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ACP 33

flight

volume 1 - history of flight

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ACP 33
FLIGHT

CONTENTS

Volume 1

History of Flight

ISSUED 2000

CHAPTER 1

LIGHTER-THAN-AIR CRAFT

Man takes to the air

1. For many years man had dreamed of flying through the air like the birds. It was not too surprising then that early attempts to fly tried to copy bird flight by using flapping wings. Leonardo da Vinci (1452-1519) the Italian artist and inventor produced many designs for aircraft which relied on flapping wings.

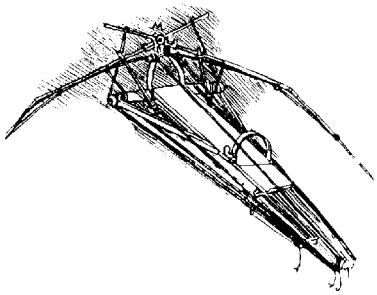


Fig 1-1 *Leonardo da Vinci's flapper*

Fortunately he never built or tested any of his designs for they would never have worked - man's muscles are far too small to operate the massive wings that would be required to get him airborne.

The first Hot-Air Balloon

2. It was not until the Montgolfier brothers built a hot air balloon in 1783 that man could realise his dream of getting airborne. The first balloon flight occurred at Annonay in France on 25 April 1783 where a 12m (39 ft) diameter un-manned balloon filled with hot air climbed to a height of 305m (1000ft) before the hot air in the envelope cooled and it began to descend. The Montgolfier brothers are said to

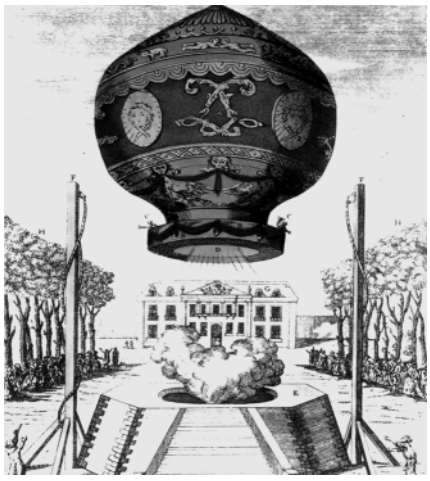


Fig 1-2 *The Montgolfier balloon (photo courtesy RAF Museum)*

have been unaware that hot air alone was responsible for the balloon rising, believing that a special light gas was generated by burning a mixture of wool and straw below the open neck of the envelope.

3. In September 1783 a further demonstration saw the balloon lift a sheep, a duck and a cockerel - the first living creatures to become artificially airborne. Later in the same year Francois Pilatre de Rozier accompanied by the Maquis d'Arlandes made the first free flight in the balloon, remaining airborne for 25 minutes and travelling a distance of 9km. Free flight in a lighter-than-air craft had at last been realised.

The first Hydrogen-filled Balloon

4. Although this was the beginning of manned flight, it was also the end of the Montgolfier balloon; almost immediately superseded by a much superior and practical hydrogen-filled balloon developed by J Charles. In this balloon both Charles and his assistant made a free flight from the gardens of the Tuileries in Paris on 1 December 1783, covering a distance of 43km (27 miles) and witnessed by over 400,000 people. The Charles balloon was so well designed that the gas-filled balloons used to this day are essentially similar to it - the main difference being that modern balloons use helium gas which does not burn, instead of hydrogen.

Why balloons fly

Why does a balloon fly?

5. An inflated balloon displaces its own volume of air and so experiences a lifting force or upthrust. This upthrust is equal to the weight of air displaced. A helium balloon inflated to the size of a house would contain about $^1/_2$ tonne of gas and would displace about 4 tonnes of air.

Fig 1-3 *A balloon must displace its own weight of air in order to float*

The difference between these two weights would be the lifting force on the helium-filled balloon. If this lifting force is greater than the total weight of the balloon, including the gas, envelope and gondola or basket, then the balloon will float.

6. As the balloon ascends, the atmospheric pressure falls and the balloon expands. To prevent the balloon from bursting, its gas must either be released gradually or allowed to expand into spare envelope space.

Hot-air Ballooning

7. Hot-air ballooning is now a very popular sport and many companies fly specially designed balloons to advertise their names. Heating up air causes it to expand and become less dense. When this lighter air fills the balloon envelope it provides lift by displacing the heavier air outside, in much the same way as hydrogen and helium gas but at a fraction of the cost. The air is heated using large propane gas burners attached below the open neck of the balloon and, while in flight, ignited in short bursts to replace the cooling air. In this way the balloon is able to maintain altitude.

