

Prentice Hall Multimedia Series in Automotive Technology

Second Edition

AUTOMOTIVE TECHNOLOGY



Principles, Diagnosis, and Service





WE SUPPORT **ASE PROGRAM** CERTIFICATION THROUGH



James D. Halderman

Chase D. Mitchell, Jr.



Jacob Been Lemoned

Contents

SECTION

Introduction |

1

The Automotive Service Industry 2

Objectives 2 Vehicle Construction 2 Frame Construction 2 Unit-Body Construction 3 Space-Frame Construction 3 Vehicle Assembly 4 Vehicle Dealer Preparation 5 Vehicle Service lobs 5 Technician Work Sites 7 Technician Pay Methods 8 Flagging an R.O. 9 Sublet Repairs 10 Parts Replacement 10 Technician Certification 11 Certification in Canada 13 Types of Jobs in the Automotive Service Industry 14 Payroll Taxes and Deductions 15 Summary 15 Review Questions 15 ASE Certification-Type Questions 16

2

Tools, Fasteners, and Safety 17

Objectives 17
Threaded Fasteners 17
Metric Bolts 18

Grades of Bolts 18 Nuts 19 Washers 20 Basic Tool List 20 Tool Sets and Accessories 28 Brand Name Versus Proper Term 29 Safety Tips for Using Hand Tools 29 Measuring Tools 29 Safety Tips for Technicians 32 Safety in Lifting (Hoisting) a Vehicle 34 Hazardous Materials 38 Material Safety Data Sheets 40 Electrical Cord Safety 40 Fire Extinguishers 40 Summary 47 Review Questions 47 ASE Certification-Type Questions 47

3

Preventative Maintenance and Service Procedures 48

Objectives 48
Identifying a Vehicle 48
Getting Ready for Service 49
Wiper Blade Inspection and Replacement 50
Air Filter Inspection/Replacement 50
Brake Fluid Level Inspection 51
Brake Fluid Types 51
Engine Oil Level and Condition 52
Engine Oil Changes 53
Viscosity of Oil (SAE Rating) 53
Quality of Oil (API Rating) 54
ILSAC Oil Rating 55
Synthetic Engine Oil 56
Engine Oil Disposal 56

Oil Filters 57 Cooling System Service 59 Antifreeze/Coolant Disposal 60 Radiator and Heater Hoses 60 Automatic Transmission Fluid Check 60 Types of Automatic Transmission Fluid 61 Power Steering Fluid 62 Windshield Washer Fluid 62 Accessory Drive Belt Inspection 63 Checking Tire Pressure 64 Tire Rotation 65 Wheel Mounting Torque 66 Tire Inspection 66 Chassis Lubrication 67 Chassis Grease 68 Other Under-the-Vehicle Lubrication Checks 69 Differential Fluid Check 70 Differential Lubrications 70 Manual Transmission/Transaxle Lubricant Check 70 Summary 76 Review Questions 76 ASE Certification-Type Questions 76

SECTION



Engine Repair 77

4

Engine Operation, Parts, and Specifications 78

Objectives 78 Energy and Power 78 Four-Stroke Cycle Operation 78 The 720° Cycle 80 Engine Classification 80 Engine Rotation Direction 82 Bore 83 Stroke 83 Engine Displacement 83 Compression Ratio 84 Compression After Machining 85 The Crankshaft Determines the Stroke 86 Torque 86 Work 87 Power 87 Horsepower 87 Horsepower and Altitude 90 Turbocharging 90 Supercharging 92 Summary 92 Review Questions 93 ASE Certification-Type Questions 93

5

Engine Condition Diagnosis 94

Objectives 94
Engine Smoke Diagnosis 94
Engine Noise Diagnosis 94
Vacuum Test 96
Compression Test 98
Wet Compression Test 100
Cylinder Leakage Test 100
Cylinder Power Balance Test 101
Power Balance Test Procedure 101
Oil Pressure Test 101
Oil Pressure Warning Lamp 102
Oil Leaks 102
Summary 107
Review Questions 107
ASE Certification-Type Questions 107

