

Composite materials

Introduction

Today's Laboratory unpacks how composite materials can respond differently to unbalanced forces.

Victorian Curriculum Outcome

Change to an object's motion is caused by unbalanced forces acting on the object; Earth's gravity pulls objects towards the centre of Earth (VCSSU103)

Checkout the racing car and surfboard



Giedo van der Garde driving the Caterham CT03 at Sepang International Circuit.

https://commons.wikimedia.org/wiki/File:Giedo_van_der_Garde_2013_Malaysia_FP1.jpg



A surfer at the Cayucos Pier, Cayucos, California.

Photo: "Mike" Michael L. Baird.

https://commons.wikimedia.org/wiki/File:Surfer_at_the_Cayucos_Pier,_Cayucos,_CA.jpg

What could be the same between the materials used a modern racing car and surfboard?
(Hint: focus on the how each is made (manufactured).)

Composite Materials

A composite material is made from two or more materials, each with different physical or chemical properties. But when combined, the whole composite has properties that are different from the individual materials.

Some composite materials are mixtures, like cements, concrete, imitation granite and cultured marble sinks and countertops, and metal alloys.

Some composite materials have one material embedded inside the other material, for example, fiberglass, concrete with steel reinforcement, and mud bricks with straw reinforcement.

Some composite materials have the individual materials in separate and distinct layers.

Scientists and engineers are developing new composite materials because they can be stronger, lighter, or less expensive when compared to traditional materials.

Key ideas

Force – a push or a pull

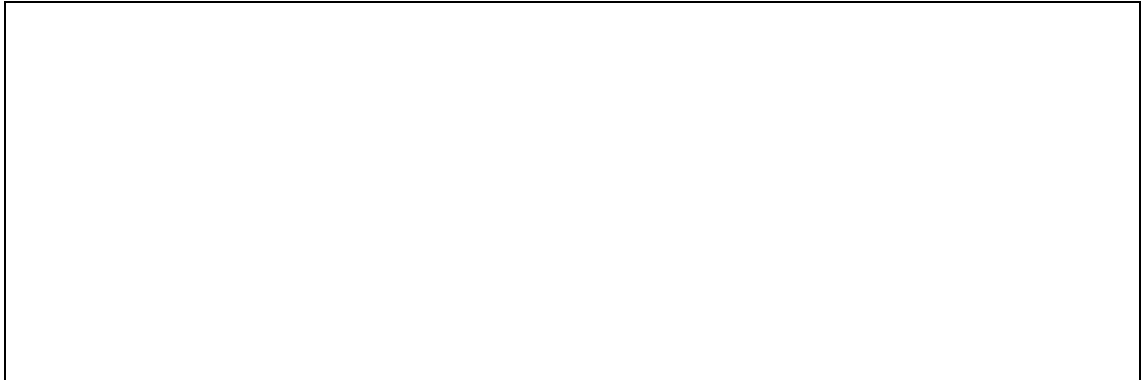
Compression force – a push that squeezes an object to try to make it smaller or shorter.

Tension force – a pull stretches an object to try to make it bigger or longer.

Aim

The composite materials activity enables you to experience and investigate the way combining the properties of two materials (polystyrene and gaffer tape) can result in a particular type of composite material. The properties of the composite are very different from the properties of the original. In the process, you will learn about tension and compression forces.

Why do we make composite materials?

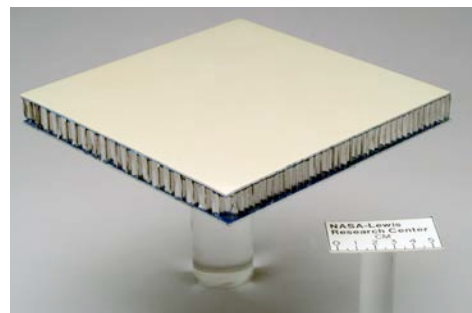


Consider the similarity between these two pictures



A bacon, lettuce and tomato sandwich on toasted bread.

Photo: Steven Groves from Denver (CO), USA.
http://en.wikipedia.org/wiki/Sandwich#/media/File:BLT_sandwich_on_toast.jpg



Glass Aluminum Reinforced (GLARE) honeycomb composite sandwich structure.

