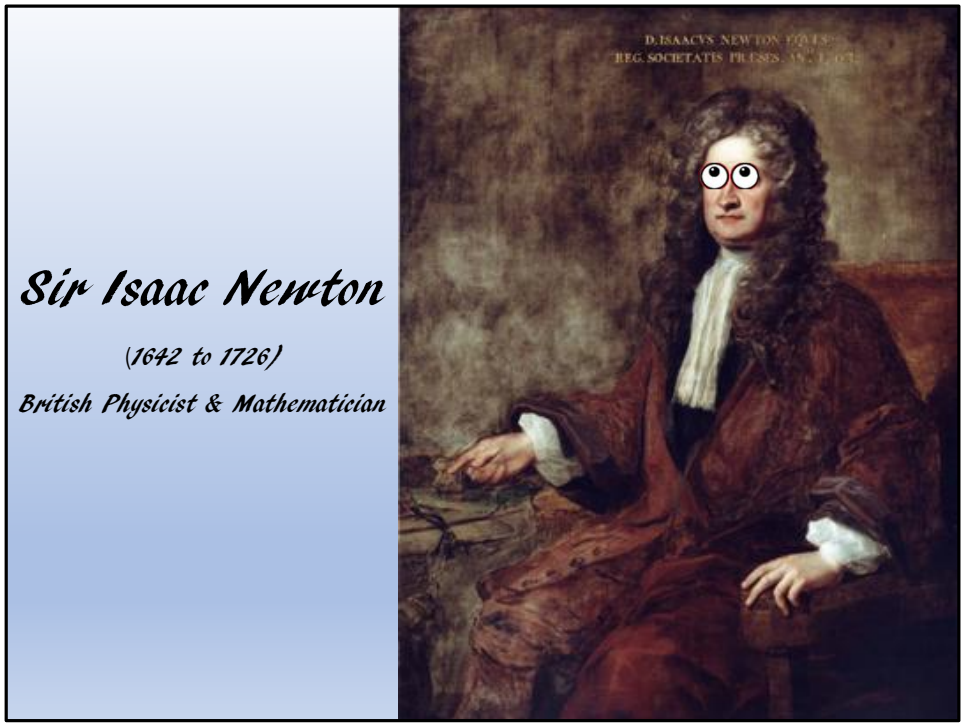
# Second Level Technologies
# Benchmark TCH 2-20a

## Power for Flight Pt 2

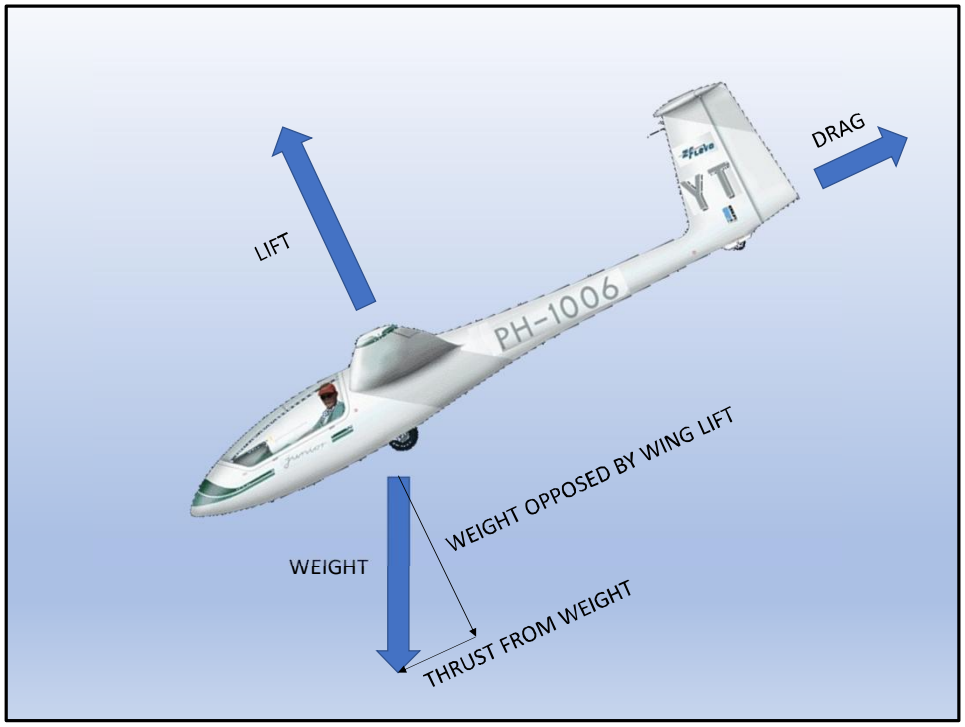
*Exploring how to achieve flight using thrust derived from an external source.*

*Exploring how the force called thrust can be supplied by the force of gravity and also how flight can be maintained by using the secondary effects of solar energy.*




Sir Isaac Newton was the man who figured out why things fall downwards and that it was the attractive force of gravity that caused things to accelerate downwards towards the surface of the earth…. *(Click)*

Our aircraft has mass so it follows that it will always be attracted down towards the ground. We can use this force to make our aircraft fly and the following diagram shows how it can be done.

