# *Automotive Technology (Canadian) 4th edition Erjavec Solutions Manual*

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# CHAPTER 1
# Careers in the Automotive Industry

## CHAPTER OVERVIEW

This chapter examines the automotive industry today and points out the changes that are occurring. Professional service provided by a properly trained technician is critical because of the technology used in today's vehicles. A detailed description is given of what it takes to be a professional technician. Included are descriptions of career opportunities, job classifications, and the various automotive education programs that are available in Canada. Automotive Service Technician Interprovincial Standards and ASE certification requirements are also provided.

## LEARNING OUTCOMES

- Describe the reasons why today's automotive industry is considered a global 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 Red Seal certification of automotive technicians.

## INSTRUCTIONAL OUTLINE WITH TEACHING HINTS

**I.** Servicing Today's Vehicles
- A. The Importance of Automotive Technicians
- B. The Need for Quality Service
- C. The Need for Ongoing Service
  1. Warranties
  2. Increased Vehicle Age

  *Hint:* Discuss the need for repairs as cars become older and what opportunities this need presents to a qualified technician.
- D. Career Opportunities
  1. Dealerships
  2. Independent Service Shops
  3. Franchise Repair Shop
  4. Store-Associated Shops
  5. Fleet Service and Maintenance

  *Hint:* Discuss career opportunities in all areas of automotive service.

**II.** Job Classifications
- A. Service Technician

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B. Shop Foreman
C. Service Adviser
D. Service Manager
E. Service Director
F. Parts Counterperson
G. Parts Manager
*Hint:* Discuss the various automotive shop positions and how they each relate to the technicians.

**III.** Related Career Opportunities
A. Parts Distribution
B. Marketing and Sales
C. Other Opportunities

**IV.** Training for a Career in Automotive Service
A. Student Work Experience
1. Job Shadowing Program
2. Mentoring Program
3. Cooperative Education
4. Part-Time Employment
B. Canada's Automotive Apprenticeship Program
C. The Need for Continuous Learning

**V.** ASE Certification
*Hint:* Introduce the various programs in your area that are available to students.

## WHAT ARE COMMON STUDENT MISCONCEPTIONS AND STUMBLING BLOCKS?

- Without experience, students will struggle with understanding how an automotive shop functions.
- Possibly have a shop owner visit the class or arrange to take the students to observe a shop during operating hours.
- To help students understand a shop's different job classifications, place various students as the shop foreman or service writer and have them arrange the "workload" for the day's shop activities.
- Have the students refer to the job classification section of the chapter as a reference for these assignments. Refer to pages 8-12 of Chapter 1 for reference.

## SHOP ACTIVITIES AND CASE STUDIES

Here are some activities you can review in-class as a group, or ask students to complete individually or in pairs:

1. Research a vehicle of your choice. Visit the manufacturer or dealership website. Make a list of all of the systems in that vehicle that are controlled by electronics. If you are unsure of system, include its name on the list and talk to your instructor about it.

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2. Look through the help-wanted section of the local newspaper or at online job websites such as www.workopolis.com, www.careerbuilder.ca, www.apprenticesearch.com, and www.jobbank.gc.ca/home. Clip out or print all of the employment opportunities available to someone trained in automotive technology. Do not limit your search to one or two job classifications; look through many.

3. Based on the ads found in the previous activity, put together a summary of the jobs that are currently available. Include in the summary the desired qualifications and the type of facilities in need of qualified technicians.

## ANSWERS TO TEXTBOOK REVIEW QUESTIONS

**1.** Electronics are widely used because they allow for rapid response to changes in operating conditions; they are inexpensive, lightweight, and very reliable.

**2.** To become a successful automotive technician, you must be able to master and keep up with the latest technologies, and you must possess the skills to work well with people.

**3.** There are a variety of types of businesses that employ automotive technicians.

a. Dealerships provide repair and maintenance on vehicles while they are under warranty and beyond. They offer the technician good technical support, special diagnostic equipment, an opportunity to specialize, and ongoing training. A disadvantage could be becoming limited to one or two particular model lines.

b. Independent repair shops service all types of vehicles, sometimes specializing in certain areas of repair, or in either import or domestic vehicles. This type of shop may present constant service and diagnostic challenges to the technician, providing an opportunity to gain a well-rounded technical background. Disadvantages may include having less sophisticated diagnostic equipment to work with and less dealership sponsored training.

c. Store-associated shops provide certain specialized services such as brakes, exhaust systems, and wheel and tire repair. An advantage to the technician is the ability to specialize in one area and product. A disadvantage is not becoming as well rounded in other areas of automotive service.

d. Specialty service shops provide repairs in specialized repair areas such as engine rebuilding, transmission/transaxle overhauling, brake, exhaust, emissions, or electrical systems. Technicians can become very skilled in the specialized area, but they can also limit themselves.

e. Fleet service and maintenance shops provide service and maintenance for a fleet of company-owned vehicles. Their technicians can become very familiar with a wide range of vehicles over an extended period of time.

**4.** There are many ways that you can gain work experience while you are a student. They include: a. job shadowing, b. mentoring, c. cooperative education, d. apprenticeship, e. part-time employment.

**5.** d. During the on-the-job portion of an apprenticeship, the apprentice must complete a prescribed set of complete vehicle repair tasks.

**6.** b. While a vehicle is still under warranty, repairs are usually performed in dealership service departments.

**7.** c. Specialty shops perform work on one or more specific automotive systems.

**8.** d. The service adviser prepares cost estimates.

**9.** a. The vehicle's electronics have produced the greatest changes in today's automobiles. Electronics have affected the operation of almost every automotive system including improvements to engine performance, emission control, braking systems, and passenger comfort to name a few.

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**10.** a. A successful technician must possess a good understanding of electronics.
**11.** d. Tire rotation would be performed under scheduled preventative maintenance. Water pump replacement and transmission overhaul would only be performed when a failure or signs of impending water pump or transmission failure occurs. Engine oil replacement is a regular maintenance item that does not necessarily have to be only performed during a preventative maintenance service.
**12.** b. The automobile manufacturer determines the new car warranty conditions for the automobile's engine and drive train systems.
**13.** d. The government mandates the length of time and amount of kilometres that emission control devices are to be covered under warranty.
**14.** d. To become a certified automotive technician in most Canadian provinces you must complete an automotive service technician apprenticeship.
**15.** b. Although each province may set a minimum grade to obtain a provincial certificate, a 70 percent grade must be achieved to obtain a Red Seal endorsement.
**16.** c. A prorated warranty decreases over time.
**17.** a. A prorated warranty is commonly provided on tires and batteries.
**18.** c. Wholesalers are commonly known in the automotive industry as jobbers. Jobbers sell aftermarket parts and supplies to automotive service shops and the general public.
**19.** a. The advantage of a Red Seal endorsement is that it allows an automotive service technician to work in most Canadian provinces without further testing because it is recognized as a high standard of achievement.
**20.** d. ASE testing in Canada is voluntary testing in various automotive technology areas.

