AUTOMOTIVE MAINTENANCE & LIGHT REPAIR

SECOND EDITION

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ASE Program Certification
Through
NATEF

Rob Thompson

Automotive Maintenance & Light Repair

Second Edition

Rob Thompson

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Automotive Maintenance & Light Repair,
Second Edition
Rob Thompson

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DEDICATION

Without the encouragement, support, and especially the patience of my wife, Vondra, this would not have been possible. Thank you.

Thanks really need to go to my students. Over my years of teaching, through all the ups and downs that are part of being an educator, I've been lucky enough to have many great students who help inspire and motivate me to always try harder and do better the next day.

I want to thank a long-time friend, colleague, and mentor, Jack Erjavec. It was Jack who many years ago put the idea of teaching in my head. Jack also introduced me to Cengage, where I have been lucky to have worked on many different projects and meet a lot of great people. Without Jack's interventions in my life, I would not be where I am today.

CONTENTS

PREFACE

Automotive Maintenance & Light Repair (AM&LR) is designed to guide and prepare students enrolled in automotive maintenance and light repair automotive programs. The textbook and accompanying workbook cover the fundamental theories, real world examples, and practical applications for each of the 2016 NATEF (National Automotive Technicians Education Foundation) Maintenance and Light Repair (MLR) tasks.

The second edition has been thoroughly revised and updated. What started out as a book going in for some maintenance and light repair work turned into a complete overhaul of many areas. This completely updated edition is designed to meet the needs of MLR programs and to prepare students for the ASE Student Certification tests.

Written by a high school automotive technology instructor, this textbook provides in-depth detail about each task, including the underlying concepts necessary to understand how and why components and systems operate. In addition, real-world examples of inspecting and servicing these components and systems are provided in both the text and the workbook.

Today's automotive students face a challenging career—the technological changes taking place with modern cars and trucks are vast. Systems unheard of only ten years ago are now common on many vehicles. The rate of adoption of new technology can only be expected to increase as consumer expectations change and technology becomes more affordable. Keeping up with technology is one of the biggest challenges technicians face today. A theme of AM&LR is helping the student become a lifelong learner; to learn how to find information and how to use the information productively. As part of this theme is the inclusion of developing the "soft" skills, such as communication, which in the modern work place are as important as technical skills.

To help prepare students for MLR tasks, the text includes a chapter on reviewing and reinforcing fundamental academic and professional skills. Chapter 4 includes a review of basic math and science skills, computer use and information about job seeking, resumes, interviewing, and work ethic. These topics are addressed because having technical skills is not always enough to be able to get and keep a job.

The layout of AM&LR is designed to logically progress from basic industry and shop operations and shop safety to automotive systems operation, service and repair. Safety is emphasized throughout the text to reinforce safe work practices addressed in Chapters 2 and 3. The sequence of chapters is from basic systems and services to complex, although it is not necessary to follow the sequence of chapters as presented.

The workbook contains a corresponding question and answer section for each textbook chapter. These sections can be used to help guide the students' reading of the textbook by requiring the answering of questions directly from the text. The workbook also contains additional activities to reinforce concepts found in the core text, as well as selected lab activities and worksheets. The lab worksheets provided are meant to reinforce important fundamental skills that each student should master.

Whether used in a high school or post-secondary training program, AM&LR is designed to guide students through the MLR tasks and onto becoming automotive professionals.

Thank you,
Rob Thompson

ACKNOWLEDGMENTS

No book project is ever the work of a single person and this is no exception. This book would not have been possible without the help and support of many others. If there are errors in content, the fault is mine and not theirs.

