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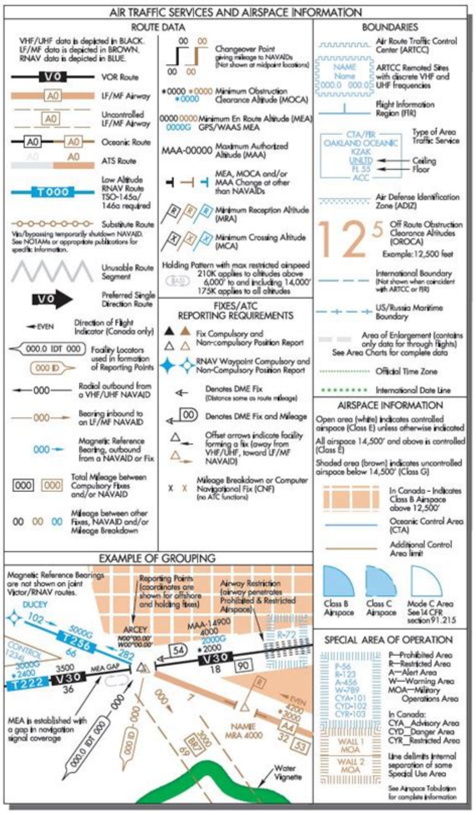

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takeoff. the wing meeting the oncoming air begins to generate lift Fig. 1 1. As the forward speed of the It is true, of course, that the density of air is low aircraft increases.When the lift force is equal to the weight of the air that makes flight possible.http://www.heatandgas.com//EditorImages/casio-ap-620-manual.xml

Air bei ng the medium aircraft, the aircraft begins to fly.The Atmosphere Temperature Changes Lapse Rate With an increase in height there is a decrease in air temperature. The reaso n is that the suns heat passes through the atmosphere without apprec iably raising the temperature. The earth, however, absorb s the heat. The temperature ofthe earth is raised and the air in contact with it absorbs some of the heat. An aircraft ope rates in a world that is very near the The Four Forces earth.This world is the atmosphere, composed of air.We must know something about this atmos main forces lift, weight. Lift acts at 90 degrees to the relative airflow Fig. 13.11is not nec essarily perpe ndicular to the horizo n; in flig ht it may act at a considerable angle to the horizon. For co m putation purposes, the total force of lift is considered to act through one point of the wing. Thi s point is called the Centre ofPress ure Fig. 14 . Relative Airflow Relative airflow is always parallel with and directly opposite to the aircrafts night path. The kite is an example. Si mply stated, the wing ge nerate s part of the total lift by deflecting air downward. A wi ng also derives par t of its lift from the pressur e differential between the up per and lower surfaces. The theoretical expres ssion of this fac t is found in Bernouilli theorem. With the uppe r surface having a greater cambe r tha n the lower Angle ofincidence refers to the fi xed angle between surface, the air flowing above the wing will be acce l the plane of the wing chord an d the lon gitudi nal ax is erate d more tha n the air flowing beneath the wing.Tests also show that as the angle of attack of an aerofoil in flight is increased, the Centre of Pressure moves gradually forward. At a point well beyond the angle of attack for ordinary flight, it begins to move back again.