Photo: NASA.
http://ballistics.grc.nasa.gov/Photographic%20Data/Images/glare_honeycomb.jpg

How do you think **sandwich composite materials** are made?

Your challenge

Today you are a scientist who has been paid to design a stronger composite product for as little cost as possible. The following demonstration is to prepare you for the task.

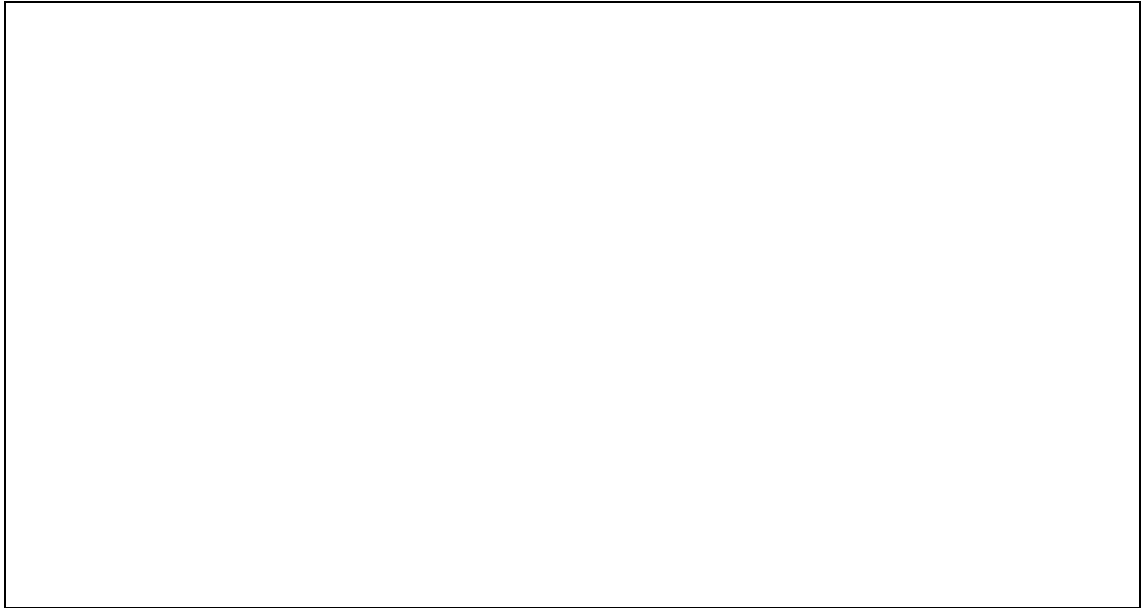
Part 1: Demonstration of the effectiveness of sandwich structures

Things to note from the demonstration:

- A polystyrene plank is not very strong. (Footnote ¹)
- When additional materials are layered onto the polystyrene it becomes a composite material and its properties change – it becomes stronger.

¹ Styrofoam is a particular brand name for polystyrene.

Draw and label the equipment and what happened.



Part 2: Comparison of three products: polystyrene on its own and 2 composite materials with different structures

Think about the demonstration you have just seen. Can you think of two different ways of making sandwich composite structures using the materials and equipment available to you?

