THE COMPLETE PRIVATE PILOT

FOURTEENTH EDITION

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The Complete Private Pilot
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By Bob Gardner

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FOREWORD

A new aviation book—one that plows new ground, one that develops material never before considered—is pretty hard to come by. And until there are some radical changes in the types of aircraft we fly and the techniques necessary to fly them, the situation is quite likely to stay that way.

But there are always better, if not "new," ways to communicate aviation information . . . that's what Bob Gardner has accomplished with *The Complete Private Pilot*.

A writer embarking on the task of creating a fundamental aviation text is faced with a formidable challenge; if prospective pilots are to reap the benefits of his work, the writing must be at once very readable and very comprehensive.

The Complete Private Pilot accomplishes both of those in spades, as Bob Gardner reaches into his own aeronautical experience and brings to the reader a clear exposition of the knowledge required by the budding private pilot.

It's not all here—you'll continue learning (we hope!) long after your initial study of regulations, weather, navigation, and so on—but this book is a great way to get started.

Your author has met the challenge well. *The Complete Private Pilot* is indeed readable, comprehensive, and perhaps more important than those, it's a book which will lead you to a greater understanding of flying's fundamentals.

I've always contended that a smart pilot is a safe pilot . . . you are to be commended for your choice of *The Complete Private Pilot* as a bedrock book in your aviation library.

Richard Taylor

ABOUT THE AUTHOR

Robert Gardner, a long-admired member of the aviation community, began his flying career in Alaska in 1960 while in the U.S. Coast Guard. By 1966, Bob had accomplished his private land and sea, commercial, instrument, instructor, CFII, and MEL. Over the next 16 years he was an instructor, charter pilot, designated examiner, freight dog, and the Director of ASA Ground Schools.

Bob held an Airline Transport Pilot Certificate with single- and multi-engine land ratings; a CFI certificate with instrument and multi-engine ratings; and a Ground Instructor's Certificate with advanced and instrument ratings. A well-known author, journalist, and airshow lecturer, Bob was a Gold Seal Flight Instructor and was named a Flight Instructor of the Year in Washington State. ASA is proud to continue Bob's work by updating his books for future generations of pilots.

Photo by Jim Fagiolo.

Books by Bob Gardner

The Complete Private Pilot

The Complete Advanced Pilot

The Complete Multi-Engine Pilot

The Complete Remote Pilot (with David Ison)

Say Again, Please—
A Pilot's Guide to Radio Communications

GETTING STARTED

So, you want to be a pilot! You've come to the right place. If you haven't already done so, go to beapilot.com or learntofly.com for background and then visit your local airport for an introductory ride. Since the first edition of this book was published in 1985, computer use is widespread. Students and certificated pilots who do not own computers have access through schools, libraries, and community centers. I will use web addresses throughout this book.

Note: When I suggest using a search box on a web page, I will put the suggested search term in quotation marks for clarity; do not use quotation marks when entering the search term.

You will want to get an up-to-date copy of Part 61 of the Federal Aviation Regulations (FARs), which fully details the regulatory requirements for obtaining a pilot certificate. Or go to faa.gov and click on Pilot Regulations on the Pilots & Airmen dropdown. This website will save you a lot of money. The following is a summary of the adventure on which you are embarking:

First, will you choose a Part 61 or Part 141 flight school? Are there flight schools of which the FAA does not approve? Are they safe? Understandable confusion. Flight schools that operate under Part 141 of the FARs are strictly regulated by the Federal Aviation Administration (FAA or Feds), their flight and ground school courses must be FAA-approved, among many, many other requirements. Students who learn better in a structured climate will choose a Part 141 school. Instructors at a Part 61 school should operate from a syllabus, just as in a Part 141 school, but they are not required to do so. Ground school is not required at a Part 61 school. If your life and work schedule do not fit into a relatively strict training regime, Part 61 is for you. Worried about safety? The airplanes and instructors at both types of school must meet the same standards.

Then, you must answer the pilot, recreational pilot, or private pilot question. If you just want to experience the joy of flight, boring holes in the sky and going to pancake breakfasts at small airports, working toward the recreational pilot certificate will require less flight time (and money), but your privileges will be somewhat restricted. Some of the restrictions can be removed by an instructor's endorsement in your logbook, others cannot. Still, getting a sport or recreational pilot certificate is a good first step toward the unrestricted private pilot certificate. Rest assured, your flight instructor wants you to know as much as possible and, if your ultimate goal is the private pilot certificate, will strongly urge you to start working on it right away.

Student Pilot Certificate

As a student you will be required to apply for and obtain a permanent student pilot certificate prior to any solo flight (the temporary certificate that you will download does not permit solo flight). Before you begin the process you must first determine if you meet the eligibility requirements: you must be at least 16 years of age (14 for the operation of a glider or balloon), and be able to read, speak, write, and understand the English language. The process of applying will require you to fill out and submit an application in person to any of the following: a Flight Standards office (faa.gov/about/office_org/field_offices), a designated pilot examiner (DPE), a certified flight instructor (CFI), or an airman certification representative (ACR) associated with a Part 141 flight school.

Any of these entities will use the ***Integrated Airman Certification and/or Rating Application (IACRA)*** online system to begin your official airman record.

Once submitted, your application will go through a security vetting by the Transportation Security Administration. That will take about a week, after which a printable certificate will be available for download. A plastic certificate will follow within 120 days—don't lose it or it will cost you $2 to replace. Now, with the proper training and endorsements from your flight instructor and your student pilot certificate in hand, you can accomplish all the solo flight required to obtain the pilot's certificate of your choosing—recreational, sport, or private.

Getting a student pilot certificate is a two-step process: obtaining the certificate itself, as noted above, and getting an initial physical examination.

Before your instructor turns you loose by endorsing your logbook for solo flight, you must visit an Aviation Medical Examiner (AME) for a flight physical. (Find one at faa.gov/pilots/amelocator.) Medical certificates come in three classes: Third Class, which has the lowest standards and is held by the vast majority of private pilots; Second Class, which is needed in order to fly for hire and has stricter standards; and First Class, which is required for airline pilots and sets the highest standards. As a private pilot, this will be your only contact with an AME; renewal of flight privileges when an initial certification expires can be performed by your personal physician.

Prospective flight students on active duty in the military can use a military physical exam to qualify for a Third Class medical; Second or First class medicals must be performed by a state-licensed physician.

