



The Pilot's Manual

PM 1

# Flight School

How to fly your airplane through all the maneuvers required for certification

*Fifth Edition*



**Foreword by Barry Schiff**

The Pilot's Manual

PM **1**

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**Aviation Supplies & Academics, Inc.**  
Newcastle, Washington

## **The Pilot's Manual Volume 1: Flight School**

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# Foreword

When it was time to take my private pilot written examination in 1955, my flight instructor handed me a pocket-size booklet. It was published by the Civil Aeronautics Administration (FAA's predecessor) and contained 200 true/false questions (including answers).

"Study these well," he cautioned with a wink, "because the test consists of 50 of these." As I flipped through the dozen or so pages, my anxiety about the pending examination dissolved into relief. Nothing could be easier, I thought. One question, for example, stated: "True or False: It is dangerous to fly through a thunderstorm." Really. (I passed the test with flying colors—but so did everyone else in those days.)

The modern pilot, however, must know a great deal more to hurdle today's more challenging examinations. This has resulted in a crop of books developed specifically to help pilots pass tests. Unfortunately, some do little else, and the student's education remains incomplete.

An exciting exception is *The Pilot's Manual* series. These voluminous manuals provide far in excess of that needed to pass examinations. They are chock-full of practical advice and techniques that are as useful to experienced pilots as they are to students.

The *Pilot's Manuals* are a refreshingly creative and clever approach that simplifies and adds spice to what often are regarded as academically dry subjects. Reading these books is like sitting with an experienced flight instructor who senses when you might be having difficulty with a subject and patiently continues teaching until confident that you understand.

*Barry Schiff*  
Los Angeles

Barry Schiff has over 27,000 hours in more than 300 types of aircraft. He is retired from Trans World Airlines, where he flew everything from the Lockheed Constellation to the Boeing 747 and was a check captain on the Boeing 767. He has earned every available FAA category and class rating (except airship) and every possible instructor's rating. He also received numerous honors for his contributions to aviation. An award-winning journalist and author, he is well known to flying audiences for his many articles published in some 90 aviation periodicals, notably *AOPA Pilot*, of which he is a contributing editor. ASA publishes several Barry Schiff titles.

# About the Editorial Team

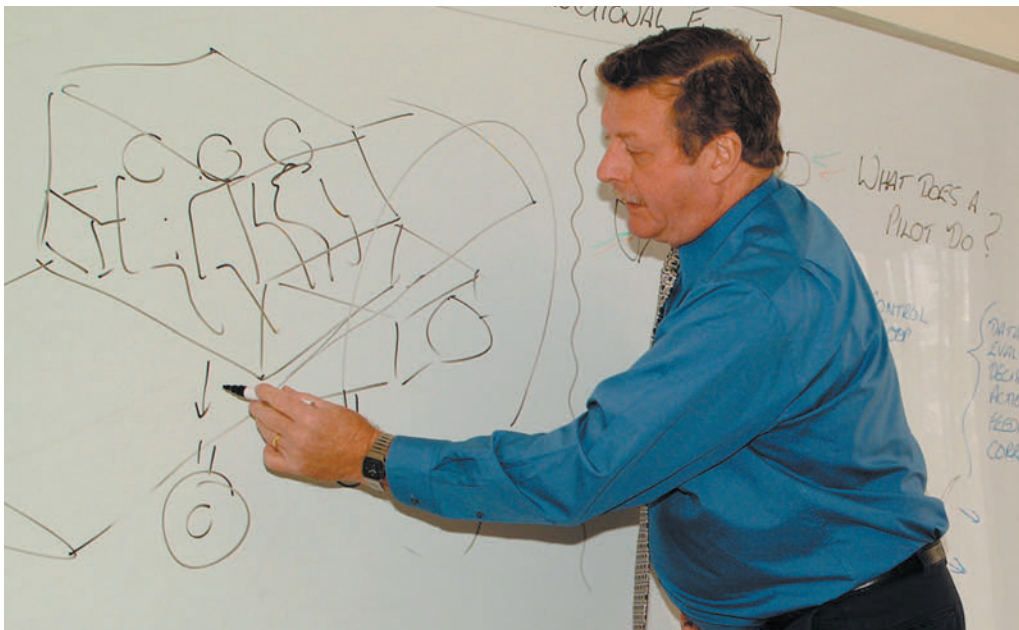
## David Robson

David Robson is a career aviator having been nurtured on balsa wood, dope (the legal kind) and tissue paper. He made his first solo flight shortly after his seventeenth birthday, having made his first parachute jump just after his sixteenth. His first job was as a junior draftsman (they weren't persons in those days) at the Commonwealth Aircraft Corporation in Melbourne, Australia. At that time he was also learning to fly de Havilland Chipmunks with the Royal Victorian Aero Club.

He joined the Royal Australian Air Force in 1965 and served for twenty-one years as a fighter pilot and test pilot. He flew over 1,000 hours on Mirages and 500 on Sabres (F-86). He completed the Empire Test Pilots' course in England in 1972, flying everything from gliders to Lightning fighters and Argosy transport aircraft. He completed a tour in Vietnam as a forward air controller flying the USAF O-2A (Oscar Deuce). In 1972 he was a member of the Mirage formation aerobatic team, the Deltas, which celebrated the RAAF's 50th anniversary.

After retiring from the Air Force he became a civilian instructor and lecturer and spent over ten years with the Australian Aviation College, a specialized international school for airline cadet pilots. During 1986–88 he was the editor of the national safety magazine, the *Aviation Safety Digest*, which won the Flight Safety Foundation's international award. He was recently awarded the Australian Aviation Safety Foundation's Certificate of Air Safety.

David holds an ATP licence and instructor's rating. His particular ambition is to see the standard of flight and ground instruction improved and for aviation instruction to be recognized as a career and be adequately rewarded.





## **Jackie Spanitz**

Jackie earned a B.S. in Aviation Technology and Operations from Western Michigan University and earned a M.S. from Embry-Riddle Aeronautical University. As Curriculum Director for ASA, Jackie oversees new and existing product development, ranging from textbooks and flight computers to electronic and online tutorials, and integration of these products into curricula. She also conducts aviation research as well as product development and project management. She holds Flight and Ground Instructor Certificates. Jackie is the author of *Guide to the Flight Review* and the technical editor for ASA's Test Prep Series.

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Madeline Tompkins is an experienced flight instructor, current Boeing 737-300/400 airline captain and crew resource management facilitator. She is well known for her part as copilot in an airliner emergency in Hawaii, about which a TV movie was made. She has received many honors, including the AOPA Air Safety Foundation's Distinguished Pilot award. A former FAA designated flight examiner, she is currently an FAA accident prevention counselor, designated knowledge test examiner, and she also teaches CFI refresher courses.

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Martin Weaver is an experienced flight and ground instructor in airplanes, helicopters and gliders. He is a former chief flight instructor and designated pilot examiner, who has been closely involved with standardization procedures for over 14 years. He holds a B.S. from the University of Southern Mississippi. He is currently a pilot in the Oklahoma Army National Guard.

## **Amy Laboda**

Amy Laboda is a free-lance writer, editor and active flight instructor. She is a member of the American Flyers Judith Resnik Scholarship committee and former editor at *Flying* magazine. She has recently been appointed as editor of *Women in Aviation*. She has a rotorcraft category, a gyroplane rating, a glider rating and a multi-engine ATP rating. She also holds a B.A. in Liberal Arts from Sarah Lawrence College.

## **Melanie Waddell**

Melanie began flying in 1994 and was awarded a Bachelor of Technology in Aviation studies from Swinburne University, Melbourne, Australia in 1997. She is a current commercial, multi-engine and instrument-rated pilot as well as a Grade I flight instructor. She hopes to captain a wide-body jet in the not-too-distant future.

# Introduction



## Becoming a Pilot

Every pilot begins as a student. If we learn by listening, observing, practicing and reading, we can make better use of our flight time. Learning is reinforced by reliving our flight lessons and by anticipating the next. To gain the maximum benefit from each hour in the air, you need to be well prepared. This is the purpose of this book. It will answer many questions, and it may promote you to ask more questions of your instructor. All of this dialogue is valuable.

Learning to fly does not take long: within the first 20 hours of flight time you will have learned the basic skills and you will have flown solo, which is a great achievement. Since the training period is so short, good habits must be developed right from the start. Habit patterns, attitudes and disciplines that are formed in the first few hours will stay with you throughout your flying life. Learn them well.

A commercial pilot must demonstrate greater accuracy and a higher level of knowledge than a private pilot. However, the basic skills for visual flight are common. The commercial pilot may have the advantage of flying regularly. It is important to reinforce your flight training after you gain your pilot's certificate. All skills and knowledge fade with time unless exercised. This manual will assist you in recalling the structure and content of each of the flight tasks.