Fig 1-4 *The 16th Bristol International Balloon Fiesta*

Making a balloon navigable

Controlling the balloon in flight

8. It was not long after the de Rozier's first flight in the Montgolfier balloon that the potential of such a vehicle used for military reconnaissance was seen. But there had to some way of steering it - a basic balloon is simply carried along by the wind. Early ideas of sails, oars and propellers proved useless. It had to be understood that if a lighter-than-air machine was to be steered, then there had to be a controllable force capable of propelling it independantly of the wind. From this realisation and

over 100 years after Montgolfier's first flight, the first airship designs were produced. Engines were attached to provide independent forward motion and control was provided by using rudders to act on the airflow caused by this forward motion.

Airships

Some advantages of airships

9. Airships are not very common nowadays but in the early 1900s they were considered by many people to be the way forward for air travel. They were quiet and provided passengers with a high degree of comfort. Their ability to remain stationary relative to the ground while using very little fuel made them ideal for scientific and military work. Their size and lifting capacity enabled them to carry large cargoes relatively cheaply. Unfortunately, they were filled with hydrogen gas which made them extremely dangerous - hydrogen gas can be ignited with a tiny spark and will explode with tremendous force.

Modern airships use helium gas

10. Because of this, there were many airship accidents and finally, when the passenger airship Hindenberg burst into flames at its moorings in 1937, many people lost confidence in them and the airship era was effectively over. Although helium gas was just becoming available as a completely safe alternative to hydrogen, it had unfortunately arrived too late.

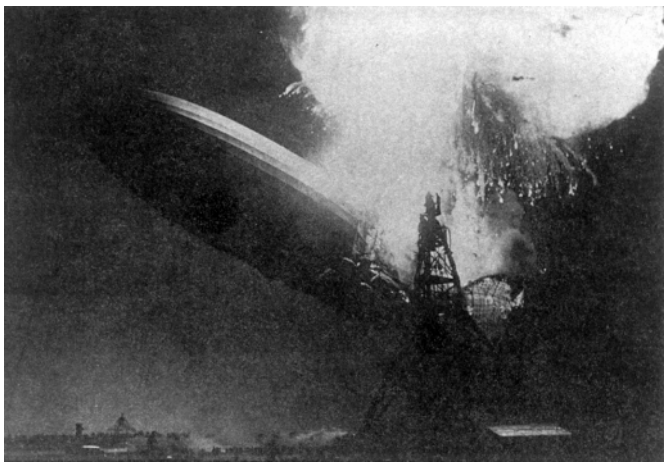


Fig 1-5 *The passenger airship Hindenberg burst into flames at its mooring post - 1937. (Photo courtesy of Hulton Deutsch Collection Ltd)*

How are Airships controlled?

11. Modern airships are benefitting from a revival. They are made with strong lightweight materials and have powerful engines which make them highly manoeuvrable.

12. Inside the main balloon are two ballonets - inflatable air bags that keep the pressure of the helium gas slightly higher than atmospheric pressure. This prevents the balloon from over inflating as the airship rises, or sagging as it descends. Also, pumping air from one ballonet to the other trims the airship balance.

Airship rising

13. Airship rising. To get the airship to rise, valves release air from the ballonets into the atmosphere, reducing the weight of the airship and allowing the helium gas to expand - giving more lift.

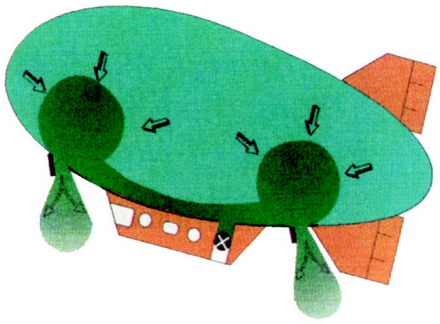


Fig 1-6 *Valves release air from the ballonets and the airship rises.*

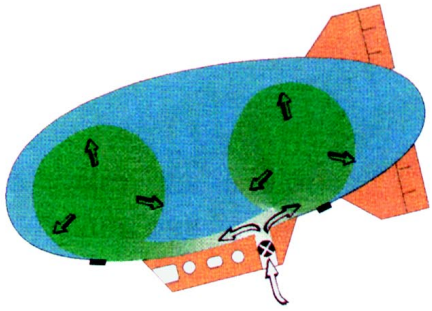


Fig 1-7 *Pumps force air into the ballonets and the airship descends.*

Airship descending

14. Airship descending. To make the airship descend, pumps force air into the ballonets, increasing the airship's weight and compressing the helium gas so that lift is reduced.

