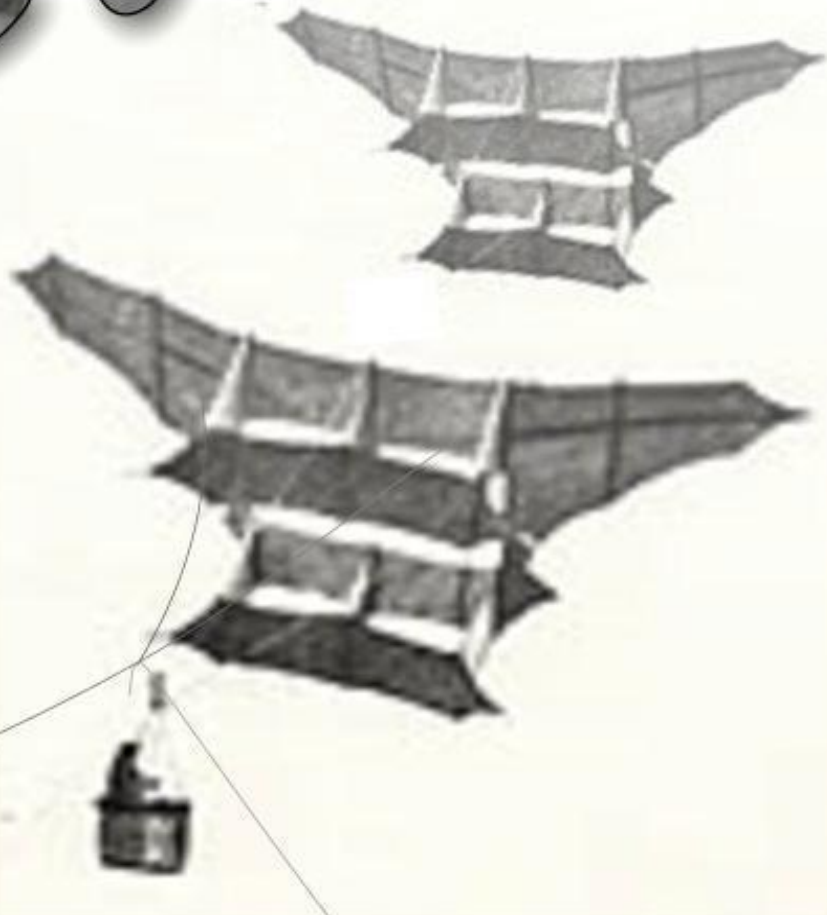
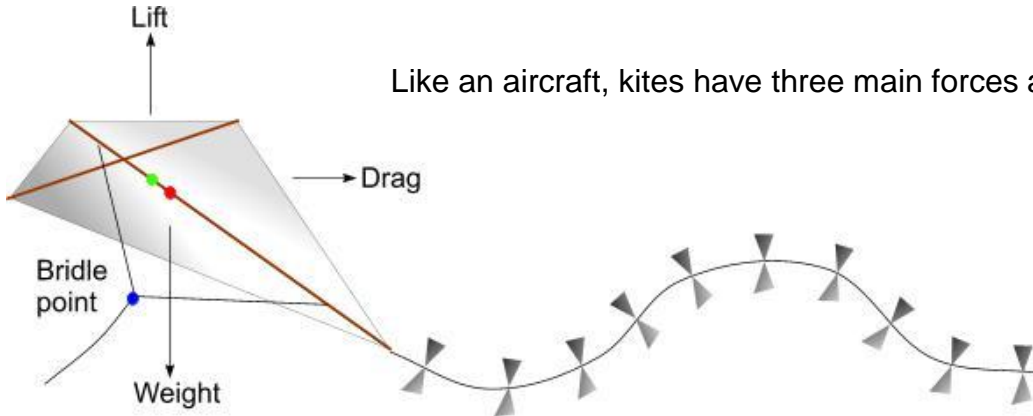


Kites



Kite design basics:

A kite flies a little like a tethered aircraft – indeed many of the early developers and pioneers such as **Sir George Cayley** (from Brompton Hall in Yorkshire); the Australian inventor of the 'Box Kite', **Laurence Hargrave**; and the **Wright Brothers** all used kites in their experiments for man-powered flight. You may wish to use your favourite 'Search Engine' to find out about these people using the Internet.



Like an aircraft, kites have three main forces acting upon them:

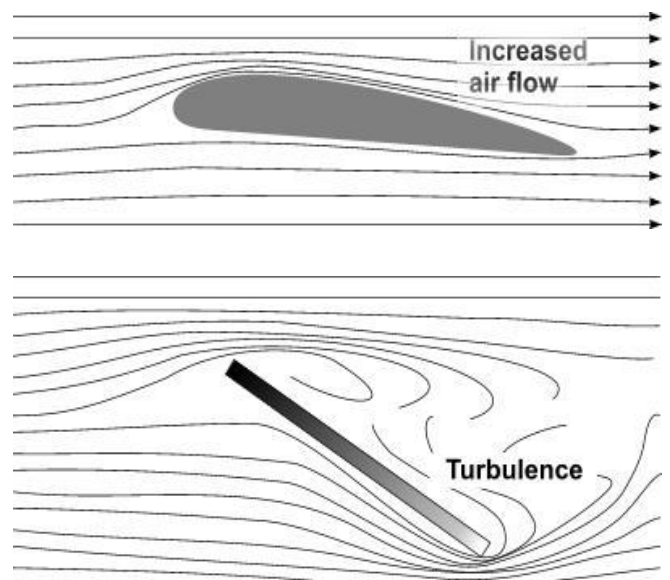
- **LIFT** – this is generated by air pressure on the flying surfaces and acts through the **Centre of Pressure (CP)** (usually the centre of area or 'Centroid' of a flat kite)
- **DRAG** – this is the kite's resistance to being pulled through the air and also acts through the centre of area.
- **WEIGHT** – this acts through the **Centre of Gravity (CG)** or balance point of the kite and should be minimised as much as possible by using lightweight materials. The CG can be found by simply balancing the kite on one finger.