*Good habits must be developed right from the start with balanced and reinforced learning.*

*Fly frequently for the most efficient training progress.*

## Planning your Training Schedule

Try to fly regularly and fairly often. If you can have flights on consecutive days, especially as you approach first solo, then the retention of learning from one flight to the next is improved, and there will be little need for repetition. As you fly you will gain confidence and skill. At the beginning you may feel some sensitivity to motion and some anxiety. This is normal. The flight environment is a new experience and therefore unknown. It is natural to be apprehensive until you become acclimated to the environment.

## How an Airplane Flies

The basic training airplane is simple in design and straightforward to operate. It has:

- a control wheel (or control column) to raise or lower the nose and to bank the wings;
- a rudder to keep the airplane coordinated so the tail follows the nose and the airplane does not fly sideways; and
- a throttle to control engine power.

The largest and fastest airliners have the same basic controls as your training airplane.

## How the Pilot Controls the Airplane

*The pilot uses the control wheel or column, rudder and throttle to set the attitude and power and control the speed and flight path of the airplane.*

The pilot controls the airplane by setting the attitude (the position of the nose), the configuration (flaps and landing gear) and the power. It's that simple. A certain combination of these settings produces a certain flight path and speed. It is a matter of learning these settings for your airplane. Once these are learned the pilot can achieve the *four basic maneuvers*:

- straight and level flight;
- turns;
- climbs; and
- descents.

The flight profile then is a combination of these basic maneuvers.

The flight limits (speeds and altitudes) are defined by what is called the flight envelope for the airplane. A jet airplane has a much greater flight envelope than a small trainer.

## Maximum and Minimum Speed

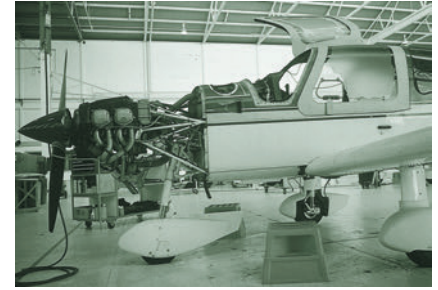
The aircraft's maximum speed when flying level is limited by power. However, an airplane can dive, and for this reason, there is a published never-exceed speed to avoid airframe damage. The minimum speed is called the *stalling speed*. It is determined by the maximum angle of the wing, beyond which the lift reduces and the aircraft sinks—not unlike the minimum speed of a bicycle when it can no longer remain upright.

## Maximum Altitude

The maximum altitude is limited by the power of the engine and the ability of the pilot to breathe the thinner air. Larger airplanes are pressurized to maintain a lower cabin altitude.

## Is Flying Safe?

Very. All airplanes are serviced to a strict schedule. Their engines are very reliable and the systems are well proven. Your instructor will show you the maintenance routine for the airplane. The most common cause of accidents is the pilot. Therefore you are in charge of your own destiny. Learn the craft well and apply the rules of safe practice and you will have a very enjoyable and rewarding hobby or career.



## Your Flying Lessons

Because of noise, workload and distractions, the cockpit can be a difficult place in which to learn, so thorough preflight preparation is essential. For each training flight you should have a clear objective and be mentally prepared to achieve it. Ideally, the actual training flight should be an illustration of principles that you already understand, rather than a series of unexpected events. Anything taught in the air should have been previously explained and discussed on the ground. Your objective is, with the guidance of your flight instructor, to achieve a standard where you:

- show good judgment, self-discipline and airmanship (common sense and sound procedure);
- apply your aeronautical knowledge;
- operate the airplane safely and within its limits; and
- demonstrate control of the airplane by confidently performing each maneuver or procedure smoothly, consistently and accurately.

The flight instructor wants to see you making decisions and correcting any deviations without prompting. You are expected to take command of the airplane. Then he or she knows you can fly safely alone.

*Airmanship* is a term that embraces many things: skill in flying the airplane, thorough knowledge, common sense, caution, courtesy, quick reactions and alertness. It comes with the right attitude, training and experience. It is the ultimate measure of a pilot.

*The cockpit is not an easy place to learn, so always be prepared for your flight lessons. Also visit the hangar.*

## Becoming a Better Pilot

An average person can learn to be a pilot. An average person can also choose to be a better-than-average pilot. An advanced, formal education is not a requirement to become a pilot. Clear English language is required for radio calls, and basic mathematics (proportions and fractions) are used. Beyond that, no special academic skills are required. The most important attribute that the student can bring and develop is their attitude to flight. This means how thorough, accurate, consistent and professional they are determined to be. This determination makes the difference between an average pilot and a better pilot.

## The Structure of This Book

This volume is structured in the form of flight tasks. You will not necessarily learn the tasks in the order they are presented. Students learn at different rates and the flight

instructor will tailor your training to suit your ability and rate of progress. Having the book separated into tasks allows the instructor to assemble the flight lessons to suit your individual needs.

## How to Use This Manual

For each stage of your training, this manual sets out:

- clear objectives;
- the principles involved;
- how to fly the maneuver;
- the actual task, summarized graphically;
- any further points relevant to the exercise; and
- review questions, to self-test and reinforce the main points.

This will prepare you well and help to minimize your training hours (and your expense). As your training progresses, the manual can also be used for revision. Earlier maneuvers can be revised simply by referring to the task pages (which act as a summary), and working through the review questions again.

The review questions should be answered mentally and confidently. For this reason, they are phrased as direct questions and are intended to be posed and answered orally. If there is doubt about a review question, check the answer in the back of the book and refer to the text for the explanation.

In Appendix 1, entitled “Your Specific Airplane Type,” there are questions that will help you to better understand your airplane. You can apply this information not only to your basic training airplane, but to any other type you may fly later on. It is essential information for all airplanes that you fly.



## An Important Note to Pilots Regarding Flight Training

Our manual will help you prepare for each flight lesson. This will make your training more efficient (better understanding and better retention) and therefore less costly. However, the ultimate responsibility for your training rests with your own flight instructor, so his or her words have authority. Ask many questions and discuss any aspects about which you are unsure. A clear understanding on the ground enables a much better opportunity for success in the air.

We welcome written comments and suggestions for improvement of this manual. Send your feedback to:

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## A Note to the Flight Instructor

First impressions are very important. Students remember best what they learn first. Our manual has been designed so correct understanding is possible the first time around. It is not just one book, but a collection of 61 tasks, each one standing alone and presenting everything that needs to be known for a specific element of flight. You will choose the content of each flight according to the progress and ability of your

student. It is simply a matter of forewarning the student of the content of the next flight lesson, so he or she can study the appropriate task.

We aim to make the learning interesting, colorful and meaningful so a student will be motivated, assimilate it easily, and understand it well enough to be able to explain the main ideas in his or her own words.

New material is presented carefully, building on knowledge and experience already gained—a building block approach to learning. The main points in each chapter are expressed in different ways and repeated periodically throughout the text to reinforce the knowledge. Active participation by the student in the learning process is encouraged with the review questions in each chapter.

The flight instructor, especially the very first flight instructor, plays a vital role in the life of a pilot. What the student learns first will stick. Remember the student will learn by your example. They will do what you do, not what you say. If you are thorough, professional and careful, they will take on those same attributes, modified by their own personality. You are under continuous close scrutiny. The best you can do is to show your student how to be a good pilot by being one yourself. We wish you well with your students.



---

# **An Introduction to Flight**

- 1. The Training Airplane**
- 2. Flight Preparation**
- 3. Communications**
- 4. Your First Flight**

# The Training Airplane 1

## Objectives

To name and describe:

- the main components of a basic training airplane; and
- the systems, controls and instruments used by the pilot.

## Considerations

### The Airframe

The structure of the airplane is called the *airframe*. It consists of a *fuselage* to which the *wings*, the *empennage*, the *landing gear* and the engine are attached. A propeller converts engine *torque* to generate *thrust* to propel the airplane through the air. Forward speed causes the airflow over the wings to generate an aerodynamic force, known as *lift*, that is capable of overcoming the force of gravity (*weight*) and that supports the airplane in flight. The airplane can even fly temporarily without thrust if it is placed in a *glide*—its forward momentum assisted by gravity keeps it moving through the air, and this allows the wings to produce lift. However, the path is inevitably downward. In the absence of vertical air currents, thrust is essential to allow level, turning and climbing flight.

*Lift is the means by which flight is attained.  
Thrust is the means by which flight is sustained.*

The tail assembly of the aircraft is situated some distance to the rear of the main load-carrying sections of the fuselage and provides a balancing, or *stabilizing*, force much like the tail feathers on an arrow or a dart. The tail section consists of a *vertical stabilizer* (or *fin*) and a *horizontal stabilizer* (or *tailplane*), both of which are shaped to produce stabilizing forces. The pilot and passengers are housed in the cockpit, usually in side-by-side seating—the pilot (or *pilot in command* in a two-pilot aircraft) sits on the left side.