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# CHAPTER 2
# Workplace Skills

## CHAPTER OVERVIEW

This chapter describes the workplace skills needed to successfully obtain a job and how to keep it. Among the topics discussed are the preparation of a resumé and cover letter, and how to prepare for a job interview. The basis for good workplace skills is respect. You must not only have respect for yourself, but also for your employer, your fellow employees, and your customers.

## LEARNING OUTCOMES

- Develop a personal employment plan.
- Seek and apply for employment.
- Prepare a resumé and cover letter.
- Prepare for an employment interview.
- Accept employment.
- Understand how automotive technicians are compensated.
- Understand the proper relationship between an employer and an employee.
- Explain the key elements of on-the-job communications.
- Be able to use critical thinking and problem-solving skills.
- Explain how you should look and act to be regarded as a professional.
- Explain how fellow workers and customers should be treated.

## INSTRUCTIONAL OUTLINE WITH TEACHING HINTS

**I.** Seeking and Applying for Employment
- A. Employment Plan
- B. Identifying Your Skills
- C. Identifying Job Possibilities
- D. Driving Record
- E. Preparing Your Resumé
- F. Digital Portfolios
- G. References
- H. Preparing Your Cover Letter
- I. Contacting Potential Employers
- J. Employment Application
- K. The Interview

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L. After the Interview

*Hint:* Show examples of good and poorly completed resumés, cover letters, and applications. Have the students apply for a mock job opening. Block out the names and have the class look at the applications, cover letters, and resumés and vote on which applicant would most likely get hired.

**II.** Accepting Employment
- A. Compensation
  1. Hourly Wage
  2. Commission
  3. Flat Rate
  4. Team System
  5. Benefits
  6. Total Earnings

**III.** Working as an Automotive Technician
- A. Employer–Employee Relationships

  *Hint:* Invite a shop foreman or service manager to speak to the students about what characteristics are most valued in employees.

**IV.** Communications
- A. Nonverbal Communication

  *Hint:* Have a student demonstrate various nonverbal communications and let the class decide what is being communicated.

**V.** Solving Problems and Critical Thinking
- A. Diagnosis

  *Hint:* Provide several puzzles or riddles to allow the students to test their critical thinking skills.

**VI.** Professionalism
- A. Coping with Change

**VII.** Interpersonal Relationships
- A. Customer Relations

  *Hint:* Invite a receptionist or a similar professional to talk to the students about telephone etiquette and customer relations.

## WHAT ARE COMMON STUDENT MISCONCEPTIONS AND STUMBLING BLOCKS?

- Young people entering the workforce will not necessarily have the skills to communicate effectively or with confidence. Practise putting students into the roles of customer and technician discussing problems with their vehicles. This will give the instructor the opportunity to discuss communication skills.
- Have the students write an ad seeking a technician for employment. Use this as a tool to evaluate what their idea is of a good employee. Refer to page 19 of Chapter 2 for reference.
- Have the students research the flat-rate time for all jobs they perform in the shop, this will help them to understand time management. Page 26 of Chapter 2 refers to flat rate.

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## SHOP ACTIVITIES AND CASE STUDIES

Here are some activities you can review in-class as a group, or ask students to complete individually or in pairs:

1. Research your local newspapers or online websites. Clip out or print four employment opportunities in the automotive field.

2. Prepare a resumé including the following elements: contact information, career objectives, skills and/or accomplishments, work experience, education, and a statement about provision of references.

3. Choose one of the employment opportunities from Shop Activity 2–1 and write a cover letter for it.

4. Prepare a repair estimate for the replacement of a clutch and be sure to include the appropriate taxes for your area of the country.

## ANSWERS TO TEXTBOOK REVIEW QUESTIONS

**1.** Your employment plan should include your specific job goals and a plan to reach them. You should list your interests, skills, and attitudes that match the job you are seeking. Include both your short-term and long-term goals along with a prioritized list of potential employers.

**2.** Flat rate means that each technician is paid according to the amount of work produced. Each job has a flat-rate time, and the technician is paid for that amount of time regardless of how long it takes to complete the task. The flat-rate system rewards the most productive technicians, while providing for more accurate repair estimates.

**3.** Your cover letter should include three paragraphs. The first should describe your interest in working for this employer and the position you are seeking. The second paragraph is used to sell yourself, and the third is used as a closing by thanking the employer and requesting an interview.

**4.** A technician can promote good customer relations by: a. learning to listen and talk clearly, b. being polite and organized on the telephone, c. being as honest as they possibly can, d. presenting themselves in a professional manner, e. dressing and acting appropriately, f. respecting vehicles and returning them undamaged, g. explaining repair processes to customers in understandable terms, h. showing respect and being courteous, and i. making repair estimates as precise as possible.

**5.** Technicians as employees have these responsibilities to their employer:

a. *Regular attendance*. A good employee is reliable. Businesses cannot operate successfully unless workers are on the job.

b. *Following directions.* Employees are part of a team. Doing things your way may not be in the best interest of the company.

c. *Team membership.* A good employee works well with others and strives to make the business successful.

d. *Responsibility.* Employees have to be willing to answer for their behaviour and work habits.

e. *Productivity.* Employees are paid for their time, as well as their skills, knowledge, and effort. An employee's duty is to be as effective as possible while at work.

f. *Loyalty.* Loyalty is expected. This requires an employee to act in the best interests of the employer, both on and off the job.

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**6**. b. A good technician will always gather as much information as they can about a problem before using valuable shop time performing tests or replacing components that may or may not relate to the problem.
**7**. a. A good resumé will be neat, uncluttered, and easy to read. It should not list all of the jobs you have ever had, and it should be a maximum of two pages in length. All important information should be listed near the beginning, so it is noticed immediately.
**8.** b. A past or present teacher would make a good reference on a resumé. Friends and family should not be used as references.
**9.** b. The best way to quit a job is to write a letter of resignation and present it personally to the employer.
**10.** d. The application should be filled out completely. Answer every question. Write "N/A" if a question does not apply to you.
**11.** a. Show up at an interview looking neat and professional by wearing clothes that you would wear on the job.
**12.** d. Leaning forward and nodding shows good nonverbal communication during an interview. Leaning forward shows that you are actively engaged in the conversation, while nodding shows understanding
**13**. b. A letter of thanks should be sent to the employer within three days after the interview.
**14**. d. You should not only look at people while they are speaking to you, but also listen carefully without interruption before responding.
**15**. c. Supervising other people is a soft skill. Soft skills are personal skills that are part of your personality and are used while relating to other people.
**16.** a. The enjoyment of solving puzzles or problems is an example of a technical skill rather than a personal skill.
**17.** d. The technician should expect to be paid $120 for the repair because the flat-rate system pays the technician for the job completed, not the actual time the technician required.
**18.** b. In person is the best method of submitting a resumé. This can provide a physical presence along with the resumé and possibly a meeting with the employer.
**19.** c. Employment and Social Development Canada issues social insurance number (SIN) cards.
**20.** a. Straight time is the recommended pay plan for new and inexperienced technicians and/or apprentices because it does not place undue stress on them to complete repairs at the same rate as experienced technicians.

