AVIATION MECHANIC SERIES

AIRFRAME STRUCTURES

Original Text by Dale Crane

FOURTH EDITION

AVIATION MECHANIC SERIES

AIRFRAME STRUCTURES

SAMPLE

FOURTH EDITION

Original Text by Dale Crane
Keith Anderson, Technical Editor

AVIATION SUPPLIES & ACADEMICS, INC.
KALAMAZOO, MICHIGAN

Aviation Mechanic Series: Airframe Structures
Fourth Edition
Based on the original text by Dale Crane

Aviation Supplies & Academics, Inc.
817 Walbridge Street
Kalamazoo, Michigan 49007
asa@asa2fly.com | 425-235-1500 | asa2fly.com

Copyright © 2026 Aviation Supplies & Academics, Inc.
First edition published 1994. Fourth edition published 2026.

Visit asa2fly.com for additional information, updates, and resources relating to this book.
Resources for instructors using this textbook in their classrooms are available at asa2fly.com.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means without the prior written permission of the copyright holder. No part of this publication may be used in any manner for the purpose of training artificial intelligence systems or technologies. While every precaution has been taken in the preparation of this book, the publisher assumes no responsibility for damages resulting from the use of the information contained herein.

None of the material in this book supersedes any operational documents or procedures issued by the Federal Aviation Administration, aircraft and avionics manufacturers, flight schools, or the operators of aircraft.

ASA-AM-STRUC4
ISBN 978-1-64425-545-2

Additional formats available:
eBook EPUB ISBN 978-1-64425-546-9
eBook PDF ISBN 978-1-64425-547-6

Printed in the United States of America
2030 2029 2028 2027 2026 9 8 7 6 5 4 3 2 1

Cover photos: *Front:* aapsky/iStock.com. *Back (left):* mediaphotos/iStock.com, *back (right, top):* Nils Hasenau/iStock.com, *back (right, middle):* cumhurkaplan/iStock.com.

Sections of some chapters are excerpted from previous publications, and have been used with permission: pp. 182–84, "Poly-Fiber Covering and Painting Material" courtesy Poly-Fiber Aircraft Coverings, Riverside, California; pp. 184–85, sections of the Superflite System manuals; pp. 185–87, Ceconite 7600 procedures provided by Blue River Aircraft Supply, Harvard, Nebraska.

Library of Congress Cataloging-in-Publication Data:
Names: Crane, Dale author | Anderson, Keith, 1960- editor | Crane, Dale. Aviation maintenance technician series
Title: Aviation mechanic series. Airframe structures / original text by Dale Crane, Keith Anderson, technical editor.
Other titles: Airframe structures
Description: Fourth edition. | Kalamazoo, Michigan : Aviation Supplies & Academics, Inc, [2026] | Series: Aviation mechanic series | Includes index.
Identifiers: LCCN 2025041235 (print) | LCCN 2025041236 (ebook) | ISBN 9781644255452 trade paperback | ISBN 9781644255469 epub | ISBN 9781644255476 pdf
Subjects: LCSH: Airplanes—Maintenance and repair | Airframes—Maintenance and repair | Airframes—Design and construction
Classification: LCC TL671.9 .C6648 2026 (print) | LCC TL671.9 (ebook)
LC record available at https://lccn.loc.gov/2025041235
LC ebook record available at https://lccn.loc.gov/2025041236

SAMPLE

Contents

Preface *v*

Acknowledgments *vii*

About the Editorial Team *ix*

1 Basic Aerodynamics 1

2 Metallic Aircraft Structures 51

3 Nonmetallic Aircraft Structures 153

4 Assembly and Rigging 241

5 Hydraulic and Pneumatic Power Systems 299

6 Aircraft Landing Gear Systems 389

Glossary *461*

Index *481*

SAMPLE

Preface

Aviation maintenance technology has undergone tremendous changes in the past decades. Modern aircraft, with their advanced engines, complex flight controls and environmental control systems, are some of the most sophisticated devices in use today, and these marvels of engineering must be maintained by knowledgeable technicians. The Federal Aviation Administration, recognizing this new generation of aircraft, has updated the requirements for maintenance technicians and for the schools that provide their training. The FAA has also instituted an Aviation Maintenance Technician Awards Program to encourage technicians to update their training.

