Newtons laws explain the physics of all flight manoeuvers.

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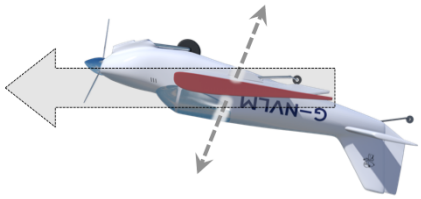
Youtube video: https://youtu.be/RG2SPEIiOqM

Abstract

This paper tests the hypothesis that Newtons laws of motion can explain the physics for how airplanes fly by analysing flight manoeuvers and other practical aspects of flight. Flight manoeuvers include: take-off, climb, slow flight, landings, stalls, flaps, inverted flight. Other practical aspects of flight include: ground effect, vortices, wind, air up-currents, engine positions on the wings, flying at high altitudes, and ditching.



So what? This analysis is significant as it provides another way to verify the Newtonian explanation for lift. This insight then helps to resolve the debate on the physics of flight. Most theories of flight (Bernoulli, Navier-Stokes, …..) only focus on analysing lift for an airplane in stable cruise flight and do not explain how lift is achieved during flight manoeuvers.

I. Introduction

The theory of flight remains unresolved. [2] Academics, engineers, pilots aviation authorities, and other pundits (e.g. NASA) promote at least twelve radically different theories of flight. Experts still cannot agree whether airplanes are pulled (sucked) upwards or pushed up; nor exactly what role vortices play. Pilots are taught a theory of flight by aviation authorities that academics disproved as far back as 1972. NASA sits firmly on the fence in this debate, showing no preference for whether airplanes are pushed or pulled upwards. [1][2]

A previous paper demonstrated that Newtons laws explain the physics of the standard textbook equation for lift. [7]

Lift = 0.5 x Aircraft Velocity^2 x Air Density x Wing Area x Lift Coefficient.

This paper analyzes the practical aspects of flight observed in reality, to assess whether they are consistent with the Newtonian explanation of lift. According to the Newtons laws, wings fly through a static mass of air through each second ('m/dt') which they accelerate downwards ('dv'), to create a downward force (Force = ma). The 'equal & opposite' upward force generates lift. See Fig 1a.

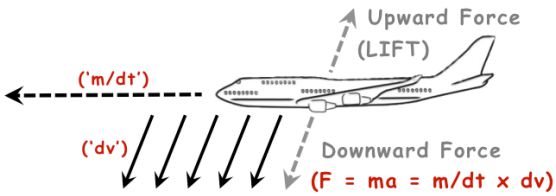


Fig 1a. Newtonian forces on an airplane.

This is explained in more detail in the next section.

The analysis in this paper is based on past papers that proposed a new explanation of lift based on Newtons laws of motion, whereby aircraft achieve buoyancy in flight:

- Buoyancy Explains How Planes Fly. [3]
- Calculation of the Air Displaced by a Wing. [4]
- Buoyancy Explains Flight. [5]

Previous relevant pre-print papers include:

- The theory of flight remains unresolved. [2]
- Archimedes principle explains helicopter flight. [6]
- Newtons laws explain the equation for lift. [7]

II. Technical Background

To be as clear as possible on the technical issues involved, this section is relatively extensive as it is not what is taught in most aeronautical engineering textbooks.

A. Newtons laws (Force = ma = m/dt x dv).

A wing with a positive angle of attack (AOA) to the direction of travel (or lift) is used to push air down. In stable cruise flight, a mass of air flown through each second ('m'/dt) is accelerated ('dv') downwards by the wings. This action generates a downward force due to Newtons 2nd law of motion (Force = ma = m/dt x dv). The 'equal & opposite' upward force created due to according to Newtons 3rd law of motion, provides lift. Lift is the vertical component of the upward force. It's simple; air goes down and the airplane goes up. See Fig 2a.

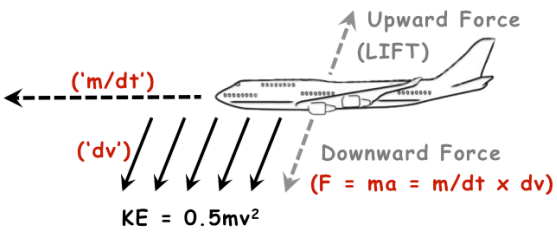


Fig 2a. Newtonian forces on an airplane.

This is summarized by the equations:

Downward Force = mass x acceleration [1]
= ma = m/dt x dv [1]

Downward Force = Upward force (Lift) [1]

Where:
- m = mass of air directly flown through and accelerated downwards by the wings.
- a = acceleration
- a = dv/dt
- dt = change in time (per second).
- dv = change in velocity of the air.
- v = velocity of the air.

In this Newtonian explanation of flight, there is no net gain or loss of momentum, kinetic energy or mass. The aircraft simply transfers momentum & kinetic energy to the air; by the wings accelerating a mass of air downwards.

Critically, the equations used in this paper for the downward force (F = ma = m/dt x dv) and kinetic energy (K.E. = 0.5 mv^2) are consistent with each other. Both equations use the same parameters: a small mass of air accelerated downwards.

B. Downwash.

The air displaced down by the wings is evident from the downwash behind low-flying airplanes and airplanes flying just above the clouds. See Fig 2b and 2c.

Fig 2b. Photo sequence of low-flying jet.

Fig 2c. Airplane downwash in clouds.