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# CHAPTER 3
# Working Safely in the Shop

## CHAPTER OVERVIEW

This chapter discusses shop safety in detail. The topics range from clothing and eye protection to handling tools, vehicle handling in the shop, and handling hazardous waste. The instructor might want to refer to this chapter for review when discussing safety issues in later chapters.

## LEARNING OUTCOMES

- Understand the importance of safety and accident prevention in an automotive shop.
- Explain the basic principles of personal safety, including protective eye wear, clothing, gloves, shoes, and hearing protection.
- Explain the procedures and precautions for safely using tools and equipment.
- Explain the precautions that need to be followed to safely raise a vehicle on a lift.
- Explain what should be done to maintain a safe working area in a shop, including running the engines of vehicles in the shop and venting the exhaust gases.
- Describe the purpose of the laws concerning hazardous wastes and materials, including the WHMIS right-to-know legislation.
- Describe your rights, as an employee and/or student, to have a safe place to work.

## INSTRUCTIONAL OUTLINE WITH TEACHING HINTS

**I.** Personal Safety
- A. Personal Safety Precautions
  1. Eye Protection
  2. Eye First Aid
  3. Clothing
  4. Hair and Jewellery
  5. Shoes
  6. Gloves
  7. Disease Prevention
  8. Ear Protection
  9. Respiratory Protection
  10. Lifting and Carrying
- B. Professional Behaviour

  *Hint:* Invite the students to tell about persons they are acquainted with who have had work-related injuries.

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**II.** Tool and Equipment Safety
- A. Hand Tool Safety
- B. Power Tool Safety
- C. Compressed Air Equipment Safety
- D. Lift Safety
- E. Jack and Jack Stand Safety
- F. Chain Hoist and Crane Safety
- G. Cleaning Equipment Safety
- H. Vehicle Operation
  1. Venting the Engine's Exhaust
- I. Electrical Safety
  1. Battery Precautions
  2. High-Voltage Systems
- J. Rotating Pulleys and Belts

  *Hint:* Show the students various items of equipment in the shop and explain the safety concerns related to each.

**III.** Work Area Safety
- A. Flammable Liquids
  1. Gasoline
  2. Ethanol
  3. Diesel Fuel
- B. Fire Extinguishers

  *Hint:* Show where the fire extinguishers are located and tell how they should be operated.

**IV.** Manufacturer's Warnings and Government Regulations

**V.** WHMIS/GHS Right-to-Know Legislation

**VI.** Hazardous Materials

*Hint:* Show the SDS sheets and the substances they apply to in your work area.
- A. Guidelines for Handling Shop Wastes
  1. Oil
  2. Oil Filters
  3. Batteries
  4. Metal Residue from Machining
  5. Refrigerants
  6. Solvents
  7. Containers
  8. Other Solids
  9. Liquid Recycling
  10. Shop Towels/Rags
  11. Hiring a Hauler
  12. Waste Storage

  *Hint:* Show the students where in their work areas these items are to be disposed of.
- B. Asbestos

## ADDITIONAL TEACHING HINTS

- Show the students the equipment they will be working with and describe the safety concerns for each item. Point out areas where personal equipment such as protective eyewear and hearing protection is required.
- Show the students the SDS manual and show a sample of each substance they will be using. Describe the safe handling and disposal procedures for each.

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- Show where the emergency phone numbers are located and describe accident reporting procedures.
- Walk through the lab with each student listing safety concerns they find such as tripping hazards, spills, and so on. Compare their lists and lead a discussion of each person's responsibility to maintain a safe work area.

## WHAT ARE COMMON STUDENT MISCONCEPTIONS AND STUMBLING BLOCKS?

- One of the most common misconceptions is the lack of realization of the effects of chronic exposure to many chemicals and solutions used in the automotive trade.
- Have the students research cases of technicians being affected by chronic exposure. If possible, bring people into the class who have suffered from chronic exposure or other types of injuries.
- Allow the students to take turns being safety officer for the class while in the shop.

## SHOP ACTIVITIES AND CASE STUDIES

Here are some activities you can review in-class as a group, or ask students to complete individually or in pairs:

1. Make a simple line drawing of the shop. Then walk around the shop and identify all safety equipment. Mark the location of the equipment on your drawing.

2. Walk around the shop and list everything that is a safety hazard

3. Identify all storage areas for hazardous materials and wastes. Make sure they are properly labelled.

4. Locate all of the fire extinguishers in the shop. Make a note of what type of fires each will extinguish.

5. Locate the SDSs or WHMIS manual in the shop.

## ANSWERS TO TEXTBOOK REVIEW QUESTIONS

**1.** Used oil filters should be drained for at least 24 hours, then crushed and recycled.
**2.** Up-to-date phone numbers for doctors, hospitals, and the fire and police departments should be clearly posted next to the phone.
**3.** Some shops have posted areas where safety glasses are required; for example, there may be a red line painted on the floor with a sign warning that safety glasses are required beyond the red line. Any time a person is working around risks such as vapours, dust, metal shavings, or liquids that may cause eye injuries, safety glasses should be worn.
**4.** A class B fire extinguisher should be used to smother the fire. Apply a blanketing, flame-interrupting covering over the entire flaming liquid surface.
**5.** When fighting a fire, stand 2 to 3 m (6.6 to 10 ft.) away from the fire and aim the fire extinguisher nozzle at the base of the fire. Use a side-to-side sweeping motion over the entire width of the fire until the fire is extinguished. Stay low to avoid inhaling the smoke and get out if it gets too hot or smoky.

