Space Careers Wayfinder

Engineering Solutions | Haley

Engineering Solutions

During Hayley's video she describes the benefit and satisfaction to her personally of 'tinkering,' and the reaction to her tinkering during the interview for an apprenticeship.

> *"There's nothing worse than something breaking down and you don't know how to fix it because you've never had that experience … learning how to tinker"*

Space exploration can be problematic. A prerequisite to surviving a potential disaster is the ability to think creatively, adapt, and use whatever is available to fulfil a need. In space, things can go wrong. Look at the accidents and tragic disasters in the following video https://www.britannica.com/list/7-accidents-and-disasters-in-spaceflight-history

The story of the factual Apollo 13 mission was made into a docudrama in 1995. Of note, is the amazing ingenuity of how the entire team comprising Earth based staff and astronaut crew troubleshooted all the difficult and life-threatening issues and the genuine victory of returning all crew safely back to Earth.

Problem solving with available materials to address specific issues is crucial to space survival. See how the Apollo 13 mission addressed the issue of carbon dioxide build up in their cabin and the teamwork involved between astronauts and ground crew. See https://www.youtube.com/watch?v=B_LD5PkV6rI

The Brief

There are astronauts marooned on Mars who have a shortage of construction materials to help secure prefabricated structures, so they need to improvise. They need a low density, mouldable, composite substitute for repairs. On Earth, your team have been tasked to create a type of composite material made from several types of flour, toilet paper and water, all of which the astronauts have in good supply.

https://www.publicdomainpictures.net/pictures/190000/velka/astronaut-at-work.jpg

The Task

From your engineering background, you know that by combining several types of **binders** with a **fibre** can enhance the physical properties of a **composite** material. In this situation the binder is formed from *different food-based glues* and the fibre is the toilet paper.

Your challenge is to work out which type of composite material is the strongest. The information would be sent to the astronauts to help with their survival until their rescue.

You need to design and implement a **fair test** to achieve this.

The strength should be quantifiable by measuring an increasing weight force until breaking.

Materials

Three of the following types of flour or alternative flour that is available. Other types of flour can be identified in the following website

https://www.kitchenaid.com/pinch-of-help/countertop-appliances/types-of-flour-and-their-uses.html

- white flour (wheat based)
- rice flour
- glutinous rice flour
- pastry flour
- 10 x 3 linked toilet paper strips
- water
- 3 x small cardboard disposable food bowls. Dispose into garbage bag after use.
  No glue is to go down any sinks
- all regular equipment available in a high school laboratory
- medium bulldog clip
- large paper clip
- stirring spoon
- digital or other scale (at least 1kg maximum load)
- materials to add mass to a suspended container to calculate breaking strain weight force
- plastic sandwich wrap or silicone baking paper for curing(drying) composite glue/fibre strips
- Post It Note or equivalent labels
- large garbage bag for waste materials

In designing this fair test, you must:

- identify all the variables
- only *change* one variable (independent), the type of food-based glue
- *measure* one variable (dependent), the strength of the composite paper by measuring the weight (N) strain before breaking
- keep all other variables the same (controlled variables)
- design a repeatable procedure that can tested
- each composite type should be tested three times to allow an average figure to be calculated
- weight (N) = mass (kg) x 9.8 m/s^2
- devise a method so that masses can be added to the paper clip ‘threaded’ onto a bulldog clip that is clipped to the dangling strip of composite paper. Record the mass it can suspend *before* it breaks
- do a control measurement of the tissue fibre alone without binder glue

Note that this inquiry is not about testing different configurations of the fibre structure. The structure should be the same for each trial, with the glue type as the only variable to be altered.

Which type of composite glue and paper was the strongest regarding the highest suspended weight?

What ideas can you think of using the available materials could enhance the weight bearing load?

Notes to the teacher:

- regarding the container and masses, use what is most conveniently available to you
- activity needs to be done over two different lessons on different days to allow the glue to cure properly for a recommended three days before testing.
- the easiest type of starch-based food glue involves mixing with cold water. See these websites for the simple mixing procedures.

https://www.thoughtco.com/homemade-glue-recipes-607826 or

https://www.youtube.com/watch?v=mnho49NLVpA from 3min 25s

- if using water for increasing mass, 1 ml water correlates to a mass of 1g
- the toilet paper choice is intentional in design, so that the breaking strain required is not too difficult to reach (<10N, equating to a maximum mass of about 1kg)

The Task

Innovation has regularly occurred in sports equipment. One such innovation is the incorporation of carbon fibres into structures. Choose a sport that now incorporates carbon fibres. Research the history of the materials used to make this piece of equipment starting from the original materials. Tabulate the chronological advances in materials and include columns with the headings 'Advantages' and 'Disadvantages.'

NASA is researching Super lightweight Aerospace Composites (SAC), the next major phase in innovation of aerospace materials involving carbon nanotubes instead of metals and carbon fibre composites. https://www.nasa.gov/directorates/spacetech/game_changing_development/projects/sac

Some examples of equipment that incorporated carbon fibres include tennis racquets, golf clubs, racing bicycles and formula one cars.

Australian Curriculum

Science

Investigate how advances in technologies enable advances in science, and how science has contributed to developments in technologies and engineering (AC9S10H02)

Plan and conduct valid, reproducible investigations to answer questions and test hypotheses, including identifying and controlling for possible sources of error and, as appropriate, developing and following risk assessments, considering ethical issues, and addressing key considerations regarding heritage sites and artefacts on Country/Place (AC9S9I02), (AC9S10I02)

Select and use equipment to generate and record data with precision to obtain useful sample sizes and replicable data, using digital tools as appropriate (AC9S9I03), (AC9S10I03)

Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information (AC9S9I04), (AC9S10I04)

Analyse and connect a variety of data and information to identify and explain patterns, trends, relationships and anomalies (AC9S9I05), (AC9S10I05)

Assess the validity and reproducibility of methods and evaluate the validity of conclusions and claims, including by identifying assumptions, conflicting evidence and areas of uncertainty (AC9S9I06), (AC9S10I06)

Design and Technologies

Analyse and make judgements on how the characteristics and properties of materials are combined with force, motion and energy to control engineered systems (AC9TDE10K03)

Analyse and make judgements on how characteristics and properties of materials, systems, components, tools and equipment can be combined to create designed solutions (AC9TDE10K06)

Analyse needs or opportunities for designing; develop design briefs; and investigate, analyse and select materials, systems, components, tools and equipment to create designed solutions (AC9TDE10P01)