PRIVATE PILOT MANUAL

FLIGHT Discovery

JEPPESEN.
Sanderson Training Products

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GUIDED FLIGHT discovery

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Welcome to Guided Flight Discovery

Jeppesen Sanderson has developed the Guided Flight Discovery Pilot Training System to provide the finest pilot training available. Through extensive use of colorful graphics, state-of-the-art computer-based training, and broadcast quality video, Guided Flight Discovery ensures that your training will be enjoyable and exciting. Guided Flight Discovery is totally different than other systems because its entire philosophy of pilot training is a departure from the conventional methods of the past. Rather than just teaching facts, Guided Flight Discovery concentrates on an application-oriented approach to pilot training. The comprehensive and complete system emphasizes the why and how of aeronautical concepts when they are presented. As you progress through your training, you will find that the revolutionary Guided Flight Discovery system leads you through essential aeronautical knowledge and exposes you to a variety of interesting and useful information which will enhance and expand your understanding of the world of aviation.

Although each element of the Guided Flight Discovery Pilot Training System may be used separately, the effectiveness of the materials can be maximized by using all of the individual components in a systems approach. To help you efficiently organize your studies and get the most out of your training, Guided Flight Discovery incorporates cross-references which are used to direct you to related Guided Flight Discovery study materials. The main components of the Private Pilot Program are described below.

Core Study Materials

Private Pilot Manual

The Private Pilot Manual is your primary source for initial study and review. The text contains complete and concise explanations of the fundamental concepts and ideas that every private pilot needs to know. The subjects are organized in a logical manner to build upon previously introduced topics. Subjects are often expanded upon through the use of Discovery Insets which are strategically placed throughout the chapters. Periodically, human factors principles are presented in Human Element Insets to help you understand how your mind and body function while you fly. Throughout the manual, concepts which directly relate to FAA test questions are highlighted by FAA Question Insets. Additionally, you can evaluate your understanding of material introduced in a particular section by completing the associated review questions. A more detailed explanation of this manual's unique features is contained in the section entitled "How the Manual Works" starting on page x.

The Private Pilot Manual also contains a FAR/AIM CD-ROM. Federal Aviation Regulations (FARs) covered on the CD-ROM include Parts 1, 43, 61, 67, 71, 73, 91, 97, 119, 125, 133, 135, 141, 142, HMR 175, and NTSB 830. FAR Study lists, along with FAR Exercises (and answers) are included. The Aeronautical Information Manual (AIM) segments consist of the complete AIM with color graphics and the entire Pilot/Controller Glossary.

Private Pilot Maneuvers Manual

This manual uses colorful graphics and step-by-step procedure descriptions to help you visualize and understand each maneuver which you will perform in the aircraft. Additional guidance is provided through highlighted text which contains helpful hints, and FAA practical test standards.

Private Pilot Syllabus

The syllabus provides a basic framework for your training in a logical sequence. Ground and flight lessons are coordinated to ensure that your training progresses smoothly and that you are consistently introduced to topics on the ground prior to being required to apply that knowledge in the airplane.

Private Pilot Maneuvers CD-ROMs

These revolutionary CD-ROMs combine art, video, animation, and interactivity to create a dynamic learning experience. From preflight inspection to takeoffs and landings, you will learn how to perform each maneuver step-by-step with an instructor as your guide. The Maneuvers CD-ROMs also examine safety and human factors issues, as well as provide you with a unique opportunity to explore the world of aviation in a fun and exciting new format.

Support Materials

In addition to the core study materials described above, a variety of support materials are available to further enhance your understanding of pilot training subject matter. A brief description of these resources is provided below.

Private Pilot Airmen Knowledge Study Guide

This valuable study tool provides you with all the FAA questions which may be included on the Private Pilot computerized test. Answers and explanations for each question are provided to allow you to instantly check your understanding of required material.

Private Pilot Test Preparation Software

The test preparation software contains information similar to the *Private Pilot Airmen Knowledge Study Guide* with the added features of question search, simulated test taking, and performance tracking. Cross-references to Jeppesen Sanderson and FAA material are also included for every question.

Private Pilot Home-Study Videos

The *Private Pilot Test Prep Video Course* provides you with a take-home video review of aeronautical knowledge needed to pass your Private Pilot computerized test. Convenient cross-references direct you to the related questions contained in the *Private Pilot Airmen Knowledge Study Guide* and *Private Pilot Test Preparation Software.*

Private Pilot Practical Test Study Guide

This study aid combines the requirements of the FAA's Practical Test Standards with background information on each required task for the FAA practical test, including illustrations which show proper performance of maneuvers. Appropriate background information from Jeppesen Sanderson and FAA material is cross-referenced throughout this study guide.

