Second Level Technologies
Benchmark TCH 2-20a

Power for Flight Pt 1

Exploring how to generate the thrust that is required to overcome aerodynamic drag.

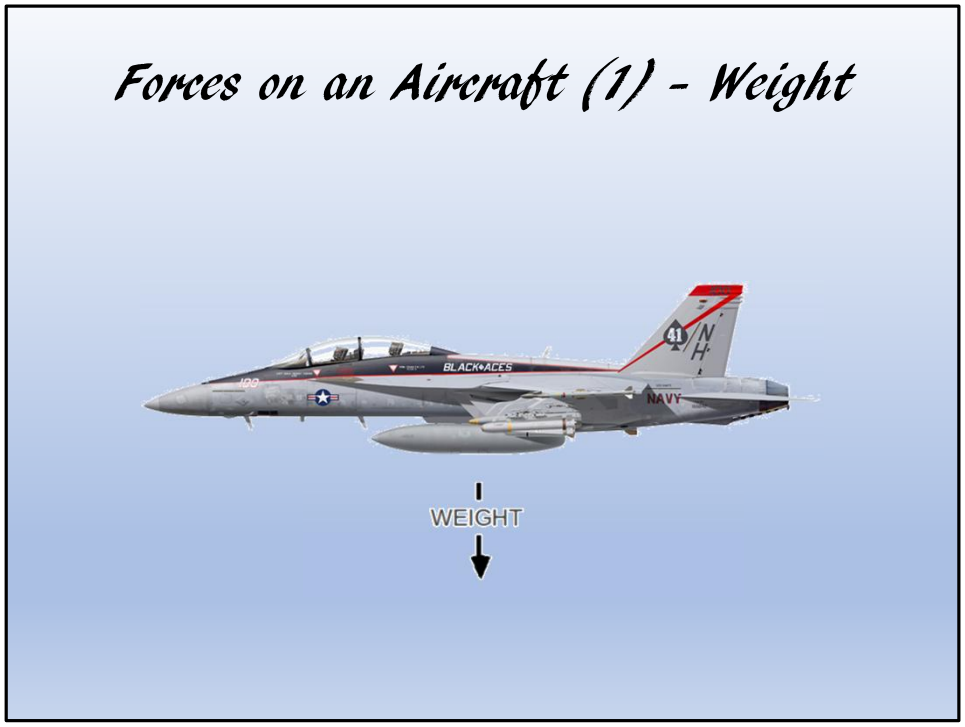
We talk about powered aircraft when we mean aircraft with engines of some kind.

In fact what we actually need is a force called thrust that is required to counteract the force called drag that is generated by the aircraft flying through the air.

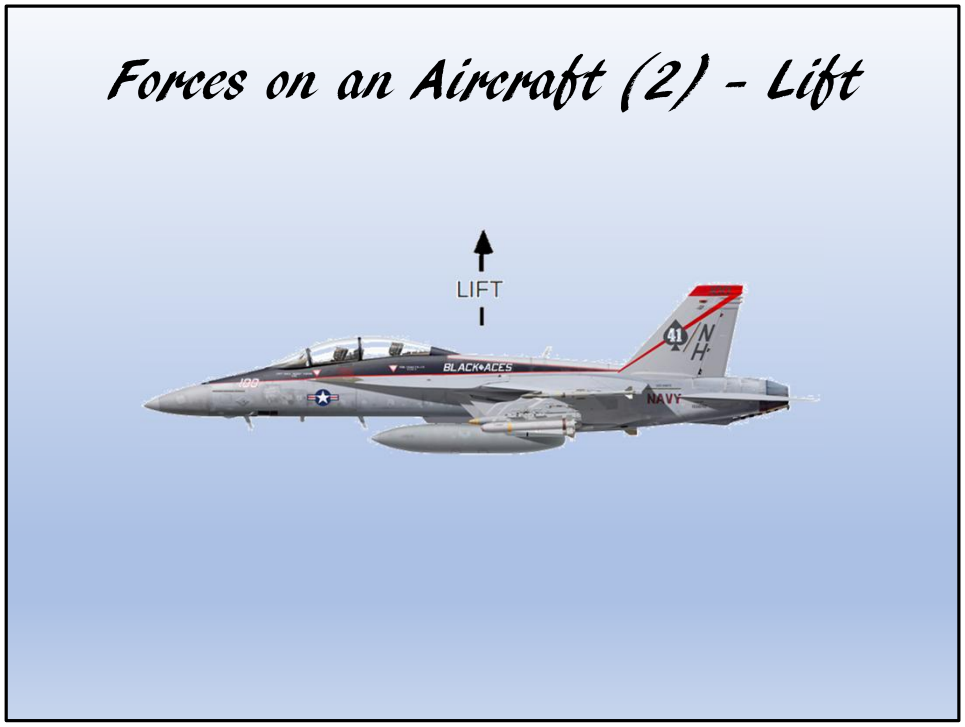
Power For Flight
or is it?