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SUPPLEMENTS

INSTRUCTOR RESOURCES

Time-saving instructor resources are available on CD or at the Instructor Companion Website found on cengagebrain.com. Either delivery option offers the following components to help minimize instructor preparation and engage students:

- PowerPoint chapter presentations with selected images that present the highlights of each chapter
- An Instructor's Guide in electronic format
- Cengage Learning Testing Powered by Cognero® delivers hundreds of test questions in a flexible, on-line system. You can choose to author, edit, and manage test bank content from multiple Cengage Learning solutions and deliver tests from your LMS, or you can simply download editable Word documents from the Instructor Resource CD or Instructor Companion Website.
- An Image Gallery includes photos and illustrations from the text.
- A NATEF Correlation Guide

WORKBOOK

The Workbook to accompany Automotive Maintenance & Light Repair, 2e is designed to work hand-in-hand with the textbook to offer additional opportunities for review and application of the chapter material. The *Workbook* includes theory-based **Activities**, procedure-based **Lab Worksheets**, and finally, **Review Questions** to help reinforce what was learned from studying the core text.

MINDTAP FOR AUTOMOTIVE MAINTENANCE & LIGHT REPAIR

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. Use it as-is or match to your syllabus exactly –hide, rearrange, add and create your own content.
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CHAPTER 1

Introduction to the Automotive Industry

Chapter Objectives

At the conclusion of this chapter, you should be able to:

- Describe the types of jobs available in the automotive industry.
- Explain training and education options for technicians.
- Explain the areas of ASE certification.
- Describe the reasons for the changes in automotive design and construction.

KEY TERMS

collision technician
entry-level technician
lifelong learning
line technician
National Automotive Technician Education Foundation (NATEF)
National Institute for Automotive Service Excellence (ASE)
parts technician
service advisor

The history of the modern automobile, a vehicle using a combustion engine to propel itself, can be traced back to the late 1800s. The first self-propelled vehicles were hand built in very limited quantities by pioneers such as Gottlieb Daimler, Wilhelm Maybach, and Karl Benz. An example of what is considered the first automobile is shown in **Figure 1-1**.

In the early days of motorized transportation, gasoline was not the only fuel source. Even in the late 1800s and early 1900s, many models of electric vehicles existed. Other vehicles had steam engines, or used types of alcohol or kerosene as their energy source. **Figure 1-2** shows a map of electric vehicle charging stations in New York City from 1923.

FIGURE 1-1 The earliest automobiles, such as this, were motorized horse buggies.