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**6.** b. A mask equipped with HEPA (high-efficiency particulate air) filters should be used when working with brake shoes or clutch discs.
**7.** c. Safety glasses should be worn any time you are working in the shop.
**8.** d. A multipurpose dry chemical fire extinguisher can be used on electrical fires. Carbon dioxide, halogenated agent, standard dry chemical, and Purple K dry chemical can also be used.
**9.** a. Brake shoes do not require approved waste disposal collection.
**10.** d. WHMIS (Workplace Hazardous Material Information System) relates to the right-to-know legislation.
**11.** c. Further cleaning to remove residue is necessary following thermal cleaning.
**12.** b. WHMIS right-to-know legislation relates to hazards associated with chemicals used in the workplace.
**13.** b. CO (carbon monoxide) is a poisonous gas that requires proper ventilation.
**14.** d. When a material reacts violently with water, or other materials, it is said to have high *reactivity*.
**15.** b. When extinguishing a fire, you should remain 2 to 3 m (6.6 to 10 ft.) away.
**16.** c. Keep your back as straight as possible when lifting an object.
**17.** d. The recommended way to store gasoline is in an approved safety container in a designated storage cabinet.
**18.** a. Compressed air can be used to blow dirt from bolt holes. Compressed air should not be used for cleaning surfaces that can be safely cleaned by other safer methods.
**19.** c. Nitrile gloves should be worn when washing parts because of their resistance to gas, oil, and solvents.
**20.** d. Oil filters should be allowed to drain for 24 hours before being crushed and recycled.

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# CHAPTER 4
# Automotive Systems

## CHAPTER OVERVIEW

This chapter discusses significant automotive features and design revolution. The latest, most progressive changes are emphasized. The basic automobile systems covered in later chapters are introduced.

## LEARNING OUTCOMES

- Explain the major events that have influenced the development of the automobile in the recent past.
- Explain the difference between unitized and body-over-frame vehicles.
- Describe the manufacturing process used in a modern automated automobile assembly plant.
- List the basic systems that make up an automobile and name their major components and functions.

## INSTRUCTIONAL OUTLINE WITH TEACHING HINTS

**I.** Historical Background
**II.** Modern Power Plants
**III.** Design Evolution
  A. Body-over-Frame Construction
  B. Unitized Construction
  C. Vehicle Construction
**IV.** Body Designs
**V.** Technological Advances
**VI.** The Basic Engine
  A. Cylinder Block
  B. Cylinder Head
  C. Piston
  D. Connecting Rods and Crankshaft
  E. Valve Train
  F. Manifolds
**VII.** Engine Systems
  A. Lubrication System
  B. Cooling System
  C. Fuel and Air System
  D. Emission Control System

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E. Diesel Emission Controls
F. Exhaust System

**VIII.** Electrical and Electronic Systems
A. Ignition System
B. Starting and Charging Systems
C. Electronic Engine Controls
D. On-Board Diagnostics

**IX.** Heating and Air-Conditioning Systems
A. Heating Systems
B. Air-Conditioning Systems
1. Compressor
2. Condenser
3. Receiver/Dryer
4. Accumulator
5. Thermostatic Expansion Valve/Orifice Tube
6. Evaporator
7. Refrigerant Lines

**X.** Drivetrain
A. Transmission and Transaxles
B. Clutch
C. Manual Transmission
D. Automatic Transmission
E. Dual-Clutch (Shaft) Transmissions
F. Continuously Variable Transmissions (CVTs)
G. Driveline
H. Rear Axle/Final Drive
I. Driving Axles
J. Transaxle
K. Four-Wheel-Drive System

**XI.** Running Gear
A. Suspension System
B. Steering System
C. Brakes
D. Wheels and Tires

**XII.** Hybrid Vehicles
A. Electric Vehicles

**XIII.** Alternative Fuels

## WHAT ARE COMMON STUDENT MISCONCEPTIONS AND STUMBLING BLOCKS?

- Constant technological changes can cause a great deal of confusion for new technicians and students. Bring three or four vehicles into the shop from the past three or four decades and demonstrate the advancements in the various systems.
- Students will stumble with understanding the multitude of systems contained within modern vehicles, and how they all tie together. Use this chapter and have the students draw block diagrams of the various systems and have them tie them together

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## SHOP ACTIVITIES AND CASE STUDIES

Here are some activities you can review in-class as a group, or ask students to complete individually or in pairs:

1. Pick 10 vehicles from those available in the lab for you to work on. Write out a complete description of each one. In this description include the type and/or size (where applicable) for each of the following: year, make, model, body design, engine, drivetrain, steering, suspension, brake system, and any other feature or accessory that may be evident.

2. Define each of the basic engine components and systems listed. Refer to your textbook. When you have completed the definitions, go into the shop and identify the components and systems on a vehicle.

3. Define each of the heating and air-conditioning components listed. Refer to your textbook. When you have completed the definitions, go to the shop and identify the components on a vehicle.

4. Define each of the drivetrain components listed. Refer to your textbook. When you have completed the definitions, go into the shop and identify the components on a vehicle.

5. Define each of the systems and components of the running gear. Refer to your textbook. When you have completed the definitions, go into the shop and identify the systems and components on a vehicle.

6. If a hybrid vehicle is available, safely identify the components of the hybrid system. Use caution around any of the high-voltage components. They are typically identified by orange cabling or conduit. **NOTE:** *Always assume a hybrid vehicle is capable of moving as the electric motors can operate silently whenever the ignition is on*.

## ANSWERS TO TEXTBOOK REVIEW QUESTIONS

**1.** The Company Average Fuel Consumption (CAFC) is a voluntary Canadian program that is similar to the mandatory Corporate Average Fuel Economy (CAFE) standards in the United States that require a certain fuel economy average for all vehicles produced by a manufacturer.
**2.** The benefits of switching from rear-wheel-drive to front-wheel-drive vehicles include improved traction, increased interior space, shorter hood lines, and a very compact driveline.
**3.** Internal combustion means that the fuel is burned inside the engine to produce energy.
**4.** In addition to the battery, a charging system should include a generator, voltage regulator, charge indicator light or gauge, and the necessary wiring.
**5.** The difference between a parallel and series hybrid design is mainly that a parallel hybrid can be propelled by either the internal combustion engine or the electric motor and a true series hybrid can only be propelled by the electric motor.
**6.** d. EGR (Exhaust Gas Recirculation) is a type of emission control system that introduces exhaust gases into the intake air to reduce the combustion temperatures. This reduces the chances of $NO_x$ forming during combustion.
**7.** c. Automatic transmissions use torque converters instead of clutches.
**8.** b. The four-stroke cycle gasoline engine is classified as an internal combustion engine because the fuel ignites and burns inside the engine or internally.