When the Centre of Pressure moves back far enough, the nose of the aircraft will pitch 6 Basic Principles ofFlight starts to become turbulent and increasingly thick. The airflow beyond this point is described as the turbulent downward suddenly as the wingenters astalledcondition layer. Fig. 19. To maintain a lamin ar flow over as much of the The boundary layer is a thin layer of air, sometimes aerofoil surface as possible, the laminar flow type no more than a hundredth of an inch 0.25 millimetres wing was developed. Th is design is con cerned with thick, flowing over the surface of a wing in flight. The the transition point. Th e laminar flow wing is often bo unda ry layer is di vided int o two parts I th e thinner tha n the co nventional aerofoil, the leading desirable laminar layer, and 2 the undesirable turbulent edge is more poi nted, and the section nearly symmet layer. Air flowing over the wing begins by conforming rica l, but most impor tant of all, the point of maximum to its shape; at this stage the boundary layer is smooth camber the point of great est convexity of the airfoil and very thin. This is the laminar layer. There is a point from its chord is much farther back than on the con of transition, which moves between the leading and ventional wing. The pressure distri buti on on the lam trailing edges of the wing, where the boundary layer inar flow wing is much more even, as the airflow is accelerated very gradually from the leadin g edge to the point of maximum cam ber. As the stalli ng speed of a laminar flow wing is approached, the transition point will move forward much more rapid ly than it will on a conventional aero foil. The total aircraft drag is the sum of induced drag and par asite drag. Induced drag is a byproduct of lift, and parasite drag is made up of all the other drag Fig. 110. Induced Drag. Wing tip vortices are formed when higher pressure air beneath the wing flows around the wing tip into lower pressure air above the wings Fig.

III . This disturbed air contributes to induced drag. In addition to vor tices, downwash is prod uced when air flowing around the wing is deflected down ward Fig. I I. Downwash is required in the produc tion of lift and results in induced drag. A way to visua lize induced drag caused by down wash is to picture the result ant lift being tipp ed back ward as the angle of attack is increased Fig. 112. Induced drag is greatest during low airspeed beca use of the large angle of attack. As speed increases the angle of attack decreases and so does induced drag. Aspect ratio affects induced drag. The aspect ratio is the ratio of the span to the mean chord Fig. 113. The greater the span of an aero foil in relation to its chord, the less the induced dr ag. A long ae rofoil with a relatively narrow chord is ca lled a high aspect ratio wmg. Parasite Drag. This is drag made upof all other drag on the aircraft that is not caused by lift. Unlike ind uced drag, parasite drag increases as the speed mcr c ase s.Interference drag is a result of the interference of airflow between two sections of the air craft. For example. where the wing and fuselage come together air flowing alongthe fuselage will interfere with the air flowing over the wing. Profile Drag. Profile drag consists of f orm drag and skinf riclion. Form Drag. Form Drag is caused by the form or shape of a body as it resists motion through the air. Streamlining of all part s of the aerop lane that are exposed to the air will greatly reduce this type ofdrag. Skin Friction. Skin friction is the tendency of air to hold an aircraft back by clinging to its surfaces. A smooth and highly polished aircraft will be affected Equilibrium Basic Principles ofFlight 9 A body at rest tend s to remain at rest and a body in Yaw, Rudder, Normal Vertical Axis motio n tend s to remain in motion in a straight line unless an externa l force is appl ied. Thi s is Newlons The left or right movement of the nose of an airc raft First Law of Mot ion.

A body that is neither acceler in fligh t is contro lled by the rudder, through the rud ating nor decelerati ng may be said to be in eq uili b der pedals. The rud der is hi nged to the trail ing edge rium. A parked air craft is in equilibrium; an aircra ft of the fin vertical stabilizer. Foot pressure o n the in straig htandlevel flig ht at a constant airspeed is in left rudder peda l ca uses the rudd er to move to the left eq uili brium; an aircraft in a straight descent or cl imb and introd uce camber to the fin; thi s causes a mass at a co nsta nt airspeed is also in equilibri um. However, of air to be accelerated to the left whi ch Newtons an aircraft in a turn at a co nstant height and airspeed Third Law moves the tail of the aircraft to the right is not in equilibrium, since duri ng a co ordinated turn and ca uses the no se to yaw move to the left. Op po the aircraft is alway s accelerati ng toward the centre of site reactio ns occur whe n pressure is ap plied to the the turn.However, a pilot must be able to di sturb this equ ilibrium to manoeu vre the Lateral aircra ft. Flight co ntrols allow a pilot to produce force s axis abo ut the three axes of the aircr aft Fig. 115. These forces di sturb the aircraft s equ ilibrium and allow the aircraft to be manoeuvred. Roll, Ailerons, Long itudina l Centre of Gravity Longitudinal Axis axis When an aircraft is roll ed, one aileron is depressed Figure 115 The Axes of an Aeroplane and the opposite one is rai sed.When the co ntrol preces sion,torque, slipstream, and asymmetric thrust.Flight controls are des igned to be rolls to the left.For example, if a turn to the left is Lateral Axis desired, movement of the control column to the left causes Lhe right aileron to move downward and Backward movem ent of the control co lumn o r wheel increase the camber of the right wing, causing that raise s theelevators. This change s the camber, prod uc wing to develop more lift and rise up Fig. 1 16.