In addition, kites have a **Bridle Point** where the kite line (or **control line**) is attached. The Bridle Point acts like a hinge or pivot and one aim of kite design is to ensure there is enough 'lift' and to keep the CG below the CP such that the kite does not tend to tip forward and become unstable. **Kite tails** are sometimes used to increase drag and lower the CG to achieve more stability.

Aircraft wings (*airfoils*) usually have a curved (or *cambered*) upper surface and achieve LIFT by being slightly tilted upwards towards the wind. As the wind meets the '*leading edge*' of the wing, some air passes straight under the flat part of the airfoil but some has to go over the top. Since the top surface is curved it is a longer distance and so the air flowing over the top of wing has to travel faster than the air passing under it.

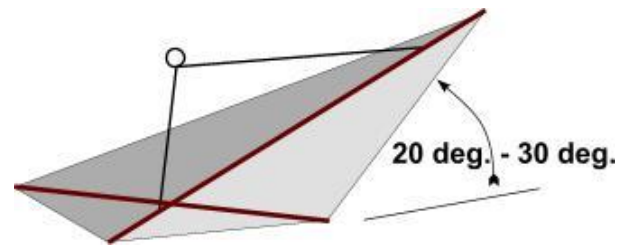
The Dutch born scientist **Daniel Bernoulli** established by experiment that, where air is flowing fastest, pressure is least. It follows that airfoils are partly pushed up by the airflow and partly drawn up by the effects of the '*Bernoulli Principle*'.

The angle at which an airfoil is presented to the wind is known as the '*angle of incidence*' or '*angle of attack*'. Aircraft wings have only a small angle of incidence, about two or three degrees, but kites fly at a much steeper angle – usually about ten times this.



An aircraft could not maintain such a steep angle but kites can because they are tethered to hold the kite stable against the forces of wind pushing against it and the effects of the *turbulence* created behind.

The angle of attack for a kite can be set by adjustment of the bridle. The normal method is to loop the bridle over one finger and suspend the kite upside down. The position of the finger is adjusted until the tail of the kite hangs down at an angle of 20 to 30 degrees to the floor.

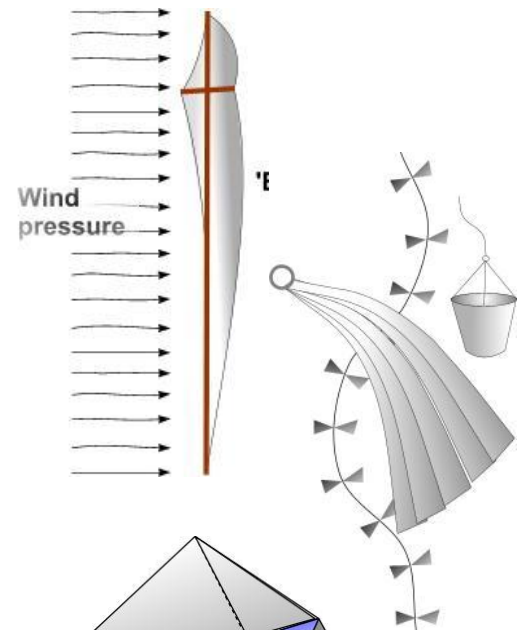


The general rule for bridle adjustment is:

- High angle for low wind speeds
- Low angle for high wind speeds.

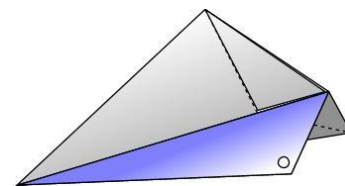
In practice, the surfaces of a kite are not completely flat – if they were, the kite would be unstable. Instead, the kite covering is pressed by the wind into curved depressions between the spars. This creates a curved or cambered surface not unlike an airfoil.

Kite stability can also be improved in other ways. Tails can be added to increase 'Drag' and to change the 'Centre of Gravity'. These should initially be about seven times the length of the kite and adjusted by trial and error.



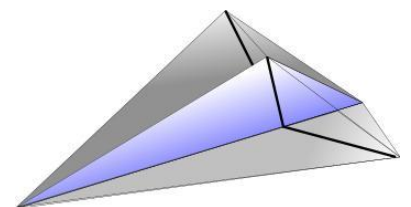
Droques (e.g. made from paper cups) can also be used.

The 'Bridle' can be made from sheet material to form a solid, stabilising **Keel**.

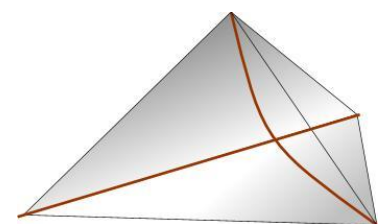


'Keels' can be added to the top of the kite to create a **Dorsal Keel** – this would need extra spars to support it.

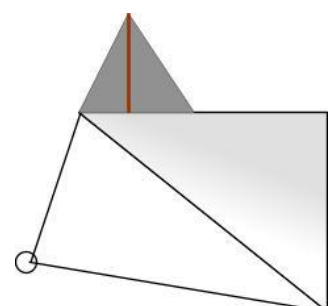
The **Cross Spar** of a kite can be bowed by stretching a bowstring across it. Alternatively, the 'Cross Spar' can be made in two halves, joined at an angle to form a **Dihedral**. The effect is to make the kite more stable in that it may float on the air much as a boat hull on water.



A kite's **Aspect Ratio** is the relationship between the 'span', or length, of the kite and the 'chord', or width, of the kite.



