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Pilot Zulu's

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ISBN 0-9770768-0-6
9 780977 076802
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Pilot Zulu's
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CONTENTS:

Pilot Zulu's Quick Reference for Pilots

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A licensed Private Pilot in the United States and in Australia

Artwork created by Claude Bordeleau / Artizans.com
Published by PilotZulu Corporation

Wilbur, E. Packer.
Pilot Zulu's quick reference for pilots / E. Packer Wilbur ;
artwork created by Claude Bordeleau. -- Southport, CT : PilotZulu,
c2007.
p. ; cm.
Includes an E6B circular flight calculator, a transparent
compass rose and plotter, scaled rulers, and a rotating pattern
indicator.
ISBN: 0-9770768-0-6
ISBN-13: 978-0-9770768-0-2
1. Airplanes--Piloting--Handbooks, manuals, etc.
2. Aeronautics--Study and teaching. 3. Flight training. I. Bordelau,
Claude. II. Title.
TL710 .W55 2005
629.132/52--dc22 CIP

PilotZulu P O Box 527 Southport, CT 06890 USA
www.PilotZulu.com

INTRODUCTION

Juliet and **Zulu** are both Master Flight Instructors. They will guide you through this book which is an essential reference summarizing the basic knowledge used by Private Pilots to fly under visual flight rules (VFR) worldwide. It is written not only for Private Pilots, Sport Pilots and flight students, but for everyone who is interested in learning about flying an airplane. It also serves as a convenient reference for licensed pilots who need to stay current.

Juliet and Zulu have designed this **Quick Reference** to explain complicated concepts in a logical way which will make learning straightforward and as easy as possible for the reader who is encountering the material for the first time. Concepts which are thoroughly understood, rather than just memorized, are much easier to apply in practice and to retain.

The light hearted, jargon free, approach is intended to make the knowledge less formidable and to make the presentation attractive to younger readers and to the non pilot.

The material is condensed and organized so that a substantial amount of information is contained in just a few pages making it easy to find and review specific items. For more detail and much more extensive explanation, the reader is referred to the several excellent and very well written Federal Aviation Administration (FAA) publications covering similar topics. The Aircraft Owners and Pilots Association (AOPA) has excellent instructional material on its website www.AOPA.org.

Any errors or misstatements can be laid at the feet of Juliet and Zulu or, possibly, those of the writer.

AUTHOR'S NOTE

Several years ago, I came down with a bacterial infection, Strep A, which moved rapidly to toxic shock and a probable fatality rate exceeding seventy percent. I was one of the lucky ones. Laura, my wife, called 911 at 7:00 AM New Year's Day and Bridgeport Hospital in Connecticut and its dedicated staff saved my life. My three children, Alison, Andrew and Gillian flew in from all over the globe and were there every possible hour for an entire month monitoring and improving my care and keeping me company.

Toward the end of my stay in the hospital; my children asked me if, on reflection - having just avoided sudden death, there was anything I might change if I could live my life over again. I didn't have to think about this for very long because I already knew that there were many things I might have done differently or anew. One of the more minor items which came to mind, though, was that I had always wanted to learn to fly an airplane. A year later, during a trip to Australia to visit Gill and her husband Peter, they gave me two introductory flying lessons at the local airport. These first two lessons were great fun and I was hooked, signed up for more, and eventually passed the various exams and my flight test.

As I did my first flights and studied the available flight training literature, I realized that there was no reference available which briefly summarized the basic knowledge needed by a pilot and explained it in a way which answered the logical questions which come to mind when the material is first encountered. Since I was still recuperating from the infection, I had some unplanned leisure so I sat down at the computer and began to write **Pilot Zulu's** Quick Reference for Pilots.

A very large amount of assistance and wise counsel was provided by David H. Faile, Jr., Master Flight Instructor and 1999 National Flight Instructor of the Year; Wallace J. Moran, Master Flight Instructor and FAA Designated Pilot Examiner; and Anne R. Jackson and David O. Jackson who fly, instruct in and build airplanes and gliders. The essential elements of good judgment and common sense were provided by Laura M. Wilbur.

E. Packer Wilbur
July, 2007

AERODYNAMICS

Okay, what is a constant speed propeller?

THE ATMOSPHERE: The atmosphere or air is a layer of gases which surround the earth. The greater mass of the earth attracts and holds the gases close to the surface through the force of gravity. These gases form a fluid with mass or weight. Since air is a gas it can be compressed or expanded and, when compressed, it becomes more dense. A high column of air will be heavier, under more pressure, and thus more dense than a lower column. Given a constant temperature, doubling air pressure will double the density. Air at a lower temperature has higher density and dry air is more dense than moist air.

As an aircraft gains altitude, air pressure and density decrease. Conversely, air is colder and thus more dense as altitude increases but the rapid drop in pressure offsets the change in temperature, so density usually decreases with altitude. Reduced density affects aircraft performance by reducing the power of the engine as it takes in less air, by making the propeller less efficient, and by reducing lift.

AN AIRFOIL (AEROFOIL IN BRITISH ENGLISH): A foil is a surface designed to maximize lift in a fluid while minimizing drag when there is relative motion between the foil and the fluid. Lift is the force generated perpendicular to the fluid flow or the motion of the foil while drag is the force generated in the direction of the flow of fluid or opposite to the motion of the foil. A flat plate set at an angle to the flow of a fluid will deflect the flow and create lift and drag. If you put your hand out the window of a rapidly moving car and hold the palm at an angle into the wind, you will feel the lift and also the drag.

A curved airfoil with a concave lower surface which is often used in kites will produce a very large amount of lift but also substantial drag. Achieving an appropriate lift/drag ratio for the planned use of the airfoil is important and, accordingly, the minimizing of drag at the design speed is critical to the design of an airfoil. In small and relatively slow general aviation aircraft, the airfoil or wing is curved at the top and nearly flat on the bottom, tapering from a thicker cross section at the front to a very thin cross section at the rear. A typical cross section is shown on the next page.

A small general aviation aircraft will have an L/D ratio of about 7/1 and, without power, will glide forward about seven feet for every foot lost in altitude. Some jet airliners with a more efficient wing have an L/D ratio of 15/1 but at a higher speed. A modern sailplane may have an L/D ratio of 30/1 or greater but the design speed is very low.

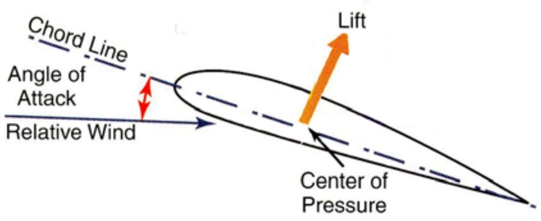
As an airfoil achieves velocity through the air, lift is created by a combination of forces acting on the airfoil. The pressure of the air against the bottom of the airfoil usually provides a portion of the lift. Other sources of lift are explained by Bernoulli's principle and by Sir Isaac Newton's Third Law. Daniel Bernoulli, an 18th century Dutch-Swiss mathematician, showed that high speed fluid flow results in lower pressure on surfaces parallel to the flow. The related Coanda Effect named for Henri Coanda an early 20th century Romanian engineer, states that a fluid stream will follow a surface that curves away. Accordingly, the curved upper surface is designed to accelerate airflow over the top surface and deflect it downwards at the rear. The reduction in pressure at the top of the airfoil caused by the accelerating airflow creates lift. In addition, the downward deflection of air, following Newton's Third Law, which states that for every action there is an equal and opposite reaction, results in a matching upward force on the airfoil. The relative amounts of lift generated by these factors vary with airfoil design and with the speed and purpose of the aircraft for which it is designed.

Jet passenger aircraft, small general aviation aircraft, supersonic fighter planes and stunt aircraft each require substantial variations in airfoil design. The Wright brothers tested more than 200 airfoil shapes in a wind tunnel of their own devising before their first flight in 1903. The shape of an airfoil can be varied in flight through the use of leading edge (Kreuger) flaps and trailing edge (Fowler) flaps. Such flaps make the airfoil more convex in order to create greater lift in slow flight.

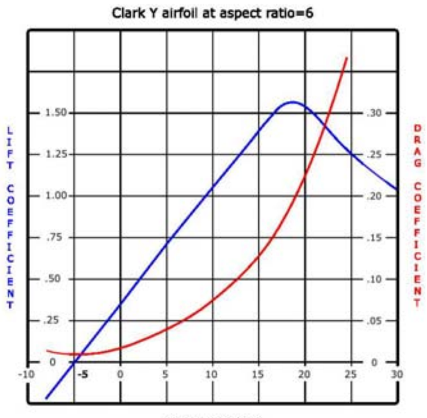
Airfoil design and the related physics are extremely complex and if a brief description such as this could be completely definitive there would be no need for aeronautical engineers.

ANGLE OF ATTACK: in aviation, the angle of attack is defined as the acute angle between the chord line of the airfoil and the direction of the relative wind (fluid flow). The chord line is an imaginary straight line drawn through an airfoil from the leading edge to the trailing edge.

The drawing to the right is the cross section of an airfoil diagramming the relationship between the chord line, the angle of attack, and the relative wind or airflow. It also shows the center of pressure or lift.



Changing the angle of attack alters the flow of air over and around the airfoil which causes changes in the amount of lift and in the amount of drag. In general; when the angle of attack is increased, and the airfoil is at a greater positive angle to the relative airflow or wind, more lift is generated and drag increases.



(Wikipedia)

As speed is reduced, the flow of air over the airfoil decreases thereby reducing lift. To counteract this, the angle of attack is usually increased to provide additional lift. As the angle of attack is increased; a critical angle is reached, usually between 16º and 20º, where the airflow will become disturbed or break away from the airfoil and lift will decrease.

The chart to the left shows that for a particular type of wing, the Clark Y airfoil, lift increases as the angle of attack increases until the airfoil stalls or loses lift at an angle of about 18º.

Juliet notes that small general aviation aircraft often have a slightly twisted wing so that the inner portion has a higher angle of attack than the outer end. This is done so that the inner, wing root, portion of the wing will stall first, with the stall progressing outward along the wing, allowing aileron control at higher angles of attack thus giving the aircraft more stable stalling characteristics. Remember that ailerons are normally attached to the outer portion of each wing.

An aviation stall is defined as a rapid decrease in lift caused by the separation of airflow from the wing's surface brought on by exceeding the critical angle of attack. The direct cause of every stall is an excessive angle of attack. A stall can occur at any pitch attitude or airspeed.

A stall can occur in low speed straight and level flying. As power is decreased, the aircraft will begin to slow and lose altitude. The pilot may compensate by pulling the nose up to increase the angle of attack in order to increase lift and maintain altitude. Continuing to pull the nose up will eventually cause the angle of attack to reach the critical angle for that airfoil and the aircraft will stall as the airflow over the wing is disrupted and it loses lift. If the pilot does not continue to pull up, lift will decrease as speed decreases toward stall speed and gravity will begin to pull the aircraft down. The slowing forward motion and increasing downward motion will shift the source of the airflow further below the front of the wing, thereby increasing the angle of attack to the critical point and causing the wing to stall.

An aircraft can also stall at high airspeeds. For example, an aircraft in a 200 knot dive can stall if the pilot pulls back too sharply on the elevator control and causes the angle of attack to exceed the critical angle. This will disrupt the airflow over the wing and result in a stall and loss of lift. Similarly, a stall can occur at higher speeds in turning flight as the pilot applies back pressure to the elevator control to counterbalance the load created by the combination of centrifugal force and weight. More information on load factors and stalling in turning flight is contained in this **Reference** on page 2 of **AIRCRAFT PERFORMANCE** and in the Pilot Operating Handbook (POH/AFM) for the particular aircraft.

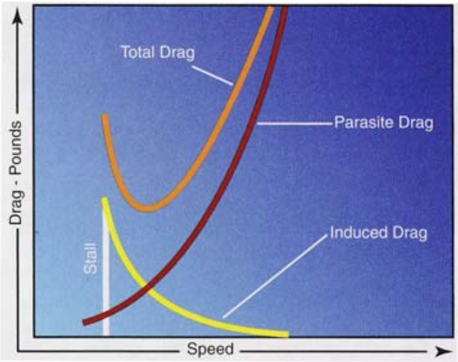
An aircraft will stall at a specific critical angle of attack regardless of airspeed, weight, load factor, or density altitude. An increase in weight or load factor will increase the airspeed at which a particular aircraft will stall but the critical angle of attack will remain the same. For instance, an aircraft which will reach its critical angle of attack of 18º and stall at 40 knots with a pilot and two passengers, will reach that critical point at a higher speed if two more passengers are added. Higher altitudes also increase the stall speed (without changing the critical angle of attack) but the situation is complicated by related changes in indicated airspeed and, in the case of faster aircraft, the compression of the air.

Changes in the angle of attack will alter the center of pressure of the airfoil. The definition of the center of pressure is a point along the wing chord line where lift is considered to be concentrated. This point is also called the center of lift and is shown on the airfoil drawing on the prior page. Generally, if the angle of attack is increased, the center of pressure moves forward. Correspondingly, if the angle of attack is decreased, the center of pressure moves aft or rearward. Since the center of gravity of the aircraft is fixed at one point, changes in the relative position of the center of pressure or lift will pitch the aircraft up or down. For example, an increase in the angle of attack will move the center of pressure forward relative to the center of gravity which will increase the angle of attack even more. The opposite occurs when the angle of attack is decreased. These factors make an ordinary airfoil unstable and explain why a horizontal tail surface or a forward horizontal canard wing are necessary to make an aircraft balance longitudinally.

FORCES ACTING ON THE AIRPLANE: The forces acting upon an aircraft are Thrust, Drag, Weight, and Lift. It is the balance between these forces that the pilot controls. **Thrust** is the forward force provided by the power-plant/propeller or jet engine. **Drag** is a rearward, retarding force acting parallel to the relative wind and is caused by disruption of the airflow by the wing, fuselage, and other protruding objects. **Weight** is the combined load of the aircraft the crew, fuel, and cargo being pulled downward by the force of gravity. Weight opposes lift and acts vertically downward through the aircraft's center of gravity. **Lift** is an upward force created by the effect of airflow as it passes over and under the wing. Lift acts perpendicular to the flight path through the wing's center of lift.

In general, in straight, level, unaccelerated flight, the opposing forces of lift/weight are equal and the same is true of thrust/drag. In small general aviation aircraft, the lift/weight forces are greater than the thrust/drag forces. If an aircraft is not flying straight, level and unaccelerated, then each of the four forces must be broken down into two components. For example, in a climb, a portion of thrust is acting as lift and a portion of weight is acting as drag. In a glide, a portion of weight is acting as thrust.

Drag is broken down into two categories, parasite drag and induced drag. Parasite drag consists of form drag, skin friction and interference drag. Form drag (usually the largest component of parasite drag) refers to the aerodynamic or streamlined shape of the aircraft, skin friction is self explanatory and interference drag is the turbulence created by adjacent parts of the aircraft. Induced drag is the drag created by the wing in the process of providing lift. An increase in the angle of attack increases induced drag. Wingtip vortices where air flows from high pressure areas under the wing to low pressure areas above the wing are also a source of induced drag. These vortices circulate counterclockwise around the right wingtip and clockwise around the left wingtip.



For the technically minded, parasite drag increases as the square of the airspeed and induced drag varies inversely as the square of the airspeed. What this means is that as speed increases, induced drag from the wings becomes a smaller portion of total drag and parasite drag becomes correspondingly larger.

The chart to the left shows the relationship of induced drag, parasite drag, total drag and airspeed. The airspeed which results in the lowest total drag yields the lowest fuel consumption and best endurance.

To accelerate, all the forces acting as thrust must exceed all the forces acting as drag. To climb, all the forces acting as lift must exceed all the forces acting as weight. In both cases, the converse is true. The pilot will adjust the angle of attack to balance lift and weight and adjust power to balance thrust and drag. In low speed flight, the angle of attack is increased to provide more lift. In higher speed flight, the angle of attack can be reduced because lift is proportional to the square of the aircraft's velocity. An aircraft traveling at 200 knots has four times the lift of the same aircraft traveling at 100 knots assuming the angle of attack and other factors remain constant.

PROPELLERS: A propeller is an airfoil and operates like a rotating wing following the principles earlier described. A propeller will have two or more blades rotating around a central hub. US built engines usually rotate propellers clockwise as viewed from within the aircraft. Training aircraft normally have **fixed pitch** or ground adjustable propellers whose pitch cannot be changed once the aircraft is flying. Because the pitch is fixed, this type of propeller is necessarily a compromise and will not be as efficient as possible at any of the stages of flight; takeoff, climbing, cruise or high speed.

Since the propeller tip travels much faster in rotation than the portion of the propeller near the hub, relative wind angles will differ at different points along the blade. To allow for this, propellers are twisted and the thickness varies from hub to tip with the greatest angle of incidence or pitch at the hub, allowing operation with a relatively constant angle of attack along the entire blade.

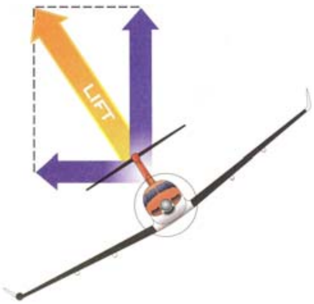
A **constant-speed** propeller, in contrast to a fixed pitch propeller, automatically keeps the blade angles adjusted for maximum efficiency during the different stages of flight. During takeoff, where maximum power and thrust are needed, the constant-speed propeller is at a low blade angle or pitch. This keeps the angle of attack small and efficient with respect to the relative wind. Since the propeller is handling a smaller mass of air on each revolution, the engine can turn at a high RPM, creating maximum thrust. During climb and again at cruising altitude, the pilot reduces the power output of the engine by decreasing manifold pressure and then increasing the blade angle to lower the RPM. The higher blade angle and higher airspeed enable the propeller to work more efficiently, handling a greater mass of air per second at smaller velocity.

Manifold pressure is the absolute pressure of the fuel/air mixture within the intake manifold which is being delivered to the combustion chamber. Manifold pressure is usually measured in inches of mercury. This pressure is directly related to the amount of power being produced by the engine. When the throttle setting is increased, more fuel and air will flow to the engine and manifold pressure will increase correspondingly.

CONTROL SURFACES: The primary control surfaces are the **ailerons, the rudder and the elevator (or stabilator)**. They are the control systems which are required to safely control an aircraft during flight.

The **Ailerons** are attached to the outboard trailing edge of each wing and are linked so that they move in opposite directions. When one aileron is up, the other is down. The use of the terms “up” or “down” are in relation to the sitting position of the pilot and not to the ground. This is to avoid confusion in steep banked turns and in more advanced maneuvers such as inverted flying. Moving the stick or control yoke to the right causes the right aileron to deflect upward and the left aileron to deflect downward. The upward deflection of the right aileron decreases the camber of the right wing reducing the lift of that wing while the corresponding downward deflection of the left aileron increases the camber of the left wing thereby increasing its lift. As a result, the aircraft will roll or bank to the right along its *longitudinal axis*. Since the left aileron is now providing more lift, it is also causing more drag which will tend to “yaw” the nose of the aircraft to the left, away from the turn.

The aircraft turns because, as it rolls or banks, total lifting force becomes the resultant of two components as shown in the diagram to the right. The vertical lift component continues to act perpendicular to the earth and opposes gravity. The horizontal lift component acts parallel to the earth’s surface to oppose inertia or centrifugal force. These two lift components act at right angles to each other, causing the resultant total lifting force to act perpendicular to the banked angle of the aircraft thereby causing the aircraft to turn in the direction of the bank. Unlike a boat, the rudder is not often used to turn an aircraft except for making miner corrections to the compass heading.



The **Rudder** is a moveable vertical surface hinged to the trailing edge of the vertical stabilizer or fin at the rear of the aircraft and rotates the aircraft around its *vertical axis*. The rudder is manipulated with foot pedals; pushing forward with the left foot moves the rudder to the left (left rudder) and vice versa. Often the aircraft’s brakes, used when taxiing on the ground, are at the top of the same foot pedals. The rudder is used to counteract the adverse “yaw” described above, where the lift created by the left aileron is also causing increased drag and moving the nose to the left, around the vertical axis, and away from the turn. If the use of the rudder, in this case tilted to the right (right rudder), is coordinated with the movement of the ailerons; the yaw will be prevented. This is referred to as a coordinated turn. Most aircraft have either a turn and slip indicator or a turn coordinator each of which contains an inclinometer which is a liquid filled glass tube with a ball inside. A skillfully coordinated turn will keep the ball centered in the tube.

The aircraft is also affected by several forces which create a tendency to turn to the left, assuming a clockwise rotation as seen from the cockpit, and right rudder is used to correct this. The effect is especially pronounced during the takeoff run. The forces vary in effect depending on the aircraft size, design, type of engine, horsepower, propeller, RPM, and type and condition of the ground surface. They include the torque reaction from the engine and propeller, the corkscrewing effect of the slipstream and its affect on the airframe and on the rudder, the gyroscopic action of the propeller, and the asymmetric loading of the propeller (P factor).

The rudder is also used to "slip" the aircraft where, if the aircraft is banked to the right the rudder is tilted to the left (left rudder) in order to lose altitude quickly. In a crosswind landing, the rudder is sometimes used to slip the aircraft in what is called the "wing-low" method to keep lined up with the runway while the wind is tending to move the aircraft sideways. To accomplish this, the wing closest to the crosswind is held low using the ailerons and the rudder is tilted to the opposite side, thus slipping into the wind but maintaining alignment with the runway. Slipping an aircraft can lead to a sharp and sudden stall if appropriate airspeed is not maintained. More information on this subject is contained in this **Reference** on page 2 of **EMERGENCIES** and in the Pilot Operating Handbook (POH/AFM) issued for each aircraft.

The **Elevator** is a horizontal, movable control surface hinged to the trailing edge of the horizontal stabilizer, usually at the rear of the aircraft, and it controls pitch by moving the aircraft through its *lateral axis*. Some aircraft use a **Stabilator** instead of an elevator. This is a one piece, movable horizontal tail surface which pivots around a central hinge point and serves as both horizontal stabilizer and elevator. Both types of control are manipulated by moving the stick or control yoke forward or back and act to decrease or increase the angle of attack during the different stages of flight.

Zulu cautions that even moderate winds can cause difficulty for small light aircraft taxiing on the ground and control surfaces must be adjusted. With a wind from the left front, use up aileron on the left wing and neutral elevator. With wind coming from the right front, use up aileron on the right wing and neutral elevator. For wind from the left rear, use down aileron on the left wing and down elevator. For wind coming from the right rear, use down aileron on the right wing and down elevator.

Secondary control surfaces such as **Flaps** and **Trim Tabs** improve the performance characteristics of the aircraft or relieve the pilot of excessive control forces. **Flaps** are usually attached to the trailing edge of the wing inboard of the ailerons and are used to increase the curvature of the wing and increase both lift and drag. They are most often used when the aircraft is slowing and preparing for landing. Usually the flaps are extended in two or more stages, indicated as degrees of flap such as 10º, 25º and 40º, by either an electric switch or a manual lever operated by the pilot's right hand. Leading edge devices are used for the same purposes as flaps and include fixed slots, leading edge flaps and moveable slats.

The most common form of **Trim Tab** is attached to the trailing edge of the elevator and is adjusted from a control wheel, hand crank or switch near the pilot. It is used to balance or trim the aircraft bringing the nose up and down and easing pressure on the elevator control. Whenever power and attitude are changed, trim usually needs to be re-adjusted. Various other secondary flight controls such as spoilers, balance tabs, antiservo tabs and ground adjustable tabs, some of which are pilot controlled and some of which are automatic, are also used to control lift and drag and to ease pressure on the controls.

Juliet reviews Bernoulli’s principle

AIRCRAFT PERFORMANCE

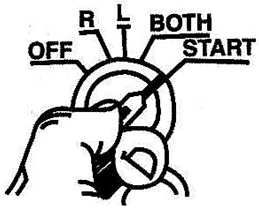
Juliet has “slipped the surly bonds of earth”
and is in her element

AIRCRAFT ENGINES: For most of the last fifty years, engines made for light general aviation aircraft have been essentially unchanged and have been produced by a handful of manufacturers worldwide. Engines in older aircraft have been repaired and rebuilt over and over again as the hours and miles have accumulated. They are not much different in concept, except for weight and air cooling, from the automobile engines of the 1950's and 1960's which were endlessly modified by generations of teenagers. Aircraft engines stayed the same because demand was limited, and certification requirements were extensive and expensive. More recently, new and modified engines have appeared which are more like modern automobile engines and modern outboard motors with computerized controls, fuel injection, stronger and lighter alloys, and sophisticated electronics. Diesel engines are now available for small aircraft and an entire new generation of lightweight jet aircraft is being developed.

The traditional designs are very simple and feature redundant systems such as duplicate magnetos and spark plugs and a backup fuel pump to make them more reliable. Two separate magnetos are turned by the crankshaft to provide electricity to two spark plugs in each cylinder. This means that the engine will keep running if one of the magnetos should fail. Once the engine is running, it does not need power from the battery because the magnetos supply current to the spark plugs and the oil and fuel pumps are driven from the crankshaft. The use of dual spark plugs provides an additional safety factor.

Some high wing aircraft use a gravity feed fuel system, eliminating the need for a fuel pump. Where a fuel pump is needed there is usually one main pump driven from the engine and another, backup, pump operated electrically. If an electric backup pump is used, it is often operated in tandem with the main fuel pump during takeoff, landing, and when changing fuel tanks. Checking the fuel and oil for quantity, type, and water and other contaminants is an essential part of the pre-flight inspection.

