



**Automotive** Fourth Edition  
**Technology**

*Principles, Diagnosis, and Service*



**James D. Halderman**

# **AUTOMOTIVE TECHNOLOGY**

## **Principles, Diagnosis, and Service**

FOURTH EDITION

**James D. Halderman**

**Prentice Hall**

Boston Columbus Indianapolis New York San Francisco Upper Saddle River  
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montreal  
Toronto Delhi Mexico City Sao Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

Editorial Director: Vernon Anthony  
Acquisitions Editor: Vernon Anthony  
Development Editor: Dan Trudden  
Editorial Assistant: Yvette Schlarman  
Director of Marketing: David Gesell  
Senior Marketing Manager: Harper Coles  
Senior Marketing Coordinator: Alicia Wozniak  
Marketing Assistant: Les Roberts  
Senior Managing Editor: JoEllen Gohr  
Project Manager: Jessica H. Sykes  
Senior Operations Supervisor: Pat Tonneman

Senior Art Director: Diane Ernsberger  
Text and Cover Designer: Anne DeMarinis  
Cover Art: Jennings Terrance/SIPA/Newscom  
Media Editor: Michelle Churma  
Lead Media Project Manager: Karen Bretz  
Full-Service Project Management: S4Carlisle  
Publishing Services/Kelli Jauron  
Composition: S4Carlisle Publishing Services  
Printer: R.R. Donnelley/Willard  
Cover Printer: Lehigh-Phoenix Color/Hagerstown  
Text Font: Helvetica Neue LT Std, 9/12

---

Copyright © 2012, 2009, 2003, 1999 Pearson Education, Inc., publishing as Pearson Education, 1 Lake Street, Upper Saddle River, New Jersey 07458. All rights reserved. Manufactured in the United States of America. This publication is protected by Copyright, and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise. To obtain permission(s) to use material from this work, please submit a written request to Pearson Education, Inc., Permissions Department, Pearson Education, 1 Lake Street, Upper Saddle River, New Jersey 07458.

Many of the designations by manufacturers and seller to distinguish their products are claimed as trademarks. Where those designations appear in this book, and the publisher was aware of a trademark claim, the designations have been printed in initial caps or all caps.

10 9 8 7 6 5 4 3 2 1

**Prentice Hall**  
is an imprint of



[www.pearsonhighered.com](http://www.pearsonhighered.com)

ISBN-10: 0-13-254261-7  
ISBN-13: 978-0-13-254261-6

# PREFACE

## UPDATES TO THE FOURTH EDITION

- Number of chapters increased from 103 to 130.
- Many long chapters were split and content was reorganized to make teaching and learning easier.
- New chapters include:
  - Chapter 17 – Preventive Maintenance and Service Procedures
  - Chapter 19 – Diesel Engine Operation and Diagnosis
  - Chapter 20 – Coolant
  - Chapter 22 – Engine Oil
  - Chapter 27 – In-Vehicle Engine Service
  - Chapter 36 – Gaskets and Sealants
  - Chapter 37 – Engine Assembly and Dynamometer Testing
  - Chapter 49 – CAN and Network Communications
  - Chapter 66 – Gasoline
  - Chapter 67 – Alternative Fuels
  - Chapter 68 – Diesel and Biodiesel Fuels
  - Chapter 79 – Gasoline Direct Injection Systems
  - Chapter 80 – Electronic Throttle Control Systems
  - Chapter 108 – Electronic Stability Control Systems
  - Chapter 110 – Tire Pressure Monitoring Systems
  - Chapter 115 – Electronic Suspension Systems
  - Chapter 127 – Automatic Transmission/Transaxle Principles
  - Chapter 128 – Hydraulic Components and Control Systems
  - Chapter 129 – Automatic Transmission/Transaxle Diagnosis and In-Vehicle Service
  - Chapter 130 – Automatic Transmission/Transaxle Unit Repair
- Over 300 new color photos and line drawings.
- New design, showing major and minor headings, is clearer and makes it easier to grasp important information.