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**9.** b. The positive crankcase ventilation (PCV) system routes fuel and engine oil vapours to the intake manifold where they can be drawn into the engine to be burnt along with the air/fuel mixture.
**10.** b. The crossover vehicle is based on a station wagon and an SUV.
**11.** a. The order of strokes in a four-stroke cycle gasoline engine is intake, compression, power, and exhaust.
**12.** d. The valve train opens and closes the intake and exhaust ports of each cylinder.
**13.** b. The pressure cap raises the boiling point of the engine cooling systems coolant by allowing the coolant to operate under a controlled pressure above atmospheric.
**14.** a. A pickup truck would most likely utilize the body-over-frame construction. This style of construction is more suited for the load carrying capabilities of pickup trucks.
**15.** b. The exhaust gas recirculation (EGR) system introduces exhaust gases into the intake manifold in order to reduce $NO_x$ emissions. The entry of exhaust gases into the combustion chamber will dilute the air/fuel mixture reducing the combustion temperature which will reduce the formation of $NO_x$ emissions.
**16.** c. The battery is part of both the charging and starting systems.
**17.** c. A front-wheel drive car commonly uses a transaxle. The transaxle contains both the transmission and final drive components.
**18.** a. The differential is part of the drive train.
**19.** c. The orifice tube works with the compressor to separate the high and low sides.
**20.** a. The reductant used in diesel exhaust systems separates the oxygen from $NO_x$ and combines with hydrogen to form water.

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# CHAPTER 5
# Hand Tools and Shop Equipment

## CHAPTER OVERVIEW

This chapter presents some of the more commonly used hand and power tools with which every technician must be familiar. Because units of measurement play such an important part in tool selection and in diagnosing automotive problems, this chapter begins with a presentation of measuring systems. Prior to the discussion on tools, there is a discussion on another topic that relates very much to measuring systems and fasteners.

## LEARNING OUTCOMES

- List the basic units of measurement for length, volume, and mass in the two measuring systems.
- Describe the different types of fasteners used in the automotive industry.
- List the various mechanical measuring tools used in the automotive shop.
- Describe the proper procedure for measuring with a micrometer.
- List some of the common hand tools used in auto repair.
- List the common types of shop equipment and state their purpose.
- Describe the use of common pneumatic, electrical, and hydraulic power tools found in the automotive service department.
- Describe the different sources for service information that are available to technicians.

## INSTRUCTIONAL OUTLINE WITH TEACHING HINTS

**I.** Measuring Systems
**II.** Fasteners
    1. Locknuts
    2. Machine Screws
A. Bolt Identification
B. Tightening Bolts
C. Washers
D. Thread Lubricants and Sealants
E. Thread Pitch Gauge
F. Taps and Dies
G. Threaded Inserts
    1. Spark Plug Thread Repair

*Hint:* Show examples of metric and SAE bolt and nut classifications and how to correctly identify them. Compare grade strengths and discuss the differences in torque and holding power. Show an example of a bolt with stretched threads.

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**III.** Measuring Tools
- A. Machinist's Rule
- B. Vernier Caliper
- C. Dial Caliper
- D. Micrometers
  - 1. Reading a Metric Outside Micrometer
  - 2. Using an Outside Micrometer
  - 3. Reading an Inside Micrometer
  - 4. Reading a Depth Micrometer
- E. Telescoping Gauge
- F. Small Hole Gauge
- G. Feeler Gauge
- H. Straightedge
- I. Dial Indicator

**IV.** Hand Tools
- A. Wrenches
  - 1. Open-End Wrench
  - 2. Box-End Wrench
  - 3. Combination Wrench
  - 4. Flare Nut (Line) Wrenches
  - 5. Allen Wrench
  - 6. Adjustable-End Wrench
- B. Sockets and Ratchets
  - 1. Special Sockets
  - 2. Crowfoot Wrench Adapters
  - 3. Extensions
  - 4. Socket Adapters
- C. Torque Wrenches
- D. Screwdrivers
- E. Impact Screwdriver
- F. Pliers
- G. Hammers
- H. Chisels and Punches
- I. Removers
- J. Hacksaws
- K. Files
- L. Gear and Bearing Pullers
- M. Bearing, Bushing, and Seal Drivers
- N. Trouble Light
- O. Creeper

**V.** Shop Equipment
- A. Bench Vises
- B. Bench Grinder
- C. Presses
- D. Grease Guns
- E. Oxyacetylene Torches
  - 1. Welding and Heating Torch
  - 2. Cutting Torch
  - 3. Precautions
  - 4. MINI-DUCTOR®

**VI.** Power Tools

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A. Impact Wrench
B. Air/Electric Ratchet
C. Drills
D. Blowgun

**VII.** Jacks and Lifts
A. Floor Jack
B. Lift
C. Portable Crane
D. Engine Stands/Benches

**VIII.** Service Information
A. Auto Manufacturers' Service Information
B. General and Specialty Repair Manuals
C. Finding Information
D. Aftermarket Suppliers' Guides and Catalogues
E. Lubrication Guides
F. Owner's Manuals
G. Hotline Services
H. iATN
I. The Internet

## ADDITIONAL TEACHING HINTS

- Discuss the power tools provided in the shop and the safety rules for each tool.
- Demonstrate as many tools in Chapter 5 as practical.
- Have the students sort and identify bolts and other fasteners by grade, thread pitch, and type.
- Demonstrate and review shop manual usage. If computer-based service manuals are available, show how to access information.

## WHAT ARE COMMON STUDENT MISCONCEPTIONS AND STUMBLING BLOCKS?

- Canadian students will have a more difficult time working in imperial measurement. Provide a number of examples where imperial and metric sizes are very similar to help with visual reference.
- Having a proper understanding of the correct tool to use for a particular job can be difficult for beginning technicians. Create a few scenarios where it would be possible to pick a variety of tools for a repair. Discuss with students why certain tools should or should not be used to perform the repair.
- Use information starting on page 87 of Chapter 5 for reference.

## SHOP ACTIVITIES AND CASE STUDIES

Here are some activities you can review in-class as a group, or ask students to complete individually or in pairs:

1. Using the formulas given in the textbook, convert the following into inch measurements: 72 mm, 113 cm, and 0.072 mm. Now convert the following inch measurements into metric measurements: ½ inch, 0.002 inch, and 3 inches.

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2. Have your instructor give you an assortment of fasteners. Identify each using the information given in the textbook. Make sure you describe the purpose and size of each.

3. Using a micrometer, list the micrometer reading of the 10 drill shanks supplied by your instructor. The masking tape on the drill shank is covering up the actual drill size; please do not remove the tape. The number on the masking tape is used as a reference in the recording of the drill shank sizes.

4. With the guidance of your instructor, raise the front of a vehicle off the ground and set it on safety (jack) stands. Secure a dial indicator with the proper holding mechanisms so that the indicator's plunger barely contacts the outside rim of one of the front wheels. With the plunger contacting the rim, set the dial to zero. Slowly rotate the wheel and watch the indicator. Any indicator needle movement indicates that there is some wheel distortion.