ing a forc e that causes the tail to go down and the Conversely, the left ailero n moves upward and nose to rise. Forward movem ent of the control lowers decreases the camber of the left wing, causing that the elevators; this prod uces the opposite reaction, rais wing to develop less lift and move down. However, in ing the ta il and lowerin g the nose. The whole effec t cau ses a mome ntary yaw to the righ t, when a had been applied in the same direction at a point 90 turn to the left is des ired.This is called gyroscopic precession.When cession. Gyroscopic effect of this kind can sometimes aileron drag causes the aircraft to yaw. The rudder pressure It is as though the pilot had reached out and applied required will vary and is necessary only while aile ron the force to the propeller at the top of the arc. If the co ntrol is bein g applied. When aileron pressure is pro pelle r rotates cloc kwi se.In most aircra ft of recent man ufact ure, using o ne or a co mbination of two design features partly com pen sates for ai leron dr ag. Differential a ilero ns are designed to cause the downgoing aile ron to move throu gh a smalle r angle than the upgoing ai leron for a given movement of the co ntrol co lumn. The upgoing aile ron prod uces more drag and helps to minimize adve rse yaw. Frise aileron s produce a similar effec t by plac ing the hinge such that the nose of the upgoing aileron projects into the airflow beneath the wing and produces extra d rag.Gyroscopic Precession. When a force is applied to a spinning gyro wheel. Brakes On many aircraft eac h main landing wheel has its own Torq ue. The e ngine rotates the prope ller in o ne indepe ndent braking system to faci litate manoeuvri ng direction, bu t in so doi ng, and in obe dience to New o n the ground. Pressure applied to the left brake pedal brakes wise, a downward force is bei ng exerted o n the left the le ft wheel and turns the aircraft to the left; pres side of the a ircraft.

To bring an aircraft to a straight stop, Unde r co ndi tio ns of hig h powe r while the aircraft eq ual o r near equal pressur e must be applied to each is on the ground, torqu e will ca use the left wheel to brake pedal.This will Trim Tabs prod uce more friction or drag on the left whee l and To improve control and balance trim of an aircraft, add to the tendency of an aircraft to yaw to the left small auxiliary control surfaces called trim tabs are on the takeoff roll.It sho uld be noted that torqu e doe s not directl y cause yaw. Slipstream. The mass of air thrust back ward by the propeller is ca lled the slipstream. It is rou gh ly the size of a cylinder of the same diameter as the propeller. The veloc ity of the slips trea m is g reater than that at whic h the aircraft is trave lling thro ugh the air. Th is mea ns that the ve loci ty of the air flow ing over those part s of the aircra ft in the slipstream wou ld be much mo re than that of the airflow over parts not in the s lips t re a m. The prop eller impart s a rotar y motion to the slip strea m in the same di rection as the propell er is turn ing. This balance is upset when the engine power is changed above or be low cruise power settings Fig. 119. Asymmetric Thrust. Ad verse yaw is also caused by the asymmetrica l loadin g of the prope ller. When an aeroplane is flying at a high angle of attack with the prope ller axis incli ned and with high power seui ngs, the downward moving blade, which is o n the right side of the propel ler as seen fro m the cockpit, has a higher ang le of attack and there fore prod uces more thrust than the upward moving blade on the le ft. Hinged tabs are controlled by the pilot. Larger air c craft, for the most part, have hinged tabs fitt ed to all c con trol surfaces to compensate for lateral shifts in loading and to provide additional rudder control in the Zopftap event of an engine failure on mult iengined aircraft.