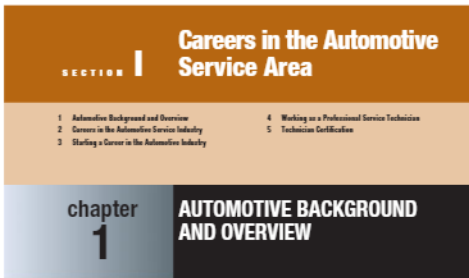
**ASE AND NATEF CORRELATED** This comprehensive textbook is divided into sections that correspond to the eight areas of certifications as specified by the National Institute for Automotive Service Excellence (ASE) and the National Automotive Technicians Education Foundation (NATEF). The areas of the ASE material certification test are listed in the objectives at the beginning of each chapter, and all laboratory worksheets are correlated to the NATEF Task List.

**A COMPLETE INSTRUCTOR AND STUDENT SUPPLEMENT PACKAGE** This book is accompanied by a full set of instructor and student supplements. Please see page v for a detailed list of supplements.

**A FOCUS ON DIAGNOSIS AND PROBLEM SOLVING** The primary focus of this textbook is to satisfy the need for problem diagnosis. Time and again, the author has heard that technicians need more training in diagnostic procedures and skill development. To meet this need and to help illustrate how real problems are solved, diagnostic stories are included throughout. Each new topic covers the parts involved as well as their purpose, function, and operation, and how to test and diagnose each system.

The following pages highlight the unique core features that set this book apart from other automotive textbooks.

# IN-TEXT FEATURES



**OBJECTIVES:** After studying Chapter 1, the reader will be able to:

- Explain the evolution of the automobile.
- Discuss the major components of a vehicle.
- Describe the evolution of engines.
- List the common components of most vehicles.
- List the eight areas of automotive careers according to ASE/NATEF.

**KEY TERMS:** Air filter 2 • Body 2 • Body-on-frame (BOF) 3 • Carbon monoxide (CO) 5 • Catalytic converter 5 • Chassis 2 • Control 2 • Drive shaft 2 • Double overhead camshaft (DOHC) 4 • Inoperative emission system (IES) 5 • Exhaust gas recirculation (EGR) 5 • Fuelhead 4 • Ignition 3 • Ignition coil 3 • Ignition control module (ICM) 5 • Intake engine 5 • Intake manifold 5 • Internal combustion engine 4 • Malfunction indicator lamp (MIL) 5 • Manufacturer's suggested retail price (MSRP) 4 • OBD-II 5 • Oil filter 5 • Oil galleys 5 • Oil pan 5 • Oil pump 5 • Oil sump 5 • Overhead camshaft (OHC) 4 • Overhead valve (OHV) 4 • Oxide of nitrogen (NO<sub>x</sub>) 5 • PCV valve 5 • Piston 3 • Positive crankcase ventilation (PCV) 5 • Regular shaft 5 • Radiator 5 • Scan tool 5 • Self-propelled vehicle 5 • Single overhead camshaft (SOHC) 4 • Thermostat 5 • Transaxle 6 • Transfer case 6 • Unibody 5 • Universal joints (U-joints) 5 • Water jackets 5 • Water pump 5

## HISTORICAL BACKGROUND

For centuries, man either walked or used animals to provide power for transportation. After the invention of electric, steam, and gasoline propulsion systems, people used self-propelled vehicles, which are vehicles that moved under their own power.

Major milestones in vehicle development include:

- 1876 The Otto four-stroke cycle engine was developed by a German engineer, Nikolaus Otto.
- 1885 The first automobile was powered by an Otto cycle gasoline engine designed by Karl Benz in Germany (1844-1929).
- 1889 Rudolf Diesel (1858-1913) received a patent for a compression ignition engine. The first diesel engine was built in 1892.

- 1886 Henry Ford (1863-1947) built the first car, called the Quadricycle. # SEE FIGURE 1-1.
- 1900 About 4,000 total automobiles were sold, including:
  - 40% were steam powered
  - 30% were battery/electric powered
  - 30% were gasoline engine powered
- 1907 Chevrolet, trademarked by General Motors (1904-1916), produced the first large-scale, affordable vehicle.
- 1908 William Durant (1863-1947) formed General Motors.
- 1908 The Ford Model T was introduced.

AUTOMOTIVE BACKGROUND AND OVERVIEW 1

**OBJECTIVES AND KEY TERMS** appear at the beginning of each chapter to help students and instructors focus on the most important material in each chapter. The chapter objectives are based on specific ASE and NATEF tasks.



## TECH TIP

### Right to Tighten

Whenever removing any automotive component, it is wise to screw the bolts back into the holes a couple of threads by hand. This ensures that the right bolt will be used in its original location.

