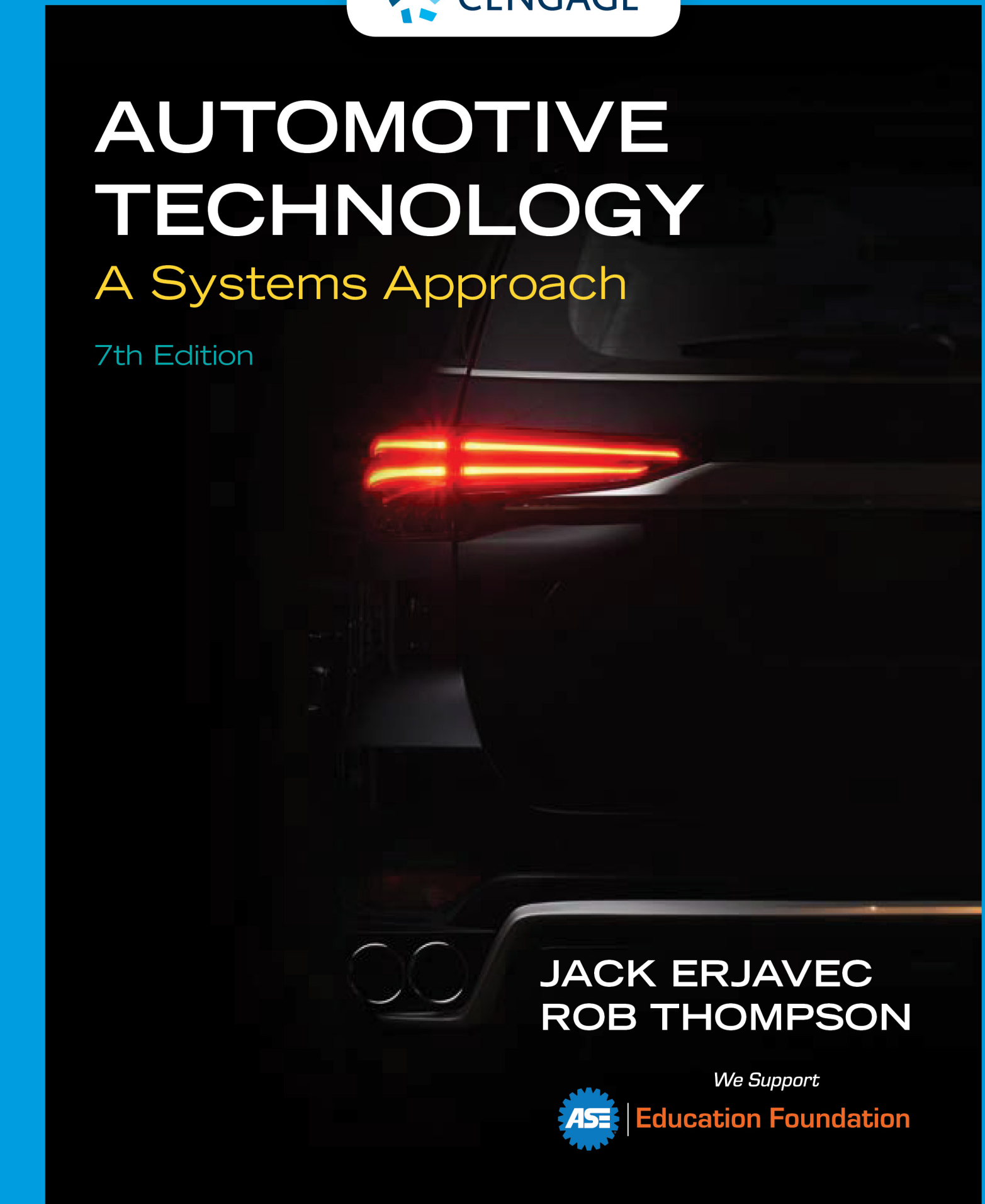
CENGAGE

AUTOMOTIVE TECHNOLOGY

A Systems Approach

7th Edition



JACK ERJAVEC
ROB THOMPSON

We Support

ASE | Education Foundation

AUTOMOTIVE TECHNOLOGY

A Systems Approach

7th Edition

Jack Erjavec

Rob Thompson

CENGAGE

Australia • Brazil • Mexico • Singapore • United Kingdom • United States

CENGAGE

***Automotive Technology: A Systems Approach*, 7th Edition**
Jack Erjavec & Rob Thompson

SVP, GM Skills & Global Product Management: Jonathan Lau
Product Director: Matthew Seeley
Senior Product Manager: Katie McGuire
Product Assistant: Kimberly Klotz
Executive Director, Content Design: Marah Bellegarde
Learning Design Director: Juliet Steiner
Learning Designer: Mary Clyne
Vice President, Strategic Marketing Services: Jennifer Ann Baker
Marketing Director: Shawn Chamberland
Marketing Manager: Andrew Ouimet
Director, Content Delivery: Wendy Troeger
Senior Content Manager: Meaghan Tomaso
Senior Digital Delivery Lead: Amanda Ryan
Senior Designer: Angela Sheehan
Text Designer: Chris Miller
Cover image(s): Photographicss/ShutterStock.com

Library of Congress Control Number: 2018958672

ISBN: 978-1-3377-9421-3

Cengage
20 Channel Center Street
Boston, MA 02210
USA

Cengage is a leading provider of customized learning solutions with employees residing in nearly 40 different countries and sales in more than 125 countries around the world. Find your local representative at **www.cengage.com.**

Cengage products are represented in Canada by Nelson Education, Ltd.

To learn more about Cengage platforms and services, register or access your online learning solution, or purchase materials for your course, visit **www.cengage.com**.

Printed in the United States of America
Print Number: 01 Print Year: 2018

CONTENTS

PHOTO SEQUENCES

PREFACE

About the Book

Manufacturers have made major and constant changes to the various systems of an automobile, and the integration and codependence of those systems have made becoming a successful technician more challenging than ever. This book, *Automotive Technology: A Systems Approach*, was designed and written to prepare students for those challenges. The basic premise is "with students having so much to learn in a short time, why fill the pages of a textbook with information they do not need?" The emphasis of this book is on those things that students need to know about the vehicles of today and tomorrow.