BasicMed

In May 2017, the FAA established a new category of medical certificate, one which is not a certificate at all. It is called BasicMed (colloquially, a driver's license medical), which permits the use of your driver's license as a medical certificate. Of course, any restrictions on your driver's license, such as "Must wear glasses," must be observed when flying. BasicMed is not available to pilots who fly for compensation or hire (those pilots must hold a First or Second Class Medical Certificate), just those who fly for fun and personal travel. Fun flyers can choose a Third Class Medical Certificate, issued by an AME, just as they did before BasicMed. It is a two-tier system for private pilots.

Under BasicMed, at least once every four years you need to visit a state-licensed physician (not necessarily an AME) and give that provider an FAA-generated checklist. After completing the checklist, the provider will certify that they are not aware of any condition that would make you unsafe to fly; keep that checklist with your logbook. No contact with the FAA is required.

Every two years, you will be required to take an online medical education course and keep the certificate of completion with your logbook. The medical checklist and the course completion certificate need not be carried on your person; you must carry your driver's license and pilot certificate on your person and display them to authorities upon request. Free courses are available online at basicmed.mayo.edu and basicmedicalcourse.aopa.org (you do not need to be a member of AOPA to take this course). Refer to FAA Advisory Circular 68-1 for details.

Recreational Pilot Certificate

A minimum of 30 hours of flight time is required (a minimum of 3 solo and 15 with an instructor—the balance divided between dual instruction and solo practice) to get your certificate. During your training you will learn to take off, maneuver, and land under a variety of conditions; how to navigate by pilotage (finger-on-the-map method); and dead-reckoning using map, compass, and watch. You will learn how to communicate with ground stations when communication is optional, but you will be prohibited from entering airspace where communication is required (this restriction can be lifted by your instructor with a logbook endorsement after additional training). You will not receive any training in night flight, and in fact will not be allowed to fly at night, and you will not receive any training in electronic navigation or aircraft control by reference to instruments. As a recreational pilot, cross-country flights will be limited to less than 50 nautical miles from the departure airport, another restriction that can be removed after you have received additional training to private pilot standards. You and your instructor will take at least one two-hour cross-country flight; no solo cross-country flights are required. Finally, your instructor will devote three hours of flight instruction to prepare you for the practical test with a DPE.

With your recreational pilot certificate in your pocket you will be able to take one passenger at a time for a flight during daylight hours in an airplane with no more than four seats, powered by an engine of 180 horsepower or less with fixed landing gear. As stated above, without additional training you will not be able to fly more than 50 miles from the departure airport or fly into airspace where radio communication is required. But you will be carrying that passenger while your private-pilot-in-training counterpart is still accumulating cross-country hours, unable to carry passengers at all.

Private Pilot Certificate

A minimum of 40 hours of flight time (10 solo and a minimum of 20 with an instructor) is required; the national average is closer to 70 hours because of the additional training required to assimilate all of the complexities that have developed since the 40-hour figure was set decades ago. You will learn to take off, maneuver, and land just as the recreational pilot does; "stick and rudder" skills are not dependent on the type of certificate you hold. You will learn electronic navigation in addition to pilotage, you will learn to communicate with air traffic controllers both en route and at tower-controlled airports, and you will learn how a pilot sees the difference between night and day. Your instructor will also give you three hours of instruction on how to control the airplane solely by reference to the flight instruments (without reference to the outside world) in case you inadvertently fly into poor visibility conditions. *Note:* This training is to be used to escape from those conditions — it does not make you an instrument pilot.

You will log at least three hours of training to fly cross-country (which for purposes of certification is any flight with a landing at an airport more than 50 nautical miles from the departure airport), including one night flight of at least 100 nautical miles in preparation for your solo cross-country flight time. (Pilots learning to fly in Alaska, where the sun doesn't set for months at a time, have special regulatory provisions for night flight).

After your instructor endorses your logbook for solo cross-country, you will log at least five hours of cross-country flying including one trip of 150 nautical miles. Finally, your instructor will devote three hours of training in preparation for the practical test.

With your private pilot, airplane, single-engine land (or sea) certificate in your pocket, you will be able to carry passengers day and night in good weather in a single-engine airplane. The certificate itself is good forever — but you must have a current medical certificate and take a proficiency check from a flight instructor every other year (if you achieve a new rating or certificate, this requirement is waived).

Both the recreational pilot and private pilot certificates require a Third Class Medical Certificate (see Pages 68 and 69) issued by an FAA-designated medical examiner before you can fly solo . . . if you have any medical condition that might affect your flying, get the medical examination before proceeding with your training. Waivers are available for just about any physical problems; you will meet wheelchair pilots, deaf pilots, and pilots with only one eye in the pilot population.

For each certificate, you will be required to pass a knowledge examination administered by an authorized testing center; pilots training under Part 61 are not required to attend a formal ground school, but doing so really helps you to get ready for the exam. Go to faa.gov and click on Training and Testing to see a selection of sample test questions. Sorry . . . no answers are provided. But there is a thriving industry eager to help; ASA's Test Prep Series is the best of the lot, but there are DVD courses, online courses . . . using a search engine will be like rubbing the genie's lamp.

The regulations do require that you have logged ground training — this is not the same thing as ground school, and many instructors miss this distinction. Ground training is best accomplished one-on-one with your instructor; Part 61 outlines the subjects that must be covered. Again, the ground training must be logged. Expect to pay your instructor for ground instruction time, by the way—it's only fair that they be compensated for their time and knowledge whether it is in the air or in the classroom. "Free instruction is worth what you pay for it" is a facile phrase that in itself is unfair to instructors who will bite the bullet and let you get away without paying.

When you have completed the minimum flight hour requirements and your instructor feels that you are ready (his or her certificate is on the line, too), you will take a practical test from a DPE. There are no mysteries to the flight test; the examiner must follow the Airman Certification Standards (ACS). Get a copy of the ACS early in your training, and be sure that your instructor does not omit anything.

You can enjoy the privileges of the recreational or private pilot certificates for as long as you can meet the physical exam requirements, or you can keep going for the following certificates and ratings (of course, recreational pilots must advance to private pilot status before adding ratings).

If you choose to fly under BasicMed, there are some restrictions on what you can do:

- You are restricted to aircraft with up to seven seats.
- You can carry up to six passengers.
- You can operate up to but not including 18,000 feet MSL.
- You can operate at speeds up to 250 knots indicated airspeed.
- You can operate only within the United States.
- You cannot operate for compensation or hire.
- You can fly day or night, VFR or IFR (if instrument rated, of course!).

