PRINCIPLES OF HIGH SPEED FLIGHT pdf

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*Principles of High Speed Flight [H. McKinley Conway] on www.enganchecubano.com *FREE* shipping on qualifying offers. This book may be of some historic significance. Written at the end of WWII, it was the world's first textbook on supersonic aerodynamics and jet propulsion.*

Category Aerodynamics Thrust is the force that opposes drag , and whenever there is more thrust than drag, the airplane accelerates along the flight path until the increasing drag restores the equilibrium. In conjunction with drag, thrust is the factor that limits the top speed of an airplane. Most airplanes use power generated by their engines to turn propellers, converting rotational energy into thrust. Jet engines produce thrust directly, through the expansion of burning gases. Interestingly, jets convert some of that thrust into rotational energy to turn their compressors and accessories. The difference between thrust and power is fundamental to an understanding of aircraft performance. Thrust must equal drag in level flight in order for the aircraft not to accelerate or slow down. In other words, a pound of thrust must be present for each pound of drag at any airspeed. Parasite drag increases as the square of airspeed, so the thrust necessary for level flight at knots will be four times the thrust needed at 75 knots, less whatever reduction there is in induced drag. On the other hand, power is the rate at which work is done, so it is tied directly to speed. It takes less power to do the same amount of work at a slower rate. If an airplane had the same amount of drag at low speed as at high speed, it would still take more power to fly at high speed, because the work of overcoming drag would be done at a faster rate. When using our familiar units of pounds, knots, and horsepower, the power required for level flight is defined as thrust required times velocity over If your airplane has pounds of drag force at knnots, it requires At knots, the drag force will be nearly pounds, and about thrust horsepower would be required. The thrust required curve A looks suspiciously like the total drag curve since thrust must equal drag in level flight. The power-required curve B is somewhat different, indicating that less power is required at very low speeds. Propeller Efficiency The propeller converts the engine power into thrust. In order to obtain maximum performance, the propeller must make this conversion as efficiently as possible. Because it is an airfoil, the propeller is subject to all the factors that affect airfoil efficiency, such as angle of attack and speed. There are additional factors that are unique to propellers because of their rotation. The shape of a propeller blade reflects many of the principles discussed in our lift section. It has a low speed airfoil at a high angle of attack near the root where the local speed is low, and a high-speed airfoil at a low angle of attack at the tip where speeds are much higher. It has a high aspect ratio to minimize induced drag, and most have an elliptical planform to distribute the load. Controllable-pitch propellers allow the pilot to vary the angle of attack of the blades. As with wings, high angles of attack creates high induced drag, and that is why the engine slows down when you cycle the propeller during your runup. In cruise flight, the forward speed of the airplane changes the relative wind that the propeller blades encounter, reducing angle of attack. When you adjust the propeller pitch in cruise, you restore the blades to an angle of attack that provides a higher coefficient of lift, increasing the thrust provided. The angle of attack is at its minimum as the blade is ascending, and reaches its maximum as it descends on the other side. This varies the amount of lift, or thrust, produced by one side of the propeller disc compared to the other, and is most noticeable during climbs. Maximum Level Flight Speed There is an upper limit to how much thrust your engine and propeller can produce. When maximum thrust is produced, the airplane accelerates until the drag force is equal to the thrust. Power and thrust available vary with speed.

2: Aeronautical Guide: High Speed Flight

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Lift-to-drag ratio Aerodynamic lift is created by the motion of an aerodynamic object wing through the air, which due to its shape and angle deflects the air. For sustained straight and level flight, lift must be equal and opposite to weight. In general, long narrow wings are able deflect a large amount of air at a slow speed, whereas smaller wings need a higher forward speed to deflect an equivalent amount of air and thus generate an equivalent amount of lift. Large cargo aircraft tend to use longer wings with higher angles of attack, whereas supersonic aircraft tend to have short wings and rely heavily on high forward speed to generate lift. However, this lift deflection process inevitably causes a retarding force called drag. Because lift and drag are both aerodynamic forces, the ratio of lift to drag is an indication of the aerodynamic efficiency of the airplane. Compressibility is also affected by the shape of the aircraft surfaces. A greater angle of attack relative to the forward movement also increases the extent of deflection, and thus generates extra lift. However a greater angle of attack also generates extra drag. Since the glide ratio is based only on the relationship of the aerodynamics forces acting on the aircraft, aircraft weight will not affect it. The only effect weight has is to vary the time that the aircraft will glide for â€” a heavier aircraft gliding at a higher airspeed will arrive at the same touchdown point in a shorter time. Buoyancy Air pressure acting up against an object in air is greater than the pressure above pushing down. A cubic meter of air at ordinary atmospheric pressure and room temperature has a mass of about 1. Therefore, any 1-cubic-meter object in air is buoyed up with a force of 12 newtons. If the mass of the 1-cubic-meter object is greater than 1. If an object of this size has a mass less than 1. Any object that has a mass that is less than the mass of an equal volume of air will rise in air - in other words, any object less dense than air will rise. Thrust to weight ratio[edit] Main article: If the thrust-to-weight ratio is greater than the local gravity strength expressed in gs , then flight can occur without any forward motion or any aerodynamic lift being required. If the thrust-to-weight ratio times the lift-to-drag ratio is greater than local gravity then takeoff using aerodynamic lift is possible.