5. Take complete inventory of the tools in your toolbox or one assigned to you. Cross-reference the supplied tool list to the tools on hand. If a tool list is not available to you, list the type of tool and the size of each tool in the set.

## ANSWERS TO TEXTBOOK REVIEW QUESTIONS

**1.** A micrometer should be checked weekly and also right after you drop it.
**2.** Use a dial indicator for such things as measuring valve lift, crankshaft endplay, flywheel or brake rotor runout, gear backlash, or crankshaft journal concentricity.
**3.** The size of a wrench is determined by the distance between its jaws measured in millimetres or fractions of an inch. This size will be slightly larger than the indicated size so that it will fit around a nut or bolt.
**4.** True. Service manual information is usually also made available by certain manufacturers on CDs, DVDs, or via the Internet.
**5.** In the imperial system, the tensile strength of a bolt is identified by the Society of Automotive Engineers (SAE) and they use a number of radial lines on the bolt's head. More lines mean higher tensile strength. A property class number on the bolt head identifies the grade of metric bolts. This numerical identification is from the International Organization for Standardization (ISO) and is comprised of two numbers. The first number represents the tensile strength of the bolt. The higher the number means the greater the tensile strength. The second number represents the yield strength of the bolt.
**6.** b. A box-end wrench is not likely to slip off a bolt or a nut.
**7.** c. The thimble on a metric micrometer has 50 graduations.
**8.** b. Each graduation on the thimble of a metric micrometer equals 1/100 or 0.01 millimetre.
**9.** c. A Pozidriv® screwdriver is similar to a Phillips, but flatter and blunter.
**10.** b. Needle nose pliers are best for grasping small parts.
**11.** b. A brass drift punch should be used to drive roll pins from aluminum components. Brass will produce much less damage to the aluminum component and drifts have straight shafts and are available in different sizes to pass through the roll pin bore.
**12.** d. An extractor is used to remove broken bolts.
**13.** a. A ball gauge would be used to measure a valve guide bore along with other small bores.
**14.** c. A micrometer should be used when the measurement must be within one-hundredth of a millimetre.
**15.** d. Fillet damage would cause a bolt head to pop off. The fillet provides support between the bolt head and shank.

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**16.** a. A hand tap can be used to thread a nut. A hand tap produces internal threads.
**17.** c. A vernier caliper can be used to measure inside, outside, and depth measurements.
**18.** a. Torx® fasteners are generally used to secure headlamp assemblies, mirrors, and luggage racks due to their ability to handle more turning force with a lesser chance of slippage.
**19.** b. Before working under a vehicle on a hydraulic lift, always ensure that all locking devices are fully engaged to prevent the vehicle from dropping due to a hydraulic failure.
**20.** c. Manufacturers publish technical service bulletins when new service procedures or component updates are needed.

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# CHAPTER 6
# Diagnostic Equipment and Special Tools

## CHAPTER OVERVIEW

This chapter describes the diagnostic equipment and special tools used by technicians to diagnose and service various automotive systems. Diagnostic equipment is used to test the performance of a system, and special tools designed for a particular purpose are used to make the necessary repairs.

## LEARNING OUTCOMES

- Describe the various diagnostic and service tools used to check and repair an engine and its related systems.
- Describe the various diagnostic and service tools used to check and repair electrical and electronic systems.
- Describe the various diagnostic and service tools used to check and repair a vehicle's drivetrain.
- Describe the various diagnostic and service tools used to check and repair a vehicle's running gear for wear and damage.
- Describe the various diagnostic and service tools used to check and repair a vehicle's heating and air-conditioning system.

## INSTRUCTIONAL OUTLINE WITH TEACHING HINTS

**I.** Engine Repair Tools
- A. Compression Testers
- B. Cylinder Leakage Tester
- C. Oil Pressure Gauge
- D. Stethoscope
  1. Electronic Stethoscope
- E. Engine Removal and Installation Equipment
- F. Ridge Reamer
- G. Ring Compressor
- H. Ring Expander
- I. Ring Groove Cleaner
- J. Dial Bore Indicator
- K. Cylinder Deglazer
- L. Cylinder Hone
- M. Cam Bearing Driver Set
- N. V-Blocks
- O. Valve and Valve Seat Resurfacing Equipment
- P. Valve Guide Repair Tools

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Q. Valve Spring Compressor
R. Valve Spring Tester
S. Torque Angle Gauge
T. Oil Priming Tool
U. Cooling System Pressure Tester
V. Coolant Condition Testing Tools
W. Coolant Recovery and Recycle System

**II.** Electrical/Electronic System Tools
A. Computer Memory Saver
B. Circuit Tester
C. Multimeter
D. Voltmeter
E. Ohmmeter
F. Ammeter
G. Volt/Ampere Tester
H. Battery Capacitance Tester
I. Lab Scopes
J. Graphing Multimeter
K. Battery Hydrometer
L. Wire and Terminal Repair Tools
M. Headlight Aimers

**III.** Engine Performance Tools
A. Scan Tools
B. Fuel Pressure Gauge
C. Pressure Transducer
D. Injector Balance Tester
E. Injector Circuit Test Light
F. Fuel Injector Cleaners
G. Fuel Line Tools
H. Pinch-Off Pliers
I. Vacuum Gauge
J. Vacuum Pump
K. Vacuum Leak Detector
L. Tachometer
M. Spark Tester
N. Logic Probes
O. Sensor Tools
P. Static Strap
Q. Pyrometer
R. Spark Plug Sockets
S. Exhaust Analyzers
T. Chassis Dynamometer
U. Hybrid Tools
1. Gloves
2. Test Equipment

**IV.** Transmission and Driveline Tools
A. Transaxle Removal and Installation Equipment
B. Transmission/Transaxle Holding Fixtures
C. Transmission Jack
D. Axle Pullers
E. Special Tool Sets

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F. Clutch Alignment Tool
G. Clutch Pilot Bearing/Bushing Puller/Installer
H. Universal Joint Tools
I. Driveshaft Angle Gauge
J. Hydraulic Pressure Gauge Set

**V.** Suspension and Steering Tools
A. Tire Tread Depth Gauge
B. Tire Pressure Monitoring Sensor (TPMS) Tester
C. Power-Steering Pressure Gauge
D. Control Arm Bushing Tools
E. Tie-Rod End and Ball Joint Puller
F. Front Bearing Hub Tool
G. Pitman Arm Puller
H. Tie-Rod Sleeve-Adjusting Tool
I. Steering Column Special Tool Set
J. Shock Absorber Tools
K. Spring/Strut Compressor Tool
L. Power-Steering Pump Pulley Special Tool Set
M. Brake Pedal Depressor
N. Wheel Alignment Equipment—Four Wheel
O. Tire Changer
P. Wheel Balancer—Electronic Type
Q. Wheel Weight Pliers
R. Road Force Balancer