We talk of “powered” flight meaning aircraft that have engines of some kind, but, if we look at the forces acting on aircraft in flight we will see that this description is not quite so simple.

Let us now look at the forces that are acting on an aircraft in flight.



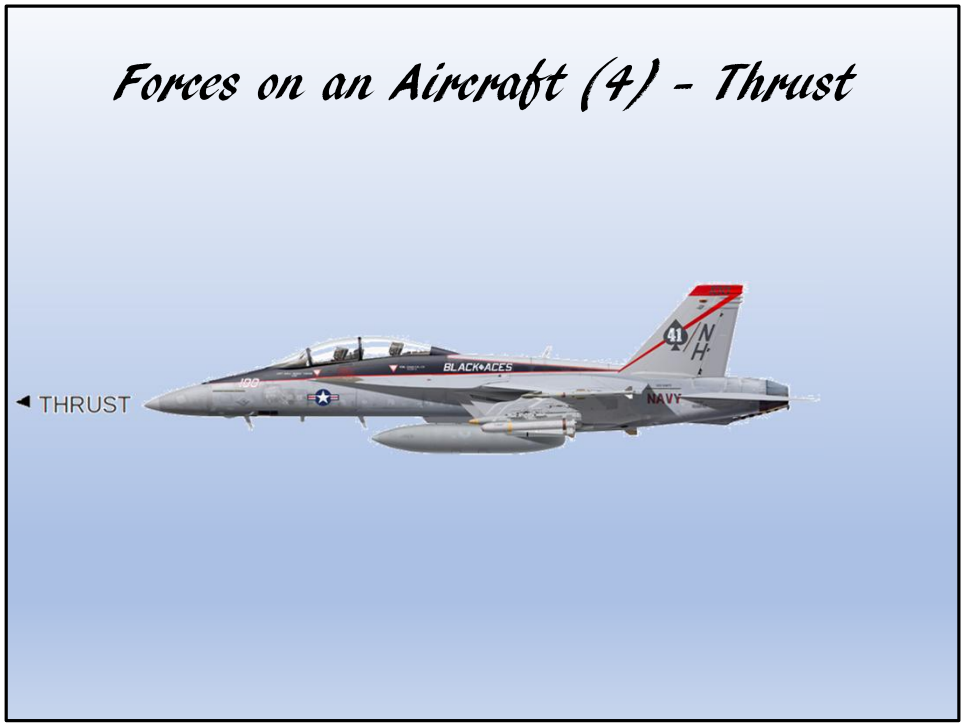
Weight is the force generated by the gravitational attraction of the Earth on the mass of the aircraft. We can not avoid this force but we can arrange to balance it by designing the aircraft to have surfaces that will develop **Lift**.



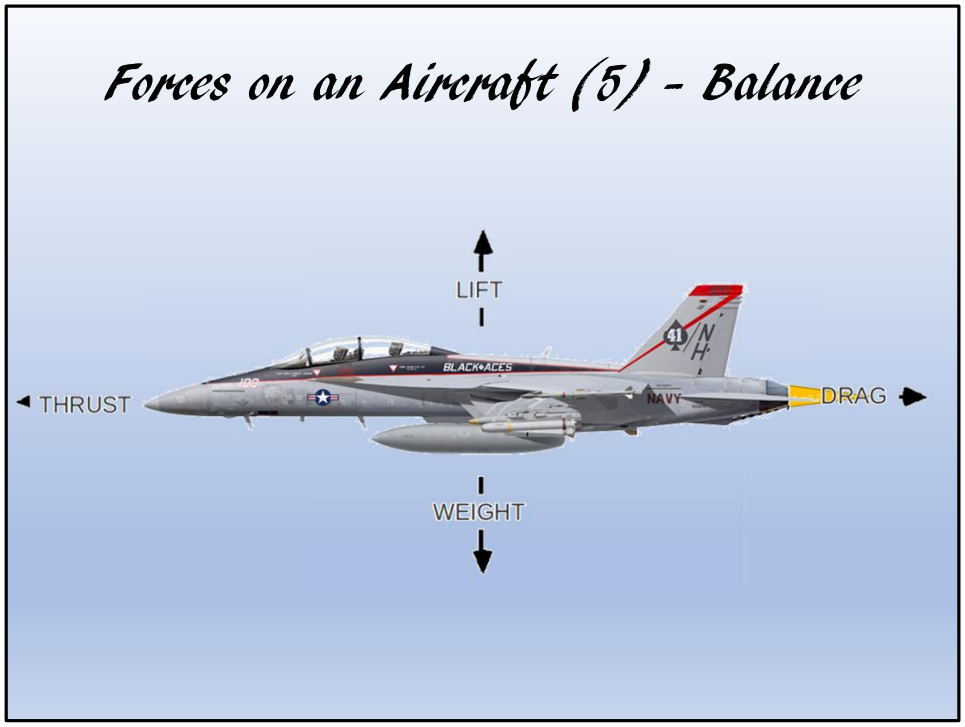
Lift is the force that directly opposes the weight of the aircraft and keeps the aircraft in the air. Most of the lift comes from the wings.

