Flying without engines

Hang glider. Note the wing is made in sections.

Have you ever flown a kite? Or maybe you've dreamed of flying a hang glider or riding in a hot-air balloon. The Met Office uses hydrogen or helium balloons to carry instruments into the upper atmosphere to take weather measurements – that's about 50 kilometres above your head!

Balloons, kites and hang gliders don't need engines – but they do need engineering. One aspect is specially designed and manufactured fabrics to keep them up in the air.

your task

- Think about what properties the fabric needs.
- Design and carry out simple tests to select suitable fabrics.
- Find out what types of fabric are actually used in commercial designs, and why.

If you have time, you may be able to build a kite or a model hot-air balloon.

some things to think about

What's the purpose of the fabric in a balloon?

What's the purpose of the fabric in a kite or hang glider?

What properties does it need, to achieve its purpose? For instance:

- Stiff or flexible fabric? (How does it keep its shape?)
- Density? (Lightweight or heavy-duty fabric?)
- Open- or close-weave? (Must it let some air through, or none at all?)
- Water resistance? (Must it be waterproof, or allow rain to pass through, or to soak in?)
- Strength? (What forces will it be subjected to?)

Are there some other important properties?

Does fabric for a hot-air balloon need different properties from hang glider fabric or weather balloon fabric?

Which types of fabric might be suitable?

How will you test fabric samples to see which is best?

Apart from size, why can't a balloon or hang glider be made from a single sheet of fabric?

How might the pieces be joined together?

what you need to do

1. Write short notes about the ideas you came up with when thinking about the points on the previous page.

2. Find out:
   - ~ how much time you will have
   - ~ what samples are available.

3. Plan the tests you think are necessary. Write down what the fabric will be used for. For each test, write down:
   - ~ the property you are investigating
   - ~ what the test will be
   - ~ how you intend to do it
   - ~ a list of materials and equipment you will need
   - ~ how you will keep the test safe.

4. Ask your teacher to check your plans.

   Note: You must not carry out any tests until your teacher gives permission.

5. Carry out the tests and record the results.

6. From your results decide which fabric is best for your chosen purpose. Explain why you think it is best.

7. Now do some research. Which types of fabric do manufacturers actually use to make kites, balloons and hang glider wings? How are they different from the ones you found to be best?

Flying without engines

Curriculum links

key stage three programme of study: design and technology		
key concepts	1.1b, 1.1d, 1.3c, 1.4b	
key processes	2a, b, f	2c-e, g and h (if making a model)
range and content	3a (textiles), b, c, e, j	3k-m (if making a model)
curriculum opportunities	4b, d, g (materials science)	
SQA technology outcomes		
third level	TCH 305C, 309D, 310D	TCH 306 – 308C (if making a model)
fourth level	TCH 409 - 411D	TCH 407C, 408D (if making a model)

Introducing the activity

The Enginuity *What is engineering?* poster shows a meteorological balloon and a passenger (hot-air) balloon. Showing the class actual photographs would help pupils appreciate what they are dealing with, since they may not be familiar with such objects.

The activity focuses on textiles – the fabrics from which the main surfaces of kites, balloons or hang gliders are made. Steer pupils away from thinking about struts and supports at this stage. (These will become relevant later if the activity is extended to building a model.)

Guide pupils towards deducing the different purposes of the fabric – to act as …

- a gas container in balloons (hydrogen, helium or hot-air)
- an aerofoil or sail in a kite or hang glider.

In groups, they can then discuss what properties the fabric needs to achieve each purpose. They should be able to deduce that the fabric must:

- be flexible
  - ~ could be continuous (such as rubber or plastic sheeting) or woven (from natural or synthetic fibres)
- have low density, to minimise weight
- not let gases pass through (low permeabilty)
  - ~ continuous sheet or closely woven
- not absorb water, since rain-soaked fabric would be much heavier
- be strong enough to withstand the pressure of:
  - ~ the gas inside (for a balloon)
  - ~ wind blowing against the fabric (for a kite or hang glider)

Pupils may also think of other properties, such as elasticity or durability (resistance to sun, rain and wind).

Pupils should now think about the types of fabrics they know that might have the required properties, including sheet materials such as rubber and plastics. They could draw up individual lists and then compile these into a class list. You may need to add any obvious omissions.

They and/or you will need to source a selection of the identified materials for testing.

Low permeability is more difficult to achieve for hydrogen or helium than for air, because the former have the smallest and lightest particles of all elements. So hydrogen molecules and helium atoms escape (diffuse) through fabrics more easily than nitrogen and oxygen molecules.

Pupils may not know this, but once you tell them, they should be able to deduce that weather balloons need a continuous, rather than woven, fabric. Point out that helium party balloons are shiny, not just to make them look pretty – the aluminised surface is less porous than rubber.

The practical activity

Working individually, or in small groups, pupils are to devise and carry out tests to decide the best fabric for one of the following:

- a kite
- a hot-air balloon
- a hydrogen or helium weather balloon
- a hang glider wing.

You may wish to allocate these or allow pupils to choose for themselves.

They will need time to decide what tests are required, and how they will perform them. The student worksheet instructs them to outline their proposals, with lists of required materials and equipment, and submit these to you for approval (relevance, feasibility and safety).

The practical testing is likely to need a significant amount of preparation and organisation. If certain items are in short supply, such as air blowers and anemometers to detect or measure air passing through fabrics, it may be necessary to rotate groups around test bases.

Pupils may suggest tests on flammability for hot air balloons. Not only is there a fire risk but some materials produce unpleasent or even toxic fumes when burned. Use only tiny pieces – size of 1p coin or less. Do NOT burn pvc (very toxic product) unless in a science department fume cupboard.

The total time required can be reduced by distributing the tests between the groups, but all tests should be carried out at least twice, preferably more, to check reliability of results.

Comparing results

Pupils should exchange results and compare them in order to make informed decisions about the most suitable fabric for each flying object.

They can then undertake research to discover what fabrics are used commercially, compare these with their own choices, and suggest reasons for any differences. They should appreciate that manufacturers often need to make compromises between performance and cost.

Differentiation

The ability of pupils to undertake this activity with minimal intervention will depend on when, within the programme of study, it is undertaken. Weaker and/or less experienced pupils may need a significant amount of help with planning fabric tests. Helpful strategies include:

- eliciting suggestions through class discussion, rather than in small groups, ensuring that weaker pupils are encouraged to propose ideas;
- providing pupils with lists of available materials and equipment, from which to select items for their tests (including a few irrelevant items, to make them think);
- close monitoring of their developing plans, to point them in appropriate directions, and avoid them veering too far away from feasibility and safety.

Possible extension

The activity could provide the starting point for a longer design and make assignment, with the aim of producing a kite or model hot-air balloon. Pupils might suggest a model hang glider to carry a toy figure, but this would involve knowledge of aerodynamics, or at least an existing design for the aerofoil wing.

Information sources

- http://www.akg.cwc.net/so%20you%20want%20to%20make%20a%20kite.htm
- http://www.lboro.ac.uk/departments/cd/research/groups/ed/PDF/academic/kite_pgs_28_50_27_5.pdf
- http://www.nybep.org.uk/publications-list.htm?file=filestore/publications/Kites.doc
- http://www.madehow.com/Volume-5/Hang-Glider.html
- http://science.howstuffworks.com/hot-air-balloon1.htm
- http://www.selah.k12.wa.us/soar/sciproj2000/HeatherK.html