C. Dynamic buoyancy.

A key consideration is that in stable cruise flight, all forces, weights and masses are equal. This is summarized by the equations:

$$\text{Force}_{\text{AIRPLANE Up}} = \text{Force}_{\text{AIR PUSHED DOWN}}$$
$$\Rightarrow \text{Weight}_{\text{AIRPLANE PUSHED UP}} = \text{Weight}_{\text{AIR DISPLACED DOWN}}$$
$$\Rightarrow \text{Mass}_{\text{AIRPLANE}} \times \text{Gravity} = \text{Mass}_{\text{AIR DOWN}} \times \text{Gravity}$$
$$\Rightarrow \text{Mass}_{\text{AIRPLANE UP}} = \text{Mass}_{\text{AIR DOWN}}$$

In summary, the downward force displaces a total mass of air down that is equal to the airplane's mass. The mass of the air displaced down (with gravity), will displace and equal mass of air up elsewhere (against gravity). So, the airplane circulates the air to achieve dynamic buoyancy. [3][4][5][6] See Fig 2d.

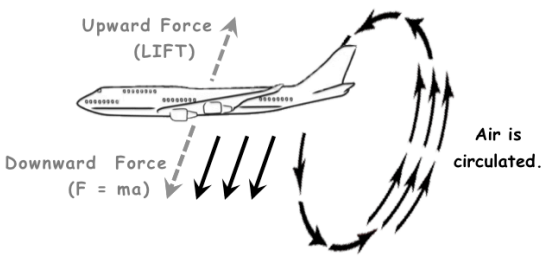


Fig 2d. Air circulated by an airplane.

D. Two wing airflows.

There are typically two airflows involved in flight:

(i) The underside of a wing will physically push air down.

(ii) The topside of the wing pulls air down in two ways. As the wing moves, a vacuum or low air pressure usually arises on the topside of the wing, behind the direction of flight. This low air pressure pulls the air above it down. Any curvature on the top-side of the wing can enhanced downward airflows due to the Coanda effect. See Fig 2e.

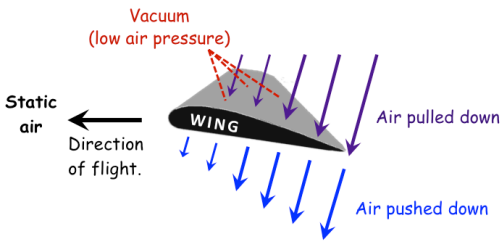


Fig 2e. Wing airflow diagram.

Normally academics and engineers portray wing airflows differently, where the wing is static and the air is moving. See Fig 2f.

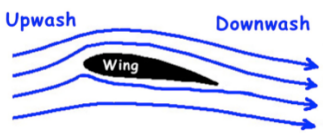


Fig 2f. Standard 2D wing airflow diagram.

This diagram can be useful for analyzing airflows, but it is unrealistic for explaining lift. [2] For example, in reality the moving wing accelerates stationary air down and slightly forwards. In contrast, in the airflow diagram above (Fig 2f) the air looks like it is going backwards (which is false).

E. The Coanda effect.

The Coanda effect has a significant impact on the physics of lift for birds. Fluid flow (airflow) naturally follows a curved surface due to the Coanda effect. Air flowing around the curved topside of a bird is similar to how falling water is re-directed by a spoon. See Fig 2g.

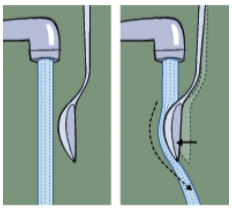


Fig 2g. Falling water being re-directed by a spoon.

As there is a lack of appropriate data and wind tunnel experiments available for birds (with smoke to show airflows), airplane wings are used as a proxy to demonstrate the Coanda effect. See Fig 2h.

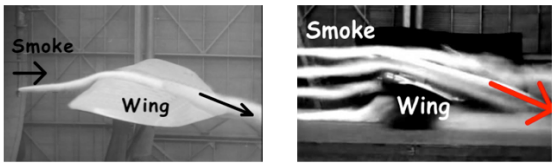


Fig. 2h. The Coanda effect on airplane wings in wind tunnels.

The Coanda effect on airplane wings shows that the amount of air re-directed depends on the maintenance of laminar (smooth) airflow. In turn this depends mostly on the AOA and shape of the wing (or bird). Any turbulence significantly reduces the amount of air displaced. See Fig 2i.

Fig. 2i. Airplane wings in a wind tunnel;
laminar and turbulent airflows.

In general, airplane wings will produce a stronger Coanda effect at lower AOA, at higher aircraft speeds and where the wings are deepest (widest). Conversely the Coanda effect is weakest at high AOA, slow aircraft speeds and where the wings are thinnest (eg. at the wing-tips).

F. Kinetic energy.

The energy required to displace this air down (and thus generate lift) can then be calculated using the standard equation for kinetic energy:

Kinetic Energy (KE) = $0.5\ m\ v^2$ [1]

Where:
- m = mass of air directly flown through and accelerated downwards by the wings.
- v = velocity of the air.

A critical point is that the kinetic energy required for lift is proportional to velocity^2 of the air displaced downwards. For the wings to push the air flown through down twice as fast (2x 'dv'), this requires four times the kinetic energy. This dynamic is shown by the graph in Fig 2j.

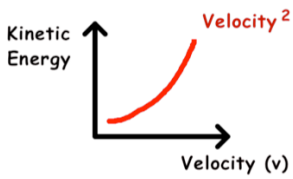


Fig 2j. Graph of kinetic energy and velocity.