However this **Lift** does not come for free. The wing has to be moved through the air to develop the lift and this in turn means that the whole aircraft has to move and that creates **Drag**.

Drag is the force that opposes an aircraft's motion through the air. Drag is caused by the shape of the aircraft, the friction between the air and the aircraft skin and by the generation of lift.



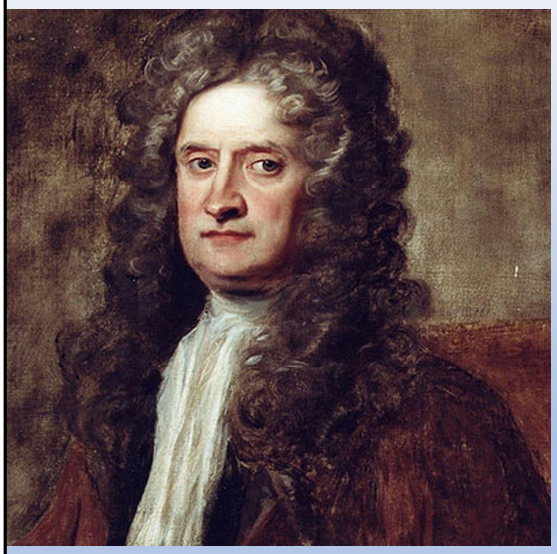
So now we have a problem. We have to find a way of balancing the Drag force otherwise the aircraft will slow down and the wing will not work causing the aircraft to fall out of the air. We need to balance the **Drag** with **Thrust**.
Thrust is the force which moves an aircraft through the air. Thrust is used to overcome the drag of the aircraft.



So now we have balanced the forces on the aircraft.
Weight is balanced by **Lift** and **Drag** is balanced by **Thrust**. *(Click)*

So now we know that the force that we need to supply to the aircraft to make it fly is Thrust.

But, it not quite as simple as that!



Sir Isaac Newton

1642 to 1726
British Physicist & Mathematician

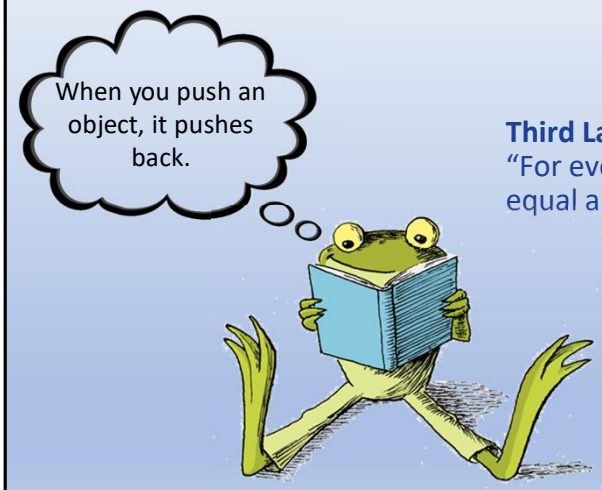
Newton's Laws of Motion

First Law :
"An object will remain at rest or in motion with the same speed and direction unless acted on by an unbalanced force."