Instrument Rating

Smart Visual Flight Rules (VFR) pilots stay on the ground when the clouds are low and the visibility is poor (or they make the six o'clock news), and they begin to work toward their instrument rating as soon as possible. The training makes you a better pilot, even if you never fly in the clouds, but those who use the rating know the joy of breaking through a low cloud layer into a sunlit sky while their VFR comrades stay in the coffee shop. The rating requires a minimum of 40 hours of actual or simulated instrument time (Part 61; 35 for Part 141), of which 15 hours must be dual instruction from a flight instructor with an instrument rating on his or her instructor certificate. A CFII, in other words. The other 25 hours can be flown with a safety pilot, but that is a discussion for another book such as *The Complete Advanced Pilot*.

Commercial Pilot Certificate

Before you can begin to get paid for flying instead of paying for it, you must have a commercial pilot certificate. You must have logged at least 250 hours of flight time (190 for Part 141), of which 100 hours must be pilot-in-command (PIC) time and 50 must be cross-country as PIC. Unless you already have an instrument rating when you get your commercial certificate, your fly-for-pay activities will be severely curtailed. Again, read my advanced pilot book when the time comes.

To fly for hire you must hold a Second Class Medical Certificate (renewable annually). As was the case with the private pilot certificate, the Part 61 ground training is done one-on-one over a cup of coffee with your instructor. Alternatives for ground school to pass the knowledge exam are the same as for the private.

What kind of jobs can a pilot who holds a commercial pilot certificate get? Pipeline patrol, glider towing, traffic reporter, fire bomber, fire patrol, banner towing, pilot for an organization that owns its own aircraft—those are only a few of the options. What can't they do? Carry passengers for hire except under the most restrictive conditions, of which participation in a drug-testing program is only one. Sightseeing flights must take off and land at the same airport without any other stops; they can't go more than 25 miles from the departure airport—good for scenic rides and that is about all. Becoming a charter pilot involves getting qualified under Parts 119 and 135 of the FARs and working for an air taxi company.

Multi-Engine Rating

If you think that two engines are better than one, there is no minimum flight time or knowledge exam requirement for the multiengine rating. Just demonstrate proficiency in a twin to a DPE via a practical test. People typically spend 10 to 20 hours learning to fly a twin—mostly dealing with emergencies—and preparing for the checkride. The expense of maintaining proficiency will drive your decision on getting this rating.

Flight Instructor Certificate (CFI)

If you enjoy sharing what you have learned, maybe teaching others to fly is for you. There is no minimum flight time requirement, but you must have a commercial pilot certificate with an instrument rating and pass two knowledge exams — one on the Fundamentals of Instruction and one that covers everything a private or commercial pilot should know plus a few extra mind-benders just to see if you have been paying attention.

If your only goal is to log flight hours toward that airline job, please do not become an instructor — your primary goal should be to graduate motivated, proficient students. If getting your CFI means just getting your ticket punched, and you can't wait to move up, you will be unfair to your students. Unmotivated instructors disillusion hundreds of potential pilots every year. There are lots of ways to log hours without taking a student's money under false pretenses.

The other side of the coin is that being a flight instructor is a truly fulfilling career — I know. There are many, many dedicated instructors who could move up to the airlines but are having too much fun giving flight instruction. And have you checked on what a newbie first officer is taking home these days?

Airline Transport Pilot

This is the pinnacle, the top of the heap. Very few of the pilots that you have referred to as "commercial pilots" all of your life have only a commercial pilot certificate in their pockets. The airlines can afford to be choosy, and an ATP certificate is only one of their requirements. If the front seat of an airliner is in your future, get a four-year college degree and log at least 1,200 hours of flight time — flying turbine-powered airplanes preferred. You must also be at least 23 years old.

Note: The path to a front seat on an air carrier has gotten steeper. A new requirement — completion of an Airline Transport Pilot Certification Training Program prior to taking the knowledge test takes an aspiring airline pilot out of Part 61 training and into FAA approved schools. A minimum of 1,500 flight hours is required, but there are ways to lower that number. Far in your future at this point. Suffice it to say that you will need a bachelor's degree at the very least.

Sport Pilot

No, I didn't forget the sport pilot certificate. This certificate allows you to fly light sport aircraft (LSA) just for fun (you cannot fly out of a tower-controlled airport without further training, you may not carry more than one passenger, nor can you fly at night). Your driver's license is your medical certificate. Whether or not the hours you log as a sport pilot count toward private pilot eligibility depends on the instructor. Time logged with a sport pilot flight instructor does not count, while time logged with a full-fledged CFI does. Check the ASA website for updates on this (see asa2fly.com/ppt). Sport pilot training takes two paths when the level flight cruising speed (V_H) of the plane exceeds 87 knots; students flying the faster planes must receive training in control of the airplane by reference to the flight instruments in the event that they encounter visibility of less than three miles. Also, some sport pilot privileges are grandfathered in for those applicants with prior light plane experience. In this book I am going to assume no prior experience. Passing a knowledge test and a practical (flight) test are required for all pilot certificates.

The stick-and-rudder skills you learn in sport pilot training will serve you well if you decide to move up and it's the least expensive and quickest path to a pilot certificate with half the required experience requirements.

A personal note: When I was a student pilot all I knew was what my instructor told me and what I read in FAA texts. I did not know what students across the field were learning, and I certainly did not know what students in other cities and states were learning or what uncertainties they were encountering. There were few opportunities to compare notes. Today, using the internet, learners can do their own research on virtually anything, and they can have discussions with students in other states and even other countries. Many areas of confusion have been uncovered when learners have gone online and asked the world at large for help. Take advantage of this wonderful opportunity.

Other Ratings

There are many other flying possibilities: you can add categories, such as rotorcraft or lighter-than-air, to your pilot certificates. You will read about "type ratings," as in "category, class, and type if required," and think that a Cessna 150 is a different type than a Bonanza, but that is not true *at the present time*. Everything you have read thus far relates to regulations and practices in 2015, and right now you need a type rating only if you want to act as PIC of an airplane that is jet-powered or weighs more than 12,500 pounds. For those aircraft, you will take a "type rating ride" with an examiner, and will have that rating added to your pilot certificate. In some countries, however, the civil aeronautics authorities *do* consider a Cessna 150 to be a different type than a Bonanza, a Seneca to be a different type than a Baron, and so forth, because to those authorities the differences between the aircraft are significant.