Fig 1-8 *Modern airships are benefitting from a revival.*

Sample Questions

Do not mark the paper in any way - write your answers on a separate piece of paper.

1. In which year did the Montgolfier brothers first fly their hot air balloon?
    a. 1673
    b. 1783
    c. 1883
    d. 1973
2. Who first flew a man-carrying hydrogen-filled balloon?
    a. Leonardo da Vinci
    b. Montgolfier
    c. Charles
    d. de Rozier
3. What gas are modern airships filled with?
    a. Helium
    b. Hydrogen
    c. Butane
    d. Propane
4. An airship rises when:
    a. The ballonets empty and the helium gas expands.
    b. The ballonets empty and the helium gas is compressed.
    c. The ballonets are filled with air and the helium gas is compressed.
    d. The ballonets are filled with air and the helium gas expands.

CHAPTER 2

HEAVIER-THAN-AIR CRAFT

1. It is believed that the first man-made flying object climbed skyward at least 3000 years ago on the end of a piece of string. The early Chinese people flew kites most probably as signalling devices or military banners heralding the approach of their armies. The technology of kite flying quickly spread throughout the world, with some kites almost certainly built large enough to lift a man used as a military observer.

How does a kite fly?

Features that make a kite fly

2. The most important features of this typical kite are its shape, its tail and the way in which the string is attached. Together, they make sure that the kite flies at the correct angle to the wind. The weight of the kite is balanced by the force of the wind underneath it, and also by a less obvious force called lift, caused by the kite's shape. Lift is produced by the wind passing over the top of the kite creating an area of low pressure, and by the air underneath the kite, at a slightly higher pressure, lifting the kite upwards.

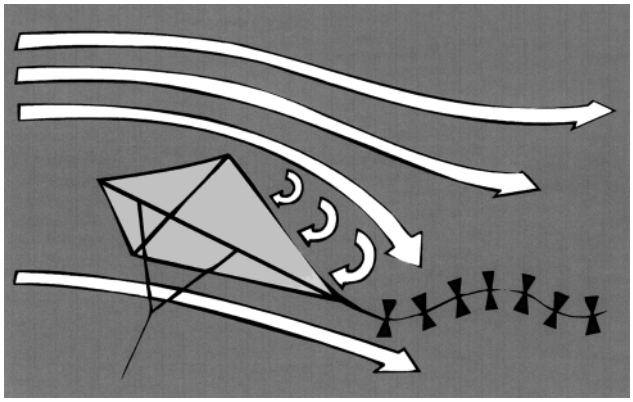


Fig 2-1 *The air supports the weight of the kite.*

Free flight

Sir George Cayley's model glider

3. The next most obvious step forward in achieving flight in an heavier-than-air machine was to develop a kite which could fly without a line to the ground. In 1804 the English Baronet Sir George Cayley built what is generally considered to be the first model glider. It was little more than a broomstick, to which was mounted a kite shaped wing at one end and vertical and horizontal tail surfaces at the other; nevertheless it was capable of stable flight over many metres.

4. With this device Cayley was able to confirm that the principles of heavier-than-air flight were definitely possible. From this first model he evolved a glider that was capable of carrying a small boy, although there was no way of controlling this craft in flight.