The kinetic energy transferred to the air will depend on a number of factors such as: the wing AOA, wingspan, wing depth (chord) and the momentum of the aircraft. (This is not an exhaustive list.)

G. Wingspans, wing depth (chord) and aspect ratios.

Wingspan is the horizontal length of the wings; measured from wingtip to wingtip. Whereas wing depth (chord) is the horizontal distance across the wing, from the trailing edge to the leading edge. See Fig 2k.

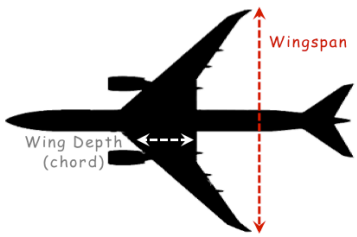


Fig 2k. Wingspan and wing depth (chord).

Wing depth (chord) can vary a lot across the wings, making it hard to measure with one number. Often a series of measurements are made at different point across the wing. Wing depth (chord) declines towards the wingtip.

As a result, wings are often compared based on the aspect ratio, which is the wingspan divided by the mean wing depth (chord) or the square of the wingspan divided by the wing area.

Aspect ratio = wingspan / mean wing depth (chord)
= wingspan^2 / wing area

III. METHODOLOGY

A. Overview of the analysis.

So, according to this Newtonian explanation of lift, the wings provide two functions:

(i) To catch air. The aircraft speed, wingspan and AOA are the key factors that determine of how much air is flown through each second ('m/dt') and caught by the wings. Note that the propeller or the engines can push additional air over the wings, depending on where they are positioned relative to the wings.

(ii) To accelerate this air down. The aircraft momentum, wing depth (chord) and AOA are the key factors that determine how fast this air caught is accelerated downwards ('dv').

The downward force created by the wing catching air and accelerating it downwards; which is a combination of these two factors. This is summarized by Newtons 2nd law of motion:

Downward Force = ma = m/dt x dv.
= 'Equal & opposite' upward force (lift)

Lift is the vertical component of the resulting 'equal & opposite' upward force.

B. Analysis – flight manoeuvers.

The analysis of flight manoeuvers is based on an airplane is shown in stable cruise flight, with a positive wing AOA, at constant airspeed and altitude. Typically, the wings are designed to have a slightly positive AOA when the airplane is flying level. See Fig 3a.

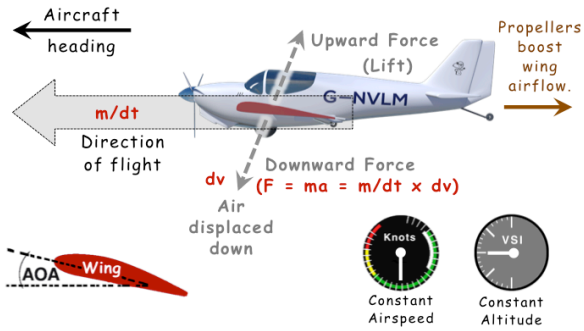


Fig 3a. Cruise flight.

IV. Flight Manoeuvers

A. Take-off / 'nose-up' climb.

In a typical take-off or 'nose-up' climb using high (maximum) engine power. Engine thrust is used to gain altitude at the cost of low airspeed.

- Overall 'm/dt' is relatively large and provides most of the lift. Low airspeed means that the wings fly through little air each second. But this is more than offset by a wide wing AOA which increase the vertical distance in which the wings catch air.
- 'dv' is relatively small. The low airspeed means that the airplane has little momentum to transfer to the air. Also, a wide AOA means that the wings are pushing the air down at a wider angle to the ground (the vertical direction); So this generates less lift and creates greater induced drag.
- The engines (propellers) are angled upwards so increase the downward force and the air displaced downwards.

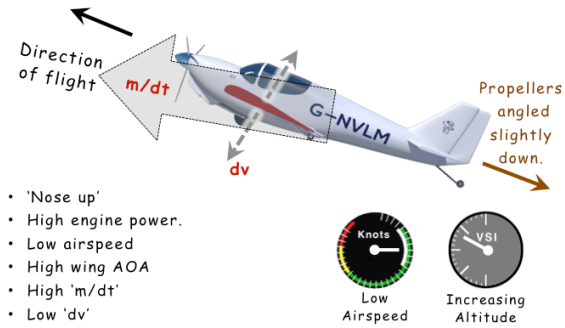


Fig 4a. Take-off.

B. Slow flight & landings.

Slow flight is somewhat similar to a climb, except low engine power is used, so the airplane is not gaining altitude. The intention of this flight manoeuver is usually to fly more slowly than a cruise, by using a wide wing AOA. In turn, landings are similar to slow flight, except that engine power is reduced to allow for the loss of altitude (at the same constant low airspeed).

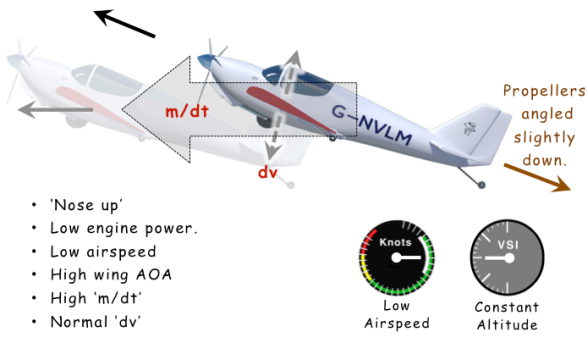


Fig 4b. Slow flight.