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History of aerodynamics Modern aerodynamics only dates back to the seventeenth century, but aerodynamic forces have been harnessed by humans for thousands of years in sailboats and windmills, [2] and images and stories of flight appear throughout recorded history, [3] such as the Ancient Greek legend of Icarus and Daedalus. The Euler equations were extended to incorporate the effects of viscosity in the first half of the s, resulting in the Navierâ€"Stokes equations. Wind tunnels were key in the development and validation of the laws of aerodynamics. In , Sir George Cayley became the first person to identify the four aerodynamic forces of flight weight , lift , drag , and thrust , as well as the relationships between them, [10] [11] and in doing so outlined the path toward achieving heavier-than-air flight for the next century. In , Francis Herbert Wenham constructed the first wind tunnel , allowing precise measurements of aerodynamic forces. Building on these developments as well as research carried out in their own wind tunnel, the Wright brothers flew the first powered airplane on December 17, During the time of the first flights, Frederick W. Lanchester , [16] Martin Kutta , and Nikolai Zhukovsky independently created theories that connected circulation of a fluid flow to lift. Kutta and Zhukovsky went on to develop a two-dimensional wing theory. Expanding upon the work of Lanchester, Ludwig Prandtl is credited with developing the mathematics [17] behind thin-airfoil and lifting-line theories as well as work with boundary layers. As aircraft speed increased, designers began to encounter challenges associated with air compressibility at speeds near or greater than the speed of sound. The differences in air flows under such conditions leds to problems in aircraft control, increased drag due to shock waves , and the threat of structural failure due to aeroelastic flutter. The ratio of the flow speed to the speed of sound was named the Mach number after Ernst Mach who was one of the first to investigate the properties of supersonic flow. William John Macquorn Rankine and Pierre Henri Hugoniot independently developed the theory for flow properties before and after a shock wave , while Jakob Ackeret led the initial work of calculating the lift and drag of supersonic airfoils. This rapid increase in drag led aerodynamicists and aviators to disagree on whether supersonic flight was achievable until the sound barrier was broken for the first time in using the Bell X-1 aircraft. The Cold War prompted the design of an ever-evolving line of high performance aircraft. Computational fluid dynamics began as an effort to solve for flow properties around complex objects and has rapidly grown to the point where entire aircraft can be designed using computer software, with wind-tunnel tests followed by flight tests to confirm the computer predictions. Understanding of supersonic and hypersonic aerodynamics has matured since the s, and the goals of aerodynamicists have shifted from the behavior of fluid flow the engineering of a vehicle such that it interacts pedictably with the fluid flow. Designing aircraft for supersonic and hypersonic conditions, as well as the desire to improve the aerodynamic efficiency of current aircraft and propulsion systems, continues to motivate new research in aerodynamics, while work continues to be done on important problems in basic aerodynamic theory related to flow turbulence and the existence and uniqueness of analytical solutions to the Navier-Stokes equations. Fundamental concepts[edit] Forces of flight on an airfoil Understanding the motion of air around an object often called a flow field enables the calculation of forces and moments acting on the object. In many aerodynamics problems, the forces of interest are the fundamental forces of flight: Of these, lift and drag are aerodynamic forces, i. Calculation of these quantities is often founded upon the assumption that the flow field behaves as a continuum. Continuum flow fields are characterized by properties such as flow velocity , pressure , density , and temperature , which may be functions of position and time. These properties may be directly or indirectly measured in aerodynamics experiments or calculated starting with the equations for conservation of mass, momentum , and energy in air flows. Density, flow velocity, and an additional property, viscosity , are used to classify flow fields. Flow classification[edit] Flow velocity is used to classify flows according to speed regime. Subsonic flows are flow fields in which the air speed field is always below the local speed of sound. Transonic flows include both regions of subsonic flow and regions in which the local flow speed is greater than the local speed of sound. Supersonic flows are defined to be flows in which the flow speed is greater than the speed of sound everywhere. A fourth classification, hypersonic flow, refers to flows where the flow speed is much greater than the speed of sound. Aerodynamicists disagree on the precise definition of hypersonic flow. Compressible flow accounts for varying density within the flow. Subsonic flows are often idealized as incompressible, i. Transonic and supersonic flows are compressible, and calculations that neglect the changes of density in these flow fields will yield inaccurate results. Viscosity is associated with the frictional forces in a flow. In some flow fields, viscous effects are very small, and approximate solutions may safely neglect viscous effects. These approximations are called inviscid flows. Flows for which viscosity is not neglected are called viscous flows. Finally, aerodynamic problems may also be classified by the flow environment. External aerodynamics is the study of flow around solid objects of various shapes e. Continuum assumption[edit] Unlike liquids and solids, gases are composed of discrete molecules which occupy only a small fraction of the volume filled by the gas. On a molecular level, flow fields are made up of the collisions of many individual of gas molecules between themselves and with solid surfaces. However, in most aerodynamics applications, the discrete molecular nature of gases is ignored, and the flow field is assumed to behave as a continuum. This assumption allows fluid properties such as density and flow velocity to be defined everywhere within the flow. The validity of the continuum assumption is dependent on the density of the gas and the application in question. For the continuum assumption to be valid, the mean free path length must be much smaller than the length scale of the application in question. For example, many aerodynamics applications deal with aircraft flying in atmospheric conditions, where the mean free path length is on the order of micrometers