6

Engine Disassembly, Cleaning, and Crack Detection 108

Objectives 108 Engine Removal 108 Engine Disassembly 109 Checking Cylinder Bore 110 Removing the Oil Pan 110 Removing the Cylinder Ridge 111 Removing the Pistons 112 Removing the Harmonic Balancer 112 Removing the Timing Chain and Camshaft 112 Removing the Main Bearing and Crankshaft 113 Remove and Disassemble the Cylinder Head 113 Mechanical Cleaning 114 Chemical Cleaners 114 Solvent-Based Cleaning 115 Water-Based Chemical Cleaning 115 Spray Washing 116 Steam Cleaning 116 Thermal Cleaning 116 Cold Tank Cleaning 116 Hot Tank Cleaning 117 Vapor Cleaning 117 Ultrasonic Cleaning 117 Vibratory Cleaning 117 Blasters 117 Visual Inspection 118 Magnetic Crack Inspection 118 Dye-Penetrant Testing 118 Fluorescent-Penetrant Testing 118 Pressure Testing 119 Crack Repair 119 Crack-Welding Cast Iron 119

Objectives 126

Cooling and Lubrication Systems 126

Purpose and Function of the Cooling System 126 Cooling System Design 127 Thermostat Temperature Control 127 Coolant 130 The Design and Function of the Radiator 131 Coolant Recovery System 132 Testing the Cooling System 133 The Water Pump 135 Radiator Cooling Fans 136 Thermostatic Fans 137 Heater Core 137 Heater Problem Diagnosis 137 Coolant Temperature Warning Light 138 Burping the System 139 The Lubrication System 139 Oil Pressure Warning Lamp 145 Summary 147 Review Questions 147 ASE Certification-Type Questions 148

8

Cylinder Heads and Valves 149

Objectives 149 Hemispherical Combustion Chamber Wedge Combustion Chamber 150 Multiple-Valve Combustion Chamber 150 Intake and Exhaust Ports 150 Removing the Overhead Camshaft 151 Cylinder Head Reconditioning Sequence 151 Valve Guides 154 Valve Guide Replacement 157 Intake and Exhaust Valves 158 Valve Reconditioning Procedure 160 Valve Seat Replacement 162 Valve Stem Height 162 Valve Stem Seals 163 Installing the Valves 164 Summary 171 Review Questions 171 ASE Certification-Type Questions 171

9

Camshafts and Valve Trains | 172

Objectives 172 Camshaft Function 172 Camshaft Location 172 Camshaft Problem Diagnosis 173 Camshaft Removal 173 Camshaft Drives 174 Camshaft Belt Drives 175 Rocker Arms 175 Pushrods 179 Camshaft Duration 179 Cam Timing Chart 180 Installing the Camshaft 181 Degreeing the Camshaft 182 Lifters 182 Summary 186 Review Questions 186 ASE Certification-Type Questions 186

10

Pistons, Rings, and Connecting Rods 188

Objectives 188
Purpose and Function of Pistons, Rings, and Connecting
Rods 188
Piston and Rod Removal 188
Pistons 189
Compression Rings 193
Connecting Rods 196
Piston and Rod Assembly 198
Summary 203
Review Questions 203
ASE Certification-Type Questions 203

11

Engine Blocks, Crankshafts, and Bearings 204

Objectives 204
Block Manufacturing 204
Casting Numbers 205
Aluminum Blocks 205
The Block Deck and Passages 206
Main Bearing Caps 207
Engine Block Service 207
Cylinder Honing 210
Crankshaft Purpose and Function 212
Harmonic Balancer 213
Crankshaft Thrust Surface 214
Crankshaft Grinding 214

Balance Shafts 215
Engine Bearings 217
Summary 223
Review Questions 223
ASE Certification-Type Questions 223

12

Engine Assembly and Installation 224

Objectives 224 Cleaning Oil Galleries in the Block 224 Block Preparation 224 Installing Cups and Plugs 225 Engine Assembly 226 Installing One-Piece Main Seals 229 Installing Timing Drives for Pushrod Engines 229 Piston Fitting 229 Installing Piston Rings Onto Pistons 230 Checking Piston Ring Side Clearance 231 Installing Piston and Rod Assemblies 232 Head Gaskets 234 Installing Manifolds 238 Installing the Vibration Damper 238 Installing the Oil Pump 239 The Oil Pan 239 Engine Installation 240 Summary 247 Review Questions 247 ASE Certification-Type Questions 247