C. Stalls.

In a typical stall the airplane has a 'nose-up' attitude, low engine power, low airspeed, and a wide wing AOA; conditions which are similar to 'slow flight.' Ice in the leading edge of the wing can also trigger a stall. At the start of a stall, the wings cease to generate enough lift to fly and the airplane falls like a stone. A stall is abrupt and dramatic. For example an airplane can fly at 60 km/hr but stall at 59 km/hr. See Fig 4c-i.

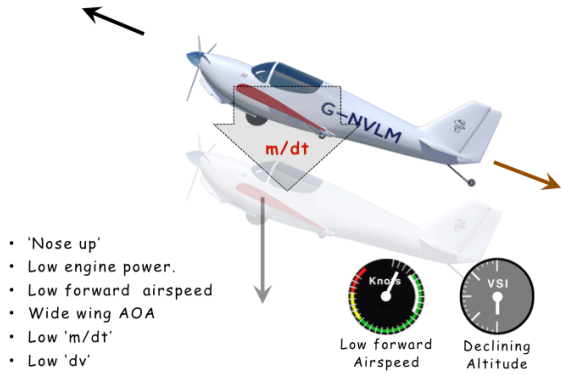


Fig 4c-i Stall.

In terms of airflows: At the start of the stall, usually turbulence arises at the trailing edge of the topside of the wing, disrupting laminar airflow. This reduces the amount of air displaced down by the wing. The airplane loses lift and stalls.

More precisely, the upper airflow is not being accelerated down fast enough to reach the trailing edge of the wing. So airflow separation occurs between the upper and lower air flows (above and below the trailing edge of the wing). As lift is lost, the turbulence spreads across the other airflows on the wings. Even less air is displaced down and more lift is lost. See Fig 4c-ii.

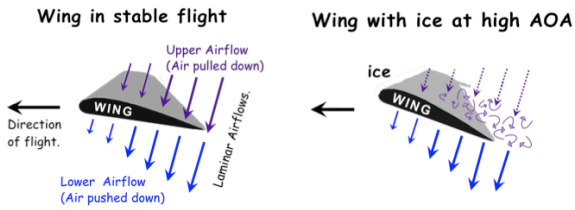


Fig 4c-ii Airflows in a stall.

As the airplane falls, the wings still displace a small amount of air, but not enough to fly. Often a stall does not last very long in modern (well-designed) airplanes, because as the airplane falls airspeed increases, boosting lift, and therefore allowing the airplane to fly again.

The conditions of an airplane stall are very similar to a boat sinking and a balloon floating. In turn, this supports the argument that boat an airplane, boat and balloon are all subject to the same physics. They all float in a fluid.

D.Flaps.

Flaps are typically extended when in slow flight on a final approach to landing. Flaps change the overall shape of the wing to increase the AOA. The impact is to boost lift by displacing more air downwards ('m/dt') at a higher velocity ('dv'); at the cost of higher drag. Engine power is typically increased to maintain airspeed, and thus offset the extra drag. Flaps can be installed at both the leading and trailing edges of the wings.

More precisely, flaps increase the vertical height of the wing, increasing the amount of air caught by the wing each second. More importantly, the wing curvature is increased, which increases the Coanda effect on the topside of the wing and the amount of air displaced downwards. A higher wing AOA also means that the air flown through ('m/dt') is redirected more vertically downwards. This increases the vertical velocity of the downwash ('dv') to boost lift. See Fig. 4d-i and 4d-ii.

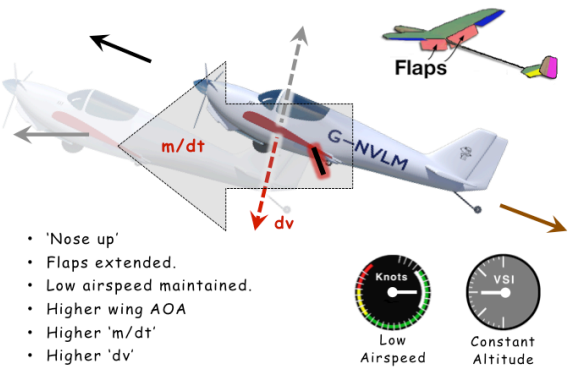


Fig 4d–i Flaps in horizontal flight.

Fig 4d–i Flaps on landing.

The use of slow flight with flaps allows the airplane to land at the slowest possible airspeed. This configuration means that when the wheels touch the tarmac (increasing drag and reducing the airspeed); and the nose of the airplane lowers, (reducing the wing AOA). These events reduce the lift generated and prevent the aircraft bouncing down the runway. In turn, this process reduces the runaway required to land and limits the stress put on the aircraft.

E. Vertical climb.

In a vertical climb high (maximum) engine power is typically used to gain altitude. Vertical airspeed tends to be low or declining (as airspeed is traded for altitude). There is no horizontal airspeed. The wings are not being used to generate lift. See Fig 4e.

- Overall 'm/dt' and 'dv' are non-existent due to the zero wing AOA and the wings are not displacing any air.

The equation used to calculate the downward force remains the same as before (Downward Force = ma = m/dt x dv); except this is based on the air accelerated down by the engines (propellers). This is the same equation used to calculate the lift generated by a rocket.