**VI.** Brake System Tools
A. Cleaning Equipment and Containment Systems
B. Hold-Down Spring and Return Spring Tools
C. Boot Drivers, Rings, and Pliers
D. Caliper Piston Removal Tools
E. Drum Brake Adjusting Tools
F. Brake Cylinder Hones
G. Tubing Tools
H. Brake Disc Micrometer
I. Drum Micrometer
J. Brake Shoe Adjusting Gauge (Calipers)
K. Brake Lathes
L. Bleeder Screw Wrenches
M. Pressure Bleeders

**VII.** Heating and Air-Conditioning Tools
A. Manifold Gauge Set
B. Electronic Leak Detector
C. Fluorescent Leak Tracer
D. Refrigerant Identifier
E. Refrigerant Charging Station
F. Thermometer
G. Compressor Tools
H. Hose and Fitting Tools

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## ADDITIONAL TEACHING HINTS

- Demonstrate DMM voltage, amps, and ohm tests on various car circuits.
- Demonstrate how to observe ignition timing with a timing light and how timing affects engine operation.
- Demonstrate how to connect and adjust a lab scope.
- Demonstrate on a two- or four-gas exhaust analyzer how the gases change if a cylinder is disabled.
- Discuss details of how to hook up an engine analyzer to a vehicle.

## WHAT ARE COMMON STUDENT MISCONCEPTIONS AND STUMBLING BLOCKS?

- Identifying specialty tools will be a stumbling block for most beginning automotive students. Create a list of 10–15 of these tools and have the students find them in the tool room. Use this chapter's diagrams to assist in their identification.
- Set up four or five vehicles in the shop with specialty tools attached to them and operating. Have the students identify the tools and what test they are performing. Visual conception helps with remembering a tools' use.
- This aid will take a little time from the instructor but should help with the understanding of the use of some of the specialty tools.

## SHOP ACTIVITIES AND CASE STUDIES

Here is an activity you can review in-class as a group, or ask students to complete individually or in pairs:

1. Use a scan tool to retrieve the diagnostic fault codes from a vehicle.

## ANSWERS TO TEXTBOOK REVIEW QUESTIONS

**1.** There are two types of test lights. The first is sometimes called a circuit tester and is used to check for the presence of voltage in a circuit. A ground clip is attached to a suitable ground, and the tester lights when the probe is touched to a portion of the circuit having sufficient voltage present. The second is sometimes referred to as a self-powered test light or continuity tester. It has an internal battery and is used to check unpowered portions of a circuit for continuity. When the ground clip is attached to the negative side of the circuit and the probe is attached to the positive side, the tester will light when there is continuity in the circuit.

**2.** Knurling is used to decrease the inside diameter of the guide by displacement of the guide material. A specified diameter reamer is then used to size the guide diameter to proper specifications. The specified stem-to-guide clearance can then be achieved.

**3.** The two types of compression gauges are push-in and screw-in.

**4.** A vacuum gauge is used to test engine manifold vacuum.

**5.** A lab scope is a visual voltmeter that shows voltage over a period of time. This information is displayed in the form of a continuous voltage line called a *waveform* or *trace.* Any change in voltage is shown as it occurs. This is beneficial when diagnosing a circuit because observing the change in waveforms live and during diagnostic procedures will give an indication of whether it's a good pattern or a faulty pattern.

**6.** b. A brake shoe adjusting gauge provides a quick, rough adjustment of the brake shoes. Further adjustment is necessary after the brake drum is installed.

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**7.** c. Due to the high current draw of a 12-volt test light, they should not be used to test engine control module circuits or any computer-controlled circuits.
**8.** a. An ohmmeter is used to measure the resistance to current flow in a circuit.
**9.** b. A properly operating engine should produce a vacuum gauge reading of at least 40 cm Hg (16 in. Hg). However, a reading of 38 to 50 cm Hg (15 to 20 in. Hg) is normally acceptable.
**10.** c. An upward movement of the trace indicates an increase in voltage.
**11.** a. Performing wheel runout compensation is the first step in performing a four-wheel alignment once the wheel units (heads) are installed. This adjustment ensures that the wheel units are aligned with the axle or spindle and not wheel deformities.
**12.** b. A manifold gauge set is used for charging and evacuating and for diagnosing trouble in an A/C system.
**13.** d. When removing a steering wheel, deploying the air bag is a major concern. Always follow the manufacturer's recommended service procedures.
**14.** c. A cylinder leakage tester is used to determine where a leak from a cylinder is located. This tester introduces air into the cylinder.
**15.** d. All of these conditions may be revealed by fuel pressure readings.
**16.** b. A compression tester reads cylinder pressure during the compression stroke.
**17.** a. A cylinder should be ridge reamed before piston removal. If the cylinder ridge is not removed it could damage the piston rings and piston ring lands during piston assembly removal.
**18.** c. Most front-wheel-drive cars have their engines removed by lowering it from the engine compartment.
**19.** a. The torque angle gauge should be used after the specified torque is obtained. Turning the bolt the additional number of degrees places the specified clamp load on the bolted components.
**20.** c. Analog multimeters have high impedance (similar to test lights) and should not be used on sensitive electronic circuits.

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# CHAPTER 7
# Basic Theories and Math

## CHAPTER OVERVIEW

This chapter introduces many of the principles taught in other courses in order to help the student become more employable and successful as a technician. These principles are covered again in greater detail according to the topic. A thorough understanding of this chapter is recommended to prepare the student for further instruction.

## LEARNING OUTCOMES

- Describe how all matter exists.
- Explain what energy is and how energy is converted.
- Calculate the volume of a cylinder.
- Explain the forces that influence the design and operation of an automobile.
- Describe and apply Newton's laws of motion to an automobile.
- Define friction and describe how it can be minimized.
- Describe the various types of simple machines.
- Differentiate between torque and horsepower.
- Interpret the difference between a vibration and a sound.
- Describe Pascal's law and give examples of how it applies to an automobile.
- Explain the behaviour of gases.
- Describe the effects of heat on matter.
- Describe what is meant by the chemical properties of a substance.
- Explain the difference between oxidation and reduction.
- Describe the origin and practical applications of electromagnetism.