SECTION

Electrical/Electronic Systems 249

13

Electrical and Electronic Principles and Circuits 250

Objectives 250
Electricity 250
Circuits 257
Series Circuits 258
Parallel Circuits 261
Series-Parallel Circuits 261
Ohm's Law 261
Kirchhoff's Voltage Law 264
Kirchhoff's Current Law 266
Determining Total Resistance in a Parallel Circuit 267
Capacitors or Condensers 269
Magnetism 270
Electronic Principles 274
Transistors 279

Solar Cells 280
Integrated Circuits 280
Electrostatic Discharge (ESD) 280
Summary 281
Review Questions 282
ASE Certification-Type Questions 282

14

Meters, Scopes, Wiring, and Schematics 283

Objectives 283 Test Lights 283 Digital Multimeters 284 AC/DC Clamp-On Digital Multimeter 289 Electrical Unit Prefixes 292 How to Read Digital Meters 293 Analog Versus Digital Storage Oscilloscope 295 Oscilloscope Display Grid 295 Automotive Wiring 300 Braided Ground Straps 302 Battery Cables 303 Jumper Cables 303 Fuses and Circuit Protection Devices 303 Terminals and Connectors 307 Wire Repair 308 Wiring Diagrams 311 Switches 312 Relay Terminal Identification 312 Using Wiring Diagrams for Troubleshooting 316 Locating a Short Circuit 317 Electrical Troubleshooting Guide 320 Summary 331 Review Questions 331 ASE Certification-Type Questions 331

15

Batteries and Battery Testing 332

Objectives 332
Purpose of a Battery 332
Battery Construction 332
How a Battery Works 335
Specific Gravity 336
Battery Ratings 337
Deep Cycling 338
Battery Service 338
Jump-Starting 345
Battery Date Codes 345
Battery Drain Testing 346
Battery Troubleshooting Guide 350
Summary 352
Review Questions 352
ASE Certification-Type Questions 352

Cranking System Operation, Diagnosis, and Service 353

Objectives 353 Cranking Circuit 353 How the Starter Motor Works 354 Types of Starter Motors 356 Armature and Commutator Assembly Permanent-Magnet Fields 359 Gear-Reduction Starters 359 Starter Drives 361 Positive-Engagement Starters 362 Solenoid-Operated Starters 363 Starting System Troubleshooting 364 Voltage-Drop Testing 365 Control Circuit Testing 365 Specifications for a Starter Amperage Test 366 Starter Overhaul 369 Starting System Troubleshooting Guide 373 Summary 376 Review Questions 376 ASE Certification-Type Questions 376

17

Charging Circuit Operation, Diagnosis, and Service 377

Objectives 377
Principles of Generator Operation 377
Alternating-Current Generators (Alternators) 377
Generator Construction 377
How a Generator Works 380
Computer-Controlled Generators 386
Charging System Testing and Service 387
Generator Disassembly 397
Generator Assembly 401
Summary 409
Review Questions 409
ASE Certification-Type Questions 409

18

Lighting and Signaling Circuit Operation and Diagnosis 411

Objectives 411
Lighting 411
Bulb Numbers 411
Brake Lights 414
Headlight Switches 415
Sealed-Beam Headlights 417
Headlight Aiming 417

Composite Headlights 419
Halogen Sealed-Beam Headlights 419
High-Intensity Discharge Headlights 420
Daytime Running Lights 420
Dimmer Switches 420
Turn (Directional) Signals 422
Hazard Flashers 423
Courtesy Lights 423
Illuminated Entry 423
Fiber Optics 425
Feedback 425
Lighting System Troubleshooting Guide 426
Summary 428
Review Questions 428
ASE Certification-Type Questions 428