This does not mean that the pages are filled with fact after fact. Rather, each topic is explained in a logical way, slowly but surely. With more than 45 years of combined teaching experience, we believe we have a good sense of how students read and understand technical material. We also know what things draw their interest into a topic and keep it there. These things have been incorporated in the writing and features of the book.

This new edition of *Automotive Technology: A Systems Approach* represents the many changes that have taken place in the automotive industry over the past few years. With each new edition, the challenge of what to include and what to delete presents itself. We hope that we have made the right choices. of course, if we did, much of the credit is due to the feedback we have received from users of the previous edition and those who reviewed this new edition while it was in the making. They all did a fantastic job and showed that they are truly dedicated to automotive education.

New to this Edition

This seventh edition is not the sixth edition with a new cover and some new pictures. Although much of the information from the previous edition was retained, each chapter has been updated in response to the changing industry. In addition, there are some new features that should be helpful to students and their instructors. We have made sure that all of the latest ASE program standards are covered in this text. Regardless of the level of program accreditation, you will find the appropriate information in this book.

The first section of chapters gives an overview of the automotive industry, careers, working as a technician, tools, diagnostic equipment, and basic automotive systems. The content of these chapters has been updated and arranged to prepare students for the responsibilities and demands of a career as an automotive technician.

Chapter 1 explores the career opportunities in the automotive industry. This discussion has been expanded to include more information about ASE certification and testing. Chapter 2 covers workplace skills and the ways to go about seeking and selecting a job in the automotive field. This chapter goes through the process of getting a job and keeping it. It also covers some of the duties common to all automotive technicians. This chapter has been updated to include online resources.

Chapter 3 covers the science and math principles that are the basis for the operating principles of an automobile. Too often, we, as instructors assume that our students know these basics. This chapter is included to serve as a reference for those students who want to be good technicians. To do that they need a better understanding of why things happen the way they do.

Chapter 4 covers the basic systems of the automobile in a very basic approach and has been updated to include hybrid vehicles and alternative fuels. Chapters 5 through 7 cover very important issues regarding the use and care of hand tools, shop equipment, and safety issues (including bloodborne pathogens). Throughout these chapters, there is a strong emphasis on safely working on today's vehicles and the correct tools required to do so. Chapter 6 gives a brief look at the special and diagnostic tools required for working in each of the eight primary ASE certification areas. The tools discussed include all of the required tools for each area as defined by the ASE Education Foundation (formerly NATEF).

Chapter 8 covers the procedures involved in common safety inspections and preventive maintenance programs. Because the industry has more hybrid

vehicles than in previous years, basic maintenance for those vehicles has been included.

Section 2, which contains the chapters on engines, has been updated to include more coverage on the latest engine designs and technologies. There is more coverage on the theory, diagnosis, and service to alloy engines and overhead camshaft engines. There are also discussions on the latest trends, including variable valve timing and lift and cylinder disabling systems. A discussion of light-duty diesel engines and those engines used in hybrid vehicles is also part of the entire section.

It is nearly impossible to work on modern cars and trucks without a solid understanding of basic electricity and electronics as contained in Section 3. As a result, little has been deleted from those chapters while new information has been added to keep up with current technology. Coverage of all the major electrical systems has been increased to include new technologies. This includes high-voltage systems, new exterior lighting systems, adaptive systems (such as cruise control), semi-autonomous and autonomous driving technologies, and many new accessories. The rest of the section has been brought up to date with additional coverage on body computers and the use of lab scopes and graphing meters.

The entire Engine Performance section (Section 4) has been updated from the introductory chapters to those that deal with overall engine performance testing. The layout represents the approach taken by most experienced technicians. It is hoped that students will be able to grasp a global look at these systems and can become better diagnosticians. The revision of the section covers the individual engine performance systems, their operation, and how to test them with current diagnostic equipment. Added emphasis on diagnostics was the main goal of the revision of the rest of this section.

Included in this section are three chapters that deal with some of the dynamic aspects of the automotive industry. Chapter 28 is dedicated to gasoline, diesel, and other fuels. It also covers the operation and service of light-duty diesel engines, including their injection and emission control systems. Due to the increasing number of hybrid and electric vehicles on the road, this edition has an entire chapter dedicated to hybrid vehicles in addition to the information that appears in various chapters. Chapter 36 focuses on currently available electric and fuel cell vehicles.

Sections 5 and 6 cover transmissions and drivelines. All of the chapters in these sections have been updated to include more coverage on electronic controls. There is also more coverage on six-, seven-, and eight and ten-speed transmissions, automatic manual transmissions, new differential designs, and electronic automatic transmissions and transaxles. In addition, there is complete coverage on the transmissions used in today's hybrid vehicles. There is a comprehensive look at torque vectoring systems, which are becoming more common on all types of vehicles.

The suspension and steering systems section has increased coverage on electronic controls and systems. This includes the new designs of shock absorbers and four-wheel steering systems. Chapter 49 has been updated to include the latest techniques for performing a four-wheel alignment.

The Brakes section has also been updated to reflect current technology. This includes the latest antilock brake, stability control, and traction control systems.

Heating and air-conditioning systems are covered in Section 9. The content in Chapters 54 and 55 includes hybrid systems, R-1234yf components and service, as well as future refrigerants.

Organization and Goals of this Edition

This edition is still a comprehensive guide to the service and repair of our contemporary automobiles. It is still divided into nine sections that relate to the specific automotive systems. The chapters within each section describe the various subsystems and individual components. Diagnostic and service procedures that are unique to different automobile manufacturers also are included in these chapters. Because many automotive systems are integrated, the chapters explain these important relationships in great detail. It is important to note that all of latest ASE Education Alliance standards are addressed in this edition.