and where the body is orders of magnitude larger. In these cases, the length scale of the aircraft ranges from a few meters to a few tens of meters, which is much larger than the mean free path length. For such applications, the continuum assumption is reasonable. The continuum assumption is less valid for extremely low-density flows, such as those encountered by vehicles at very high altitudes e. In those cases, statistical mechanics is a more accurate method of solving the problem than is continuum aerodynamics. The Knudsen number can be used to guide the choice between statistical mechanics and the continuous formulation of aerodynamics. Conservation laws[edit] The assumption of a fluid continuum allows problems in aerodynamics to be solved using fluid dynamics conservation laws. Three conservation principles are used: In fluid dynamics, the mathematical formulation of this principle is known as the mass continuity equation , which requires that mass is neither created nor destroyed within a flow of interest. Momentum within a flow is only changed by the work performed on the system by external forces, which may include both surface forces , such as viscous frictional forces, and body forces , such as weight. The momentum conservation principle may be expressed as either a vector equation or separated into a set of three scalar equations x,y,z components. In its most complete form, the momentum conservation equations are known as the Navier-Stokes equations. The Navier-Stokes equations have no known analytical solution and are solved in modern aerodynamics using computational techniques. Because of the computational cost of solving these complex equations, simplified expressions of momentum conservation may be appropriate for specific applications. The Euler equations are a set of momentum conservation equations which neglect viscous forces and may be used in cases where the effect of viscous forces is expected to be small. The energy conservation equation states that energy is neither created nor destroyed within a flow, and that any addition or subtraction of energy to a volume in the flow is caused by the fluid flow, by heat transfer , or by work into and out of the region of interest. The ideal gas law or another such equation of state is often used in conjunction with these equations to form a determined system that allows the solution for the unknown variables. Branches of aerodynamics[edit] Aerodynamic problems are classified by the flow environment or properties of the flow, including flow speed , compressibility , and viscosity. External aerodynamics is the study of flow around solid objects of various shapes. Evaluating the lift and drag on an airplane or the shock waves that form in front of the nose of a rocket are examples of external aerodynamics. Internal aerodynamics is the study of flow through passages in solid objects. For instance, internal aerodynamics encompasses the study of the airflow through a jet engine or through an air conditioning pipe. Aerodynamic problems can also be classified according to whether the flow speed is below, near or above the speed of sound. A problem is called subsonic if all the speeds in the problem are less than the speed of sound, transonic if speeds both below and above the speed of sound are present normally when the characteristic speed is approximately the speed of sound , supersonic when the characteristic flow speed is greater than the speed of sound, and hypersonic when the flow speed is much greater than the speed of sound. Aerodynamicists disagree over the precise definition of hypersonic flow; a rough definition considers flows with Mach numbers above 5 to be hypersonic. Some problems may encounter only very small viscous effects, in which case viscosity can be considered to be negligible. The approximations to these problems are called inviscid flows. Flows for which viscosity cannot be neglected are called viscous flows. Although all real fluids are compressible, a flow is often approximated as incompressible if the effect of the density changes cause only small changes to the calculated results. This is more likely to be true when the flow speeds are significantly lower than the speed of sound. Effects of compressibility are more significant at speeds close to or above the speed of sound. The Mach number is used to evaluate whether the incompressibility can be assumed, otherwise the effects of compressibility must be included. Subsonic flow[edit] Subsonic or low-speed aerodynamics describes fluid motion in flows which are much lower than the speed of sound everywhere in the flow. There are several branches of subsonic flow but one special case arises when the flow is inviscid , incompressible and irrotational. This case is called potential flow and allows the differential equations that describe the flow to be a simplified version of the equations of fluid dynamics , thus making available to the aerodynamicist a range of quick and easy solutions. Compressibility is a description of the amount of change of density in the flow. When the effects of compressibility on the solution are small, the assumption that density is constant may be made. The problem is then an incompressible low-speed aerodynamics problem. When the density is allowed to vary, the flow is called compressible. In air, compressibility effects are usually ignored when the Mach number in the flow does not exceed 0. Compressible flow According to the theory of aerodynamics, a flow is considered to be compressible if the density changes along a streamline. This means that â€” unlike incompressible flow â€" changes in density are considered. In general, this is the case where the Mach number in part or all of the flow exceeds 0. Transonic, supersonic, and hypersonic flows are all compressible flows. Transonic The term Transonic refers to a range of flow velocities just below and above the local speed of sound generally taken as Mach 0. It is defined as the range of speeds between the critical Mach number , when some parts of the airflow over an aircraft become supersonic , and a higher speed, typically near Mach 1. Between these speeds, some of the airflow is supersonic, while some of the airflow is not supersonic. Supersonic Supersonic aerodynamic problems are those involving flow speeds greater than the speed of sound. Calculating the lift on the Concorde during cruise can be an example of a supersonic aerodynamic problem. Supersonic flow behaves very differently from subsonic flow. Fluids react to differences in pressure; pressure changes are how a fluid is "told" to respond to its environment. Therefore, since sound is in fact an infinitesimal pressure difference propagating through a fluid, the speed of sound in that fluid can be considered the fastest speed that "information" can travel in the flow.