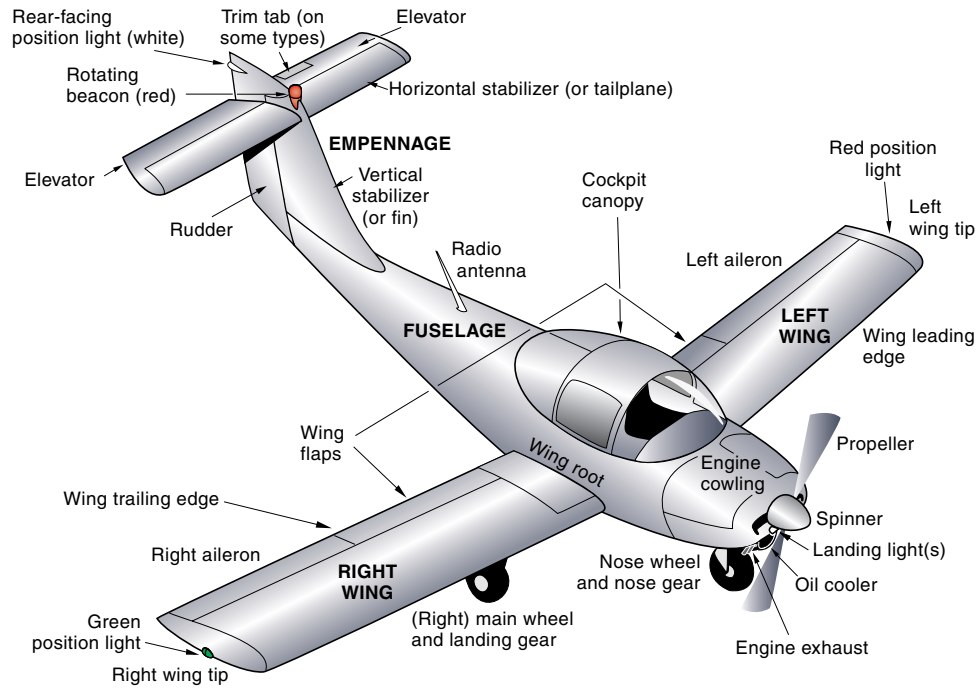
**Figure 1-1** A Cessna trainer.



**Figure 1-2** Tobago aircraft.



Controls and instruments are placed in the cockpit to enable the safe and efficient operation of the airplane and its systems, and for navigation and communication.



**Figure 1-3** Parts of an airplane.

## Aircraft Types

Light aircraft were traditionally classified under Federal Aviation Regulation (FAR) 23 which described structural and performance standards. These represented the fleet of General Aviation aircraft up to a certain weight limit.

More recently, the FAA has introduced a new category—the *Light Sport Aircraft* (LSA) category which offers relaxed construction, performance and licensing standards for pleasure flying and for training.



**Figure 1-4** Vans Aircraft RV-6A light-sport airplane.

The LSA category allows a wide range of designs that are placed between the ultralights and the GA categories. It allows adventurous designs and fun flying at lower cost, using less energy and with less of the burden of regulations and testing.

Many pilots are now introduced to aviation via the LSA category and traditional, well respected manufacturers such as Cessna are now testing new designs that will be placed within this category.

This manual describes flight techniques which are equally applicable to all GA and LSA airplanes although there will be unique characteristics shown by some more radical designs and configurations. The techniques remain a vital foundation for a trainee pilot.

## Primary Controls

### Flight Controls

The most common primary flight control has been the wheel or *yoke*. This is still prevalent although there are more diverse options available now. The yoke came about because of high control forces and the need to be able to use both hands for control inputs. It also allowed relief so that the pilot could change hands. Also, the yoke provided a convenient place for transmit buttons, trim switches and some autopilot functions. It is retained in many larger aircraft even though the control forces have now been overcome by hydraulic actuators.

With the widespread use of ultralights and home-built aircraft there was a reappearance of the central control column or *joystick*. Many feature the transmit button on the top and some even have electric trim switches. The stick is better for highly maneuverable aircraft—for aerobatics, display flying and crop dusting—as it provides greater leverage and instantaneous control deflection. (It can also be held between the knees when cruising).

As more advanced types have been introduced into the General Aviation (GA) fleet the *side-stick* as used in modern complex transport airplanes, has appeared. The control forces and response have been refined to the point where only a small mechanical advantage is needed. The magnificent Cirrus and Sky Arrow aircraft both used side sticks—as does the Australian Lightwing Speed.

### Aircraft Attitude

The attitude of the aircraft together with thrust from the propeller allows the aircraft to sustain a particular flight path. This is the essence of aircraft control.



**Figure 1-5** Traditional control wheel or yoke.

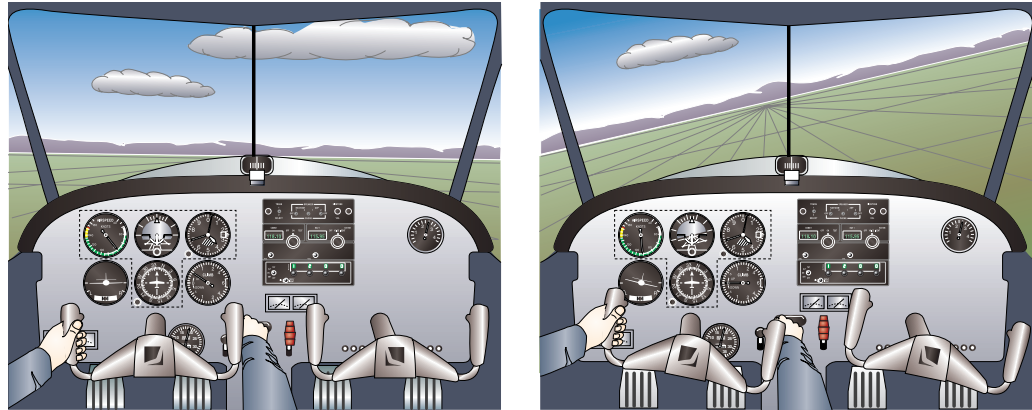


**Figure 1-6** Traditional joystick—Lancair.



**Figure 1-7** Side stick control—Cirrus.

Thus the pilot's task is to set an attitude and power, check the response from the instruments and make a correction if necessary. This is the process of piloting the aircraft. The *attitude* is simply the position of the nose of the aircraft in relation to the horizon: high, low, tilted left or right, and by how much. It is a matter of a visual judgment that is easy to learn.



**Figure 1-8** Visual attitudes—nose-up and right bank.

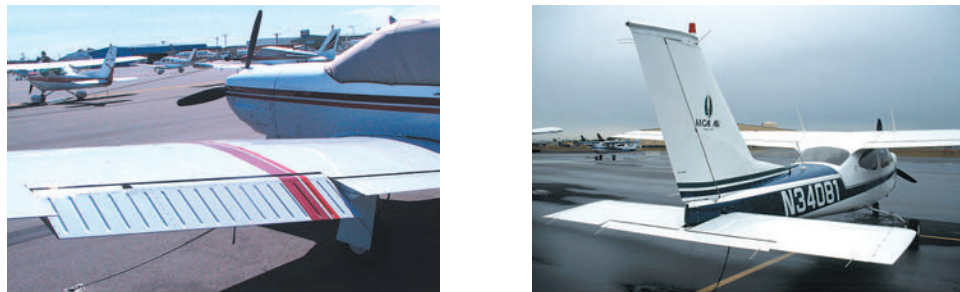
The attitude, or position in flight, of the airplane is controlled using the flight controls. These are surfaces that, when deflected, alter the pattern of the airflow around the wings and tail, causing changes in the aerodynamic forces they generate.

### **Control Surfaces**

The movable parts of the aircraft's structure are called *control surfaces*:

- The *elevators* (hinged to the trailing edge of the horizontal stabilizer) control pitching of the nose up or down and are operated from the cockpit with backward and forward movements of the control column.
- The *ailerons* (hinged to the outer trailing edge of each wing) control rolling of the airplane and are operated by left and right movement of the control column.
- The *rudder* is the movable surface controlled by the rudder pedals on the floor of the cockpit (hinged to the trailing edge of the fin or vertical stabilizer). The rudder is used to steer the aircraft on the ground and to balance the aircraft in the air.
- The *flaps* are surfaces that move down only, operated by a manual lever or dedicated switch. They are attached to the inner rear section, known as the *inboard section*, of each wing and move together. They provide additional lift and better

*The primary controls include the elevators, ailerons and rudder.*



**Figure 1-9** Left aileron (left); vertical stabilizer and rudder (right).

forward and downward view for flight at low speeds. They are used mainly for the approach and landing.

- The elevator has a smaller hinged surface, to balance the elevator control force, called a *trim tab*. It is usually operated by a trim wheel or handle beside the pilot or above in the cabin ceiling. Some aircraft also have trim tabs on the rudder and ailerons.