Effective diagnostic skills begin with learning to isolate the problem. The exact cause is easier to pinpoint by identifying the system that contains the problem. Learning to think logically about troubleshooting problems is crucial to mastering this essential skill. Therefore, logical troubleshooting techniques are discussed throughout this text. Each chapter describes ways to isolate the problem system and then the individual components of that system.

This *systems approach* gives the student important preparation opportunities for the ASE certification exams. These exams are categorized by the automobile's major systems. The book's sections are outlined to match the ASE test specifications and competency task lists. The review questions at the end of every chapter give students practice in answering ASE-style review questions.

More importantly, a *systems approach* allows students to have a better understanding of the total vehicle. With this understanding, they have a good chance for a successful career as an automotive technician. That is the single most important goal of this text.

Acknowledgments

I would like to acknowledge and thank the following dedicated and knowledgeable educators for their comments, criticisms, and suggestions during the review process:

Michael Abraham, Porter and Chester Institute, Woburn, MA
Donnie Ray Allen, TTC at McMinnville, McMinnville, TN
Curt Andres, Mid-State Technical College, Marshfield, WI
Wayne A. Barton, Porter and Chester Institute, Branford, CT
Arthur S. Bernier, Porter and Chester Institute, Woburn, MA
Rick Bland, WyoTech, Blairsville, PA
Alfred Blume, Lincoln Technical Institute, Philadelphia, PA
Dennis Blumetti, Lincoln Technical Institute, Union, NJ
Ronnie Bush, Tennessee Technology Center at Jackson, Jackson, TN
Arlen Crabb, Lincoln College of Technology, Columbia, MD
Eric Evensen, WyoTech, West Sacramento, CA
Jack Fetsko, WyoTech, Blairsville, PA
Dave Fish, WyoTech, Blairsville, PA
Gary Forgotson, Lincoln Technical Institute, Mahwah, NJ
David Foster, Austin Community College, Austin, TX
Gary R. Grote, Porter and Chester Institute, Rockyhill, CT
Carl L. Hader, Grafton High School, Grafton, WI
Mark Hankins, Shoreline Community College, Shoreline, WA
Matthew Herndon, WyoTech, West Sacramento, CA
Roger Ito, WyoTech, Sacramento, CA
Ken Jefferson, Southeast Community College Lincoln, NE
Igor Joffe, Lincoln Technical Institute, Mahwah, NJ
David P. Jones, Lincoln College of Technology, Melrose Park, IL
Mike Keener, WyoTech, Blairsville, PA
John V. King, Lincoln College of Technology, Columbia, MD
Joe Krystopa, Lincoln Technical Institute, Philadelphia, PA
Calvin Lofton, WyoTech, Long Beach, CA
Jack Longress, WyoTech, Laramie, WY
Philip Lowry, Lincoln Technical Institute, Whitestone, NY
Louis Luchsinger, Lincoln Technical Institute, Union, NJ
Larry Marshall, Lawson State Community College, Bessemer, AL
Kevin McCurry, North Georgia Technical College, Clarkesville, GA
James Melby, Porter and Chester Institute, Belchertown, MA
Brian Noel, Cosumnes River College, Sacramento, CA
Paul O'Connell, Riverside City College, Riverside, CA
Joseph A. Oliva, Lincoln Technical Institute, Whitestone, NY
Marvin Olson, Fort Peck Community College, Poplar, MT
Vernon Ouellette, Porter and Chester Institute, Branford, CT
Douglas Peterson, Lincoln Technical Institute, Philadelphia, PA
David Reynolds, Lincoln College of Technology, Indianapolis, IN
Eric Rising, WyoTech, Blairsville, PA
Steven Russo, Lincoln Technical Institute, Union, NJ
Mike Sarver, WyoTech, Blairsville, PA
Paul Schenkel, WyoTech, West Sacramento, CA
Terry Lynn Shaffer, Bates Technical College, Tacoma, WA
Michael Shephard, Lincoln Technical Institute, Union, NJ
Timothy Shockley, WyoTech, Sacramento, CA
Frank Spirig, Lincoln Technical Institute, Union, NJ
Wendell Soucy, Porter and Chester Institute, Enfield, CT
Steven Struthers, Porter and Chester Institute, Enfield, CT
James Taylor, WyoTech, Blairsville, PA
Tom Velardi, Lincoln Technical Institute, Whitestone, NY
James Warga, Lincoln Technical Institute, Mahwah, NJ
Glen F. Weiss, Lincoln Technical Institute, Philadelphia, PA
James M. Yetso, Porter and Chester Institute, Branford, CT

About the Author

Jack Erjavec has become a fixture in the automotive textbook publishing world. He has many years of experience as a technician, educator, author, and editor and has authored or coauthored more than forty automotive textbooks and training manuals. Mr. Erjavec holds a Master of Arts degree in Vocational and Technical Education from Ohio State University. He spent 20 years at Columbus State Community College as an instructor and administrator and has also been a long-time affiliate of the North American Council of Automotive Teachers, including serving on the board of directors and as executive vice-president. Jack was also associated with ATMC, SAE, ASA, ATRA, AERA, and other automotive professional associations.

Rob Thompson started his teaching career as an adjunct faculty member at Columbus State Community College while still working full-time as a technician. Since 1995, he has taught the high school automotive technology program that he himself graduated from a long time ago. Rob has an associate of applied science degree in automotive technology, has been a board member and is a past-president of the North American Council of Automotive Teachers (NACAT). Rob has ASE Master and Advanced Level Technician certifications.

FEATURES OF THE TEXT

Learning how to maintain and repair today's automobiles can be a daunting endeavor. To guide the readers through this complex material, we have built in a series of features that will ease the teaching and learning processes.

Objectives

Each chapter begins with the purpose of the chapter, stated in a list of objectives. Both cognitive and performance objectives are included in the lists. The objectives state the expected outcome that will result from completing a thorough study of the contents in the chapters.