4: High Speed Flight â€“ Subsonic Versus Supersonic Flow

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High Speed Flight Subsonic Versus Supersonic Flow In subsonic aerodynamics, the theory of lift is based upon the forces generated on a body and a moving gas air in which it is immersed. At speeds of approximately knots or less, air can be considered incompressible in that, at a fixed altitude, its density remains nearly constant while its pressure varies. Under this assumption, air acts the same as water and is classified as a fluid. In reality, air is compressible and viscous. While the effects of these properties are negligible at low speeds, compressibility effects in particular become increasingly important as speed increases. Compressibility and to a lesser extent viscosity is of paramount importance at speeds approaching the speed of sound. In these speed ranges, compressibility causes a change in the density of the air around an aircraft. During flight, a wing produces lift by accelerating the airflow over the upper surface. This accelerated air can, and does, reach sonic speeds even though the aircraft itself may be flying subsonic. It is therefore entirely possible to have both supersonic and subsonic airflow on an aircraft at the same time. When flow velocities reach sonic speeds at some location on an aircraft such as the area of maximum camber on the wing , further acceleration results in the onset of compressibility effects, such as shock wave formation, drag increase, buffeting, stability, and control difficulties. Subsonic flow principles are invalid at all speeds above this point. Wing airflow Speed Ranges The speed of sound varies with temperature. An aircraft traveling at the speed of sound is traveling at Mach 1. Aircraft speed regimes are defined approximately as follows: Subsonicâ€”Mach numbers below 0. Drag begins to rise sharply. Above this altitude, an MMO of 0. Although the stalling speed has remained the same for our purposes, both the Mach number and TAS have increased. However, it is flying at higher Mach number. Another factor to consider is the speed of sound. A decrease in temperature in a gas results in a decrease in the speed of sound. Thus, as the aircraft climbs in altitude with outside temperature dropping, the speed of sound is dropping. Simultaneously, the speed of sound in KCAS has decreased from to and the Mach number has increased from 0. All the while, the KCAS for stall has remained constant at This describes what happens when the aircraft is at a constant KCAS with increasing altitude, but what happens when the pilot keeps Mach constant during the climb? In normal jet flight operations, the climb is at KIAS or higher e. Assuming for illustration purposes that the pilot climbs at a MMO of 0. KCAS goes from to The KIAS at each altitude would follow the same behavior and just differ by a few knots. The speed of sound is decreasing with the drop in temperature as the aircraft climbs. The Mach number is simply the ratio of the true airspeed to the speed of sound at flight conditions. At some point, the stall speed of the aircraft in Mach number could equal the MMO of the aircraft, and the pilot could neither slow down without stalling nor speed up without exceeding the max operating speed of the aircraft. There are two different types of boundary layer flow: Laminar Boundary Layer Flow The laminar boundary layer is a very smooth flow, while the turbulent boundary layer contains swirls or eddies. The laminar flow creates less skin friction drag than the turbulent flow but is less stable. Boundary layer flow over a wing surface begins as a smooth laminar flow. As the flow continues back from the leading edge, the laminar boundary layer increases in thickness. Turbulent Boundary Layer Flow At some distance back from the leading edge, the smooth laminar flow breaks down and transitions to a turbulent flow. From a drag standpoint, it is advisable to have the transition from laminar to turbulent flow as far aft on the wing as possible or have a large amount of the wing surface within the laminar portion of the boundary layer. The low energy laminar flow, however, tends to break down more suddenly than the turbulent layer. Boundary Layer Separation Another phenomenon associated with viscous flow is separation. Separation occurs when the airflow breaks away from an airfoil. The natural progression is from laminar boundary layer to turbulent boundary layer and then to airflow separation. Airflow separation produces high drag and ultimately destroys lift. The boundary layer separation point moves forward on the wing as the AOA is increased. Because of this warning, the air begins to move aside before the airplane arrives and is prepared to let it pass easily. Rather, the air particles pile up in front of the airplane causing a sharp decrease in the flow velocity directly in front of the airplane with a corresponding increase in air pressure and density. This same type of wave is formed whenever a supersonic airstream is slowed to subsonic without a change in direction, such as when the airstream is accelerated to sonic speed over the cambered portion of a wing, and then decelerated to subsonic speed as the area of maximum camber is passed. A shock wave forms as a boundary between the supersonic and subsonic ranges. A supersonic airstream passing through a normal shock wave experiences these changes: The airstream is slowed to subsonic. The airflow immediately behind the shock wave does not change direction. The static pressure and density of the airstream behind the wave is greatly increased. The energy of the airstream indicated by total pressureâ€”dynamic plus static is greatly reduced. Shock wave