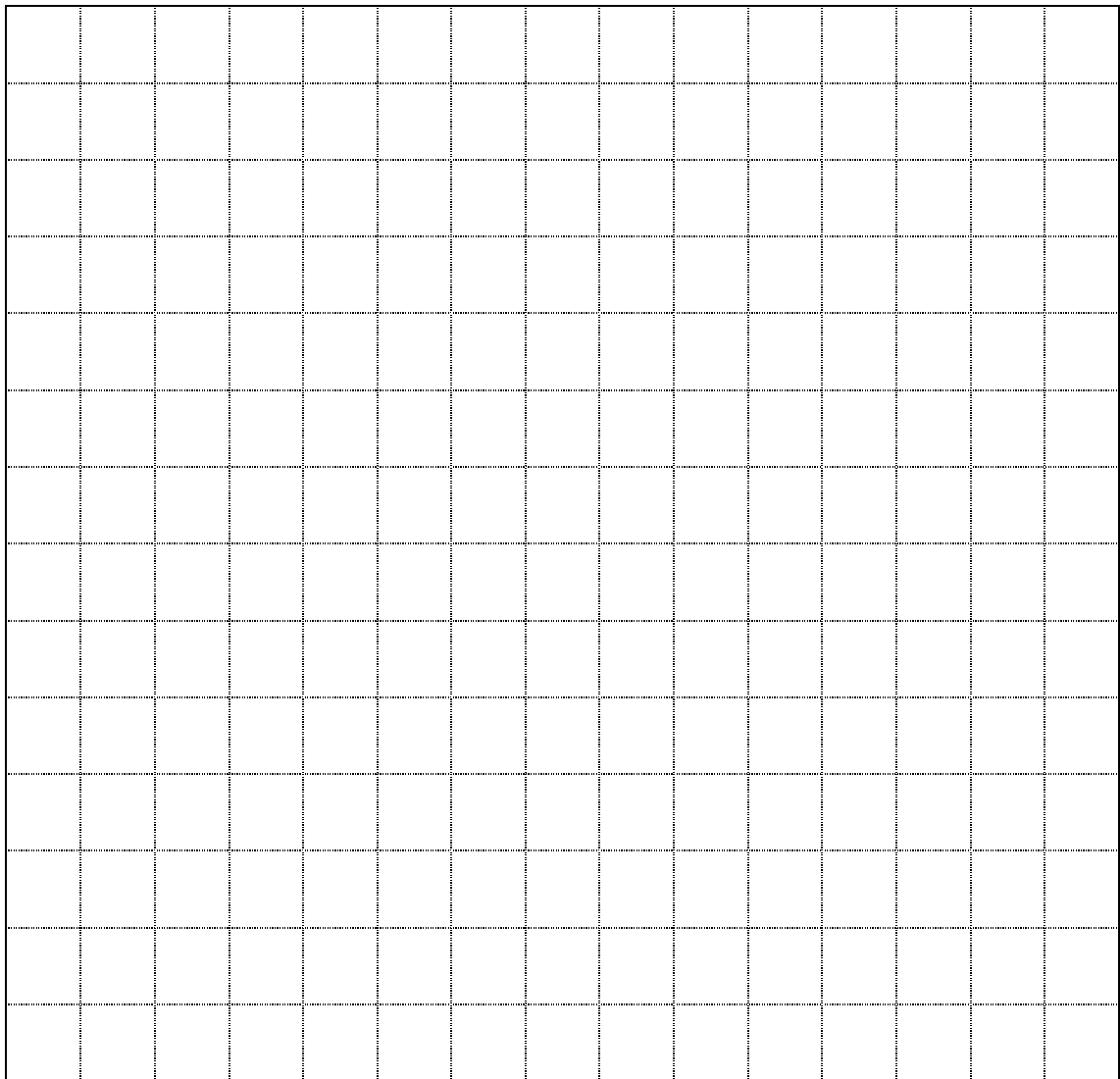


Re-do the demonstration with your group. You will need to work out a way of measuring the rigidity or how much bending there is for each individual weight added. Talk with your partner to decide how you will measure the amount of bending and how you will record the data in an appropriate table below. Your support structures need to be 21 cm apart (Footnote ²).

Record the data in an appropriate table to show the difference between the polystyrene and the composite material structures 1 and 2.

² 21 cm has been chosen because it is the width of an A4 page and is easy to set up. If you wish, you could use some other separation distance.

Graph the data to show the difference between the polystyrene and the composite material structures 1 and 2.
(Hint: put all the data on a single graph.)



Describe in words what was revealed through the data analysis of the graph.



Part 3: Analysis of forces

Roofs and bridges have to span large gaps while supporting massive weight.