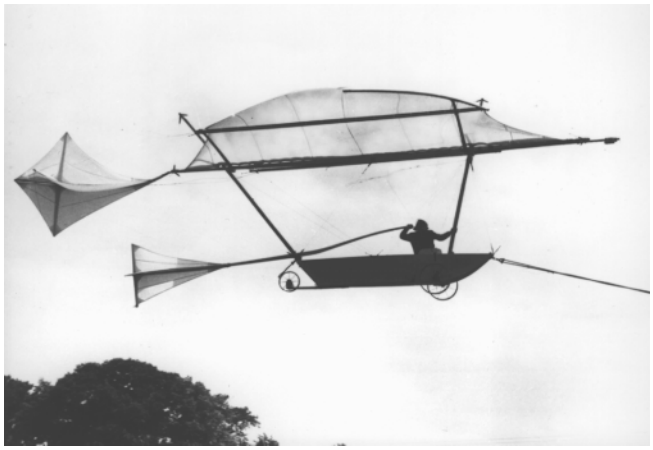


Fig 2-2 *Reproduction of the Cayley glider (photo courtesy of RAF Museum).*

Lack of power

5. Also, around this time there were many men beginning to improve the construction of fixed-wing aircraft that could fly. Their main problem, however, was to find a reliable and light enough engine to provide the power they required. In June 1848, John Stringfellow from Chard in Somerset successfully flew his 10-foot wingspan model, powered by a tiny steam engine, across a long room in a disused lace mill. Attempts to make larger versions of steam powered craft were unfortunately unsuccessful. The problems of suitable engines dogged aviation pioneers for many years.

Forerunner of the Hang-Glider

6. The more practical aviators however, accepted this lack of sufficient engine power and concentrated on improving airframe design. They experimented with lightweight construction and tried to discover practical methods of controlling the aircraft in flight. Nobody was more successful in this than the German Otto Lilienthal (1848-1896) who built extremely lightweight gliders enabling him to make many thousands of flights. His gliders were the forerunners of the modern hang-glider, designed so that the mass of the body could be moved to allow some degree of control. Despite many successful flights Lilienthal was killed in a flying accident on 9th August 1896, when he was 48 years old.

7. In 1885 a German by the name of Gottlieb Daimler developed the world's first single cylinder internal combustion engine which produced a power-to-weight ratio far superior to any other form of engine available for aircraft propulsion - the long awaited power plant for aircraft had finally arrived.

Fig 2-3 *Otto Lilienthal flew well-built hang-gliders (photo courtesy RAF Museum).*

The beginning of controlled flight

The first controlled flight

8. On a cold Thursday morning on the 17th December 1903 Orville and Wilbur Wright rolled out their 'Flyer' for the first test flight. With Orville at the controls the Flyer flew a full 120 feet in controlled flight. Three other test flights followed, the last and the best of that day covering 260m (852 ft) and ending with the elevator being damaged as the Flyer landed. Later Orville wrote:

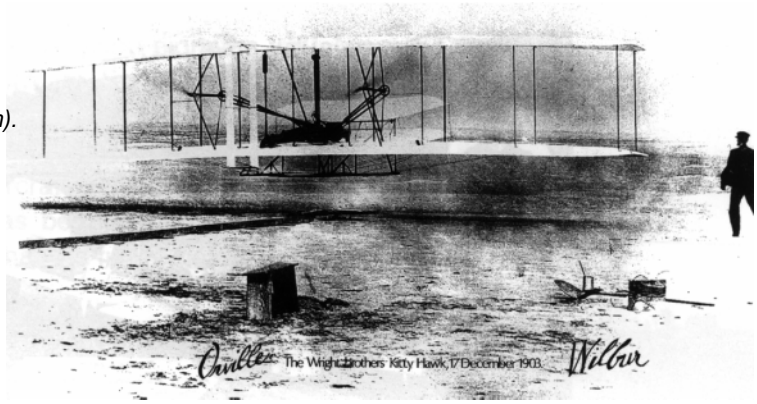


Fig 2-4 *The Wright brothers' first (photo courtesy RAF Museum).*

> "The course of the flight up and down was exceedingly erratic. The control of the front rudder (elevator) was difficult. As a result the machine would rise suddenly to about ten feet, and then as suddenly dart for the ground. A sudden dart, when a little over 120 feet from the point at which it rose into the air, ended the flight."

9. The important feature of these flights was that man had been airborne and in control of a powered heavier-than-air machine for the very first time.

10. With improvements to the design of the Flyer, by the end of 1908 and flying from Auvours in France, Wilbur Wright had made more than 100 flights, totalling in excess of 25 flying hours. His last flight of the year, on 31st December lasted 2 hours 20 minutes during which time he covered a distance of 77 miles (124 km) to set a new world record and win the Michelin prize. While Wilbur was busy in Europe, Orville was demonstrating the Flyer at Fort Myer in Virginia. These demonstrations attracted and thrilled many thousands of people who came from miles around to see an areoplane in flight. Tragically they ended after only a few weeks when the aircraft crashed, seriously injuring Orville and killing his passenger - Lt Thomas E Selfridge - the first man in the world to be killed in a powered aircraft accident.