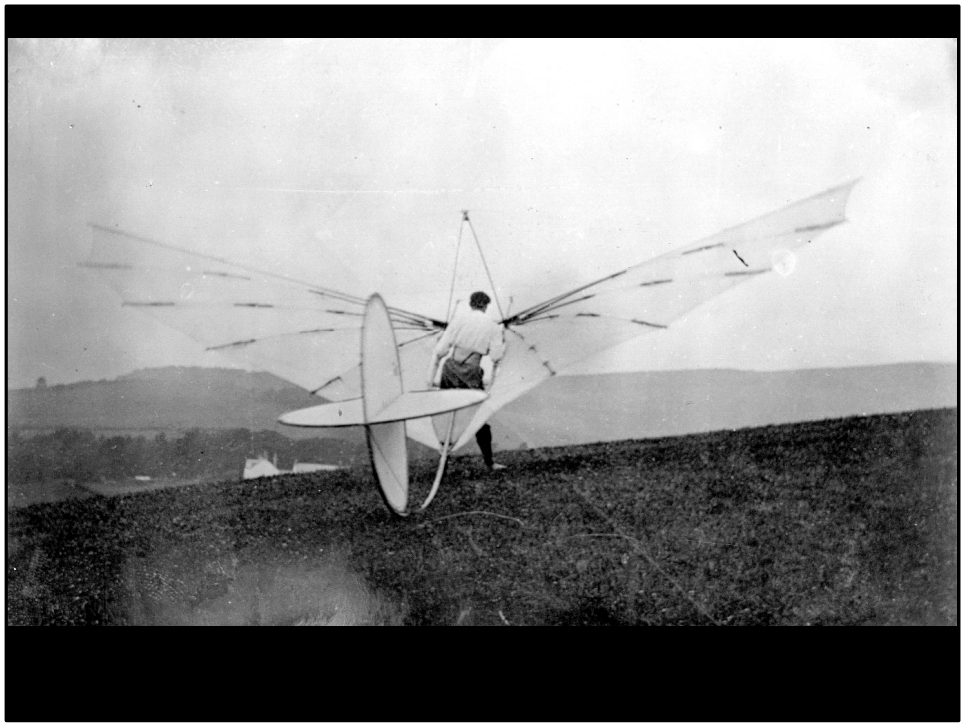



When the aircraft flies downhill, the lift *(Click)* and the drag *(Click)* remain in line with the vertical and longitudinal axis of the aircraft but the weight *(Click)* still acts straight down. This means that the weight and lift forces are no longer in line with each other and, as a result, *(Click)* a small resultant force is generated which is the thrust. *(Click)*


If the aircraft is like the space shuttle which has an awful lot of drag then it has to fly downhill quite steeply to generate enough thrust. This can make it very difficult to land the aircraft without losing too much speed.

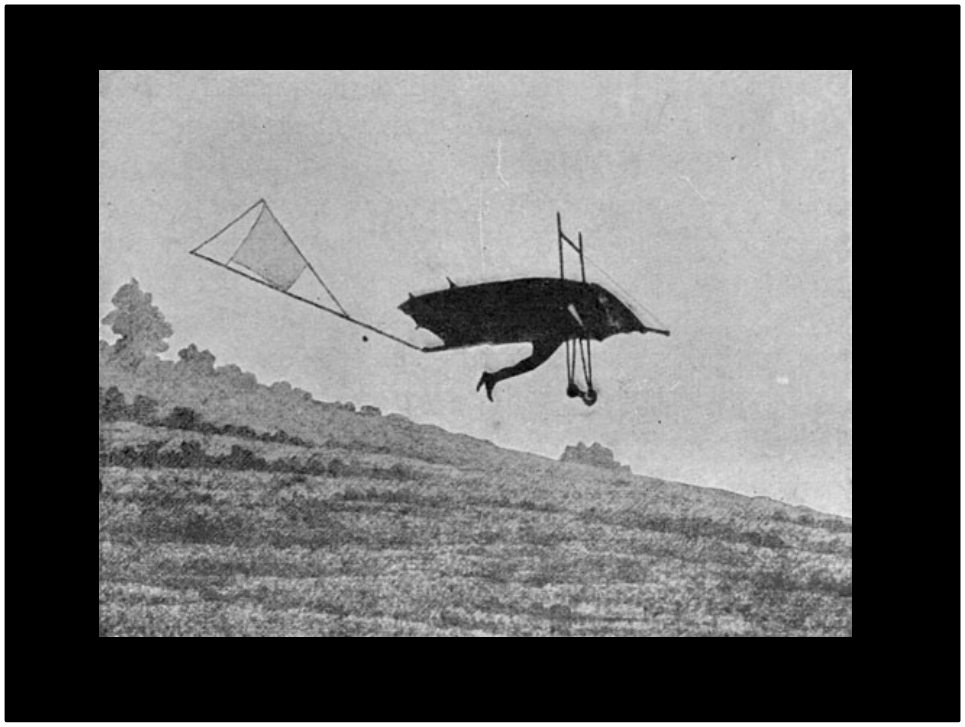
If however the aircraft is like this very efficient sports glider with a drag force that is very small, the aircraft only needs to fly down a very shallow slope to generate enough thrust.  This type of aircraft requires some form of additional thrust to get airborne and climb to altitude.  They may be winched into the air on the end of cable or towed by a powered aeroplane.