New technologies used in modern aircraft increase the importance of maintenance technicians having a solid foundation in such basic subjects as mathematics, physics, and electricity. The Aviation Mechanic Series has been produced by ASA to provide the needed background information for this foundation and to introduce the reader to aircraft structures, powerplants, and systems.

These textbooks have been carefully designed to assist a person in preparing for FAA technician certification, and at the same time serve as valuable references for individuals working in the field. The subject matter is organized into categories used by the FAA for the core curriculum in 14 CFR Part 147, Aviation Maintenance Technician Schools, and for the Subject Matter Knowledge Codes used in the written tests for technician certification. In some cases in the ASA series, these categories have been rearranged to provide a more logical progression of learning.

This textbook is part of the ASA series of coordinated maintenance technician training materials. The series consists of the Aviation Mechanic Series textbooks, *General*, *Airframe Structures, Airframe Systems,* and *Powerplant* textbooks with study questions, the test guides for aviation mechanics, exam software for Aviation Maintenance Technician tests, the *Aviation Mechanic Oral and Practical Exam Guide*, the *Dictionary of Aeronautical Terms*, and the *Aviation Mechanic Handbook*.

To supplement this fundamental training material, ASA reprints the FAA Advisory Circulars (ACs) 43.13-1 and 43.13-2 in *Aircraft Inspection, Repair, and Alterations: Acceptable Methods, Techniques, and Practices*, as well as the FAR-AMT, excerpts from the Federal Aviation Regulations that are applicable to the aviation maintenance technician.

Dale Crane

SAMPLE

Acknowledgments

Textbooks such as this Aviation Mechanic Series could never be compiled without the assistance of the aviation community. Many individuals have been personally helpful, and many companies have been generous with their information. We want to acknowledge this and say thank you to them all.

ACES Systems—TEC Aviation Division, *Knoxville, TN*
Aero Quality International, *Stamford, CT*
Aero-Mach Labs, Inc., *Wichita, KS*
Aeroquip Corporation, *Jackson, MI*
Aerostar International, *Sioux Falls, SD*
Airborne Division, Parker Hanniflin Corporation, *Elyria, OH*
Aircraft Braking Systems Corporation, *Massillon, OH*
Allied Signal Aerospace, *Phoenix, AZ*
Allison Engine Company, *Indianapolis, IN*
American Avionics, *Seattle, WA*
ASCO Aeronautical, *Columbus, OH*
Aviation Laboratories, Inc., *Houston, TX*
Barfield, Inc., *Atlanta, GA*
Beech Aircraft Corporation, *Wichita, KS*
Bendix Electrical Components Division, *Sidney, NY*
Biddle Instruments, *Blue Bell, PA*
Blue River Aircraft Supply, *Harvard, NE*
Cessna Aircraft Company, *Wichita, KS*
Chadwick-Helmuth Company, Inc., *El Monte, CA*
Champion Aviation Products Division, *Liberty, SC*
Christie Electric Corp., *Gardena, CA*
Continental Motors Group, *Mobile, AL*
Dayton-Granger, *Fort Lauderdale, FL*
DeVilbiss Ransburg Industrial Equipment, *Maumee, OH*
Dowty-Rotol, Inc., *Cheltenham, England*
Dynamic Solutions Systems, Inc., *San Marcos, CA*
Engine Components, Inc., *San Antonio, TX*
Evergreen Weigh, Inc., *Lynnwood, WA*
General Electric Company, *Cincinnati, OH*
Grayhill, Inc., *La Grange, IL*
Grumman Corporation, *Bethpage, NY*
Gulfstream Aerospace, *Savannah, GA*
Hamilton Standard Division of United Technologies, *Windsor Locks, CT*
Heatcon Composite Systems, *Seattle, WA*
Hobart Brothers Company, *Troy, OH*
Howell Instruments, Inc., *Fort Worth, TX*