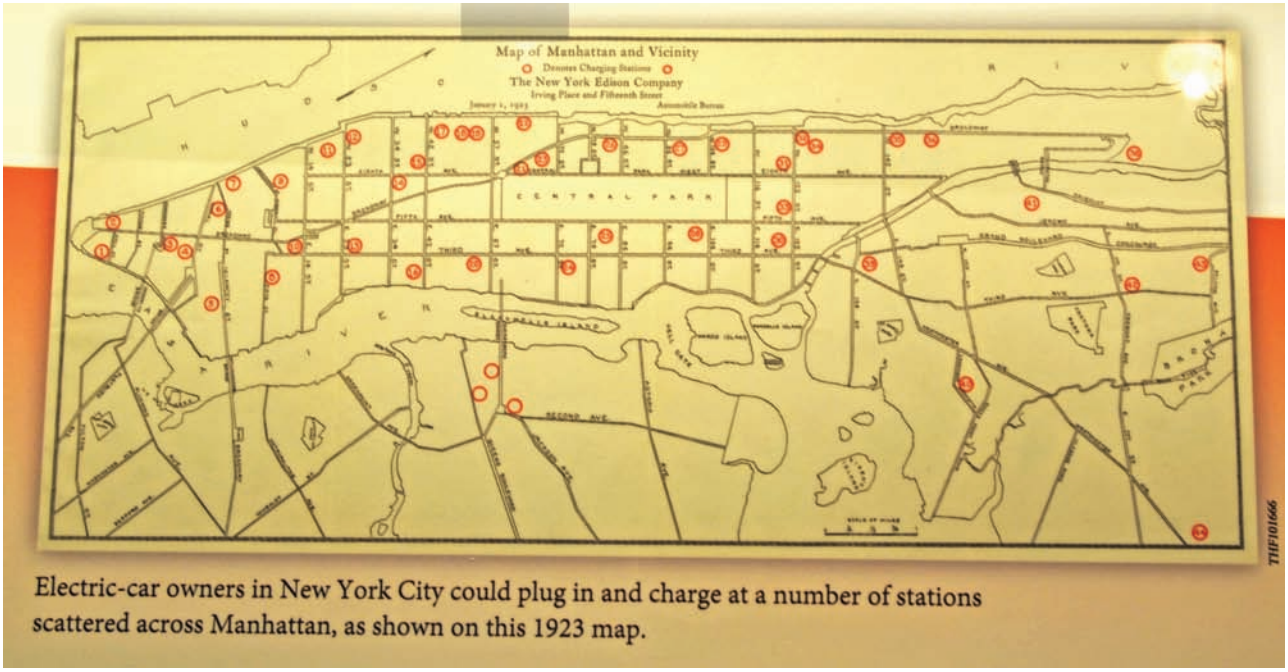

FIGURE 1-2 Electric cars were very popular and had many charging stations in the early 1900s.

In the early 1900s, Ransom E. Olds began mass production of the Oldsmobile. This process was greatly improved upon by Henry Ford in the 1910s with the Model T. Ford's use of standardized parts and the assembly line brought the cost of manufacturing the Model T down enough that it became affordable to many more Americans.

Decreased manufacturing costs created fierce competition among brands and helped to push design advancements. However, despite the advances in service life, safety, and efficiency, cars and trucks remained largely unchanged for decades. Not until electronics began to be integrated into new car technology in the 1970s did major changes come to the automotive industry.

The Automotive Industry

The automotive industry is part of the domestic (and international) transportation industry. In the United States, the number of jobs associated with automobiles is large; however, these jobs are just part of a bigger picture encompassing all transportation-related jobs. Approximately 1 in 7, or about 14%, of all jobs in the United States are transportation related. This includes indirect jobs that support the cars and light trucks on the country's roads, heavy-duty trucks and equipment, aviation, shipping, and off-road and recreational vehicles. All these industries have changed due to the growth or loss of markets; changes in technology; and changes in laws, regulations, and the economy. Regardless of the path you choose, if you remain in a transportation-related career, you will need to be able to adapt and grow as things change around you.

CHANGE IN THE AUTO INDUSTRY

There are many reasons for the changes and advancements made over the last 100 years. Improvements in manufacturing, materials, and electronics have played significant roles in the industry's evolution, and how these improvements came into being deserves some attention.

■ ***Emissions and the Environment.*** At the end of World War II, the American economy, booming due to the needs of war production, needed to change to consumer production. Factories that had been producing tanks, airplanes, and war supplies shifted to producing household goods and automobiles. General Motors, Ford, and Chrysler restarted new car production in 1946. Returning veterans and their families needed housing and transportation as suburban development began. As the number of vehicles on the road increased each year, noticeable changes occurred in the air around certain parts of the country.

As more vehicles were sold and more road miles traveled, more pollution was released into the atmosphere. In parts of California, the combination of pollution and weather patterns created a thick, heavy haze over cities, called *smog*, a combination of smoke and fog (**Figure 1-3**). The California government knew that the automobile was contributing to the pollution and began to take steps to decrease the amount of pollution produced by cars and trucks. The very first emission control

FIGURE 1-3 Automotive exhaust contributes to air pollution. Emission control has been a major contributor to automotive design since the 1970s.

device, the positive crankcase ventilation (PCV) valve, was introduced in 1957. Since then, passage of the Clean Air Act, Clean Water Act, and many more emission control laws have forced vehicle manufacturers to meet increasingly strict exhaust emission standards.

■ ***The Economy and Fuel Prices.*** Before the energy crisis in 1973, American cars and trucks were, in general, large, heavy, powerful, and not fuel efficient. The energy crisis of the 1970s caused a shift in consumer attitudes toward the cars the domestic auto makers produced. In 1975, Congress passed the corporate average fuel economy (CAFE) standards. These standards require auto makers to reach increasingly higher fuel economy ratings across all their vehicles sold in the United States. Currently, the National Highway Traffic Safety Administration (NHTSA) projects fleet average fuel economy will be between 40.3 and 41 mpg by 2021 (**Figure 1-4**). Changes in engines, vehicle construction, and other areas will be necessary as future vehicles will be required to achieve better fuel economy.