The Three Cs

New in the previous edition and updated for this edition is the feature called *The Three Cs*. The Three Cs, meaning the *concern, cause, and correction*, are used to help technicians identify the concern or customer complaint, the underlying reason or cause of the concern, and how to correct the problem. The chapter openers in Sections 2 through 9 each contain a Three Cs scenario where the reader is presented with a shortened repair order (RO) and customer concern. Within the chapter, information regarding the concern's possible causes and corrections are provided. Finally, at the end of the chapter, the cause and correction to the scenario are presented to the reader, with rationale notes about any special considerations regarding the diagnosis and repair. In many of The Three Cs scenarios, the details are taken from real-world situations. We hope this feature will be useful in providing a real-world look at how vehicles are presented to technicians and how customer concerns are resolved.

Cautions and Warnings

Instructors often tell us that shop safety is their most important concern. Cautions and warnings appear frequently in every chapter to alert students to important safety concerns.

Shop Talk

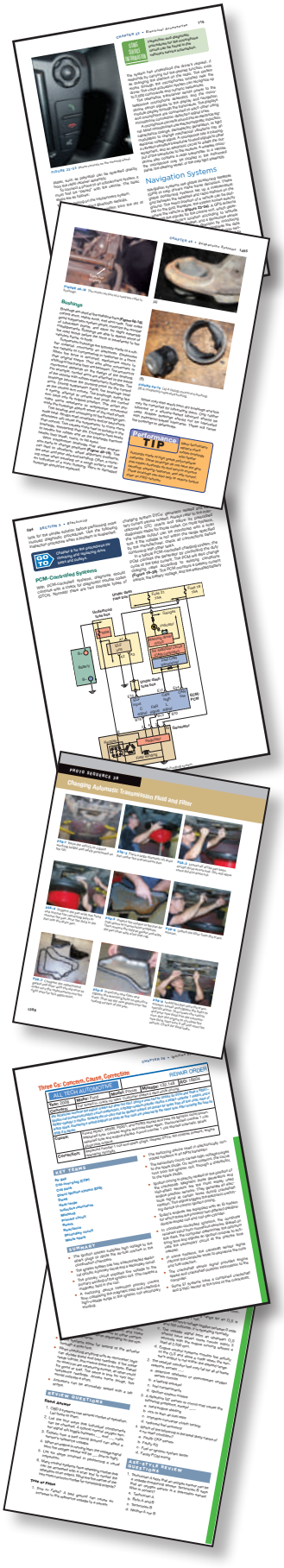
These features are sprinkled throughout each chapter to give practical, commonsense advice on service and maintenance procedures.

Customer Care

Creating a professional image is an important part of shaping a successful career in automotive technology. The customer care tips were written to encourage professional integrity. They give advice on educating customers and keeping them satisfied.

Tool Care

The Tool Care feature discusses proper use and care of common tools so that they can remain functioning and usable for years to come.



Using Service Information

Learning to use available service information is critical to becoming a successful technician. The source of information varies from printed material to online materials. The gathering of information can be a time-consuming task but nonetheless is extremely important. We have included a feature that points the student in the right direction to find the right information.

Performance Tips

This feature introduces students to the ideas and theories behind many performance-enhancing techniques used by professionals.

"Go To" Feature

This feature is used throughout the chapters and tells the student where to go in the text for prerequisite and additional information on the topic.

Photo Sequences

Step-by-step photo sequences illustrate practical shop techniques. The photo sequences focus on techniques that are common, need-to-know service and maintenance procedures. These photo sequences give students a clean, detailed image of what to look for when they perform these procedures. This was a popular feature of the previous editions, so we now have a total of 51.

Procedures

This feature gives detailed, step-by-step instructions for important service and maintenance procedures. These hands-on procedures appear frequently and are given in great detail because they help to develop good shop skills and help to meet competencies required for ASE certification.

Key Terms

Each chapter ends with a list of the terms that were introduced in the chapter. These terms are highlighted in the text when they are first used, and many are defined in the glossary.

Summary

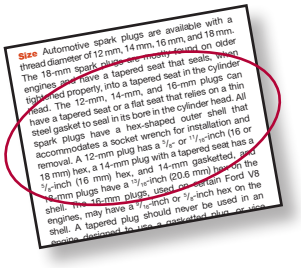
Highlights and key bits of information from the chapter are listed at the end of each chapter. This listing is designed to serve as a refresher for the reader.

Review Questions

A combination of short-answer essay, true or false, and multiple-choice questions make up the end-of-chapter review questions. Different question types are used to challenge the reader's understanding of the chapter's contents. The chapter objectives are used as the basis for the review questions.

ASE-Style Review Questions

In any chapter that relates to one of the ASE certification areas, there are ten ASE-style review questions that relate to that area. Some are quite challenging and others are a simple review of the contents of the chapter.



Metric Equivalents

Throughout the text, all measurements are given in UCS and metric increments.

Supplements

The Automotive Technology package offers a full complement of supplements:

Tech Manual

The Tech Manual offers students opportunities to strengthen their comprehension of key concepts and to develop their hands-on, practical shop experience. Each chapter includes Concept Activities and Job Sheets, which are directly correlated to ASE Education Foundation tasks. Service information report sheets and review questions are also included to offer a rounded approach to each lesson.

Instructor Resources

The Instructor Resources (on CD and companion website) for the seventh edition include the following components to help minimize instructor prep time and engage students:

- **PowerPoint**—Chapter outlines with images, animations, and video clips for each textbook chapter.
- **Computerized Test Bank in Cognero**—Hundreds of modifiable questions for exams, quizzes, in-class work, or homework assignments in an online platform.
- **Image Gallery**—Access to hundreds of images from the textbook that can be used to easily customize the PowerPoint outlines.
- **Photo Sequences**—Each of the Photo Sequences from the textbook are provided within PowerPoint for easy classroom projection.
- **End-of-Chapter Review Questions**—Word files of all textbook review questions are provided for easy distribution to students.
- **Instructor's Manual**—An electronic version of the Instructor's Manual provides lecture outlines with teaching hints, answers to review questions from the textbook, and answers to *Tech Manual* questions, as well as guidelines for using the *Tech Manual*. A correlation chart to the current ASE Education Foundation Standards provides references to topic coverage in both the text and *Tech Manual*.
- **ASE Education Foundation Correlations**—The current ASE Education Foundation Automobile Standards are correlated to the chapter and page numbers of the core text and all relevant *Tech Manual* job sheets.
- **Job Sheet Template**—For instructors who develop their own job sheets, a template is provided to help with their formatting.