SAMPLE

John Fluke Manufacturing Company, *Everett, WA*
Lincoln Electric Company, *Cleveland, OH*
Machida Incorporated, *Orangeburg, NY*
Maule Air, Inc., *Moultrie, GA*
McCauley Accessory Division Cessna Aircraft Company, *Vandalia, OH*
Micro-Surface Finishing Products, *Wilton, IA*
Milbar Corporation, *Chagrin Falls, OH*
Miller Electric Manufacturing Company, *Appleton, WI*
Monsanto Chemical Company, *St. Louis, MO*
NASA Lewis Research Center, *Cleveland, OH*
Northrop Corporation, *Pico Rivera, CA*
Optronics Engineering, *Goleta, CA*
Piper Aircraft Company, *Vero Beach, FL*
Poly-Fiber Aircraft Coatings, *Riverside, CA*
Pratt & Whitney Canada, *Longueuil, Quebec, Canada*
Precision Airmotive Corporation, *Everett, WA*
Quan-Tech, *Flanders, NJ*
Raisbeck Engineering, *Seattle, WA*
Ram Aircraft Corporation, *Waco, TX*
Randolph Products, *Carlstadt, NJ*
Saft America, Inc., *Valdosta, GA*
Simpson Electric Company, *Elgin, IL*
Slick Aircraft Products, Division of *Unison, Rockford, IL*
Standard Aero, *Winnipeg, Manitoba, Canada*
Stanley-Proto Industrial Tools, *Covington, GA*
Stead Aviation Corporation, *Manchester, NH*
Sundstrand Corp., *Rockford, IL*
Superflite, *Elk Grove Village, IL*
Superior Air Parts, Inc., *Addison, TX*
Technical Chemical Company, *Dallas, TX*
Teledyne Battery Products, *Redlands, CA*
Textron Lycoming, *Williamsport, PA*
TRW Hartzell Propeller Products Division, *Piqua, OH*
T.W. Smith Engine Company, Inc., *Cincinnati, OH*
UE Systems, Inc., *Elmsford, NY*
United Technologies, Pratt & Whitney, *East Hartford, CT*
Welch Allyn Imaging Products Division, *Skaneateles Falls, NY*
Zetec, Inc., *Issaquah, WA*

A special thanks goes to David Jensen and Pete Owsley of Heatcon Composite Systems of Seattle, Washington, for their valuable input on composite construction. A very special thanks goes to Terry Michmerhuizen, Leard Wylie, and Robert Aardema of the School of Aviation Sciences of Western Michigan University for their careful editing, critiquing, and many suggestions in early editions. The publisher would also like to thank Robert Scherer for the use of his "NC-51" Beech Starship photograph.

SAMPLE

About the Editorial Team

Fourth Edition

Based on the original text by Dale Crane

Dale Crane (1923–2010), the original author of this series, was involved in aviation for more than 50 years. He began his career in the US Navy as a mechanic and flight engineer in PBYs. After World War II, he attended Parks Air College. After college, he worked as an instrument overhaul mechanic, instrument shop manager, and flight test instrumentation engineer. Later he became an instructor and then director of an aviation maintenance school.

Dale was active as a writer of aviation technical materials, and as a consultant in developing aviation training programs. ATEC presented to Dale Crane their special recognition award for "his contribution to the development of aviation technicians as a prolific author of specialized maintenance publications." He also received the FAA's Charles Taylor "Master Mechanic" award for his years of service in and contributions to the aviation maintenance industry, and the recognition of his peers for excellence as a leader and educator in aircraft maintenance, and aviation safety advocate

Keith Anderson has over 40 years of experience in aviation as an A&P mechanic, authorized inspector (IA), commercial pilot, flight instructor, and aeronautical engineer. He has worked in Part 91, 121, and 135 operations, has held multiple DOM (director of maintenance) positions, and has taught at the university level. His pilot/mechanic experience includes 10 years of living and working in Central and South America and Africa. Keith has worked as a design engineer in aircraft design and certification and has held multiple leadership roles including engineering director and vice president positions that have included STC certifications and the type certification (TC) of a single-engine turboprop airplane.