formation causes an increase in drag. One of the principal effects of a shock wave is the formation of a dense high pressure region immediately behind the wave. The instability of the high pressure region, and the fact that part of the velocity energy of the airstream is converted to heat as it flows through the wave, is a contributing factor in the drag increase, but the drag resulting from airflow separation is much greater. If the shock wave is strong, the boundary layer may not have sufficient kinetic energy to withstand airflow separation. A considerable increase in thrust power is required to increase flight speed beyond this point into the supersonic range where, depending on the airfoil shape and the AOA, the boundary layer may reattach. As flight speed approaches the speed of sound, the areas of supersonic flow enlarge and the shock waves move nearer the trailing edge. The loss of lift due to airflow separation results in a loss of downwash and a change in the position of the center pressure on the wing. Airflow separation produces a turbulent wake behind the wing, which causes the tail surfaces to buffet vibrate. The nose-up and nose-down pitch control provided by the horizontal tail is dependent on the downwash behind the wing. Movement of the wing CP affects the wing pitching moment. This is the primary reason for the development of the T-tail configuration on many turbine-powered aircraft, which places the horizontal stabilizer as far as practical from the turbulence of the wings. Sweepback Most of the difficulties of transonic flight are associated with shock wave induced flow separation. Therefore, any means of delaying or alleviating the shock induced separation improves aerodynamic performance. One method is wing sweepback. Sweepback theory is based upon the concept that it is only the component of the airflow perpendicular to the leading edge of the wing that affects pressure distribution and formation of shock waves. This airflow on the swept wing has the effect of persuading the wing into believing that it is flying slower than it really is; thus the formation of shock waves is delayed. Advantages of wing sweep include an increase in critical Mach number, force divergence Mach number, and the Mach number at which drag rise peaks. In other words, sweep delays the onset of compressibility effects. At this speed, the airflow separation induced by shock wave formation can create significant variations in the drag, lift, or pitching moment coefficients. In addition to the delay of the onset of compressibility effects, sweepback reduces the magnitude in the changes of drag , lift , or moment coefficients. A disadvantage of swept wings is that they tend to stall at the wingtips rather than at the wing roots. Because the tips of a swept wing are on the aft part of the wing behind the CL , a wingtip stall causes the CL to move forward on the wing, forcing the nose to rise further. The tendency for tip stall is greatest when wing sweep and taper are combined. Wingtip pre-stall The stall situation can be aggravated by a T-tail configuration, which affords little or no pre-stall warning in the form of tail control surface buffet. In this situation, without reliable AOA information, a nose-down pitch attitude with an increasing airspeed is no guarantee that recovery has been affected, and up-elevator movement at this stage may merely keep the aircraft stalled. T-tail stall It is a characteristic of T-tail aircraft to pitch up viciously when stalled in extreme nose-high attitudes, making recovery difficult or violent. The stick pusher inhibits this type of stall. At approximately one knot above stall speed, pre-programmed stick forces automatically move the stick forward, preventing the stall from developing. A G-limiter may also be incorporated into the system to prevent the pitch down generated by the stick pusher from imposing excessive loads on the aircraft. Mach Buffet Boundaries Mach buffet is a function of the speed of the airflow over the wingâ€”not necessarily the speed of the aircraft. This very high AOA has the effect of increasing airflow velocity over the upper surface of the wing until the same effects of the shock waves and buffet occur as in the high-speed buffet situation. The AOA of the wing has the greatest effect on inducing the Mach buffet at either the high-speed or low-speed boundaries for the aircraft. The conditions that increase the AOA, the speed of the airflow over the wing, and chances of Mach buffet are: High altitudesâ€”the higher an aircraft flies, the thinner the air and the greater the AOA required to produce the lift needed to maintain level flight. Heavy weightsâ€”the heavier the aircraft, the greater the lift required of the wing, and all other factors being equal, the greater the AOA. G loadingâ€”an increase in the G loading on the aircraft has the same effect as increasing the weight of the aircraft. High Speed Flight Controls On high-speed aircraft, flight controls are divided into primary flight controls and secondary or auxiliary flight controls. The primary flight controls maneuver the aircraft about the pitch, roll, and yaw axes. They include the ailerons, elevator, and rudder. Secondary or auxiliary flight controls include tabs, leading edge flaps, trailing edge flaps, spoilers, and slats. Spoilers are used on the upper surface of the wing to spoil or reduce lift. High speed aircraft, due to their clean low drag design, use spoilers as speed brakes to slow them down. Spoilers are extended immediately after touchdown to dump lift and thus transfer the weight of the aircraft from the wings onto the wheels for better braking performance. Control surfaces Jet transport aircraft have small ailerons.