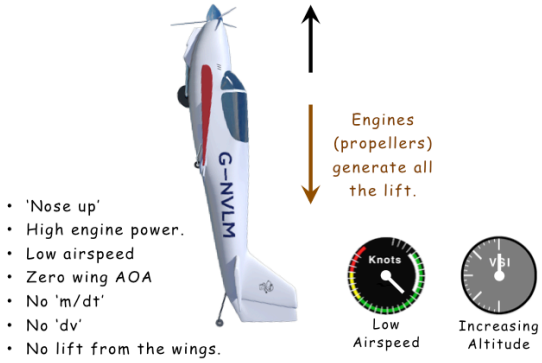


Fig 4e. Vertical climb.

F. Vertical descent.

In a vertical descent altitude is traded for an extremely high airspeed. The engine power is typically set low to avoid excessive airspeed. There is no horizontal airspeed. The wings are not being used to generate lift. See Fig 4f.

- Overall 'm/dt' and 'dv' are non-existent due to the zero wing AOA and the wings are not displacing any air.

Fig 4f. Vertical descent.

G. Steep descent.

In a steep descent altitude is traded for an high airspeed. The engine power is typically set low to avoid excessive airspeed. There is no reduced airspeed. The wings are generating a lot of lift due to the high airspeed. Typically this high lift has to be offset by the pilot applying pressure on the control stick to maintain the descent. Without this pressure, a modern (well balanced) airplane would automatically return to normal cruise flight. See Fig 4g.

Note that if the descent becomes steep enough, the wing AOA will mean that the upward force will be in the direction of flight, (so no induced drag arises).

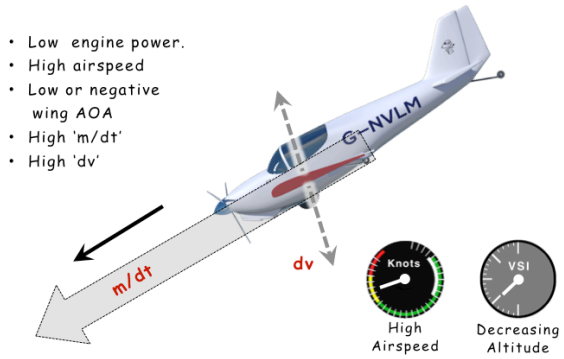


Fig 4g Steep descent.

H. Banking.

In a bank, the direction and orientation of the airplane is changed using the ailerons to redirection airflow. See Fig 4h-i.

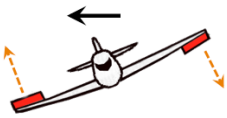


Fig 4h-i. Ailerons used to roll the airplane to the left.

This manoeuver is typically performed in a manner that maintains a constant altitude and airspeed. As the wings' angle to the horizontal increases, air is no longer being displaced directly down, so a small amount of lift is lost. To offset this loss of lift, additional power and a slightly raised nose are applied. See Fig 4h-ii.

Fig 4h-ii. Banking.

I. Inverted flight.

In an inverted flight at constant altitude and airspeed compared to normal cruise flight, the airplane's heading needs to be slightly up for the wings to have a positive AOA. This means that the airplane's orientation is less aerodynamic to the direction of flight and drag increases. Any wing curvature is now facing downwards, so the benefits of the Coanda effect are reversed, reducing the net amount of air displaced downwards. However, these two negative factors are partly offset by the engines (propellers) being angled upwards, which increase the downward force and the air displaced downwards.

Additional engine power and increased wing AOA are usually needed to offset the overall negative aerodynamic effects of flying inverted. This maintains both 'm/dt' and 'dv' compared to normal cruise flight. See Fig 4i.

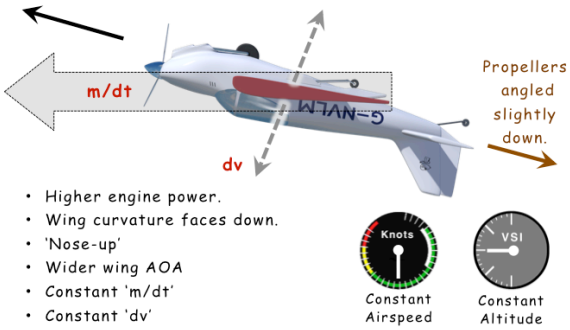


Fig 4i. Inverted flight.

J. Wings v. Engines.

Newtons laws can be used to explain the upward force (lift) generated by both a rocket and an airplane. Specifically, the same equation can be used to calculate the downward force:

Downward Force = ma = m/dt x dv

The 'equal & opposite' upward force generates the lift.

This analysis makes a few simple assumptions:

- The mass of the airplane & rocket are constant.
- The speed and force generated are constant.
- Gases are displaced down at a constant velocity.

For the rocket the equation is defined slightly differently:

- 'm/dt' is the mass of exhaust gas displaced down each second,. This is the mass flow rate.
- 'dv' is the velocity of the exhaust gasses.

Both the rocket and wings generate a force by pushing gases downwards. The rocket's engines push exhaust gasses down, which is mostly H_20 and CO_2. Whereas the airplane's wings push air down, which is mostly gaseous nitrogen and oxygen.

In a vertical climb, only the engines of the airplane are generating an upward force (lift). As the angle of climb of the airplane declines to the horizontal, the lift becomes increasingly generated by the wings and less by the engines. See Fig 4j.