SAMPLE

BASIC AERODYNAMICS 1

Basic Fixed-Wing Aerodynamics 3

The Beginnings of Flight 3
Two Types of Lift 3
Aerostatic Lift 3
Aerodynamic Lift 4
Properties of the Atmosphere 5
Standard Atmospheric Conditions 5
Bernoulli's Principle 6
Axes of an Aircraft 6
Forces Acting on an Aircraft in Flight 7
Thrust 7
Lift 8
Weight 8
Drag 8
Development of the Aerodynamic Forces 9
Airfoil Sections 9
Aerodynamic Lift 11
Induced Drag 13
Parasite Drag 14
Flight at High-Lift Conditions 15
Ground Effect 15
Effect of High-Lift Devices 16
Boundary Layer Control 16
Vortex Generators 17
Effect of Wing Planform 18
Slots and Stall Strips 19
Wing-Tip Vortices 20
Stability and Control 21
Static Stability 21
Dynamic Stability 22
Longitudinal Stability 23
Longitudinal Control (Rotation About the Lateral Axis) 23
Lateral Stability 25
Lateral Control (Rotation About the Longitudinal Axis) 25
Turning Flight 25
Directional Stability 26
The Effect of Sweepback 27
Dutch Roll 28
Directional Control (Rotation About the Vertical Axis) 28
Study Questions: Basic Fixed-Wing Aerodynamics 28

SAMPLE

Basic High-Speed Aerodynamics 31

Compressibility 31
Compressible and Incompressible Flow 32
The Speed of Sound 33
Flight Speed Ranges 33
Subsonic Flight 33
Transonic Flight 34
Effect of Sweepback 34
Forward-Swept Wing 34
Supersonic Airflow 35
Normal Shock Waves 35
Oblique Shock Waves 35
Expansion Waves 36
Study Questions: Basic High-Speed Aerodynamics 36

Basic Rotor-Wing Aerodynamics 37

Aerodynamic Principles 38
Lift, or Rotor Thrust 38
Dissymmetry of Lift 39
Torque 40
Autorotation 40
Retreating Blade Stall 40
Ground Effect 41
Translational Lift 42
Gyroscopic Precession 42
Transverse Flow Effect 43
Coriolis Effect 43
Vortex Ring State 44
Helicopter Flight Controls 44
Collective Pitch Control 44
Cyclic Pitch Control 45
Horizontal Stabilizer 45
Antitorque Pedals 45
Stabilization Systems 46
Stabilizer Bar 46
Offset Flapping Hinge 47
Electronic Stability Augmentation System 47
Study Questions: Basic Rotor-Wing Aerodynamics 48

Answers to Chapter 1 Study Questions 49

SAMPLE

Basic Fixed-Wing Aerodynamics

The Beginnings of Flight

People have dreamed of taking to the air since the earliest observers watched the graceful flight of birds. It was only natural the first thoughts of flight assumed a need for flapping wings. In Greek mythology, Daedalus and his son Icarus escaped from Crete by making wings of feathers held together with wax. Icarus was so enamored of flight, he flew too close to the sun. The wax melted, and he plunged into the sea and drowned.

The earliest experimental flying machines emulated the bird, using flapping wings for propulsion. These machines, or "ornithopters," were unsuccessful. The first successful heavier-than-air flying machines were built and flown by the Chinese centuries before Christ, kites held in the air by the same aerodynamic forces that sustain modern airplanes and helicopters.

ornithopter. A heavier-than-air flying machine that produces lift by flapping its wings. No practical ornithopter has been built.

Two Types of Lift

Two types of lift raise aircraft against the force of gravity: aerostatic and aerodynamic. Aerostatic lift is produced when the weight of air displaced by the aircraft is greater than the weight of the aircraft. Aerodynamic lift is produced when movement of the aircraft through the air forces down a weight of air greater than the weight of the aircraft.

Aerostatic Lift

While the Chinese were flying kites and raising objects with the kites' aerodynamic lift, most experiments in Europe were of an aerostatic nature. In November of 1783, the Montgolfier brothers launched a manned hot-air balloon from Paris, France. Between the two world wars of the twentieth century, huge lighter-than-air flying machines carried aloft thousands of persons and transported tons of cargo, and in 1929 the German *Graf Zeppelin* made a round-the-world flight of more than 21,000 miles.