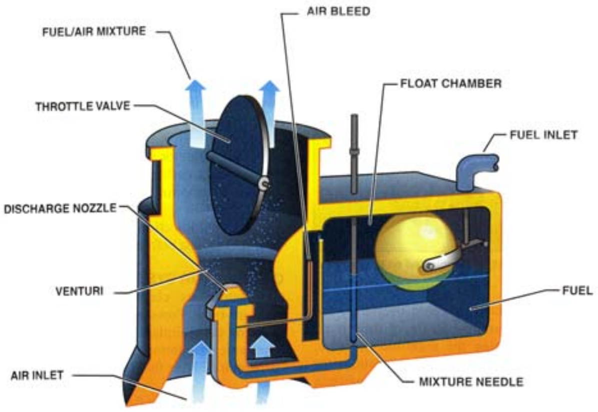
The magnetos are controlled in the cockpit by an **Ignition Switch** with five positions: OFF, R (Right), L (Left), BOTH, START. The system operates with BOTH selected and the individual magnetos are tested by briefly switching to each one and observing the decrease in engine RPM. The exact procedures and readings differ for each individual aircraft and are covered in the Pilot Operating Handbook (POH). When START is selected, current is routed from the battery to the starter motor.



Small aircraft often use a **Master Switch** to control the electrical system. The Master Switch is usually a two part rocker switch, battery on one side to control electric current from the battery, and alternator on the other to control current from the alternator. Both sides can be turned off and on together. The alternator circuit can be turned off separately if the alternator malfunctions. Most aircraft use an alternator instead of a generator because an alternator provides sufficient current when operated at low speeds. The electrical system is not needed to keep the engine running unless it is needed to power the backup fuel pump but it does run lights, radio, the turn indicator, instrument lights, Pitot heat, fuel gauges, the stall warning system, the starter, and other operational and navigation items. An ammeter measures the electrical current being produced and also indicates whether or not the battery is charging.

Aircraft engines generally have four or six cylinders and are classified as four stroke with an operating cycle consisting of intake, compression, power and exhaust. Some smaller engines operate on a two stroke cycle. Most small aircraft engines use a carburetor to mix the fuel and air and supply it to each cylinder through the intake manifold. Some more recent engines replace the carburetor with a fuel injection system. In a fuel injection system, the fuel is injected either directly into the cylinders or just ahead of the air intake valve. Gauges indicate RPM, oil pressure, oil temperature and, often, cylinder-head temperature and manifold pressure.

CARBURETOR ICING: The formation of ice is a concern with carburetors and, to a lesser extent, with fuel injection systems. In both carbureted and fuel injection systems, ice can form on the exterior of the aircraft and block the air intake. Because of this, both systems usually have an alternate source of air within the engine cowling.



A carbureted system is particularly prone to icing. A carburetor works through the use of a venturi which is a narrowing throat in the air intake where the air entering the carburetor is made to move faster by the action of the venturi. As the air moves more quickly, a low pressure area is created which pulls fuel into the carburetor where it mixes with the air and is then introduced into the combustion chamber portion of each cylinder. In the combustion chambers it is compressed and ignited creating the power which moves the piston and turns the crankshaft. The decrease in air pressure and the vaporization of the fuel within the venturi cause a drop in temperature which can freeze the water vapor in the incoming air and form ice on the interior surfaces of the carburetor. The throttle plate which is the moving part of the throttle valve can become very cold causing water vapor to condense on its surfaces, freezing and forming ice on both sides of the plate. The formation of ice can restrict the flow of fuel and air in the carburetor or obstruct the operation of the throttle valve causing the engine to produce less power or stop altogether.

Within the carburetor, the temperature drop can be as great as 70º (21ºC), so icing can occur even with temperatures as high as 100º F (38º C) and humidity as low as 50%. It is, however, most likely to occur when temperatures are below 70º F (21º C) and relative humidity is above 80%. To protect against carburetor icing, small aircraft use a carburetor heat system which preheats the air entering the carburetor, usually by adjusting a flap which diverts air from around the hot exhaust manifold. Carburetor heat (carb heat), is checked during the preflight run-up and used whenever icing is anticipated or suspected and, in some aircraft, during descent and final approach to landing. Some authorities recommend that it be turned off shortly before landing.

When icing is suspected, carb heat should be left on for long enough to be reasonably certain that the ice has been removed. In a rapid descent at low power, power should be increased periodically to keep the air supplied to the carburetor by carb heat as warm as possible and also to keep the excess air flow from shock cooling the engine. The use of carb heat causes a decrease in engine power because the heated air is less dense than the outside air. Because of this, carb heat is not used when full engine power may be required such as during takeoff and during the last stages of landing when a go around may become necessary. The recommended use of carb heat varies for each type of aircraft and pilots should consult the appropriate Pilot Operating Handbook (POH/AFM).

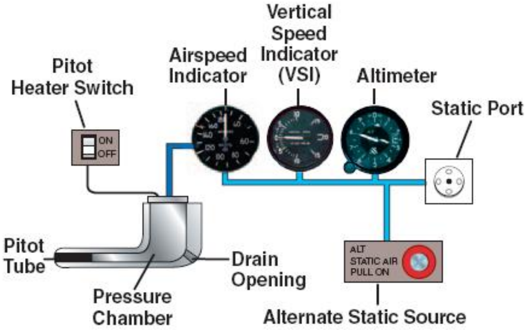
SUPERCHARGERS AND TURBOCHARGERS: A supercharger is an engine driven compressor which increases manifold pressure and forces the fuel/air mixture into the cylinders. The higher the manifold pressure, the more dense the fuel/mixture and the more power an engine can produce. Compression of the fuel/air mixture compensates for decreased air density as the aircraft gains altitude and allows the aircraft to fly higher and faster. A turbocharger is similar but uses a turbine to harness energy from the engine exhaust gases to drive the compressor. Since compression of the air supplied to the manifold creates heat, an intercooler is sometimes used to cool the hot compressed gases.

FLIGHT INSTRUMENTS: Aircraft instrumentation for General Aviation is improving very rapidly with the introduction of glass (computer display) Instrument panels, GPS, collision and storm avoidance systems, real time weather Information, and hand held and miniaturized computer power. The basics haven't changed though, and pilots still depend on instruments which have been standard for many years. Even with the glass panels, the older type instruments are present for backup.

(*Wikipedia)*

There are six basic flight instruments, usually arranged in a standardized arrangement known as the "basic T" and sometimes referred to as the "six pack." The attitude indicator is in top center, airspeed to the left, altitude to the right and heading indicator under the attitude indicator. The other two, turn-coordinator and vertical-speed are usually found under the airspeed and altitude respectively.

PITOT-STATIC INSTRUMENTS: Three of the instruments are called pitot-static instruments and operate with inputs from the Pitot tube and the static ports. These are the **Airspeed Indicator**, the **Vertical Speed Indicator** and the **Altimeter.**



The diagram to the left shows the relationship between these instruments and the Pitot tube and static ports. The Pitot tube is named for the French engineer Henri Pitot and measures the ram air pressure created by the forward motion of the aircraft through the air. It is usually mounted facing forward on the front portion of a wing or the fuselage where the air flow will be relatively undisturbed. The static ports measure the air pressure at the actual altitude of the aircraft and consist of flush-mounted holes located on one or on both sides of the fuselage and connected to the instruments via a hollow tube. Sometimes both the Pitot tube and a static port are combined in a Pitot-static tube. As illustrated in the diagram, the Vertical Speed Indicator and the Altimeter get their input from the static ports only and the Airspeed Indicator receives and compares the inputs from both the Pitot tube and the static ports.

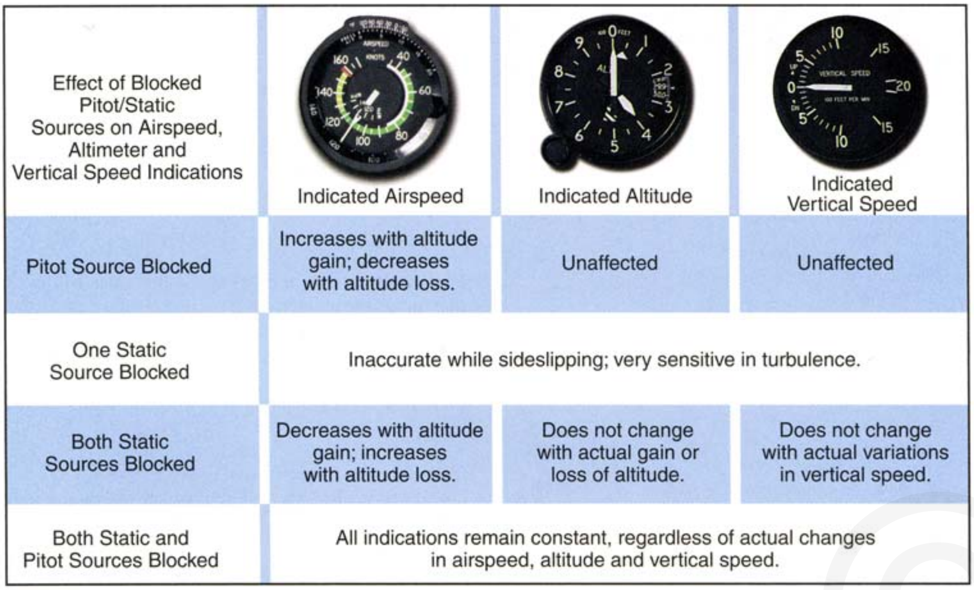
As discussed in the accompanying **AERODYNAMICS** section of this **reference**, air pressure decreases as the aircraft gains altitude and vice versa. Air pressure and the changes in pressure are transmitted to the instruments via a connection from the static ports.

Often, as shown in the diagram, there will be an alternative source of static pressure to be used if the exterior static ports become blocked. The alternative source is usually vented inside the cockpit. Because of the venturi effect of airflow over the cockpit, pressures are usually lower inside the cockpit and, when the alternative source is used, the altimeter may indicate higher than actual, the airspeed may indicate greater than actual, and the vertical speed indicator may indicate a climb when the aircraft is actually in level flight.

If there is no alternative source of static pressure, breaking the glass seal on the Vertical Speed Indicator will allow ambient air pressure to enter the system but will make the Vertical Speed Indicator unusable. Because ice can form and block the Pitot tube, a heater is often provided.

The airspeed indicator depends on both the Pitot tube and the static ports for inputs so a blockage of either source will affect its operation. If the Pitot tube and its drain hole are blocked but the static source is open, the airspeed indicator will tend to act as an altimeter showing an increase in speed as the aircraft climbs and vice versa. The altimeter and the vertical speed indicator depend only on the static ports and will be unaffected by blockage of the Pitot tube but will not indicate accurately if the static ports are blocked.

The chart below shows the effect of Blocked Pitot and static sources on the Pitot-static instruments.



Effect of Blocked Pitot/Static Sources on Airspeed, Altimeter and Vertical Speed Indications	Indicated Airspeed	Indicated Altitude	Indicated Vertical Speed
Pitot Source Blocked	Increases with altitude gain; decreases with altitude loss.	Unaffected	Unaffected
One Static Source Blocked	Inaccurate while sideslipping; very sensitive in turbulence.		
Both Static Sources Blocked	Decreases with altitude gain; increases with altitude loss.	Does not change with actual gain or loss of altitude.	Does not change with actual variations in vertical speed.
Both Static and Pitot Sources Blocked	All indications remain constant, regardless of actual changes in airspeed, altitude and vertical speed.		

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The **AIRSPEED INDICATOR** measures and compares the difference between the ram air pressure created by the forward motion of the aircraft and the pressure measured by the static ports. The greater the difference between the two, the greater the airspeed. Speeds for light aircraft are usually indicated in knots though older aircraft may indicate in miles per hour. The Airspeed Indicator usually has standard markings and ranges referred to as "V" or velocity speeds which are specified by the manufacturer and required by the FAA.

As shown on this airspeed indicator, the range marked with a white arc is the normal range of operating speeds in landing configuration with flaps down. The green arc is the operating range for the aircraft with flaps up. The yellow arc is an operating range in smooth air when no turbulence or abrupt control inputs are expected. A red line marks **V**NE for Velocity - never exceed. The most common "V" speeds are shown below.

"V" Speeds:

VSO	The stalling speed or the minimum steady flight speed in the landing configuration at maximum weight. In small airplanes, this is the power-off stall speed with gear and flaps down. The lower limit of the white arc.
VSI	The stalling speed or the minimum steady flight speed obtained in a specified configuration. For most airplanes, this is the power-off stall speed at the maximum takeoff weight in the clean configuration (gear and flaps up). The lower limit of the green arc.
VX	Best angle of climb. The airspeed at which an airplane gains the greatest amount of altitude in a given distance.
VY	Best rate of climb. The most altitude gain in a given period of time.
VFE	Maximum speed, flaps down. The top of the white arc.
VLE	Maximum speed, gear down.
VLO	Maximum speed to lower or raise landing gear.
VNO	Maximum structural cruise. Do not exceed except in smooth air. The upper limit of the green arc and the bottom of the yellow arc.
VA	Design maneuvering speed. The maximum speed for abrupt maneuvers. Not shown on the Airspeed Indicator.
VNE	Never exceed speed. The red line at the top of the yellow arc.
VREF	The reference landing approach speed (often 1.3 times **V**SO plus 50% of the wind gust speed in excess of the mean wind speed).

It is useful to understand the differences between indicated airspeed (IAS), true airspeed (TAS) and calibrated airspeed (CAS). Indicated airspeed is the reading shown on the Airspeed Indicator. True airspeed is the airspeed related to the ground. Calibrated airspeed is the speed that the Airspeed Indicator should theoretically show if there were no error in the inputs from the Pitot tube and the static sources. In small aircraft, calibrated airspeed and indicated airspeed are usually nearly the same with IAS lower than CAS at slow speeds and higher than CAS at high speeds.

At higher altitudes the airspeed indicator will show a lower airspeed (IAS) than the true speed over the ground (TAS) because of the reduced density of the air flowing into the Pitot tube, but the indicated "V" speeds still apply. For instance the aircraft will still stall at indicated **V**SI even though the speed over the ground is greater making the true (TAS - relative to the ground) stall speed correspondingly greater.

Aircraft speeds which exceed the speed of sound are measured in **Mach Numbers** which relate aircraft speed to the speed of sound. This measure is named after an Austrian physicist Ernst Mach. Traveling at the speed of sound is measured as Mach 1, twice the speed of sound is Mach 2 and so forth. Because approaching and exceeding the speed of sound begins to compress the air, the airflow around airfoils and control surfaces changes. Sound travels faster at higher temperatures so traveling at the speed of sound (Mach 1) at just above sea level (662 knots - 762 mph - at a temperature of 59º F or 15º C), is faster by nearly 100 knots than traveling at the speed of sound at 36,000 feet where the temperature is much lower. Measuring speed using Mach numbers is useful for a pilot because the effects of increasing air compression and the resulting changes in airflow are the same regardless of level as the aircraft approaches and exceeds Mach speeds.

The **VERTICAL SPEED INDICATOR** (illustrated to the left) shows the rate of climb and the rate of descent in feet per minute so that the pilot can determine whether the aircraft is climbing, descending or in level flight. Because the instrument is actually measuring the change in pressure input from the static ports (using what is called a calibrated leak or restricted diffuser) there is a delay of several seconds between the actual motion of the aircraft and the indication of the Vertical Speed Indicator.

The **ALTIMETER** measures the changes in air pressure as the aircraft's altitude changes. Air, like water or any other fluid, has weight, expressed as air pressure and measured in inches or millimeters of mercury. If you measure air pressure at sea level and then take another measurement at 5,000 feet, the pressure is much lower at the higher altitude. An aviation altimeter contains an aneroid barometer which is sealed except for its connection through a hollow tube to the static ports. As the aircraft climbs, the outside air pressure decreases and is transmitted through that connection to the sealed instrument. As the pressure inside the instrument decreases, the barometer bellows expands. A mechanical linkage indicates this expansion on the Altimeter dial as increased altitude, shown in feet. The converse is true as the aircraft descends.

As an altimeter measures the pressure of the air it is indicating the height of an airplane above a given pressure level which, in aviation, is sea level (MSL or mean sea level). Accordingly, the reading or indication in feet of elevation on the instrument is **not** the distance above the ground below, but the distance above sea level.

It should be noted that sea level is actually a theoretical concept, being a standard datum plane (SDP) where the surface temperature and pressure are standard (59º F or 15º C and 29.92 in. Hg. or 1013.2 millibars). This may be above or below actual sea level at any given time, depending on the actual temperature and pressure at that location.

If there were no temperature changes and no weather patterns creating highs and lows of air pressure (explained in the **WEATHER** section of this reference) then aviation altimeters could be calibrated to sea level at the factory and would never need to be reset except for occasional recalibration. Since, however, our weather is variable; air pressure will vary from hour to hour at any given location as temperatures change and as weather patterns pass through. Accordingly, altimeters have to be reset very frequently in order to accurately indicate elevation at a particular location.

An altimeter shows feet of elevation on a circular dial and air pressure in a small window. This window is called the Kollsman window, named for Paul Kollsman who developed one of the first aviation altimeters, and it is usually located on the right side of the face of the instrument. When you turn the setting knob and select an air pressure level in the small window, say 30.00 inches, the hand on the circular dial will indicate the aircraft's elevation in feet above that particular air pressure level. In aviation, the air pressure level which is set in the small Kollsman window is the pressure at sea level corrected for the highs and lows present where the aircraft is located at the time of the setting. This corrected air pressure level is available from a control tower, Flight Service Station (FSS), or Automated Terminal Information Service (ATIS) and, in aviation terminology, is called the QNH. After it is set, the aircraft altimeter will read the elevation in feet above sea level.

The QNH is one of a series of three letter "Q" codes which are a carryover from the days when radio communication was in Morse code. The original "Q" codes were created by the British government as a "shorthand" system of communication between ships and coast stations. As it turned out, "Q" codes facilitated communication between operators speaking different languages and the system was adopted by the 1912 International Radiotelegraph Convention. Later, all of the codes between QAA and QNZ were reserved for aeronautical use and these codes have since been adopted by the International Civil Aviation Organization (ICAO), an agency of the UN which regulates international aviation. The actual meaning of QNH is "What should I set on the subscale of my altimeter so that the instrument would indicate its elevation if my aircraft were on the ground at your station?"

If an aircraft is on the ground and the altimeter is set at the actual elevation of the airfield above sea level as shown on a topographical map, then the linked Kollsman window air pressure reading will be sea level pressure corrected for local variations in pressure and it will be close to the official and more precisely calibrated QNH obtained from the tower, an FSS or ATIS. The QNH **is not** the actual air pressure at that location. To measure the actual air pressure at that location, you would set the altimeter to zero feet in elevation and read off the pressure in inches or millimeters. This won't work for Denver or other high altitude airfields because the barometric pressure range available in the Kollsman window on a typical altimeter is only about 28 to 31 inches and Denver's actual air pressure is usually lower, in the range 24 to 25 inches.

If you receive a QNH reading from an official source and adjust your altimeter accordingly, the resulting reading in feet above sea level should be very close to the actual airfield elevation. If it is not, then the aircraft altimeter may need servicing. When adjusting the altimeter, and at elevations below 10,000 feet, one inch of pressure is equal to about 1,000 feet of altitude and one millibar is equal to about 27 feet.

As a further example, assume that an aircraft is at an airfield with an elevation of about 1,000 feet, say Pittsburgh International at 1,204 feet. If we set the altimeter to zero elevation, it will read approximately 28.65 inches or 970 millibars, which is the actual ground level air pressure at that location and at that moment. Now we turn the setting knob in a direction which moves the elevation pointer around from zero to 1,204 feet. As we do this, we can see that the air pressure reading in the Kollsman window increases form the 28.65 inches or 970 millibars until you reach 1,204 feet and an air pressure reading of close to sea level – somewhere close to 29.92 inches or 1013.2 millibars. This air pressure reading in the Kollsman window is sea level pressure adjusted for the local weather variation. In this case, increasing the elevation on the dial also increased the air pressure, somewhat counter intuitive.

Two more examples to better illustrate the coordinated movement of the elevation dial and the pressure setting. First, assume that an aircraft is flown form a pressure level of 28.75 in. Hg. to a pressure level of 29.75 in. Hg. The altimeter would show a decrease of approximately 1,000 feet in altitude.

Next, assume that an aircraft is parked on a ramp at an elevation of 1,000 feet and the altimeter shows 30.00 in. Hg. (QNH). An hour later, the local pressure decreases and the altimeter now shows an elevation of 1,500 feet. If the setting in the Kollsman window is now adjusted down to the current sea level pressure of 29.50, the indicated elevation will be reduced back to 1,000 feet. In this case, moving the altitude down in the Kollsman window also moved the elevation arrow down. Also counter intuitive.

If enroute, pilots use the settings available from stations along the route and within 100 NM. If you are on the ground at a known elevation and a specified setting is not available, set the altimeter to the known elevation. Above 18,000 feet (MSL) the altimeter is set to standard sea level pressure; 29.92 in. Hg. or 1013.2 millibars (this is referred to by the "Q" code QNE) and is not adjusted to compensate for local highs and lows caused by shifting weather patterns and changing temperatures. At lower flight levels it is important to compensate for variations in local air pressure caused by highs and lows so that pilots can know accurately how far they are from the ground. At higher flight elevations with very low temperatures and higher aircraft speeds, pilots set the same standard sea level pressure (QNE) into their altimeters so their altitude readings will be coordinated and separation by ATC (Air Traffic Control) can be facilitated.

When flying between areas of differing pressures and temperatures, altimeter settings must be adjusted and pilots must be aware of the changing conditions because the altimeter will read incorrectly if not adjusted. **"From HIGH to LOW look out BELOW"** is an often used aviation rule of thumb. In this case, the altimeter will read higher than actual height above sea level (MSL), and the pilot may be dangerously low with regard to the expected ground level elevations along the route. This is because flying from an area of high pressure into an area of lower pressure will cause the altimeter to read the lower pressure as a higher altitude unless the altimeter is adjusted for the pressure change. **Juliet notes that this rule of thumb is not always applicable when flying into regions of very low and reducing temperatures where the air may be very dense and pressure gradients may be packing closer to each other. In this situation, an aircraft flying along a gradient (showing on the altimeter as a specific altitude) may inadvertently follow a pressure gradient path which is curving towards the ground.** Air pressure readings above mountain ranges may also cause the altimeter to indicate higher than actual elevation. For more information, consult the accompanying **WEATHER** section of this Reference.

Pressure Altitude and Density Altitude are important concepts related to the performance of the aircraft at different elevations and temperatures and they are discussed separately at the end of this section and in the accompanying **AERONAUTICS** section of this **Reference**.

As air traffic increases, the **TRANSPONDER** becomes a very important instrument to show altitude and aircraft identification. A transponder receives a radar signal from an air traffic control radar beacon system or from another aircraft and replies in either Mode A with aircraft identification information in a four letter code or in Mode C with aircraft identification and with altitude information in 100 foot increments. Mode S transponders, providing traffic avoidance, are also used as part of more comprehensive Traffic Collision Avoidance Systems (TCAS). The usual four digit identification for an aircraft flying under visual flight rules (VFR) is 1200. Pilots say that they are "squawking 1200." Other codes are used by aircraft flying in airspace controlled by air traffic controllers and by larger commercial and military aircraft. Transponders capable of Mode C (Altitude) transmission are required for aircraft flying into Class B & C airspace. Codes in common use are 7700 - emergency, 7600 - radio failure, and 7500 - hijacking. The usual settings on a transponder are **OFF**, **SBY** - Standby (warm up), **ON** - Mode A, **ALT** - Mode C & A (Altitude and Identification). There are switches or push buttons to self test the transponder and to **Squawk** or **Ident** which transmits a special pulse identifier with the transponder reply which identifies the aircraft on the ground controller's display.

GYROSCOPIC INSTRUMENTS: The remaining three basic instruments are called Gyroscopic Instruments and include the **Attitude Indicator**, the **Turn Indicator**, and the **Heading Indicator**. In many General Aviation aircraft, the gyroscopes for all three instruments are powered by a vacuum or pressure system using an engine driven pump. To provide redundancy, the turn indicator usually has a backup source of electric power or may always be operated from the aircraft's electrical system.

The **ATTITUDE INDICATOR** (illustrated at the top left) shows the pitch and bank of the aircraft, usually displaying a miniature airplane and a horizon bar which reflect the attitude or degree of pitch and bank of the larger aircraft. The attitude indicator is crucial in bad or obscured weather where the actual ground and horizon cannot be seen.

The **TURN INDICATOR** (The center illustration) may be either a *Turn and Slip Indicator* which indicates **rate** of turn or a *Turn Coordinator*, common in training aircraft, which can indicate **rate** of roll or bank as well as **rate** of turn. The turn coordinator often has a depiction of a miniature airplane which banks in the direction the airplane is rolled. It **does not indicate either amount of bank or amount of pitch and is not a substitute for the Attitude Indicator.** Both types of turn indicator include an inclinometer to depict aircraft yaw and to assist in coordination. A turn indicator is usually the backup instrument should the other gyroscopic instruments stop working and is used to assist in keeping the wings level and in coordinating standard rate turns when visibility is obscured. Sometimes, a second Attitude Indicator with an alternate source of power is substituted for the Turn Indicator.

The **HEADING INDICATOR** (illustrated at the bottom left) indicates the magnetic compass direction or heading of the aircraft. It is used because the aircraft's magnetic compass lags a turn and has acceleration, deceleration and turning errors. The heading indicator is gyroscopically driven and does not indicate these particular errors. It is set initially to conform to the magnetic compass, after the engine is started and after the gyroscope has had time to warm up and settle at an appropriate revolution speed. Because the heading indicator, being gyroscopically driven, will precess or drift away from an accurate heading as time passes, it must be checked against the compass very frequently, approximately every fifteen minutes, and reset as necessary.

Remember that, with older liquid filled spherical compasses, the adjustment to the heading indicator may be opposite from the direction indicated by the compass. For instance, if the curser on the compass moves left against the stationary compass card, moving from 180º to 210º as the aircraft changes course, the adjustment to the heading indicator is in the opposite direction, to the right. The compass itself will not be completely accurate due to its position in the aircraft relative to metallic components and electrical circuits which will cause it to deviate from the actual magnetic heading. Each compass has a compass correction card to enable the pilot to adjust his or her course to correct the deviation. Deviation is different from variation which is the measure of the difference between True North and Magnetic North.