Flight School Support Materials

Flight schools which use the Guided Flight Discovery Pilot Training System may provide a variety of additional resources and instructional support materials. Designed specifically to provide you with a well administered, quality training program, Guided

Flight Discovery flight school support materials help foster an environment which maximizes your potential for understanding and comprehension on your way to becoming a fully competent pilot. Some of these resources are described below.

Private Pilot Videos

The *Private Pilot Videos* are divided between basic aeronautical material and maneuvers analysis. The dynamic videos use state-of-the-art graphics and animation, as well as dramatic aerial photography to help easily explain complex ideas.

PC-Based Aviation Training Device (PCATD)

Flight schools may also provide access to Jeppesen Sanderson's PC-based aviation training device. The PCATD is designed specifically for pilot training and skill enhancement, and can be a great tool for giving you a head start on certain flight maneuvers.

Instructor's Guide

The *Instructor's Guide* is available for use by flight instructors and flight school operators. The *Instructor's Guide* helps flight training professionals effectively implement the Guided Flight Discovery Pilot Training System.

Feeling comfortable with your grasp of aviation concepts and your ability to apply them is fundamental to conducting safe and enjoyable flight operations. Historically, the majority of problems which occur during flight can be traced to a pilot's judgment and decision making. Aeronautical judgment is based primarily on the pilot's ability to apply the knowledge which was learned during training and gained through experience. The information presented in this textbook and the related Guided Flight Discovery materials is designed to provide you with the foundation of knowledge and experience needed to exercise good judgment and make sound decisions throughout your flying experience.

Preface

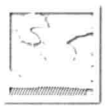
The purpose of the *Private Pilot Manual* is to provide you with the most complete explanations of aeronautical concepts in the most effective and easy-to-use manner possible. Through the use of colorful illustrations, full-color photos, and a variety of innovative design techniques, the *Private Pilot Manual* and other Guided Flight Discovery materials are closely coordinated to make learning fun and easy. To help you organize your study, the *Private Pilot Manual* is divided into five parts:

Part I — Fundamentals of Flight

The information needed to begin your aviation journey is introduced in this part. The first chapter, Discovering Aviation, answers many of your questions about the training process. Chapter two introduces you to the basics of airplane systems. In Chapter three you will gain an understanding of aerodynamic principles.

Part II — Flight Operations

Part II contains information you need to know about the environment in which you will fly. You will study subjects such as airport facilities, air traffic control services, communication procedures, and sources of flight information.



Part III — Aviation Weather

In Part III, you will be introduced to the variable atmosphere and its effect on aircraft operations. A thorough understanding of the information contained in this Part will help you maximize safety by minimizing your exposure to weather-related aviation hazards.

Part IV — Performance and Navigation

Aircraft capabilities and limitations in terms of performance parameters are covered in Part IV. You also will learn the basics of navigation using charts and radio aids.

Part V — Integrating Pilot Knowledge and Skills

The application of aeronautical decision-making principles and flight-related physiological factors is discussed in Chapter 10. A scenario in Chapter 11 provides insight into how previously learned knowledge and skills can be applied during a cross-country flight.

How the Manual Works

The *Private Pilot Manual* is structured to highlight important topics and concepts and promote an effective and efficient study/review method of learning. To get the most out of your manual, as well as the entire Guided Flight Discovery Pilot Training System, you may find it beneficial to review the major design elements incorporated in this text.

Learning Objectives

Learning objectives are provided at the beginning of each part to help you focus on important concepts.

PART I

Although we have never been able to duplicate the skill of birds, we have mastered the art of flying in our own unique way. We have built flying vehicles to transport us from town to town, coast to coast, around the world, and into space. As you explore Part I, you will begin to understand not only why we endeavor to fly, but how the goal of flight is achieved. *Discovering Aviation* answers your questions about the pilot training process and introduces you to the world of aviation. You will discover how the components of the airplane operate in *Airplane Systems*, and as you examine *Aerodynamic Principles*, you will gain knowledge of the forces acting on an airplane in flight.

CHAPTER 3

AERODYNAMIC PRINCIPLES

Cross-Reference Icon

A cross-reference icon is included at the beginning of each chapter to direct you to the corresponding video which supports and expands on introduced concepts and ideas.