Zeppelin. The name of large rigid lighter-than-air ships built by the Zeppelin Company in Germany prior to and during World War I.

During the 1920s and 1930s, the US Navy experimented with several huge lighter-than-air flying machines, using two of them, the *USS Akron* and the *USS Macon*, as flying aircraft carriers. Interest in lighter-than-air craft was dealt a serious blow on May 6, 1937, when the German airship *Hindenburg* burned as she docked at the US Naval Air Station in Lakehurst, New Jersey. Strained diplomatic relations between the ruling parties in Germany and the United States meant the Germans did not have access to helium gas (only found in commercial quantities in the United States). They used the extremely flammable hydrogen gas to lift the *Hindenburg*.

Experimental work with large lighter-than-air machines continues today, and gas-filled blimps frequently advertise above our cities. The most common lighter-than-air aircraft, though, are hot-air balloons (Figure 1-1). Made of modern high-strength synthetic fabrics, these aircraft use propane burners to heat the air.

blimp. A cigar-shaped, nonrigid lighter-than-air flying machine.

SAMPLE

Figure 1-1. *The modern hot-air balloon uses the same type of aerostatic lift that carried two aeronauts aloft in France more than two centuries ago. (iStockphoto.com/Dan Harmesan)*

Aerodynamic Lift

aerodynamic lift. The force produced by air moving over a specially shaped surface called an airfoil. Aerodynamic lift acts in a direction perpendicular to the direction the air is moving.

airfoil. Any surface designed to obtain a useful reaction, or lift, from air passing over it.

Most modern aircraft employ aerodynamic lift, which requires relative movement between the air and the aircraft.

To create aerodynamic lift, a specially shaped surface, called an airfoil, is moved through the air. A low pressure is produced above its surface, and a relatively high pressure is produced below it. This pressure differential deflects the air downward, and the mass of the air forced down is balanced by an equal force that pushes upward on the airfoil. This upward force is the aerodynamic lift.

Properties of the Atmosphere

The atmosphere is the layer of gases that surrounds the earth from its surface to a height of about 22 miles. These gases consist of a mixture of nitrogen and oxygen with a small percentage of other gases, including water vapor.

In the troposphere, the lowest layer of the atmosphere, all our weather exists. The troposphere extends from the surface to about 36,000 feet, and in this layer, the temperature and pressure decrease steadily as the altitude increases.

Immediately above the troposphere is the stratosphere, which extends to the upper limit of the atmosphere. The temperature in the stratosphere remains constant at −56.5°C (−69.7°F), but the pressure continues to decrease. The boundary between the troposphere and the stratosphere is called the tropopause.

Standard Atmospheric Conditions

The ICAO (International Civil Aeronautical Organization) standard atmosphere, also known as the International Standard Atmosphere (ISA), is a hypothetical condition whose parameters have been accepted by international agreement as representative of the atmosphere surrounding the earth for the purposes of aircraft design and performance calculations and the calibration of aircraft instruments. See Figure 1-2.

Parameter	Metric Units	British Units
Pressure, P_0	1013.25 hPa 760 mmHg	2116.22 lb/ft^2 29.92 inHg
Temperature, T_0	288.15°K 15.0°C	518.67°R 59.0°F
Acceleration due to gravity, g_0	9.80665 m/sec^2	32.1741 ft/sec^2
Specific weight, $g_0\rho_0$	1.2230 kg/m^3	0.76474 lb/ft^3
Density, ρ_0	1.2250 kg/m^3	0.002378 slug/ft^3

Figure 1-2. *Conditions of the ICAO standard atmosphere.*

In practical flight conditions, air pressure is measured in terms of altitude rather than inches of mercury or pounds per square inch. The altimeter is an absolute-pressure gauge, or barometer, that measures the pressure of the air and indicates the altitude at which that pressure exists.

pressure altitude. The altitude in standard atmosphere at which the pressure is the same as the existing air.

When the barometric scale of the altimeter is set at the standard sea level pressure, 29.92 inches of mercury (inHg), the indication is called pressure altitude.