The secondary controls include flaps and trim tabs.

**Figure 1-10** Flaps (left); elevator and trim tab (right).

Even though the aerodynamic components of various airplane types serve the same basic functions, their actual location on the structure and their shape can vary. For example, the wings may be attached to the fuselage in a high-, low- or mid-wing position; the horizontal stabilizer is sometimes positioned high on the fin (known as a *T-tail*); and the combined horizontal stabilizer and elevator is sometimes replaced by a *stabilator* (or *all-flying tailplane*). The stabilator is also fitted with a tab.

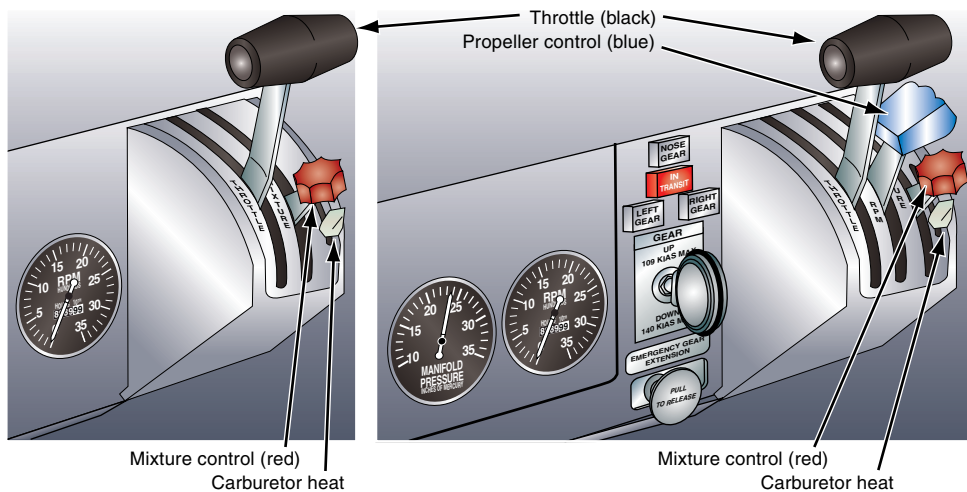


**Figure 1-11** Stabilator with tab.

### Engine/Propeller Controls

The throttle, which is operated by the pilot's right hand, controls the power (thrust) supplied by the engine-propeller combination. *Opening* the throttle by pushing it forward increases the fuel-air supply to the engine, resulting in increased revolutions and greater power. Retarding the throttle, or *closing* it, reduces the power to idle RPM but does not stop the engine, being just the same as the accelerator in your car.

Push the throttle forward for a greater power and pull it back for reduced power.



**Figure 1-12** Engine controls—fixed-pitch propeller (left) and constant-speed propeller (right).



**Figure 1-13** Push/pull knobs for throttle, propeller and mixture controls (Cessna aircraft).



**Figure 1-14** Manifold pressure gauge and tachometer.



**Figure 1-15** Tricycle landing gear.



**Figure 1-16** Tail wheel landing gear.

Some airplanes have the engine controls in the form of push/pull knobs. Push/pull controls are direct mechanical plungers which are pushed forwards (in) for greater power or propeller RPM. Some have a vernier (rotational) facility for fine adjustment once the broad setting has been made.

The engine rotates the propeller and together, they produce the thrust to propel the aircraft. The power of the engine is controlled by the throttle, which determines the amount of fuel to the engine. The propeller is driven directly by the engine and may have fixed blades or variable-pitch blades. In the case of variable-pitch blades, there is an additional propeller lever next to the throttle and an additional instrument, called the *manifold pressure gauge*, next to the RPM indicator or tachometer.

### **Landing Gear**

Most modern training airplanes have a tricycle landing gear (or undercarriage) that consists of two main wheels and a nose wheel to provide support on the ground. Other aircraft have a tail wheel instead of a nose wheel. The nose wheel on most aircraft types is connected to the rudder pedals so that movement of the pedals will turn it, assisting in directional control on the ground. Most aircraft have brakes on the main wheels. Brakes are operated individually or together by pressing the top of the rudder pedals; thus, they can be used to assist steering as well as braking. There is also a parking brake knob or lever.

## **Aircraft Systems**

### **Engine and Propeller**

The typical training airplane has a piston engine that uses aviation gasoline (AVGAS). The engine revolutions per minute (RPM) are controlled by the throttle. This is indicated in the cockpit on the *tachometer*, or RPM gauge. Oil for lubricating and cooling the engine is stored in a sump at the base of the engine. Its quantity should be checked with a *dipstick* prior to flight. There are two cockpit gauges to register oil pressure and oil temperature when the engine is running. These gauges are normally color-coded, with the normal operating range shown as a green arc or by upper and lower green marks.

Fuel is mixed with air in a *carburetor*, and the mixture passes through the induction system (*manifold*) into the cylinders where combustion occurs. The carburetor heat control, located near the throttle, is used to supply hot air to protect the carburetor from icing.

### **Fuel System**

The fuel is usually stored in wing tanks. High-wing airplanes usually rely on gravity to supply fuel to the engine-driven pump, whereas low-wing airplanes have an additional electric fuel pump



**Figure 1-17** The oil quantity should be checked during the preflight inspection prior to every flight.

(boost pump). There are fuel gauges in the cockpit to indicate the quantity, but they are not always totally reliable. Therefore, it is a requirement to check the contents of the tanks, either visually or by using a dipstick, prior to each flight. It is also essential to confirm both that the fuel is of the correct grade (which is identified by its color) and that it is not contaminated, the most likely contaminant being water. Water is more dense than AVGAS and gathers at the lowest points in the fuel system. The check is performed by inspecting a small sample taken from the fuel drain valve beneath each fuel tank and from the fuel strainer or filter.

A fuel tank selector in the cockpit allows fuel to be supplied from each tank as desired or, in some cases, from both tanks simultaneously. The fuel selector can also be used to prevent the supply of fuel to the engine compartment in the event of a fire.

A mixture control adjusts the richness of the fuel-air mixture provided to the engine and is suited for flight at higher altitudes, generally above 5,000 feet. When pulled fully out, the mixture control has the function of cutting the fuel supply to the engine altogether. It is used to shut down the engine to ensure the fuel lines are evacuated.

### Ignition System

The engine has dual ignition systems that provide sparks to ignite the fuel-air mixture in the cylinders. The electrical current for the sparks is generated by two *magnetos* geared to the engine. The dual ignition systems provide more efficient combustion and greater safety in the event of one system failing. They function with the rotation of the engine and do not require an electrical current. Battery power is only required for starting the engine.

An ignition switch in the cockpit is normally used to select both magnetos, although it can select the left or right magneto individually to check for correct functioning of each. It also has an off position to prevent inadvertent starting of the engine if the propeller is turned.

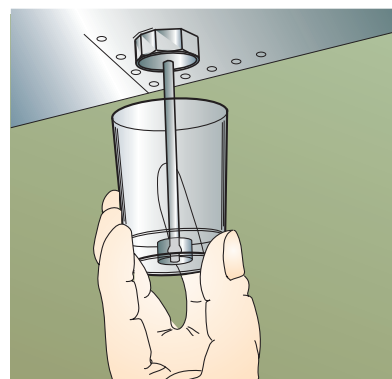
The ignition switch is not generally used to stop the engine. The fuel mixture control has a *cutoff* position. Most ignition switches have a further position, *start*, that connects the battery to an electric starter. Once the engine starts, the ignition switch returns to *both*—it springs back to this position when released—and the engine runs without electrical supply from the battery.

### Electrical System

The battery is a source of electrical power to start the engine. The battery also provides an emergency electrical backup supply for lights and radios if the engine-driven alternator (or generator) fails. There is a master switch to turn the battery circuit on and off.

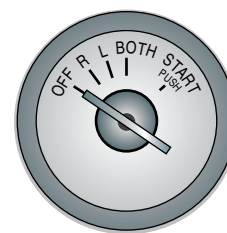
The electrical system supplies various aircraft services, such as some flight instruments, the radios, cabin lights, landing lights and navigation lights. In some aircraft,

*Fuel management is a high priority—the fuel tanks should be checked visually prior to each flight.*



Transparent container to check quality and type of fuel sample

**Figure 1-18** A typical method of checking the fuel.



**Figure 1-19** The combined ignition/start switch.

*The battery is used to start the engine. The alternator (or generator) is used to power the electrical system once the engine is running.*

it also supplies the flap motor, the pitot heater and the stall warning system. Airplanes equipped with an alternator need a serviceable battery so that the alternator has an exciter current. The electrical system incorporates an ammeter and/or warning light to verify the electrical current is flowing. There may be a separate switch for the alternator circuit. Each electrical circuit is protected from excessive current by a fuse or a circuit breaker. Note that the two magneto systems providing the ignition sparks to the engine are totally separate from the electrical system (alternator/generator, battery, circuit breakers and fuses).