Louis Bleriot

Bleriot crosses the Channel

11. Things were also happening much closer to home. On the 25 July 1909 a frail looking monoplane landed close to Dover Castle in Kent.

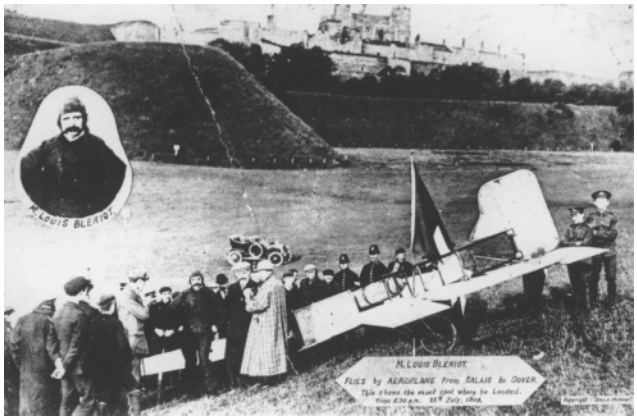


Fig 2-5 *Louis Bleriot lands near Dover Castle after crossing the channel (photo courtesy RAF Museum).*

The pilot was a Frenchman called Louis Bleriot and he had just completed the first crossing of the English Channel by a heavier-than-air machine. Bleriot's Type XI monoplane had taken 37 minutes to make the crossing, but had very nearly ended in failure when his 3 cylinder Anzani engine started to lose power as it overheated. Fortunately a shower of rain cooled the engine sufficiently to complete the crossing. Bleriot's monoplanes went on to achieve many important world firsts, including first over the Alps (1910), first London to Paris non-stop flight (1911), the first official carriage of airmail in Britain (1911) and almost inevitably, the first use of an aeroplane in war (1911). Man had finally realised his dream of mastering the skies.

A Maturing Industry

12. By the time war was declared in August 1914, the leading nations' armed forces had already established air arms. The stimulus of war accelerated the development of aeroplanes and engines and the industry expanded rapidly. Skirmishes between observation aircraft early in the war led to the development of more sophisticated gun technology such as the Fokker synchronised-gear machine gun, which ensures that bullets were fired between propeller blades. The SE5a was one of the most popular British fighters, which continued its career after the war. Bombing was adopted to a limited extent, with little military effect, but stimulated the design of much larger twin-engined aircraft. Some of these designs provided the basis for the first post-war airliners.

1914 to 1939

13. After World War One, new uses for aircraft were pioneered. The machine which made the biggest impact in 1919 was the Vickers Vimy bomber. A converted Vimy flown by Alcock and Brown made the first non-stop crossing of the Atlantic. This was the first of many feats which showed the growing potential of aviation. Between the two world wars a number of women broke records and made pioneering long-distance flights. Amy Johnson flew a Gipsy Moth when in 1930 she made the first solo flight from England to Australia by a woman. There was a growth in popular flying and flying clubs multiplied. The Moth was typical of the practicable, sturdy aircraft used for the purpose, and evolved into a whole family of de Havilland light aircraft including the famous Tiger Moth, which became the Royal Air Force's trainer in World War Two.

The Schneider Trophy

14. Aeroplanes were pushed to ever greater speeds and altitudes. The Schneider Trophy was devised in 1912 to stimulate the development of sound, practicable transport aircraft – instead it produced a series of beautiful but freakish high-speed racers.

The Birth of the Modern Airliner

15. Airliner development made great strides in the USA in the 1930s. Fast, all-metal monoplanes were developed by Northrop, Lockheed, Douglas and Boeing. Significant advances included the development of wing flaps (to improve low-speed

lift and reduce landing speed), variable pitch propellers and retractable undercarriages.

From Pistons to Jet

1939 to 1945

16. In 1939, war again accelerated technological development in the aircraft industry. The Battle of Britain (1940) was a contest as much between engines as between aircraft. The Rolls-Royce Merlin engine, which powered both the Spitfire and Hurricane, represented the pinnacle of engineering design and production skill.

17. The most important development towards the end of the war was the jet. British and German teams raced to develop jet designs. In June 1944 Germany launched pilotless, explosive-carrying jet planes against Britain: the V-1, nicknamed the 'Doodle Bug' and 'Flying Bomb'. The first British fighter, the Gloster Meteor, entered service one month later in an effort to destroy the V-1s. In the late stages of the war Germany used the rocket-powered Messerschmitt Komet fighters to intercept enemy bombers.