■ ***Market Share.*** Imported cars had a small percentage of the total automotive market share before the mid-1970s. When oil and gas prices rose, many car buyers started to look at the small, fuel-efficient models offered by Honda, Toyota, Datsun (later Nissan), VW, and others. In 1970, Americans bought about 313,000 Japanese-manufactured vehicles and approximately 750,000 vehicles from Germany. In comparison, sales by General Motors, Ford, and Chrysler exceeded 7.1 million vehicles—more than 85% of the market. In 2015, sales of imported cars in the United States accounted for about 55% of total sales. A chart of U.S. auto sales is shown in **Figure 1-5**.

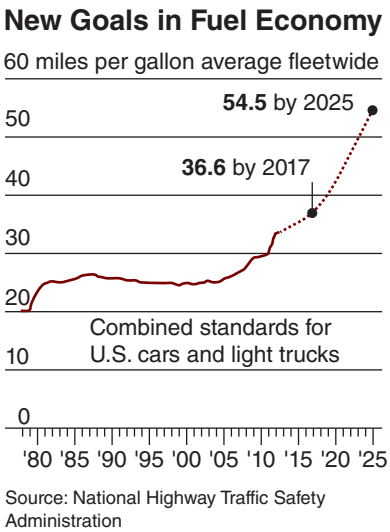

FIGURE 1-4 Reducing emissions and increasing fuel economy have been major factors in vehicle design.

One factor in market share was product quality. Even though domestic manufacturers began making smaller and more efficient vehicles, they were still being surpassed in quality by the imports. The cars imported from Japan and Germany were more efficient, were well built, and often lasted longer than domestically built vehicles. Consumers responded to this by buying more and more imported cars and trucks. While General Motors, Ford, and Chrysler made improvements, the availability of so many other makes and models reduced their market share steadily over the years.

■ ***The Electronic Revolution.*** As production of smaller and less expensive electronic components and magnets increased, more accessories, such as power windows, could be supplied at lower cost. Features such as power door locks, rear window defoggers, and air conditioning, once expensive options, are standard equipment on today's vehicles.

Most modern options such as navigation systems, Bluetooth phone integration, adaptive cruise control, occupant safety systems, antilock brakes, and vehicle stability control would not exist without low-cost electronics. In addition, electrical and electronic components are replacing items that have traditionally been either mechanical or hydraulic (powered by pressurized fluid). For example, some vehicles use electrically controlled torque-vectoring systems, designed to increase handling and performance by controlling the power to each drive wheel (**Figure 1-6**). Electric power steering is common on many cars, and Nissan has a steer-by-wire system available on the Infiniti Q50. Using electronic components gives design engineers more flexibility and often reduces manufacturing, maintenance, and repair costs.

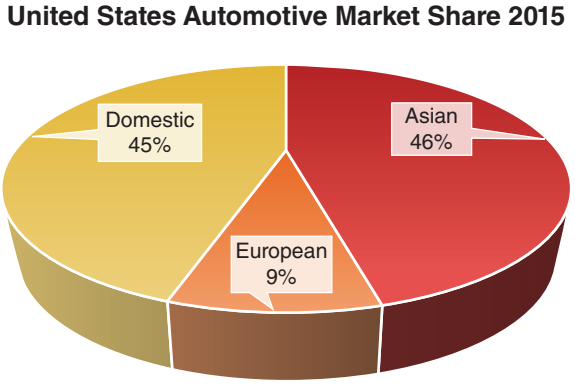

FIGURE 1-5 The share of new car sales among the U.S. production and foreign manufacturers.