The regulations for pilot certification that I have cited are based on what we now understand is outdated technology. They prepare a learner to pass a test, instead of introducing realistic scenarios, and emphasize maneuvers instead of decision making and risk management. Also, there is insufficient emphasis on new flight technologies such as GPS and multifunction devices. In the old days, a pilot or instructor could move from one type (current definition) of aircraft to another and expect the controls and electronics to be functionally the same. No more. An instructor who speaks Garmin 1000 fluently will have no idea how to use the Avidyne PFD without advance study and practice. Manufacturers of these advanced airframes and avionics have taken the lead by developing their own training systems; there are on-line simulators for many of these devices.

Advances in avionics and aircraft manufacturing have outstripped the FAA's ability to keep pace, and the FAA readily admits that this is the case. That is why FITS is important now, and why it will become more important in the future.

FAA and Industry Training Standards (FITS)

As I write this, pilots are learning to fly *ab initio* (Latin for "right from the beginning") in sleek, composite-construction airplanes that have autopilots, single-knob, computerized engine controls, and glass cockpits consisting of digital displays of flight instrumentation, weather, terrain, moving-map navigation information, engine operating parameters, and on and on. These Technically Advanced Aircraft (TAA) are so different from those we have instructed in for the past several decades that the old regulations no longer meet our goal of preparing pilots to fly safely in a complex airspace structure at speeds only dreamed of in the past.

You might be one of those pilots. Or, after being trained in a 1940s technology aircraft, you might buy or join a club that uses TAA. One way or the other, you are going to be affected, so let's see what FITS, a new FAA/Industry plan will do.

The program will integrate the following:

- Aeronautical Decision Making (Lesson 5)
- Situational Awareness
- Single Pilot Resource Management (Lesson 12)
- Risk Management
- Task Management
- Controlled Flight Into Terrain Awareness (CFIT)

See faasafety.gov, search "FITS" to see how FITS will work.

Note that FITS applies to technically advanced aircraft only. If you are training in a "legacy" airplane, nothing changes.

After I have covered the individual nuts and bolts of what you need to know under today's standards, I will put it all together at the end in Lesson 12.

What Will This Book Do For You?

Your mind is like a computer's memory bank. When you have a new experience or sensation, your mind compares it to earlier experiences and sensations and either modifies what was stored or adds the new data to the memory bank. Each flight will add new experiences and soon your mind will say "That's not new—I've done that before!" . . . and flying high above the mountains or gliding quietly onto a grass strip will quickly become a part of you. This book is intended to build your aviation knowledge the same way.

Like all instructors, I talk a lot, and I might repeat myself on occasion. I learned long ago that presenting the same material in different ways can be the key to understanding. If you think I am going over the same ground more than once, it is to meet an instructional goal.

There is a new secondary reference that will help a lot. Go to asa2fly.com/ppt to access the Reader Resources where I have uploaded links, articles, pictures, and other information that have come to my attention between editions or that help explain or illustrate concepts in the book. I think you will like it.

Several of the lessons refer to aeronautical charts, and an excerpt from the Seattle sectional chart is provided in the full-color Appendix D, Figure D-8—you'll be using this chart excerpt for many interactive exercises throughout the text. Aviation has a language all its own, and you want to speak it fluently, so we have provided a glossary. It includes the Pilot/Controller Glossary, compiled from the *Aeronautical Information Manual,* for understanding the terms used in the Air Traffic Control System. Always look there first when you hear something new.

Each lesson contains review questions so that you can test your understanding of the material contained in that lesson—but you can go to faa.gov to read many more questions you might be asked on your knowledge exam or, as I mentioned earlier, you could purchase a separate book such as ASA's *Private Pilot Test Prep* that is written specifically to prepare you for this test.

Instructing Your Instructor

The student-instructor relationship is key to your success. You must be comfortable with your instructor, and confident that they will teach you everything you need to know in order to pass your knowledge test and checkride. I hate to shatter your dreams, but that last part is impossible. No instructor knows everything. You must take an active role in your training by doing your own research using online industry and government publications available at faa.gov.

Lesson 4 contains a laundry list of publications that you will need as your training progresses. Your instructor should teach from a syllabus and provide you with a copy so you always know what will come next and prepare for it; you also need a copy of the Airman Certification Standards for the Private Pilot Certificate because it lays out in detail exactly what your designated examiner will ask you to do and the standards of completion. The examiner is required to follow the test standards precisely; no additions or deletions are allowed. Note that each maneuver in the ACS should follow the FAA *Airplane Flying Handbook*.

As you read Part 61 of the Federal Aviation Regulations, specifically 61.81 through 61.85, you will note that the responsibility for ensuring that all required areas are covered is yours. Those sections are addressed to student pilots, not to instructors. (If your instructor is using a syllabus, as is recommended, this should be a slam dunk . . . but it is still your job to look at the requirements and ask your instructor "Why haven't we done this yet?" if a subject has not been covered.) Read the regulations—all of Part 61—and know what is required of you, both before and after your checkride. When the examiner asks you a question or tells you to perform a maneuvers, you don't want to say "My instructor never told me/taught me that . . ."

Note also that Part 61 of the regulations requires that you receive and log ground instruction. This is not "ground school," which is intended to help you pass the knowledge exam (and isn't logged), but face-to-face interaction between you and your instructor on maneuvers or procedures. If you are not receiving (and paying for) ground instruction, your instructor is not performing professionally.

During your training, you might fly with another instructor; some schools require it. I'm very much in favor of having your progress monitored by someone else. When flying with another instructor, however, you may run into the procedure versus technique problem: Procedures are contained in manufacturer's manuals and handbooks, while techniques are pretty much a matter of individual taste. For example, the pilot's operating handbook might have "Carburetor heat – On" in the pre-landing checklist; this is a *procedure*. Different instructors might disagree on just where in the pattern the carburetor heat should be applied . . . this is *technique*.

If an instructor wants you to divert from a recommended procedure, ask him or her where the changed procedure is documented; the manufacturer is always right. If an instructor wants you to add flaps at a different point in the pattern than another instructor taught you to do, or tells you to reduce power at a different place or a different amount than you were originally taught to do, that is technique . . . follow his or her instruction, note the result, and file it away for future reference. No instructor knows it all, and the more insights you develop, the better. Don't get into the " . . . but Bob told me to . . . " discussion.

If the airplane you train in is equipped with state-of-the-art navigation equipment, you may need training in its use beyond what your instructor can give you. Manufacturers provide online training materials and in some cases put on training seminars. The FAA also supplies a lot of information on the website faasafety.gov. I encourage you to take advantage of these sources.

Instructors must renew their certificates every 24 months. However, there are several methods of renewal, only one of which involves attendance at a refresher course where new regulations and procedures are discussed. Accordingly, many busy instructors who have graduated at least five students in the past 24 months with 80 percent passing on the first attempt, never attend a refresher class.