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The theoretical concept that summarizes the direction and force of lift is the centre of pressure. Lift opposes weightâ€”during level cruise, lift equals weight; during climb, lift is greater than weight; and during descent, weight is greater that lift. Thrust Thrust is an artificial force manipulated by pilot and generated through engine s that acts horizontally, parallel to flight path; thrust opposes dragâ€”when airspeed constant, thrust equals drag; when airspeed accelerating, thrust is greater than drag; and when decelerating, drag is greater than thrust. Drag is a horizontal force acting parallel to flight path, and is opposed to thrust. A straight line from leading edge to trailing edge is referred to as the chord. Parasitic Drag Parasitic drag is drag created by those parts of an aeroplane that do not contribute to liftâ€”e. There are, in turn, three forms of parasitic dragâ€—form drag, skin-friction drag, and interference drag. Form drag is caused by the frontal areas of the aeroplane, and is reduced by streamlining. Skin-friction drag is caused by the air passing over the aeroplane surfaces, and is reduced by smoothing the surfaces flush riveting, smooth paints, and waxing. Induced drag does not increase with speed; instead, as speed decreases induced drag increases. Induced drag is associated with difference in pressure that exists above and below a wing surfaceâ€”as airspeed decreases, an airfoil must produce an increased low pressure above the wing, and an increased high pressure below the wing. As the airfoil approaches the critical angle of attack, the point of transition, or separation point, moves forward enough to exceed the design factor of the wing. In contrast, the centre of pressure moves forward as the angle of attack is increased until the critical angle of attack is achieved; when a stall occurs, the centre of pressure moves rearward, causing the instability associated with stall phenomena. Since most aircraft lack angle-of-attack indicators, airfoil angle is measured by indicated airspeed IAS â€”our best estimate of the actual angle of attack. As a rule, aircraft will usually stall near the stalling speed published in the Pilot Operating Handbook; however, IAS does not always accurately indicate angle of attack, as in the case of a high-speed stall. Factors that affect the Stall Contaminants. Snow, frost, ice and dirtâ€”all of these disrupt the laminar flow and therefore reduce airfoil lift capability. Increased weight requires increased lift and an increased angle of attack; therefore the critical angle of attack stall will occur at higher airspeeds. Stated another way, if two aircraft are travelling at the same airspeed, but one is heavier than the other, the angle of attack of the heavier aircraft is greater than the lighter aircraft and therefore that much closer to the critical angle of attack. Stalling speed increases as the aircraft C of G moves forward. Conversely, stalling speeds decrease as the C of G moves aft as less negative lift is required from the tail and the aircraft is aerodynamically lighter. While the benefits of a rearward C of G is a lower stall speed, the adverse result of a rearward C of G is less stability as there is less tail force that can be manipulated by the pilot through elevator or stabilator control. Upward vertical gusts abruptly increase the angle of attack beyond the stalling angle, irrespective of airspeed. During a turn in level flight, greater lift is required to offset increased load factor; the critical angle of attack is therefore reached at higher airspeeds. During a climbing turn, the inner wing has a smaller angle of attack than the outer wing; the outer wing will therefore stall first. The reverse is the case for descending turn, where the inner wing has a larger angle of attack and will therefore stall first. An increase in airfoil lift is produced by the use of flaps, and the stall speed is decreased by their use. Spinning involves simultaneous roll, yaw, and pitch as it develops a helical or corkscrew path nose down. Lift and Drag Concepts Factors that affect lift and drag can be expressed in the following formulas: Note, however, that the rest of the equation is the same for both lift and drag, and further note that air density and TAS, and wing area are concepts which you are likely already familiar with. So what is the big deal with these formulas? The answer is this: Lift and drag increase exponentially with speedâ€”if speed is doubled, drag or lift will be quadrupled. In contrast the relationship between lift or drag and air density is a direct relationship such