19

Dash Instruments Operation and Diagnosis 429

Objectives 429 Analog Dash Instruments 429 Computer-Controlled Instrument Panels 430 Dash Instrument Diagnosis 432 Telltale Lamps 432 Oil Pressure Warning Devices 432 Temperature Lamp Diagnosis 432 Brake Warning Lamp 434 Digital Electronic Dash Operation 435 Electronic Speedometers 439 Electronic Odometers 439 Electronic Speedometer and Odometer Service 441 Electronic Fuel-Level Gauges 441 Electronic Dash Instrument Diagnosis and Troubleshooting 442 Maintenance Reminder Lamps 444 Summary 447 Review Questions 447 ASE Certification-Type Questions 447

20

Accessory Circuits Operation and Diagnosis 449

Objectives 449
Blower Motor Operation 449
Blower Motor Diagnosis 449
Windshield Wipers 450
Horns 453
Cruise Control 455
Power Windows 456
Power Seats 458
Electric Power Door Locks 460

Heated Rear Window Defoggers 461
Airbags 463
Electrical Accessory Troubleshooting Guide 468
Summary 475
Review Questions 475
ASE Certification-Type Questions 475

21

Audio System Operation and Diagnosis 477

Objectives 477
Radios 477
Radios 477
Antennas 477
Speakers 479
Speaker Types 481
Crossovers 482
Powerline Capacitors 482
Radio Interference 483
Summary 486
Review Questions 486
ASE Certification-Type Questions 486

SECTION

Heating and Air Conditioning 487

Heating, Ventilation, and Air Conditioning Principles 488

Objectives 488 Principles of Heating and Refrigeration 488 Heating System 490 Air-Conditioning Refrigeration Cycle 491 Expansion Valve Systems 493 Orifice Tube Systems 493 Thermostatic Control 494 Refrigerants 495 Refrigerant Oils 496 Condenser 497 Evaporator 498 Receiver-Drier 498 Accumulator 498 Refrigerant Lines and Hoses 500 Thermostatic Expansion Valves 501 Fixed-Orifice Tubes 505 Compressors 505 Compressor Controls 507 **HVAC Controls 509** Summary 511 Review Questions 511 ASE Certification-Type Questions 511

Heating and Air Conditioning Diagnosis and Service 513

Objectives 513
Heater Trouble Diagnosis 513
Checking A/C System Performance 515
Temperature and Pressure Measurements 517
Refrigerant Line Connections 523
Retrofitting a CFC-12 System to an HFC-134a System 526
Summary 530
Review Questions 530
ASE Certification-Type Questions 530



Engine Performance 533

24

Ignition System Operation, Diagnosis, and Service 534

Objectives 534 Ignition System Operation 534 Ignition Coils 534 Distributor Ignition 541 Waste Spark Ignition Systems 546 Coil-on-Plug Ignition 547 Checking for Spark 550 Electronic Ignition Troubleshooting Procedure 551 Ignition Coil Testing Using an Ohmmeter 551 Pickup Coil Testing 552 Testing Magnetic Sensors 553 Testing Hall-Effect Sensors 553 Testing Optical Sensors 553 Ignition System Diagnosis Using Visual Inspection 553 Testing for Poor Performance 556 Testing for a No-Start Condition 557 Ignition System Service 557 Firing Order 558 Distributor Cap and Rotor Inspection 558 Spark Plug Wire Inspection 560 Spark Plug Service 561 Quick and Easy Secondary Ignition Tests 564 Ignition Timing 565 Scope-Testing the Ignition System 568 Scope-Testing a DIS Ignition System 576 Ignition System Troubleshooting Guide 577 Summary 580 Review Questions 580 ASE Certification-Type Questions 580

Computers and On-Board Diagnostics 582

Objectives 582
Computer Control 582
The Four Basic Computer Functions 582
Digital Computers 583
Fuel Control System Operating Modes 586
On-Board Diagnostics Generation-II (OBD II) Systems 586
Diagnosing Computer Problems 592
Summary 594
Review Questions 594
ASE Certification-Type Questions 594

26

Computer Sensor Operation, Diagnosis, and Service 595

Objectives 595
Engine Coolant Temperature Sensors 595
Intake Air Temperature Sensor 599
Manifold Absolute Pressure 600
Barometric Pressure Sensor 60!
Throttle Position Sensors 603
Oxygen Sensors 606
Speed Density 610
Air Vane Sensor 611
Hot Film Sensor 612
Hot Wire Sensor 612
Sensor Testing Using Diagnostic Trouble Codes 615
Summary 622
Review Questions 622
ASE Certification-Type Questions 622