The early pioneers of flight started with gliders because they avoided the complication of engines. A suitable hill had to be found to launch the glider from. This is the German called Otto Lilienthal who made over 2,000 flights in gliders in the 1890's and showed that unpowered human flight was possible.

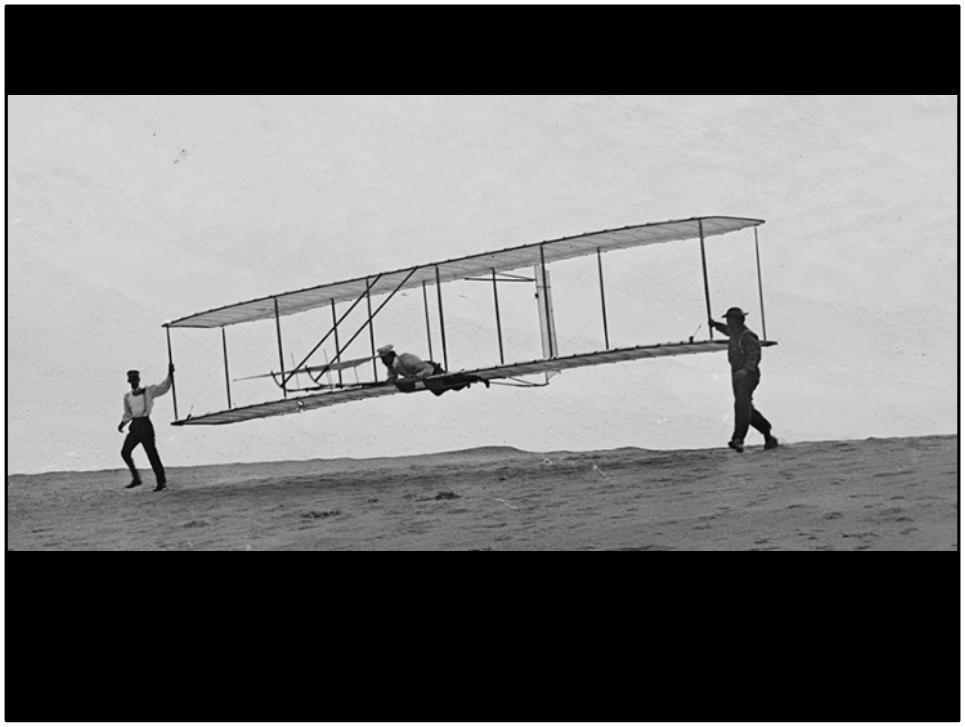


Percy Pilcher was the first man in Britain to build and repeatedly fly a heavier-than-air aircraft. He is shown here about to launch his first aircraft, the Bat, down a hill near Helensburgh on the north bank of the river Clyde.