Instructors who belong to the National Association of Flight Instructors (NAFI), the Society of Aviation and Flight Educators (SAFE), and similar organizations are kept up-to-date on regulatory and procedural changes. Ask your instructor what method they use to stay on top of things.

You are your instructor's customer (or a customer of the flight school), and they are there to provide a service. If you are not satisfied with the way your instructor teaches, go to the chief flight instructor and ask to try another instructor or instructors. Our common goal is to make you a safe pilot.

One more thing: I often read posts in aviation forums that include the phrase "I was taught . . . " or "My instructor told me. . . . " This indicates to me that the scope of the writer's aviation knowledge mirrors that of their instructor. Don't be that pilot! Instead of "I was taught . . . " say, "I have learned . . . " because the universe of aviation knowledge is *immense* and you can never stop learning. Question what you are told. "*Can you show me where it says that in writing?*" saves you from passing on "old wives' tales."

Good luck!

LESSON 1

Basic Aerodynamics

Training Airplane Features

In this book we are going to assume that your training airplane is all-metal (although airplanes that are partially or completely made of composites are increasingly available), has one engine, a fixed-pitch propeller, and a non-retractable landing gear. A stroll along the ramp of your hometown airport will show you there are many variables, however, and you may want to compare features on other airplanes with the one you fly. Here are some things to look for:

Fuselage Construction

The fuselage (or cabin, in most modern airplanes) is the basic structure to which the wings and empennage (Figure 1-1) are attached. Most of the small airplanes you will see during your flight training are unpressurized (Lesson 2)—you can tell by the square windows and non-airtight doors. Airplanes that are pressurized for passenger comfort at high altitudes have round or oval windows and tight-fitting doors.

The fuselage of almost every airplane you see will be of aluminum construction with internal strengthening members. A close look will show that on some models more attention has been paid to reducing drag caused by rivet heads and other protrusions. Looking at non-metal airplanes will take you to both the past and the future. Fabric-covered airplanes with tubing structures (wood-framed airplanes are really classics!) are lovingly restored and flown by proud owners. No less proud are the pilots of modern composite aircraft, formed of plastic reinforced with glass fibers, carbon fibers, or similar materials which offer great strength and minimal drag. Most light sport aircraft (LSA) and technically advanced aircraft (TAA) are made of composites. Technically advanced aircraft, by definition, have an IFR-approved Global Positioning System navigator with a moving-map display, and an integrated autopilot. Most go beyond this to replace the traditional "six-pack" of analog instruments (see Lesson 3) with digital instruments, leading to the term "glass cockpit."

It is altogether possible that you might take your initial training in a composite airplane, but right now they are outnumbered by aluminum planes and that is what I will emphasize.

Wings

The "main spar" within the wing is the structural member that supports the load. Airfoil-shaped ribs are attached to the main spar and the metal or fabric skin is attached to the ribs to give the wing its shape, and it is that airfoil shape that makes the wing capable of developing enough lift to support the airplane in flight. The wings of composite aircraft are formed with molds and have no internal ribs. They do have a main spar, of course.

Almost all modern airplanes have a single wing, mounted either above or below the fuselage. Most, but not all, high wing airplanes have supporting struts. Low wing and strutless high wing airplanes are cantilevered: the internal structure is designed to support the load so there are no struts.

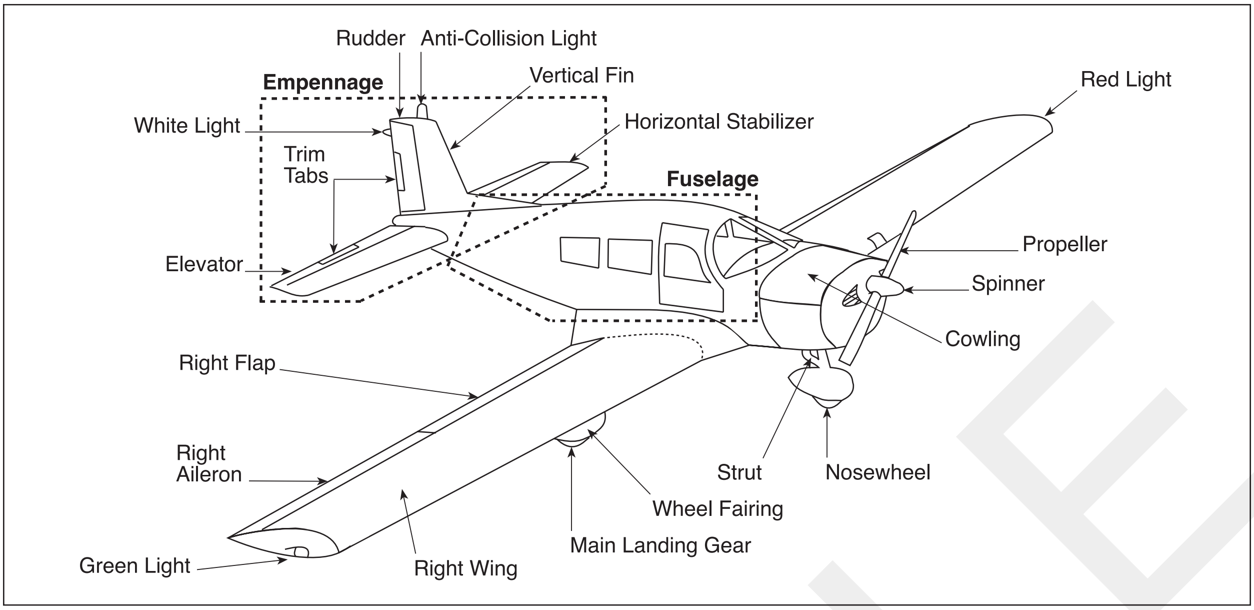

Figure 1-1. The fuselage

You may see vortex generators (little metal tabs adhering to the upper surface of the wing). They act to keep the airflow over the wing surface attached at high angles of attack and reduce stall speed (see Pages 6 and 8).

Wing fuel tanks are either "wet wings" with the wing structure serving as the fuel container, or there are rubber bladders contained within the wing.

Empennage

The horizontal stabilizer, the rudder, the vertical fin, the elevator, or any combination thereof is called the airplane's empennage or "tail feathers." These surfaces allow the pilot to change the airplane's attitude in relation to the horizon by moving the nose up and down (using the yoke or control stick) or left and right (using the rudder pedals) as seen by the pilot. There may be a fixed horizontal stabilizer with a movable elevator, or the whole horizontal assembly may be movable (called a stabilator).