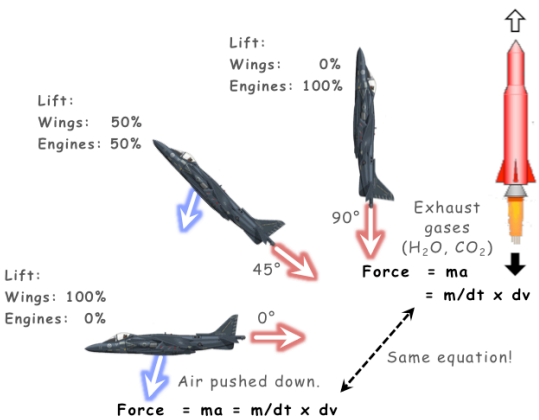


Fig 4j. Lift generation shift from the engines to the wings;
But the equation for lift remains the same.

In summary, the same Newtonian equation is used to explain lift generated by an airplane in horizontal flight, and lift from the engines in a vertical climb. It's the same thing. Both are generating a force by pushing a gas (fluid) downwards. This is both logical and consistent to apply of the same Newtonian equation to explain the same physics of flight. Yet, this is not the accept view held by most academics and engineers.

K. Conclusion – flight manoeuvers.

In summary, all flight manoeuvers are shown to be consistent with the Newtonian explanation of flight.

These flight manoeuvers include: take-off, climb, slow flight, landings, stalls, flaps, banking, vertical climb, vertical descent, steep descent, inverted flight, lift from wings v. engines, and the upper airflow (Coanda effect).

V. Other practical aspects of flight

The other practical aspects of flight includes: ground effect, vortices, wind, air up-currents, engine positions, high altitudes and ditching.

A. Ground effect.

According to a reputable aviation dictionary: "Ground effect - ….. increases the amount of lift produced. It extends upward for approximately one-half the (airplane) wing span or one-half the (helicopter) rotor diameter." [13] See Fig. 5a-i.

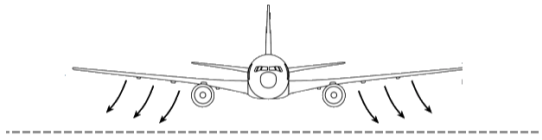


Fig 5a-i Ground effect diagram.

The explanation of ground effect is that the air pushed down by the wing has something harder (the runway) to push against. This creates a greater resistance and a bigger 'equal and opposite' upward force (lift). Ground effect is most easily seen in airplanes flying low just above the water. See Fig. 5a-i.

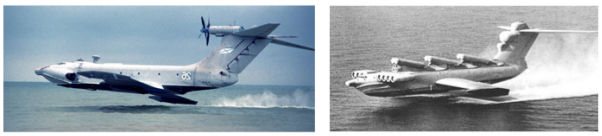


Fig 5a-ii Ground effect seen behind low-flying airplanes.

A curious aspect is that ground effect is seen in the downwash behind airplanes. But ground effect directly boosts lift. The implication is that this is consistent with the Newtonian theory of flight; here the wings exert a downward force that pushes the air down and the airplane up.

As ground-effect boosts lift near the ground it reduces the runway needed on take-off, but increases the runway needed on landing. Overall, as landings usually require much for runway distance than take-off, ground effect is considered a hindrance to aircraft performance.

This explains why STOL (Short Take-Off and Landing) aircraft typically have high wings, place above the fuselage. High wing airplanes usually are less affected by ground effect, compared to low wing aircraft. This means that STOL airplanes require less runway on landing. See Fig 5a-iii.

Fig 5a-iii Airplanes with high and low wings.

In summary, ground effect is consistent with the Newtonian explanation of flight.

B. Ground effect – commercial airliners.

Commercial airliners will take-off with a much greater mass of fuel than when they land. For example, the 787 has a maximum landing weight of 172,000 kg, which is 56,000 kg less than its maximum take-off weight (MTOW). [12] A 787 would not be able to take-off a maximum weight and then land immediately afterwards.

At maximum fuel capacity, fuel represents about 44% of the 787's maximum take-off weight (MTOW). See Calculation 1 below.

Therefore, it is understandable that commercial airliners like the 787 are designed with low wings, to benefit from ground effect on take-off, to minimize the runway needed. See Fig 5b. This is probably a priority over the disadvantages of ground effect on landing; which will be relatively less noticeable as the airliners will have lower mass on landing due to fuel burn during flight.

Fig 5b Commercial airliners with low wings.

Calculation 1:
A 787 airliner has a fuel capacity of about 126,000 liters (or 126 m^3 at 1,000 liters = 1 m^3). At a density of 800 kg/m^3, this is 100,800 kg (100,800 kg = 126 m^3 x 800 kg/m^3). This is about 44% of the 787's maximum take-off weight (MTOW); (44% = 100,800 kg / 228,000 kg). [11][12]

Just for comparison; when loaded with maximum passengers and crew, these represent about 11% of a 787's MTOW: which is a lot less than the 44% represented by the fuel. See Calculation 2 below.

Calculation 2:
The 787 has a seating capacity for 250 people (242 passengers plus 8 crew). Assuming an average mass of 100 kg (80 kg per person plus 20 kg luggage). Then this is a total mass of 25,000 kg for the people and their luggage (25,000 kg = 100 kg x 250 people). This is about 11% of the 787's maximum take-off weight (MTOW); (11% = 25,000 kg / 228,000 kg). [11][12]

In summary, ground effect in commercial airliners is consistent with the Newtonian explanation of flight.

C. Vortices.

Vortices are complicated. There are numerous different types of vortices that can either boost or reduce lift depending on the circumstances.