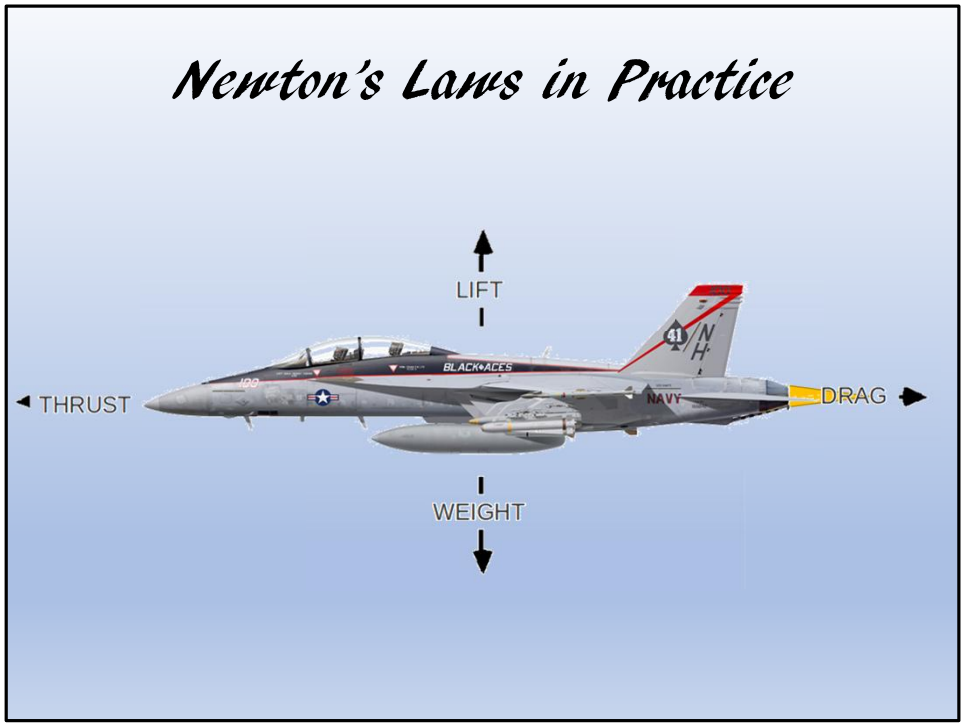
Newton's Laws of Motion

Second Law :
"Acceleration is produced when a force acts on a mass.
The greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object)."

Newton's Laws of Motion



Third Law :
"For every action there is an equal and opposite reaction."



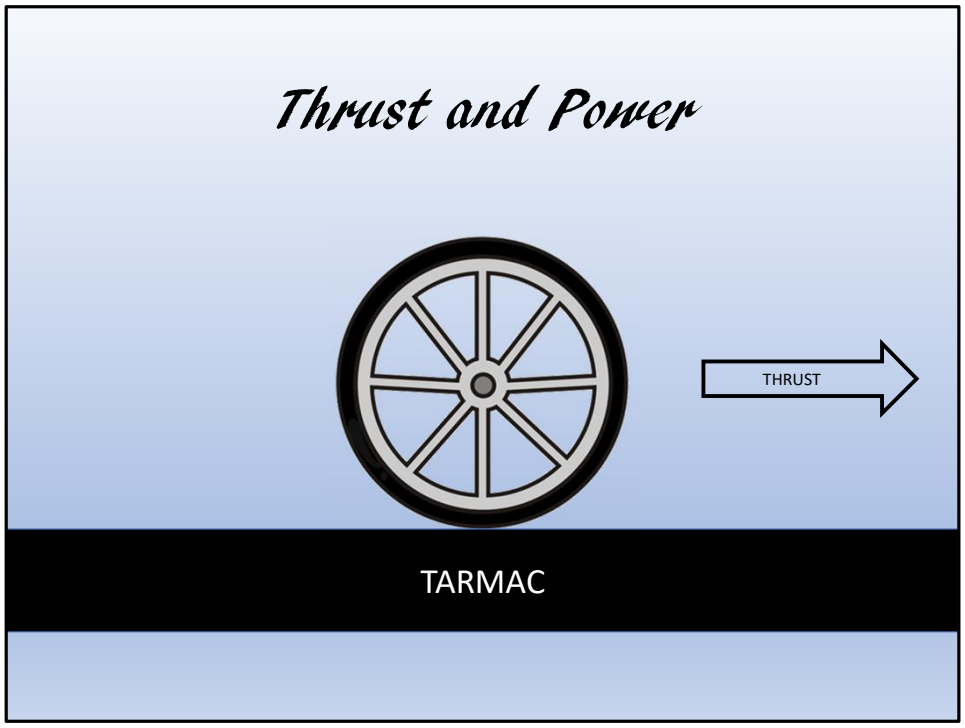
The motion of the aircraft through the air depends on the relative strength and direction of the forces. If the forces are **balanced** the aircraft flies at constant velocity (1st law) without gaining of losing height.