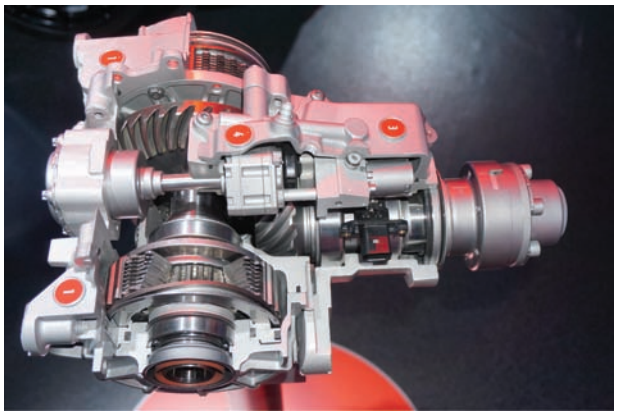

FIGURE 1-6 Changes in technology continue to drive automotive design. Systems that were once only found on very high-end cars, such as ABS, are now standard on all new cars sold in the United States.

■ ***Safety.*** Founded in 1969, the Insurance Institute for Highway Safety (IIHS) has worked to improve vehicle safety by concentrating on three areas involved in motor vehicle crashes: human, vehicle, and environment factors. Prior to the work of the IIHS, there was little safety regulation regarding the design and construction of passenger vehicles. Seat belts did not become a standard feature until 1968, due in part to the way in which vehicle manufacturers evaluated vehicle safety and conducted tests. In fact, the federal government did not incorporate vehicle crash testing until the NHTSA began testing in 1979.

Since then, the United States government, the IIHS, and the auto makers themselves have conducted extensive testing to improve vehicle crashworthiness. This has led to improved vehicle designs that not only reduce injuries but also help prevent accidents from occurring. Because of the work of organizations such as the IIHS and NHTSA, vehicles now are designed from the start with safety as a primary concern. This has led to the standardization of many safety systems, such as:

- Antilock brake systems (ABS) and stability control
- Supplemental restraint systems
- Tire pressure monitoring systems
- Rear-view backup cameras

Also, due to crash test studies, vehicles are built with features—impact zones or crumple zones, collapsible steering columns, door reinforcements, dash bracing, and so on—that allow the vehicle to absorb and deflect impact forces away from the occupants and to reduce injuries (**Figure 1-7**). These factors have made modern cars and trucks much safer and have helped reduce traffic accident deaths over the years.

■ ***Passenger Comfort and Expectations.*** As the consumer electronics industry introduces new and more exciting products, customers demand more of these types of devices and conveniences for their vehicles. GPS-linked navigation, adaptive lighting and cruise control, wireless media integration, voice recognition, and intelligent computer systems are all standard or available on many of today's vehicles. Most new cars and trucks are equipped with display screens that are used for the driver and passengers to interface with the various onboard systems (**Figure 1-8**).

As these features become less expensive to integrate, they eventually trickle down to even the lowest-cost

FIGURE 1-7 Safety is another key aspect of the evolution of the modern automobile. As vehicles become smaller and lighter, manufacturers must develop new technologies to keep the passengers and pedestrians safe.

FIGURE 1-8 Customers expect voice-activated systems such as navigation, phone, entertainment, and customizable vehicle settings.

vehicles as options or standard equipment. However, as vehicles become more complex, the necessity of qualified technicians to service and repair these systems when they fail increases.

CAREERS

Without the transportation industry, the U.S. and world economies would stop. There are more than 11 million jobs in the United States directly related to transportation, including sales, marketing, engineering, and production. The career choices available are staggering. Beyond the servicing and repairing of automobiles, there is collision repair; diesel, heavy-duty, and agriculture equipment repair fields; small engine; marine and air transportation; and countless other jobs related to cars and trucks.

■ ***Auto Technicians.*** According to the Bureau of Labor Statistics, there are currently more than 630,000 automotive technicians in the United States servicing more than 241 million cars, SUVs, and light trucks. This does not include collision, heavy-duty, off-road, or power sports technicians. Most automotive technicians begin their careers in an entry-level position, then progress to jobs with more responsibility and higher pay.