Flight Controls

Fore-and-aft movement of the control wheel or stick is transmitted by pushrods or cables and pulleys to these control surfaces, and left-right movement is controlled by the rudder, which is mounted at the rear of the vertical fin (Figure 1-2). The pilot depresses the rudder pedal in the desired direction of nose movement and a cable system moves the control surface. You will see V-tails, T-tails, and straight tails, and maybe a home-built airplane with no horizontal surfaces mounted on the tail.

Ailerons

You won't find many airplanes that do not have ailerons, which are movable control surfaces at the outer trailing edge of the wings. Ailerons are used to bank the airplane. A control wheel or stick at the pilot station is moved in the direction of bank desired (left or right). The ailerons are deflected through a system of cables, pulleys, and bellcranks or pushrods. When no control force is exerted, the ailerons are held flush with the wing surface by the airstream.

Flaps

The hinged portions of the trailing edges of the wings near the fuselage are called flaps, and are normally used to steepen the glide angle without increasing airspeed. As you walk along the ramp you will see many different types of flaps, some that simply hinge down and others that extend down and backward. Older airplanes may not have any flaps at all.

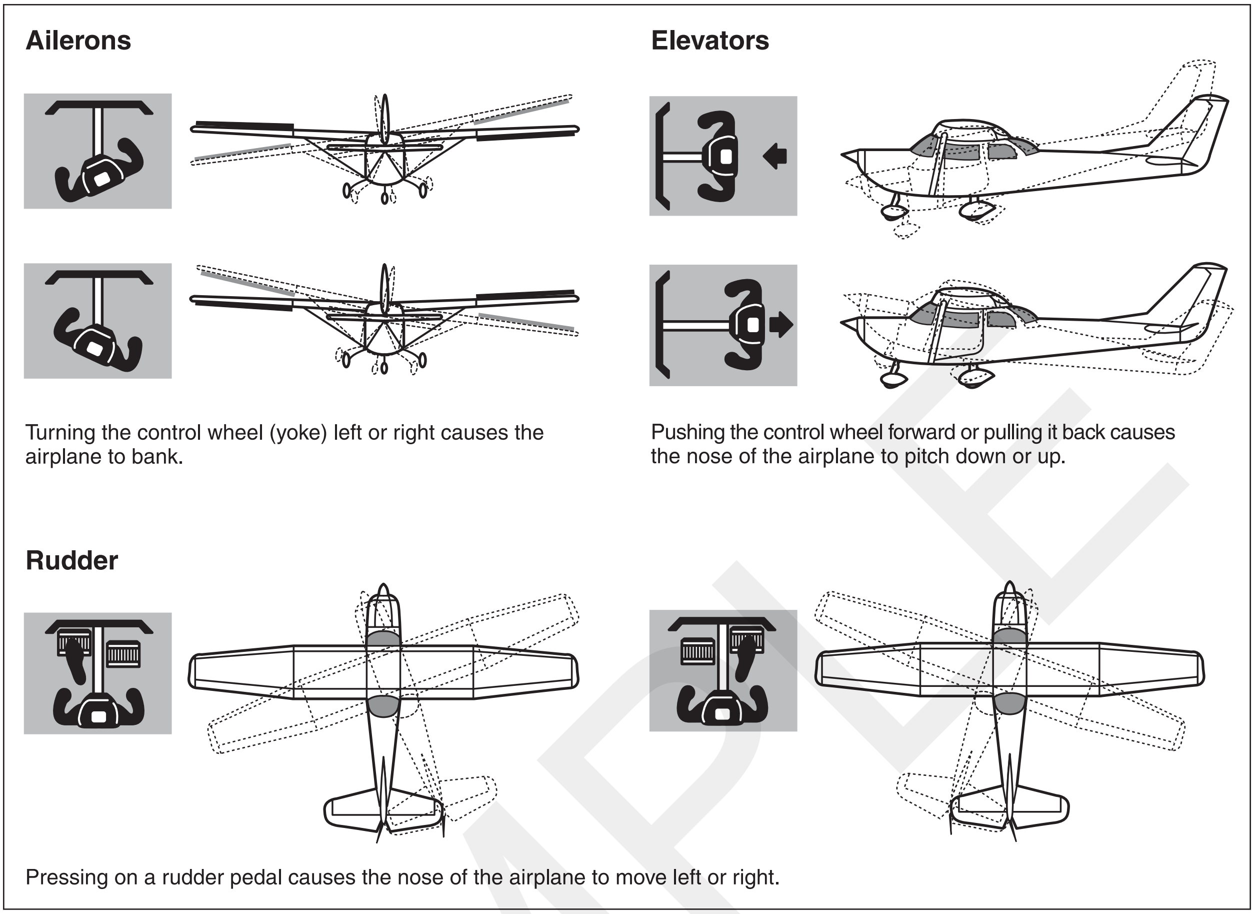

Figure 1-2. Flight controls

Landing Gear

The two main landing wheels and their supporting structure are designed to withstand landing loads and support the airplane on the ground. A third, smaller wheel mounted either forward (tricycle) or aft (conventional) is for ground steering control only. Nosewheels are usually close to or a part of the engine mount and are definitely not designed to absorb landing loads. (Your instructor will devote a lot of training time to making sure that you do not land on the nose wheel!)

The shiny cylinders on nose wheels and some main landing gear are called struts (the Katana's nosewheel uses replaceable rubber "doughnuts"). They absorb the bumpiness of runways and taxiways. The shiny kind are filled with air and oil, just like your car's shock absorbers. When a strut is "flat" there is no cushioning effect and vibrations are transmitted to the entire airframe. You will see some airplanes which use a spring steel assembly on the main landing gear instead of a strut.

Wheel pants, or fairings, may or may not be present. They reduce aerodynamic drag and add a knot or two to airspeed. Your airplane may have either non-retractable (straight leg) or retractable landing gear. Landing gear that retract into the wing or fuselage add considerably to cruise speed.

Almost all airplanes use disc brakes on the main landing gear, and you can see the discs if there are no wheel pants. Checking brake condition is considerably easier to do on airplanes than it is on cars. The nose wheel is usually not steerable with the rudder pedals and swivels freely, so steering is accomplished by tapping the brake lightly on the side toward the turn.

Propeller

The propellers you see may be either fixed or variable in pitch, or blade angle. You will probably see some amphibians (airplanes that can land on either land or water) with pusher-type propellers, but most are mounted up front and pull the airplane through the air. The conical spinner is not only decorative but serves to direct air into the cooling air intakes.