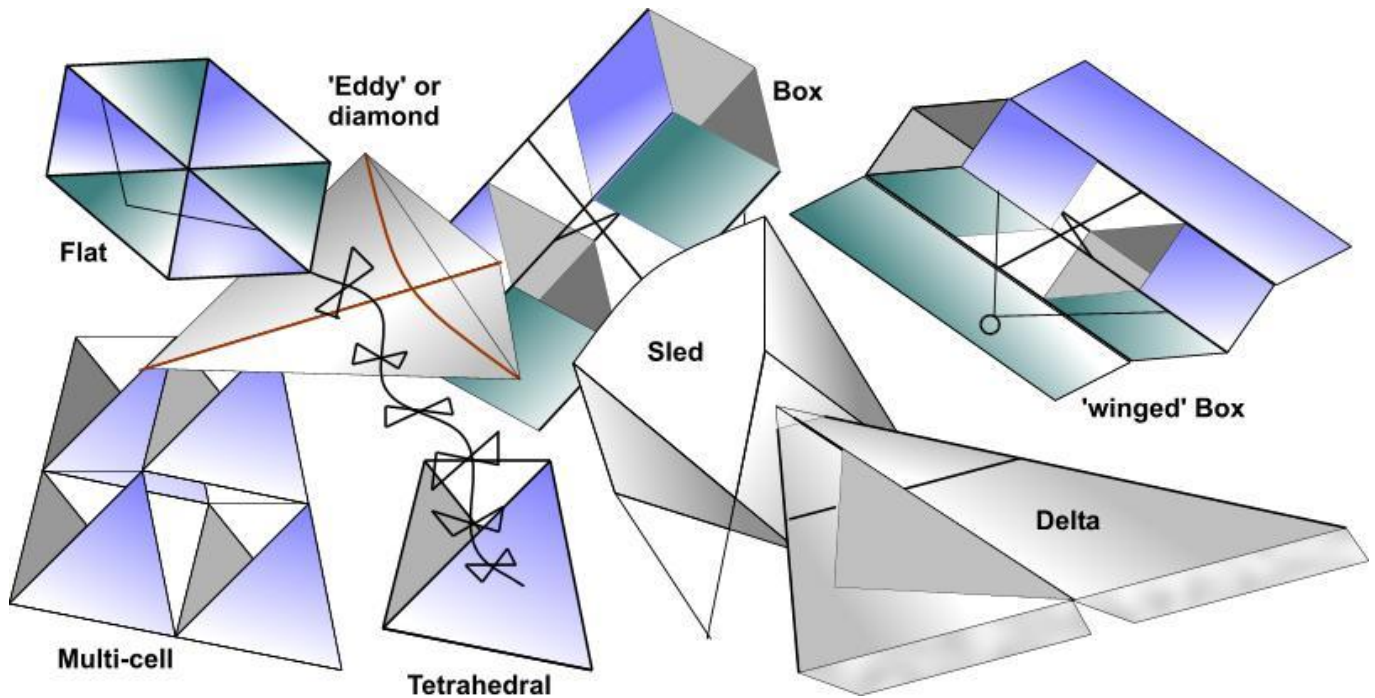
A kite of high 'aspect ratio' is considerably wider than it is long and. Although capable of very buoyant flight, it is very difficult to stabilise – 'stunt kites' that use two 'control lines' to overcome this often have a high 'aspect ratio'.



A kite with a low 'aspect ratio' is longer than it is wide and, although very stable, it has a high sink rate. This is an example of the kind of situation that engineers and designers commonly experience and have to optimise the various components to reach a working compromise.

Types of kite:

“Anything flat, firm and fairly light in relation to its surface will make a kite”.



Kite materials:

Spars -

- Drinking straws – for very small tissue paper kites
- Barbeque skewers – useful for small paper kites
- Wood dowel - a good material for kite building beginners but easily broken.
- Split bamboo garden canes and flower sticks - cheap and easily available. Tougher than dowel but not as smoothly finished
- Fibreglass rods and tubes - these are flexible, very strong, and inexpensive but the solid rods are fairly heavy.
- Carbon Fibre - the standard material for kites. It's strong, light and doesn't bend as much as fibre glass.

Sails –

- Newspaper - very cheap and easily available but has no strength when wet and has a poor strength to weight ratio.
- Tissue paper - available in bright colours and lightweight but poor strength when wet. Like newspaper, can be sprayed with water and left to dry to shrink tight.
- Brown paper or wrapping paper - stronger than newspaper but also can be heavier.
- Mylar - the silver hologram paper quite popular as a gift-wrap paper. It is very light, cheap and decorative but easily torn.

- Polyethylene - cheap and easily available in the form of waste bin liners and carrier bags. Difficult to glue but adheres to tapes well.
- Tyvek - a registered trademark of the DuPont company. It is a synthetic material resembling paper but made of high-density polyethylene fibres and often used for packaging and disposable overalls. Tyvek is very strong and difficult to tear but easily cut with scissors.
- Polyester cotton - the fabric that many modern items of clothing and household bedding are made from. A suitable weight for kite making is that used for making shirts or lightweight bed sheets.
- Rip-stop Nylon is a lightweight, water-repellent nylon fabric that resists ripping or tearing. It is often used in hot air balloons, kites, parachutes, camping equipment such as lightweight tents and sleeping bags, flags, and banners. Rip-stop Polyester (or rip-stop Dacron) is becoming more common for kites because it stretches less than nylon and has greater strength for a given weight. The best way to cut rip-stop is with a "heat knife" or soldering iron with a flattened tip in a well-ventilated area - the fumes are unhealthy. Specialist adhesives are available by the best way to join fabrics in kite making is to use a sewing machine.
- Nylon Taffeta - is a light, plain-weave fabric with a high lustre, originally made from silk and now often used in single line kites.