By way of illustration of this, wing-tip turbulence or vortices are considered positive for lift in birds and delta wing airplanes; but a drag for commercial airliners (which is why commercial airliners have winglets). For example, the Concord (a delta wing aircraft) was able to land at a low speed with a high wing AOA, due to leading-edge vortices. See Fig 5c-i.

Fig 5c-i Leading edge vortices on a delta wing airplanes.

In addition, "leading edge vortices (LEVs)" can boost lift for insects. For example, some research into vortices and insect flight stated: "A prominent leading edge vortex remains stably attached on the insect wing …. Its presence greatly enhances the forces generated by the wing, ... " See Fig 5c-i.

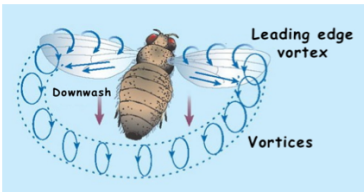


Fig 5c-i Leading edge vortices from a bee's wings.

This paper considers that the correct wing design allows vortices to boost lift by increasing the vertical velocity downwards ('dv') of the air flown through by the wings each second ('m/dt'). This increases the downwash and the amount of air circulated by the wings. See Fig 5c-ii.

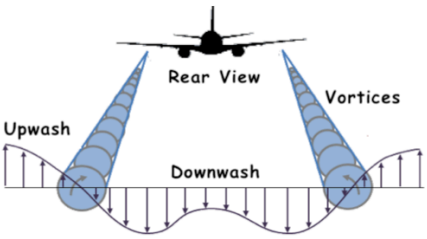


Fig 5c-i Downwash behind an airliner.

The physics for this is unproven. But it can be explained by the spiraling vortices generating a Magnus effect that enhances the downwash.

Nonetheless, contrary to the Prandtl lifting line theory of flight, vortices are not seen by this paper as a primary cause of lift. But vortices do permit airplanes to perform unusual flight manoeuvers under certain circumstances.

D. Wind and air currents.

Wind and air currents (updraft and downdrafts) are known to affect lift and lift. Gliders are rely on up currents to gain altitude. The explanation is simple; the moving air mass physically pushes the airplane in the same direction.

The force exerted on the airplane by the wind can be calculated using the same Newtonian equations as for lift;

Force = ma = m/dt x dv.

Here the force equals the mass of air displaced by (pushing against) the airplane each second ('m/dt'), multiplied by the change in velocity of this air when it hits the airplane ('dv'). The greater the surface area exposed to the wind or air current, then the greater the force exerted by the wind on the airplane. Similarly, the less aerodynamic the airplane's shape facing the direction of the wind, then the more that the airplane will slow the wind hitting it. In turn, this means that the wind will exert a greater force against the airplane.

Airplanes will always prefer to take-off and land into wind as the wind increases the airplane's airspeed relative to the ground (the true airspeed). In turn, this minimizes the runway distance needed to take-off or land. In contrast, taking-off and landing into wind significantly increases the runway distance required. See Fig 5e-i.

Fig 5e-i Taking-off and landing into the wind.

It's noteworthy that a strong 20-knot wind will not cause all airplanes to deviate by 20 knots in the direction of the wind. The wind will cause greater deviation for a plane on a flight path 90° to the wind (side-on), where the sides of the fuselage are exposed to the wind, than an airplane flying directly into the wind. See Fig 5e-ii.

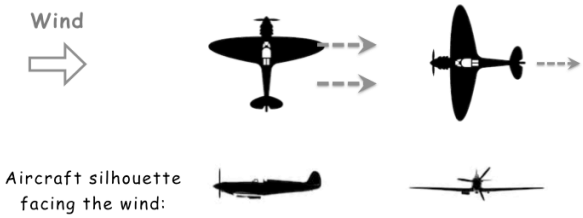


Fig 5e-ii How wind affects airplanes.

It's also worth noting that some airplanes such as gliders can actually increase airspeeds when flying into wind. This uses the same physics that explains how birds such as albatrosses can fly effortlessly into wind ('dynamic soaring'). In turn, this is similar to how sailboats can sail into wind.

In summary, how wind and air currents affect flight is consistent with the Newtonian explanation of flight.

E. Engine positions.

Engines push air backwards. The 'equal & opposite' forces pushes the airplane forwards. Propellers physically push air in the same way that helicopter rotors push air. Jet engines suck air in and accelerate it backwards, while also pushing exhaust gases from burnt fuel backwards.

Consequently, where engines are positioned affects the airflows created by the airplane. Engines are usually positioned at the back and under the wings on high-speed aircraft such as the old Concord. This maximizes the amount of air pushed horizontally backwards by the engines, undisturbed by the airplane's wings or fuselage. In turn, this maximizes speed rather than lift. See Fig 5f-i.

Fig 5f-i High speed airplanes (e.g. Concord).

On the other hand, engines are usually positioned above and at the front of wings on STOL (Short Take-Off and Landing) airplanes. Here the priority is lift generation not speed. This position allows the airflows created by the engines to be directed downwards by the wings due to the Coanda effect. This is evident from the exhaust (smoke) traces on the wings behind the engines. In turn, this increases the amount of air displaced down to boost lift, rather than backwards (which would boost airplane's speed). See Fig 5f-ii.

Fig 5f-ii STOL airplanes.

This analysis reinforces the importance of the upper airflow and the Coanda effect on lift.

Albeit, engine position also depends on: noise, maintenance and design (eg. the "area rule") considerations.