### **Radios**

The radios have an on/off switch and volume control (usually combined in the one knob), a *squell* control to eliminate unwanted background noise, a microphone for transmitting, and speakers or headphones for receiving messages. There may be an avionics master switch for all radios and navigation aids. There will be a separate control panel for the *intercom* (internal communications system).



**Figure 1-20** Radio control panels.

## Instruments and Units of Measurements

### Instruments

The panel in front of the pilot contains instruments that provide important information. The main groups of instruments are the *flight instruments* (which are directly in front of the pilot) and the *engine instruments* (which are generally situated near the throttle).



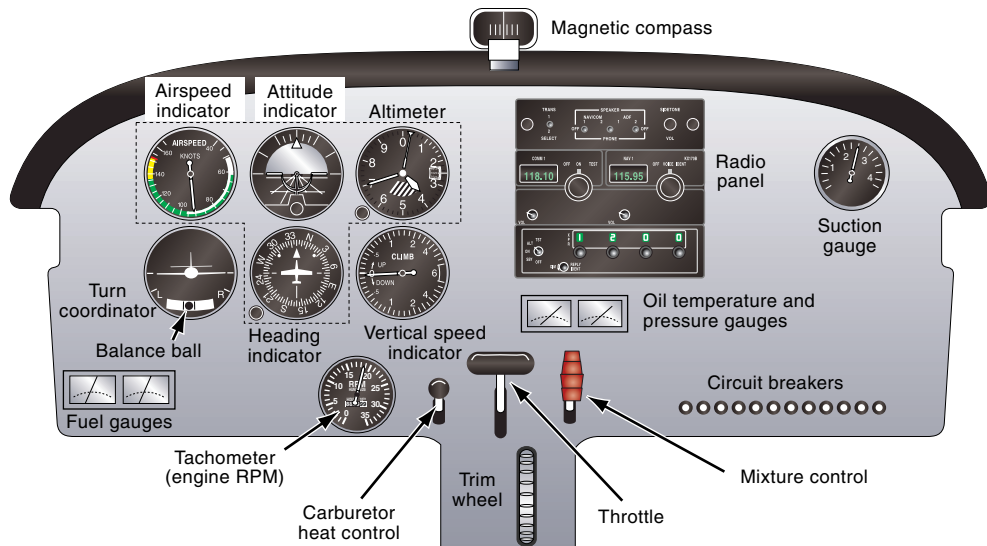
Figure 1-21 Typical instrument panel (Cessna).



Figure 1-22 Typical instrument panel (Piper).



The flight instruments include an *airspeed indicator* (ASI), an *attitude indicator* (AI) to depict the airplane's attitude relative to the horizon, an *altimeter* (ALT) to indicate height above a selected reference, a *vertical speed indicator* (VSI) to show climb or descent, a *heading indicator* (HI) (sometimes called a *directional gyro* (DG)) to show direction, and either a *turn coordinator* or *turn indicator* with an associated *balance ball*.



**Figure 1-23** A typical instrument panel.

There are two types of flight instruments:

- *control* instruments (to set attitude and power); and
- *performance* instruments (to confirm that the flight path and airspeed are as desired).

The instruments related to airspeed and altitude are sensitive to static and dynamic (moving) air pressure obtained from the pitot-static pressure system. Those instruments related to attitude, direction and turning are operated by internal spinning gyroscopes (with the exception of the magnetic compass). The gyroscope rotors may be spun electrically or by a stream of air induced by suction from the vacuum system. The magnetic compass is usually located well away from the magnetic influences of the instrument panel and radio.

The engine instruments include the *tachometer* (engine RPM), and in the case of an aircraft with a constant-speed propeller, there is also a *manifold pressure gauge* (MP gauge). In this instance, the pilot sets both controls to a preset value to obtain a desired power output. There are oil pressure and oil temperature gauges, and there may be a fuel pressure gauge. Some aircraft also have a *cylinder head temperature* (CHT) or *exhaust gas temperature* (EGT) gauge. Other instruments may include an *ammeter*, to monitor the electrical system, a *suction gauge* for the vacuum system and a *carburetor inlet temperature gauge* to warn of possible icing.

### **Units of Measurement**

In aviation, there is a multiplicity of units and variance in their use. Although some metric units are used, the international aviation community has retained some traditional units of measurement for very valid operational reasons. In particular, the United States is yet to transfer to international units and many aircraft are manufac-

tured in this country. Be extra careful and check with your instructor for the units displayed in your aircraft.

### Speed and Distance

The standard unit for airspeed is the *knot*, which is derived from nautical traditions. A knot is one nautical mile per hour. The knot is retained in aviation because it is a division of the system of measuring position and distance over the surface of the earth—*latitude* and *longitude*.

A distance of one nautical mile equates to one sixtieth of a degree of latitude at the equator. A *nautical mile* is 6,076 feet, 1.1508 statute miles or 1.852 kilometers. A knot is one nautical mile per hour. Thus 60 knots is close to 70 mph. Don't try to convert this: you will become familiar with knots and learn what flying at 100 knots feels like.

Some aircraft still use miles per hour, but such aircraft must also have knots shown on the airspeed indicator. Some European aircraft use kilometers per hour (kph), but this is not the standard. Wind speed is also given in knots for airports and for flight forecasts. Takeoff and landing performance charts outside the United States use units of meters for distance instead of feet. A foot is approximately 30 centimeters. A meter is 39.37 inches.

### Airspeed

Airspeed is measured in knots (nautical miles per hour). The ASI is provided with ram air pressure through the pitot head.

### Altitude

The unit for altitude is *feet* in hundreds or thousands. All aeronautical charts have the height of terrain in feet above mean sea level (MSL), and weather forecasts show the height of cloud in thousands of feet. The altimeter has three pointers for hundreds, thousands, and tens of thousands of feet. It is read cumulatively, in the same way as the traditional clock face of hours *plus* minutes—here thousands plus hundreds of feet.

### Direction

Direction is indicated in degrees relative to magnetic north, since the compass aligns to this reference. North is both  $000^\circ$  and  $360^\circ$  (i.e. there are  $360^\circ$  in a full circle); however, it is always referred as  $360^\circ$ . East is  $090^\circ$ , south is  $180^\circ$  and west is  $270^\circ$ .

Runway direction is indicated to the nearest ten-degree increment, i.e. plus or minus  $5^\circ$ . Runway 27 points west (it is within plus or minus  $5^\circ$  of west or  $270^\circ$ ) and Runway 4 points to the north east. The opposite direction on the same runway (called the *reciprocal*) is  $180^\circ$  about. Runway 27 and 09 are the same runway but in two opposite directions, as are 4 and 22.

A direct-reading magnetic compass (figure 1-28, page 14) is also part of a standard cockpit.



Figure 1-24 Airspeed indicator (ASI).



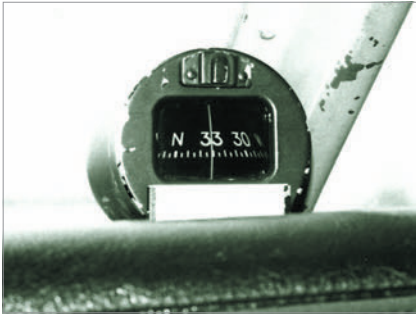
Figure 1-25 Pitot head.



Figure 1-26 Altimeter.



Figure 1-27 Heading indicator.



**Figure 1-28** Magnetic compass.



**Figure 1-29** Attitude indicator.



**Figure 1-30** Tachometer.



**Figure 1-31** Manifold pressure gauge.

## Attitude

The vertical direction in which the nose of the aircraft is pointing relative to the horizon is described in degrees of *pitch* (how far above or below the horizon). *Bank* is the degree of tilt, left or right. Turns are described by the *angle of bank*, e.g. a 30°, or 45°, banked turn, or bank. Attitude is a combination of pitch and bank and is set by reference to the visual horizon or the attitude indicator (AI).

On all instruments, except the HI and the AI, the needles move. On the HI, the card rotates to show heading at the top. In the AI, the horizon moves to remain aligned with the earth's horizon.

## Weight/Mass

United States aircraft have performance charts and load sheets with units of pounds (lb), whereas other parts of the world use the kilogram for weight. A kilo is approximately 2.2 pounds.

## Fuel

United States aircraft have fuel tanks, gauges and charts calibrated in U.S. gallons (USG) and gallons per hour. Many other countries use metric units and so the volume of fuel is measured in liters, and consumption of fuel is measured in liters per hour. One USG is approximately four liters.

## Pressure

Tire and fuel pressure is indicated in *pounds per square inch* (psi), and manifold pressure (in the engine intake) is indicated in *inches of mercury* (in. Hg), which is a very traditional unit of atmospheric pressure. This is also used for atmospheric pressure but metric is again common outside the United States where millibars (mb) or hectopascals (hPa) are used.