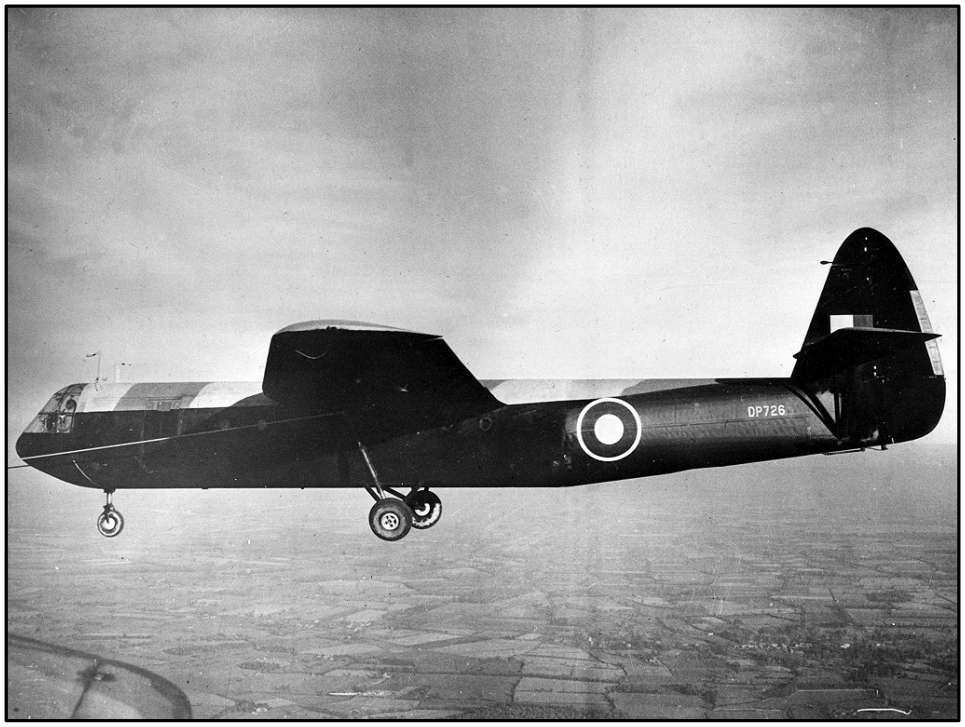
This historic first flight in Britain in 1895 was celebrated some 100 years later by building a reproduction of the Bat and it can be seen in the Riverside Museum in Glasgow.



This is Percy Pilcher flying the Hawk, his most successful glider, down a hill in Leicestershire in 1897. He carried out tests with this glider and discovered how much thrust would be required to sustain level flight. Amazingly this aircraft still exists and can be seen in the National Museum of Scotland in Edinburgh. It is the oldest surviving aircraft in Britain and possibly the world.



Meanwhile, in America in 1901, the Wright brothers were testing gliders by flying them down sand dunes at the Kill Devil Hills in North Carolina. However, unlike previous pioneers, they developed moveable surfaces to control the glider rather than using weight shift control as Lillienthal and Pilcher had done. This was a very important breakthrough in design and allowed further progress.




During World War Two gliders were used to transport troops into battle. The intention was for the gliders to land close to where the troops were required, having been….*(Click)*

…towed close to the landing zone by powered aircraft.  This military use of gliders was used by both sides during the conflict.  Modern technology has made the military transport glider obsolete.

Sport hang-gliders are a modern re-incarnation of the types of gliders that Pilcher and Lillienthal flew. They are still controlled by weight-shift and are no larger or heavier that the gliders of more that 100 years ago.

Para-gliders are a modern development of parachutes. The fabric wing aerofoil shape is maintained by the forward speed of the glider which causes the air to inflate the wing.  These type of gliders can be carried easily to the tops of hills to start the flight and, although good fun, are not as good gliders as most modern aircraft.