THE JET AGE

The Birth of the Jet

1945 to Present Day

18. The technology developed during World War Two transformed aviation in the subsequent years. The jet engine – with it speed capability and high power-to-weight ratio – inspired new experimental ideas and shapes. The results included jet passenger services, supersonic flight and vertical take-off and landing.

The First Jet Airliner

19. The world's first jet airliner was the de Havilland Comet 1, which flew in July 1949 and entered service in 1952. On long flights the Comet could have the journey time of piston-engined airliners. Smooth and quiet, its pressurised cabin enabled it to fly in all weather conditions. The most successful aircraft of this first generation of jet airliners was the swept-wing Boeing 707, which entered service in 1958.

Bigger or Faster?

20. In the 1960s commercial aviation began to follow two different paths – one leading to greater passenger-carrying capacity, the other to greater speed. The

British and French governments funded a supersonic transport project which eventually produced Concord – an aeroplane that can fly at twice the speed of sound, but has served with only two airlines, British Airways and Air France, because of its high operating costs. In the USA Boeing started planning for an entirely different approach: a huge airliner with 400 seats. The resulting 747 produced a second revolution in jet transport and made international travel an almost commonplace experience.

21. The design and development of aircraft have come a long way from those early days of Lilenthal and the Wright bothers. There is no doubt that powered flight has, in less than a century, transformed the world. Journeys have shrunk from weeks to hours and travel across the world has become a possibility for everyone. There will however, always be new challenges to meet and goals to aim for. In 1977 for example, Dr. Paul McCready's Gossamer Condor aircraft, powered and controlled by racing cyclist Bryan Allen, was flown in a figure-of-eight circuit around two pylons 0.8km (0.5 mile) apart. This was the first significant man-powered flight, and won the £50,000 Kremer Prize which had been so long in finding a home. Dr. McCready's Gossamer Albatross aircraft went on in 1979, to set the world distance record for man-powered flight.

Gossamer Condor wins the Kremer Prize

22. Aviation pioneers will always be with us testing new designs and pushing the frontiers of technology to their limits. The progress made in aircraft design in the past 100 years has been breathtaking - who knows what the future holds!

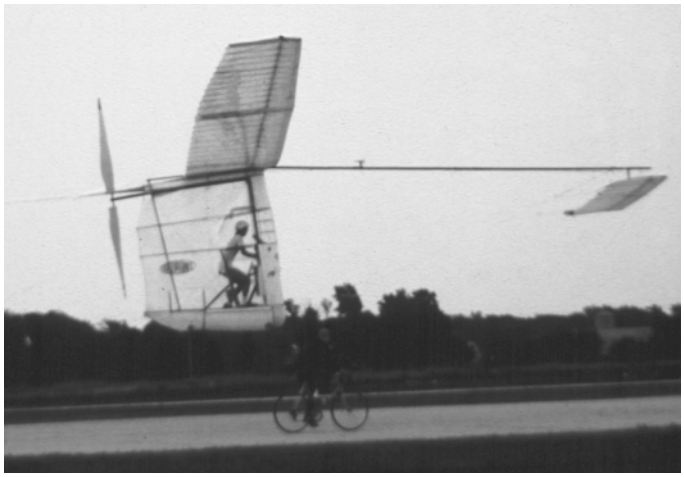


Fig 2-6 *Gossamer Albatross (photo courtesy Quadrant Picture Library).*

Sample Questions

Do not mark the paper in any way - write your answers on a separate piece of paper.

1. Who is thought to have produced the first model glider in 1804?
    a. Wright brothers
    b. Sir George Cayley
    c. Louis Bleriot
    d. John Stringfellow
2. Otto Lilienthal is well known for:
    a. building controllable gliders considered to be the forerunner of the modern hang-glider.
    b. Developing the world's first single cylinder internal combustion engine.
    c. Flying non-stop from London to Paris for the first time.
    d. Building the first heavier-than-air powered aircraft large enough to carry a man.
3. Who was the first person to fly a powered aircraft across the English channel?
    a. Orville Wright
    b. Bryan Allen
    c. Wilbur Wright
    d. Louis Bleriot
4. The aircraft to win the Kremer prize was called:
    a. Gossamer Condor
    b. Wright's Flyer
    c. Gossamer Albatross
    d. McCready's Flyer

CHAPTER 1

INSTRUCTORS GUIDE

Page 33.1.1-1 Para 1

Archimedes Principle

Archimedes, a Greek mathematician, discovered why things float. It is believed that he formulated his principle, while lowering himself in to his bath. The story goes, that in his excitement he leapt out of the bath and ran to his workshop shouting Eureka (I have found it!) - completely forgetting to dress.