that an increase or decrease in air density will cause an increase or decrease in both drag and lift. This is referred to as the drag curve. At the bottom of the drag curveâ€—that is, the position at where drag is at the combined minimum valueâ€—is the speed for maximum rangeâ€—i. To decrease speed from VMR would increase fuel consumption as a result of increased induced drag, while to increase speed from VMR would increase fuel consumption as a result of increased parasitic drag. The bottom of the drag curve is the most efficient speed at which the airfoil can generate maximum lift and minimum dragâ€"this is the speed at which you will maximum-distance glide. If you were to express lift and drag as a ratio, this position would be referred to as the maximum lift-drag ratio. The bottom of the power curve would be the maximum endurance speed VME. On the laminar foil, a greater portion of the upper camber is dedicated to laminar airflow; there is therefore less surface friction drag. The cost of this, however, is that the transition or separation point jumps rapidly forward at the approach of a stall. Additionally, the laminar foil is more susceptible to surface contamination. This means that the entire wing will not stall simultaneously; instead, the stall will progressively move from the roots to the tips. Since the wing tips are the last to stall, the ailerons will remain effective longer during the stall. The result is that the high-speed roots stall before the low-speed tipsâ€"again, this prolongs aileron control. Wing Fences Wing fencesare vertical fins that are attached to the upper wing surface and serve the function of reducing the out-flow of air over the upper camber and therefore reduce induced drag. Winglets Winglets 3 are vertical wing-like surfaces attached to the wingtips; they serve the function of inhibiting the development of wingtip vortices, and therefore reduce induced drag. Slots and Slats These are two leading-edge devicesused to enhance lift in high angle of attack attitudes. The space between the two airfoils is considered to be a slot. Spoilers and Speed Brakes Spoilers are designed to spoil lift and increase drag in the portion of the upper wing surface where they are located. Spoilers may be designed only to operate during roll movements, in which case they are referred to as roll spoilers. On some aircraft such as the Mitsubishi MU-2, only roll spoilers create roll as there are no ailerons; on the Dash 8, two roll spoilers are automatically activated on the down-going wing to assist aileron deflection at speeds below KTS, while only one roll spoiler operates on the down-going wing at airspeeds greater than Unlike spoilers, speed brakes do not increase the sink-rate of an aircraft, but simply decrease airspeed. Flap Variations There are six types of flaps commonly used: Stability Aeroplane movement is based on three axes: Swept wing aircraft are particularly susceptible, and many are equipped with yaw damper, which is an automatic device that senses yaw and counters it with corrective control inputs before the Dutch roll oscillations can develop. Brown and Mark J. One wing yawing forward in this situation changes the effective span between left and right wings. The wing yawed forward momentarily creates more lift than the one of the other side. The result is that the forward wing rises and starts a rolling movement. The problem is aggravated by the fact that the forward wing, due to its increased lift, also has more drag, pulling that wing back once again and starting an oscillation in the other direction. Viewed from the pilot seat, the right side of the prop disc is the down-going side and therefore produces greater thrust than the up-going left side in most conventional engines. Slipstreamâ€"propeller slipstream spirals around the fuselage and strikes the vertical stabilizer on the port side. Critical Engine The effect of asymmetric thrust in multi-engine aeroplanes is to create what is referred to the critical engine. The critical engine is defined as the engine that, should a failure occur, will most adversely affect aircraft performance and control. On a twin-engine aircraft when both propellers turn clockwise as viewed from the rear of the aircraft , the failure of the left engine will have the more adverse effect because the remaining thrust from the right engine, owing to asymmetric thrust, would be further from the longitudinal axis than would be the case if the right engine failed and only the left were producing thrust. Note that some twin-engine aircraft do not have a critical engine as the right engine has a counter-rotating propeller. Below high-speedâ€"what