Density altitude, used to determine the amount of lift produced by an airfoil and the amount of power produced by an engine, is found by correcting pressure altitude for nonstandard temperature.

density altitude. The altitude in standard air at which the density is the same as that of the existing air.

SAMPLE

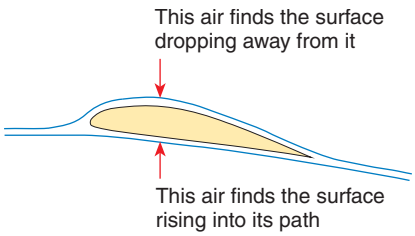


Figure 1-3. *The air flowing over the upper surface of this airfoil finds the surface dropping away, and is forced to speed up. The air flowing below the airfoil finds the surface rising into its path, and is forced to slow down.*

kinetic energy. Energy that exists because of motion.

potential energy. Energy possessed in an object because of its position, chemical composition, shape, or configuration.

downwash. Air forced down by aerodynamic action below and behind the wing of an airplane or the rotor of a helicopter. Aerodynamic lift is produced when the air is deflected downward. The upward force on the aircraft is the same as the downward force on the air.

Bernoulli's Principle

Aerodynamic lift is produced by the relative movement between an airfoil and the air. Air is a viscous fluid: it "wets," or tends to adhere to, any surface over which it flows.

An airfoil like the one in Figure 1-3 is shaped in such a way that the air flowing over its upper surface finds the surface dropping away from it, and it must speed up. The air flowing below the airfoil finds the surface rising into its path and it is forced to slow down.

In 1738, the Swiss physicist Daniel Bernoulli explained the relationship between potential and kinetic energy in the air as it flows over an airfoil. Air's potential energy relates to its pressure, and kinetic energy to its velocity. The sum of potential and kinetic energy in the air is its total energy.

Bernoulli's principle explains that if the total energy in the air flowing over an airfoil remains constant, any increase in its velocity will cause a corresponding decrease in its pressure.

Since the air flowing over the top of the airfoil speeds up, its pressure decreases, and air above it flows down to fill the low pressure. The air flowing under the airfoil is slowed down and its pressure increases. Air is forced away from the high pressure. The net result is that the air flowing around the airfoil is forced downward. See Figure 1-4. The weight of forced-down air is exactly balanced by the force pushing upward on the airfoil, aerodynamic lift.

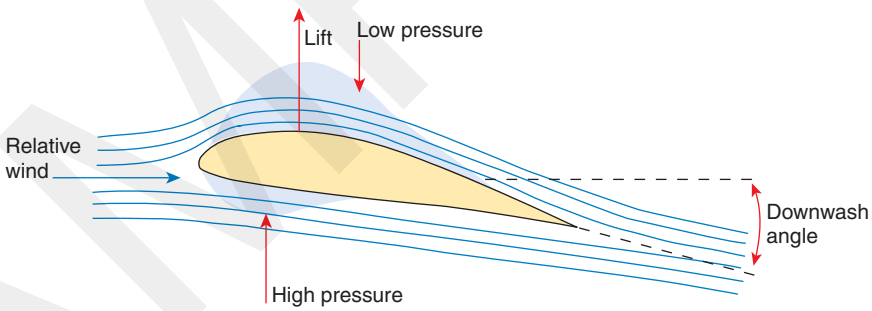


Figure 1-4. *Aerodynamic lift is produced by a relatively low pressure above the airfoil surface pulling air down to the surface, while a relatively high pressure below the surface forces the air away. The mass of the air deflected downward is balanced by an equal upward force on the airfoil.*

Axes of an Aircraft

An aircraft in flight is free to rotate about three axes: the longitudinal, or roll axis; the lateral, or pitch axis; and the vertical, or yaw axis. See Figure 1-5.