His principle states:

Any object immersed in a fluid (liquid or gas) experiences an upthrust (it appears to weigh less). The size of this upthrust is equal to the weight of the fluid displaced by the object. This means that an object will float in a fluid when it displaces it's own weight of fluid. For example:

A 1000 tonne ship floats when it has displaced 1000 tonnes of water.

A one tonne balloon will float when it displaces one tonne of air.

From the earliest times man had aspirations to fly. By the beginning of the Sixteenth Century Leonardo da Vinci considered the problem of aviation in a more scientific spirit. By observation he learned much about the mechanics of the gliding and soaring flight of birds. He concluded that the long, narrow, slightly curved outstretched wings supported them because of the upward pressure of the air.

In the centuries which followed many adventurous men killed or injured themselves by leaping off towers with flapping wings attached to their arms and legs. In the end it came to be realised that man's unaided muscles could never sustain him in controlled flight.

CHAPTER 2

INSTRUCTORS GUIDE

The Father of Aerial Navigation

Page 33.1.2-1 Para 3

The English Baronet Sir George Cayley (1773-1857) did much to deserve the title “Father of Aerial Navigation”. In 1804 he built what is generally regarded as the first successful model glider which he used to confirm the principles of heavier-than-air flight.

He suggested the use of an internal combustion engine for powered flight and demonstrated that a curved aerofoil shape provides lift. He went on to demonstrate that biplane or triplane wings would provide maximum lift from a lightweight, robust structure.

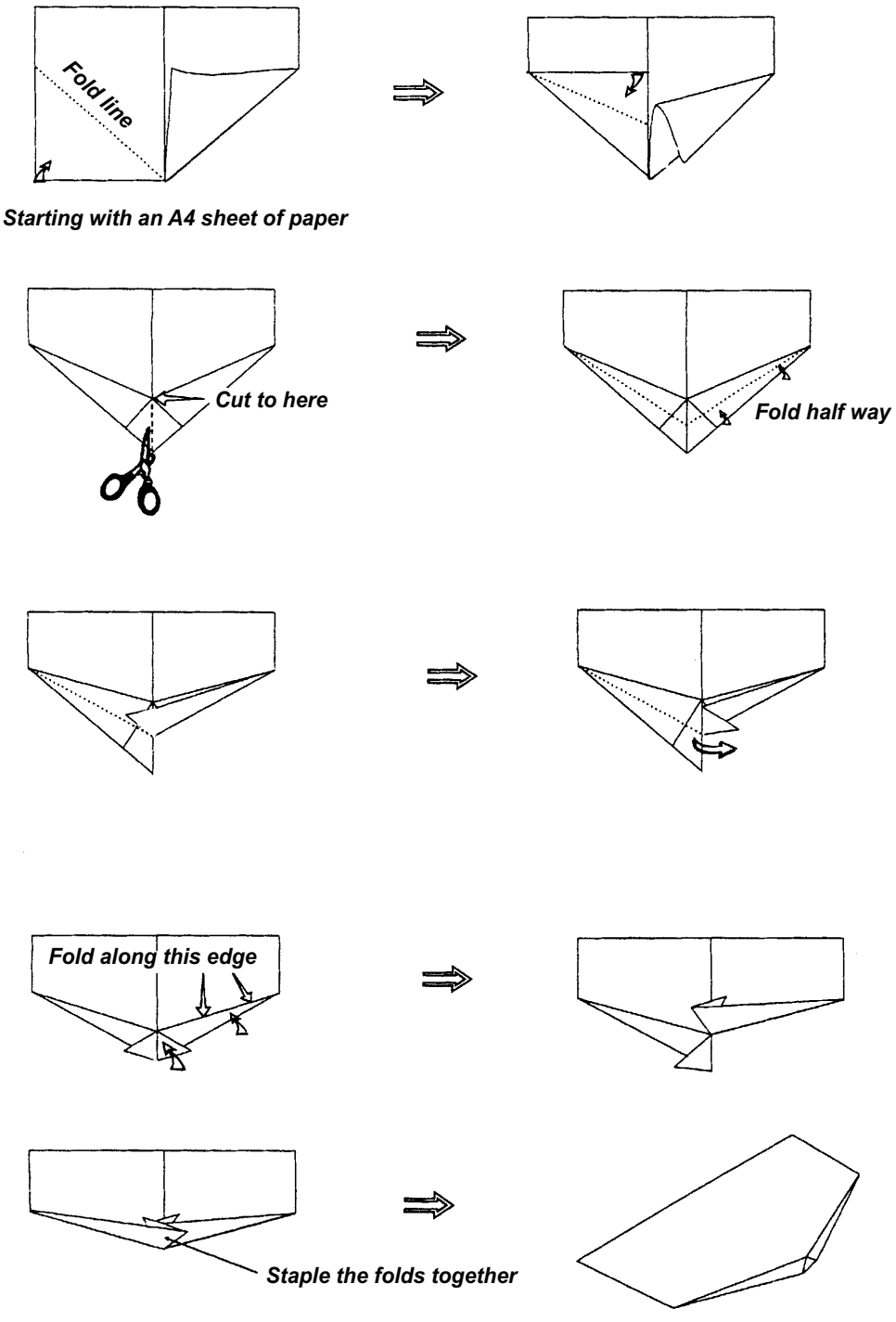
In the same year that Cayley died a French naval officer, Felix du Temple, flew the first model aeroplane powered by a clockwork motor. Seventeen years later he was flight testing a full-size man-carrying aeroplane powered by a steam-engine. Piloted by an unknown sailor, at Brest, this aircraft was the first in the world to achieve a short hop into the air, following it’s launch down an inclined ramp.