In the case of most small singlee ngined aircraft, such as those used for flight traini ng.Elevator trim compensates for the constantly changing longitudinal stability resulting fro m varyi ng attitudes of flight. Fixed trim tabs. if fitted, are normally adequate for the lateral aileron and directional rudder stability and control of this class of aircraft. Variable Incidence Tail Planes Horizontal Stabilizer On some aircraft the incidence of the tail plane can be varied in flight to trim the aircraft longitudi nally. The effect is much the same as trimmi ng the elevators on an aircraft with a f ixed tail plane. Sta lling speed is decreased. Stability 2. A steeper approach to landin g can be made with A stable aircraft is one that tends to return to its orig out an increase in airspeed.The stability of an aircraft concerns its three landi ng due to the lower position of the nose.The plain flap is actua lly a portion of the main aero and in the yawing plane, directional stability. foil. incl udi ng upper and lower surfaces, which hinge downward into the relative airflow. However, in the Lateral Stability. One design feature that provides case of more sophisticated artic ulated flap systems stability in the rolling plane is dihedral. This is a wing Za p and Fowler arc typical exa mples, there is an design feature in which the wing tips are higher than effective increase of the chord of the aerofoil.When flaps arc fully retracted up they conform to the shape of the wing. Flaps must be used j udici ously at all times but extreme ca re must be taken when retr acting them in flight espe cia lly near the ground beca use of the sudden loss of lift and change in the aircraft s balance.Of all the characteristics that a irc ra ft.Because of its distance from but this stability is also influenced by changes of the Ce ntre of Gravity, which gives it great leverage, even a small force on the tail plane will produ ce a large correc ting moment.

Dihedral causes a slip or a skid to produce a roll Slip toward the lower wing More lift produced by the lower wing 0 Figure 121 Dihedral Keeps the Aircraft Level 14 Basic Principles ofFlighl vertical i ft Mu ch like the tail feathers on an arrow, the tail 200l es.Outsid e influ Figure 122 Load Facto r In 60 Degree Ba n ked ences and forces may be likened to unco ordinated use Tum of the fli ght co ntrols, to which a stable properly trimmed aircra ft will al so offer resistance. A stable facto r rise s as it approaches the 90 degree bank line, aircraft will not attempt to co unterac t force s inten which it reaches only at infin ity.Th erefor e, although an ai rcraft may be banked to 90 degrees, a constant alt itud e t urn with th is amo unt Direct iona l Stabi lity. Directional stability conce rns of bank is mathematically impossi ble for co nvent ional the motion of th e aircraft about th e normal axi s, or aircraft. At slightly more th an 80 degree s of ba nk the the yawing mo tion o fthe airc raft. An automobile has load fact or exce eds 6 G s, whi ch is ge nerally the fli ght a d irecti o nal sta bility that can be see n every tim e th e load factor limit o f aircraft structurally designed fo r ca r turns a co rner. Aft er th e turn is mad e and th e acro batic fli ght. For conventional light aircr aft, th e steering wheel rel eased, th e wheel s straighten and the ap proxi ma te maximum bank, in a sustained leve l co car moves in a stra ight direct ion. Th is is direct ional or dinated turn, is 60 degrees. An addi tional 10 degr ee s sta bil ity. Th e vertical stab ili zer co ntrib utes to the o f bank will inc rea se th e load fac tor by approxima te ly directi on al stab ili ty of an aircra ft. I G, bri nging the load ing close to th e point at whi ch str uctura l damage may occur.