27

Engine Fuels and Combustion 623

Objectives 623
Gasoline 623
Volatility 623
Normal and Abnormal Combustion 624
Octane Rating 624
Gasoline Grades and Octane Number 626
Octane Improvers 626
Oxygenated Fuels 626
Alcohol Additives—Advantages and Disadvantages 628
Testing Gasoline for Alcohol Content 628
Combustion Chemistry 628
High-Altitude Octane Requirements 629
Valve Recession and Unleaded Fuel 629
Reformulated Gasoline 630

General Gasoline Recommendations 631 Summary 632 Review Questions 632 ASE Certification-Type Questions 633

28

Computerized Carburetor Operation, Diagnosis, and Service 634

Objectives 634
Mechanical Fuel Pump 634
Fuel System Operation 635
Computerized Carburetors 636
Choke Operation and Service 641
Idle Mixture Screw Adjustment 644
Feedback Carburetor Mixture Control 645
Carburetor Troubleshooting Guide 648
Summary 648
Review Questions 648
ASE Certification-Type Questions 648

29

Electronic Fuel-Injection Operation, Diagnosis, and Service 650

Objectives 650
Electronic Fuel-Injection Operation 650
Throttle-Body Injection 653
Port Fuel Injection 655
Idle Air Speed Control 662
Summary 672
Review Questions 672
ASE Certification-Type Questions 672

30

Emission Control Device Operation, Diagnosis, and Service 673

Objectives 673
Smog 673
Positive Crankcase Ventilation (PCV) System 674
Air Pump System 676
Evaporative Emission Control System 679
OBD II Evaporative Control Systems 683
Exhaust Gas Recirculation System 684
OBD II EGR System Monitor 687
Catalytic Converters 688
Summary 694
Review Questions 694
ASE Certification-Type Questions 694

Engine Performance Diagnosis and Testing 695

Objectives 695 The Eight-Step Diagnostic Procedure 695 Diagnosing Using Diagnostic Trouble Codes 704 Flash Code Retrieval on General Motors Vehicles 706 Retrieving Ford Diagnostic Codes 707 Retrieving Chrysler Diagnostic Codes 715 Retrieving OBD II Codes—16 Pin 715 Exhaust Analysis and Combustion Efficiency 715 Oxides of Nitrogen (No_x) 720 I/M 240 721 Summary 730 Review Questions 730 ASE Certification-Type Questions 730

SECTION



Brakes 733

32

Brake System Principles and Operation 734

Objectives 734 How Brakes Stop Vehicles 734 Weight Transfer During Braking 736 Friction 737 Brake Fluid 737 Brake Lining Composition 740 Lining Edge Codes 741 The Dangers of Exposure to Asbestos 742 Antilock Brake System (ABS) Operation 743 Summary 744 Review Questions 744 ASE Certification-Type Questions 744

33

Master Cylinders and the Hydraulic System 746

Objectives 746 Brake Pedal Mechanical Advantage 746 The Hydraulic Braking System 746 Pascal's Law 747 Master Cylinder Reservoirs 748 Master Cylinder Reservoir Diaphragm 749 Master Cylinder Operation 749 Disassembly of the Master Cylinder 757 Pressure-Differential Switch (Brake Warning Switch) Diagnosing a Red "Brake" Dash Warning Lamp 761 Proportioning Valve 762 Metering Valve 764 Brake Lines 765 Flexible Brake Hose 769 Bleeding Procedure 769 Summary 777 Review Questions 777 ASE Certification-Type Questions 777

34

Wheel Bearings and Service 779

Objectives 779 Antifriction Bearings 779 Bearing Greases 782 Seals 782 Symptoms and Diagnosis of Defective Bearings 783 Non-Drive Wheel Bearing Inspection and Service 783 Front-Wheel-Drive Sealed Bearing Replacement 787 Rear Axle Bearing and Seal Replacement 788 Bearing Failure Analysis 791 Summary 794 Review Questions 794 ASE Certification-Type Questions 794