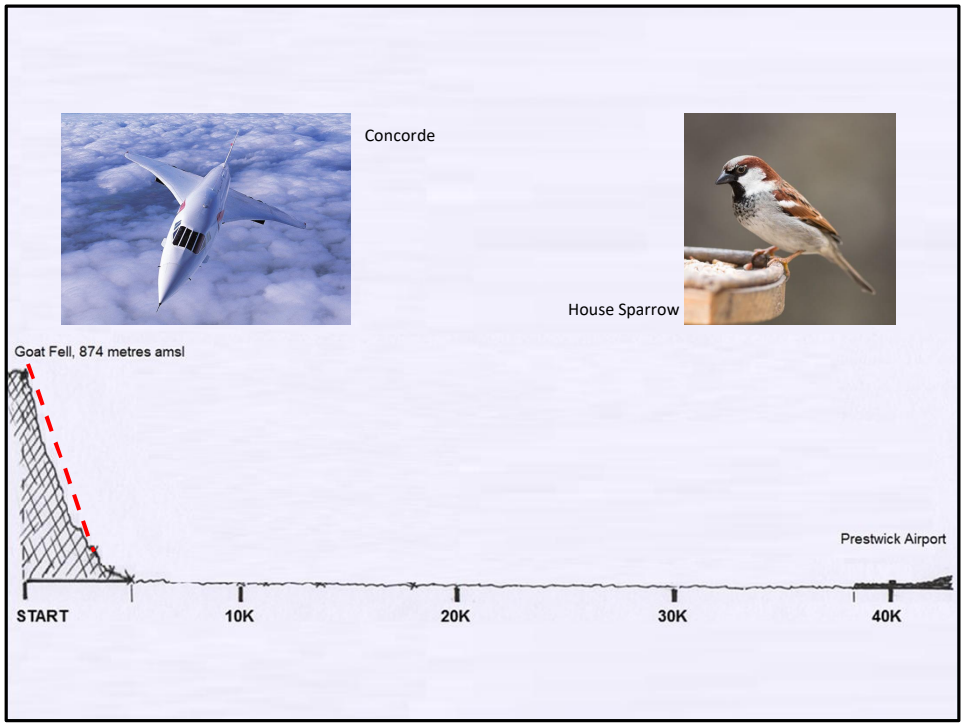

Modern airliners are very efficient aircraft and as a result make surprisingly good gliders. Although it is not the sort of thing that you would want to do very often, there have been quite a few cases where airliners have been forced to glide when engine power was totally lost. An A320 similar to this one glided about ninety miles to a safe landing when it ran out of fuel over the Atlantic Ocean. The passengers were somewhat relieved by the safe outcome.

| Subject | Glide Angle |
|---|---|
| Concorde (on approach to landing) | 1:4 |
| House Sparrow | 1:4 |
| Space Shuttle (on approach to landing) | 1:4.5 |
| Percy Pilcher's 'Bat' glider | 1:5 |
| Modern Paraglider | 1:11 |
| Fulmar (and Herring Gull) | 1:12 |
| Boeing 777 and Airbus A350 | 1:15 |
| Wandering Albatross | 1:20 |
| Modern Sport Glider | 1:45 |

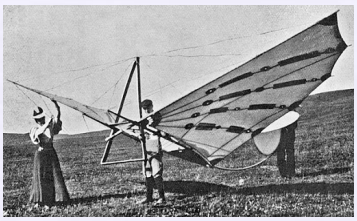
An interesting comparison can be made of the gliding performance of various aircraft and birds.
The table gives some examples of the possible glide angles in still air on a cool day and at low altitude.
Let's see what these numbers mean in practice…


This is a view of the Firth of Clyde taken from space and shows the Island of Arran lying off the west coast of Ayrshire.

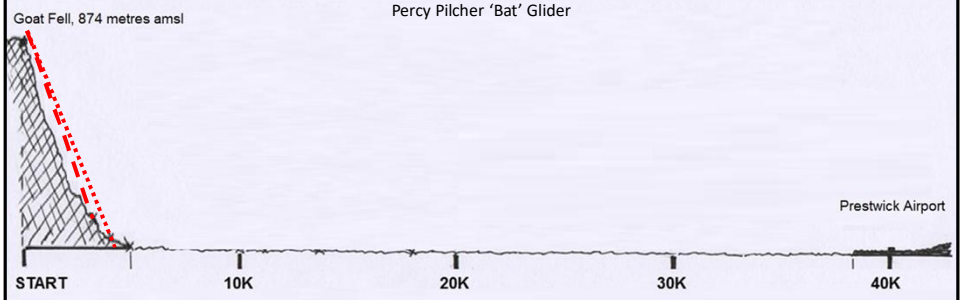

If we rotate the photo we can see that we could draw a straight line between Goat Fell, the highest mountain on Arran, and the international airport at Prestwick. The two points are 40km apart.



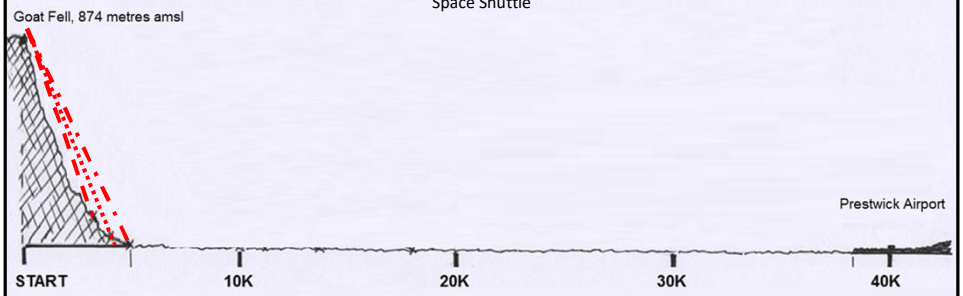

This illustration shows a section taken through the 40 km separating Goat Fell and Prestwick Airport. The gliding performance of various birds and aircraft can be shown assuming that the flight starts at 900 metres above sea level, just above the top of Goat Fell on the Isle of Arran. The first group of hopeless gliders, shown in red, would not even make it off the island. The next group of reasonable gliders, shown in blue, would start to splash down in the Firth of Clyde not even halfway to the mainland. Note that the Albatross out-performs anything else in this class. The modern high-performance glider is so much better than all the others that it would easily make it to the Ayrshire coast and a safe landing at Prestwick Airport. You might want to consider why the Concorde, Space Shuttle and the Sparrow are so bad and the Competition Glider is so good.
Interestingly, the paper gliders that we made in Science of Flight Pt 6 have gliding angles somewhere between the Space Shuttle and the Paraglider.