An **entry-level technician** is expected to be able to perform basic inspections and maintenance services. Most will need to have a basic tool set consisting of socket sets, wrenches, pliers, screwdrivers, and an assortment of other basic tools (**Figure 1-9**). As a beginning technician, you should have at least a basic understanding of the various systems found on modern vehicles and the ability to make simple repairs. For example, it is expected that an entry-level technician should be able to:

- Perform an engine oil and filter change and reset the maintenance reminder system.
- Service tires and tire pressure monitoring systems.
- Inspect the brake system and perform basic brake repairs.
- Replace batteries and either maintain or restore memory functions.
- Replace transmission and differential fluids.
- Service the cooling system.
- Replace various lights, wipers, and other maintenance items.
- Perform some computer programming functions.

FIGURE 1-9 An example of a starter tool kit, suitable for an entry-level technician.

As important as these skills and equally important are the abilities to locate and interpret technical information, to work well with colleagues and customers, and to have a good work ethic. As cars and trucks become more complex, the ability to locate and correctly interpret technical information is of significant importance. Very little can be done to modern vehicles that do not require looking up information on a computer or connecting to the vehicle's onboard network with a scan tool.

Interpersonal skills for working in teams are important for the overall operation of the business. Customer service industries also require the ability to communicate well, to present a professional image, and to relate well to others. These qualities, plus having initiative, good attendance, and a positive attitude, are necessary to be successful in the modern workplace.

After an entry-level technician acquires additional skills and experience, he or she may become a line technician. A **line technician** is one who is certified and has experience with most of the systems on the vehicle. As a line technician, you will be expected to perform increasingly more difficult repairs quickly and profitably, and you may even assist in training new employees.

Many shops designate their technicians by categories, such as A, B, and C technicians. An A technician, also called a *lead technician*, has the most experience and certifications. He or she can perform repairs on all the vehicle systems and can generate a lot of income. A C-level technician is often young and has the least experience in the shop. He or she may have a couple of certifications and only a couple of years of experience. C-level technicians often work on specific areas such as brakes or suspension systems. B-level technicians generally fall in between C- and A-level technicians. An example of technician skill-level work is shown in **Figure 1-10**.

OTHER TYPES OF TECHNICIANS

As stated previously, there are many more career opportunities in the transportation industry than being an

	Skill Level	Warranty Time	Standard
(1) HUB & BEARING, R&R			
All Models (2WD)			
One Side	B	(0.8)	1.0
Both Sides	B	(1.5)	1.9

Parts

	Mfg. Part No.	Price (MSRP)*
HUB & BEARING		
All Models		
1/2 Ton		
w/Crew Cab	15946732	$509.50
w/o Crew Cab	15233111	$453.46

FIGURE 1-10 Skill levels shown in a parts and time guide. A shop may have one A-level or master technician, several B-level technicians, and many C-level technicians.

FIGURE 1-11 Engine machinists specialize in engine rebuilding.

FIGURE 1-12 Collision technicians repair body damage, straighten the frame, and restore the paint and finish.

automotive technician. Many people who love cars and trucks specialize in one of the many other fields related to the auto industry.

■ ***Engine Machinist.*** Automotive machinists are generally employed in specialty shops, called *machine shops*. Machinists are those men and women who repair and rebuild engines, service cylinder heads and blocks, and, in some cases, build high-performance racing engines. They perform work such as reboring cylinder blocks, replacing cylinder liners or sleeves, machining the block deck and cylinder head surfaces, fitting pistons and connecting rods, and performing varied types of crack repairs (**Figure 1-11**).

■ ***Collision Technician.*** A **collision technician** repairs a vehicle after it has been involved in a collision or has suffered some type of body or structural damage. Depending on the type of repair facility, one technician may perform nonstructural body repairs while another technician is responsible for painting and refinishing (**Figure 1-12**). In some shops, one technician may perform the entire repair and paint the vehicle also. In the *aftermarket*, many collision technicians specialize in painting and refinishing or custom painting. Custom painting has seen an increase in demand as more people want to customize their cars, trucks, motorcycles, boats, and other vehicles.