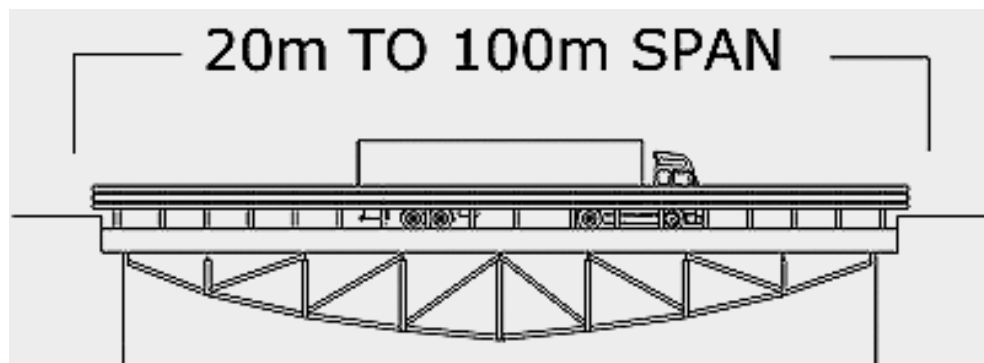
Consider the bridge below. The schematic diagram following is of a similarly designed bridge.



Steel frame truss bridge, located on the Southern Highway, Belize, Central America.

Photograph © John Reid & Sons (Strucsteel) Ltd.

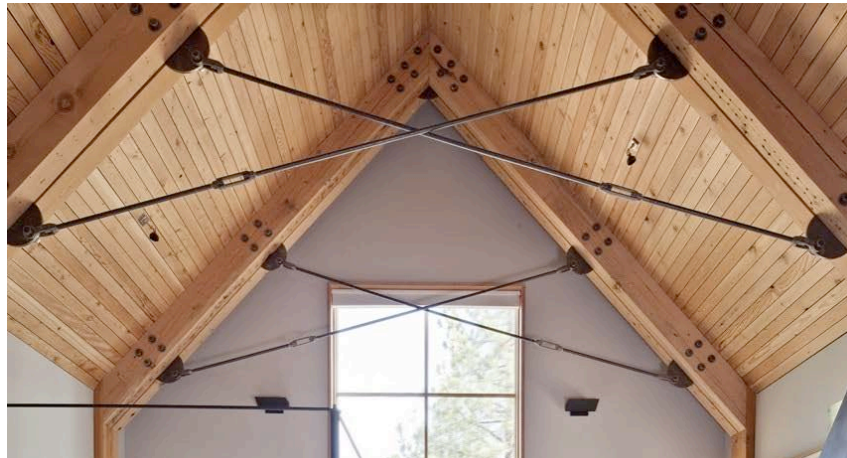
<http://www.steel-bridges.com/under-truss-bridge.html>



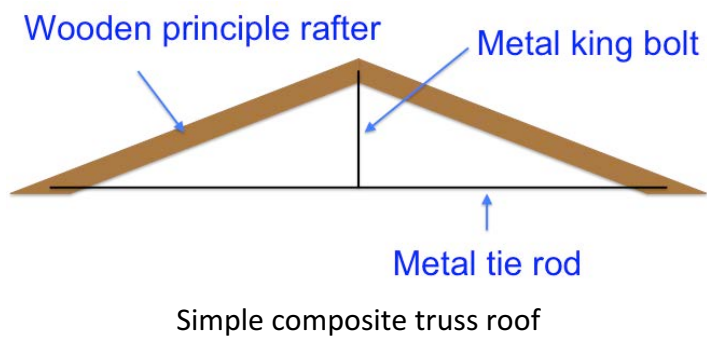
Steel frame truss bridge design. The concrete deck and the steel strusses form a composite structure. Diagram © John Reid & Sons (Strucsteel) Ltd.

<http://www.steel-bridges.com/under-truss-bridge.html>

Consider the roof/ceiling below. The schematic diagram following is of a similarly designed roof.



Composite truss roof, Tahoe Ridge House, California. Photograph © WA Design Inc
<http://www.wadesign.com/newbuilding#/tahoe-ridge-house/>



All these roofs and bridges have one element (or part) that spans the top of the structure and one element that spans the bottom of the structure.

Can you represent the main forces that you think are acting on these two elements of the structures?

How many elements span your polystyrene structure? Why do you think the polystyrene structure is relatively weak?

How many elements span your sandwich structure? Can you represent why you think the sandwich structure works to alter the strength and rigidity?

What is the role of the tape and what properties make it work well?

Would one piece of tape above or below the polystyrene be as effective as two pieces of tape in a bridge structure?