Kite lines –

- Sewing cotton - can be used for small tissue paper kites
- Household linen string – not really suitable but can be used if necessary
- Braided, or twisted pair fishing line (NOT monofilament line) - ask at the fishing shop for Dacron line.
- Nylon cord - 50 lb. test nylon kite line can be used for diamond kites, small box kites, small and medium delta kites
- Polyester – braided polyester Dacron line for single line kite flying is economical, tough and has half the stretch of nylon lines.
- High Density Polyethylene – sold under the brand names of Dyneema or Spectra, and now the preferred material for sports kite lines for two main reasons: the low stretch means that control inputs to the kite are transferred quickly and secondly the low friction allows the kite to remain controllable up to about ten twists in the line.

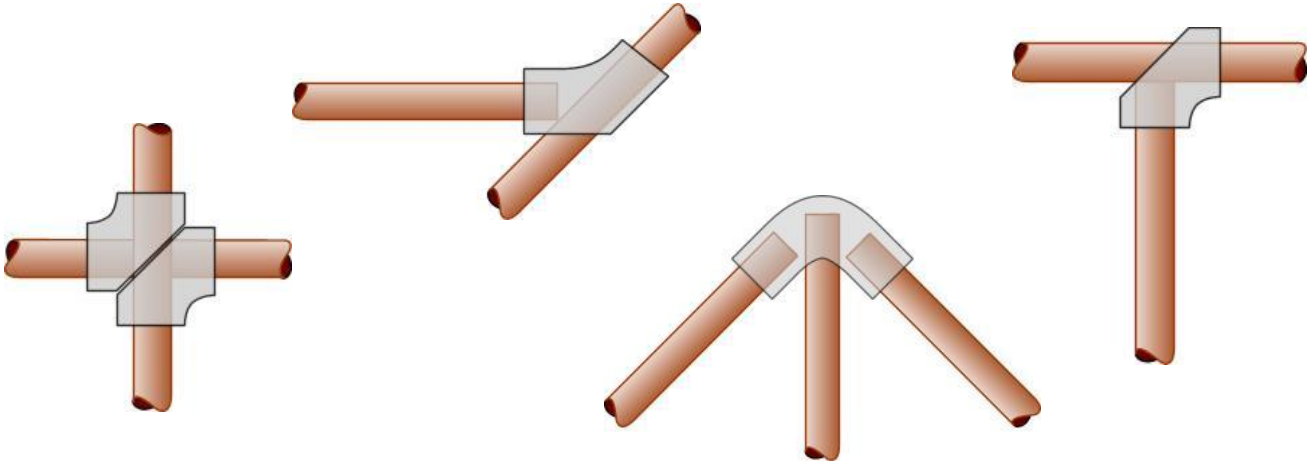
Kite making supplies:

- The Kite Shop - Chandlers Ford, Eastleigh - <http://www.kiteshop.co.uk>
- Kites R Us - Gillingham, Kent - <http://kitesrus.co.uk>
- Free Spirit Kites - Oxley, Wolverhampton - <http://www.freespiritkites.com/pages>
- Power Kite Shop - Oldbury, West Midlands - <http://www.powerkiteshop.co.uk>
- Brookite Ltd - Okehampton, Devon - <http://www.brookite.com>
- Sky High Kites - Aylesbury, Buckinghamshire - www.skyhighkites.co.uk

Kite construction:

Spars can simply be taped to small paper kites. For larger kites, cross-joints can be bound with string and glue or fixed by cable ties.

More generally, very positive and quickly formed joints for the spars can be made using plastics tubing. Neoprene and Polythene are thermo-plastics, which means the material softens when heated and stiffens again when cold. It is easily cut and shaped to form joints as follows:



Kite flying:

- The best places to fly kite are –
 - A flat field
 - The windward side of a hill
 - Near the sea or a lake
- NEVER fly kites –
 - Near overhead power cables
 - In a thunderstorm
 - Near a road or railway
 - Near an airport