Word Wall

Aftermarket—Aftermarket means the parts and service suppliers to the automotive industry not supplied by the vehicle manufacturers and their dealers.

■ ***Parts Technician.*** A **parts technician** may work for a dealer, an independent store, or a chain store. A parts person is knowledgeable about the parts industry and works with the public, helping to find the right parts for the customer (**Figure 1-13**). Some parts persons work only with commercial accounts, such as local auto and truck repair facilities.

Being a parts person requires good people skills and some basic automotive knowledge because many parts stores provide free services such as wiper blade and battery installation.

■ ***Service Advisor.*** An automobile service advisor specializes in communications between the customer and others in the shop (**Figure 1-14**). In addition to communication skills, a service advisor is knowledgeable about vehicle systems, has sales skills, and often can perform some basic shop operations.

The **service advisor** typically greets the customer upon entering the service department, completes the service order, then routes the service order to the appropriate technician. Once the technician has completed the diagnosis and estimate, the service advisor then contacts the customer to discuss the needed repairs and services and their costs. It is important for a service advisor to have a good understanding of the various automotive systems so that he or she can accurately communicate with the technicians and customers.

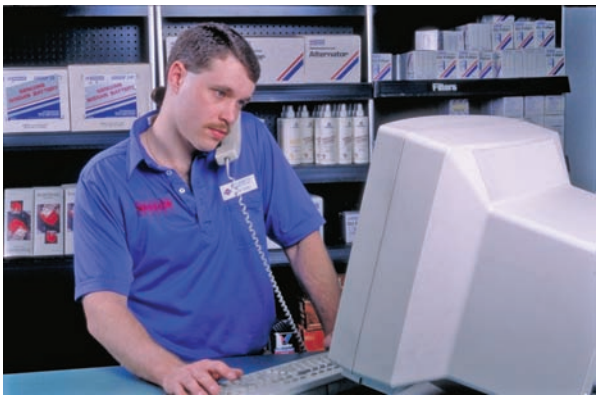

FIGURE 1-13 Parts technicians specialize in parts distribution and working with customers.

FIGURE 1-14 Service advisors work with customers when dropping the vehicle off, contacting them with the estimate, explaining what repairs and services are required, and handle the bill when the car is picked up.

■ ***Sales.*** Salespeople are often the most visible people in the automotive industry. A salesperson provides the expertise about the various makes and models of vehicles that helps the customer make a decision when buying a vehicle. Salespeople often work with the service department to ensure that new vehicles are properly prepped and ready for delivery.

■ ***Training and Education.*** Some technicians become trainers and educators. Vehicle manufacturers, equipment suppliers, tool companies, and even parts stores employ technical trainers to provide training on tools and repair procedures.

Some technicians become high school and college instructors. To teach, an instructor needs to be an experienced technician. In addition, he or she should have excellent communication and people skills and the desire to help others succeed in the automotive industry.

■ ***Diesel, Heavy-Duty, and Agriculture Technicians.*** One of the greatest needs of the transportation industry is for qualified diesel technicians. Every heavy-duty truck, piece of construction equipment, and large ship have a diesel engine (**Figure 1-15**). Even though the diesel industry was slower to adopt

FIGURE 1-15 Heavy-duty equipment technicians keep trucks and other equipment in operation.

the use of electronics for vehicle management than the auto industry, modern diesels often have as much or more electronic monitoring and controlling of engine operation than a gasoline-powered engine. This is due in part to the cost of a heavy-duty diesel engine and in part to increasingly strict diesel emission standards. More than 180,000 jobs existed in 2015 in the diesel, heavy-duty, and agriculture equipment repair fields.

■ ***Motorcycle and Other Outdoor Power Equipment.*** There are more motorcycles, ATVs, snowmobiles, and personal watercraft in use today than ever before, with the numbers expected to increase each year.