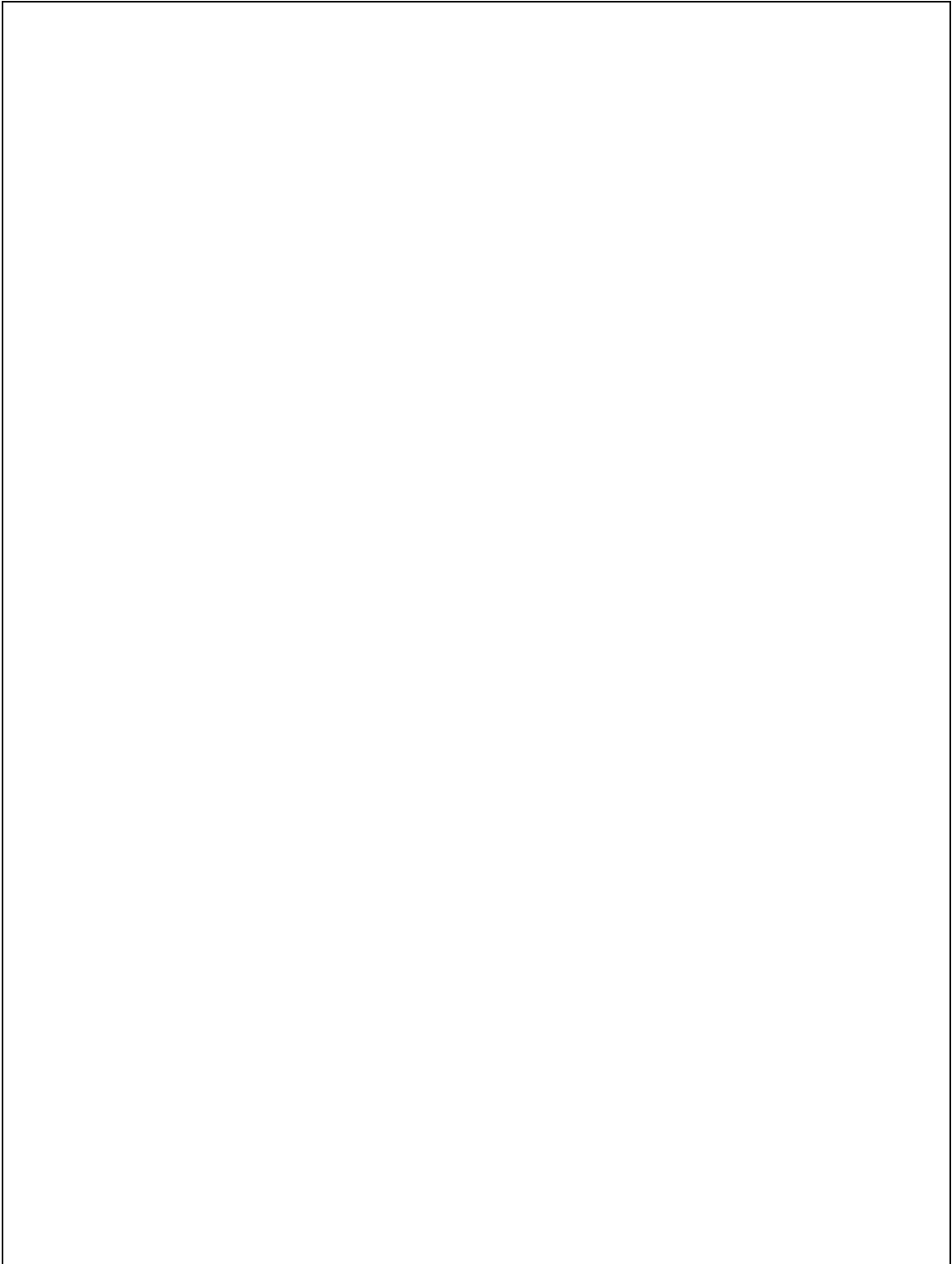
Discuss with your team, how a composite material might be used in boat hulls, swimming pools, race car bodies, surf boards, spacecraft and aircraft. Can you represent why you think an “open-sandwich” structure (similar to tape only on one side of the polystyrene) would perform better or worse than a regular sandwich structure (similar to tape on both sides of the polystyrene)?