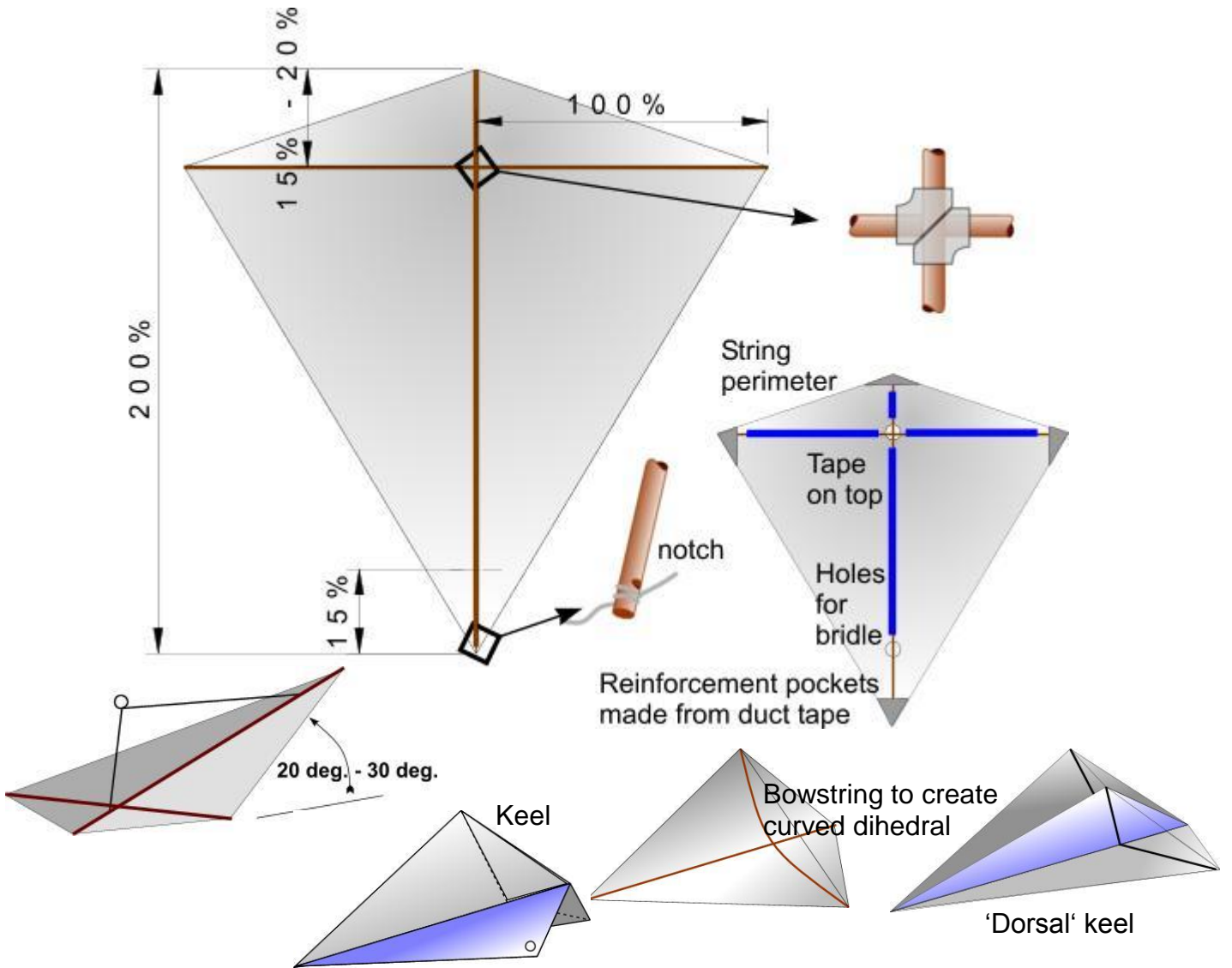
Don't try launching a kite by running with it – this is very inefficient. The easiest way to launch a kite is by 'winching' – i.e. the kite is launched by repeatedly reeling in and then giving slack. If the kite seems unstable and always rotates one way because of a manufacturing inaccuracy, try adding a tail or drogue to one side only to compensate.

Further work:

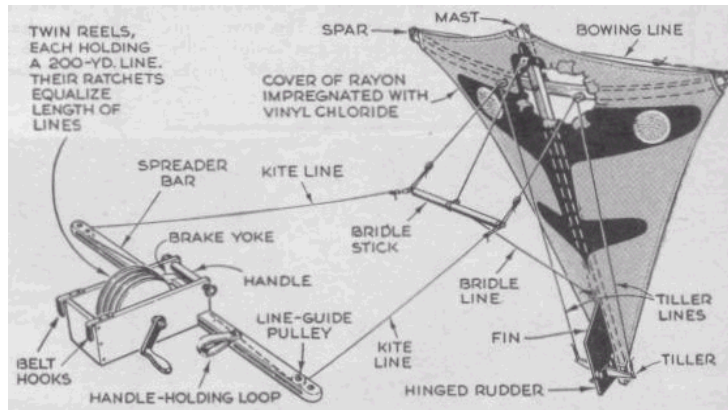
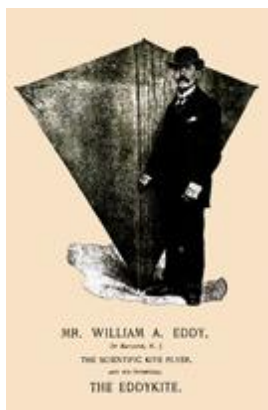
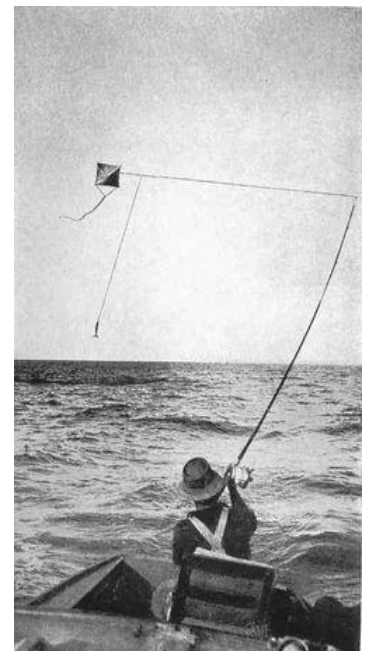
- Find out a method of determining how high the kite is flying.
- Make your kite produce a sound when airborne.
- Devise a way of dropping a parachute or launching a glider from the kite.
- Find out the maximum payload kites can lift and establish if this can be predicted.
- Use a kite for aerial photography.
- Devise a method of measuring wind speed.
- Try flying a 'train' of kites.
- Design a kite flying game
- Design a launching reel or winch.

Diamond, Eddy or Malay kite:

Suitable for light to moderate breezes

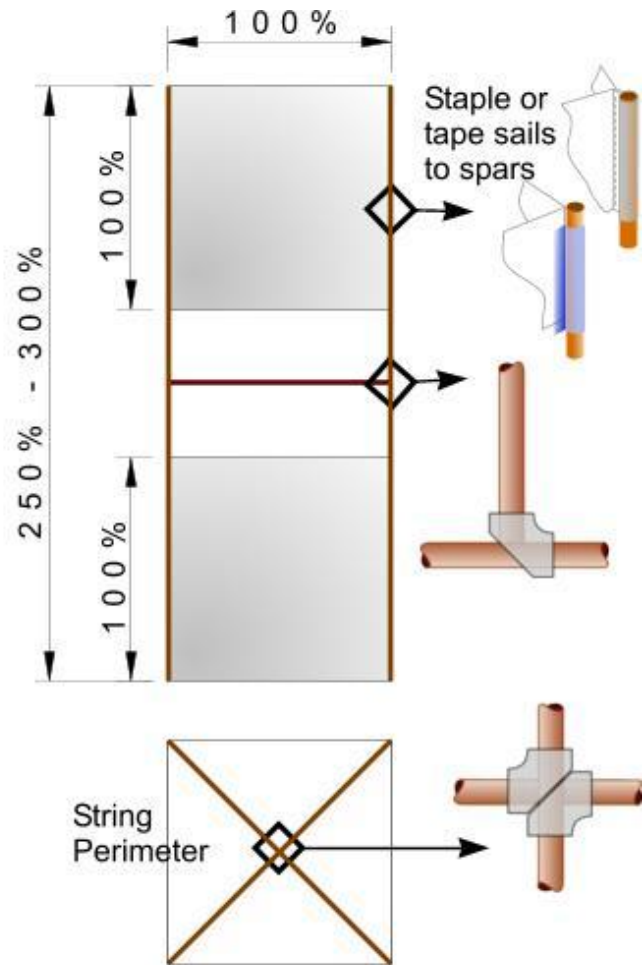
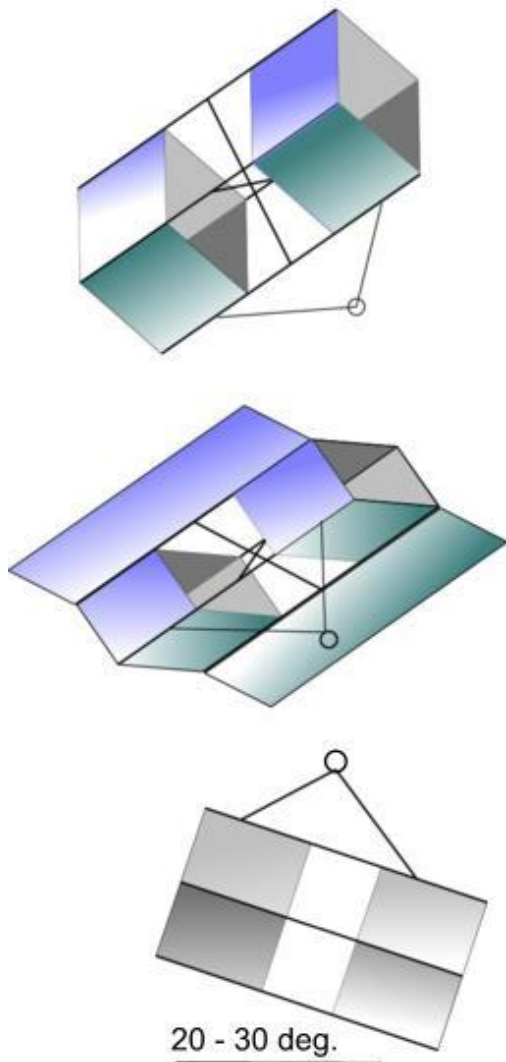


- In May 1891, William Eddy attached Malayan kites together to gain the height needed for weather measurements.
- In 1942, US Navy Commander Paul Garber develops a controllable diamond kite to provide targets for gun practice.

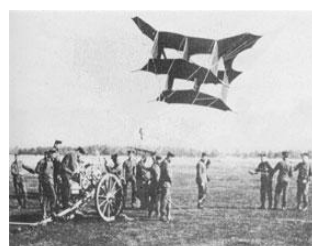
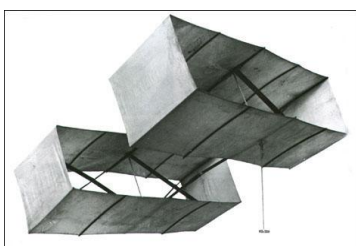


Box kite:

Suitable for moderate to strong breezes

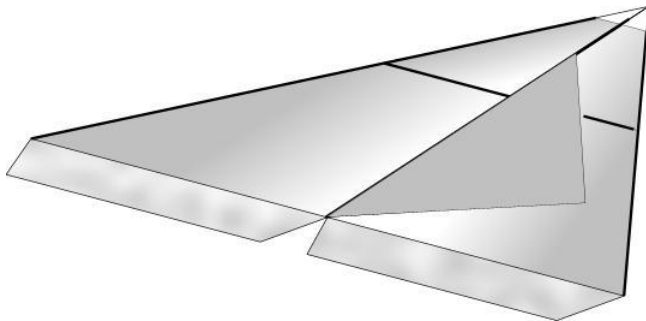
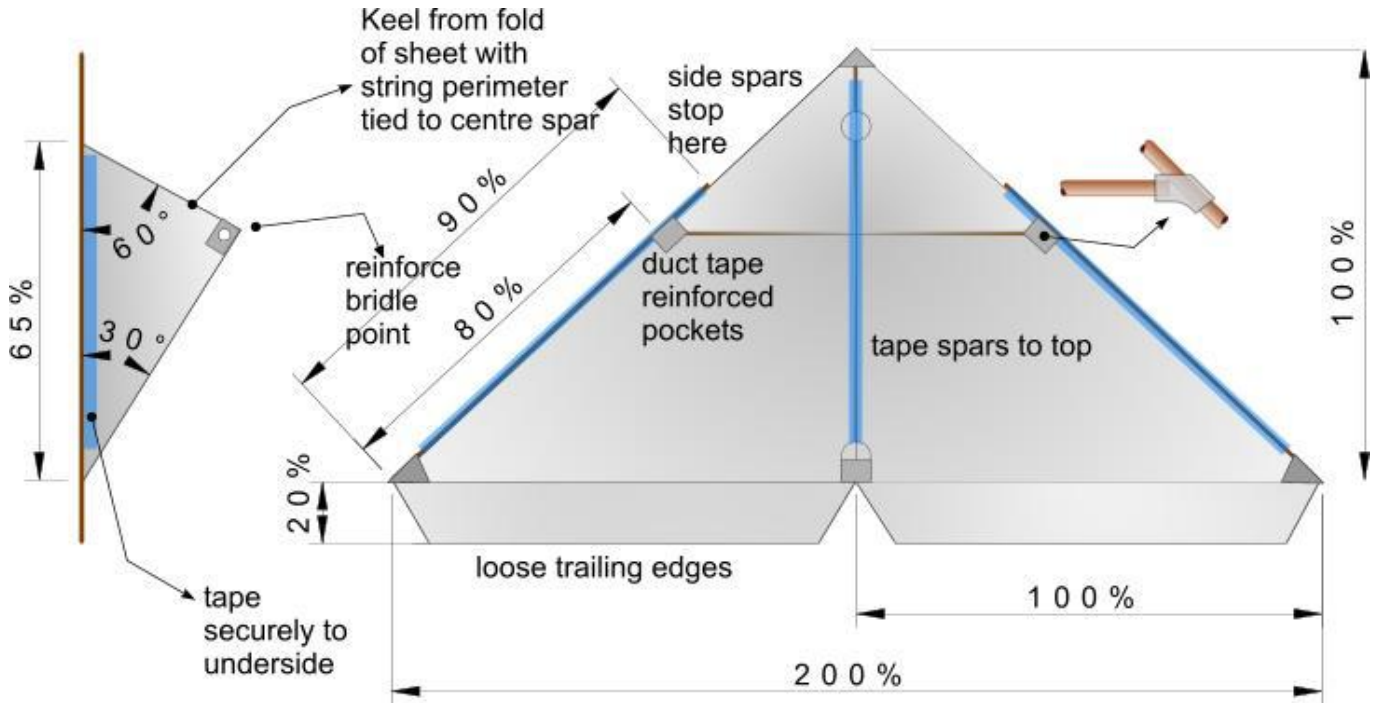