35

Drum Brake Operation, Diagnosis, and Service 796

Objectives 796 Drum Brake Parts 796 Brake Drum Removal 799 Drum Brake Disassembly and Inspection 802 Reassembling the Drum Brake The Parking Brake 809 Drum Brake Troubleshooting Guide 812 Summary 813 Review Questions 814 ASE Certification-Type Questions 814

36

Disc Brake Operation, Diagnosis, and Service 815

Objectives 815 Disc Brake Operation and Parts 815 Diagnosis and Service 819 Reassembling Disc Brake Calipers 823 Rear Disc Brakes 829 Disc Brake Troubleshooting Guide 831 Summary 836 Review Questions 836 ASE Certification-Type Questions 836

Machining Brake Drums and Rotors 838

Objectives 838
Brake Drums 838
Machining Drums 841
Disc Brake Rotors 843
Machining a Disc Brake Rotor 847
Summary 852
Review Questions 852
ASE Certification-Type Questions 852

38

Power-Assisted Brakes 854

Objectives 854
Vacuum Booster Operation 854
Diagnosing Vacuum-Booster Problems 859
Hydro-Boost Hydraulic Brake Booster 860
Hydro-Boost Troubleshooting Guide 863
Summary 863
Review Questions 863
ASE Certification-Type Questions 863

39

Antilock Brakes 865

Objectives 865
Theory of Operation 865
Purpose and Function of ABS Components 866
ABS Hydraulic Operation 867
Rear-Wheel Antilock Systems 873
Integral and Nonintegral 874
Integral Antilock Braking Systems 876
Nonintegral (Remote) ABS 876
Traction Control 876
Vehicle Stability System 877
ABS Diagnosis and Service 877
Summary 888
Review Questions 888
ASE Certification-Type Questions 888





Suspension and Steering 891

40

Tires and Wheels 892

Objectives 892
Parts of a Tire 892

Tire Valves 895 Service Description 898 High-Flotation Tire Sizes 898 Load Index and Equivalent Loads 900 Speed Ratings 900 Tire Conicity 901 Rim Width and Tire Size 902 Uniform Tire Quality Grading System 902 All-Season Tire Designation 903 DOT Tire Code 903 Spare Tires 904 Run-Flat Tires 904 Wheels 905 Unsprung Weight 910 Lug Nuts 910 Tire Mounting Recommendations 912 Tire Rotation 913 Tire Inspection 914 Tire Balancing 915 Tire Leak Detection 918 Tire Repair 918 Summary 926 Review Questions 926 ASE Certification-Type Questions 926

41

Steering System Diagnosis and Service 927

Objectives 927
The Steering Column 927
Conventional Steering Gear 927
Manual Rack-and-Pinion Steering 932
Power Steering Pumps 934
Integral Power Steering Gear Operation 935
Power Rack-and-Pinion Steering 935
Variable-Effort Power Steering 937
Steering System Inspection 939
Power Steering Diagnosis and Troubleshooting 944
Summary 953
Review Questions 953
ASE Certification-Type Questions 953

42

Suspension System Diagnosis and Service 955

Objectives 955
Types of Suspensions 955
Suspension Principles and Types 960
Parts of a Suspension System 964
Rear Suspensions 968
Suspension System Diagnosis 973
Summary 981
Review Questions 981
ASE Certification-Type Questions 981

Wheel Alignment Principles, Diagnosis, and Service 983

Objectives 983
Alignment-Related Problems 983
Prealignment Checks 991
Reading Alignment Specifications 994
Alignment Setup Procedures 995
Types of Alignments 998
Aftermarket Alignment Methods 1005
Summary 1014
Review Questions 1014
ASE Certification-Type Questions 1014





Manual Drive Trains and Axles 1017

44

Clutches | 1018

Objectives 1018
Purpose and Function of a Clutch 1018
Component Parts and Operation of a Clutch Assembly 1018
Clutch Problem Diagnosis 1029
Clutch Replacement 1032
Clutch Pedal Adjustment 1033
Bleeding the Hydraulic Clutch 1034
Clutch Troubleshooting Guide 1035
Summary 1035
Review Questions 1035
ASE Certification-Type Questions 1035