CHAPTER 2

Page 33.1.2-2 Para 6

Making a paper glider

Experiment with the effects of control surfaces on this model.



Self Assessment Questions - Answer Sheet

Chapter 1 Page 33.1.1-7

1. b
2. c
3. a
4. a

Chapter 2 Page 33.1.2-7

1. b
2. a
3. d
4. a

PIONEERS – AIRCRAFT HISTORY

A

Alcock, John	Made the first transatlantic flight, 1919.
Antoinette, Marie	Witnessed early flight of the Montgolfier balloon, 1783.
Arlandes, Marquis d'	Made the first human flight, in a balloon, 1783.

B

Bedford, Bill	Test pilot of first vertical take-off and landing (VTOL) jet aeroplane, 1961.
Bleriot, Louis	Made the first crossing of English Channel, 1909.
Brown, Arthur Whitten	Made the first transatlantic flight, 1919.

C

Cody, Leila Marie	First woman to fly, 1902.
Cody, Samuel Franklin	Made the first powered flight in Britain, 1908.

D

da Vinci, Leonardo	Made one of the first scientific studies of flight, c1500
Daedalus	Greek mythological character who created wings for himself and his son Icarus.

F

Fokker, Anthony	Developed the synchronised-gear machine gun for aircraft, 1915.
Frost, Edward Purkis	Experimented with ornithopters, c1900.

H

Harding, H J	Early twentieth-century aeroplane enthusiast.
Hill, Captain C T R	Designed the Hill Pterodactyl, early 1920s.

I

Icarus	Greek mythological character who flew too near the Sun.

J

Johnson, Amy	First woman to fly solo to Australia, 1930.

K

King Louis XIV	Witnessed early flight of the Montgolfier balloon, 1783.

L

Levavasseur, Leon	French artist-designer who created the Antoinette, c1909.
Lilienthal, Otto	Foremost experimenter in flight in the nineteenth century.

M

Mitchell, Reginald	Aircraft designer who created the Supermarine Spitfire and S6B, 1930s and 1940s.
Montgolfier, Joseph	Developed the first hot-air balloon, c1783.

N

Northcliffe, Lord	Owner of the *Daily Mail* and aviation propagandist, c1906.

P

Pitts, Curtis	Designed the Pitts Special Aerobatic Biplane 1944

R

Roe, Alliott Verdon	One of Britain's great pioneers of aviation, c1909.

S

Savage, Major Jack	Pioneered the art of skywriting, c1922.
Sayer, Gerry	Test pilot of the first British jet aircraft, 1941.
Short, Eustaceand Oswald	Pioneers of balloon flight, c1900.

W

Watson-Watt, Robert	Pioneered the use of radar in World War Two.
Whittle, Sir Frank	Developed Britain's first jet engine, 1930s.
Wright, Orville and Wilbur	First powered and controlled flight, 1903.