DENSITY ALTITUDE: Density Altitude is calculated to approximate the actual density of the air at a particular altitude and temperature. As an aircraft gains altitude, air pressure and density decrease. Increases in temperature and humidity also reduce the density of the air. Reduced density affects aircraft performance by reducing the power of the engine as it takes in less air, by making the propeller less efficient, and by reducing lift. Takeoff and climb performance are especially sensitive to decreases in air density. Aircraft performance at different density altitudes is shown in the Pilot's Operating Handbook (POH/AFM) for each individual aircraft. High temperatures at an airport at any altitude, but particularly at higher altitudes, can significantly degrade aircraft performance.

The altimeter can measure air pressure and calculate altitude but it cannot adjust for temperature. Because of this, Pilots first determine a particular altitude called **Pressure Altitude** using their altimeters and then calculate **Density Altitude** by adjusting for the actual temperature. Density altitude is defined as pressure altitude corrected for variations from standard temperature.

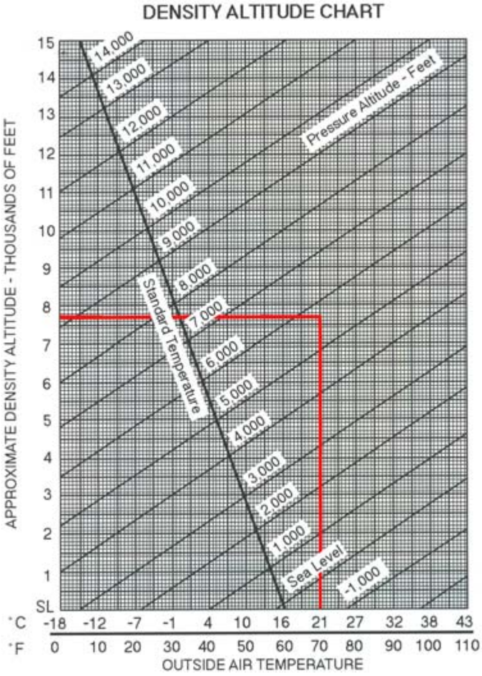
Pressure altitude in feet at a given location is defined as the altitude indicated when the altimeter setting window is adjusted to standard sea level pressure (29.92 in. Hg or 1013.2 mb and termed QNE). Pressure altitude adjusted for any variation from standard temperature (remember, standard temperature decreases as altitude increases) is density altitude. At the standard temperature for a particular altitude, density altitude is the same as pressure altitude. To determine pressure altitude, you can go to your aircraft and set the altimeter Kollsman window to standard sea level pressure (QNE) and read off the elevation in feet. An alternative method is to obtain the QNH for that particular airport from the tower, ATIS, or FSS and adjust it to pressure altitude by using the pressure altitude conversion factor shown in the table on the next page.

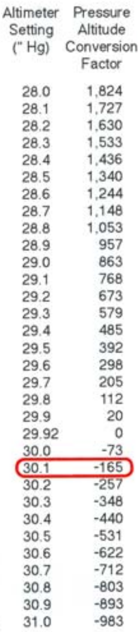
In the example shown on the next page, pressure altitude is calculated using QNH as supplied for the particular airport by the tower, FSS or ATIS and using the elevation of the field. Since the QNH at 30.10 is a higher pressure than standard pressure (QNE), it is clear that local weather has created a high pressure area over the airport. To adjust QNH to standard pressure, the appropriate number of feet must be subtracted from airfield elevation so that when that new elevation is placed on the altimeter dial, standard sea level pressure (QNE - 29.92 in. Hg or 1013.2 mb) will appear in the altimeter's Kollsman window. (If local weather had created a low over the field, the adjustment would be added to field elevation.)

The appropriate number of feet to be subtracted in the example can be taken from the column labeled "pressure altitude conversion factor" opposite 30.1, in this case minus 165 feet. Remember from the examples used in the ALTIMETER section, that movement of the elevation scale downward also moves the pressure in the Kollsman window down – somewhat counter intuitive. Because of the high pressure area over the field, pressure altitude will be lower than field elevation.

Once pressure altitude is known, then it is adjusted for the actual temperature at the airport. Remember to do the calculation for the temperature at the time takeoff is planned and for the temperature expected in the hot sun over the runway – an early morning calculation may be misleading later in the day. High humidity can also decrease aircraft performance and should be evaluated although it is not included in density altitude tables. Trust your Airspeed Indicator (Indicated Air Speed - IAS), and not your eyes, for POH/AFM specified approach and landing "V" speeds (especially stall speeds) at high density altitudes because speed over the ground (True Air Speed - TAS) in the lower density air will be higher than you are used to at lower levels. At higher altitudes the air flowing into the Pitot tube is less dense so the aircraft will be going faster over the ground (TAS) than the speed indicated (IAS) by the Airspeed Indicator.

Most flight calculators, in either electronic or circular slide rule form, can calculate density altitude and TAS given pressure altitude and temperature. Alternatively, density altitude can be determined using a chart such as the one shown below. The text beside the chart lays out the steps to determine both pressure altitude and density altitude given field elevation and equivalent sea level pressure (QNH) obtained from the tower, an FSS, or ATIS.





Altimeter Setting (" Hg)	Pressure Altitude Conversion Factor
28.0	1,824
28.1	1,727
28.2	1,630
28.3	1,533
28.4	1,436
28.5	1,340
28.6	1,244
28.7	1,148
28.8	1,053
28.9	957
29.0	863
29.1	768
29.2	673
29.3	579
29.4	485
29.5	392
29.6	298
29.7	205
29.8	112
29.9	20
29.92	0
30.0	-73
30.1	-165
30.2	-257
30.3	-348
30.4	-440
30.5	-531
30.6	-622
30.7	-712
30.8	-803
30.9	-893
31.0	-983

FOR EXAMPLE:

As illustrated by the **red lines** in the Density Altitude Chart to the left; assume an airport elevation of 5,883 feet (MSL), and a local temperature of 70° F, with local QNH or sea level equivalent of 30.10 in. Hg. On the chart, locate 30.10 in. Hg, read to the right, and subtract 165 feet from the airport elevation to yield 5,718 feet. From 70° F on the temperature scale read up to 5,718 on the pressure altitude line and read across to the left to the approximate density altitude of **7,700 feet**. This is the altitude to use when estimating aircraft performance at this elevation under current conditions of atmosphere and temperature.

The conversion factor can also be determined by interpolation. Knowing that an altitude change of 1000 feet is roughly equal to one inch of pressure, the change from 30.10 to standard atmosphere of 29.92 is minus .18 of one inch, or 18% of 1000 feet, roughly minus 180 feet. Since the actual change in pressure decreases for each successive 1,000 feet of altitude, using this formula produces only a rough approximation of the conversion factor.

WEIGHT & BALANCE: Weight and balance requirements are detailed for each individual aircraft in the Pilot's Operating Handbook (POH) which is also known as the Airplane Flight Manual (AFM). This POH/AFM must contain the serial number of the aircraft and the specific weight and center of gravity (CG) calculated for that particular aircraft. The center of gravity (CG) requirement is specified as a range within which the loaded CG must fall. If additional equipment is added to the aircraft which will affect weight and/or CG calculations, the figures in the POH/AFM must be amended - following specific and documented procedures.

If a pilot exceeds maximum takeoff weight or operates an aircraft which is out of balance, either nose or tail heavy, performance characteristics are likely to differ from those expected. In aviation, the unexpected is often dangerous.

Very few general aviation aircraft will actually stay within the maximum takeoff weight requirement and CG requirements if each seat is occupied by an adult and the aircraft is fully fueled. Even small two seat training aircraft will often exceed weight and CG limitations if the two occupants are larger than average and full fuel is carried.

Different manufacturers specify widely different methods of calculating weight and especially CG using a variety of charts and graphs. The methods of calculation always appear in the POH/AFM except in the case of very old aircraft built before these regulations went into effect. It is beyond the scope of this reference to discuss the various methods and each pilot should understand the concepts "arm" and "moment" and become very familiar with the appropriate calculations for his/her particular aircraft. Excellent references are the FAA Pilot's Handbook of Aeronautical Knowledge available online at the FAA website or the FAA Weight and Balance Handbook (found online at www.faa.gov/library/manuals/aircraft/media/FAA-H-8083-1A.pdf). In general, the calculations for any aircraft are similar to those described on the next page.

Add the Moments for the aircraft itself and for each item of weight (Weight x Arm = Moment), then divide total Moment by total weight to get Center of Gravity (CG). (Total Moment / Total Weight = Center of Gravity (CG)). Moment is sometimes shown divided by 100 or by a larger constant in order to simplify calculations. Check that the CG falls within the limits specified for the aircraft at calculated weight. Don't forget to check for the maximum takeoff and landing weights specified for the aircraft. Check to see whether aircraft weight includes unusable fuel & undrainable oil. Weights of common fluids are shown below:

Fluid	Color	lbs/gal
Gasoline 80	**Red**	6
Gasoline 100	**Green**	6
Gasoline 100LL	**Blue**	6
Engine Oil		7.5
Water		8.4
Hydraulic Fluid		7.2
Jet Fuel JP-4		6.5

STALL SPEED, BANK ANGLE, and LOAD FACTOR: The stall speed of an aircraft increases as the aircraft is banked or tilted into a turn. Knowledge of stall speeds and bank angles is particularly important during maneuvering at slow speeds prior to landing. The theory is not difficult to understand and is explained below and in the **AERODYNAMICS** section of this **Reference**. The load factor is the ratio of the load supported by the airplane's wings to the actual weight of the aircraft and its contents. Load factor is expressed as a "G" factor, where a load of two times the weight is termed 2 "G's". The upshot is that as you bank and turn the airplane, centrifugal force takes effect, the load on the aircraft increases and the stall speed goes up. This means that as the wing is made to support a greater load, the angle of attack increases, the smooth flow of air over the airfoil breaks up and separates, and the airplane will be unable to fly once the stall speed is reached. As shown below, an airplane which stops flying at the low speed of 35 knots will stop flying at the much higher speed of 49 knots if it is banked to an angle of sixty degrees.

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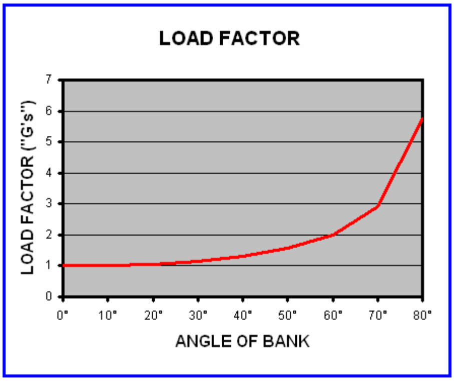
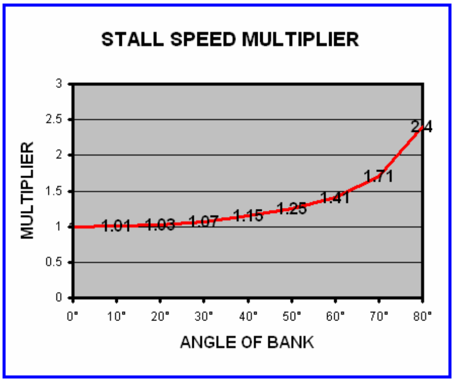




The stall speed increases in proportion to the square root of the Load ("G") Factor and the Load Factor increases as the angle of bank is increased. The **Load Factor** chart, above left, shows the load factor for an aircraft at differing angles of bank. The next chart labeled **Stall Speed Multiplier** shows the square root of that load factor for each angle of bank. For example, at a 60° angle of bank the load factor is 2 and the square root of 2 is 1.41.

TO USE THE CHARTS: Determine from the POH/AFM the level flight uaccelerated stall speed of your aircraft and multiply it by the number shown for the desired angle of bank. For a Cessna 152 (1985), the flaps down stall speed is 35 knots indicated. Multiply 35 times 1.41 and the result, 49 KIAS, is the calculated stall speed at 60° of bank for this particular aircraft.

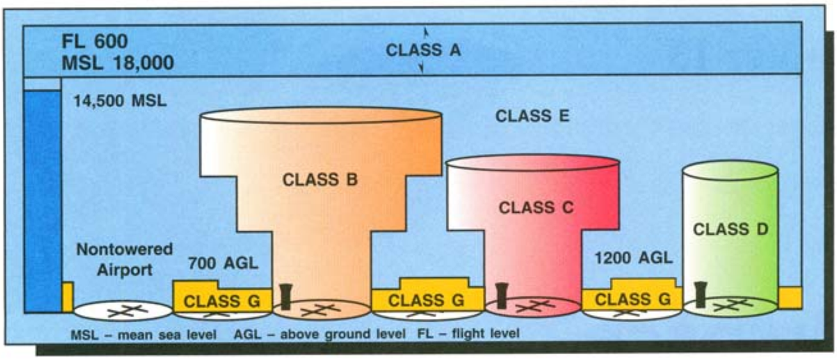
Juliet downwind for MIA (Miami) where she will give a presentation to FAA personnel on GPS Navigation

AIRSPACE
&
AIRPORTS

Zulu turns back the clock in his vintage tail dragger

AIRSPACE: The International Civil Aviation Organization (ICAO) is an agency of the UN and it has adopted a classification system for airspace which is followed by most nations and used for over the water areas outside of national boundaries. Individual nations follow these rules with some modifications to fit in with local history and local needs. Pilots fly under either instrument flight rules (IFR) or visual flight rules (VFR). Pilots flying VFR must also observe visibility and distance from cloud limitations as shown in the chart on page 4-3. A flight plan must be filed for IFR flying and may be filed for VFR flight. Flight plans are covered in another section of this Reference.

The US classifies airspace as Class A, B, C, D, & E for controlled airspace and Class G for airspace which is uncontrolled. Controlled airspace is defined as an airspace of defined dimensions within which air traffic control (ATC) services are provided to IFR flights and to VFR flights in accordance with the airspace classification. The US does not use Class F and other countries eliminate some classes and substitute others. For instance, Australia does not use Class B and has a special category called a General Aviation Airport Procedures Zone (GAAP) for center city general aviation airports. The classifications used in the US, with some exceptions, are shown and illustrated below:



CLASS A is that airspace from 18,000 feet MSL (**above Mean Sea Level**) up to and including FL 600 (60,000 feet MSL), including the airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous States and Alaska. Unless otherwise authorized, all persons must operate their aircraft under IFR.

CLASS B is that airspace from the surface to 10,000 feet MSL (**above Mean Sea Level**) which surrounds the nation's busiest **airports**. The configuration of each Class B airspace area is individually tailored and consists of a surface area and two or more layers (some Class B airspaces areas resemble upside-down wedding cakes), and is designed to contain all published instrument procedures once an aircraft enters the airspace. An ATC clearance is required for all aircraft to operate in the area, and all aircraft that are so cleared receive separation services within the airspace. The cloud clearance requirement for VFR operations is "clear of clouds."

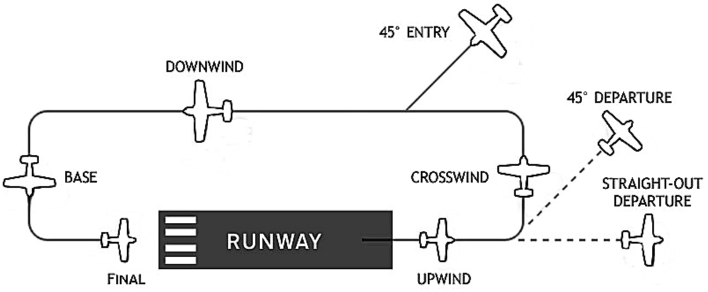
CLASS C is that airspace from the surface to 4,000 feet **above the airport elevation** (charted in MSL) surrounding those **airports** that have an operational control tower, are serviced by a radar approach control, and that have a certain number of IFR operations or passenger enplanements. Although the configuration of each Class C area is individually tailored, the airspace usually consists of a surface area with a 5 nautical mile radius, a circle with a 10 nautical mile radius that extends no lower than 1,200 feet up to 4,000 feet above the airport elevation and an outer area that is not charted. Each person must establish two-way radio communication with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those

CLASS D is that airspace from the surface to 2,500 feet **above the airport elevation** (the airport elevation is charted in MSL) surrounding those **airports** that have an operational control tower. The configuration of each Class D airspace area is individually tailored and when instrument procedures are published, the airspace will normally be designed to contain the procedures. Arrival extensions for instrument approach procedures may be Class D or Class E airspace. Unless otherwise authorized, each person must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while in the airspace. No separation services are provided to VFR aircraft.

CLASS E is defined in the following way. If the airspace is not Class A, Class B, Class C, or Class D, and it is controlled airspace, it is Class E airspace. Class E airspace extends upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace. When designated as a surface area, the airspace will be configured to contain all instrument procedures. Also in this class are Federal Airways, airspace beginning at either 700 or 1,200 feet AGL used to transition to/from the terminal or en route environment, en route domestic, and offshore airspace areas designated below 18,000 feet MSL. Unless designated at a lower altitude, Class E airspace begins at 14,500 MSL over the United States, including that airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous States and Alaska, up to, but not including 18,000 feet MSL, and the airspace above FL 600.

CLASS G is that airspace not designated as Class A, B, C, D, or E and it is not controlled.

THE PATTERN: Aircraft traffic patterns around airports are governed by the preference that aircraft land and take off into the prevailing wind. Accordingly, the terminology used is based on wind direction; upwind, crosswind and downwind. Aircraft turn from the downwind leg to the base leg and then onto final approach. At major airports where most flights are larger commercial and business aircraft, air traffic control (ATC) will specify the runway to use and the flight paths. At smaller airports with an operational control tower and at uncontrolled airports the standard pattern or circuit is as shown below with an altitude of **1000 feet AGL** (above ground level). The direction of the pattern is **left** with a left turn from base to final.



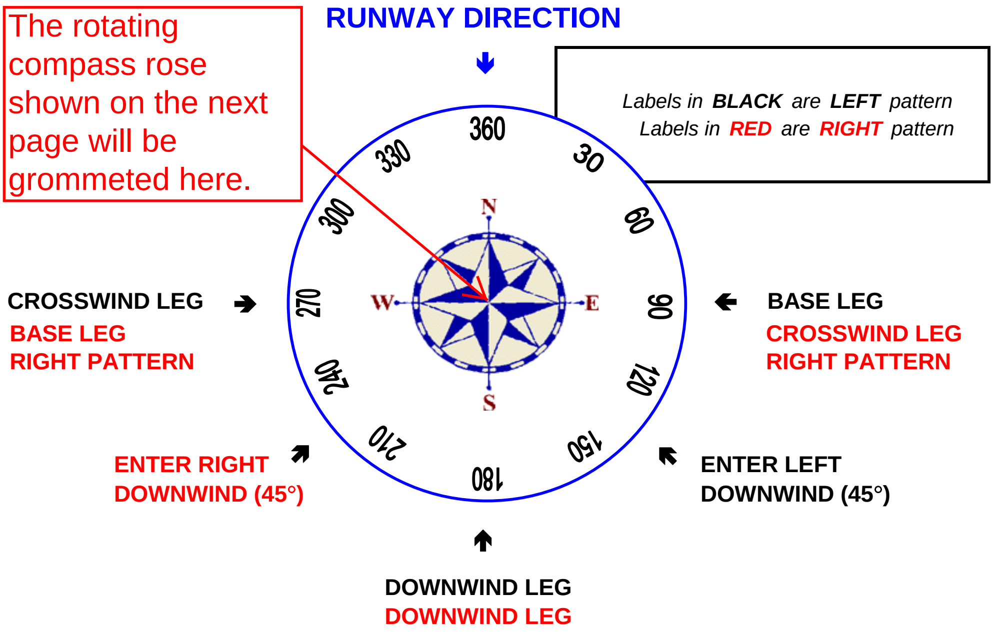
Traffic patterns differ from this standard when there is a need to avoid local hazards and/or to reduce noise or as instructed by ATC. Local exceptions, such as a right hand pattern or a different altitude are shown on Sectional Charts, in the FAA Airport/Facility Directory, in AOPA publications and in published commercial guides. At airports without an operational control tower, pilots consult the above references, use the radio (ATIS, AWOS, CTAF, and Unicom), and observe other aircraft (often over-flying the airport above pattern altitude) to determine wind direction and strength and the pattern and runway in use. A windsock or other wind indicator and an “L” shaped traffic pattern indicator (displayed with a segmented circle and showing the appropriate base and final legs) are often adjacent to the runway and visible from the air. Ground references such as smoke and wind patterns on bodies of water can be useful. In the US, the recommended entry to the pattern is a 45º entry from outside the downwind side. In some other countries, the recommended entry is crosswind.

VFR WEATHER MINIMUMS: No person may operate an aircraft under VFR when the flight visibility is less, or at a distance from clouds than is less than shown in the chart below for the classes of airspace and altitudes shown. There are certain exceptions to this for specific situations and for "special VFR operations" with an ATC clearance, both of which are prescribed in Part 91.155 and 91.157 of the US Federal Aviation Regulations.

BASIC VFR WEATHER MINIMUMS

Airspace	Flight Visibility	Distance from Clouds
Class A	Not Applicable	Not Applicable
Class B	3 statute miles	Clear of Clouds
Class C	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
Class D	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
Class E *Less than 10,000 feet MSL*	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
At or above 10,000 feet MSL	5 statute miles	1,000 feet below 1,000 feet above 1 statute mile horizontal
Class G *1,200 feet or less above the surface (regardless of MSL altitude).*		
Day, except as provided in section 91.155(b)	1 statute mile	Clear of clouds
Night, except as provided in section 91.155(b)	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
More than 1,200 feet above the surface but less than 10,000 feet MSL.		
Day	1 statute mile	500 feet below 1,000 feet above 2,000 feet horizontal
Night	3 statute miles	500 feet below 1,000 feet above 2,000 feet horizontal
More than 1,200 feet above the surface and at or above 10,000 feet MSL.	5 statute miles	1,000 feet below 1,000 feet above 1 statute mile horizontal

PATTERN INDICATOR: When approaching an airport, once you have identified the runway in use, use the diagram below to identify the magnetic courses for a 45° entry to downwind and for downwind, base and final. Just set the dial so that the magnetic direction of the active runway is opposite **RUNWAY DIRECTION** at the top, and read off the desired courses:



The rotating compass rose shown on the next page will be grommeted here.

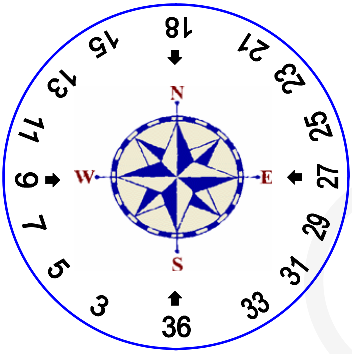
AIRPORT ROTATING BEACONS: **Civilian Land** - white & green; Military - two quick white & one green; Heliport - white, yellow, green; Civilian **Water** - white & yellow.
WIND DIRECTION INDICATORS: **Windsock** - the wide end points into (toward) the wind; Tetrahedron – the sharp end points into the wind; Wind **Tee** - the top (wide) end of the “T” points into the wind.
LIGHTS; Runway - White (Amber, last 2000 feet or last half); Taxiway - Blue (Green centerline & turnoff). At selected non-towered airports - key the mike x times within 5 seconds - 7x = bright, 5x = medium, 3x = low.

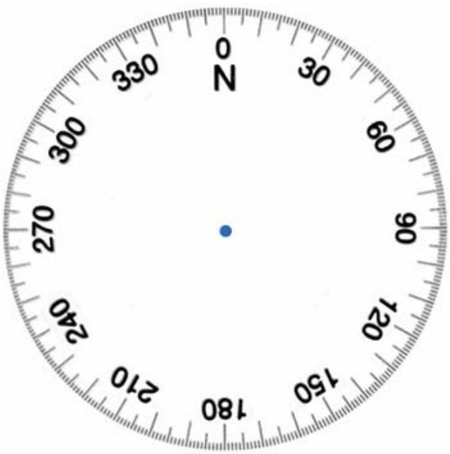
RUNWAY DIRECTION INDICATOR:

Sometimes it can be difficult to visualize the location and orientation of the runways when approaching an unfamiliar airport.

The diagram at the right lays out each runway on a north facing airfield as would be shown on a chart. The numbers are shown as you would see them when coming in on final approach.