Engine

Modern airplanes have four- or six-cylinder flat opposed engines: when you open the cowling you will see that the cylinders are on opposite sides of the engine, and that the flat profile allows maximum aerodynamic streamlining of the cowling. As you walk along the ramp you may see an older airplane with a radial engine, its cylinders arranged in a "star" pattern. Most light sport aircraft use water-cooled Rotax engines.

Lights

The lighting system on a modern airplane consists of position lights on the wing tips (red on the left, green on the right) and a white light on the tail, an anticollision light system which may be either red or white (or both) and one or more landing lights. Many airplanes also have bright flashing strobe lights to increases the chances of being seen during both day and night flights.

Light Sport Aircraft

When your pilot certificate says "PRIVATE PILOT Airplane—Single Engine—Land" you are free to fly any single-engine airplane, subject to the endorsement requirement for tailwheel, high performance, and complex airplanes. When it says SPORT PILOT, however, you are limited to those weighing less than 1,320 pounds with no more than two seats, fixed landing gear, and a cruise speed of no more than 120 knots.

Introduction to the Flight Deck

This is a typical non-glass flight deck instrument panel layout. Airplane manufacturers have their own ideas about where engine instruments should be located, but the locations of the six flight instruments on the left side of the panel are standardized among manufacturers. (see Figure 1-3.)

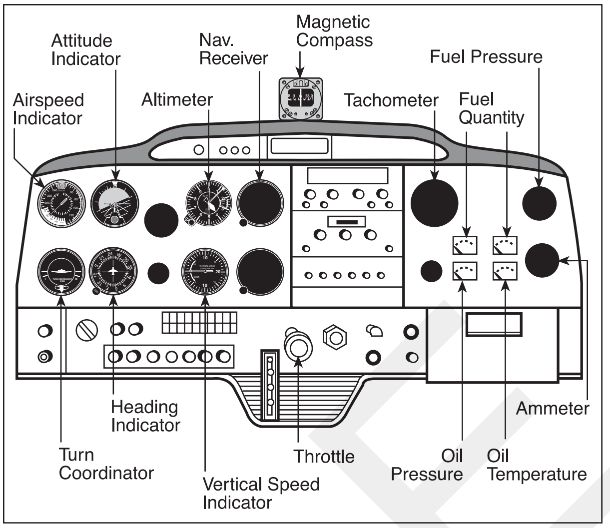

Figure 1-3. Typical "six-pack" of traditional non-digital instruments

If you are training in a Technically Advanced Aircraft ("TAA" in FAA-speak), all of these "steam gauges" will exist on a flat-screen digital display, similar to the G1000 shown in Figure D-1 in the color section (Appendix D).

Aerodynamics

The subject of aerodynamics deals with forces acting on bodies in motion through the air; in fact "aerodyne" means an aircraft deriving lift from its motion through the air. To oversimplify, an airplane flies because the pilot causes it to accelerate down the runway until its wings develop a lifting force greater than its weight, and it lands because the pilot causes the lifting force to be less than its weight. In flight, the pilot controls the magnitude and direction of lift through use of the flight controls.

To make the airplane go where you want it to go and do what you want it to do, you must use the flight controls as tools and, like any artisan, you have to know what your tools are capable of and how they are used to accomplish the four fundamentals of flight . . . straight-and-level, turns, climbs, and descents.

As a pilot you will be working with the forces of lift, drag, thrust, and weight. Of these, lift is the force that allows you to move in three dimensions. While it is true that *anything* can be made to "fly" if enough power is applied, an airplane features **airfoils**—shapes specifically designed to develop lift. The amount of lift generated by an airfoil is a function of the area of the lifting surface, the density of the air, the velocity of the airflow over the lifting surface, and the coefficient of lift. This is how these elements are related:

$$\text{Lift} = \text{Coefficient of Lift} \times \text{Area} \times \text{Velocity}^2 \times \text{Density}/2$$

Coefficient of Lift

Don't be intimidated by the words "coefficient of lift"—they apply to physical relationships that are easy to visualize. Before investigating just what coefficient of lift means, or how the other factors affect lift development, you should understand how an airfoil develops lift. Figure 1-4 shows a fluid (illustrated as ping-pong balls) moving through a tube with a restriction in it. If 1,000 units of fluid enter one end of the tube each second, and 1,000 units leave the tube each second, and there is not enough room at the restriction for 1,000 units of fluid to pass, something clearly has to change at the restriction. That "something" is velocity—fewer units must travel at a higher velocity if 1,000 units per second are going to pass the restriction.

As the fluid moves through the tube, its total energy consists of forward movement (**kinetic energy**) and the static force it exerts against the walls of the tube. At the restriction, the energy of forward movement increases, and since total energy can neither increase nor decrease within the system, the static pressure has to decrease. A scientist named Daniel Bernoulli discovered this effect: when a fluid is accelerated the pressure it exerts is reduced. Bernoulli's Theorem accounts for most of the lift developed by an airfoil.

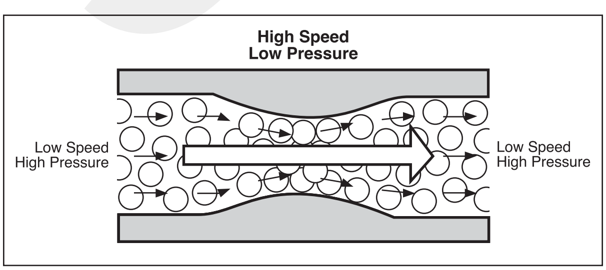

Figure 1-4. Bernoulli tube

You might think of an airfoil as a device designed to accelerate airflow and change its direction.

If you are having difficulty relating tubes and fluids to airplane wings, the airfoil in Figure 1-5 represents the bottom half of Bernoulli's restricted tube, and the length of the arrows indicates the energy imparted to air molecules as they travel over it. They move most rapidly over the curved surface, which is the area of least pressure.

A second contributor to total lift is Newton's Third Law: for every action there is an equal and opposite reaction. As the airfoil moves through the air it pushes the air downward and, in accordance with Newton's Law, the air exerts an equal upward force. Because of differences in wing design and operating conditions, it is impossible to say what percentage of total lift can be attributed to Bernoulli or to Newton at any time. In Figure 1-6, the dashed lines represent lift due to pressure difference and the solid lines indicate lift due to Newton's Law.

