 2 – Analyze the Material

Determine the density of the composite material. Record your data in Table 2.

1. Remove the cooled sample after 10 minutes from the wrapper and shape the Rice Krispies treat into a cylinder so that it is about the same size as a large marshmallow.
2. Measure each sample's mass using a balance.
3. Measure each sample's dimensions. (Record the height and diameter of the top.)
4. Calculate and record the area of the top of each sample. Area of a circle =  $\pi r^2$
5. Calculate and record each sample's volume (surface area of the top x height).
6. Calculate and record each sample's density (mass/volume).

**Table 2. Composite Recipes**

	Mass (g)	Height (cm)	Diameter (cm)	Area of the top (cm <sup>2</sup> )	Volume (cm <sup>3</sup> )	Density (g/cm <sup>3</sup> )
Composite Material 1						
Composite Material 2						
Composite Material 3						

### Part 3 – Strength Test

Determine the composite material's Young's modulus. Record your data in Tables 3a-c.

1. Use a wooden block to uniformly compress your composite. Measure the mass of the wooden block.
2. Place the wooden block on top of the composite material you made, and measure the new (compressed) height of the sample after the block has been on the material for about 15 seconds.
3. Calculate the force applied to the block. The force is equal to the weight applied.

$$weight = mass (g) \times 9.8N/kg$$

4. Calculate and record the distance the sample compressed. (This is the difference between the original height and the compressed height.)

$$distance = original\ height - compressed\ height$$

5. Calculate the strain by dividing the distance the sample compressed by the original height of the sample.

$$strain = \frac{compression}{original\ height}$$

Name: \_\_\_\_\_ Date: \_\_\_\_\_

- Calculate the stress by dividing the force applied by the surface area of the sample.

$$\text{stress} = \frac{\text{applied force}}{\text{sample surface area}}$$

- Add weights to the wooden block and record the distance the material compresses until you have completed five different trials.
- Repeat for each composite sample.

Note: To use a force sensitive resistor to measure forces, use the circuit diagram and code for Arduino (with and without analog inputs) that can be found at: <https://learn.adafruit.com/force-sensitive-resistor-fsr/using-an-fsr>

**Table 3a. Strength Test Results for Composite Material 1**

Trial	Mass Applied (g)	Force applied (N)	Original height of sample (cm)	Compressed Height of Sample (cm)	Distance Material Compressed (cm)	Strain (cm/cm)	Stress (N/cm <sup>2</sup> )
1							
2							
3							
4							
5							

**Table 3b. Strength Test Results for Composite Material 2**

Trial	Mass Applied (g)	Force applied (N)	Original height of sample (cm)	Compressed Height of Sample (cm)	Distance Material Compressed (cm)	Strain (cm/cm)	Stress (N/cm <sup>2</sup> )
1							
2							
3							
4							
5							

**Table 3c. Strength Test Results for Composite Material 3**

Trial	Mass Applied (g)	Force applied (N)	Original height of sample (cm)	Compressed Height of Sample (cm)	Distance Material Compressed (cm)	Strain (cm/cm)	Stress (N/cm <sup>2</sup> )
1							
2							
3							
4							
5							

Name: \_\_\_\_\_ Date: \_\_\_\_\_

### Analysis

Using Microsoft Excel® or similar software, graph stress vs. strain for each composite material on the same set of axes. Include a line of best fit and an equation of the line for each of the three composite materials' data.

### Discussion Questions

1. Find Young's modulus for each of the materials.

Material 1	Material 2	Material 3

2. Do stiffer materials have a larger or smaller Young's modulus? Explain your answer.

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3. Which of your samples has the greatest ratio of strength to density? Why?

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4. Considering the materials' strengths and densities, which material would you prefer to use for building in New Orleans? Explain.

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### Extension Questions

1. How could you improve on your design to make a better material for building? Explain.

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2. Research a material that has syntactic foam and explain how it is used and why building with hollow spheres is desirable.

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3. Describe a material or object that could be improved by making it with syntactic foam. Explain.

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