RUNWAY DIRECTION INDICATOR

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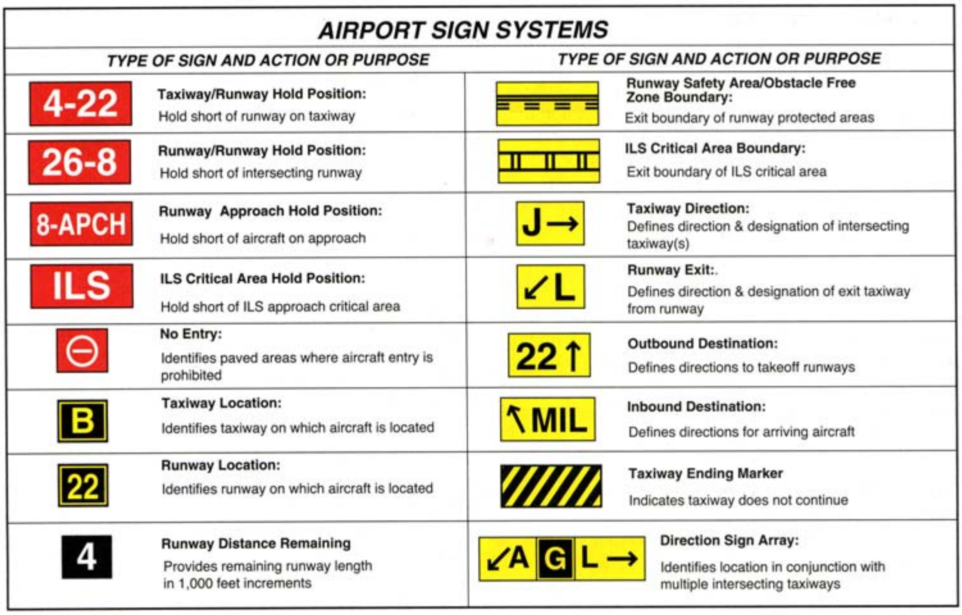


AIRPORT SIGN SYSTEMS

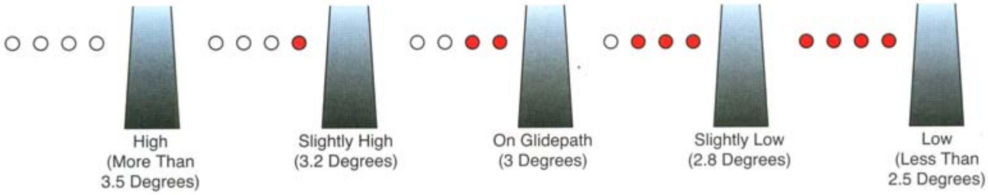
TYPE OF SIGN AND ACTION OR PURPOSE		TYPE OF SIGN AND ACTION OR PURPOSE	
4-22	**Taxiway/Runway Hold Position:** Hold short of runway on taxiway	═ ═ ═	**Runway Safety Area/Obstacle Free Zone Boundary:** Exit boundary of runway protected areas
26-8	**Runway/Runway Hold Position:** Hold short of intersecting runway	╪╪╪	**ILS Critical Area Boundary:** Exit boundary of ILS critical area
8-APCH	**Runway Approach Hold Position:** Hold short of aircraft on approach	J→	**Taxiway Direction:** Defines direction & designation of intersecting taxiway(s)
ILS	**ILS Critical Area Hold Position:** Hold short of ILS approach critical area	↙L	**Runway Exit:.** Defines direction & designation of exit taxiway from runway
⊖	**No Entry:** Identifies paved areas where aircraft entry is prohibited	22↑	**Outbound Destination:** Defines directions to takeoff runways
B	**Taxiway Location:** Identifies taxiway on which aircraft is located	↖MIL	**Inbound Destination:** Defines directions for arriving aircraft
22	**Runway Location:** Identifies runway on which aircraft is located	▨	**Taxiway Ending Marker** Indicates taxiway does not continue
4	**Runway Distance Remaining** Provides remaining runway length in 1,000 feet increments	↙A G L→	**Direction Sign Array:** Identifies location in conjunction with multiple intersecting taxiways

SPEED LIMITS: **250** knots (288 mph) indicated airspeed below 10,000 feet MSL; **200** knots (230 mph) at or below 2,500 feet AGL and within 4 nautical miles of a Class C or D airport; **200** knots (230 mph) underlying Class B airspace and along any designated VFR corridor through such airspace. **ALTITUDE:** Over congested areas - **1000** feet above the highest obstacle within a horizontal radius of 2,000 feet; **500** feet over other than congested areas except over open water or a sparsely populated area where the aircraft may not be operated closer than 500 feet from any person, vessel, vehicle, or structure. **VFR CRUISING ALTITUDES:** Above 3,000 feet AGL and below 18,000 feet MSL - on a magnetic course of 0° through 179° maintain an altitude of an odd thousand feet MSL plus 500 feet (3,500, 5,500, 7,500). On a magnetic course of 180° through 359° maintain an altitude of an even thousand feet MSL plus 500 feet (4,500, 6,500, 8,500). Remember **"Flying to the EAST is ODD"** **RIGHT OF WAY:** an aircraft in distress has the right of way (ROW) over all other aircraft. Head on - **each pilot shall alter course to the right**. Two aircraft of the same category converging - the aircraft to the other's right has ROW. While converging - a balloon has ROW over any other category, a glider has ROW over all other categories except a balloon. An aircraft that is being overtaken has the right of way and the overtaking aircraft shall alter course to the right to pass well clear. An aircraft on final approach or while landing, has ROW over all other aircraft in flight or on the surface but shall not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way. When two or more aircraft are approaching an airport to land - the aircraft at lower altitude has ROW but shall not take advantage of this rule to cut in front of another which is on final approach to land or to overtake that aircraft. No person may operate an aircraft so close to another aircraft as to create a collision hazard. **SAFETY BELTS & SHOULDER HARNESSES:** Required flight crewmembers must be at the crewmember station except to perform duties in connection with the operation of the aircraft or in connection with physiological needs and must keep safety belts fastened while at the station. Crew member shoulder harnesses shall be fastened during takeoff and landing. Each passenger must occupy an approved seat with a safety belt and, if installed, a shoulder harness properly secured during movement on the surface, takeoff and landing. **SPECIAL VFR:** With an ATC clearance, clear of clouds, visibility one statute mile. **AUTHORITY:** The pilot in command is the **final authority** as to the operation of an aircraft. A pilot may deviate from Federal Aviation Regulations (FAR's) to the extent required to meet an emergency.

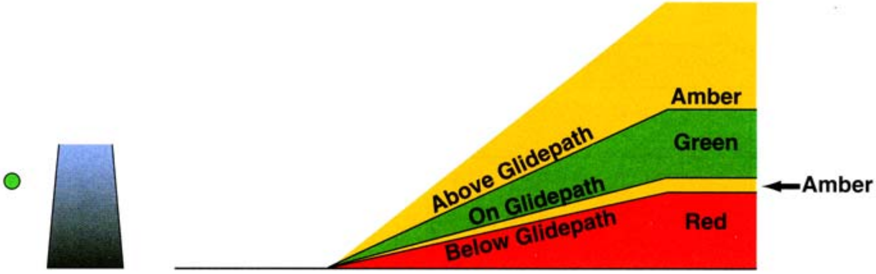
VISUAL GLIDESLOPE INDICATORS:

1. **Visual Approach Slope Indicator** (VASI) – Remember **"red over white, you're all right"**:

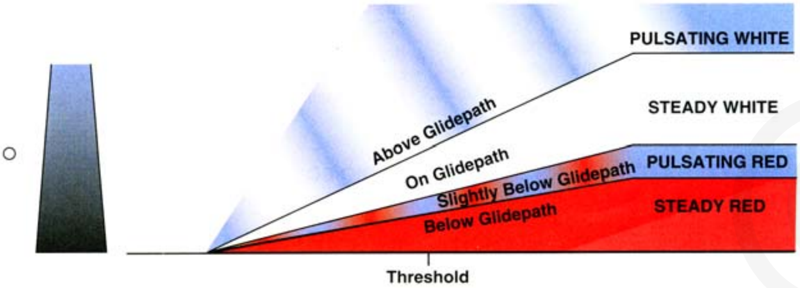
2. **Precision Approach Path Indicator** (PAPI):



3. **Tri-Color System** - Remember that there is a small area of dark amber just below the green glidepath which should not be mistaken for the "above glidepath" indication:



4. **Pulsating System –** Steady white is "on glidepath" – pulsating white or red are above or below and steady red is too low:



COMMUNICATIONS

AIRCRAFT COMMUNICATIONS: International aviation communications procedures are developed by the International Civil Aviation Organization (ICAO), an agency of the UN. Some procedures are classified as mandatory "standards" and some are classified as "recommended practices." In the US, the Federal Aviation Authority (FAA) specifies the procedures to be followed, conforming to the procedures developed by ICAO. **The standard language used in aviation worldwide is English**. The following material is taken directly from FAA manuals and the reader is referred to the latest edition of the Federal Aviation Regulations/Aeronautical information Manual (AIM) for the most comprehensive and up to date information. The last two pages of this section give the most essential radio frequencies and provide examples of communications used in typical situations.

Section 4-2-1 of AIM is very clear:

*"The single, most important thought in pilot-controller communications is **UNDERSTANDING**. It is essential, therefore, that pilots acknowledge each radio communication with ATC by using the appropriate aircraft call sign. Brevity is important, and contacts should be kept as brief as possible, but controllers must know what you want to do before they can properly carry out their control duties. And you, the pilot, must know exactly what the controller wants you to do. Since concise phraseology may not always be adequate, use whatever words are necessary to get your message across."*

FAA SUGGESTIONS FOR RADIO COMMUNICATIONS:

Listen before you transmit. Many times you can get the information you want through ATIS or by monitoring the frequency. Except for a few situations where some frequency overlap occurs, if you hear someone else talking, attempting to transmit will be futile. You will probably jam ("step on") someone else's attempt to transmit, causing a need to repeat the call. If you have just changed frequencies, first pause and listen to make sure the frequency is clear.

Think before keying your transmitter. Know what you want to say and, if it is lengthy, (e.g., a flight plan or IFR position report), jot it down so you do not waste transmission time trying to remember what you need to say.

Position the microphone very close to your lips. After pressing the mike button, a slight pause may be necessary to be sure that the first word is transmitted. Speak in a normal conversational tone.

Be patient. When you release the transmit button, wait a few seconds before calling again. The controller or FSS specialist may be jotting down your number, looking for your flight plan, transmitting on a different frequency, or selecting the transmitter to your frequency.

Be alert to the sounds, or lack of sounds, in your receiver. Check your volume, recheck your frequency, and make sure your microphone is not stuck in the transmit position. Frequency blockage can occur for extended periods of time due to unintentional transmitter operation. This type of interference is commonly referred to as "stuck mike," and controllers may refer it in this manner when attempting to assign an alternate frequency. If the assigned frequency is completely blocked by this type of interference, use the procedures described for en route IFR radio frequency outage to establish or reestablish communications with ATC.

Be sure that you are within the performance range of your radio equipment, and also the ground station equipment. Remote radio sites do not always transmit and receive on all of a facility's available frequencies, particularly with regard to VOR sites where you may hear but not reach a ground station's receiver. Remember that higher altitude increases the range of VHF "line of sight" communications.

INITIAL CONTACT: The term "initial contact" or "initial callup" means the first radio call you make to a given facility, or the first call to a different controller or FSS specialist within a facility. Use the following format: **who** you are calling, your **call sign**, where you are (**position**), and what you want to do if it is short (**request**).

If radio reception is reasonably assured; then including your position or altitude, or brief reports such as the phrase "with Information Charlie" (for ATIS), in the initial contact helps decrease radio frequency congestion. Use discretion, though, and do not overload the controller with information he does not need. If you do not get a response from the ground station, recheck your radios or use another transmitter, but keep the next contact short.

INITIAL CONTACT WHEN TRANSMITTING AND RECEIVING FREQUENCIES DIFFER: If you are attempting to establish contact with a ground station and you are receiving on a different frequency than that transmitted, be sure to indicate the VOR name or the frequency on which you expect a reply. Most FSSs and control facilities can transmit on several VOR stations in the area. Use the appropriate FSS name as indicated on charts. New York FSS transmits on the Kennedy, Hampton and Calverton VORTACs. If you are in the Calverton area, your initial call would be:

"New York Radio, Cessna three one six zero foxtrot, listening Calverton VOR."

If the chart indicates FSS frequencies above the VORTAC or in FSS communications boxes, transmit or receive on those frequencies nearest your location. If you are unable to establish contact and you need to call any ground station, your call might be:

"Any (radio) (tower) (station), call Cessna three one six zero foxtrot on (frequency) or (VOR)."

If an emergency exists or you need assistance, say so immediately!

SUBSEQUENT CONTACTS AND RESPONSES TO CALLS FROM A GROUND FACILITY: Use the same format as used for initial contact, except that if possible, you should state your message or request in the initial call. The ground station name may be omitted if the message requires an obvious reply and there is no possibility for misunderstanding. You should acknowledge all calls or clearances unless the controller or FSS specialist advises otherwise.

There are some occasions when the controller must issue time-critical instructions to other aircraft, and may be in a position to observe your response, either visually or on radar. If the situation demands your response, take appropriate action or immediately advise the facility of any problem. Acknowledge with one of the following words, Wilco - “I will comply,” Roger - “I have received and understood your last transmission,” Affirmative - “Yes,” Negative - “No,” or use other appropriate remark. If you have been receiving services; e.g., VFR traffic advisories and you are leaving the area or changing frequencies, advise the ATC facility and terminate contact.

ACKNOWLEDGEMENT OF FREQUENCY CHANGES: When advised by ATC to change frequencies, acknowledge the instruction. If you select the new frequency without an acknowledgement, the controller's workload is increased because there is no way of knowing whether you received the instruction or have had radio communications failure.

COMPLIANCE WITH FREQUENCY CHANGES: When instructed by ATC to change frequencies, select the new frequency as soon as possible unless instructed to make the change at a specific time, fix, or altitude. A delay in making the change could result in an untimely receipt of important information. If you are instructed to make the frequency change at a specific time, fix, or altitude, monitor the frequency you are on until reaching the specified time, fix, or altitudes unless instructed otherwise by ATC.

AIRCRAFT CALL SIGNS: Civil aircraft pilots should state the aircraft type, model or manufacturer's name followed by the digits/letters of the registration number. When the aircraft manufacturer's name or model is stated, the prefix "N" is dropped (e.g. Aztec Two Four Six Four Alpha). It is very important to ensure use of correct call signs. Aircraft with similar call signs may be on the same frequency, and improper use of call signs can result in one pilot executing a clearance intended for another aircraft. To avoid this problem, **never** abbreviate your call sign on an initial contact, or at any time when other aircraft call signs you hear on the frequency have similar numbers/sounds or identical letters/numbers to those of your own aircraft (e.g., Cessna 6132F, Cessna 1622F, Baron 123F, Cherokee 7732F, etc.).

For example, assume that a controller issues an approach clearance to an aircraft at the bottom of a holding stack and an aircraft with a similar call sign (at the top of the stack) acknowledges the clearance with the last two or three numbers of his call sign. If the aircraft at the bottom of the stack did not hear the clearance and intervene, flight safety would be affected, and there would be no reason for either the controller or pilot to suspect that anything is wrong. This kind of "human factors" error can strike swiftly and is extremely difficult to rectify.

Pilots must therefore be certain that aircraft identification is complete and correct before taking action on an ATC clearance. ATC will not abbreviate call signs of an air carrier or other civil aircraft having authorized call signs. ATC may initiate abbreviated call signs of other aircraft by using the prefix and the last three digits/letters of the aircraft identification after two-way communications have been established. The pilot may use the abbreviated call sign in subsequent contact with ATC.

When aware of similar/identical call signs, ATC will take action to minimize errors by emphasizing certain numbers/letters, repeating the entire call sign, repeating the prefix, or by asking pilots to use a different call sign temporarily. If you have any doubt as to whether a control instruction is intended for you, do not hesitate to make sure. Use the phrase, *"Verify clearance for (your call sign)" to* request clarification.

GROUND STATION CALL SIGNALS: When calling a ground station, begin with the name of the facility being called, followed by the type of the facility being called. The correct terms are as follows: Airport Unicom - *Shannon Unicom;* FSS - *Chicago Radio;* Control Tower - *Augusta Tower;* Clearance Delivery - *Dallas Clearance;* Tower Ground Control - *Miami Ground;* Approach Control - *Potomac Approach;* Departure Control - *Tampa Departure;* ARTCC (Center) - *Atlanta Center.*

STUDENT PILOT RADIO IDENTIFICATION: To help the student pilot acquire sufficient practical experience in the environment in which he or she will be required to operate, special procedures exist for student pilots who wish to receive additional assistance while operating in areas of concentrated air traffic. If you are a student pilot, you should identify yourself as such during the initial call to an FAA facility. For example:

"Dayton Tower, Fleetwing 1234, Student Pilot."

This special identification will alert ATC to provide the student pilot with any extra assistance and consideration needed. Though highly recommended, this procedure is not mandatory.

Alpha
Bravo
Charlie
Delta
Echo
Foxtrot
Golf
Hotel
India
Juliet
Kilo
Lima
Mike
November
Oscar
Papa
Quebec
Romeo
Sierra
Tango
Uniform
Victor
Whisky
X-Ray
Yankee
Zulu

---

35 = three five, 18,000 feet = Flight Level one eight zero, 12,500 feet = one two thousand, five hundred, 5 degrees = zero zero five, 122.00 = one two two point zero, Three = Tree, Five = Fife, Nine = Niner, 29.92 in. Hg = two niner niner two, Affirmative, Negative, Wilco, Roger, Say Again, Blocked, Acknowledge, Unable, Verify, Advise Intentions, Abeam, Back Taxi, Read Back, Traffic in Sight, When Able, Words Twice, Squawk, Maintain, Expect.

CTAF - Common Traffic Advisory Frequency. **Multicom** - 122.9, used as CTAF when no tower, Unicom or FSS. **Unicom** - privately operated, ground radio station. **ATIS** - Automatic Terminal Information Service. **AWOS/ASOS** - Automated Weather (Surface) Observing System. **FSS -** Flight Service Station "Radio." **EFAS** – Enroute Flight Advisory Service "Flight Watch." **VHF Reception** (Altitude/NM) **=** 1000/39, 3000/69, 5000/87, 10000/122, 15000/152, 20000/174.

CRISIS: Call on ATC frequency in use or **121.5. MAYDAY** (3x) - life threatening emergency **PAN PAN** (3x) - urgent problem (fuel, location, weather). Transponder **7700** for either crisis, **7600** for radio failure, **1200** VFR.

NO TOWER (communicate on CTAF/Multicom).

CTAF

Latrobe Valley Traffic, Cessna 25M, (two five Mike) 10 (one-zero) miles South, inbound for landing, Latrobe Valley.
Latrobe Valley Traffic, Cessna 25M, entering left (right) downwind (base, final), runway 21, Latrobe Valley.
Latrobe Valley Traffic, Cessna 25M, clear of runway 21, Latrobe Valley.
Piper over Latrobe Valley Airport, please state your position.

CTAF

Latrobe Valley Traffic, Cessna 25M, taxiing to runway 21 for takeoff, Latrobe Valley.
Latrobe Valley Traffic, Cessna 25M, crossing runway 27, Latrobe Valley.
Latrobe Valley Traffic, Cessna 25M, back-taxiing for takeoff on runway 21, Latrobe Valley.
Latrobe Valley Traffic, Cessna 25M, departing runway 21, staying in the pattern, Latrobe Valley.

CLASS D AIRPORT (must establish two way communication)

Control Tower

Danbury Tower, Cessna 3425M, 15 miles Southeast, inbound for landing, with Kilo. **(listen for and write down runway, left or right pattern, instructions for next contact, confirm and repeat back only the key items, see note "CONFIRMATION" at bottom of next page.**
Cessna 25M, downwind (report *where instructed to report*, turning base, etc.), for runway 26. **(listen for clear to land, follow, or other instructions, confirm)**

Ground Control

After Control Tower Handoff – **Danbury Ground**, Cessna 3425M, clear of runway 26, (if unfamiliar with airport) request progressive taxi instructions to General Aviation ramp. **(listen for taxi instructions)**

Ground Control

Danbury Ground, Cessna 3425M, GA ramp, taxi for takeoff, Southbound to Bridgeport with Kilo. **(listen for taxi route and possible hold short instructions, confirm)**

Control Tower

Danbury Tower, Cessna 3425M, runway 26, Southbound, ready for departure**. (listen for Cleared for Takeoff, Hold Short, or Position and Hold. Confirm; Pilots are required to read back all hold short and position instructions)**

CLASS B & C AIRPORTS

(must have clearance to land in or fly through Class B; must establish two way communication and have a transponder for both Class B & Class C)

Approach Control

Pittsburgh Approach, Cessna 3425M, VFR, Rostover Airport, 4500, inbound for landing at Pittsburgh, with Kilo. **(listen for: Remain Clear of Class B Airspace or Cleared to Enter Class B Airspace. DO NOT ENTER CLASS B WITHOUT THIS CLEARANCE. No clearance is necessary to enter Class C Airspace but two way communication and a transponder are required. Listen for and write down transponder code, heading and altitude instructions, altimeter setting, when to contact tower and on what frequency as well as possible other instructions, confirm key items)**

Cessna 3425M, squawking _______.

Cessna 3425M, cleared into Class Bravo airspace, Altimeter _____, Maintain VFR.

At handoff to Tower - Cessna 3425M, tower frequency _______.

Control Tower

Pittsburgh Tower, Cessna 3425M is inbound for landing. **(listen for instructions and confirm key items)**

Pittsburgh Tower, Cessna 3425M, downwind for runway 28 Left.

Clearance Delivery

Pittsburgh Clearance, Cessna 3425, request VFR departure to the South at 3500 feet enroute to Philadelphia, with Kilo. **(listen for instructions, departure frequency, transponder code and confirm)**

Ground Control

As in Class D procedure

Control Tower

As in Class D procedure

When instructed by Tower, contact Departure Control

Departure Control

Pittsburgh Departure, Cessna 3425M, climbing through 1000 for 3500. **(listen for heading and altitude instructions; later, listen for handoff instructions – most likely to VFR transponder code 1200, radar service terminated, and resume your own navigation)**

Cessna 3425M, resuming own navigation, thank you.

FLIGHT FOLLOWING

(radar separation, vectors, etc., if workload allows)

Approach Control or Air Route Traffic Control Center

New York Approach, Cessna 3425M.

Cessna 3425M, over Bridgeport 6500, enroute to Williamsport, request flight following. **(listen for transponder code, altimeter setting, other instructions)**

Cessna 3425M, squawking ___, altimeter ___.

New York Approach, Cessna 3425M request temporary frequency change to check weather. **(listen and confirm instructions, call back when you return)**

CONFIRMATION: Transmissions should be acknowledged with the Aircraft Call Sign and Roger, Wilco, or Affirmative/Negative except for readbacks including the runway assignment, instructions to cross an active runway, hold short, hold in position, land and hold short, clearances, altitude and vector assignments and specifically requested readbacks. Transmissions which require clarification should be read back; for instance "Confirm, Taxiway Golf?"

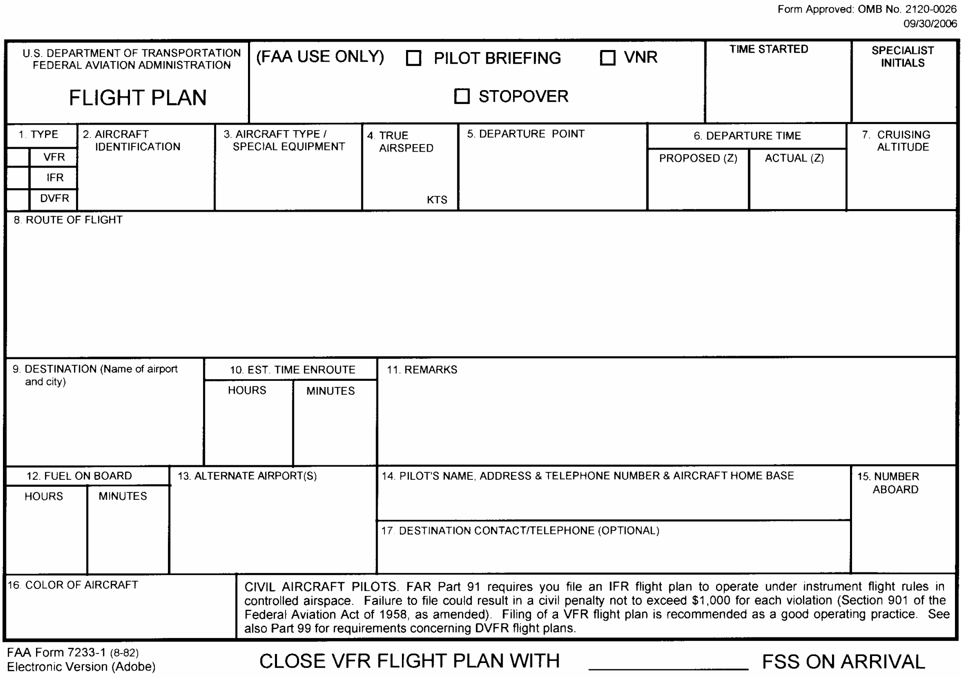
FREQUENCIES:

121.5	**EMERGENCY**
122.0	Enroute flight Advisory Service EFAS (Flight Watch)
122.9	Multicom
122.95	Unicom at Towered Airports (Other Unicom: 122.7, 122.725, 122.8, 122.975, 123.0, 123.05, 123.075)
122.2	FSS; also monitor 121.5, others shown on charts
122.75-122.85	Air to Air & Private Airfields
121.6-121.9	Ground Control, often given as "point 6"

FLIGHT PLANNING

Zulu on final for Oshkosh

FAA FLIGHT PLAN: A flight plan is not required for visual flight rules (VFR) flight but is strongly recommended by the FAA to ensure VFR Search and Rescue Protection. File by telephone or in person with a Flight Service Station (FSS). A pilot may file by radio if no other means is available. After takeoff, radio the FSS and give the time of departure to activate the plan. The plan will be held until one hour after the proposed departure time and then cancelled if the departure time is not revised or an actual departure time received. For flights with several stops, file separate flight plans. Close the plan with the nearest FSS or other FAA Facility, VFR flight plans are not automatically canceled by the tower. If you do not change your Estimated Time of Arrival (ETA), or close the plan, the FAA will begin a search thirty minutes after ETA.



Form Approved: OMB No. 2120-0026
09/30/2006

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
FLIGHT PLAN

(FAA USE ONLY) ☐ PILOT BRIEFING ☐ VNR ☐ STOPOVER

TIME STARTED

SPECIALIST INITIALS

1. TYPE
☐ VFR
☐ IFR
☐ DVFR

2. AIRCRAFT IDENTIFICATION

3. AIRCRAFT TYPE / SPECIAL EQUIPMENT

4. TRUE AIRSPEED KTS

5. DEPARTURE POINT

6. DEPARTURE TIME
PROPOSED (Z) ACTUAL (Z)

7. CRUISING ALTITUDE

8. ROUTE OF FLIGHT

9. DESTINATION (Name of airport and city)

10. EST. TIME ENROUTE
HOURS MINUTES

11. REMARKS

12. FUEL ON BOARD
HOURS MINUTES

13. ALTERNATE AIRPORT(S)

14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE

15. NUMBER ABOARD

17. DESTINATION CONTACT/TELEPHONE (OPTIONAL)

16. COLOR OF AIRCRAFT

CIVIL AIRCRAFT PILOTS. FAR Part 91 requires you file an IFR flight plan to operate under instrument flight rules in controlled airspace. Failure to file could result in a civil penalty not to exceed $1,000 for each violation (Section 901 of the Federal Aviation Act of 1958, as amended). Filing of a VFR flight plan is recommended as a good operating practice. See also Part 99 for requirements concerning DVFR flight plans.