Load Factors 9 An y forc e applied to an aircraft to deflect its fli gh t from a straight lin e produce s stress on it s structure, 8 the amount o f whic h is termed a load fa ctor. Lo ad facto r is the rati o of the load suppo rted by the ae ro 7 pl anes wi ngs to th e ac tual wei ght of th e airc raft and its co ntents. Eo 6 J A load factor of 3 means that the total load on an to aircraft s structure is 3 times its gross weight. A load factor I of 3 is usually spoken of as 3 Gs. Thu s,aroughestima teof 2 the load factor obtained in a manoeuvre ca n be made by considering the degree to which a person is pressed down 1 in the seat.Bank angle in degrees Fig. 122 shows an aircraft ban ked at 60 degrees. Degrees of Bank at Co nstant Altit ud e Th e aircr aft we ight is 2,000 pounds 907 kilogr am s. Th e ratio of total lift to weight is 2. So we say the load facto r is 2. Fig. 123 reveals an important fact about turns the load factor increases at a trem endou s rate afte r the bank has reached 50 degrees. It is important to remember that the wing must prod uce lift equ al to the load facto r, otherwi se it will be impo ssible to main tain altitude. Withi n the limit s of its structure and Turbulen ce the physica l stre ngth ofthe pilot.Aircraft are de signed to take gust loads of consi der able inten sity. Gust loads represent loa di ng im pose d Th e stalli ng spee d of an aircraft incre ases in pro upon an aircr aft, particularly the wings, as a result of porti on 10 the lo ad factor. If it were defi nition, gust load factor is an acceleration imposed possibl e to impose a load factor of 9 G s upon this upo n an airc raft flow n into a gust. Gust load fa ctors air craft, it cou ld be stalled at 150 KT.

Th is knowl ed ge increase as airspeed increases in moder ate or extreme must be app lied from two poi nts of view I the da n turbulence, suc h as may be encountere d near th un ger of unintentio nally sta lling an aircraft by increasing derstorms or fron tal weather cond itio ns, it is wi se to the load factor, as in a stee p turn or a spiral; 2 the reduce airspe ed to the manoeu vring speed spec ified tremendous load factor imposed upon an aircraft when for the aircra ft. Th is is the speed least li kely to perm it it is intentionally stalled above its manoeu vring speed.Abrupt or exce ssive deflection of the flight controls Abrupt manoeu vring or high di ving speeds in tu rbu can impose severe structural loads upon an aircraft, len t air at airspeed s above the speci fie d manoeuvri ng and these load factors are direc tly pro portiona te to the speed can place dama ging stresses o n the whole struc aircrafts speed. This type of loading may occur when ture of an airc raft.The cumulative effe ct of Flight Man ual of a part icular aircraft.Load factors can be measured by certain instruments, but since the se instrumen ts are not com CHAPTER TWO Weight and Balance Centre of Gravity even though the maximum permissible overall weight is not exceeded. For example. if the fuel load of a It is the responsibility of the pilotincommand to load four place aircraft is reduced to remain within maxi the aeroplane in accordance with the weight and bal mum permissible takeoff weight.This lightweight people are placed in the forward seats, two information limits the maximum load that can be car very heavy people are placed in the rear seats, and the ried. It also limits the placement of the load within aft luggage compartment is loaded to its maximum the aeroplane. In order to do this.

An aircraft so loaded could have mand must ensure that the weight is below the gross such an excessive aft Centre of Gravity that the pilot weight of the aeroplane and the Centre of Gravity is would have control problems beginning from takeoff.Should an aircraft with excessive aft loading To simplify loading problems, most manufacturers be permitted to enter a spin.Of prime interest to the pilotincommand is the useful The Centre of Gravity for each aircraft is calculated load an aircraft can carry. In light aircraft. useful load at the factory and recorded on the weight and balance consists of crew. passengers. baggage. usable fuel and report. The method used to find the Centre of Gravity oil.The weight of the basic It is imperative, for optimum control response and aircraft.You can seriously affect the controllability of your air 2. Basic Empty Weight. The weight of the basic craft by positioning the load incorrectly. If the Centre aircraft.The maximum controls. If the Centre of Gravity is permi tted to go permissible gross takeoff weight specified in the air beyond the forward limitations.Careless aft loading can lead to very hazardous balance and control problems, 16 Weight and Balance 17 passenger weights must be used for aircraft with lim in front of the nose. To avoid negative numbers, ited seating capacity. Light aircraft can easily be most aircraft balance datums are situated so that all loaded outside lim its when estimat es or average useful loads are positioned aft of the balance datum.If in doubt, ask passengers how much they ance datum.The maximum permissible weight must never be Concerning the proposed load, the pilotincommand exceeded.Curre nt weight and balance data should be carried as part of the aircraft documentation; unless I. The balance moment of the empty aircraft is found loaded in accordance with this information, the air by multiplying the empty weight by the moment craft cannot be considered airworthy. In addition, it arm of the aircraft.