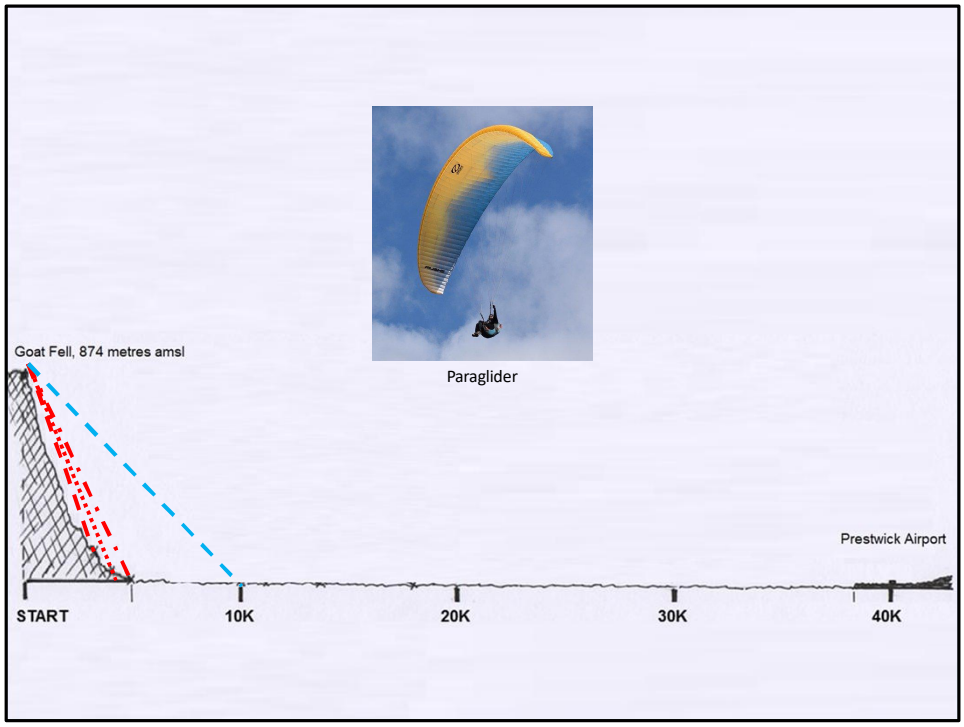


Percy Pilcher ‘Bat’ Glider



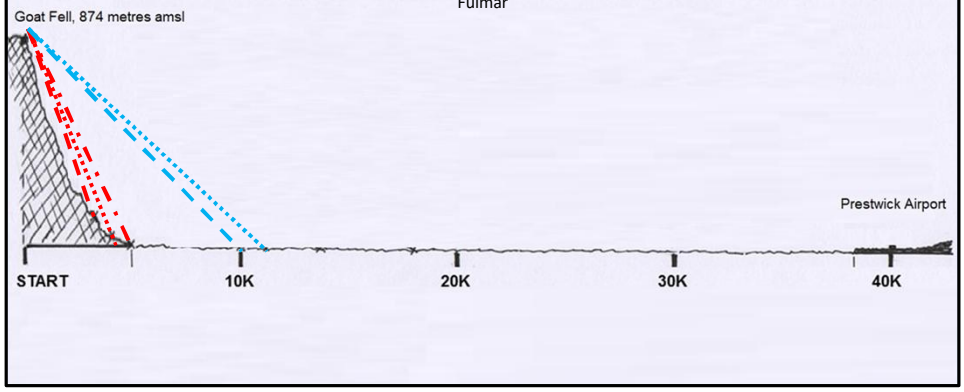
Space Shuttle



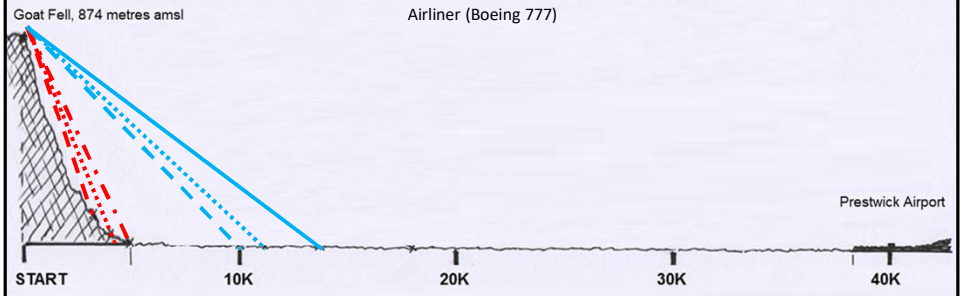

Goat Fell, 874 metres amsl
Prestwick Airport
START
10K
20K
30K
40K

Paraglider

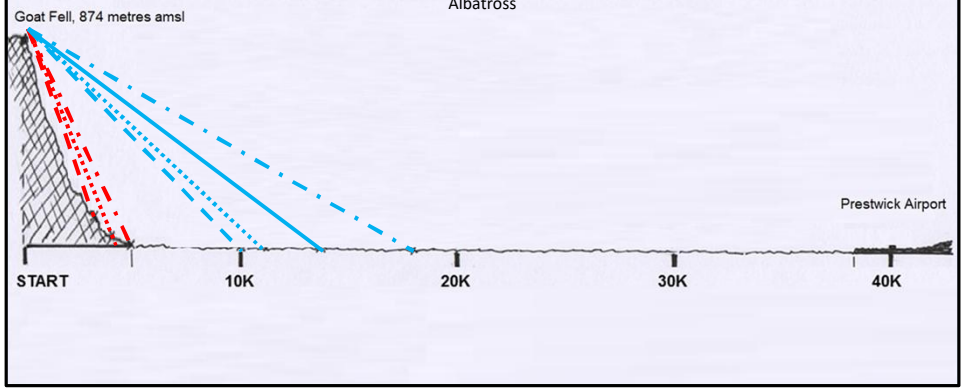