SAMPLE

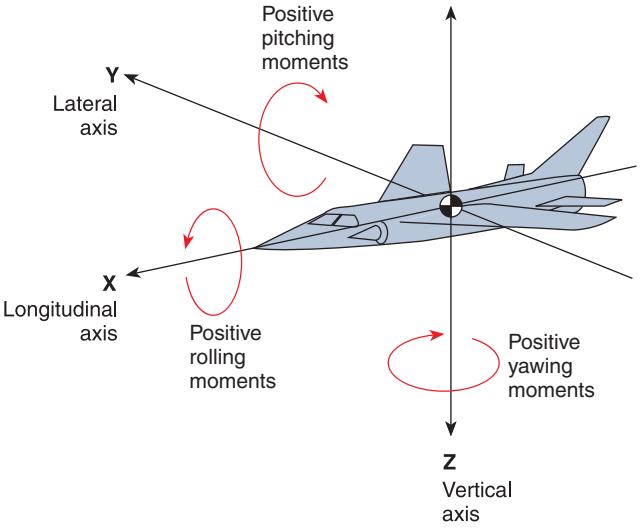


Figure 1-5. *An airplane in flight is free to rotate about its longitudinal, lateral, and vertical axes. These three axes are mutually perpendicular, and all pass through the aircraft's center of gravity.*

Forces Acting on an Aircraft in Flight

Four basic forces act on all aircraft in flight. During straight-and-level, unaccelerated flight, these forces are balanced and act through the aircraft's center of gravity. See Figure 1-6.

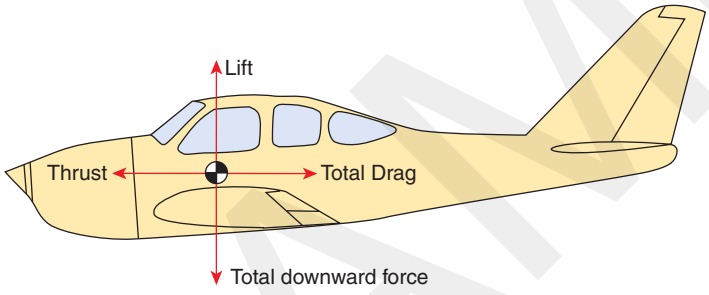


Figure 1-6. *Four basic forces act on an airplane in flight: a forward force of thrust, an upward force of lift, a rearward force of drag, and a downward force made up of weight and an aerodynamic down load on the tail.*

Thrust

The propeller or jet stream of an airplane, and the forward vector of the lift produced by a helicopter's rotor, provide thrust, or a force that causes forward movement. Thrust for a glider and for an airplane under reduced power, is produced by the forward component of lift and weight caused by the aircraft's downward flight path. See Figure 1-7.

When the thrust line is above the center of gravity, an increase in thrust rotates the airplane nose-down about its lateral axis. A decrease in thrust lets the airplane rotate nose-upward.

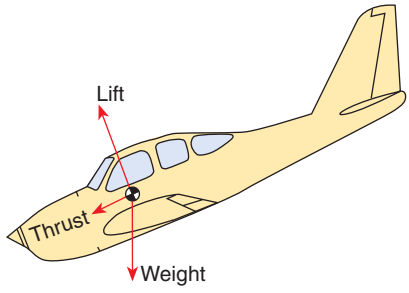


Figure 1-7. *When an airplane is in a power-off glide, the thrust is produced by the forward component of the lift and weight vectors.*

SAMPLE

Lift

Lift is the total upward force produced by the aerodynamic reaction of the air flowing over the airfoil-shaped surfaces of the aircraft. The lift force is perpendicular to the relative wind, and may be tilted by varying the amounts of lift produced by each wing panel. Lowering the left aileron while raising the right aileron changes the shape of the wing airfoil, increasing the lift on the left side of the airplane and decreasing the lift on the right side. The airplane rolls to the right and the lift tilts. Lift now has two components: one vertical and one horizontal. See Figure 1-8. It is this horizontal component of lift that causes an airplane to turn.