In 2015, there were more than 65,000 motorcycle, marine, and small engine technicians in the United States. With the expected increases in ownership of these types of vehicles, there is continued growth in the need for service technicians. Just as cars and trucks have become more complex in the last couple of decades, motorcycles and off-road machines also are becoming more complex (**Figure 1-16**). Many manufacturers now use electronic spark control and fuel injection systems.

Snowmobiles, ATVs, and lawn maintenance equipment may also be serviced by a motorcycle technician during the off-season.

■ ***Aircraft Technicians.*** There were about 124,000 aircraft and avionics technicians in 2015. Most of those jobs are located around major airports in large cities, though employment can be found at smaller commercial and private airports as well. Service and repair of general aviation aircraft, such as small propeller-driven planes, is very similar to automotive repair. Many of the same skills used in fixing cars and trucks are used for repairing aircraft. Propeller-driven aircraft use small gasoline engines, hydraulic brakes, and an electrical system for lighting and instrumentation.

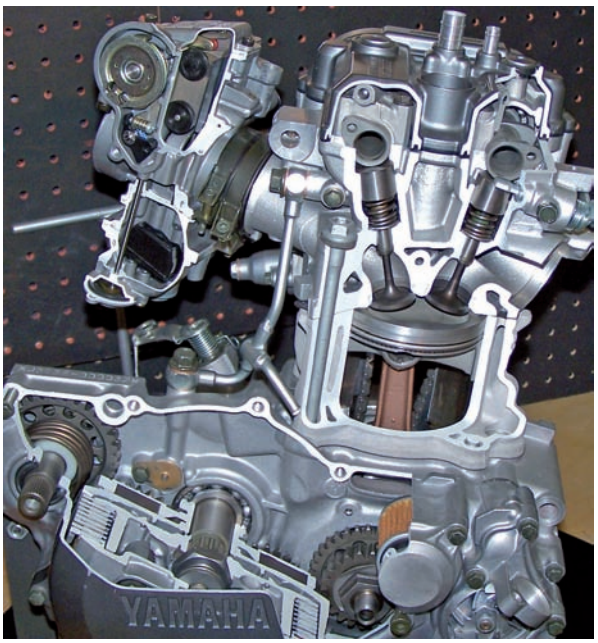

FIGURE 1-16 Many aspects of automotive repair are similar to working on motorcycles, ATVs, boats, and other forms of transportation.

EDUCATION AND TRAINING

The most important consideration for future auto technicians is education. Before 1975, the only electronic components likely to be found on a vehicle were in the radio. In 1975, the need to increase fuel economy and reduce exhaust emissions saw the implementation of electronics in automobiles and light trucks. Small, mysterious boxes began to replace mechanical ignition parts that had been in use for decades. What had been for years a repair-based industry started to move to a diagnose-and-replace industry. These changes required mechanics to learn new skills and adapt to the increasing amount of electronics and changing technology. Today's vehicles have dozens of electronic modules monitoring and controlling nearly every aspect of the automobile. Technology use will continue to increase as consumers expect more of their vehicles.

■ ***Secondary Schools.*** The best preparation for a future technician is participation in a formal training program. Many high schools and career centers throughout the United States provide training in automotive repair, collision repair, diesel repair, and even aviation repair. These programs offer training and experience in the automotive repair industry and are often linked with local dealerships and community colleges. Some schools participate in the Automotive Youth Education System (AYES), a partnership between several vehicle manufacturers and secondary schools, that provides work experience in addition to automotive training.

High school programs take many different forms, though one- and two-year courses are common. In this type of program, students can learn about the basic aspects of auto technology, collision repair, or diesel technology. Due to time constraints, it is difficult for high school programs to prepare graduates for more than entry-level positions. For those students who plan on attending post-secondary education, a high school program often can provide the student with advanced placement credit with cooperating colleges and universities.

■ ***Post-Secondary Schools.*** Automotive programs at community colleges, technical schools, and universities