Mindtap for Automotive

MindTap is a personalized teaching experience with relevant assignments that guide students to analyze, apply, and improve thinking, allowing you to measure skills and outcomes with ease.

- *Personalized Teaching:* Becomes YOURS with a Learning Path that is built with key student objectives. Control what students see and when they see it—match your syllabus exactly by hiding, rearranging, or adding you own content.
- *Guide Students:* Goes beyond the traditional "lift and shift" model by creating a unique learning path of relevant readings, multimedia, and activities that move students up the learning taxonomy from basic knowledge and comprehension to analysis and application.
- *Measure Skills and Outcomes:* Analytics and reports provide a snapshot of class progress, time on task, engagement and completion rates.

CHAPTER 1

CAREERS IN THE AUTOMOTIVE INDUSTRY

OBJECTIVES

- Describe the various types of jobs available in the automotive industry.
- Explain how computer technology has changed the way vehicles are built and serviced.
- Explain why the need for qualified automotive technicians is increasing.
- Describe the major types of businesses that employ automotive technicians.
- List some of the many job opportunities available to people with a background in automotive technology.
- Describe the different ways a student can gain work experience while attending classes.
- Describe the requirements for ASE certification as an automotive technician and as a master auto technician.

The Automotive Industry

Each year millions of new cars and light trucks are produced and sold in North America **(Figure 1–1)**. The automotive industry's part in the total economy of the United States is second only to the food industry. Manufacturing, selling, and servicing these vehicles are parts of an incredibly large, diverse, and expanding industry.

Forty years ago, America's "big three" automakers—General Motors Corporation, Ford Motor Company, and Chrysler Corporation—dominated the auto industry. This is no longer true. The industry is now a global industry **(Table 1–1)**. Automakers from Japan, Korea, Germany, Sweden, and other European and Asian countries compete with companies in the United States for domestic and foreign sales.

Several foreign manufacturers, such as BMW, Honda, Hyundai, Mercedes-Benz, Nissan, Toyota, and Volkswagen, operate assembly plants in the United States and Canada. Automobile manufacturers have joined together, or merged, to reduce costs and increase market share. In addition, many smaller

FIGURE 1–1 Ford's F-150 pickup has been the best-selling vehicle in America for many years.

auto manufacturers have been bought by larger companies to form large global automobile companies. Most often the ownership of a company is not readily identifiable by the brand name.

This cooperation between manufacturers has given customers an extremely wide selection of vehicles to choose from. This variety has also created new challenges for automotive technicians, based on one simple fact: Along with the different models come different systems.

The Importance of Auto Technicians

The automobile started out as a simple mechanical beast. It moved people and things with little regard to the environment, safety, and comfort.

TABLE 1–1 FACTS ABOUT THE PASSENGER CARS AND LIGHT- AND MEDIUM-DUTY TRUCKS SOLD IN NORTH AMERICA (ALL FIGURES ARE APPROXIMATE).

Manufacturer	Owned by	Common Brands	Country of Origin	Annual Sales
BMW AG	Shareholders 53% and Family 47%	BMW, Mini, and Rolls-Royce	Germany	350 thousand
Chrysler Group	Fiat 59% and UAW 41%	Chrysler, Dodge, and Ram	Italy and North America	2.2 million
Daimler AG	Aabar Investments 8%, Kuwait Investments 7%, Renault-Nissan 3%, and Shareholders 81%	Bentley, Daimler Trucks & Buses, Mercedes-Benz, and Smart	Germany	478 thousand
Fiat S.P.A.	Family 30% and Shareholders 70%	Abarth, Alfa Romeo, Chrysler, Ferrari, Fiat, Lancia, and Maserati	Italy	33 thousand
Ford Motor Company	Family 40% and Shareholders 60%	Ford and Lincoln	North America	2.4 million
Fuji Heavy Ind. Ltd.	Shareholders 81%, Toyota 16%, Suzuki 2%, and Fuji 1%	Subaru	Japan	647 thousand
Geely Automotive	Li Shu Fu 50% and Shareholders 50%	Volvo	China	81 thousand
General Motors	UAW Trust 10%, Canada DIC 9% and Shareholders 81%	Buick, Cadillac, Chevrolet, GMC, and Holden	North America	3 million
Honda Motor Co.	Shareholders 80%, Japan Trustee Bank 8%, and Master Trust Bank of Japan, Moxley & Co., and JP Morgan Chase 4% each	Acura and Honda	North America and Japan	1.5 million
Hyundai Motor Co.	Shareholders 74%, Hyundai Mobis 21%, and Chung Mong-Koo 5%	Hyundai and Kia	Korea	1.3 million

TABLE 1–1 *(continued)*

Manufacturer	Owned by	Common Brands	Country of Origin	Annual Sales
Mazda Motor Corp.	Shareholders 80%, Japan Trustee Bank and Chase Manhattan 5% each, and Master Trust of Japan, Mitori Bank Corp., and Ford Motor Co. 4% each	Mazda	Japan	289 thousand
Mitsubishi Motors	Shareholders 71% and Mitsubishi Corp. 29%		Japan	103 thousand
Nissan Motor Corp.	Shareholders 52%, Renault SA 44%, Nissan 1%, and Daimler 3%	Nissan and Infiniti	Japan	1.6 million
Porsche Auto Holding	Volkswagen AG	Porsche	Germany	55 thousand
Tata Motors	Tata 35%, Indian Banks 14%, and Shareholders 50%	Jaguar, Rover, and Tata	India	128 thousand
Toyota Motor Corp.	Shareholders 85%, Toyota 9%, and Others 6%	Daihatsu, Isuzu, Lexus, Scion, Telsa, and Toyota	Japan	2.4 million
Volkswagen AG	Porsche 54%, Lower Saxony 20%, Qatar Holding 17%, and Shareholders 10%	Audi, Bentley, Bugatti, Lamborghini, and Volkswagen	Germany	500 thousand

Through the years, these concerns have provided the impetus for design changes. One area that has affected automobile design the most is the same area that has greatly influenced the rest of our lives, electronics. Today's automobiles are sophisticated electronically controlled machines. To provide comfort and safety while being friendly to the environment, today's automobiles use the latest developments of many different technologies—mechanical and chemical engineering, hydraulics, refrigeration, pneumatics, physics, and, of course, electronics.