FAA Form 7233-1 (8-82)
Electronic Version (Adobe)

CLOSE VFR FLIGHT PLAN WITH ________________ FSS ON ARRIVAL

FLIGHT PLAN SEQUENCE:

Type: VFR/IFR/DVFR
Aircraft
Identification ("N")
Type & Equipment
True Airspeed (TAS)
Departure Airport
Departure Time (ZULU)
Initial Altitude
Define Route of Flight
Destination Airport
Time Enroute
Remarks
Useable Fuel in hrs./min
Alternate Airport
Name/Home Base/phone
Persons Onboard
Color of Aircraft

SPECIAL EQUIPMENT:

/X - No Transponder
/T - Transponder w/o Altitude Encoding
/U - Transponder w/ Altitude Encoding
/B - DME,Transponder w/o Altitude Encoding
/A - DME, Transponder w/ Altitude Encoding
/C - RNAV, Transponder w/o Alt. Encoding
/I - RNAV, Transponder w/ Alt. Encoding
/G - GPS w/ Enroute & Terminal Capability

POSITION REPORT FORMAT:

Identification, Position, Time, Altitude, Type of Flight Plan (VFR), ETA – next reporting point (Fix), Next Succeeding Fix.

NAVIGATION

Juliet reads up on the International Date Line

NOTE: The subject of aircraft navigation is too large and too complex to be covered adequately in a **Reference** such as this. What we can do is give the reader some basic information and a calculator and transparent plotting sheet.

CHARTS: US FAA Sectional Charts have a scale of 1:500,000. **As a rule of thumb, one inch = 6.86 nautical miles (NM or Knot) and about 8 statute miles**. VFR Terminal area charts show more detail at a 1:250,000 scale and World Aeronautical Charts cover a larger area with less detail at 1:1,000,000.

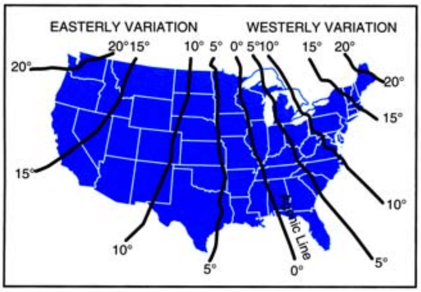
A nautical mile is defined as the average distance on the Earth's surface represented by one minute of latitude. Accordingly, one NM is 1/60 of one degree and the circumference of the earth is 360 x 60 or 21,600 NM. At the rate of one complete rotation in 24 hours, any point along the equator is moving at 900 nautical miles per hour, making each time zone about 900 NM wide at its widest point. Be aware that these numbers are approximations because the earth is not a perfect sphere and its rotation is eccentric. One nautical mile = 1.15 statute miles.

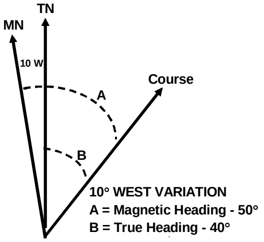
Latitude lines can be visualized as horizontal and parallel slices through the earth and are measured going north and south from the equator at 0º with Boston at 042ºN Latitude, Melbourne, Australia at 038ºS Latitude, and the Poles at 090ºN & 090ºS. Longitude lines are vertical and always run between the poles, like sections of an orange. Remember that you can measure nautical miles accurately along the longitude (vertical) scale but not along the latitude (horizontal) scale except at the equator because the circumference becomes smaller as the lines move away from the equator. You will never get mixed up if you remember latitude (circumference) as **"fatitude."** The convention in aviation is to state latitude first, then longitude, using three numbers; 042°N Latitude, 080°W Longitude.

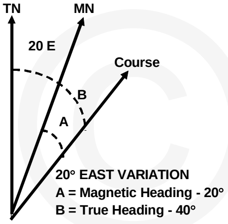
On a Sectional Chart, small tick marks represent each NM, a larger tick mark is shown every 10 NM and one degree is 60 NM. **Juliet warns; don't make the common error of working in 10's and calculating 100 NM instead of 60 NM per degree.**

When estimating the time it will require to fly a distance, it can be helpful to think of 60 Knots as 1 mile per minute or ten miles in ten minutes, 90 K as 1½ mpm or ten miles in about seven minutes, 120 K as 2 mpm or ten miles in five minutes, 150 K as 2½ mpm or ten miles in four minutes, and 180K as 3 mpm or ten miles in just over three minutes.

HEADING: To determine an accurate compass course, it is necessary to correct the course as measured on a chart for the effects of wind, regional magnetic variation, and the deviation of the compass (due to magnetic influences within the specific aircraft). The formula is: **True Course** – left or + right **Wind Correction Angle** = **True Heading** – east or + west variation = **Magnetic Heading** – east or + west deviation = **Compass Heading**. **(TC ± WCA=TH ± VAR=MH ± DEV=CH)** **A Pilot Zulu rule of thumb is to remember WAR.** You **A**dd **R**ight wind correction angle and **W**est variation and deviation. The map below (circa 2000) shows how magnetic variation differs across the US and the drawings illustrate the relationship between True (chart) North, Magnetic North and Magnetic Heading or Course:







CROSSWINDS & HEADWINDS: Use the chart below to determine the effect of the wind on takeoff and landing. Match the angle of the wind to its velocity in knots and read the headwind and crosswind off the chart. **EXAMPLE:** assume a wind from the right front at 30° and a wind speed of 20 knots. The corrected headwind is 17 knots and the crosswind is 10 knots. Interpolate for intermediate angles and speeds. **A Pilot Zulu rule of thumb is that at a 30° wind angle, the crosswind will always be approximately one half of the wind speed.**

CROSSWIND CORRECTION

(IN KNOTS)

HEADWIND → 0 / 0 **← CROSSWIND**

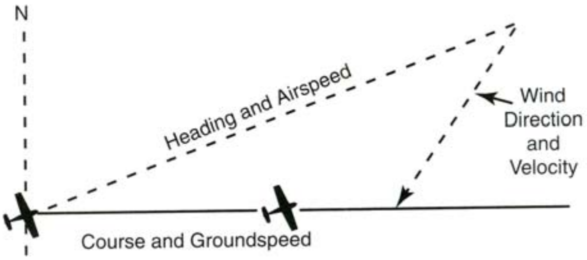
ANGLE BETWEEN WIND DIRECTION & TRUE COURSE

WIND SPEED IN KNOTS

	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
10	10 0	10 2	9 3	9 5	8 6	6 8	5 9	3 9	2 10	0 10
20	20 0	20 3	19 7	17 10	15 13	13 15	10 17	7 19	3 20	0 20
30	30 0	30 5	28 10	26 15	23 19	19 23	15 26	10 28	5 30	0 30
40	40 0	39 7	38 14	35 20	31 26	26 31	20 35	14 38	7 39	0 40
50	50 0	49 9	47 17	43 25	38 32	32 38	25 43	17 47	9 49	0 50
60	60 0	59 10	56 21	52 30	46 39	39 46	30 52	21 56	10 59	0 60
70	70 0	69 12	66 24	61 35	54 45	45 54	35 61	24 66	12 69	0 70

If you don't have access to a Crosswind Correction Chart, you can make a very rough estimate of the crosswind **for wind angles of up to 50°** by multiplying the wind angle by 1.6 and, taking the answer as a percentage, multiplying it times the wind speed. For instance, with a wind angle of 40° and wind speed of 20 knots, multiply 40° by 1.6 to get 64%, multiply it times the wind speed of 20 knots to get 12.8 knots of crosswind. This method is not accurate for wind angles above 50°, as the crosswind strength becomes closer to the actual wind speed.

WIND TRIANGLE: To determine Wind Correction Angle (WCA) and Groundspeed (GS) use a flight computer, E6B, or log table or draw a scaled wind triangle as illustrated below:



WCA and GS can also be estimated with reasonable accuracy by using Pilot Juliet rule of thumb methods. Estimate WCA by dividing the crosswind by the True Airspeed (TAS) and multiplying by 60. **EXAMPLE:** if the crosswind is 13 knots and TAS is 100 knots, divide 13 by 100 and multiply by 60 to calculate a WCA of 8°. Doing it in your head, you would simplify to 13 times 6 divided by 10 or whatever is easiest for you.

To estimate the effect of a headwind or a tailwind on groundspeed (GS), calculate the strength of the wind by deducting the wind angle from the number 115. Take the result as a percentage of the actual wind speed and subtract for a headwind or add for a tailwind. **EXAMPLE:** with a headwind of 15 Knots coming from an angle of 30°, deduct 30 from 115 getting 85%. Take 85% of 15 Knots and deduct the result, 13 Knots, from TAS to calculate GS. If the wind angle exceeds

60°, use 105 instead of 115 as the fixed number from which to subtract wind angle. If the WCA calculates to greater than 10°, then calculated GS should be reduced by a further 2% for a 10° WCA, 3%/15°, 6%/20°, 10%/25°, and 12%/30°. Note that when assessing the effect of a crosswind on travel over a distance, even a 90° crosswind creates a headwind component because of the need to crab towards the crosswind and away from the true heading.

RULE OF SIXTY: If you know how many miles you have traveled and how far the wind has taken you off your course at that point, the "Rule of Sixty" can help you determine how many degrees you have to adjust to get headed in the right direction and how many more degrees to adjust to intercept your original plotted course. This rule is sometimes referred to as the "One in Sixty" Rule. **EXAMPLE:** you have traveled 60 miles and find that you are 4 miles off course. Each mile off course at 60 miles is equal to one degree. A correction of 4º will get you headed in the correct direction. To intercept your original plotted course, you will have to adjust further. To intercept in another 60 miles you would adjust back by another 4º (closing angle) for a total of 8º. If you want to intercept more quickly, in 30 miles, you would adjust twice as much or a closing angle of 8º for a total of 12º. Once you intercept the course, you would subtract the 8º (closing angle) portion of the adjustment; retaining the 4º original track error adjustment to keep you on course, assuming that the wind remains the same.

To take another example; if you find that you are off course by 2 miles in the first 20 miles of travel, by extension, you would be off 6 miles if you went 60 miles, so you are off course by 6º. The same applies if you are off course by, say, 10 miles over a distance of 120 miles. Adjusting back from 120 miles to 60 miles you would have been off course by 5 miles or a 5º track error. The way the Rule of Sixty is derived is interesting. If you assume a circle of 360 degrees which is also 360 miles in circumference, then each mile equals one degree. The circumference of a circle is equal to 2 π radius. So, if a circle has a circumference of 360 miles, then the radius is about 60 miles (360 / (2 * 3.14) = 57.3 = roughly 60).

The chart below on the left, shows the conversion from the number of miles deviated off course (track error) during the miles traveled to the number of **degrees required to correct your course to the proper heading**. It also shows the additional number of **degrees** (the closing angle) to correct your heading to return to the original and planned track in a specified distance. The degrees in the chart are based on a radius of 57 miles.

TRACK ERROR & CLOSING ANGLE:

MILES TRAVELLED or MILES TO GO

MILES OFF TRACK	10	20	30	40	50	60	120	150	200
1	6	3	2	1	1	1	0	0	0
2	11	6	4	3	2	2	1	1	1
3	17	9	6	4	3	3	1	1	1
4	23	11	8	6	5	4	2	2	1
5	29	14	10	7	6	5	2	2	1
6		17	11	9	7	6	3	2	2
7		20	13	10	8	7	3	3	2
8		23	15	11	9	8	4	3	2
9		26	17	13	10	9	4	3	3
10		29	19	14	11	10	5	4	3
15			29	21	17	14	7	6	4
20				29	23	19	9	8	6

CORRECTION TO REGAIN THE PLANNED HEADING:

$$\frac{\text{Miles Off Course}}{\text{Miles Traveled}} = \frac{\text{Track Error (\%)}}{60}$$

CORRECTION FROM THE PARALLEL COURSE TO INTERSECT PLANNED TRACK:

$$\frac{\text{Miles Off Course}}{\text{Miles Remaining}} = \frac{\text{Closing Angle (\%)}}{60}$$

Another calculation is useful for departing from a plotted course to avoid or go around an obstacle such as a populated area or an area of raised terrain. The pilot will deviate from the course by a planned number of degrees, say 30º or 45º for a predetermined length of time or distance and then turn back twice the number of degrees (60º or 90º) for the same time or distance, thus intersecting the original course and continuing on as planned.

ZULU: Zulu is the abbreviation for Universal Coordinated Time (UTC) as measured at 0° Longitude, the prime meridian, at Greenwich, England. **Aviation worldwide runs on Zulu time.** Zulu time is measured like twenty-four hour military time in four digit increments starting with 0001 and ending with 2400. 8:00 AM is 0800 hours and 8:00 PM is 2000 hours. Although pilots fly all over the world on Zulu time they need to revert to local time when they arrive at a destination, so it is useful to understand local time zones, daylight savings time, and the International Date Line. Local time zones are measured east (minus) and west (plus) from the prime meridian. For instance; New York, standard time, is five hours behind Zulu - at 2:00 PM in NY it is 7:00 PM Zulu and 10:00 PM in Moscow. To convert **local time** to **Zulu**, use the following factors:

Eastern Standard (US)	+5	Paris	-1
Eastern Daylight	+4	Berlin	-1
Central Standard	+6	Moscow	-3
Central Daylight	+5	Riyadh	-3
Mountain Standard	+7	Bangkok	-7
Mountain Daylight	+6	Singapore	-8
Pacific Standard	+8	Shanghai	-8
Pacific Daylight	+7	Hong Kong	-8
Hawaii	+10	Tokyo	-9
Lima	+5	Melbourne	-10
Buenos Aires	+3	Wellington	-12

DAYLIGHT SAVINGS TIME: This is an adjustment which sets the time forward by one hour in the summer when there are more hours of sunlight (**Spring Forward, Fall Back**). The effect is to extend the hours of sunlight further into the evening. **DST** begins in March or early April and ends in late October. In the Southern Hemisphere, the seasons are reversed so daylight savings time begins in October and ends in March. Zulu (Universal Coordinated Time UTC) is not adjusted for daylight savings. Accordingly, in the Eastern Hemisphere, time is closer to Zulu during DST and the above conversion factors are reduced by one hour as shown. In the Western Hemisphere, DST increases the difference from Zulu so the conversion factors shown above are increased by one hour. During Melbourne's DST you would adjust to Zulu by subtracting eleven rather than the normal ten.

INTERNATIONAL DATE LINE: Since pilots operate on Zulu time, the International Date Line is not important until they reach a destination and revert to local time. Wherever he or she is in the world, Zulu time is the same as it is in Greenwich, England at 0º Longitude and moves forward hour by hour and calendar day by calendar day at the same rate.

The International Date Line (IDL) is an imaginary line established by an 1884 International Meridian Conference. A similar nautical date line was established for determining time on board military and merchant ships in 1915. The line is on the opposite side of the world from Greenwich running through an area which is largely open ocean and roughly tracks the 180º meridian, zigzagging to avoid national boundaries. It deviates between Alaska and Russia so that each area stays within its own national time zone.

The IDL is necessary because each area of the world keeps time by the motion of the earth relative to the sun. When the sun is approximately overhead, it is 12:00 noon. Each country sets its time zones accordingly. If you were in a very fast aircraft traveling at about 900 nautical miles per hour west from London toward New York and then on to Los Angeles and then Hawaii and on non- stop around the world, you would be traveling at the same speed as and opposite to the motion of the earth as it rotates under the sun.

If you started at 6:00 AM sunrise in London, you would pass over each city at sunrise, the same time as you left London. To adjust to local sunrise time, you would set your watch back one hour every hour so that you would be at 6:00 AM local time as you tracked the sunrise over each city. When you arrived back in London, it would still be sunrise and your time and calendar date would be the same as when you left. Local time in London, however, would be 24 hours or one calendar day later. If you had stayed on Zulu time and not reset your watch, you would have traveled for 24 hours and would arrive one calendar day later and your calendar would agree with local time.

On an ocean voyage, sailors go much more slowly and change their own local time periodically, sometimes 15 minutes every evening, so that the sun is approximately overhead at Noon. Because they travel relatively slowly, they use local time not Zulu time. The effect is exactly the same as in the aircraft example. When Magellan's expedition returned to Spain in 1522 after a westward circumnavigation, the surviving crewmembers were convinced, based on their meticulous ships logs, that the correct day was 24 hours earlier than local calendar time. This is called the "circumnavigator's paradox" and the earliest historical reference to it is in the writings of a Syrian geographer and historian in about 1300. A circumnavigation to the east results in the recording of an extra day by the traveler, as happened to Phileas Fogg in "Around the World in Eighty Days."

The International Date Line (IDL) compensates for this paradox by arbitrarily changing the date so that the east side of the line is 24 hours later than the west side of the line. Thus local hourly time remains the same but the date is advanced by one day as you cross the line going east and set back one day as you travel west.

VOR: This stands for VHF Omnidirectional Range, a land based radio navigation system which provides a course to the transmitting equipment for each of the 360º compass points or radials extending away from the equipment. If you are flying to the East toward a VOR on the 270° radial, with the course selector set at 90°, the indication will show "To." Remember that if you reverse direction to fly to the West (270°) while staying in approximately the same location and leaving the selector set at 90°, the indication will remain "To". To use a VOR, tune it in and check the identifiers; then rotate the azimuth dial until the needle centers and the indication is "From" in order to identify the radial you are on (and where you are). Then rotate the azimuth dial until the indication is "To" and the needle is again centered. Turn the aircraft to the heading then shown on the VOR (which will be the reciprocal of the radial you have just identified) and begin tracking. If you drift off to one side or the other, correct by turning toward the needle to correct for the wind. Don't reset the course selector or you will keep drifting with the wind.

For example, the VOR illustrated to the left is set to the 254º radial, the needle is centered and the indication is "From." This indicates that the aircraft is on the 254º radial which is roughly west-southwest of the VOR station. It does not indicate what direction the aircraft is flying at the time. The aircraft could be flying north and just momentarily crossing the 254º radial. To fly towards the station on the 254º radial, turn the OBS (Omni Bearing Selector) dial until the indication is "To" and the needle is again centered. The new reading will be 74º. If you turn the aircraft to that heading (74º), you will be tracking roughly east north-east towards the VOR on the 254º radial.

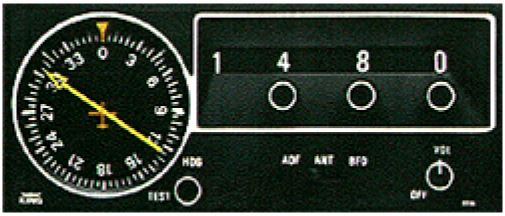
Avoid confusion by always flying **toward** the VOR with a **"To"** indication and away from the VOR with a "From" indication so you can correct by **turning toward the needle**. When checking the VOR on the test frequency, 180° shows as "To" and 0° shows as "From."

VOR transmitting stations are shown in the various FAA charts and in the FAA Airport/Facility Directory with latitude and longitude coordinates. VOR signals are VHF and the range is line of sight and about 25 miles at an altitude of 1000 feet and further at higher altitudes.

DME is distance measuring equipment giving the slant range (from aircraft altitude) distance to the VOR. A VOR with DME capability is labeled a VOR/DME or VORTAC if it also includes military navigation equipment. **VOR/DME RNAV** uses an onboard computer to calculate a direct course even though the VOR's used are located to either side of the desired course.

GPS: The Global Positioning System (GPS) is a satellite based UHF radio navigation system installed and maintained by the US Department of Defense. There are 24 satellites, each of which circles the earth twice a day in a very precise orbit and transmits signal information to earth. A GPS receiver will lock onto the signals from at least three satellites, comparing the time a signal was transmitted by a satellite to the time it was received. This time difference tells the GPS receiver how far away it is from the satellite. With signals from three satellites, it can triangulate and determine latitude and longitude and track movement. With four or more satellites in view, it can also determine altitude.

Using WAAS (wide area augmentation system) technology, tests have demonstrated an accuracy of about three meters, both horizontally and vertically. GPS UHF radio signals pass through clouds, glass and plastic but are obstructed by solid objects such as buildings and mountains. A GPS system can provide a wide variety of information including position, speed, bearing, track, trip distance, distance to destination, and sunrise & sunset time. Some GPS systems are programmed with additional data and communications capability to provide terrain avoidance information and data linked weather information with weather charts, current METAR's and TAF's and even TFR's (Temporary Flight Restrictions).



ADF/NDB: The Automatic Direction Finder on an aircraft detects the AM radio signal from a Non Directional Beacon and determines the direction of that station relative to the aircraft. An ADF can also identify the direction to a commercial AM broadcast station but it is important to make sure that the station identification and location are correct.

Within the US, VOR navigation has largely replaced the use of NDB's but NDB systems are in extensive use worldwide and beacon locations are shown on the charts and in Airport/Facility directories.

Aboard the aircraft, ADF equipment consists of a radio tuner to locate the frequency for the NDB desired and a relative bearing indicator (RBI) to show the location of the beacon relative to the aircraft. An arrow rotates around a dial and points to the beacon selected.

There are a variety of indicators or displays available, some of which can manually or automatically orient the direction to the beacon with the compass heading of the aircraft.

The most basic relative bearing indicator has a fixed azimuth or fixed card with the zero degree position at the top of the card corresponding to the direction of the aircraft. If the pilot turns the aircraft so that the arrow points to zero at the top of the relative bearing indicator, then the aircraft is flying directly toward the beacon (NDB). Alternatively, if the pilot turns the aircraft so that the arrow is pointing to 180º at the bottom of the display then the aircraft will be tracking directly away from the beacon.

The **Relative Bearing** is the bearing of the NDB station relative to the nose of the aircraft and the angle is measured clockwise from the nose of the airplane to a line drawn from the airplane to the station. The **Magnetic Bearing** to the station is the angle formed by a line drawn from the aircraft to the station and a line drawn from the aircraft to magnetic north. The magnetic bearing to the station can be determined by adding the relative bearing to the magnetic heading of the aircraft. For example, if the relative bearing is 060º and the magnetic heading is 130º then the magnetic bearing to the station is 190º. This means that, in still air, a magnetic heading of approximately 190º would be flown to the station. If the total of the relative and magnetic bearings is greater than 360º, subtract 360º from the total to obtain the magnetic bearing to the station.

Tracking to or from the station requires correcting for wind drift. For instance, as shown to the left; if the magnetic bearing to the station is 340º, a correction for a left crosswind would result in a magnetic heading of 330º and the ADF arrow would indicate 10º to the right or a relative bearing of 010º.

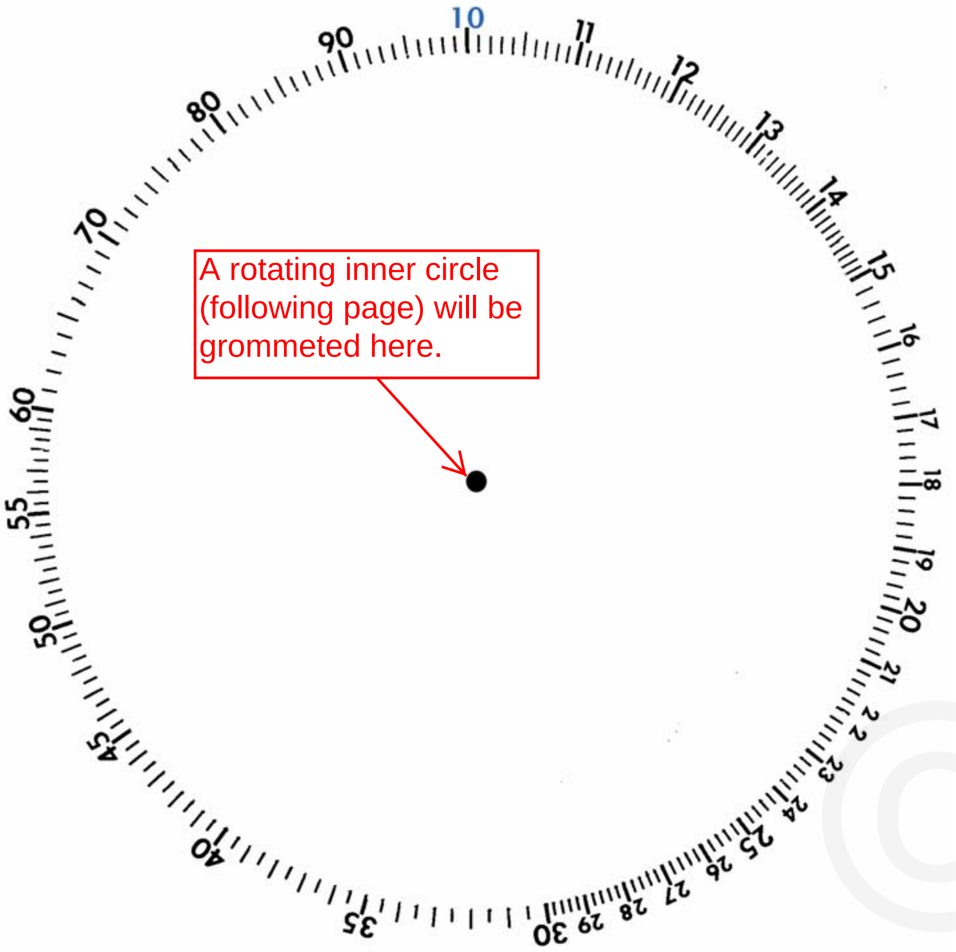
If a pilot can tune in two or more NBD's or a combination of NBD's and VOR's, he or she can locate or "fix" the position of the aircraft at the point where the bearing lines intersect.