- On February 15th 1893 Australian inventor, Lawrence Hargrave, flew his box kite design at a beach near Wollongong, south of Sydney in New South Wales.
- The Wright brothers' develop their control system with kites from 1899 before Orville's first flight on December 17th, 1903 in an aircraft very similar to a box kite.
- In 1900, Texan Samuel F. Cody developed a large winged box kite that was used for man-lifting experiments and adopted for aerial observation by the British War Office in 1906.
- During World War 2, aircrews were issued with box kites to use to attract attention the event of being 'downed'.

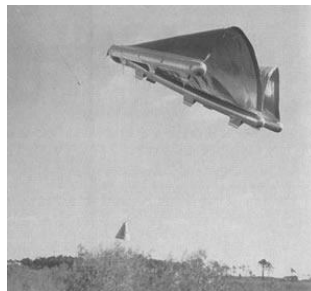


- **Delta kite:**

Suitable for moderate breezes



- Hang gliders are based on the flexible kite wing designed in 1948 by Francis Rogallo, a NASA aeronautical engineer and in 1958 further developed by him into the 'parawing', a structure-less kite used to enable spacecraft to land.



Beaufort scale:

Francis Beaufort, of the British Royal Navy, devised his scale of wind force in 1805, when serving aboard HMS Woolwich, and first mentioned it in his private log on 13 January 1806. Accounts from 1704 show that a similar scale was in use a century earlier and it would be surprising if medieval Arab seafarers and the mariners of ancient times didn't use such a scale.

The Royal Navy adopted the Beaufort Scale in 1838 when it became mandatory for all ships log entries. Beaufort's scale of wind force assumed its present form around 1960, when probable wave heights and probable maximum wave heights were added.

| Beaufort force | Description | Effects on land | Wind speed | | | Type of kite suitable |
|----------------|-----------------|---|-------------|---------|---------|--|
| | | | knots | km/ hr | mph | |
| 0 | Calm | Smoke rises vertically. | Less than 1 | | | |
| 1 | Light air | Wind direction shown by smoke drift but not strong enough to turn wind vanes. | 1 – 3 | 1 - 6 | 1 - 3 | Only the lightest small kites with maximum lift. |
| 2 | Light breeze | Wind felt on face. Leaves rustle. Wind vanes respond to wind. | 4 – 6 | 7 - 11 | 4 – 7 | Lightweight small and medium sized kites. |
| 3 | Gentle breeze | Leaves and small twigs in constant motion. Wind extends light flags. | 7 – 10 | 12 - 19 | 8 – 12 | Perfect for most kites except very heavy ones |
| 4 | Moderate breeze | Raises dust and paper. Moves small branches. | 11 - 15 | 20 - 29 | 13 - 18 | Medium and large kites. Best for box kites. |
| 5 | Fresh breeze | Small trees begin to sway. | 16 - 21 | 30 - 39 | 19 - 24 | Strong, sturdy kites with good stability |
| 6 | Strong breeze | Large branches in motion. Telegraph wires hum. Umbrellas difficult. | 22 - 27 | 40 - 50 | 25 - 31 | Very strong kites only |
| 7 | Near gale | Whole trees in motion. Effort needed to walk against the wind. | 28-33 | 51-62 | 32-38 | Not suitable for kite flying |

History of kites:

Kites have been in existence for about 25 centuries and probably originated in China. They were first mentioned in a story about Mo Ti, a contemporary of Confucius, around 500 B.C.

The Chinese used kites for many military purposes including gauging the distance to besieged palaces, making eerie sounds to frighten enemies, and lifting men to act as look-outs.

Kites developed as a source of amusement and ceremonial. They evolved from their simple rectangular shape to more elaborate and brightly painted constructions. Korean and Japanese fighting kites became the basis of a fast and exciting sport.

The Japanese were known to have used kites to lift building materials during tower construction and in Malaya fishing kites developed and are still in use in Asia today. These kites do not need a tail as the fishing line provides sufficient drag.