An understanding of electronics is a must for all automotive technicians **(Figure 1–2)**. The needed level of understanding is not that of an engineer; rather, technicians need a practical understanding of electronics. In addition to having the mechanical skills needed to remove, repair, and replace faulty or damaged components, today's technicians also must be able to diagnose and service complex electronic systems.

Computers and electronic devices are used to control the operation of nearly all systems of an automobile. Because of these controls, today's automobiles use less fuel, perform better, and run cleaner than those in the past. The number of electronically controlled systems on cars and trucks increases each year. There are many reasons for the heavy insurgence of electronics into automobiles. Electronics are based on electricity and electricity moves at the speed of light. This means the operation of the various systems can be monitored and changed very quickly. Electronic components have no moving parts, are durable, do not require periodic adjustments, and are very light. Electronics also allow the various systems to work together, which increases the efficiency of each system, and therefore the entire vehicle.

The application of electronics has also led to the success of hybrid and electric vehicles **(Figure 1–3)**. A hybrid vehicle has two separate sources of power. Those power sources can work together to move the vehicle or power the vehicle on their own. Today's hybrid vehicles are moved by electric motors and/or a gasoline engine. Hybrid vehicles are complex machines and all who work on them must be

FIGURE 1–2 An understanding of electronics is a must for all automotive technicians.

properly trained. Advanced electronics has also led to the resurgence of pure electric vehicles, with over 150,000 new electric vehicles sold in the United States in 2016 alone.

The design of today's automobiles is also influenced by legislation. Throughout history, automobile manufacturers have been required to respond to new laws designed to make automobiles safer and cleaner running. In response to these laws, new systems and components are introduced. Anyone desiring to be a good technician and have a successful career must regularly update his or her skills to keep up with the technology.

Legislation has not only influenced the design of gasoline-powered vehicles, it has also led to a wider use of diesel engines in passenger vehicles. By mandating cleaner diesel fuels, the laws have opened the door for clean burning and highly efficient diesel engines. Many states have laws that require owners to have their vehicles exhaust tested on an annual basis. Some states require automobiles to pass an annual or biannual inspection.

FIGURE 1–3 A charging station at a new car dealership.

The Need for Quality Service

The need for good technicians continues to grow. Currently there is a great shortage of qualified automotive technicians. This means there are, and will be, excellent career opportunities for good technicians. Good technicians are able to diagnose and repair problems in today's automobiles **(Figure 1–4)**.

Car owners demand that when things go wrong, they should be "fixed right the first time." The primary reason some technicians are unable to fix a particular problem is simply that they cannot find the cause of the problem. Today's vehicles are complex and a great amount of knowledge and understanding is required for good diagnostic skills. Today's technicians must be able to identify and solve problems the first time the vehicle is brought into the shop.

FIGURE 1–4 Good technicians are able to follow specific manufacturers' diagnostic charts and interpret the results of diagnostic tests.

The Need for Ongoing Service

Electronic controls have not eliminated the need for routine service and scheduled maintenance **(Figure 1–5)**. In fact, they have made it more important than ever. But electronic systems can automatically make adjustments to compensate for some problems, a computer cannot replace worn parts. A computer cannot tighten loose belts or change dirty coolant or engine oil. Simple problems such as these can set off a chain of unwanted events in an engine control system. Electronic controls are designed to help a well-maintained vehicle operate efficiently. They are not designed to repair systems.

Electronic systems are based on the same principles as a computer. In fact, these systems rely on computers to control the operation of a component or system. Instead of a keyboard, automotive electronic systems rely on sensors or inputs. These send information to the computer. The computer receives the inputs and through computer logic causes a component to change the way it is operating. These controlled outputs are similar to your computer screen or printer.

Each automobile manufacturer recommends that certain maintenance services be performed according to a specific schedule. These maintenance procedures are referred to as **preventive maintenance (PM)** because they are designed to prevent problems. Scheduled PM normally includes oil and filter changes; coolant and lubrication services; replacement of belts and hoses; and replacement of spark plugs, filters, and worn electrical parts **(Figure 1–6)**.

If the owner fails to follow the recommended maintenance schedule, the vehicle's warranty might

FIGURE 1–5 Regular preventive maintenance (PM) is important for keeping electronic control systems operating correctly. A common part of PM is changing the engine's oil and filter.

5,000 MILES OR 6 MONTHS

- Replace engine oil and oil filter
- Reset service reminder indicator display
- Rotate tires
- Visually inspect brake linings and fluid level
- Inspect wiper blades
- Check windshield washer fluid level and system
- Check tires and spare wheel for pressure and wear

Additional items for special operating conditions

- Rotate tires and reset TPMS
- Inspect ball joints and dust covers
- Inspect drive shaft boots
- Inspect air filter
- Inspect steering linkage and boots
- Re-torque drive shaft bolt
- Tighten nuts and bolts on chassis

15,000 MILES OR 18 MONTHS

(Same as 5,000 miles and 6 months) ***Plus****:*

- Inspect battery and cables
- Check and replenish coolant level
- Clean or replace cabin air filter
- Replace fuel filter
- Lubricate hinges
- Rotate tires and reset TPMS
- Inspect the following:
  - Engine for leaks
  - Exhaust for leaks
  - Transmission for leaks
  - Final drive(s) for leaks
  - Drive belts
  - All lighting
  - Horn operation
  - Ball joints and dust covers
  - Drive shaft boots
  - Drive axle play
  - Water drain for A/C
  - Engine air filter
  - Steering linkage and boots
  - Re-torque drive shaft bolt
  - Tighten nuts and bolts on chassis