The RDF/NDB system has one advantage over VOR. Because AM radio signals follow the curvature of the earth and are not line of sight, they can be received at greater distances. Like the radio signals we are used to on home and car radios, the signal is affected by electrical storms, mountainous terrain and interference from other stations. Stations are identified by a three letter Morse code transmission. Stations may also broadcast ATIS, AWIS, AWOS, TWEB and other information. In the event of the failure of VHF communication with the tower, Air Traffic Control (ATC) may be able to transmit instructions using an AM NBD frequency.

OTHER PILOT INFORMATION SYSTEMS: A variety of other information systems are available which use satellite radio, radar, electromagnetic impulses (sferics), and transponder interrogation to, in that order, provide cockpit weather information, identify nearby rain or snow, locate thunderstorms and provide collision warning and avoidance by identifying and locating nearby aircraft.

FLIGHT COMPUTER - E6B: We have included a simplified E6B circular slide rule below to help with quick time, speed, distance, and fuel calculations. The original E6B was invented by US Naval Lt. Philip Dalton in the late 1930's. Commercially available flight computers, both slide rule and electronic, can perform many additional useful calculations. Learning to use this simplified version is a good starting point. The relevant formulas are shown on the inner wheel of the E6B. This printed E6B will be less precise than a calibrated metal E6B.

Groundspeed; If you know that you have traveled 50 miles in 22 minutes you can easily determine groundspeed. Set TIME on the inside wheel (22) opposite MILES (50) on the outer wheel. Look around to the right on the inside TIME wheel and locate 60 minutes which is always indicated by a large arrow. Just above 60, you will see the rate which, in this case, is between 136 and 137 knots per hour. If you plan to cover 200 miles, you can calculate the time this will take at 136 K by locating 20 (for 200 – remember, you are using proportions and working in 10's) on the outside scale and reading the answer, 88 minutes, under it. **Fuel Consumption:** For the same flight, assuming that your aircraft uses 8 GPH at 65% power, set 60 (for one hour) on the inside wheel opposite 80 (representing 8 GPH) on the outside wheel and look around to the right to find 88 minutes on the inside wheel. Just above that 88 is the fuel used at 11.73 Gallons. Remember to add in an appropriate reserve and to estimate the fuel to be consumed during taxi, climb, descent and time in the pattern. **Juliet advises that an ironclad rule in doing slide rule or ratio calculations is to look at each result and think out whether it is a reasonable answer to the problem.**



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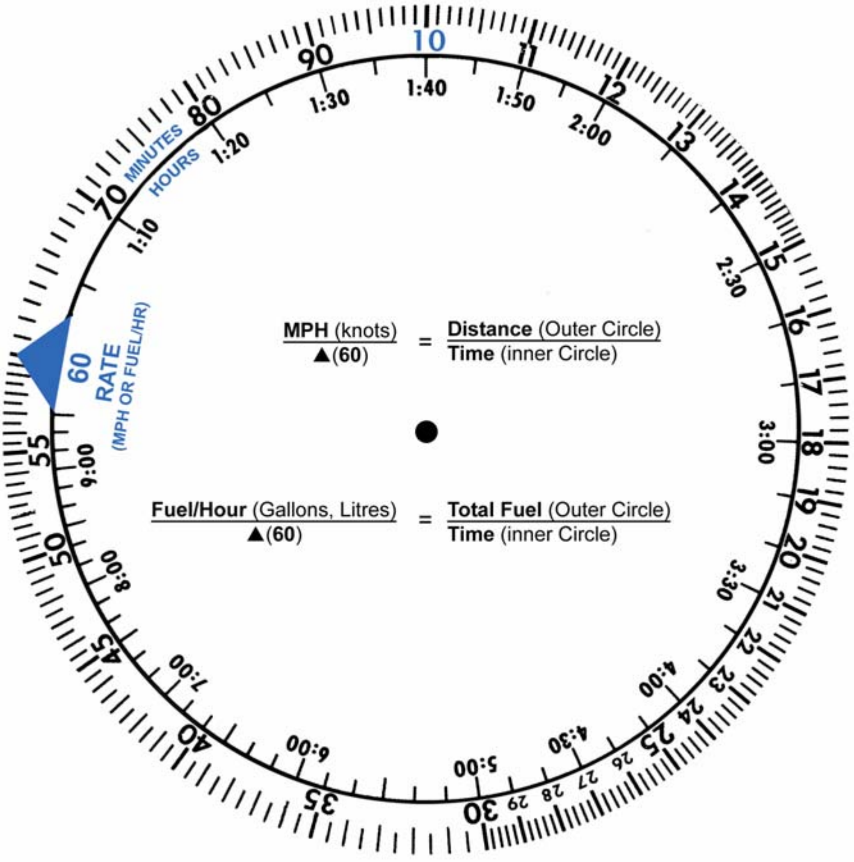
MPH (knots) / ▲(60) = Distance (Outer Circle) / Time (inner Circle)
Fuel/Hour (Gallons, Litres) / ▲(60) = Total Fuel (Outer Circle) / Time (inner Circle)
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RATE
(MPH OR FUEL/HR)
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HOURS
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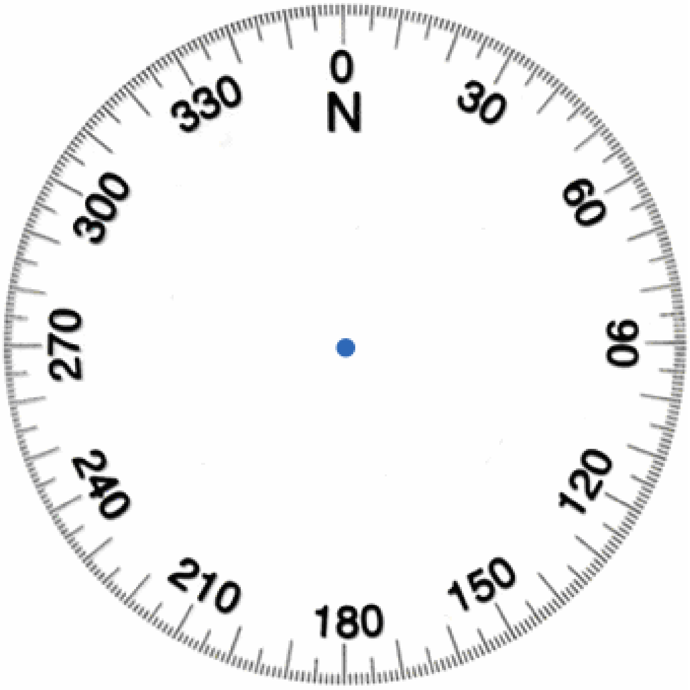
This is a transparent plotting page to be laid over a chart to determine the direction of a course line drawn on the chart.



PLOTTER: To read true course, place the **BLUE DOT** at the center of the compass rose anywhere along your course line on the chart, align the bottom or the top of the page with a latitude (horizontal) line, and read off the true course on the compass rose.

CONVERSIONS: °Fahrenheit = 9/5(°Centigrade) + 32. °C = 5/9(°F-32). **An easy Pilot Juliet rule of thumb is to multiply °C by 2, subtract 10% and add 32**. For example, 15°C (Standard Temperature) x 2 = 30 – 10% = 27 + 32 = 59°F.

°C	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0
°F	-76	-67	-58	-49	-40	-31	-22	-13	-4	5	14	23	32
°C	5	10	15	20	25	30	35	40	45	50	55	60	65
°F	41	50	59	68	77	86	95	104	113	122	131	140	149

29.92 inches in height of a column of mercury (Standard Atmosphere) = 1013.2 Millibars (mb). One inch of mercury = 33.86 Millibars. One US Gallon = 3.785 Litres. One Litre = .264 US Gallons. One Nautical Mile = 1.15 Statute Miles. One Statue Mile = 1.609 Kilometers. One Nautical Mile = 1.85 Kilometers. One Kilometer = .621 Statute Miles. One Kilometer = .539 Nautical Miles. On a Sectional Chart, One inch is about 6.86 Nautical miles and 8 Statute Miles. One Foot = 30.48 Centimeters = .3048 Meters. One Meter = 3.2808 Feet. One Inch = 2.54 Centimeters = 25.4 Millimeters. One Centimeter = .3937 Inches. One Pound = .4537 Kilograms = 453.6 Grams. One Kilogram = 2.205 Pounds.

This nautical miles scale will be shown along the right edge of the preceding transparent page so that it can be laid over a chart and the distance between two points read off.

WEATHER

Zulu checks the Weather Glossary

PILOT WEATHER: Pilots are interested in weather reports and weather forecasts because they need to know how weather conditions will affect a planned flight and how changing air pressures, temperatures and humidity will affect aircraft performance.

It is obvious that weather conditions such as visibility, air turbulence, wind speed and direction, icing, and runway condition are critically important to all pilots. They are even more critical for pilots flying smaller aircraft at lower altitudes and for pilots flying under visual flight rules (VFR). Weather is local and conditions vary dramatically for pilots flying in different areas of the world, so pilots need to understand the general principles of meteorology and how to apply them in the particular area in which they fly. Differing conditions include flying in mountains and at high altitude, in the bush or outback, in foggy coastal areas, in extremes of heat and cold, in sandstorms or in snow and ice. In the following paragraphs, this **Reference** provides an overview of how weather systems are created. In addition, pilots should know where to obtain local weather information, should understand the principles governing the formation of thunderstorms, fog, clouds, inversions, ice and wind, and should become very familiar with synoptic charts with their fronts, isobars, ridges, troughs, and cols. None of this, including METAR and TAF reports, is very difficult and all of it is essential.

THE ATMOSPHERE: The atmosphere of the earth is very thin relative to its size. The earth is approximately 7,000 nautical miles in diameter and 75% of the earth's atmosphere is within six or seven statute miles of the surface. 99% is within 20 miles of the surface. So it is easy to see that heat from the sun and friction from the rotation of the earth will create movement or churning within this very thin layer of atmosphere or air. Areas where the air is moving down cause the molecules which make up the air to be compressed creating areas of high pressure and making the air more dense. Usually, a high pressure area is dome shaped with the highest pressures at the surface under the dome's highest point. Areas where the air is rising release the pressure and molecules become further apart creating bowl shaped areas of low pressure and low air density with the lowest pressures at the surface near the center. Warm rising air near the equator creates a series of low pressure areas or systems, sinking air in the mid-latitudes creates high pressure systems and the polar regions are characterized by a polar high with high pressure and very cold and dense sinking air.

Because there is less atmosphere in a low pressure system column, air from a high pressure system tends to flow towards it at the surface. Accordingly, the air in a high pressure system is usually descending (its weight is compressing the air) to move toward the bottom of the adjoining column of low pressure air as the atmospheres merge and the pressures begin to equalize. This downward movement reduces cloud formation in a column of high pressure air. In a low, air is pulled in at the surface and then rises as the system tries to equalize pressure or the relative weights of the adjoining columns of air. As this air rises, it cools, moisture condenses, and clouds and thunderstorms are produced. If an area is experiencing high pressure (a high), the weather is likely to remain unchanged for several days. In a low pressure area, the weather is likely to change more rapidly with increased winds and precipitation.

In the northern hemisphere, winds are created by these temperature and pressure differences with cold air flowing in from the north and west and warm air from the south and east. Together with surface friction created by the rotation of the earth, these factors create the continually changing and moving high and low pressure systems. In this hemisphere, the eastward movement of the earth interacting with these flows, usually produces a clockwise circulation of air or wind around an area of high pressure and counterclockwise circulation around a low pressure area. The opposite is true in the southern hemisphere.

The temperatures and air pressures within masses of air are relative to the temperatures and pressures in adjoining masses of air. Accordingly, an air mass which seems warm to us may be cold relative to adjoining air masses and be descending, creating an area of high pressure relative to nearby areas.

In addition, when the surface of the earth is warmed by the sun during daylight hours, an area of high pressure above it is warmed and expands causing the high pressure area to grow in height. The column of air has become less dense but not less heavy and will continue to descend and exert pressure relative to surrounding air masses. So, in the summertime, a high pressure area can sometimes also be hot and humid even though we usually think of highs as containing colder air.

If there were no heat and rotation, air pressure and density would decrease progressively and uniformly with increasing height. There would be a standard reading of 29.92 in. Hg or 1013.2 mb at sea level decreasing to about 850 mb at 5,000 feet and 500 mb at 18,000 feet. As a matter of interest, the lowest sea level air pressure ever recorded was 870 mb (25.69 in. Hg) in the eye of a typhoon over the Pacific Ocean, while the highest sea level air pressure was 1084 mb (32.01 in. Hg) at Siberia associated with an extremely cold air mass. The usual range of pressures is from 970 mb (28.64 in. Hg) to 1040 mb (30.71 in. Hg).

ALTIMETER ADJUSTMENTS: During flight training, pilots learn "**From HIGH to LOW, look out BELOW**." This is because when flying from an area of high pressure to an area of low pressure, the altimeter will read the lower pressure as a higher altitude thus leading the pilot to think that he or she is higher above the ground than is actually the case. For instance, an aircraft flying from an area of higher pressure at 29.88 in. Hg (1012 millibars) into an area of lower pressure at 29.65 in. Hg (1004 mb) will find that the altimeter reads 230 feet higher than actual if the altimeter is not adjusted for the lower pressure.

Juliet notes that, as is true of many simplified statements, the opposite can also be true. This happens when flying into an area of colder air such as the polar high. As the air becomes colder it becomes more dense, bringing the pressure surfaces closer together. The effect is that the pressure surface at which you are flying (which is indicated as a specific altitude by the altimeter) may be curving downward toward ground level causing the aircraft to descend while the altimeter continues to read the earlier elevation. Air pressure drops more rapidly with altitude in a column of colder more dense air than in a column of warmer or less dense air. To stay out of trouble, the altimeter should be adjusted at least every 100 nautical miles when flying under normal conditions and even more frequently when there are extremes of temperature.

PERFORMANCE: Wings and propellers develop less lift and thrust as altitude increases and air pressure and density decrease. Changes in temperature and humidity will also affect the performance of the aircraft. Air at higher temperatures is less dense than air which is relatively colder. In addition; warm air will hold more moisture than cooler air and, since water vapor is lighter than air, the air will be less dense. At an aircraft flies higher, the air pressure is lower, reducing air density. At the same time, the air becomes colder with increasing height and thus more dense but the loss in density due to height more than offsets the effect of the cooler air. When calculating density, it is usually easiest to compensate first for changes in air pressure which can be measured by an altimeter and then adjust for temperature and humidity.

TEMPERATURE & DEWPOINT: The dewpoint of an air mass is the temperature at which moisture present within the air will condense into fog or clouds (really the same thing). If the dewpoint and the ground temperature are within 4°F then rain, fog, snow, or low clouds are very likely. Under normal conditions, the atmosphere cools at about 3.5°F per 1000 feet (the normal lapse rate) but when radiation from the ground sets up a thermal, lifting the air, cooling is at about 5.4°F/1000. The dewpoint is also declining with height by about 1°F/1000. The lowest cloud layer will usually form where the two temperatures converge and the rate of convergence is calculated as 5.4°F – 1°F or 4.4°F. If the temperature at the airport is 82°F and the dewpoint is 62°F, the difference is 20°F (11.1°C). Divide this by 4.4°F (2.4°C) and you can estimate the base of the clouds at about 4600 feet.

WEATHER BRIEFING: Flight Service Station (FSS) "Radio," the primary source for preflight weather information and filing a flight plan, can be contacted at 800 WX-BRIEF (992-7433). This number will also reach an automated (AFSS) briefing. In late 2006, most Flight Service Stations were outsourced from the FAA to an outside contractor, Lockheed Martin, which is continuing the services with the same telephone numbers and radio frequencies as before. The present 58 FSS facilities will be consolidated into 20 locations and tied together with a common database. Telephone numbers for each of the FSS facilities are listed on the Lockheed Martin website at AFSS.com. Pilots can telephone for briefings, walk into any of the locations or use the internet address for flight plan filing, updated weather, NOTAMs, and other flight services. Continuing services include the weather briefings, airport advisory service, lost aircraft orientation, search & rescue, IFR/VFR flight planning, issuing and coordinating NOTEMs, special use airspace including ADIZ and FRZ and US Customs requests.

Pilot weather information services are laden with cryptic acronyms and abbreviations and a glossary is included in the following pages.

In requesting a briefing, a pilot should indicate whether the flight is VFR or IFR, aircraft identification and type, departure point, ETD, altitude, route, destination and estimated time en route. Ask for a Standard, Abbreviated or Outlook Briefing, all of which are described in FAA publications and on the AFFS and DUATS websites. In addition to a briefing, various reports are available including an Aviation Routine Weather Report (METAR), pilot reports (PIREPs), radar weather reports (SDs), Terminal Aerodrome Forecasts (TAFs, for larger airports) and Aviation Area Forecasts (FA; the US is divided into six forecast areas).

INFLIGHT RADIO SERVICES (FLIGHT WATCH): The locations also provide inflight radio services. In-flight briefings may be obtained from the Enroute Flight Advisory Service (EFAS) "Flight Watch" at a common frequency of 122.0, specifically designed for pilots flying between 5,000 feet and 17,500 feet AGL. Information is also available from any FSS within radio range at the frequencies specified in the Airport/Facility Directory. The common AFSS frequency is 122.2.

Navaids are navigational aids, either visual or electronic and airborne or on the surface, which provide point-to-point guidance information or position data to aircraft in flight. Navaids often broadcast recorded information as Transcribed Weather Broadcasts (TWEB), Hazardous In-Flight Weather Advisories (HIWAS), Automated Surface Observing System (ASOS), and Automated Weather Observing System (AWOS). Frequencies and availability are shown on FAA VFR Sectional Charts, on IFR Low Altitude Charts and in the FAA Airport/Facility Directory. In the air, they are intended to have a range of 25 NM or more and be received at altitudes up to 10,000 feet AGL. HIWAS reports include severe weather alerts such as AWW, CWA, SIGMETs, Conductive SIGMETs, AIRMETs and urgent PIREPs.

ATIS (AUTOMATIC TERMINAL INFORMATION SERVICE): This is a continuous, recorded, broadcast of essential information from larger airports with a control tower. Pilots arriving and departing usually listen to the information before contacting the tower. Each broadcast is identified by a letter of the alphabet, "Moorabbin Information **B**ravo," and the letter is changed progressively down the alphabet as updated broadcasts are substituted. Pilots contacting the tower identify themselves and use the phrase "with

Bravo” (or **C**harlie, **D**elta, **E**cho, etc. as appropriate), to indicate that they have listened to that ATIS broadcast and so that ATC (Air Traffic control) can confirm that they have the latest available information. The radio frequency for each ATIS can be found on FAA Sectional and Terminal Area Charts and in the FAA Airport/Facility Guide as well as in AOPA (Aircraft Owners and Pilots Association) guides and in commercial publications. A typical ATIS broadcast will include the airport name, the alphabetic identifier, the active runway or runways in use, wind direction and velocity, visibility, clouds by type and altitude, temperature and dewpoint, altimeter setting (QNH), other important information, and the airport name and alphabetic identifier again.

OTHER SERVICES: The FAA and third party providers also provide cockpit displays of weather information for aircraft so equipped. Weather Charts are also available by computer and by telecommunication; including Surface Analysis Charts, Weather Depiction Charts, and Radar Summary Charts. In addition to weather briefings, pilots may use Flight Watch to file, activate, close or change a flight plan; request an IFR clearance for areas outside ATC/ARTCC areas of control; file position reports; request information on the status of Special Use Airspace; and request assistance in any in-flight emergency situation.

Zulu advises that useful internet links to services for pilots are available from the FAA at faa.gov/pilots, pilotweb.nas.faa.gov, and from the Aircraft Owners and Pilots Association (AOPA) at aopa.org. For Temporary Flight Restrictions, the FAA site tfr.faa.gov is a useful reference.

DIRECT (USER) ACCESS TERMINAL SYSTEM (DUATS): Two outside organizations, under contract to the FAA, provide similar online services using the name Direct (User) Access Terminal System (DUATS). The DUATS portals may be used for weather information and to file a flight plan via computer. They also provide other useful aids and information for pilots. The two DUATS websites may be reached at duats.com and duat.com or by computer modem at 800-767-9989 and 800-245-3828. It is possible that the DUATS services will be replaced by the Lockheed Martin AFSS.com website.

NATIONAL WEATHER SERVICE (NWS): National Weather Service (NWS) briefings are also available in some areas but do not provide aeronautical information (NOTAM’s, etc.). Look for the numbers in the Airport/Facility Directory or in the US Government section of the local phone book under Dept. of Trans., FAA or Dept. of Commerce, NWS. A very useful service is provided by the NWS and the FAA through Aviation Digital Data Service (ADDS) at adds.aviationweather.noaa.gov.

The National Weather Service publishes an excellent online bi-monthly magazine entitled “The Front” which can be accessed at aviationweather.gov/general/pubs/front. It contains well written and extensively illustrated articles about weather and aviation topics.

PIREPs: Pilot Weather Reports, submitted to ATC (Air Traffic Control) or other ground stations by pilots during flight are important and the information cannot be gathered from any other source. The reports should follow a standard reporting format; Type of Report, Location, Time (Zulu), Altitude or Flight Level, Aircraft Type, Sky Cover, Visibility/Weather, Temperature (C°), Wind, Turbulence, Icing, Remarks.

GLOSSARY OF AVIATION WEATHER TERMINOLOGY:

ADIZ:	Air Defense Identification Zone
AFSS:	Automated Flight Service Station
ASOS-AWOS:	Automated Surface Observation System, Auto. Weather Observing System
CHARTS:	Surface Analysis Chart, Weather Depiction Chart, Radar Summary Chart
CWA:	Center Weather Advisory issued by the National Weather Service
DUATS:	Direct User Access Terminal Service (explained in preceding text)
EFAS:	Enroute Flight Advisory Service
FA:	Aviation Area Forecast (covers a large area, six FA areas in the US), issued 3x per day and valid for 18 hours.
FD:	Winds and temperatures aloft forecast
FSS:	FAA Flight Service Station (primary source for preflight weather information)
HIWAS:	Hazardous In-Flight Weather Advisory
METAR:	Aviation Routine Weather Report (current airport weather, updated hourly)
NOAA:	National Oceanic and Atmospheric Administration
NOTEM'S:	Notices to airmen, time critical information
NWS:	National Weather Service
PIREP:	Pilot Weather Report concerning weather in flight
SD:	Radar Weather Reports
TAF:	Terminal Aerodrome Forecast (airport weather forecast, good for 9-24 hours)
TDWR:	FAA terminal Doppler weather radar
TIBS:	Transcribed Information Briefing Service
TWEB:	Transcribed Weather Broadcast

TYPES OF WEATHER BRIEFING:

Standard:	The most complete briefing from a specialist at an FSS, AFSS or NWS.
Abbreviated:	A shortened version of the Standard Briefing to update a prior briefing.
Outlook:	Requested when a planned departure is six or more hours away.

WEATHER ADVISORIES, IN-FLIGHT (broadcast on ATIS and ALSO available from a FSS)

AIRMET:	Airman's Meteorological Information issued every six hours for a particular area forecast region.
SIGMET:	A Significant Meteorological Information Advisory issued on an unscheduled basis concerning non convective weather which is potentially hazardous. A **CONVECTIVE SIGMET** is issued for severe thunderstorms.

METAR & TAF: Aviation current and forecast weather reports are published in a standardized and international language format and referred to as METAR (International Aviation Routine Weather Forecast) and TAF (Aerodrome Forecast) reports. The format looks difficult, but Juliet assures us that a few hours of practice will make it easy and quick to absorb and understand the reports. The use of the standardized language reduces the possibility for error and misunderstanding, particularly for pilots for whom English is not the first language. We include samples of the standardized language below followed by plain English translations:

METAR KPIT 201955Z 22015G25KT 3/4SM R28R/2600FT TSRA OVC010CB 18/16 A2992 RMK OCNL LTGICCG

Where: Pittsburgh International **- When**: 20th day of month at 1955Z - **Wind:** 220 degrees at 15 gusting to 25 knots (typical: variable direction, 20015KT 220V280 or VRB, variable direction when speed is less than or equal to 6 knots) - **Visibility:** 3/4 statute miles (typical: 2 3/4SM, 1SM) – **Runway Visual Range** (RVR): Runway 28 Right visibility 2600 feet (M, used for RVR less than lowest reportable sensor value, e.g. M0600FT; P, used for RVR greater than highest reportable sensor value e.g. P6000FT; V, variable) - **Significant Weather:** thunderstorm, moderate rain - **Sky Condition:** overcast clouds at 1000 feet consisting of cumulonimbus (typical: SKC, FEW, SCT, BKN, VV004 indefinite ceiling, Vertical Visibility 400 feet) - **Temperature/Dew Point:** 18 degrees Celsius/dew point 16 degrees Celsius (M, minus meaning below zero) - **Altimeter:** inches of mercury - **Remarks:** occasional lightning in clouds and from cloud to ground.

KPIT 091730Z 091818 22020KT 3SM -SHRA BKN020 WS015/30045KT
FM2030 30015G25KT 3SM SHRA OVC015 TEMPO 2022 1/2 TSRA OVC008CB
FM2300 27008KT 5SM -SHRA BKN020 OVC040 PROB40 0407 00000KT 1SM -RA
BRFM1000 22010KT 5SM -SHRA OVC020 BECMG 1315 20010KT P6SM NSW SKC

Where: Pittsburgh International - **When:** 9th day at 1730Z - **Valid Period:** 9th day at 1800Z to next day (10th) at 1800Z - **Wind:** 220 degrees at 20 knots - **Visibility:** 3 statute miles (typical: 2 3/4SM, 1SM, P6SM - Greater than 6 statute miles) - **Significant WX:** light rain showers (typical: FEW, SCT, BKN, OVC, VV004 indefinite ceiling vertical visibility 400 feet. CB and TCU clouds noted when present) - **Wind Shear:** low level wind shear at 1500 feet forecast to be 300 degrees at 45 knots (only nonconvective, low level, wind shear is forecast) - **FM2030:** From 2030Z, **TEMPO 2022:** Temporarily between 2000Z and 2200Z, **FM2300:** From 2300Z, **PROB40 0407:** There is a 40 percent probability between 0400Z and 0700Z, **FM1000:** From 1000Z, **BECMG 1315:** Becoming between 1300Z and 1500Z. Note: Weather conditions such as wind and sky condition may be omitted after PROB40, TEMPO, and BECMG if no change is expected from those same conditions given in the previous time block.