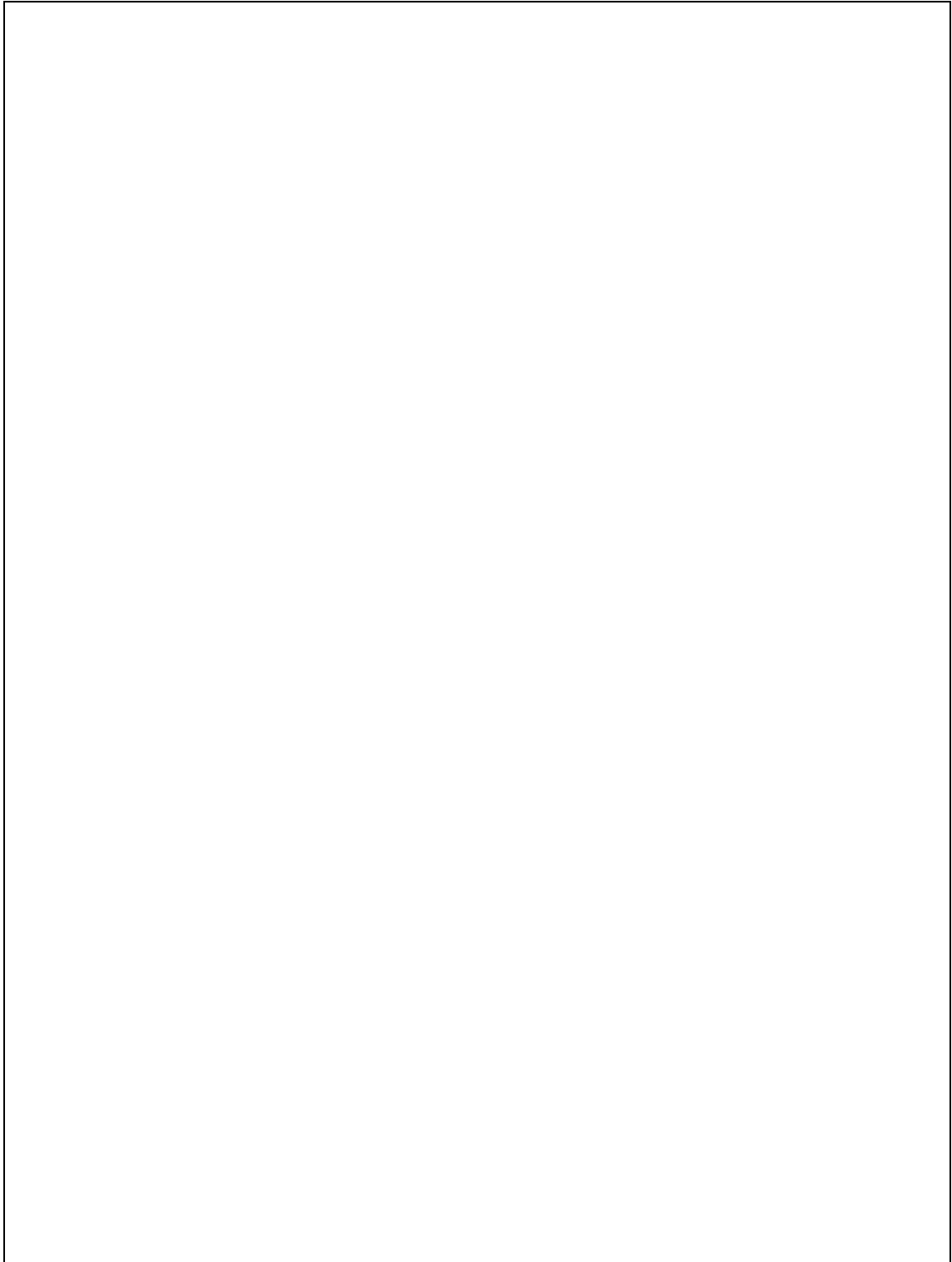
Part 4: Challenge

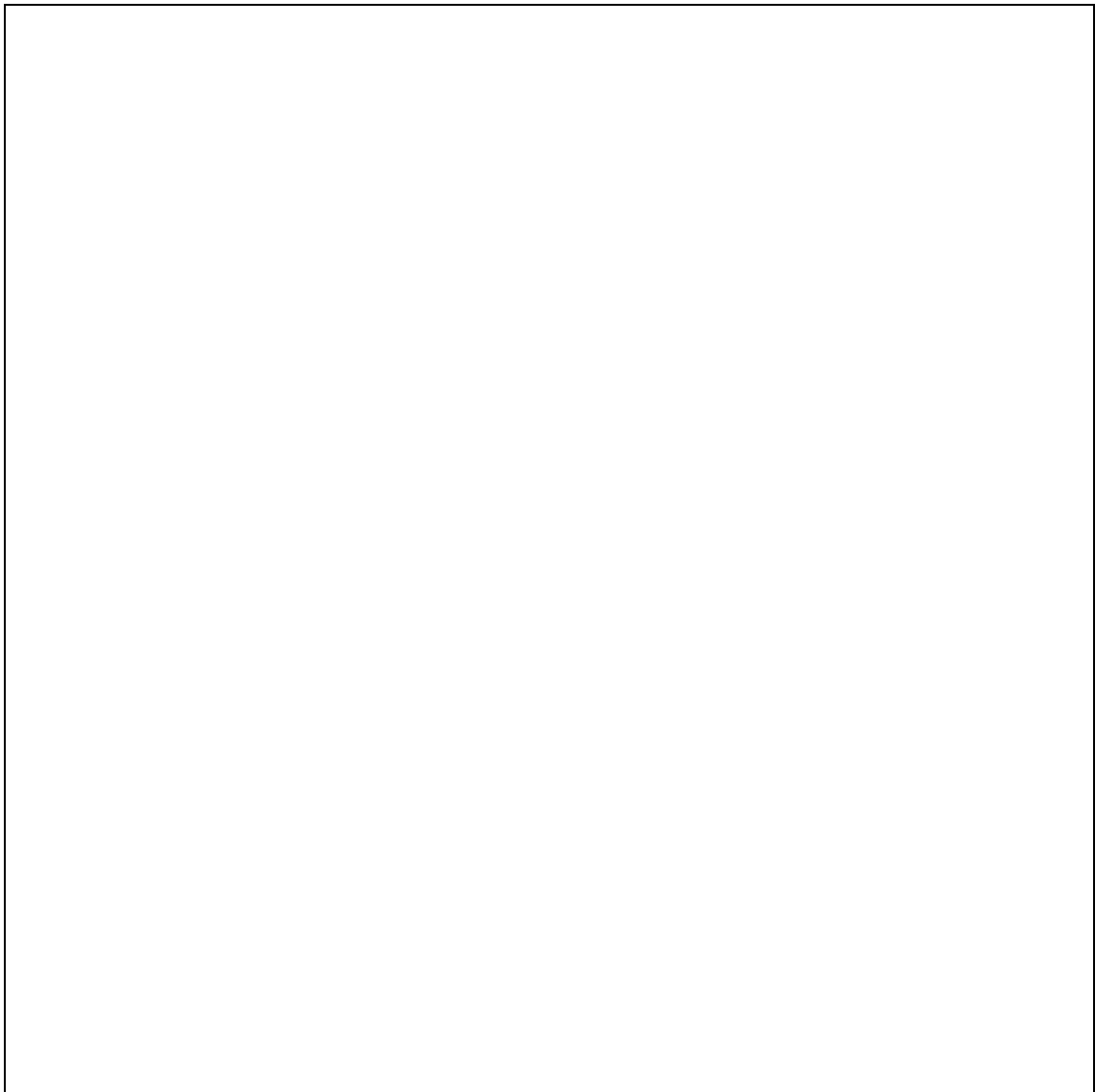
Your job as a Scientist is to create a stronger composite material using the least amount of material (polystyrene and tape) to reduce cost.

Work with your group to design to strongest sandwich structure composite material using the least tape. Test each design for strength and rigidity to decide the best design.

Decide how you will collect your data for each trial and produce a report that describes the design that works best. Include evidence (data) and an explanation as to why (using diagrams and words).







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