The altimeter's pressure setting is adjusted for surface pressure. The standard setting is 29.92 in. Hg. This setting varies with changing weather patterns, and the altimeter is adjusted for the day and the time of the flight.

## Propeller Speed

The speed of rotation of the propeller is indicated in *revolutions per minute* (RPM) on the tachometer. The typical range is from 800 RPM as the engine idles to about 2,700 at full power.

## Manifold Pressure

Your first aircraft may have a constant-speed propeller, in which case, the power is a combination of RPM and manifold pressure (MP). Units for MP are *inches of mercury* or *simply inches*. A typical cruise power setting might be 23 inches and 2,300 RPM.

## Cockpit Design

The modern GA or LSA aircraft has made great advances in design. At last the private pilot can have features and comfort that was previously only available to high performance and expensive airplanes—military or civilian.

The structures are more efficient with beautiful aerodynamic shaping, well balanced and responsive control and electronic displays (glass cockpits) with powerful computing power and data processing for flight planning, weather reporting, navigation and flight management.

## Electronic Instruments

While the data required by a pilot remains the same, many modern aircraft display this information in novel ways.

If we take a closer look at the primary flight display (PFD) you can see the essential data.

## Other Equipment

A fire extinguisher may be provided in the cockpit. The fire extinguisher should be checked for serviceability and that it is security-fitted. Light aircraft fire extinguishers may be toxic in a confined space, and ventilation must be provided as soon as possible after



Figure 1-32 Cockpit of Lightwing aircraft.



Figure 1-33 Cirrus instrument panel showing the primary flight display (PFD) and multi function display (MFD).

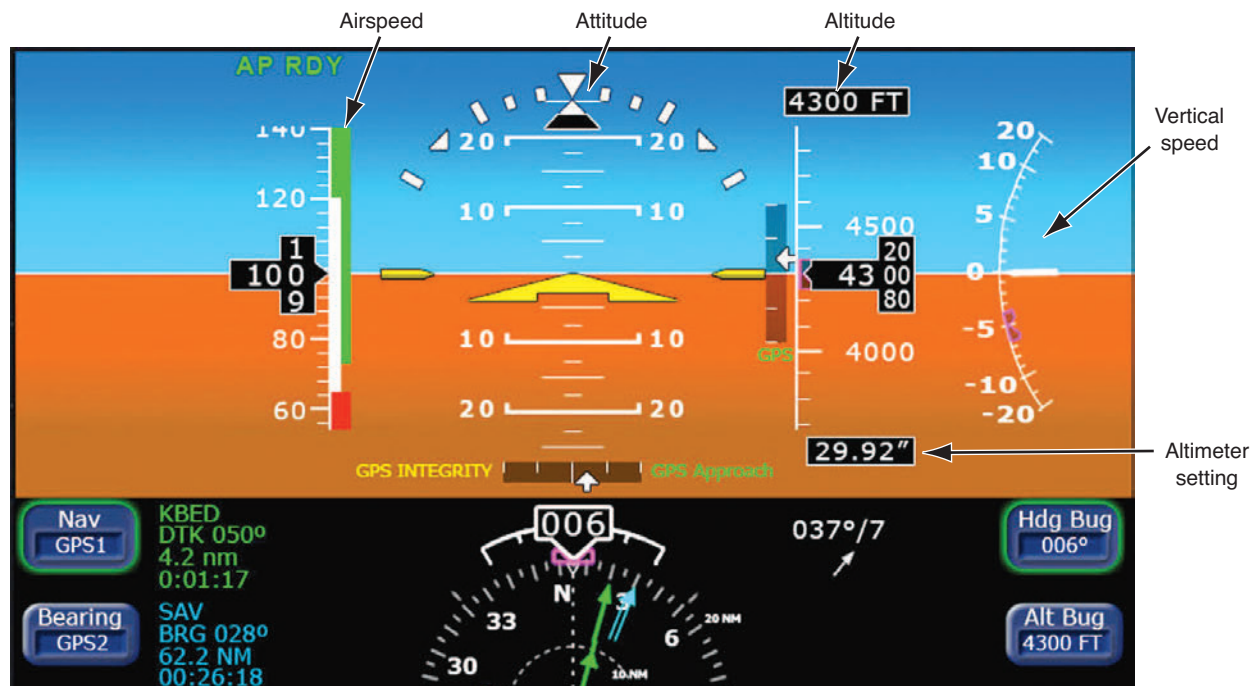


Figure 1-34 Close-up of Avidyne PFD.

use. *Control locks* may be carried. These are fitted internally to lock the control column and externally on the actual flight controls. The purpose of control locks is to prevent control-surface movement and damage from the wind when the airplane is parked. It is vital that you remember to remove control locks prior to flight.

A *pitot cover* may be carried to protect the pitot head from blockage by insects and water while the airplane is parked. The pitot cover must be removed prior to flight if the airspeed indicator is to read correctly. Wheel chocks may be carried to place ahead of and behind the wheels as a precaution against movement when the airplane is parked. There may also be a tie-down kit of ropes, pegs and mallet to secure the airplane to the ground and prevent strong winds lifting the wings or tail. A first-aid kit may be carried.



**Figure 1-35** Pitot cover and tie-down rope.



**Figure 1-36**  
Socata TB 20 Trinidad.

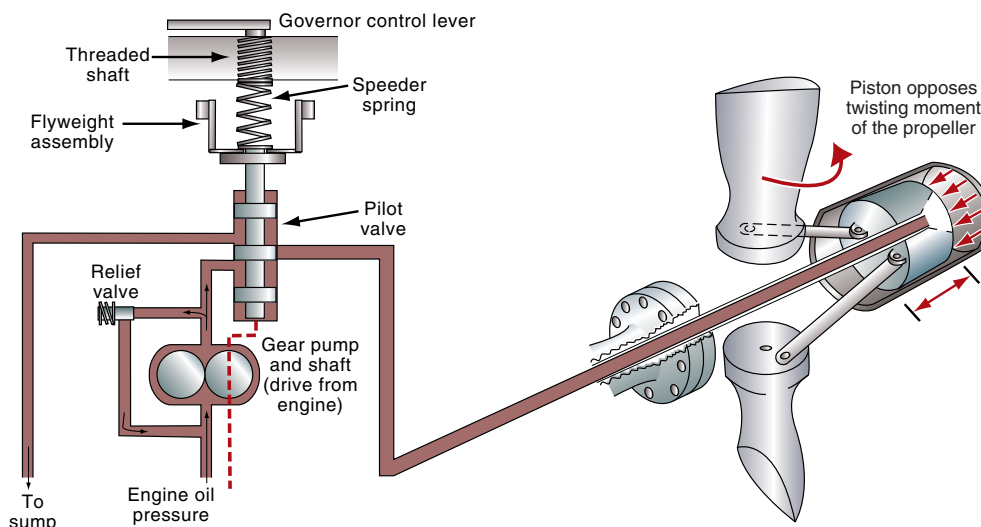
## **Additional Design Features**

While most student pilots will commence their training in a conventional Cessna, Piper or similar airplane, many will start on an airplane with additional features. This section will briefly introduce these various systems and features, but you must learn in detail the features and idiosyncrasies of your aircraft.

### ***Constant-Speed Propeller***

Many pilots learn to fly in an aircraft with a variable-pitch (constant-speed) propeller. In this system the propeller blade angle can be adjusted in flight within a governed range to provide the optimum power versus fuel economy.

This propeller acts in much the same way as the automatic transmission in your car with best acceleration when required (fine pitch) and best economy when cruising (coarse pitch). The mechanism is powered by oil pressure, and if the oil is lost, the propeller goes automatically to fine pitch for maximum thrust at low speed. The mechanism, called the *constant-speed unit* (CSU), is contained within the spinner.



**Figure 1-37** Constant-speed mechanism.

**Why Complicate Things?** The fixed-pitch propeller is a one-piece unit made from wood, kevlar or aluminum. The CSU adds weight and complexity. However, in return, it optimizes the angle of the propeller blades to produce maximum thrust at a particular forward speed and RPM.

**How to Operate the CSU.** The pilot now has two controls, one for engine power and one for propeller blade angle (together they generate thrust):

- the throttle controls manifold pressure (the pressure and amount of fuel-air mixture inducted to the engine); and
- the propeller lever (sometimes called the pitch lever) to set blade angle.

The throttle lever is topped by a smooth black knob and the propeller lever by a blue ribbed disc so they can be felt as well as seen. (The mixture lever is capped by a red indented knob.) With the propeller lever fully forward, the throttle changes the engine speed and manifold pressure just like a fixed-pitch propeller. A governor limits the maximum RPM (provided the throttle is used smoothly and slowly).