SECTION C
AERODYNAMICS OF MANEUVERING FLIGHT

The extent to which an airplane can perform a variety of maneuvers is primarily a matter of design and a measure of its overall performance. Although aircraft design and performance may differ, the aerodynamic forces acting on any maneuvering aircraft are essentially the same. Understanding the aerodynamics of maneuvering flight can help you perform precise maneuvers while maintaining your airplane within its design limitations.

CLIMBING FLIGHT

The aerodynamic forces acting on an airplane established in a stabilized climb are in equilibrium; however, since the flight path is inclined, the relationship between these forces is altered. For example, the total force of weight no longer acts perpendicular to the flight path, but is comprised of two components. Although one component still acts 90° to the flight path, a rearward component of weight acts in the same direction as drag, opposing thrust. [Figure 3-48]

A transition from level flight into a climb normally combines a change in pitch attitude with an increase in power. If you attempt to climb just by pulling back on the control wheel to raise the nose of the airplane, momentum will cause a brief increase in altitude, but airspeed will soon decrease. The amount of thrust generated by the propeller for cruising flight at a given airspeed is not enough to maintain the same airspeed in a climb. Excess thrust, not excess lift, is necessary for a sustained climb. In fact, as the angle of climb steepens, thrust will not only oppose drag, but also will increasingly

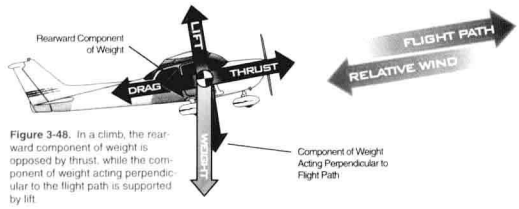


Figure 3-48. In a climb, the rearward component of weight is opposed by thrust, while the component of weight acting perpendicular to the flight path is supported by lift.

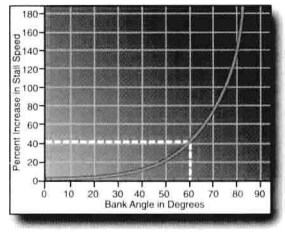
Full-Color Graphics

The full-color graphics used throughout the text are carefully designed to make difficult concepts easy to understand.

LOAD FACTOR AND STALL SPEED

The additional load factor incurred during constant altitude turns will also increase stall speed. [Figure 3-69] In fact, stall speed increases in proportion to the square root of the load factor. For example, if you are flying an airplane with a one-G stalling speed of 55 knots, the airplane will stall at twice that speed (110 knots) with a load factor of four G's. Stalls that occur with G-forces on an airplane are called accelerated stalls. An accelerated stall occurs at a speed higher than the normal one-G stall speed. These stalls demonstrate that the critical angle of attack, rather than airspeed, is the reason for a stall.

Figure 3-69. If you attempt to maintain altitude during a turn by increasing the angle of attack, the stall speed increases as the angle of bank increases. The percent of increase in stall speed is fairly moderate with shallow bank angles — less than 45°. However, once you increase the bank angle beyond 45°, the percent of increase in the stall speed rises rapidly. For example, in a 60°, constant-altitude bank, the stall speed increases by approximately 41%; a 75° bank increases stall speed by about 100%.



Increasing the load factor will cause an airplane to stall at a higher speed.

FAA Question Insets

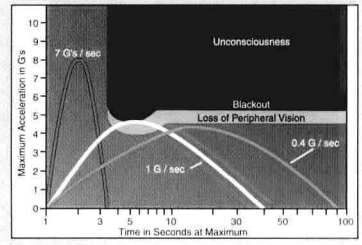
Information which relates directly to FAA test questions appears in tan insets. In addition to highlighting important concepts, the FAA Question Insets provide a good review tool when preparing for the Private Pilot computerized test.

HOW MANY G'S ARE TOO MANY?

From the files of the NTSB...
Aircraft: *Pitts S-2A — destroyed*
Crew: *One — seriously injured*
Narrative: *The witness stated the pilot was performing aerobatic maneuvers. At the top of the loop (approx. 3,000 ft AGL), the aircraft remained inverted, power was reduced, and an inverted spin was entered. The aircraft remained in the inverted spin to water impact. The pilot does not recall the accident flight, but stated he had been having problems with G-loads and low blood pressure.*

It is possible, even likely, that some aerobatic aircraft may be able to withstand more G's than the pilot. A particular pilot's G-tolerance is a function of many factors, including the intensity, duration, and direction of the G-forces. The main physical problems associated with G-forces are caused by basic changes within the cardiovascular system. Positive G's create a pooling of blood in the lower extremities of the body, impairing circulation and reducing blood pressure at head level. Continued or increased G-loading will result in a decrease of visual acuity, ultimately followed by unconsciousness, or blackout.