The abbreviations used in METAR and TAF Reports are summarized below:

ABBREVIATIONS:

AMD	Amended Forecast
BECMG	Becoming
CAVOK	Ceiling & Visibility OK (not an official FAA Phrase)
CLR	Clear at or below 12,000
COR	Correct to the observation
FM	From - 4 digit time
LDG	Landing
M	Minus or below zero
M	In RVR - visibility very low
NO	Not available
NSW	No significant weather (check full FAA definition)
P	In RVR - visibility high
P6SM	Visibility > than 6 SM
PK	Peak Wind
PROB40	Probability 40%
R	Runway (in RVR)
RMK	Remark
RY/RWY	Runway
SLP	Sea level pressure
SM	Statute Miles
SPECI	Special Report
TEMPO	Temporary changes
TKOF	Takeoff
V	Varies (wind direction & RVR)
VC	In the Vicinity
VRB	Variable wind dir < or = 6K
VV	Vertical Visibility
WS	Wind Shear

DESCRIPTORS:

BC	Patches
BL	Blowing
DR	Low Drifting
FZ	Supercooled/freezing
MI	Shallow
PR	Partial
SH	Showers
TS	Thunderstorm

PRECIPITATION:

RA	Rain
DZ	Drizzle
SN	Snow
GR	Hail
GS	Small Hail/ Snow Pellets
PL	Ice Pellets
SG	Snow Grains
IC	Ice Crystals
UP	Unknown Precipitation

INTENSITY VALUES:

(-)	Light
No Sign	Moderate
(=)	Heavy

OBSTRUCTED VISIBILITY:

FG	Fog
HZ	Haze
FU	Smoke
PY	Spray
BR	Mist
SA	Sand
DU	Widespread Dust
VA	Volcanic Ash

OTHER WEATHER:

SQ	Squall
SS	Sandstorm
DS	Dust Storm
PO	Dust/Sand Whirls
FC	Funnel Cloud
+FC	Tornado/Water Spout

CLOUD TYPES:

CB	Cumulonimbus
TCU	Towering Cumulus

SKY COVER:

SKC	Sky Clear
FEW	1/8 -2/8 cloud cover
SCT	Scattered 3/8 - 4/8 cover
BKN	Broken 5/7 cloud cover
OVC	Overcast 8/8 cloud cover

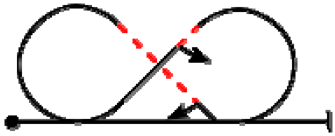
AEROBATICS

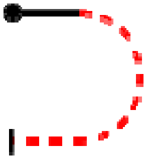
AEROBATICS: The term Aerobatics refers to the sport of performing precision maneuvers such as rolls, loops, stalls, spins, and dives with an airplane. Anyone who has read all the way through the preceding chapters deserves a little fun!

There are three basic aerobatic maneuvers; a roll, a loop and a spin, each a rotation around one of the three axes (longitudinal, lateral and vertical), which are perpendicular to each other and which intersect at the aircraft's center of gravity. In three dimensional space, an axis is a line around which rotation occurs. Rotation around the longitudinal axis, which is a line drawn from the nose of the aircraft to the tail, is called a bank or roll. Rotation around the lateral axis, which is a line drawn from wingtip to wingtip, is called pitch. Rotation around the vertical axis, which is a line drawn from top to bottom of the aircraft, is termed yaw. Each axis relates to the position of the aircraft regardless of its orientation to the earth.

More complicated aerobatics are combinations of the three basic maneuvers with lines (flown horizontally, vertically or angled), and gyroscopic and tumbling maneuvers using the torque provided by the engine and propeller. In this section, we will show each of the basic maneuvers and then show some of the combinations.

NOTATION: In aerobatics, as in dance and music, there is a system of notation or shorthand which uses symbols to describe physical movement in three dimensions. The system is known as the Aresti System, named for its creator, Spanish pilot Jose Luis Aresti. The system was developed in the early 1960's and quickly adopted by the Federation Aeronautique Interanationale (FAI) in Lausanne, Switzerland which is the non governmental international body formed in 1905 for the purpose of furthering aeronautical activity worldwide. In the US, the International Aerobatic Club (a division of the Experimental Aircraft Association, Inc. and of the National Aeronautic Association) is responsible for promoting the sport of aerobatics under the regulations of the FAI. Three typical Aresti symbols are shown below, a Cuban Eight, an English Bunt, and a Tail Slide.





All Aresti Symbols - Wikipedia

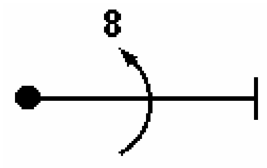
AIRCRAFT: Many different types of aircraft have been designed and certified to be used in aerobatics and they include high wing and low wing aircraft as well as biplanes. Aerobatic aircraft differ from normal aircraft in that they are designed to withstand greater stresses and often have fuel and oil systems which will function when inverted.

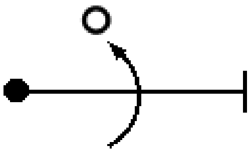
The **Extra 300L**, which we have used as a model in the following pages, competes in the unlimited category and is approved to plus/minus 10G's, has a roll rate of up to 400º per second and will cruise at 170 knots. It has two seats in a tandem arrangement, fixed landing gear, a constant speed propeller, and a six cylinder 300 HP engine. And, it is a great looking airplane!

AEROBATIC MANEUVERS - ROLLS: A roll is a rotation around the longitudinal axis of the aircraft. Types of rolls include an **aileron roll**, a **hesitation roll**, a **slow roll**, a **barrel roll** and a **snap roll**.

An **aileron roll** is performed by using the ailerons to initiate and control the roll, and using the rudder for coordination, to minimize yaw or movement away from the longitudinal axis. A four or eight point aileron roll with a short hesitation at each point is termed a **Hesitation Roll**. The Aresti symbol for an eight point roll is shown below on the left. The starting point for the aircraft is the black dot on the left. Moving to the right along the straight line represents upright flight, and the arrow indicates an eight point roll to the left. The symbol for a simple aileron roll (without hesitation) is as shown below on the left, but omitting the number.

A **barrel roll** is a maneuver where the aircraft is rolled around an imaginary point at 45º to the original flight path. The pilot is completing both a loop and a roll at the same time. The path of the aircraft resembles a horizontal corkscrew or stretched out spring. Done expertly, this maneuver places very little stress on the aircraft and its passengers. The Aresti symbol is shown below on the right.



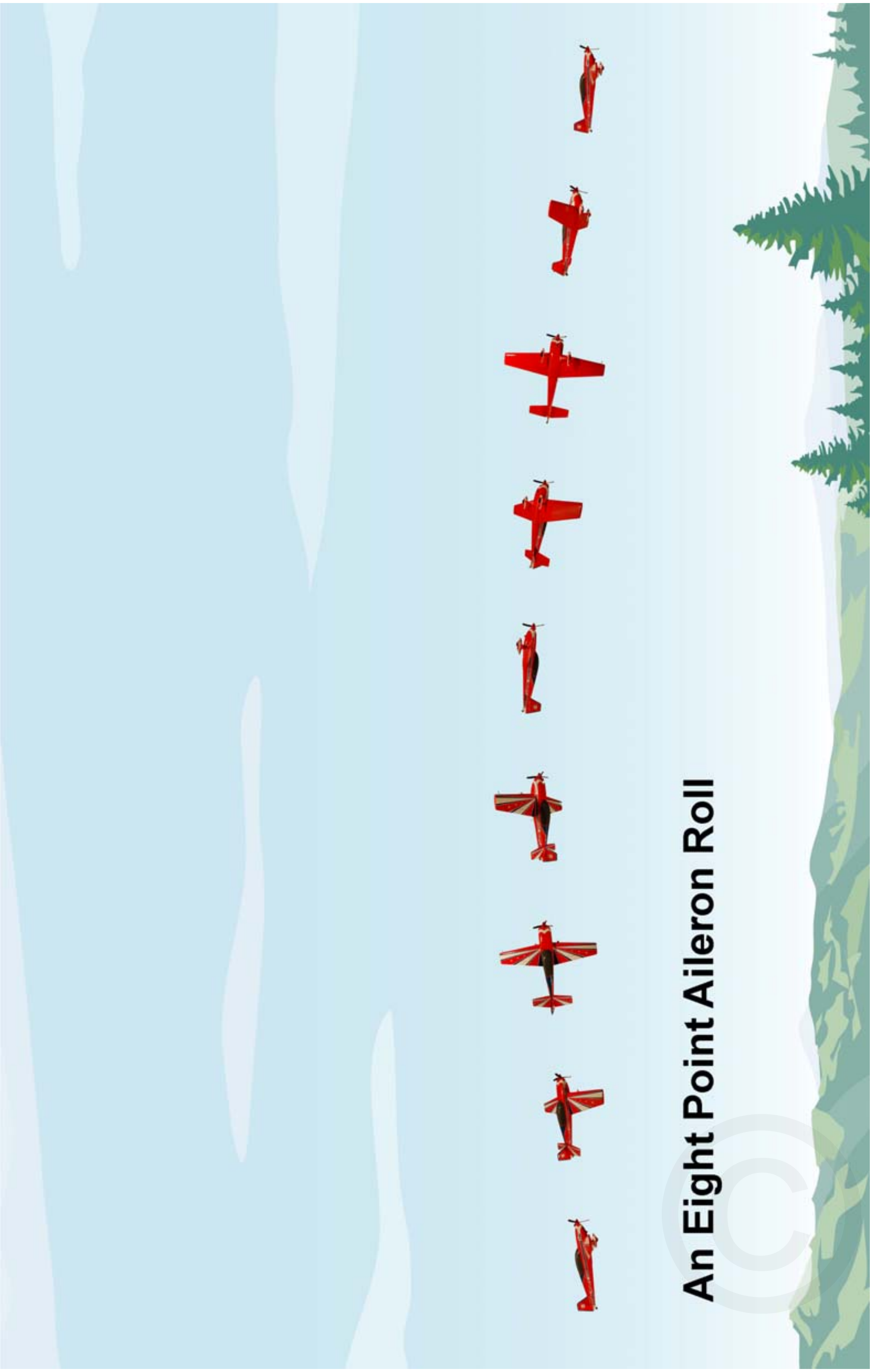


Bob Hoover, a very well known and expert US pilot, used a barrel roll as one of the maneuvers to demonstrate the capabilities of a twin-engined piston business aircraft known as the Shrike Commander. He would put a drinking glass on the top of the panel in front of him and then slowly pour it full of iced tea while guiding the aircraft through a complete barrel roll. In an interview, he maintained that passengers riding with him could hold a cup of coffee right through a barrel roll and never spill a drop.

A **snap roll** does roll an aircraft around its longitudinal axis, but the aerodynamics of a snap roll are similar to those experienced in a spin so we will describe this maneuver under that heading.

EXAMPLE: We have used **an eight point aileron roll** as an example on the next page. In this and in the other examples used, the maneuver is compressed in order to show an entire maneuver on one page without making the miniature airplane even smaller. In this case we show a roll to the right though beginning aerobatic pilots often find it easier to roll to the left. Techniques differ somewhat depending on the aircraft and the following procedures are intended only to give the reader a feel for what is required to perform a specific maneuver. No one should attempt these maneuvers without appropriate instruction.

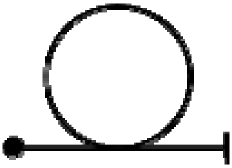
To reach the desired entry speed it is sometimes necessary to ease the nose over prior to beginning the roll. At the entry point, the nose is usually pulled up to an attitude between 10º and 30º, wings level. This is done to prevent coming out of the roll in a nose low position. In competitions where high performance aircraft are used, rolls are flown in a straight line. The maneuver is then initiated with right aileron and rudder as if entering a steep turn. As the aircraft passes a 45º bank, less rudder is used and as the bank passes 90º, back pressure on the control column is slowly relaxed. Additional right aileron is applied to maintain the speed of the roll. As the aircraft rolls inverted (180º) and then through 270º, more right rudder is applied and as 300º is passed, more back pressure is applied and then all aileron, rudder and elevator deflections are gradually reduced as the wings come level.

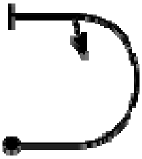


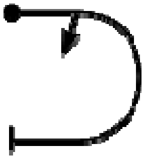
An Eight Point Aileron Roll

AEROBATIC MANEUVERS - LOOPS: A loop is a rotation around the lateral axis of the aircraft. Types of loops include a basic round **Loop**, an **Immelmann** turn, a **Split S** and varieties of a **Cuban Eight**.

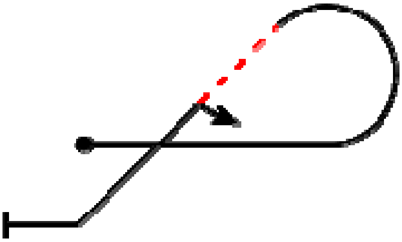
A basic round **Loop** is self explanatory and the Aresti illustration is shown below to the left. An **Immelmann** turn (usually just called an Immelmann) and a **Split S** are variations of a loop which result in a change of direction. The Immelmann, shown below in the center, is a half loop up leaving the aircraft inverted. A half roll, indicated by the downward pointing arrow, brings the aircraft upright and flying in the opposite direction. The maneuver is named for Max Immelmann, a German World War I flying ace who was killed midway through the war at the age of 25. The Split S, shown on the right below, is the reverse of an Immelmann and trades altitude for speed while also reversing direction.





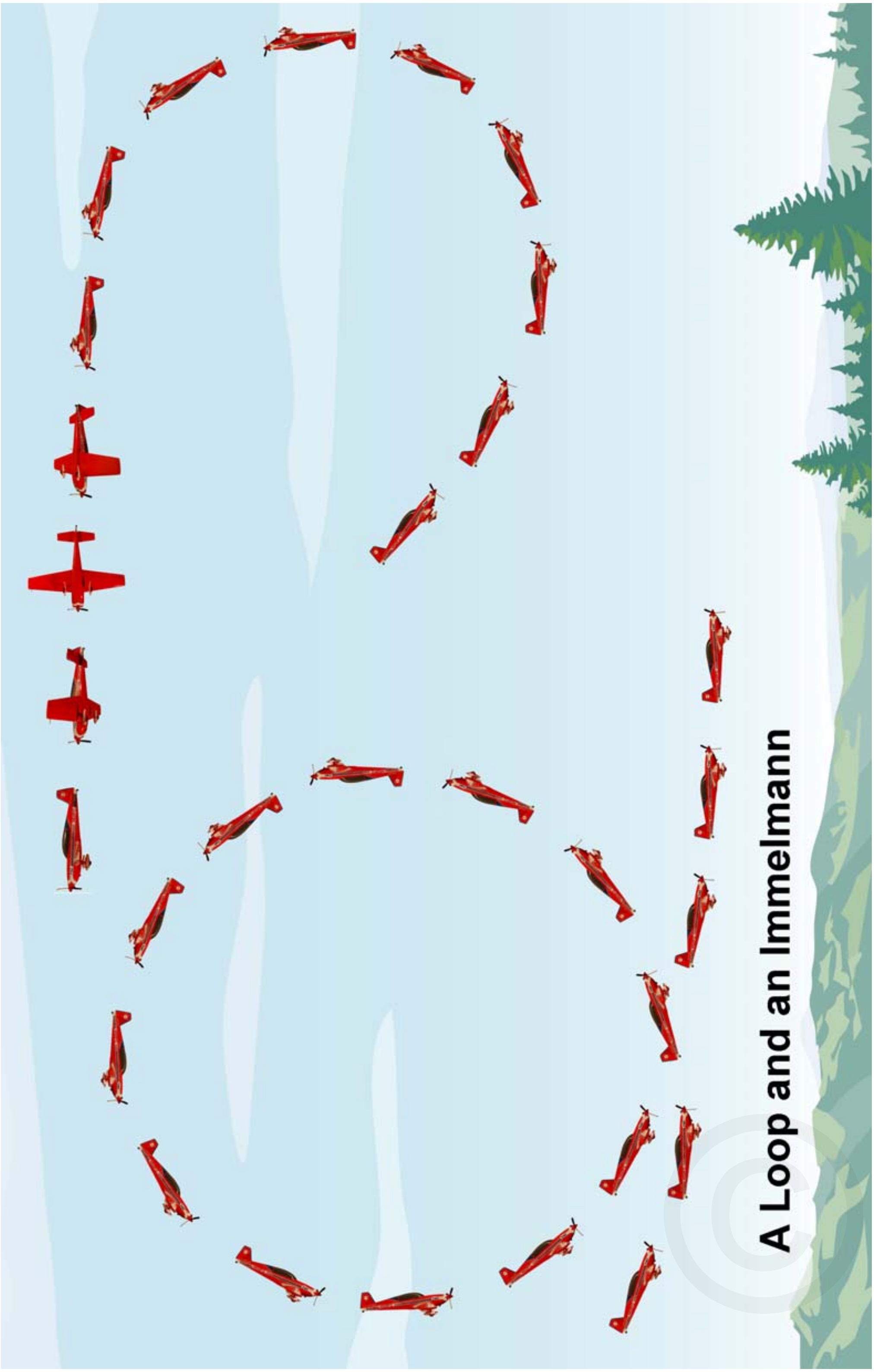


Another variation of a loop is the **Cuban Eight**. There are many varieties of this maneuver, a half Cuban Eight, a reverse Cuban Eight, and various inverted Cuban Eights. We show a **Half Cuban Eight** below (a full Cuban Eight is illustrated earlier). The red dashed line represents inverted flight and the downward pointing arrow shows a half roll back to upright.



EXAMPLES: On the next page, we use our Extra 300L to illustrate a **Loop** and an **Immelmann**. The **loop** requires the attainment of a designated entry speed which may require easing the nose over prior to the loop. When the proper speed is reached, begin a smooth pull up. Full power is used as the nose moves up to vertical. As the aircraft moves past the vertical, speed will be decreasing and more back pressure will be needed. The controls will be getting lighter. As the aircraft approaches the inverted position, back pressure is eased off somewhat and then increased carefully again on the back side of the loop. Throughout the loop, check that the wings are level. Power is reduced as the aircraft becomes vertical on the back side. Be careful on the pull-up not to use too much back pressure too quickly to avoid adding to the stress on the aircraft and passengers and possibly resulting in a stall.

An **Immelmann** follows the same procedures through a half loop, followed by a roll-out at the top.

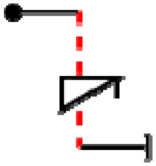


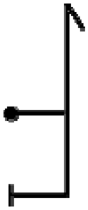
A Loop and an Immelmann

AEROBATIC MANEUVERS - SPINS: A spin is a rotation around the vertical axis of the aircraft where one wing is stalled before the other causing the aircraft to fall off and rotate, usually nose down. A **spin** is an integral part of some more advanced aerobatic maneuvers. Spins include **normal spins, inverted spins** and **flat spins.** The Aresti symbol for a spin is the left hand figure below, and we illustrate a spin on the next page.

A **snap roll** can be described as a horizontal spin where one wing is stalled. While traveling at a speed higher than the normal stall speed, the aircraft is quickly stalled by applying positive g forces, using up elevator (the control column pulled back), while applying full rudder in the direction of the desired roll. Because one wing is stalled while the other is still flying and because the aircraft retains momentum, it will roll quickly in the direction of the rudder deflection. Recovery is initiated at about 270º of rotation by applying full opposite rudder and moving the control column forward bringing the elevator down. A snap roll happens very quickly and the roll rate can be very fast. Sometimes the ailerons are used to assist in beginning and ending the maneuver. The Aresti symbol for a snap roll is the center figure shown below.

A **hammerhead** is another vertical maneuver which also rotates around the vertical axis. The Aresti symbol is shown below to the right, and we illustrate a hammerhead on the next page.

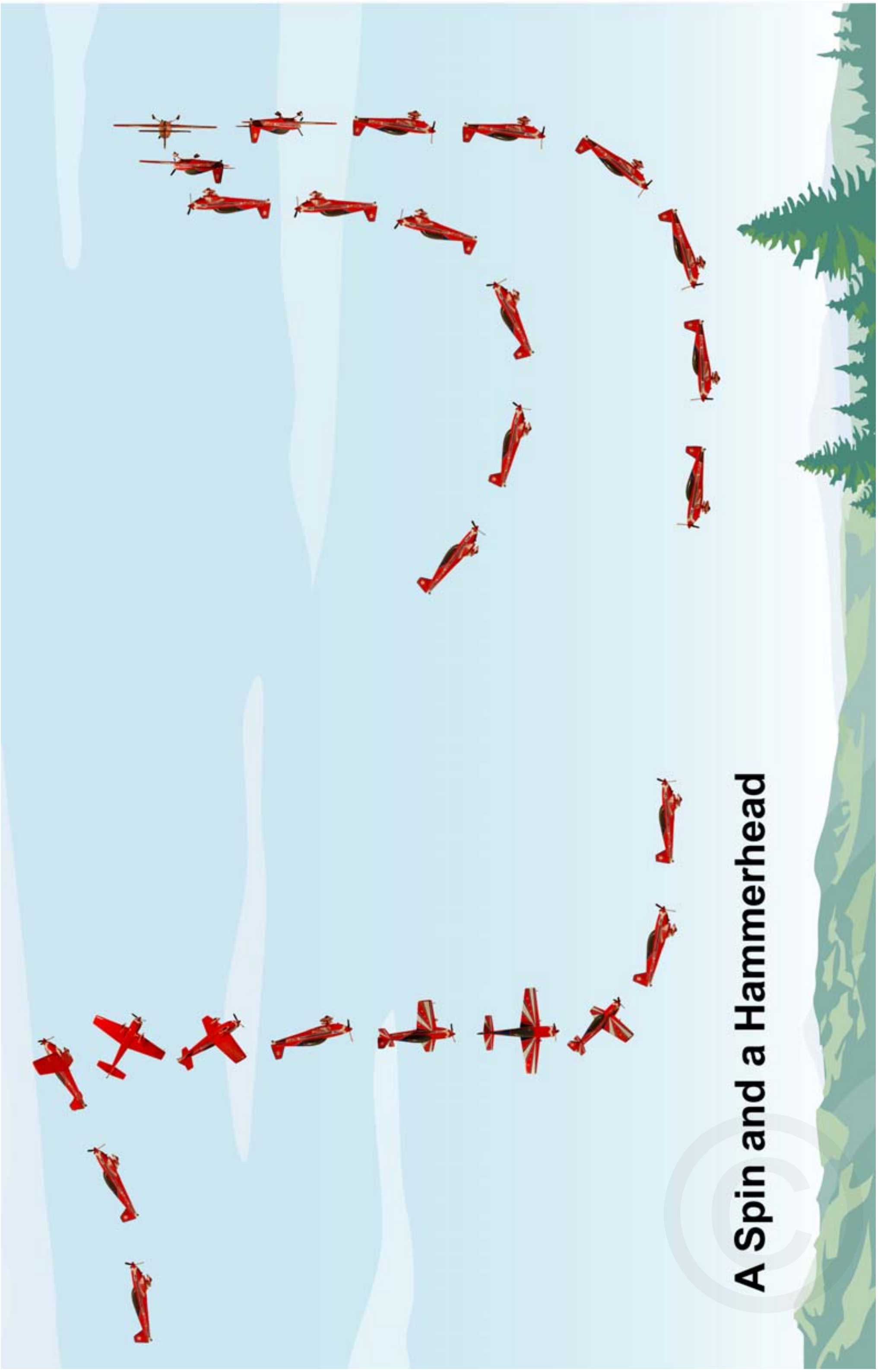




EXAMPLES: On the next page, we use our Extra 300L to illustrate a **spin** and a **hammerhead**. The **spin** is initiated from a flaps-up stall where power is reduced and the aircraft is pulled up using up elevator (control column back). As the stall begins, full rudder is applied in the direction of the desired spin. The wing on that side stalls and loses lift more rapidly than the other wing and drops rapidly causing the aircraft to begin a rotating motion, usually nose down. Recovery for most aircraft is initiated by reducing power, neutralizing the ailerons, applying full opposite rudder so that both wings are equally stalled, and briskly pushing the control column forward to break the stall. As rotation stops, the pilot neutralizes the rudder and eases back on the control column to pull out of the dive.

The **hammerhead** (illustrated on the next page) begins with a vertical climb which is continued until the aircraft has nearly stopped. At that point, the pilot applies full left rudder, causing the aircraft to pivot sideways to the left until it is pointing straight down. The pilot eases out of the dive and ends up flying the opposite direction.

NOTE: The reader should note that the material in this section is provided for illustrative purposes only and is not intended to be an accurate guide to the various maneuvers shown. Each aerobatic aircraft requires control inputs which are specific to that type of aircraft. No person should attempt any of these maneuvers without specific training with an experienced instructor in an aircraft designed and maintained for the purpose and at appropriate altitudes and in appropriate weather conditions. Parachutes are routinely worn by pilots and passengers when aerobatic maneuvers are performed. The applicable FAA, CAA or other national regulations should be consulted by anyone contemplating aerobatics.



A Spin and a Hammerhead

NOTES & CHECKLISTS

Zulu Gives His Opinion on Checklists

NOTES & CHECKLISTS: This section contains slide-in plastic pockets for pilot notes, checklists, airport diagrams and other useful information. FAA and Jeppesen approach plates will fit in these pockets.