**TECH TIP** feature real-world advice and “tricks of the trade” from ASE-certified master technicians.



## SAFETY TIP

### Shop Cloth Disposal

Always dispose of oily shop cloths in an enclosed container to prevent a fire. ● **SEE FIGURE 1-69.** Whenever oily cloths are thrown together on the floor or workbench, a chemical reaction can occur, which can ignite the cloth even without an open flame. This process of ignition without an open flame is called **spontaneous combustion**.

**SAFETY TIPS** alert students to possible hazards on the job and how to avoid them.



## REAL WORLD FIX

### Lightning Damage

A radio failed to work in a vehicle that was outside during a thunderstorm. The technician checked the fuses and verified that power was reaching the radio. Then the technician noticed the antenna. It had been struck by lightning. Obviously, the high voltage from the lightning strike traveled to the radio receiver and damaged the circuits. Both the radio and the antenna were replaced to correct the problem. ● **SEE FIGURE 26-26.**

**REAL WORLD FIXES** present students with actual automotive service scenarios and show how these common (and sometimes uncommon) problems were diagnosed and repaired.



## FREQUENTLY ASKED QUESTION

### What Is an “SST?”

Vehicle manufacturers often specify a **special service tool (SST)** to properly disassemble and assemble components, such as transmissions and other components. These tools are also called special tools and are available from the vehicle manufacturer or their tool supplier, such as Kent-Moore and Miller tools.

**FREQUENTLY ASKED QUESTIONS** are based on the author’s own experience and provide answers to many of the most common questions asked by students and beginning service technicians.

**NOTE:** Most of these “locking nuts” are grouped together and are commonly referred to as *revailing torque nuts*. This means that the nut will hold its tightness or torque and not loosen with movement or vibration.

**NOTES** provide students with additional technical information to give them a greater understanding of a specific task or procedure.

**CAUTION:** Never use hardware store (nongraded) bolts, studs, or nuts on any vehicle steering, suspension, or brake component. Always use the exact size and grade of hardware that is specified and used by the vehicle manufacturer.

**CAUTIONS** alert students about potential damage to the vehicle that can occur during a specific task or service procedure.

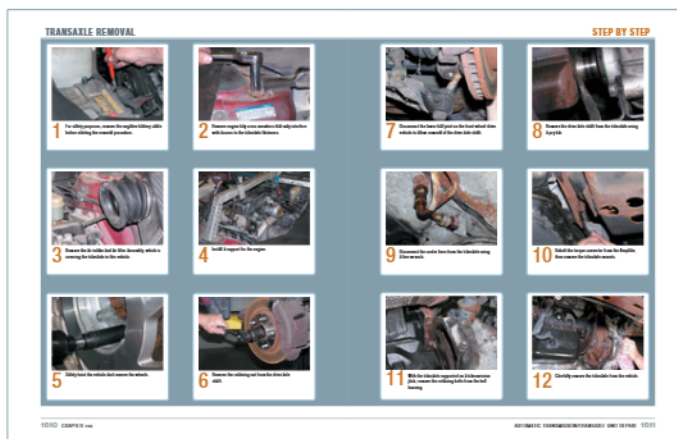




## WARNING

Do not use incandescent trouble lights around gasoline or other flammable liquids. The liquids can cause the bulb to break and the hot filament can ignite the flammable liquid which can cause personal injury or even death.

**WARNINGS** alert students to potential dangers to themselves during a specific task or service procedure.



**STEP-BY-STEP** photo sequences show in detail the steps involved in performing a specific task or service procedure.

## REVIEW QUESTIONS

1. What are the typical operations needed when disassembling an automatic transmission/transaxle?
2. What are two methods of checking a clutch pack?
3. Why is it important to perform an end play check of an automatic transmission/transaxle during the reassembly process?
4. Why is it important to flush the automatic transmission fluid cooler when a rebuilt or replacement automatic transmission/transaxle is being installed in a vehicle?