If however the forces are **unbalanced** the aircraft accelerates in the direction of the largest force (2nd law).
In real aircraft the forces are nearly always trying to become unbalanced.
The total **weight** can change as fuel is used and the position of the **weight** can move if passengers walk around the cabin. If the **weight** changes or moves then the **lift** has to change and the aircraft has to be re-trimmed and that will in turn change the **drag** which in turn will change the **thrust** required.

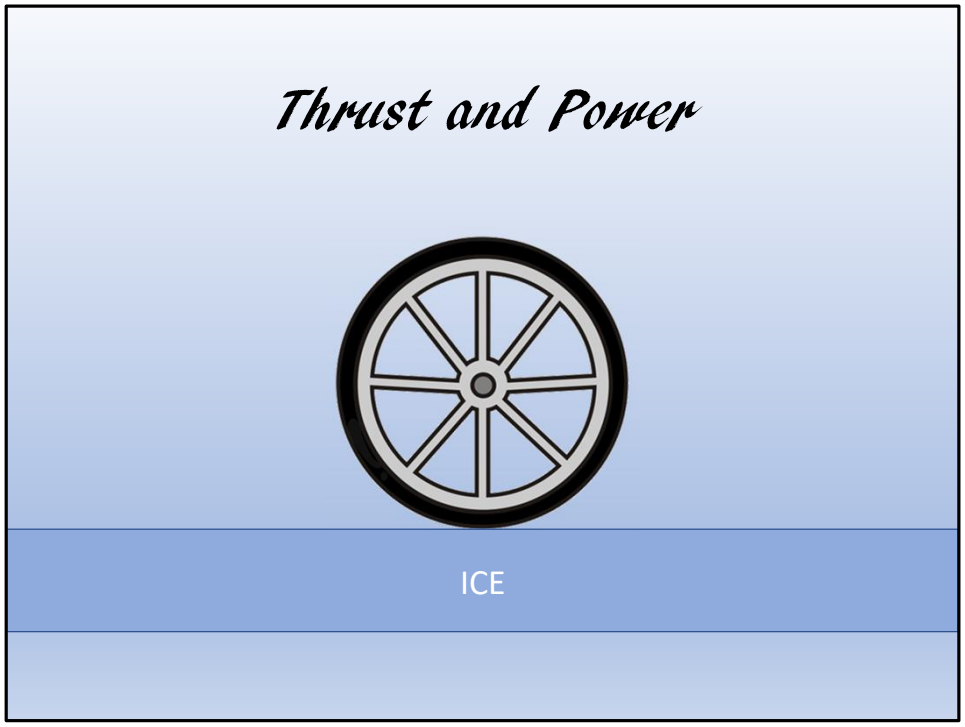
So, we need some way of developing **thrust** in a way that can be adjusted to keep the aircraft in balance.

Thrust can be produced in many ways and we will look at this later! *(Click)*

The car's engine develops power and this power is transmitted as torque to the driven wheels via a gearbox. These wheels, which could be the pair at the front or back of the car or even all four wheels, are mounted on axles which try to rotate the wheels. The wheels are fitted with rubber tyres which have a good co-efficient of friction on the tarmac road surface.



In this first case, when the axle tries to rotate the wheel, the friction between the tyre and the road surface prevents the rotation and the wheel is forced to roll along the road carrying the axle with it. The axle, being connected to the car, pushes the whole car along the road.



In this second case, when the axle tries to rotate the wheel, there is almost no friction between the tyre and the ice. The wheel now rotates freely and almost no thrust is produced to move the car forward. It does not matter how much power the engine develops hardly any thrust will be produced.

So, although Jeremy Clarkson on Top Gear was always shouting for more Power we now know that what he really wanted was Thrust.

There is no point in having an engine that can develop a lot of power if it can not be converted into a force that will move the car.
In a car this can be done by using the friction of a rubber tyre on a good road surface. The wheel, turned by the engine, reacts to the friction force causing the whole wheel to roll forward, or backwards if the car is in reverse gear.
If the friction force between the tyre and the road is reduced by say water or ice then it does not matter how much power the engine can develop, the thrust will be reduced and the car's acceleration or top speed will be reduced.

The problem of how to convert power into useful thrust was a difficult one that aircraft designers had to resolve. We will look at how they did that later.

So now we know that it is not simply power that we need to sustain flight.

What we need is thrust.

We talk of “powered” flight meaning aircraft that have engines of some kind, but, if we look at the forces acting on aircraft in flight we will see that this description is not quite so simple.