Fulmar


Goat Fell, 874 metres amsl
Prestwick Airport
START
10K
20K
30K
40K

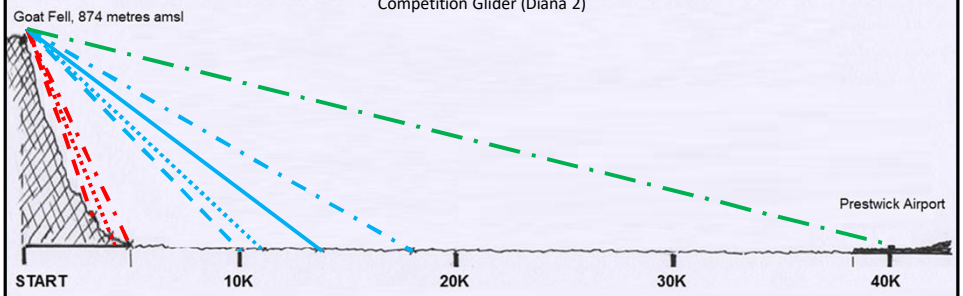

Airliner (Boeing 777)

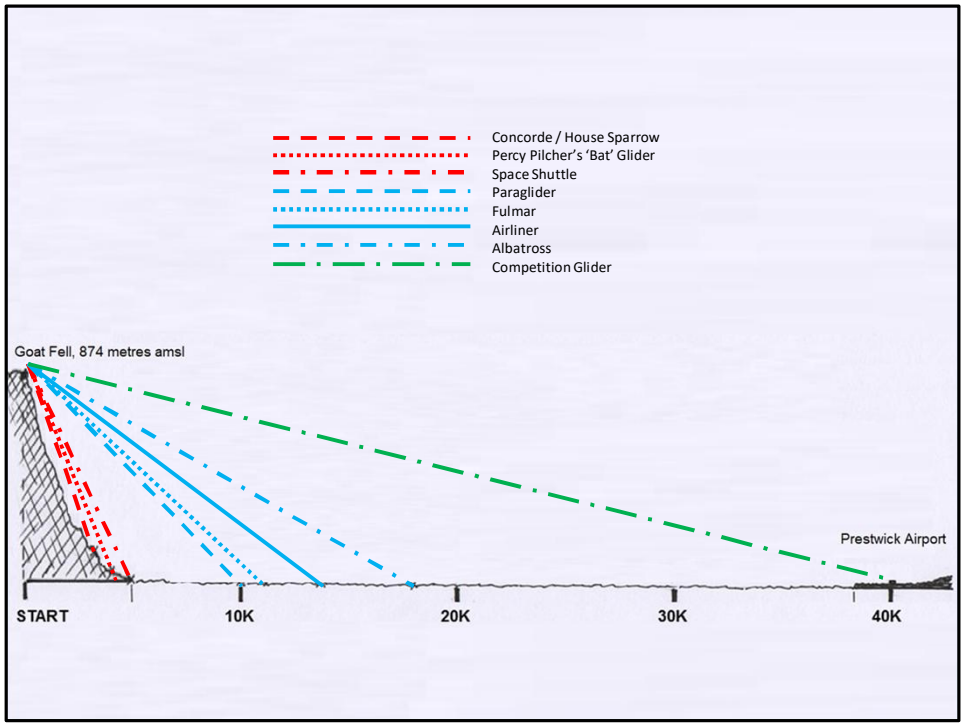


Albatross


Goat Fell, 874 metres amsl
Prestwick Airport
START
10K
20K
30K
40K

Competition Glider (Diana 2)