45

Manual Transmissions/Transaxles 1037

Objectives 1037
The Need for a Transmission 1037
Gear Types 1038
Gear Ratios 1040
Torque, Speed, and Power 1041
Power Train Gear Ratios 1042
Transmission Construction 1042
Torque Flow Through a Manual Transmission 1043
Speed Gears 1043
Synchronizer Parts and Operation 1044
Five-Speed Gearbox Torque Flow 1048

Manual Transaxle Construction 1053
Transmission/Transaxle Removal 1054
Transmission/Transaxle Disassembly 1055
Hard-to-Shift Problem Diagnosis 1057
Manual Transmission Installation 1058
Gear Lubrication 1058
Summary 1066
Review Questions 1066
ASE Certification-Type Questions 1066

46

Drive Shafts and CV Joints 1068

Objectives 1068
U-Joint Design and Operation 1068
Drive Shaft and U-Joint Inspection 1075
U-Joint Replacement 1076
Measuring Drive Shaft Angles 1077
Constant Velocity Joints 1079
CV Joint Diagnosis 1081
CV Joint Service 1082
Summary 1097
Review Questions 1097
ASE Certification-Type Questions 1097

47

Differentials 1098

Objectives 1098 Purpose and Function of a Differential 1098 Parts of a Differential 1099 Differential Gear Ratios 1100 Differentials 1102 Ball Bearings/Rear Axles 1108 Straight Roller Bearings/Rear Axles Tapered Roller Bearings/Rear Axles 1108 Differential Identification 1109 Determining the Axle Ratio of a Differential 1109 Rear End Noise Diagnosis 1109 Differential Inspection 1110 Tooth Contact Pattern Test 1110 Differential Disassembly 1112 Pinion Shaft Bearing Replacement 1113 Drive Pinion Depth 1114 Pinion Gear Preload 1115 Checking and Correcting Backlash 1115 Setting Side Bearing Preload 1116 Reassembly of the Differential Assembly 1118 Differential Lubricant 1118 Summary 1120 Review Questions 1120 ASE Certification-Type Questions 1120

Four-Wheel Drive and All-Wheel Drive | 1122

Objectives 1122
Four-Wheel-Drive Systems 1122
All-Wheel Drive 1126
Front and Rear Differential Axle Ratios 1127
Transfer Case 1127
Interaxle Differential 1131
Four-Wheel-Drive Axles 1133
Transfer Case Service and Problem Diagnosis 1135
Diagnosing and Servicing Locking Hubs 1137
Transfer Case Service 1138
Summary 1145
Review Questions 1145
ASE Certification-Type Questions 1145

SECTION



Automatic Transmissions and Transaxies | | | 47

49

Automatic Transmission/Transaxle Principles 1148

Objectives 1148
Torque Converters 1148
Planetary Gear Sets 1156
Apply Devices 1159
Hydraulic Servos 1160
Accumulators 1160
Multiple-Disc Clutches 1160
One-Way Clutches 1163
Pump 1164
Typical Torque Flow 1172
Summary 1176
Review Questions 1176
ASE Certification-Type Questions 1177

50

Automatic Transmission/Transaxle Diagnosis and Service 1178

Objectives 1178

Preliminary Automatic Transmission/Transaxle Problem Diagnosis 1178

Removing the Automatic Transmission/Transaxle for Service 1186

Automatic Transmission/Transaxle Disassembly 1187
Reassembling an Automatic Transmission/Transaxle 1191
Reinstalling the Automatic Transmission/Transaxle 1194
Road Test 1195
Summary 1196
Review Questions 1196
ASE Certification-Type Questions 1197

Answers to Even Numbered End-of-Chapter ASE Certification-Type Questions 1198

APPENDIXES (Sample ASE Certification Tests)

- I Engine Repair (AI) 1200
- 2 Automatic Transmission/Transaxle (A2) 1206
- 3 Manual Drive Train and Axles (A3) 1211
- 4 Suspension and Steering (A4) 1216
- 5 Brakes (A5) 1220
- 6 Electrical/Electronic Systems (A6) 1225
- 7 Heating and Air Conditioning (A7) 1230
- 8 Engine Performance (A8) 1236
- 9 NATEF Task Lists 1243

English-Language Glossary 1257

Spanish-Language Glossary 1277

Index 1297