## CHAPTER QUIZ

1. Technician A says that the torque converter should be separated from the flex (drive) plate before removing the automatic transmission/transaxle. Technician B says that the clutches should be installed "dry" when replacing the frictions and steels in a clutch pack. Which technician is correct?
  - a. Technician A only
  - b. Technician B only
  - c. Both Technicians A and B
  - d. Neither Technician A nor B
2. Air pressure checking is used to test \_\_\_\_\_.
  - a. Clutch packs
  - b. TV adjustment
  - c. Vacuum modulators
  - d. Governors
3. Technician A says that all friction and steel plates in a clutch pack should be replaced during an overhaul. Technician B says that the automatic transmission fluid cooler should always be flushed when a unit is rebuilt or replaced. Which technician is correct?
  - a. Technician A only
  - b. Technician B only
  - c. Both Technicians A and B
  - d. Neither Technician A nor B
4. Slide hammers or special pullers are used to remove what component?
  - a. Extension housing
  - b. Filter
  - c. Pump
  - d. Rear seal
5. What part must be replaced if dropped?
  - a. Pump
  - b. Torque converter
  - c. Extension housing
  - d. Pan
6. Technician A says that the sharp edges of spool valves should be rounded, using 400 grit sandpaper. Technician B says that all valve body parts should be cleaned and then dried using low pressure, filtered compressed air. Which technician is correct?
  - a. Technician A only
  - b. Technician B only
  - c. Both Technicians A and B
  - d. Neither Technician A nor B
7. Clutch pack clearance can be changed if not correct by using selective \_\_\_\_\_.
  - a. Piston
  - b. Pressure plate
  - c. Snap ring
  - d. One of the above depending on the unit
8. Friction discs should be \_\_\_\_\_ before being installed.
  - a. Sanded
  - b. Soaked in ATF
  - c. Surface roughed up
  - d. All of the above
9. How much transmission fluid should flow through the cooler?
  - a. 2 quarts every 30 seconds
  - b. 1 quart per minute
  - c. 2 quarts per minute
  - d. 2 pints per minute
10. Why should not assembly lube be avoided?
  - a. Can harm friction disks
  - b. Too slippery
  - c. Clogs filters
  - d. Looks like an ATF leak when it melts

1616 CHAPTER 130

**THE REVIEW QUESTIONS AND CHAPTER QUIZ** at the end of each chapter help students review the material presented in the chapter and test themselves to see how much they've learned.

## SUPPLEMENTS

**INSTRUCTOR SUPPLEMENTS** The instructor supplement package has been completely revamped to reflect the needs of today's instructors. The **Annotated Instructor's Guide (ISBN: 0-13-255157-8)** is the cornerstone of the package and includes:

- Chapter openers that list:
  - NATEF/ASE tasks covered in the chapter
  - All key terms
  - All chapter objectives
- The entire text (matching page numbers with student edition) with margin notes. These notes include:
  - Tips for in-class demonstrations
  - Suggested hands-on activities
  - Cross-curricular activities
  - Internet search tips
  - Assessments

- Safety Tips
- Classroom discussion questions
- A guide to using MyAutomotiveLab in the course

Also included in the instructor supplement package are:

- PowerPoint presentations
- Image Library containing every image in the book for use in class or customized PowerPoints
- TestGen software and test bank
- Chapter Quizzes
- Chapter Review Questions
- English and Spanish glossary
- NATEF Correlated Task Sheets
- NATEF/ASE Correlation Charts

To access supplementary materials online, instructors need to request an instructor access code. Go to [www.pearsonhighered.com/irc](http://www.pearsonhighered.com/irc) to register for an instructor access code. Within 48 hours of registering, you will receive a confirming e-mail including an instructor access code. Once you have received your code, locate your text in the online catalog and click on the Instructor Resources button on the left side of the catalog product page. Select a supplement, and a login page will appear. Once you have logged in, you can access instructor material for all Prentice Hall textbooks. If you have any difficulties accessing the site or downloading a supplement, please contact Customer Service at <http://247.prenhall.com>.

**STUDENT SUPPLEMENTS** Today's student has more access to the Internet than ever, so all supplemental materials are downloadable at the following site for no additional charge: [www.pearsoned.com/autostudent](http://www.pearsoned.com/autostudent)

On the site, students will find:

- PowerPoint presentations
- Chapter review questions and quizzes
- English and Spanish glossary
- A full Spanish translation of the text

## ACKNOWLEDGMENTS

A large number of organizations have cooperated in providing the reference material and technical information used in this text. The author wishes to express sincere thanks to the following organizations for their special contributions:

Accu Industries, Inc  
 Allied Signal Automotive Aftermarket  
 Arrow Automotive  
 ASE  
 Automotion, Inc  
 Automotive Engine Rebuilders Association (AERA)  
 Automotive Parts Rebuilders Association (APRA)  
 Automatic Transmission Rebuilders Association (ATRA)  
 Battery Council International (BCI)  
 Chrysler Corporation  
 Clayton Associates  
 Cooper Automotive Company  
 Dana Corporation, Perfect Circle Products  
 Defiance Engine Rebuilders, Incorporated  
 Delphi Chassis, GMC  
 The Dow Chemical Company  
 Duralcan USA  
 EIS Brake Parts  
 Envirotec Systems Corporation  
 Fel-Pro Incorporated  
 Fluke Corporation  
 FMSI  
 Ford Motor Company  
 General Electric Lighting Division  
 General Motors Corporation Service  
 Technology Group  
 Goodson Auto Machine Shop Tools and Supplies  
 Greenlee Brothers and Company  
 Hennessy Industries  
 Hunter Engineering Company  
 Jasper Engines and Transmissions  
 John Bean Company  
 Modine Manufacturing Company  
 Neway  
 Northstar Manufacturing Company, Inc.  
 Parsons and Meyers Racing Engines  
 Perfect Hofmann-USA  
 Raybestos Brake Parts, Inc.

Reynolds and Reynolds Company  
 Robert Bosch Corporation  
 Rottler Manufacturing  
 Shimco International, Inc.  
 SKF USA, Inc.  
 SnapOn Tools  
 Society of Automotive Engineers (SAE)  
 Specialty Productions Company  
 Sunnen Products Company  
 Toyota Motor Sales, USA, Inc.  
 TRW Inc.  
 Wurth USA, Inc.

The author would also like to thank the following individuals for their help.

Dan Avery  
 Tom Birch  
 Randy Dillman  
 Rick Escalambre, Skyline College  
 Bill Fulton, Ohio Automotive Technology  
 Jim Linder, Linder Technical Services, Inc.  
 Scot Manna  
 Dan Marinucci, Communique'  
 Jim Morton, Automotive Training center (ATC)  
 Dr. Norman Nall  
 Dave Scaler, Mechanic's Education Association  
 John Thornton, Autotrain  
 Mark Warren  
 Mike Watson, Watson Automotive LLC

**TECHNICAL AND CONTENT REVIEWERS** The following people reviewed the manuscript before production and checked it for technical accuracy and clarity of presentation. Their suggestions and recommendations were included in the final draft of the manuscript. Their input helped make this textbook clear and technically accurate while maintaining the easy-to-read style that has made other books from the same author so popular.

**Jim Anderson**  
 Greenville High School  
**Rankin E. Barnes**  
 Guilford Technical Community College

**Victor Bridges**

Umpqua Community College

**Darrell Deeter**

Saddleback College

**Matt Dixon**

Southern Illinois University

**Dr. Roger Donovan**

Illinois Central College

**A. C. Durdin**

Moraine Park Technical College

**Herbert Ellinger**

Western Michigan University

**Al Engledahl**

College of DuPage

**Robert M. Frantz**

Ivy Tech Community College, Richmond

**Christopher Fry**

Harry S. Truman College

**Larry Hagelberger**

Upper Valley Joint Vocational School

**Oldrick Hajzler**

Red River College

**Gary F. Ham**

South Plains College

**Betsy Hoffman**

Vermont Technical College

**Marty Kamimoto**

Fresno City College

**Richard Krieger**

Michigan Institute of Technology

**Steven T. Lee**

Lincoln Technical Institute

**Carlton H. Mabe, Sr.**

Virginia Western Community College

**Roy Marks**

Owens Community College

**Tony Martin**

University of Alaska Southeast

**Kerry Meier**

San Juan College

**Clifford G. Meyer**

Saddleback College

**Kevin Murphy**

Stark State College of Technology

**Fritz Peacock**

Indiana Vocational Technical College

**Dennis Peter**

NAIT (Canada)

**Kenneth Redick**

Hudson Valley Community College

**Matt Roda**

Mott Community College

**Omar Trinidad**

Southern Illinois University

**Mitchell Walker**

St. Louis Community College at Forest Park

Thanks to the myautomotivelab advisory board and contributors.