Checklists are a subject of much discussion among pilots. Many pilots prefer to use mnemonics or memory aids such as **Lights, Camera, Action** which is used when cleared for takeoff to remind pilots to turn on the landing light and set the transponder to ALT. Certainly, when you are flying alone on downwind on a late hazy summer afternoon with the sun in your eyes and traffic everywhere, you don't want to have your eyes glued to a checklist sliding around on your lap. Some flight schools teach their students to use selected mnemonics to supplement written checklists. We have listed some commonly used ones below.

If the human memory were perfect and if human beings operated like computers, there would be no need for printed checklists - and there would be no gear-up landings either. Some pilots fly many different types of aircraft; pilots are old and young, high time and low time, some pilots fly every day, some very infrequently. Memory and learning capacity differ. Pilots are subject to very human limitations which affect their ability to perform uniformly and efficiently. They are sometimes preoccupied, tired, foolish, ill, frightened or angry. For these reasons and because of the increased complexity of the tasks required, military and commercial pilots are required to use detailed printed checklists. In the US, FAA Designated Pilot Examiners require the use of a written checklist during General Aviation flight tests.

Most private pilots fly without a co-pilot and fly smaller and less complicated single and twin engine aircraft. At busy times and in emergencies, using a printed checklist is difficult and possibly dangerous. On the other hand, a pilot can forget, ignore or shortcut a mnemonic checklist too. Probably the best solution is to use both. Have a printed checklist to review and use before and during the flight. Use the written checklist before entering busy airspace. The checklist should be taken directly from the Pilot's Operating Handbook and the FAA approved Airplane Flight Manual for the particular aircraft. Most good checklists include this information and supplement it with reminders involving, lights, radio calls, transponders, etc. Use mnemonics for pre-landing checks and for emergencies. Make sure that the mnemonics are written down too so that they can be reviewed frequently. Practice their use, so they are second nature, especially in emergencies. Many pilots find that mnemonic checklists work best when coordinated with physical movements of the feet, hands and eyes in a logical scan or flow pattern.

There are hundreds and possibly thousands of mnemonics or memory aids for pilots. The AOPA website lists many of them. Try an internet search engine and type in "pilot mnemonics" or "aviation checklists." Check with nearby flying clubs or flying schools. Here are a few of Zulu's suggestions: **GUMPS; G**as, **U**ndercarriage, **M**ixture, **P**ropeller, **S**witches. **BUMFOH; B**rakes, **U**ndercarriage, **M**ixture (**M**aster, **M**agnetos), **F**uel (**F**uel Sufficient, **F**uel Pump), **O**il (Pressure & Temperature), **H**atches & **H**arnesses. **FIST; F**laps**, F**uel Pump, **S**witches, **T**ransponder. **CIGARS; C**ontrols Free, **I**nstruments Checked, **G**as on Fullest Tank, **A**ttitude - Elevator Trim Set, **R**unup Complete, **S**eat Belts & Harnesses fastened. **CLEAR OF; C**ompass, **L**og, **E**ngine, **A**ltitude, **R**adio, **O**rientation, **F**uel. **BUSH; B**rakes, **U**ndercarriage, **S**witches, **H**atches & **H**arnesses. **ANDS; A**ccelerate **N**orth, **D**ecelerate, **S**outh. **AROW; A**irworthiness Certificate, **R**egistration, **O**perating Limitations, **W**eight & Balance. **T**rue **V**irgins **M**ake **D**ull **C**ompany: **T**rue course +/- **V**ariation = **M**agnetic course +/-**D**eviation = **C**ompass course. **WAR:** Add **R**ight wind correction angle and **W**est variation and deviation. Here is a creative way to remember the transponder emergency codes:

7500 Still Alive (hijack)
7600 Got No Clicks (no radio)
7700 Going To Heaven (all out emergency)

The Notes & Checklists Section will contain five or six 6.5 x 9 inch plastic pockets for the pilot's checklists, airport diagrams and other notes.

We have included a sample checklist on the following pages, this one for a Piper Archer II. When produced, it is printed and laminated on both sides of two A5 (5.83 x 8.27 inches) cards and will fit in the plastic pockets provided.

PREFLIGHT

Weather Density Altitude
Weight & Balance Flight Plan
Frequencies & Phone #'s Alternate Airfields
Papers: AROW *Airworthiness, Registration, Operating Limits (POH/AFM, Placards), Weight & Balance, Pilot Certificate, Current Medical*

WALK AROUND - A CRITICAL LOOK FOR DAMAGE OR ANYTHING UNUSUAL

COCKPIT

Control Wheel Lock or Belts	Remove
Parking Brake	Set
Ignition	Off, Key Removed
Avionics Power Switch	Off
Master Switch	On
Flaps	Check Operating Range, UP
Fuel Selector Valve	Desired Tank
Fuel Quantity	Check
Pitot Heat	Test
Lights & Strobes	Check
Windows	Clean
Static Pressure Alt. Source Valve	Off
Hobbs/Tachometer	Record Time
Master Switch	Off

EXTERIOR

ALWAYS USE THE SAME SEQUENCE

Tie-Downs, Chocks, Gust Lock	Remove
Pitot & Static Covers	Remove
Fuel	Check Quantity, Color, Water, Dirt
Caps/Drains/Vents	OK
Oil	Check Level, Dipstick Seated
Belts, Engine, Exhaust, Leaks	Check
Cowling, Inspection Covers	Secure
Air Intake	Clear
Propeller/Spinner	Check for Damage
Stall Warning	Test
Ailerons & Flaps	Free & Secure
Wings	Free of Ice, Snow, Frost
Pitot & Static Ports	Unobstructed
Fuselage, Antennas	Undamaged
Rudder, Elevator, Trim Tab	Free & Secure
Tires, Brakes, Struts	Main 4.5", Nose 3.25"
Baggage Door, Tow Bar	Close & Secure

INTERIOR

Inspection & Passenger Briefing	Completed
Brakes	Test & Set
Seat Tracks	Secure
Belts & Harnesses	Secure
Loose Items, Baggage	Secure
Flight Documents/Charts	Organized

START

Avionics Power Switch	Off
Beacon & Navigation Lights	On
Circuit Breakers	In
Fuel Selector Valve	Desired Tank
Carburetor Heat	Off
Mixture	Rich
Throttle	Open 1/4 inch
Brakes	Test & Set Again
Propeller Area	**CLEAR PROP**
Master Switch	On
Electric Fuel Pump	On
Ignition Switch (Prime if Needed)	Start
Throttle	Adjust to 800-1200 RPM
Oil Pressure	Check Green
Avionics Power Switch, Radios	On

PRE-TAXI & TAXI

Flaps	Up
Avionics/Radios	On/Set Frequencies
Transponder	STBY
ATIS or AWOS	Listen & Note
Altimeter	Set
Test & Set:	Brakes, Compass, Altitude, Heading & Turn Indicators, and Inclinometer
Landing/Taxi Lights	As Required

RUN-UP

Brakes	Set & Hold
Seats, Belts, Harnesses	Upright & Secure
Cabin Doors, Windows	Closed & Latched
Flight Controls	Free & Correct
Primer	In & Locked
Fuel Selector	Proper Tank, Quantity OK
Fuel Pump	Off, Check Fuel Pressure, ON
Mixture	Rich or Appropriate
Elevator & Rudder Trim	Set for Takeoff
Annunciator Panel	Press to Test
Autopilot & Air Conditioner	Check, Off
Throttle	2000 RPM

Check:

Magnetos	R,B,L,B
	(Up to a 175 RPM drop in either Magneto or 50 RPM differential)
Carburetor Heat	On, Off, leave Off
Vacuum Gauge	Normal (5 inches ± .1)
Amps/Volts	In the Green
Oil Pressure & Temp.	In the Green

Throttle	1000 RPM, Check Idle & Friction
Flaps	Set for Takeoff
Pitot Heat	As Required
Heading Indicator	Adjust to Compass
Transponder	ALT

FLIGHT

BE READY TO ABORT TAKEOFF

NORMAL TAKEOFF

Proper Runway	Check Runway Heading
Traffic	Check
Strobes, Landing Light	On when Cleared
Flaps & Trim	Set for Takeoff
Carburetor Heat	Off
Electric Fuel Pump	On, Pressure OK
Mixture	Rich (above 5,000, Lean)
Brakes	Release
Throttle	Full Open
Oil Pressure & Temperature	In the Green
Elevator	Rotate at **52-65** KIAS (60-75)
Vy/Vx	**76/64** KIAS (87/74)
Normal Climb Out	**76** KIAS (87)

SHORT FIELD

Follow the initial steps from the **NORMAL TAKEOFF** checklist above, then:

Flaps	25º
Brakes	Hold & then Release
Throttle	Full Open
Oil Pressure & Temperature	In the Green
Elevator	Rotate **41-49** KIAS (47-56)
Initial Climb Speed	**45-54** KIAS (52-62)
Flaps	Retract Slowly at Safe Altitude

CLIMB

Airspeed	76-87 KIAS (87-100)
Throttle	Full Open
Mixture	Rich (above 5,000, Lean)
Engine Instruments	Check
Landing/Taxi Lights	Off
Flight Plan	Call to Open

CRUISE

Power	75% or Less
Elevator & Rudder Trim	Adjust
Mixture	Lean above 5000
Fuel	Change Tanks as Required
Fuel Pump	Off (On when changing Tanks)
Engine & Flight Instruments	Consult
Altimeter	Set QNH
Heading Indicator	Adjust to Compass

DESCENT

Carburetor Heat	On as Required
Power	2500 RPM
Airspeed	122 KIAS (140)
Mixture	Full Rich
ATIS/AWOS	Listen & Note, Set QNH
Wind	Check Direction & Crosswind

LANDING CHECKLIST

Brakes	Pressure in Pedals
Undercarriage	Down & Welded
Mixture, Master, Magnetos	Rich, On, Both
Fuel Selector Valve	Proper Tank
Electric Fuel Pump	On
Oil	Pressure & Temperature OK
Hatches & Harnesses	Secure
Seat Backs	Most Upright Position
Carburetor Heat	On
Autopilot & Air Conditioner	Off
Landing/Taxi Lights	On

NORMAL LANDING

Mixture	Full Rich
Electric Fuel Pump	On
Power	As Required
Approach Airspeed	**75** KIAS (86) Flaps Up
Flaps	As Required, ≤102 KIAS (117)
Final	**66** KIAS (76) (Flaps 40º)
Carburetor Heat	Off AT 200 feet
Brakes	Minimum Required

SHORT FIELD LANDING

Full flaps and enough power to maintain the desired airspeed and approach flight path. Reduce speed during flareout and contact the ground at close to the stalling speed. Brake while holding nose wheel off ground.

GO AROUND

Throttle	Full Open
Carburetor Heat	Off
Electric Fuel Pump	On
Flaps	Retract to 25°
Airspeed	**64** KIAS (74)
Flaps	Retract Slowly after 76 KIAS (87)

AFTER LANDING

Flaps (**NO STEP** unless flaps up)	Up
Electric Fuel Pump	Off
Landing/Taxi Light	As Required
Strobes	Off
Transponder	STBY
Trim	Takeoff

SHUT DOWN

Parking Brake	Set if Necessary
Avionics/Electrical/All Lights/ELT	Off
Magnetos	Check; R,B,L, B
Mixture	Idle Cut-Off
Ignition Switch & Master Switch	Off
Hobbs/Tachometer	Record
Chocks, Tie Downs, Covers, Doors	Secure
Flight Plan	Call to Close

EMERGENCIES

MAINTAIN CONTROL

ENGINE FIRE - START

Starter	Crank Engine
Mixture	Idle Cut-Off
Throttle	Open
Electric Fuel Pump	Off
Fuel Selector	Off

If fire continues for more than a few seconds, then fire should be extinguished by the best external means.

POWER LOSS – TAKEOFF

If sufficient runway remains for a normal landing, land straight ahead.

If insufficient runway remains, maintain safe airspeed, make only shallow turns to avoid obstructions, flaps as situation requires.

If sufficient altitude has been gained to attempt a restart – maintain safe airspeed:

Fuel Selector	Switch to tank containing fuel
Electric Fuel Pump	Check On
Mixture	Check Rich
Carburetor Heat	On
Primer	Locked

If power is not regained, proceed with power off landing.

FIRE IN FLIGHT

ELECTRICAL FIRE (Smoke in Cabin):

Master Switch	Off
Vents	Open
Cabin Heat	Off

Land as soon as practicable

ENGINE FIRE:

Fuel Selector	Off
Throttle	Closed
Mixture	Idle Cut-Off
Electric Fuel Pump	Off
Heater & Defroster	Off

Proceed with power off landing procedure.

LOSS OF FUEL PRESSURE

Electric Fuel Pump	On
Fuel Selector	Check on Full Tank

LOSS OF OIL PRESSURE HIGH OIL TEMPERATURE

Land Aircraft	As Soon As Possible

Prepare for Power Off Landing

POWER LOSS - IN FLIGHT

ATTEMPT RESTART:

Fuel Selector	Switch to tank containing fuel
Electric Fuel Pump	On
Mixture	Rich
Carburetor Heat	On
Primer	In & Locked
Master, Magnetos	Check On, Both
Engine Gauges	Check for Cause

If no fuel pressure is indicated, check tank selector position again

If time permits, turn the ignition switch to L then to R then back to BOTH. Move the Throttle and Mixture control levers to different settings. Try other fuel tanks. Water in the fuel could take some time to be used up, and allowing the engine to windmill may restore power. If power loss is due to water, fuel pressure indications will be normal.

IF POWER IS RESTORED:

Carburetor Heat	Off
Electric Fuel Pump	Off

IF POWER IS NOT RESTORED - POWER OFF LANDING:

Airspeed (Best Glide)	76 KIAS (87)
Note Wind	Look for Best Landing Site

Establish Spiral Pattern; try to be at 1000 feet above field at downwind position.

Radio	Emergency Call
Transponder	Squawk 7700
Passengers	Brief
Approach	66 KIAS (76)

Touchdown at lowest possible airspeed with full flaps.

When Committed to Landing:

Ignition	Off
Master Switch	Off
Fuel Selector	Off
Mixture	Idle Cut-Off
Seats Upright, Belts, Harnesses	Secure
Doors	Unlatch

ALTERNATOR INOPERATIVE LIGHT:

Ammeter	Check to verify Inop. Alternator
Electrical Load	Reduce
Alternator Circuit Breaker	Check & Reset
Alternator switch (ALT)	Cycle, Off, On

If power is not restored, turn off ALT, leave Battery (BAT) on. Battery is the only remaining source of electrical power. Reduce electrical loads, land ASAP

AMMETER INDICATES HIGH OUTPUT:

High reading may be caused by a low battery, or other abnormal electrical load.

If interlocked BAT/ALT switch, turn ALT Off, use battery only, land ASAP. If separate BAT/Alt switches, cycle BAT switch. If the Ammeter reading does not decrease within five minutes, turn BAT switch Off, use alternator only and land as soon as possible.

USEFUL DATA

Rate of Climb – Sea Level, Std. °	730 FPM
Service Ceiling	13650 Feet
Landing - 50', Sea Level, Std. °	1400 Feet
Landing - Ground Roll	920 Feet
Takeoff - 50', 25% flaps, SL, Std. °	1680 Feet
Takeoff - Ground Roll	900 Feet
Maximum Weight (Ramp)	2558 Lbs
Empty Weight (varies/each aircraft)	1600 Lbs
Maximum Useful Load	958 Lbs
Fuel Capacity:	Std 50 USG (48 usable) 24 USG usable, each tank (17 to tabs) (unusable fuel included in empty weight)
Oil (included in empty aircraft weight)	8 USQ
Fuel Type	100 LL (Blue), 100 (Green)

All critical flight information must be verified by the user by reference to the official and current publications of the applicable government and of the manufacturers of the aircraft and its equipment. The main reference for this material is the Official Archer II, PA-28-181 Information Manual issued July 2, 1979 and revised through April 2, 1998. Data contained herein should be considered approximate and will vary depending on the model year, age, weight, loading and upkeep of the particular aircraft and on the weather, altitude, terrain, and skill of the pilot. Neither the Corporation nor the authors assume any responsibility for the use of the material contained herein.

IMPORTANT SPEEDS

		KIAS	MPH
Climb, Best Angle	Vx	64	74
Climb, Best Rate	Vy	76	87
Stall (full flaps)	Vso	49	56
Stall (flaps up)	Vsi	55	63
Max Speed, flaps	Vfe	102	117
Max Structural Cruise	Vno	125	144
Maneuvering Speed	Va		
2550 lbs		113	130
1634 lbs		89	102
Never Exceed	Vne	154	177
Crosswind Landing (max demo)		17	19
Rotation		52-65	60-75
Enroute Climb		87	100
Best Glide (1.6nm/1000 ft.)		76	87
(Flaps Up, No Wind, Power Off, 2550 Lbs.)			
Approach		75	86
Final Approach (full flaps)		66	76

CRUISE PERFORMANCE

Standard Temperature - 59°F/15°C, No Wind Wheel Fairings Installed, 2550 Lbs.

RPM	% Power	KTAS	GPH	NMPG
2,000 feet MSL:				
2220	55%	97	7.8	12.4
2360	65%	110	9.0	12.2
2520	75%	119	10.6	11.2
6,000 feet MSL:				
2300	55%	102	7.8	13.1
2460	65%	116	9.0	12.9
2600	75%	125	10.6	11.8
10,000 feet MSL:				
2380	55%	108	7.8	13.9
2540	65%	122	9.0	13.6
10,000 feet MSL, Economy				
(Mixture leaned to 100º F Rich of Peak EGT)				
------*	55%	104	6.3	16.5
------*	65%	119	7.6	15.7

* Not provided in Pilot Operating Handbook

KTAS = Knots True Airspeed
KIAS = Knots Indicated Airspeed
KCAS = Knots Calibrated Airspeed

Rule of Thumb – KIAS to KTAS, add 2% per 1000' of altitude.

Juliet meets the press after receiving her Master Flight Instructor rating

EMERGENCIES

EMERGENCY 121.5 EMERGENCY

LIGHT GUN SIGNALS:	**IN AIR**	**ON GROUND**
Steady Green	Cleared to Land	Cleared for Takeoff
Flashing Green	Return for Landing	Cleared for Taxi
Steady Red	Give Way, Circle	Stop
Flashing Red	Airport Unsafe, Do not Land	Taxi Clear of Runway
Flashing White	Not Applicable to Aircraft in Air	Return to Starting Point
Alternating **Red** & **Green**	Exercise Extreme Caution	Exercise Extreme Caution

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TRANSPONDER: Squawk **7700** for emergencies, **7600** for loss of communication.

CALLS: **MAYDAY** 3 times, for life threatening emergency; **PAN PAN** 3 times, for urgent problem (fuel, location, weather).

The following information is summarized from the FAA Airplane Flying Handbook, the FAA Pilot's Handbook of Aeronautical Knowledge, FAA approved Pilot's Operating Handbooks and Airplane Flight Manuals for specific aircraft, and from published flight manuals. Procedures vary depending upon the aircraft, location, weather conditions, the skill and experience of the pilot and other factors. It is the responsibility of each pilot to know and understand the factors applicable to his or her particular situation.

LOST: The FAA recommends; **Confess, Climb, Communicate, Comply** which are self explanatory. Some instructors add; **Conserve** and **Cool**. Conserve fuel by slowing down to about 1.2 to 1.5 times the clean stall speed and lean the mixture to maximize available flying time and range. Stay cool; if you have missed a checkpoint, look for the next one. Try to identify terrain features, use your chart to find roads, railroads, lakes, hills and other terrain features. Locate nearby VOR's and their frequencies and determine your position relative to them. Use the ADF to home in on a non-directional beacon. Divert to any airport you can locate. Some pilots carry a small inexpensive GPS and a spare portable VHF Transceiver - with these as backup, it will be difficult to be lost or out of touch for long. If you are low on fuel and cannot locate an airport, it is probably best to find an alternative landing site and get the aircraft down before you run out of fuel and choices.

COMMUNICATIONS FAILURE: Check the **volume** control and circuit breakers; try both radios if there are two. Are you within VHF range? Try a different headset or mike. If you cannot establish contact and do not have a backup radio, set the transponder to **7600** and follow normal radio out airport procedures as specifically described in The FAA Aeronautical Information Manual (AIM), section 4-2-13. Stay outside or above the pattern, determine direction and flow of traffic, watch for light signals; if you can receive transmissions, acknowledge by rocking the wings or turning the navigation lights on and off. Enter the pattern and keep **very alert** for other aircraft.

WAKE TURBULENCE: Stay alert when near larger jet aircraft or helicopters. Turbulence can last for up to two minutes. Try to avoid landing immediately after larger aircraft. If this is unavoidable, stay above the larger aircraft's flight path and land beyond its touchdown point. If on a parallel runway; exercise the same caution, being alert to where the wind might blow the vortices. Departing, rotate before the larger aircraft's rotation point and climb above its climb path until you can turn clear.

VHF FLIGHT INTO IFR CONDITIONS: The pilot must understand that unless he or she is trained, qualified and current in the control of an aircraft solely by reference to flight instruments he or she will be unable to do so for any length of time. The only way to control the airplane safely is by using and trusting the flight instruments. Attempts to control the airplane *partially* by reference to flight instruments while searching outside the cockpit for visual confirmation of the information provided by these instruments will result in inadequate airplane control. The first rule is to **stay calm**, the pilot must not panic. The main concern at this point is to **keep the wings level**. **Continued next page.**

VHF FLIGHT INTO IFR CONDITIONS (continued from prior page): Most airplanes are, by design, inherently stable platforms and, except in turbulent air, will maintain approximately level flight if properly trimmed and left alone. **Trim** the airplane with the elevator trim so that it will maintain hands-off level flight. Do not over control. **Fly the attitude indicator with fingertip control**. **Make all attitude changes smooth and small**, yet with positive pressure. **Make use of any available aid** in attitude control such as autopilot or wing leveler. **The primary instrument for attitude control is the attitude indicator.** Once the airplane is trimmed so that it will maintain hands-off level flight, that airspeed need not vary until the airplane must be slowed for landing. If the pilot determines that he or she can resume VFR flight by returning in the opposite direction, the turn must be made very carefully, using the smallest practical bank angle. It may be helpful to turn a few degrees and then return to level flight, repeating the process until the desired heading is reached. For the more experienced pilot, do a standard rate turn using the reference marks in the turn indicator or the attitude indicator to set the angle of bank and timing the turn for one minute, rolling out just before the completion of sixty seconds. A standard rate turn is 3° per second or 180° per minute. **A Zulu Rule of Thumb to determine the appropriate bank angle is to divide the airspeed in knots by 10 and multiply by one and one half (1.5)**, thus an airspeed of 100 knots will require a bank angle of 15°. Don't try to keep on going; "scud running" into worsening conditions.

ENGINE FAILURES, FORCED LANDINGS, INFLIGHT FIRES, ICEING, ELECTRICAL PROBLEMS, AND INSTRUMENT FAILURES: Procedures for dealing with each of these emergencies differ for different aircraft. The FAA requires that manufacturers cover each of these situations in detail in the Aircraft Pilot's Operating Handbook or Airplane Flight Manual (POH/AFM) which is supplied with the aircraft and is required to be on board. **THE RECOMMENDED PROCEDURES ARE CHECKLIST ITEMS** in the POH/AFM and in the checklists which we and other publishers prepare. It seems obvious that the pilot in command should continually review and practice these procedures and should always have the appropriate checklist within easy reach.

STALL, SPIN & SPIRAL RECOVERY: A **STALL** is a rapid decrease in lift caused by the separation of airflow from the wing's surface resulting from exceeding the critical angle of attack. It can occur at any pitch or bank angle and at any airspeed. A particularly dangerous type of stall can occur when a pilot attempts to tighten a turn from base to final by using rudder and skidding the aircraft around to avoid having to increase the bank angle. As the outside wing speeds up, the aircraft banks in and the pilot may react by holding the aileron against the turn and increasing back pressure thereby crossing the controls and starting a cycle which can end with the inside wing stalling first, causing the nose to drop abruptly to the inside. A **SPIN** is an aggravated stall where one wing is stalled before the other causing the aircraft to fall off and rotate, usually nose down. In a spin, airspeed is usually near the level unaccelerated flight stall speed and the turn Indicator will be tilted all the way to one side. Ignore the ball in the inclinometer because it can go to either side depending on where it is mounted in the instrument panel. A **SPIRAL DIVE** is a steep diving turn which can occur when a pilot loses the horizon reference and becomes disoriented, often by inadvertently flying into IFR conditions. Unlike a spin, a spiral is characterized by high and increasing airspeed and a more moderate rate of turn indication in the turn Indicator. **RECOVERY** - *Pilots should consult the Pilot's Operating Handbook or Airplane Flight Manual (POH/AFM) for their specific aircraft because recovery procedures differ. The procedures detailed below are general and apply to most small general aviation aircraft. Never deliberately spin an aircraft which is placarded against spins.* **STALL** - Release back pressure and **lower the nose**, apply **full power**, using coordinated ailerons and rudder to keep the wings level. **SPIN** - Close the throttle, **neutralize the ailerons**, apply **full opposite rudder** against the roll or turn, then (when the rudder hits the stop) **briskly push the wheel or stick forward** to stop the stall, and then pull carefully out of the dive keeping the ailerons neutral. **SPIRAL DIVE** - **level the wings** with coordinated aileron and rudder, throttle back and **carefully bring the nose up**, gradually reducing the speed.

Pilot Zulu's QUICK REFERENCE FOR PILOTS

The Reference is planned to be 6.5 x 9 inches with labeled tabs for each section and will be spiral bound so that it lies flat and can be folded over for ease of use and so that the transparent plotter and E6B calculator can be used. Unfortunately, a spiral bound book can get lost on a bookstore bookshelf. The best solution to this is to add a slip case and put the title and characters on the spine of the slipcase. This may also enhance the perception of value. It might also make the book a more likely impulse purchase to be used as a gift.