In summary, the physics of where engines are placed on the aircraft is consistent with the Newtonian explanation of flight.

F. Upper airflow and the Coanda effect.

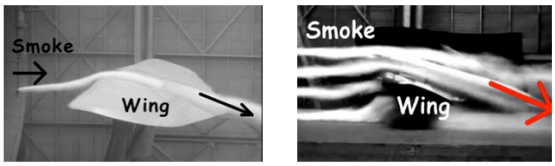


Fig. 5f-i The Coanda effect on airplane wings in wind tunnels.

The Coanda effect (see Fig 5f-i) on the topside of the wing displacing air in the upper airflow downwards is believed to be extremely significant by the author of this paper for several reasons:

(i) The amount of air displaced down by the upper airflow can vary a lot, due to the Coanda effect. Whereas the lower airflow displaced down by the underside of the wing is more stable and varies a lot less. For example, these airflows are effect differently by changes in the shape of the wing (e.g. due to the flaps) or the wing AOA. This is evidence by stalls typically arising on the trailing edge of the topside of wings. In short, the upper airflow is a lot more sensitive to prevailing conditions than the lower airflow.

(ii) The absolute amount of air displaced down in the upper airflow (due to the Coanda effect) under the right conditions can be a lot more than the lower airflow. This helps to explain why gliders are so much more effective at displacing air down than fighter jets. The glider's wings have more pronounced curvature (camber) and their longer wingspans provide greater overall curvature than the short wings of fighter jets. See Fig 5f-ii.

Fig. 5f-iii Curved glider wings.

This point is confirmed by NASA: "Wings with high aspect ratio /gliders) have lower induced drag than wings with low aspect ratio for the same wing area." [1] Albeit NASA incorrectly then claims that this feature is due to wingtip vortices; without providing any detailed logic or experimental evidence to support this claim. So, NASA's observation is correct, but their explanation is wrong. This author believes that lower induced drag on low aspect ratios wings is due to a stronger Coanda effect, for the reasons given above.

This logic helps explain why airplanes keep the topside of wings clear of any obstructions that could disrupt the upper airflows. For example fighter jets will always carry their payloads under their wings. Albeit there are usually other reasons for this as well (eg. ease of maintenance, many bombs are dropped so cannot be on the top of wings, ….). See Fig 5f-iii.

Fig. 5f-iii Fighter jet payloads.

G. High altitude.

Airplane performance is known to deteriorate when the air is less dense, in summer and at higher altitudes. Airplanes cannot fly above certain altitudes once the air becomes too thin. As altitude increases and air density declines, the mass of air flown through each second ('m/dt') also declines. There is less air mass for the wings to push down, so less capacity to generate lift. To compensate for this airliners at high altitude fly faster (or increase their wing AOA) to increase 'm/dt'. But drag on the airplane is reduced as air density decreases. In addition, at higher altitudes engine performance can deteriorate with thinner air (and less oxygen). See Fig 5g.

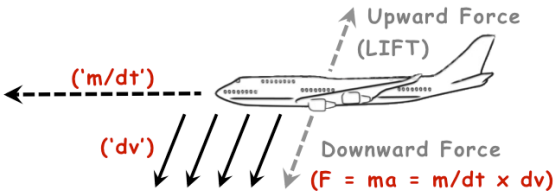


Fig 5g Newtonian forces on an airplane.

Lift is proportional to air density in the standard equation for lift: [1]

Lift = 0.5 x Aircraft Velocity^2 x Air Density x Wing Area x Lift Coefficient.

Mostly by trial and error, commercial airliners found that flying long distances at about 10,000 meters (or about 33,000 ft.), was most efficient. This altitude and lower air density provided the optimum trade-off between less lift and less drag, given the engine performance.

In summary, this explanation of how altitude affects lift is consistent with the Newtonian explanation of flight.

H. Ditching.

Some airplanes can float in the water, and some can float in the air. The physics is the same. Both these airplanes push a fluid (air or water) down to generate a sufficient equal and opposite upward force to float. The airplane in water is passively displacing enough water downwards to float. The airplane flying is actively displacing air downwards to fly. See Fig 5h.

Fig 5h Airplanes can float in water and in the air.

In summary, this is consistent with the Newtonian explanation of flight.

I. Conclusion – other practical aspects of flight.

In summary, all these other practical aspects of flight are shown to be consistent with the Newtonian explanation of flight.

VI. Discussion of Results

In summary, all flight manoeuvers and other practical aspects of flight are shown to be consistent with the Newtonian explanation of flight. This is significant as no other theory of flight can provide such a complete explanation.

It is worth emphasizing the importance of the amount of lift generated by the upper airflow, due to the Coanda effect.

These results are theoretical and not comprehensive evidence or proof for the Newtonian explanation for flight. Experiments have yet to be completed to provide empirical evidence to support the assertions and conclusions of this paper. Nonetheless, the argument for the Newtonian explanation for flight is compelling as it is theoretical sound and consistent with what can be observed in reality.

There is no evidence that Newtons laws cannot explain the physics of flight.

It should not be a surprise to find that Newtons laws of motion explain the physics of how airplanes fly.

VII. Conclusions

The evidence and logic provided in this paper for all flight manoeuvers and other practical aspects of flight confirmed the hypothesis that Newtons laws of motion can explain the physics for how airplanes fly. More experimentation and analysis needs to be done to establish definitive proof for this thesis.

VIII. Additional Information

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Corresponding authors: None.

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