The information on these by multiplying its weight by its respective moment placards must be observed scrupulously. arm. Weight and balance limitations are imposed for the 3. The new Centre of Gravity is found by dividing following principal reasons the total balance moment by the total weight of the I. The effect of the disposition of weight and sub aircraft.A sample weight and balance slow flight, and stability.The 30 200 items of informatio n ava ilable o n the Weigh t and 1,420 20 Balance Report are 38,900 I. Empty weight, in pounds, Metric Version Wei ght Moment Balance 2. Balance Datum. This is the reference point from Arm Moment Aircraft empty kg kgmetres which all weight and balance calculations are Pilot metres made. It could be anywhere on the aircraft, pref Passenger 453.6 345.6 erably somewhere forward of the Centre of Gravity. Fuel 77.1 0.762 39.0 It could even be a point in open space several feet Oi l 86. 2 0.508 43.6 22.7 0.508 17.3 0.762 4.5 0.508 2.3 644.1 447.8 18 Weight and Balance Metric Version The new Centre of Gravity is 27.4 inches 0.695 m Aircraft empty Weight Moment Balan c e aft of the balance datum. The example 185 LB each 140 above uses a balance datum somewhere aft of the nose One passenger 120 36 9,BOO to illustrate a minus item; in this aircraft the oil in fear seat 330 11,400 reservoir is forward of the balance datum and therefore Baggage 70 must be shown as a minus quantity on the total scale Fuel, 55 US g als. 15 95 15,840 of balance. If they are not, the aircraft should not be considered airworthy until satisfactory adjustments are made. CHAPTER THREE Engine Handling A typical fourcylinder aircraft engine has over 250 of fuel from the fuel strainer drain into a suitable glass moving parts and 70 nonmoving parts. The failure of container. Make sure that the fuel is free of water and any part may result in a complete loss of power, or sediment. Look for oil and fuel leaks.

Physically sufficient power loss to require an immediate landing.Check the propeller and and parts, a high degree of quality control is achieved, spinner for nicks and security. If in doubt concerning resulting in the aircraft engine being one of the most damage to any part of the aircraft, cheek with your reliable mechanical components in use today. Whether flight instructor or an Aircraft

Maintenance Engineer.Besides its flight operation, that can be done to ensure that it will perform the handling of an engine includes the use of rec properly ommended fuels and oils, preflight inspections, and a basic knowledge of how an engine and its ancillary I. Verify the fuel supply by a physical check of the components work. Since it represents the majority of fuel tanks.In most cases, Inspection if a cap comes off in flight, the contents of the tank will empty rapidly through the filler neck, due Before any flight the pertinent logbooks are studied to the syphoning action of the airflow.The engine oil can be is of higher viscosity than that used in most other checked for acceptable level and the carburettor air engines and becomes very thick when cold. With filter checked for obstructions. Drain a small sample the ignition switch off and mixture control in idle cutoff position, turn the propeller by hand for sev eral revolutions to help break the drag created by cold oil between the piston and the cylinder wall. This will ease starting and reduce the load on the starting mechanism and battery. The primer draws filtered fuel from the fuel system and injects a fine facilities are available, because condensation and spray directly into the engine intake ports. This system flakes of rust are often present in the drums. Since is useful particularly for cold weather starts when fuel most of the foreign material settles to the bottom is difficult to vaporize.A chamois strainer primers are should be used, since it not only removes solids but also resists the passage of water.