By the beginning of the 18th century, kite flying had become a popular pastime in Europe and in 1749 the first scientific application was recorded. Alexander Wilson in Scotland used a 'train' of kites to gain extra height for meteorological experiments. This was the first recorded of a 'train' of kites where several kites are flown one above the other on one line. Three years later in 1752, Benjamin Franklin performed his famous (and very dangerous) electricity experiment with a kite. By 1898 kites were commonly used for meteorological purposes and were not superseded by balloons until the early 1930's.

The early kites were many shapes but were all plane-surface (i.e. flat) and required tails for stability. At the beginning of the 19th century, Sir George Cayley in North Yorkshire and some years later around 1750, W.A. Eddy in U.S.A., developed the dihedral. The wings of the kite were bowed back to form a 'keel', which stabilises the kite in air just as a boat hull in water.

In 1893 Australian Lawrence Hargrave invented his box kite. This was the result (as was Cayley's work) of experiments into manned flight and included experimentation with cambered aerofoil surfaces to increase lift. The box kite was used in World War 2 as part of the survival kit for 'downed' pilots so that they might be spotted and rescued.

In 1901 S.F. Cody patented a man-lifting kite - a variation of Hargrave's box kite. The British Army later adopted this for use by its artillery observers. The Wright Brothers' famous aircraft is basically a box kite with an engine added.

Later developments in kite technology came from NASA where in 1948 Francis Rogallo patented his Flexible Kite that resulted in the Delta Wing kite and development of hang gliders, as we know them today.

In 1956, William Allison designed the 'Sled' kite and in 1972, Peter Powell created the two-line controllable stunt kite. In 1982, Don Tabor developed the two-line delta kite and the 'sports kite' was born.

Power kites or traction kites are large kites designed to be used for sports such as kite-surfing, kite-boarding on land, snow-kiting, and kite buggying. There are two main types: foil kites and Leading Edge Inflatables.

Foils are soft, structure-less kites based on the design of the parafoil consisting of a number of cells open at the front allowing air to inflate the kite to form an airfoil section. One of the first was the Flexifoil, developed in England by Ray Merry and Andrew Jones in the early 1970's

In the early 1990s, Peter Lynn of New Zealand built and used the first kite buggy - a lightweight vehicle powered by a traction kite (power kite). They can achieve speeds up to around 110 km/h (70 mph) and are classified as Class 8 Land Yachts.

A leading edge inflatable kite, LEI or C-Kite is a single skin kite with inflatable bladders providing structure first developed in 1984. In 2003, these were improved by Bruno Legaignon in France to create the Bow kite.

Useful websites for kite builders:

- Beginner's Guide to Kites

<http://www.grc.nasa.gov/WWW/K-12/airplane/bgk.html>

This site was prepared at NASA Glenn by the Learning Technologies Project (LTP) (<http://www.grc.nasa.gov/WWW/K-12>) to provide background information on kites as teaching aids for math and science teachers. The site includes a link (<http://www.grc.nasa.gov/WWW/K-12/airplane/kiteprog.html>) to Interactive Kite Modeler Version 1.4a as a JAVA applet that runs in your browser. This program can also be downloaded to your machine.

- Kite Plans

<http://members.tripod.com/~TKOGunn1/kiteplans.htm>

Links to the "Best of the Best", kite making plans on the internet from Troy Gunn, USA national kiteflying champion and world record holder.

- Virtual Kite Zoo

<http://www.blueskylark.org/zoo/index.html>

If you want to know about kites, all about kites, every kind of kite, big kites, little kites, strange kites, fancy kites, plain kites ... then step inside, and explore sketches and descriptions of every kind of kite you can imagine - and some more.

- Kite Flyer Info

<http://www.kiteflyerinfo.com/index.shtml>

Basic kite designs by W.J. Rayment from Harbor Beach, Michigan, USA, that utilize basic materials that can be found about the house - eg newspaper and packaging tape.

- Anthony's Kite Workshop

<http://www.cit.gu.edu.au/~anthony/kites/>

Numerous kite projects and designs - particularly the unusual and strange kite designs like Rotor (UFO), Circoflexi, and Tetrahedrals kite designs. Anthony Thyssen is a systems programmer at Griffith University, Brisbane, Australia

- The Australian Kite Association

<http://www.aka.org.au/index.html>

Information about the association, kite plans and a section on "Kites in the classroom".

- Kites 'R Us Website: Constructing An Eddy Kite

<http://www.zianet.com/katgraham/kites/eddylesson.html>

This Website is a working collection of items for a Kite Investigation Project: EDUC 521 Sponsored by RETA of New Mexico (Regional Educational Technology Assistance).

- Kite Flying and Design

<http://www.andywardley.com/index.html>

Web site of Andy Wardley, a self confessed freestyle kite flying fanatic. The site includes several video clips of kite flying tricks at in Stoke Park, Guildford, UK

- Kite Jan

<http://www.kitejan.me.uk/index.htm>

This site attempts to help others who are looking into kites.

- So you want to make a kite

<http://www.akg.cwc.net/so%20you%20want%20to%20make%20a%20kite.htm>

A step by step guide to getting your first kite together

- Kite Patents : a compendium of historical kite patents

<http://kitepatents.blogspot.com/>

Historic kite patents are a freely available source of inspiration and ideas with their own kind of aesthetic appeal. Expired patents are often great kite plans for the DIY kite builder.

- Billy Bear's Mini Kite

<http://www.billybear4kids.com/graduation/summer/kite/make-it.html>

Small tissue paper kite that really does fly.

- Kites.com

<http://design.and.construction.kitez.com/>

List of web pages relating to kite design and construction

- Carnet de Vol

<http://www.carnetdevol.org/>

Kite history web site