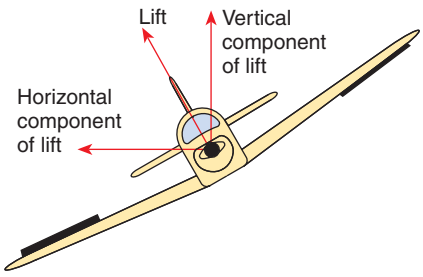
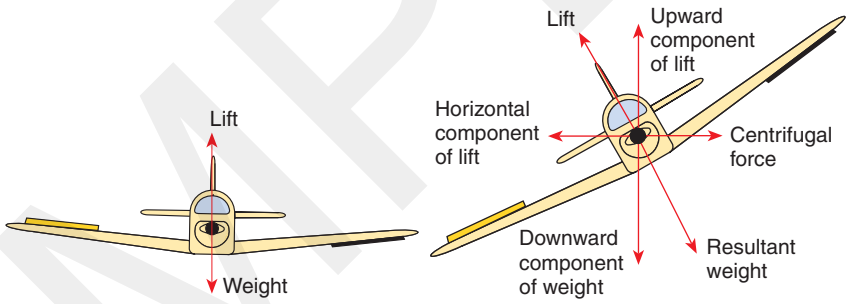


Figure 1-8. *Lift acts in a direction that is perpendicular to the lateral axis and may be tilted by rolling the airplane about its longitudinal axis. When the lift is tilted from its true vertical, it produces both a vertical and a horizontal component.*

Weight

The weight of an airplane is the total pull of gravity. Weight acts through the center of gravity directly toward the center of the earth and is the greatest part of the downward force—but there are also other downward forces.

An airplane's downward tail load changes with its airspeed, and may be adjusted so all the downward forces are exactly equal to the upward forces. The combination of the downward forces moves the center of gravity to the same location as the center of lift, and the airplane balances about its center of gravity. See Figure 1-9.



In straight and level trimmed flight, the lift exactly balances the weight.

In turning flight, centrifugal force adds to the weight, and if the lift is not increased, the downward component of weight will be greater than the upward component, and the airplane will descend.

Figure 1-9. *Forces acting on an airplane in straight-and-level flight and turning flight.*

trimmed flight. A flight condition in which the aerodynamic forces acting on the control surfaces are balanced and the aircraft is able to fly straight-and-level with no control input.

For the airplane to remain at the same altitude, the total upward force must equal the total downward force. When the airplane is turning, centrifugal force causes a horizontal movement away from the center of the turn. This centrifugal force adds vectorially to the aircraft's weight to produce a resultant weight that is greater than the lift. If the lift is not increased as the airplane turns, the upward force will not equal the downward force, and the airplane will descend in the turn.

Drag

An airplane's drag is the sum of the forces that hold it back against the forward force of thrust. There are two basic drag forces: induced drag, which is produced by the same factors that produce aerodynamic lift, and parasite drag, which is caused by all factors not producing lift.

induced drag. Aerodynamic drag produced by an airfoil when it is producing lift. Induced drag is affected by the same factors that affect induced lift.

parasite drag. A form of aerodynamic drag caused by friction between the air and the surface over which it is flowing.

SAMPLE

AIRFRAME STRUCTURES

Airframe Structures, the second textbook in Dale Crane's four-part Aviation Mechanic Series, details the subjects associated with aircraft structures including aerodynamics and rotorcraft fundamentals, hydraulic and pneumatic systems, metallic and nonmetallic structures, flight controls, assembly and rigging, and aircraft landing gear systems. The content meets FAA aviation maintenance technician school curriculum requirements and prepares applicants for the structure-related subjects tested on the Airframe FAA Knowledge Exam.

This new fourth edition features updated content reflecting new regulations and changes affecting aviation mechanic certification. Originally written by Dale Crane in 1994, this textbook has been reviewed and updated by an editorial team consisting of aviation mechanics, university professors, and pilots.

ASA's Aviation Mechanic Series is a current, comprehensive, and effective learning resource for aviation mechanic training. Designed for use in classrooms and for independent study, these textbooks feature color figures, study questions with answer keys, and extensive glossaries and indexes.

Also in the **Aviation Mechanic Series:**

Aviation Supplies & Academics, Inc.
817 Walbridge Street
Kalamazoo, Michigan 49007 USA
425-235-1500 | asa2fly.com

ASA-AM-STRUC4

TRANSPORTATION USD $59.95

ISBN 978-1-64425-545-2

9 781644 255452 55995 >