**Chris Tran**

San Jacinto College

**Homer Swihart**

San Jacinto College

**Craig Robinson**

Broward College

**Eric Erskin**

Ivy Tech Community College

**Robert Huettl**

Ivy Tech Community College

**Al Gentles**

Ranken Technical College

**Steve Quinn**

Olympic College

*Contributors:*

**David W. Foor**

Columbus State Community College

**Kevin Ruby**

Chattahoochee Technical College

**John Gardner**

Chipola College

**Dennis A. Iudice**

KDI Automotive University

**William T. Reny**

Transportation Component Solutions, LLC

**SPECIAL THANKS** I also wish to thank Chuck Taylor, Blaine Heeter, and Mike Garblik from Sinclair Community College in Dayton, Ohio, for their help with many of the photo sequences. A special thanks to Dick Krieger for his detailed and thorough reviews of the manuscript before publication.

Most of all, I want to thank my wife, Michelle Halderman, for her help in all phases of manuscript preparation.

—James D. Halderman



## ABOUT THE AUTHOR



**JIM HALDERMAN** brings a world of experience, knowledge, and talent to his work. His automotive service experience includes working as a flat-rate technician, a business owner, and a professor of automotive technology at a leading U.S. community college for more than 20 years.

He has a Bachelor of Science Degree from Ohio Northern University and a Masters Degree in Education from Miami University in Oxford, Ohio. Jim also holds a U.S. Patent for an electronic transmission control device. He is an ASE certified Master Automotive Technician and Advanced Engine Performance (L1) ASE certified.

Jim is the author of many automotive textbooks all published by Pearson Prentice Hall Publishing Company.

Jim has presented numerous technical seminars to national audiences including the California Automotive Teachers (CAT) and the Illinois College Automotive Instructor Association (ICAIA) as well as a member and presenter at the North American Council of Automotive Teachers (NACAT). Jim was also named Regional Teacher of the Year by General Motors Corporation and outstanding alumni of Ohio Northern University.

Jim and his wife, Michelle, live in Dayton, Ohio. They have two children.

[jim@jameshalderman.com](mailto:jim@jameshalderman.com)

# BRIEF CONTENTS

---

<b>SECTION I</b>	<b>Careers in the Automotive Service Area</b>	<b>1</b>
<b>chapter 1</b>	Automotive Background and Overview	1
<b>chapter 2</b>	Careers in the Automotive Service Industry	8
<b>chapter 3</b>	Starting a Career in the Automotive Industry	16
<b>chapter 4</b>	Working as a Professional Service Technician	24
<b>chapter 5</b>	Technician Certification	34
<b>SECTION II</b>	<b>Safety, Environmental, and Health Concerns</b>	<b>41</b>
<b>chapter 6</b>	Shop Safety	41
<b>chapter 7</b>	Environmental and Hazardous Materials	48
<b>SECTION III</b>	<b>Tools, Shop Equipment, and Measuring</b>	<b>57</b>
<b>chapter 8</b>	Fasteners and Thread Repair	57
<b>chapter 9</b>	Hand Tools	68
<b>chapter 10</b>	Power Tools and Shop Equipment	82
<b>chapter 11</b>	Vehicle Lifting and Hoisting	91
<b>chapter 12</b>	Measuring Systems and Tools	97
<b>SECTION IV</b>	<b>Principles, Math, and Calculations</b>	<b>105</b>
<b>chapter 13</b>	Scientific Principles and Materials	105
<b>chapter 14</b>	Math, Charts, and Calculations	114
<b>SECTION V</b>	<b>Vehicle Service Information, Identification, and Routine Maintenance</b>	<b>119</b>
<b>chapter 15</b>	Service Information	119
<b>chapter 16</b>	Vehicle Identification and Emission Ratings	125
<b>chapter 17</b>	Preventative Maintenance and Service Procedures	130
<b>SECTION VI</b>	<b>Engine Repair</b>	<b>146</b>
<b>chapter 18</b>	Gasoline Engine Operation, Parts, and Specifications	146
<b>chapter 19</b>	Diesel Engine Operation and Diagnosis	158
<b>chapter 20</b>	Coolant	175
<b>chapter 21</b>	Cooling System Operation and Diagnosis	182
<b>chapter 22</b>	Engine Oil	198
<b>chapter 23</b>	Lubrication System Operation and Diagnosis	210
<b>chapter 24</b>	Intake and Exhaust Systems	219
<b>chapter 25</b>	Turbocharging and Supercharging	227
<b>chapter 26</b>	Engine Condition Diagnosis	237
<b>chapter 27</b>	In-Vehicle Engine Service	252
<b>chapter 28</b>	Engine Removal and Disassembly	261