30,000 MILES OR 36 MONTHS

(Same as 5,000 miles and 6 months) ***Plus****:*

- Replace cabin filter
- Rotate tires and reset TPMS
- Replace engine air filter
- In addition, inspect the following:
  - Brake lines and hoses
  - Differential oil
  - Engine coolant
  - Exhaust pipes and mountings
  - Fuel lines and connections, fuel tank band and fuel tank vapor system hoses
  - Fuel tank cap gasket
  - Radiator core and condenser
  - Steering gear box
  - Steering linkage and boots
  - Transmission fluid or oil

Additional items for special operating conditions

(Same as 5,000 miles and 6 months)

45,000 MILES OR 54 MONTHS

(Same as 15,000 miles and 18 months)

Additional items for special operating conditions

(Same as 6,000 miles and 6 months)

60,000 MILES OR 72 MONTHS

(Same as 15,000 miles and 18 months) ***Plus****:*

- Inspect:
  - Drive belts
  - Engine valve clearance

Additional items for special operating conditions

(Same as 6,000 miles and 6 months) ***Plus****:*

- Replace differential oil
- Replace transmission oil or fluid

75,000 MILES OR 84 MONTHS

(Same as 15,000 miles and 18 months) ***Plus****:*

- Check power-steering fluid
- Inspect:
  - Drive belts
  - Engine valve clearance

Additional items for special operating conditions

(Same as 6,000 miles and 6 months)

FIGURE 1-6 A typical preventive maintenance schedule.

not cover problems that result. For example, if the engine fails during the period covered by the warranty, the warranty may not cover the engine if the owner does not have proof that the engine's oil was changed according to the recommended schedule and with the correct oil.

Warranties A new car warranty is an agreement by the auto manufacturer to have its authorized dealers repair, replace, or adjust certain parts if they become defective. This agreement typically lasts until the vehicle has been driven 36,000 miles (58,000 km), and/or has been owned for 3 years. However, some manufacturers offer warranties that cover some systems as long as 100,000 miles (161,000 km) or 10 years.

The details of most warranties vary with the manufacturer, vehicle model, and year. Most manufacturers also provide a separate warranty for the powertrain (engine, transmission, and so on) that covers these parts for a longer period than the basic warranty. There are also additional warranties for other systems or components of the vehicle.

Often, according to the terms of the warranty, the owner must pay a certain amount of money called the **deductible**. The manufacturer pays for all repair costs over the deductible amount.

Battery and tire warranties are often prorated, which means that the amount of the repair bill covered by the warranty decreases over time. For example, a battery with a 72-month warranty fails after 60 months. The original price of the battery is divided by 72 and the cost per month is then multiplied by the months remaining in the warranty period. Some warranties are held by a third party, such as the manufacturer of the battery or tires. Although the manufacturer sold the vehicle with the battery or set of tires, their warranty is the responsibility of the maker of that part.

There are also two government-mandated warranties: the Federal Emissions Defect Warranty and the Federal Emissions Performance Warranty. The Federal Emissions Defect Warranty ensures that the vehicle meets all required emissions regulations and that the vehicle's emission control system works as designed and will continue to do so for 2 years or 24,000 miles. The warranty does not cover problems caused by accidents, floods, misuse, modifications, poor maintenance, or the use of leaded fuels. The systems typically covered by this warranty are:

- Air induction
- Fuel metering
- Ignition
- Exhaust
- Positive crankcase ventilation
- Fuel evaporative control
- Emission control system sensors

The Federal Emissions Performance Warranty covers the catalytic converter(s) and engine control module for a period of 8 years or 80,000 miles (129,000 km). If the owner properly maintains the vehicle and it fails an emissions test approved by the Environmental Protection Agency (EPA), an authorized service facility will repair or replace the emission-related parts covered by the warranty at no cost to the owner. Some states, such as California, require the manufacturers to offer additional or extended warranties.

The manufacturers of hybrid vehicles typically have a warranty on the vehicle's battery that covers 8 to 10 years and up to 100,000 miles (161,000 km). This is important because the batteries may cost thousands of dollars.

All warranty information can be found in the vehicle's owner's manual. Whenever there are questions about the warranties, carefully read that section in the owner's manual. If you are working on a vehicle and know that the part or system is covered under a warranty, make sure to tell the customer before proceeding with your work. Doing this will save the customer money and you will earn his or her trust.

Career Opportunities

Automotive technicians can enjoy careers in many different types of automotive businesses **(Figure 1–7)**. Because of the skills required to be a qualified technician, there are also career opportunities for those who do not want to repair automobiles the rest of their lives. The knowledge required to be a good technician can open many doors of opportunity.

Dealerships New car dealerships **(Figure 1–8)** serve as the link between the vehicle manufacturer and the customer. They are privately owned businesses. Most dealerships are franchised operations, which means the owners have signed a contract with particular auto manufacturers and have agreed to sell and service their vehicles.