Concorde / House Sparrow
Percy Pilcher's 'Bat' Glider
Space Shuttle
Paraglider
Fulmar
Airliner
Albatross
Competition Glider
Goat Fell, 874 metres amsl
Prestwick Airport
START
10K
20K
30K
40K

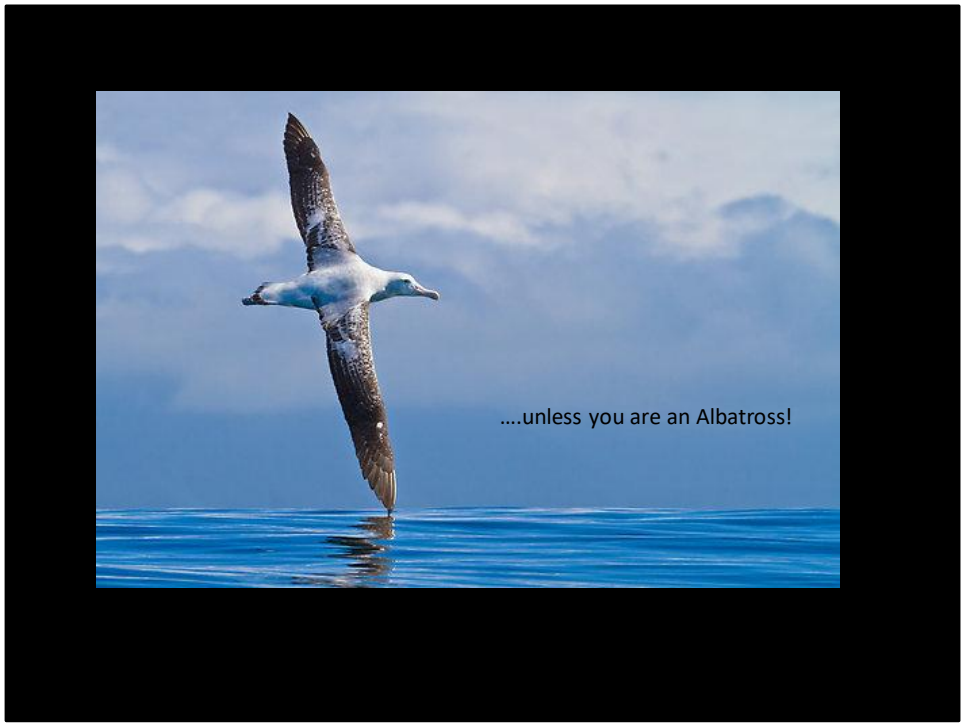
Once designers had managed to produce a glider that had a good shallow glide angle it became apparent that although the glider always had to fly downhill it was possible to fly through air that was going uphill faster than the glider was going down. The art of soaring had been discovered. Warm air rising from the ground warmed by the sun and winds deflected by rising ground are both created by solar energy.

Of course there were already many example of birds that were experts at soaring. The mighty Condor of the South American Andes and the Vultures of the African plains can remain airborne all day by gliding in the columns of warm air rising from the ground. In this country, with less warm air about, our own Golden Eagles and Buzzards can do the same. Also our Ravens, Gannets and Fulmars are masters at using rising air currents deflected up the faces of hills, cliffs and waves.

This guy with the fearsome beak and far-seeing eye is a Ruppell's vulture.  He knows a thing or two about using thermals to cruise at altitude above the African plains on the lookout for something to eat.
These birds can fly at heights up to about 11,000 metres and can be a hazard to airliners cruising at the same altitude.

Modern sports glider pilots have refined these skills and now, with good weather pre-planning, can remain in flight for hours or cover great distances.
This still does not allow flight in all weathers and to chosen destinations.  A more reliable form of transport is required.

So, gliding is great fun but it requires very special aircraft and great piloting skills to maintain or gain height.  Also it is difficult in bad weather… *(Click)*,




So we have seen how it is possible to use gravity to generate thrust to be able to fly. Also we can extend our flight time by using external energy created by the Sun. However this method of flight can not be considered as a viable means of transport since it requires either starting the flight at altitude or the use of some temporary external thrust to gain the altitude in the first place.

To be able to fly an aircraft from take-off to landing in all weathers what we need is a reliable form of thrust. This was a challenge for the early pioneers and various forms were proposed and tried ranging from flapping wings to steam engines and even explosive devices and rockets.

However the first successful powered flights were carried out by using power generated by the internal combustion engine. The next problem was how to convert, as efficiently as possible, the power of the engine into thrust.

In the next part of the story we will see how that was done.