When the airplane is climbing or cruising, the pilot can set the optimum RPM by retarding the propeller lever and adjust the manifold pressure by retarding the throttle to achieve optimum engine conditions and fuel economy. Full power is used for takeoff and usually reduced to around 25 inches or 2,500 RPM for climb and maximum continuous power and around 23 inches or 2,300 RPM for cruise, but check the settings for your airplane.

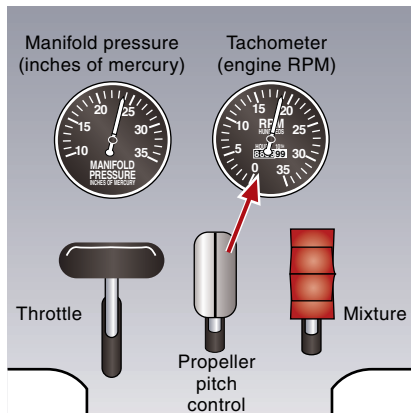


**Figure 1-38**  
Constant speed propeller  
(Beechcraft Bonanza A36).



**Figure 1-39**  
Engine instruments—CSU.

*When increasing power, advance the propeller lever first. When reducing power, reduce the throttle first.*



**Figure 1-40**  
Engine controls—CSU.



**Figure 1-41**  
Two-stroke engine.

For changes in airspeed and small changes in throttle setting, the governor maintains the set RPM. As the aircraft climbs, the manifold pressure will drop (no turbocharger) and so the throttle must be advanced to maintain 25 inches. For all engines, make the throttle and RPM changes smoothly and not too quickly. About two full seconds from idle to full power is normal. For the propeller RPM, a similar time is needed from cruise settings to full power.

The main principles to recall are:

- when operating at low power (start, taxi, run-up etc.) always have the propeller in fine pitch (high RPM, lever fully forward);
- for engine start and shutdown have the propeller lever fully forward;
- when increasing power always advance the propeller lever before the throttle;
- when reducing power always retard the throttle before the propeller RPM;
- when reducing power to idle always set the propeller to high RPM for a power increase when you may need it;
- for takeoff the propeller must be in high RPM and there may be a time limit (5 minutes or so) on maximum RPM;
- in the climb, adjust the throttle to maintain manifold pressure;
- on base leg or final approach, always put the propeller to high RPM in case you need to go around;
- before critical exercises, such as stalling and unusual attitude recoveries, place the propeller in high RPM for instant power for recovery (also full rich mixture is usual); and
- for a practice forced landing, have the propeller in high RPM for the go-around but, for an actual forced landing, the propeller generates less drag in the low RPM (full coarse) position.

### **Fuel Injection**

A fuel-injected engine has the fuel injected directly into the engine cylinders in metered amounts. Most systems are electronically controlled and are more efficient than the traditional carburetor.

However, some are prone to fuel vaporization and overfueling on start, and they may be difficult to start when hot. If your engine is designated, say, IO 360 or IO 540, it is the injected version of the engine. Learn and practice the hot-start procedure with your instructor.

### **Two-Stroke Engine**

Many light or ultralight aircraft have two-stroke engines, which are lightweight, powerful, have a high RPM and may be air-cooled or liquid-cooled. Because the two-stroke engine works best at very high RPM, the propeller may be driven via a gearbox or belts to reduce propeller RPM and noise. (Airplanes usually have a direct drive to the propeller, even with a CSU.)

## Low-Inertia Airplanes

Many pilots learn on ultralight airplanes that have relatively high drag and low momentum. They are often called *low-inertia* airplanes. These require greater and quicker pilot reaction in the event of engine failure and also when operating near the ground. They are more vulnerable to wind, vertical gusts and turbulence. Some have limited control and performance. However, they are great fun to fly if treated with respect.

## Tail Wheel

A tail wheel airplane requires particular consideration. If you are learning to fly in a tail wheel airplane, which is very valuable training, consider the ASA publication in the Focus series entitled *Conventional Gear: Flying A Taildragger* (Newcastle, Washington: ASA, 2001) by David P. Robson.

## High-Lift Devices

Some training airplanes have high-lift devices in addition to conventional trailing-edge flaps. These may include less common drooped ailerons (which act like additional flaps) and leading-edge slats. Slats are small airfoil sections (miniature wings) attached ahead of the leading edge of the main wing. Slats may extend along the complete span of the wings. They considerably increase the maximum lift that can be generated by a wing and so minimize speeds and distances for takeoff and landing. They also allow a much slower but steeper climb and approach path. The slats may be fixed open or may be retractable to reduce drag when cruising.

These devices retain attachment of the airflow over the upper surface of the wing at high angles of attack (the angle the wing presents to the air) and thus increase the lift coefficient (the lifting capacity of the wing). The higher lift allows the aircraft to fly at lower speeds—sometimes very slow speeds. Airplanes with full-span slats need very long landing gear legs because their attitude on landing is so high.

## Features for Safer Stall Characteristics

Most airplanes have devices to reduce the symptoms of the stall and in some cases prevent the full stall altogether. Features include:

- limited elevator deflection;
- slots;
- stall strips;
- vortex generators;
- tapered wing planform;
- wing twist (called *washout*); and
- different airfoil section of the outer part of the wing to encourage the inner area to stall first.

All of these affect the symptoms and behavior of the aircraft at the stall and you should know about any that are fitted to your airplane. Don't forget the other factors such as CG position that also affect stall behavior.



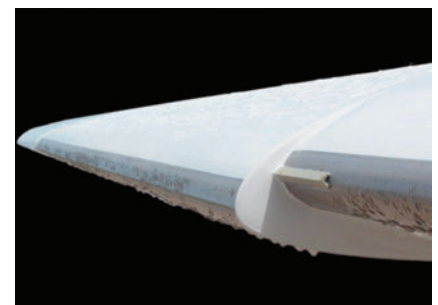
**Figure 1-42**  
Low-inertia tailwheel airplane.



**Figure 1-43**  
Leading-edge slats.



**Figure 1-44**  
Washout.



**Figure 1-45**  
Modified leading edge.

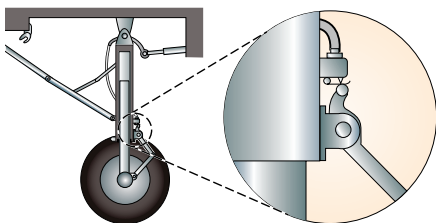




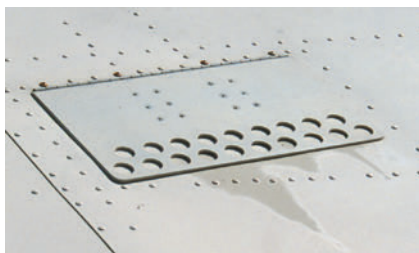
**Figure 1-46**  
Electric flaps.



**Figure 1-47**  
Retractable gear.



**Figure 1-48**  
Squat switch.



**Figure 1-49**  
Speed brake.

### **Electric Flaps**

Your airplane may have mechanically actuated flaps (operated by a handle as with the parking brake) or electrically operated by a switch. These may have two to three predetermined settings or may be infinitely variable over the range of travel. In the event of electrical failure, there may be a need to conduct a no-flap landing, hence it is taught in emergency procedures.

### **Retractable Gear**

The retractable landing gear is usually electrically operated by a direct-drive motor or hydraulically by an electrical hydraulic pump. Both have specific techniques for emergency (manual) extension of the gear in the event of electrical or hydraulic system malfunctions.

The direct-drive version has to be cranked down; the hydraulic version may have a hand pump, emergency pressure accumulators or simply use gravity by unlocking the gear legs and allowing them to fall into the down and locked position. The emergency extension for your airplane must be learned but also practiced in clear conditions—for example, one aircraft requires 50 cranks of a handle that is located behind the front seats, and this requires some skill to operate and fly at the same time.

All airplanes have a maximum airspeed for gear extension and perhaps a higher speed for flight with the gear down and locked. The gear can be damaged above these speeds. Some aircraft with very high gear-down speeds can make use of this added drag for emergency descents as the drag of the gear allows a much steeper and quicker descent.

Retractable gear airplanes have a warning horn that sounds if the throttle is closed with the gear retracted. There is also a micro-switch (squat switch) that prevents retraction on the ground if there is weight on the landing gear.

### **Speed Brakes/Air Brakes**

Some very low drag airplanes have speed brakes to increase drag for slowing to approach speeds and to contain speed during cruise descents.

### **Aileron/Rudder Interconnect**

You will learn about a negative feature, called *adverse aileron yaw*, where the drag of the aileron causes yaw in the opposite direction to the commanded roll. Thus it is adverse because it resists the roll.