The human body is less tolerant of negative G's, which force blood into the head. Large amounts of sustained negative G's can result in uncomfortable symptoms such as facial pain and redout. Although some experienced aerobatic pilots may be able to withstand 7 or 8 positive G's before blackout occurs, most will be incapacitated by only -3G's. You can improve your G-tolerance by maintaining good physical conditioning and avoiding smoking, hyperventilation, and hypoxia. Most civil pilots, however, will not encounter G-forces of sufficient strength during normal flight to cause any major problems.



Human Element Insets

Human Element Insets are presented in Chapter 2 through Chapter 9 to introduce the human factors aspect of flight. The topics, which can range from physiology to decision making, are presented with emphasis on flight related applications.

The Canard Design

Although the tail-down force created by the horizontal stabilizer is excellent for longitudinal stability and balance, it is aerodynamically inefficient. The wings must support the negative lift created by the tail, and the negative angle of attack on the stabilizer increases drag. If an airplane design permitted two lifting surfaces, aerodynamic efficiency would be much greater.

A canard is a stabilizer that is located in front of the main wings. Canards are something like miniature forward wings. They were used in the pioneering days of aviation, most notably on the Wright Flyer, and are now reappearing on several original designs. The Beechcraft Starship (see photo) employs a variable sweep canard design. The canard provides longitudinal stability about the lateral axis by lifting the nose of the airplane.

Since both the main wings and the canard produce positive lift, the design is aerodynamically efficient. A properly designed canard is also stall/spin resistant. The canard stalls at a lower angle of attack than the main wings. In doing so, the canard's angle of attack immediately decreases after it stalls. This breaks the stall and effectively returns the canard to a normal lift-producing angle of attack before the main wings have a chance to stall. Ailerons remain effective throughout the stall because they are attached to the main wings. In spite of its advantages, the canard design has limitations in total lift capability. Critical design conditions also must be met to maintain adequate longitudinal stability throughout the flight envelope.

POWER EFFECTS

If you reduce power during flight, a definite nose-down pitching tendency occurs due to the reduction of downwash from the wings and the propeller which reduces elevator effectiveness. Although this is a destabilizing factor, it is a desirable characteristic because it tends to result in a nose-down attitude during power reductions. The nose-down attitude helps you maintain, or regain, airspeed. Increasing power has the opposite effect. It causes increased downwash on the horizontal stabilizer which decreases its contribution to longitudinal stability and causes the nose of the airplane to rise.

A power reduction in airplanes, other than T-tails, will decrease the downwash on the horizontal stabilizer from the wings and propeller slipstream. This is what causes the nose to pitch down after a power reduction.

The influence of power on longitudinal stability also depends on the overall design of the airplane. Since power provides thrust, the alignment of thrust in relation to the longitudinal axis, the CG, the wings, and the stabilizer are all factors. The thrustline is determined by where the propeller is mounted and by the general direction in which thrust acts. In most light general aviation airplanes, the thrustline is parallel to the longitudinal axis and above the CG. This creates a slight pitching moment around the CG. If thrust is decreased, the pitching moment is reduced and the nose heaviness tends to decrease. An increase in thrust increases the pitching moment and increases nose heaviness. [Figure 3-37] Notice that these pitching tendencies are exactly the reverse of the pitching tendencies resulting from an increase or decrease in downwash. This thrustline design arrangement minimizes the destabilizing effects of power changes and improves longitudinal stability.

3-30

Discovery Insets

Discovery Insets are included throughout the text beginning with Chapter 2 to expand on ideas and concepts presented in the accompanying material. The information presented in each Discovery Inset varies, but is designed to enhance your understanding of the world of aviation. Examples include references to National Transportation Safety Board investigations, aviation history, and thought-provoking questions and answers.

Color Photographs

Color photographs are included to enhance learning and improve understanding.

Key Terms

For ease of recognition and quick review, key terms are highlighted in red type when they are first introduced and defined. A list of key terms is included at the end of each section.

V_A normally is not marked on the airspeed indicator, since it may vary with total weight. V_A decreases as weight decreases since an aircraft operating at lighter weights is subject to more rapid acceleration from gusts and turbulence. The POH and/or a placard in the airplane are the best sources for determining V_A.