Don't get into any arguments about what creates lift—Bernoulli and Newton share the credit, with Newton holding a slight edge. The bottom line is that there must be a net positive pressure difference between the top and bottom of the lifting surface.

Part of the explanation of coefficient of lift has to do with the curvature, or **camber**, of the upper surface of the wing and angle of incidence. A large curve,

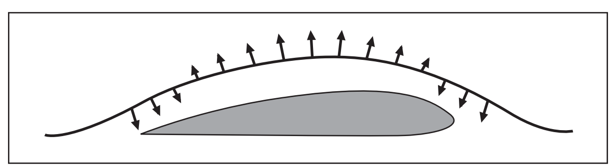

Figure 1-5. Bernoulli airfoil

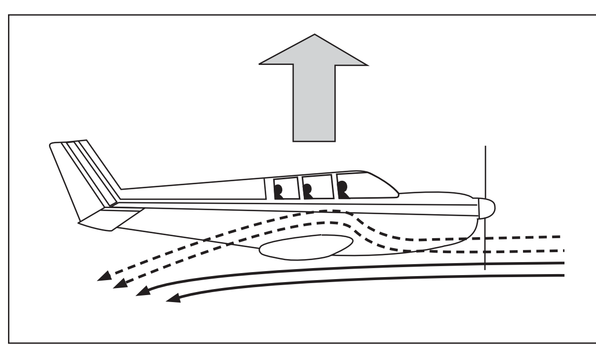

Figure 1-6. Sources of lift

or camber, means greater acceleration of the air over the upper surface. Oncoming free air is drawn upward toward the low pressure area on top of the wing, accelerates over the curvature, and flows off the trailing edge creating **downwash**. Most general aviation airplanes change camber and increase lift by moving the trailing edge up or down with control surfaces called ailerons and flaps. Changing lift development by changing wing camber is largely the province of the designer, and is only partially under the control of the pilot. **Angle of incidence**, *which is defined as the angle at which the wing is fastened to the fuselage*, is set by the designer at 1° to 3° in relation to the longitudinal axis and is beyond the control of the pilot.

Wing design is one element of the coefficient of lift, and the other is **angle of attack**—over which the pilot has direct control. An imaginary line drawn from the leading edge of the wing to the trailing edge is called the chord line, and *the angle between the chord line and the relative wind is called the angle of attack* (Figure 1-7). If relative wind is an unfamiliar term, consider this: you are sitting in a convertible at a stop light with the wind blowing on the left side of your face; the wind that you feel is the true wind. When the light changes, and the car accelerates, the wind strikes you directly in the face—that is the relative wind, caused by motion.

In flight, *the relative wind is parallel and opposite to the flight path*. Figure 1-8 shows this relationship in level flight, climbing, and descending. To the wing of a military jet climbing almost vertically, the relative wind is coming straight down, while to the wing of an aerobatic airplane completing a loop, the relative wind is coming straight up. More importantly, when a pilot attempts to maintain altitude by using angle of attack alone, without adding power, the relative wind strikes the bottom of the wing as shown in Figure 1-9. The angle between where the airplane is pointed and where it is going is the angle of attack, and as it approaches about 17 degrees a stall is imminent; the illustration exaggerates the angle to make a point. This is called mushing flight; back pressure must be released and power added to avoid a hard landing.

Lift developed by pressure difference (Bernoulli lift) depends on a smooth flow of air over the upper surface of the wing. As angle of attack is increased (Figure 1-10), the air being drawn over the top surface of the wing begins to tear away from the wing surface at the trailing edge, causing loss of lift. This

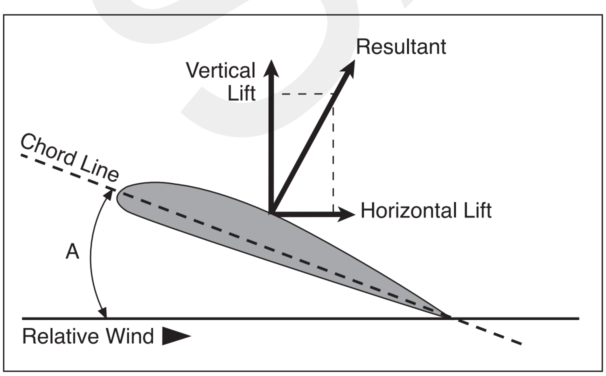

Figure 1-7. Angle of attack

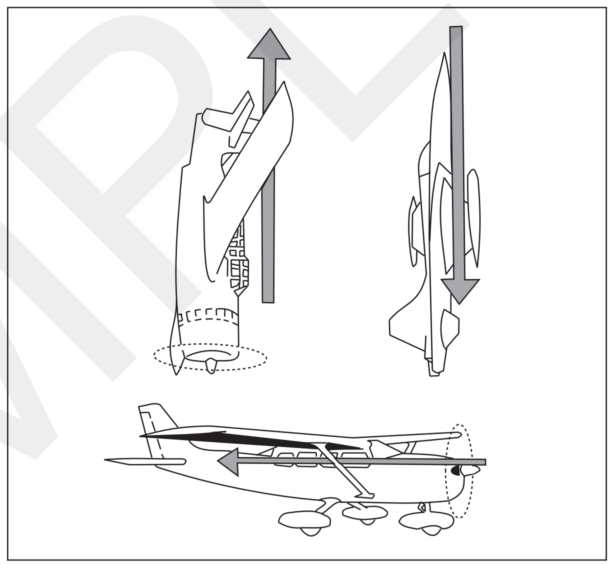
Figure 1-8. Relative wind is opposite to flight path

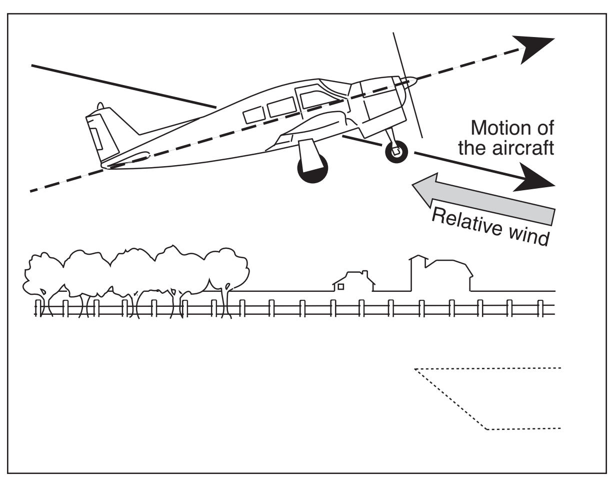

Figure 1-9. Mushing flight

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