The manufacturer usually sets the sales and service policies of the dealership. Most warranty repair work is done at the dealership. The manufacturer then pays the dealership for making the repair. The manufacturer also provides the service department at the dealership with the training, special tools, equipment, and information needed to repair its vehicles. The manufacturers also help the dealerships get service business. Often, their commercials

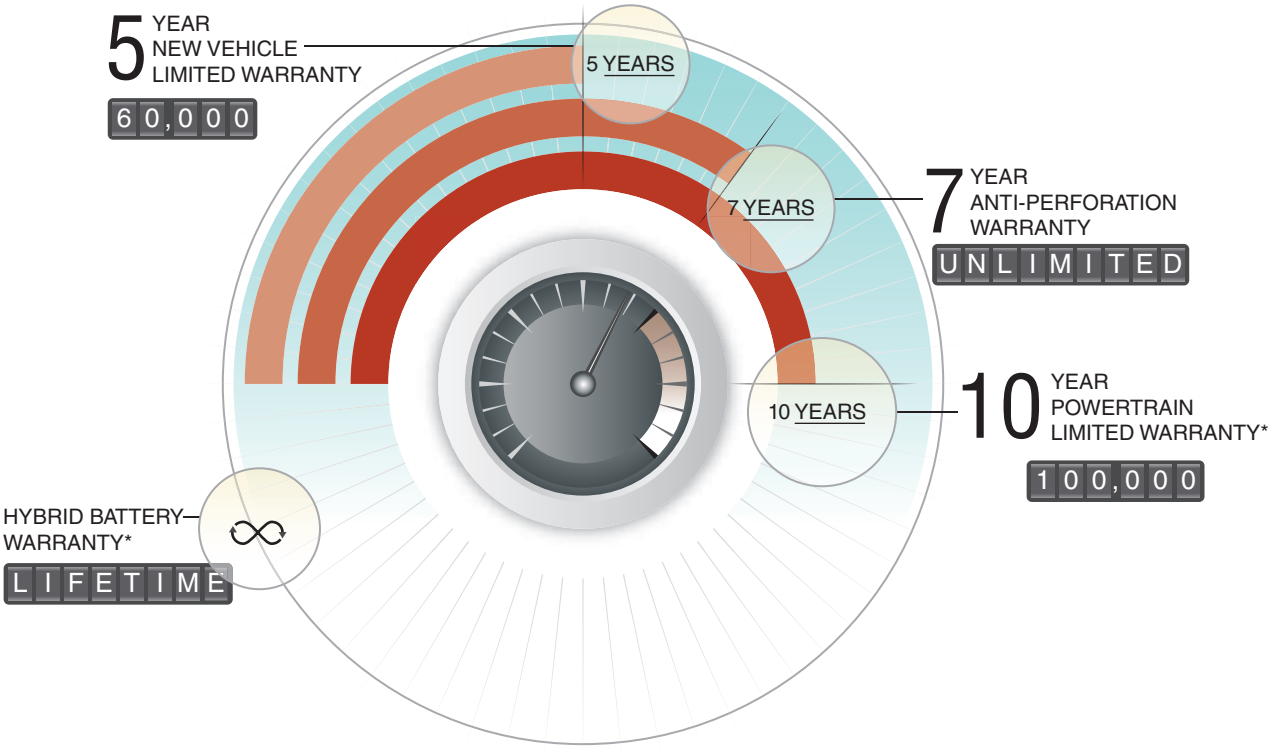


FIGURE 1–7 An example of different warranties all on one vehicle.

stress the importance of using their replacement parts and promote their technicians as the most qualified to work on their products.

Working for a new car dealership can have many advantages. Technical support, equipment, and the opportunity for ongoing training are usually excellent. At a dealership, you have a chance to become very skillful in working on the vehicles you service. However, working on one or two types of vehicles does not appeal to everyone. Some technicians want diversity.

Independent Service Shops Independent shops **(Figure 1–9)** may service all types of vehicles or may specialize in particular types of cars and trucks, or specific systems of a car. Independent shops outnumber dealerships by six to one. As the name states, an independent service shop is not associated with any particular automobile manufacturer. Many independent shops are started by technicians eager to be their own boss and run their own business.

FIGURE 1–8 Dealerships sell and service vehicles made by specific auto manufacturers.

FIGURE 1–9 Full-service gasoline stations are not as common as they used to be, but they are a good example of an independent service shop.

FIGURE 1–10 A bay in an independent service shop.

An independent shop may range in size from a two-bay garage with two to four technicians to a multiple-bay service center with twenty to thirty technicians. A bay is simply a work area for a complete vehicle **(Figure 1–10)**. The amount of equipment in an independent shop varies; however, most are well equipped to do the work they do best. Working in an independent shop may help you develop into a well-rounded technician.

Specialty shops specialize in areas such as engine rebuilding, transmission overhauling, and air conditioning, brake, exhaust, cooling, emissions, and electrical work. A popular type of specialty shop is the "quick lube" shop, which takes care of the PM of vehicles. It hires lubrication specialists who change fluids, belts, and hoses in addition to checking certain safety items on the vehicle.

The number of specialty shops that service and repair one or two systems of the automobile have steadily increased over the past 10 to 20 years. Technicians employed by these shops have the opportunity to become very skillful in one particular area of service.

Franchise Repair Shop A great number of jobs are available at service shops that are run by large companies such as Firestone, Goodyear, and Midas. These shops do not normally service and repair all of the systems of the automobile. However, their customers do come in with a variety of service needs. Technicians employed by these shops have the opportunity to become very proficient in many areas of service and repair.

FIGURE 1–11 Independent repair shops are often affiliated with a large business. In these arrangements, the shops are still run independently.

Some independent shops may look like they are part of a franchise but are actually independent. Good examples of this type of shop are the NAPA service centers **(Figure 1–11)**. These centers are not controlled by NAPA, nor are they franchises of NAPA. They are called NAPA service centers because the facility has met NAPA's standards of quality and the owner has agreed to use NAPA as the primary source of parts and equipment.

Store-Associated Shops Other major employers of auto technicians are the service departments of department stores. Many large stores that sell automotive parts often offer certain types of automotive services, such as brake, exhaust system, and wheel and tire work.

Fleet Service and Maintenance Any company that relies on several vehicles to do its business faces an ongoing vehicle service and PM problem. Small fleets often send their vehicles to an independent shop for maintenance and repair. Large fleets, however, usually have their own PM and repair facilities and technicians **(Figure 1–12)**.

Utility companies (such as electric, telephone, or cable TV), car rental companies, overnight delivery services, and taxicab companies are good examples of businesses that usually have their own service departments. These companies normally purchase their vehicles from one manufacturer. Technicians who work on these fleets have the same opportunities and benefits as technicians in a dealership. In fact, the technicians of some large fleets are authorized to do warranty work for the manufacturer. Many good career opportunities are available in this segment of the auto service industry.