The amount of excess load that can be imposed on an airframe depends on the aircraft's speed.

SUMMARY CHECKLIST

- ✓ In climbing flight, one component of weight acts perpendicular to the flight path, and another component of weight acts rearward, in the same direction as drag.
- ✓ Four left-turning tendencies associated with propeller-driven airplanes are torque, gyroscopic precession, asymmetrical thrust, and spiraling slipstream.
- ✓ During descending flight, one component of weight acts forward along the flight path, while another component acts perpendicular to the flight path.
- ✓ The least drag, best glide angle, and maximum gliding distance can be obtained by maintaining the angle of attack that corresponds to L/D_{max}.
- ✓ Changes in aircraft weight will not affect glide ratio, but a higher airspeed will have to be maintained in a heavier aircraft in order to cover the same distance over the ground.
- ✓ Centripetal force, which is created by the horizontal component of lift, is the center-seeking force that acts on a turning airplane.
- ✓ The effects of adverse yaw can be countered by maintaining a coordinated turn using rudder.
- ✓ Rate of turn increases and radius of turn decreases as angle of bank is increased in a constant airspeed turn. If angle of bank is held constant and airspeed is increased, turn rate will decrease and turn radius will increase.
- ✓ The ratio of the weight that the wings must support to the actual weight of the aircraft is termed load factor.
- ✓ Accelerated stalls occur when the critical angle of attack is exceeded at an airspeed higher than the one-G stall speed.
- ✓ The V-g diagram defines the airplane's envelope, which is bounded by the stall region, limit load factor, and V_{NO}.

KEY TERMS

Torque	Spiraling Slipstream
Gyroscopic Precession	Maximum Lift-to-Drag Ratio
Asymmetrical Thrust	Best Glide Speed
P-Factor	Glide Ratio

Summary Checklists
Summary Checklists are included at the end of each section to help you identify and review the major points introduced in the section.

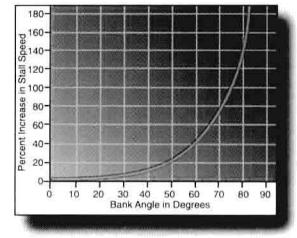
Glide Angle	Radius of Turn
Centripetal Force	Load Factor
Centrifugal Force	Accelerated Stalls
Adverse Yaw	Limit Load Factor
Overbanking Tendency	V-g Diagram
Rate of Turn	Design Maneuvering Speed (V_A)

QUESTIONS

1. Identify the aerodynamic force that opposes the rearward component of weight in a climb.
2. What relative airspeed, power, and angle of attack conditions produce the most noticeable left-turning tendencies common to single-engine, propeller-driven aircraft?
3. Name at least three design elements that can be used to help offset left-turning tendencies.
4. All else being equal, will two aerodynamically identical aircraft with different weights be able to glide the same distance over the ground? If so, how can this be accomplished and why?
5. What causes an airplane to turn?
6. If angle of bank and altitude are held constant, what can be done to increase the rate of turn?

Given a wings-level, 1G stall speed of 55 knots, use the chart provided to determine the stall speed under the following conditions:

7. Bank angle, 30°
8. Bank angle, 45°
9. Bank angle, 75°



10. True/False. Maneuvering speed increases with an increase in weight.

Questions
Questions are provided at the end of each section beginning with Chapter 2 to help you evaluate your understanding of the concepts which were presented in the accompanying section. Several question formats are provided including completion, matching, true/false, and essay. Perforated answer sheets, which are organized by chapter, are included at the back of the text.

PART I
FUNDAMENTALS OF FLIGHT

The bird has learned [his] art . . . so thoroughly that its skill is not apparent to our sight. We only learn to appreciate it when we try to imitate it.

— Wilbur Wright

PART I

Although we have never been able to duplicate the skill of birds, we have mastered the art of flying in our own unique way. We have built flying vehicles to transport us from town to town, coast to coast, around the world, and into space. As you explore Part I, you will begin to understand not only why we endeavor to fly, but how the goal of flight is achieved. *Discovering Aviation* answers your questions about the pilot training process and introduces you to the world of aviation. You will discover how the components of the airplane operate in *Airplane Systems*, and as you examine *Aerodynamic Principles*, you will gain knowledge of the forces acting on an airplane in flight.

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CHAPTER 1

DISCOVERING AVIATION