is regarded as slow-speed flightâ€"the movement of air around an aircraft during flight does not involve compression of the airflowâ€"what is referred to as compressibility. Instead, the behaviour of slow-speed airflow entails the rules of aerodynamics discussed thus farâ€"the flow of air is like the flow of water around rocks in a stream, where the flow accelerates or slows, based on size and surface features of obstructions to the flow of water. In contrast, high-speed flight is different. Because of the speed of the airframe and wings, etc. Compressibility introduces radical changes in aerodynamic principles of high-speed flight. As the aircraft speed increases and approaches the speed of the propagated pressure wave, less and less warning is provided and smooth orderly flow is lost. Pendleton describes the situation as follows: The greater the aircraft speed, the fewer air particles will be able to move out of its path. As a consequence, the air particles begin to pile up in front of the aircraft, and the air density increases. The speed of the pressure wave is, of course, the speed of sound, and compressibility occurs when the aircraft itself approaches the speed of sound. Essentially, compressibility inhibits laminar flow, and instead of the air particles accelerating smoothly, the speed of airflow decreases dramatically. Transonic Flight The speed of air flow over the upper camber of a wing varies, and it follows, therefore, that portions of the air flowing over the wing will attain the speed of soundâ€"Mach 1. While this portion has attained M 1. Pendleton writes as follows: If the aircraft is flown at speeds in excess of its critical Mach number, numerous unsettling and potentially disastrous events occur. Boundary layer separation on the control surfaces might cause the surfaces to rapidly oscillate, which is called buzz. The airfoil shape over the length of the wing is seldom constant, and the differing onset of formation of shock waves and movements of centers of pressure cause this effect. This effect is unnerving at the least. Severe buffeting will almost surely be the next compressibility effect that is sure to show up. This buffeting, if allowed to continue, has been known to cause separation of the tail from the aircraft. If all this has not caused the pilot to slow down and escape compressibility effect by now, a more violent effect is about to occur. The important point is that the first signs of compressibility effects call for immediate pilot action. The airspeed must be reduced, and the nose must be eased up. The power reduction has to be fast, for when the tuck starts and the aircraft starts into a dive, the situation is going to get rapidly worse. The increased speed will cause the separation of the airflow to become more pronounced, and the severity of the buffet will become greater. The greater the turbulence over the tail, the greater will be the elevator angle and the stick force required to pull out of the dive. Some have not been successful in this manoeuvre, and some have lost the tail of the aircraft before they had time to begin recovery. Effective communication is complicated by variations in Mach 1. MMO is displayed automatically on the airspeed indicators of high speed by what is referred to as the barber poleâ€"a self-adjusting needle that predicts the MMO based on ambient temperature and pressure altitude. An aural over-speed warning device is also wired to the systemâ€"referred to as a clacker. References 1 Of course, we know these vortices as wake turbulence, which is greatest with large, slow speed, clean configuration aircraftâ€"all features of flight in which the angle of attack is at its greatest.

6: Principles of Flight - Define Aviation

principles of flight. line, thus its speed and pressure remain about the same. Since high pressure always moves toward low pressure, the air below the wing pushes.

7: Flight - Wikipedia

How to Cite. Swatton, P. J. () High-Speed Flight, in Principles of Flight for Pilots, John Wiley & Sons, Ltd, Chichester, UK. doi: /ch

8: Principles of Thrust - www.enganchecubano.com powered

High-speed flight is flight near, but below the speed of sound. Below high-speedâ€"what is regarded as slow-speed flightâ€"the movement of air around an aircraft during flight does not involve compression of the airflowâ€"what is referred to as compressibility.

9: Principles of high speed flight. - CORE

Introduction This chapter presents aerodynamic fundamentals and principles as they apply to helicopters. The content relates to flight operations and performance of normal flight tasks.

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