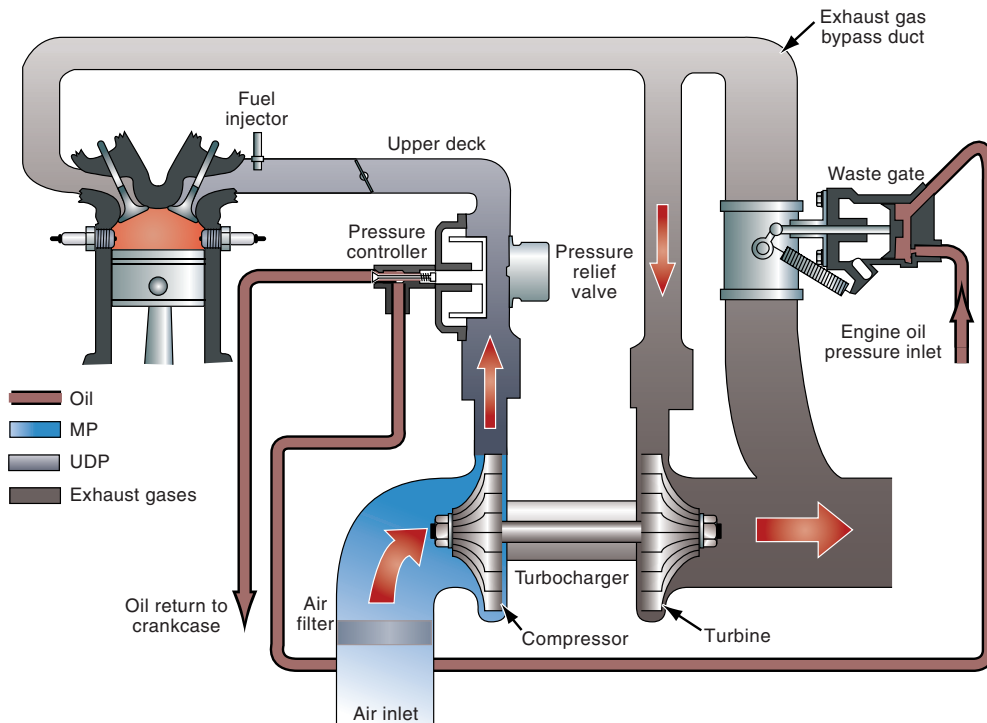
One method to counter this effect is to have the rudder automatically deflect in the same direction as the applied aileron, thus yawing the airplane in the same direction as the roll. This is a mechanical interconnect and as well as the positive counter to adverse yaw has some limitations.

When taxiing, the yoke rotates as the rudder is applied as there is a tendency to try to steer the airplane with the yoke, which is less effective than the rudder. So, in a crosswind landing, where the pilot needs to apply aileron and rudder in opposite direction, there is some resistance due to the interconnect. Discuss these features with your flight instructor.

## Supercharger/Turbocharger

It is unlikely you will have a boosted engine in your training airplane. If you do there are strict conditions on power increases and reductions to allow the temperatures to stabilize before descent, glides and engine shutdown. Some turbos have manual controls; other are completely automatic and produce power on demand.

The primary purpose of the turbocharger in an airplane is to compensate for the reduction in power as the airplane climbs. The turbocharger maintains sea-level full power until a certain altitude, called *full throttle height*.



**Figure 1-50** Turbocharger.

## Tip Tanks

Some airplanes have additional fuel carried in tanks mounted on the wing tips. These tip tanks also provide structural and aerodynamic advantages. Check how to fill these tanks and how to access all the aircraft's fuel in the correct sequence and the tank selections needed.



**Figure 1-51**  
Tip tank.

*The use of supplemental oxygen is recommended above cabin altitudes of 10,000 feet MSL.*

## Oxygen

An airplane that can climb and cruise above 10,000 feet (probably turbocharged) will also require crew oxygen or cabin pressurization. In the latter case emergency oxygen and quick-donning masks are also essential elements. You should not only learn to operate the system but practice using it. Be careful to use only *aviator's grade* oxygen in certified delivery systems.

While the use of supplemental oxygen is *recommended* above cabin altitudes of 10,000 feet MSL, it is *required* by the Federal Aviation Regulations for:

- all time in excess of 30 minutes above 12,500 feet MSL cabin altitude; and
- all time above 14,000 feet MSL cabin altitude.

The term cabin altitude is used to describe the air in the cockpit that a pilot is breathing. A pressurized airplane flying at 31,000 feet may have the cabin pressurized to 8,000 feet, which means the pilots have the same amount of oxygen to breathe as in an unpressurized airplane at 8,000 feet MSL. In this case, there is no need to use the oxygen masks. If, however, there was a sudden depressurization and the cabin air escaped, the pilots would require oxygen immediately.

## Pressurization and Air Conditioning

A training airplane has insufficient excess power to be able to power pressurization turbines and air-conditioner compressors. It is the higher-performance turbocharged airplane that carries these systems and their use will be part of your type rating. You need to learn about the particular system in your airplane. Also check the maximum cabin pressure differential your aircraft can accept as this will impose maximum altitude limits.

## Cirrus Airframe Parachute System

Some designs even feature a unique safety measure—a parachute system that will lower the complete aircraft and its passengers safely to earth. One is called the *Cirrus Airframe Parachute System* (CAPS). This feature offers a safe escape in the event of engine failure at night or over harsh terrain, if control is lost in marginal weather, or safe recovery by a passenger in the event of pilot incapacitation.



**Figure 1-52** Cirrus CAPS system.

## Review 1

### The Training Airplane

1. Locate the following on the diagram below:
  - fuselage;
  - right wing;
  - left wing;
  - empennage;
  - nose wheel;
  - oil cooler;
  - wing trailing edge;
  - vertical stabilizer;
  - elevator;
  - propeller;
  - rudder;
  - left and right wing tips;
  - wing root;
  - flaps;
  - spinner;
  - wing leading edge;
  - radio antenna;
  - (right) main landing gear;
  - cockpit canopy;
  - rotating beacon (red);
  - red position light;
  - right aileron;
  - elevator trim tab
  - green position light;
  - engine cowling;
  - rear-facing position light (white);
  - landing light(s);
  - left aileron; and
  - horizontal stabilizer.

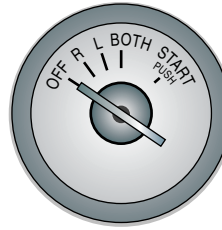


2. Will easing the control column rearward in normal flight raise or lower the nose of the airplane?
3. Rotating the control column to the right will cause the airplane to roll in which direction?
4. How is the rudder operated?
5. Will moving the throttle forward increase or decrease engine power?
6. On the ground, wheel brakes can be operated by pressing the top of which pedals?
7. Where are the fuel tanks located?
8. What fluid is used to lubricate and cool the engine?
9. Identify the following on the diagram below:
  - the flight instruments;
  - the engine gauges and controls;
  - the radio panel;
  - the magnetic compass.



10. Which control adjusts the fuel-air mixture?
11. Which components generate the spark that ignites the fuel-air mixture? In what way do dual ignition systems affect the efficiency of the combustion in each cylinder? Do dual ignition systems provide more safety in the case of failure to one system?
12. What is the source of the electrical power needed to start the engine?
13. Radios and other electrical services can be powered by the battery when the engine is not running. When the engine is running, how are the radios and other services powered and the battery recharged?

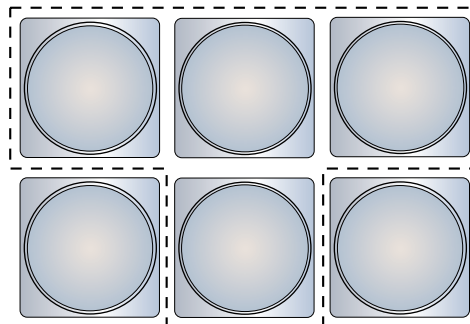
14. Which switch is pictured below?



15. Identify the item of equipment pictured below. What does the SQ label stand for? What is removed when this control is activated?



16. Where on an instrument panel are the following instruments located: attitude indicator, heading indicator, airspeed indicator, turn coordinator, altimeter and vertical speed indicator? Where is the balance ball located?



*Answers are given on page 563.*

# The Pilot's Manual

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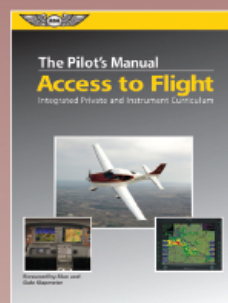
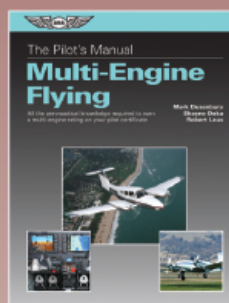
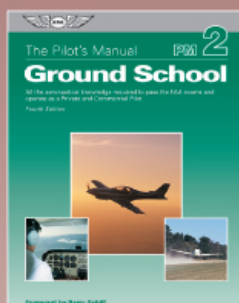
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