## INSTRUCTIONAL OUTLINE WITH TEACHING HINTS

**I.** Matter
- A. Atoms and Molecules
- B. Ions
  - 1. Plasma
- C. States of Matter
  - 1. Absorption and Adsorption

**II.** Energy
- A. Kinetic and Potential Energy
  *Hint:* Give examples of the various forms of energy.
- B. Energy Conversion
- C. Mass and Weight
- D. Size

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**III.** Volume
- A. Ratios
- B. Proportions

**IV.** Force
- A. Automotive Forces
  - 1. Balanced and Unbalanced Force
  - 2. Turning Forces
- B. Forces on Tires and Wheels
- C. Centrifugal/Centripetal Forces
- D. Wheel and Tire Balance
- E. Pressure

**V.** Time

**VI.** Motion
- A. Rates
- B. Newton's Laws of Motion
- C. Friction
  - 1. Lubrication
  - 2. Rollers
- D. Air Resistance

**VII.** Work
- A. Simple Machines
  - 1. Inclined Plane
  - 2. Pulleys
  - 3. Levers
  - 4. Gears
  - 5. Wheels and Axles

  *Hint:* Have the class think of examples in which the simple machines listed here may be found in a typical automobile.
- B. Torque
  - 1. Torque Multiplication
- C. Power
- D. Horsepower

  *Hint:* Discuss the difference between torque and horsepower.

**VIII.** Waves and Oscillations
- A. Vibrations
- B. Sound
  - 1. Speakers
- C. Noise

**IX.** Light
- A. Photo Cells

**X.** Liquids
- A. Laws of Hydraulics
- B. Mechanical Advantage with Hydraulics

  *Hint:* Have the class list all of the systems in an automobile that use hydraulics.

**XI.** Gases
- A. Behaviour of Gases
- B. Air Pressure
  - 1. Vacuum

**XII.** Heat
- A. Heat Transfer
- B. The Effects of Temperature Change

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C. Controlling Heat

**XIII.** Chemical Properties

A. Specific Gravity
B. Chemical Reactions
C. Catalysts and Inhibitors
D. Acids/Bases
   1. pH
E. Reduction and Oxidation
   1.Rust and Corrosion
F. Metallurgy
   1. Hardness
G. Solids under Tension
H. Electrochemistry

**XIV.** Electricity and Electromagnetism

A. Electricity
B. Magnets
C. Electromagnetism
D. Producing Electrical Energy
E. Radio Waves

*Hint:* Have the class list the systems in an automobile that would not function without electricity and magnetism.

## ADDITIONAL TEACHING HINTS

- Using principles learned in the classroom, have the students calculate the displacement of a single cylinder and then the total displacement of several sizes of sample engines.
- Conduct a tour of the shop and have the students list where energy conversions occur in the shop equipment and vehicles found there. Compare lists and lead a discussion of the different forms of energy and their usefulness to us.

## WHAT ARE COMMON STUDENT MISCONCEPTIONS AND STUMBLING BLOCKS?

- Most physics theories will be a struggle for automotive students, so the best way to have them understand these theories is to show them practical examples such as brake pressures/Pascal's law on page 174 in Chapter 7.
- To help the students relate the theories to practical applications, have them list a number of the laws from this chapter and list the systems that use them.

## SHOP ACTIVITIES AND CASE STUDIES

Here are some activities you can review in-class as a group, or ask students to complete individually or in pairs:

1. Using the formula in the textbook (under "Volume," page 158), calculate the cubic centimetre and cubic inch displacement of an engine. Measure engine bore and stroke and calculate engine displacement. Give the metric equivalent of engine displacement in litres.

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2. Using the formula in the textbook (under "Torque Multiplication," page 169), calculate the overall gear ratios for each gear level of a current model of a standard transaxle.

3. Using Pascal's law and applying the formula given in the textbook (under "Laws of Hydraulics," page 174), calculate the output forces and operating pressure of the following hydraulic system: the brake system has a master cylinder piston of 10 $cm^2$, the input force is 40 kg, the front brake caliper pistons are 40 $cm^2$ each, and the rear-wheel cylinder pistons are 10 $cm^2$ each.

4. For the next part of this activity, convert all numeric values in the Pascal's law problem to imperial values and give the imperial values for the output force of all output pistons.

5. Finally, sketch the hydraulic system, labelling the output pistons and indicating the output forces at each location.

## ANSWERS TO TEXTBOOK REVIEW QUESTIONS

**1.** a. Newton's first law of motion is referred to as inertia. It means that an object at rest tends to remain at rest, and an object in motion tends to remain in motion unless some force acts on it. For example, when a car is parked on a level street, it remains stationary unless it is driven or pushed.
**2.** b. Pascal's law would most likely be applied in the brake system.
**3.** There are six different forms of energy: chemical, electrical, mechanical, thermal, radiant, and nuclear.
**4.** Types of energy conversion commonly used in automobiles are chemical-to-thermal energy (as in the combustion of the fuel); chemical-to-electrical energy (as in the battery); electrical-to-mechanical energy (as in the starter); thermal-to-mechanical energy (as in an internal combustion engine); mechanical-to-electrical energy (as in an alternator or AC generator); and electrical-to-radiant energy (as in lighting); and kinetic-to-mechanical-to-electrical energy (as in hybrid regenerative braking).
**5.** c. When energy is released to do work, it is best described as kinetic energy.
**6.** d. Weight placed evenly around the tire on a diagonal to the tire's centreline will create a dynamic imbalance. A dynamic imbalance can result in a wobble or shimmy.
**7.** a. A tire hopping up and down best describes tire tramp. This is caused by static tire imbalance.
**8.** b. The nucleus of an atom contains *protons* and *neutrons*.
**9.** c. Work is calculated by multiplying the *applied force* by the *distance the object moved*.
**10.** b. Energy may be defined as the ability to do *work*.
**11.** b. The brake pedal is an example of a class 2 lever. The resistance is placed between the pivot and the effort point.
**12.** a. Hertz is the measurement of frequency.
**13.** d. Torque is defined as a twisting force that does work with a *turning* (or rotating) action.
**14.** c. Newton-metres (N•m) are a measurement term for torque.
**15.** b. Pascal's law is a law referring to hydraulics.
**16.** c. To increase the output force in a hydraulic system, the input piston must be smaller than the output piston.
**17.** b. The automobile brake system converts the vehicle's kinetic energy to heat or thermal energy.
**18.** d. The formula for calculating the volume of a cylinder is 3.1416 × radius × radius × stroke.
**19.** b. Having a small gear driving a larger gear will produce a torque increase through gearing.
**20.** a. Specific gravity is the heaviness or relative density of a substance compared to that of water.

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# CHAPTER 8
# Preventive Maintenance and Basic Services

## CHAPTER OVERVIEW

This chapter covers repair orders, the basic understanding of preventive maintenance services that are performed on vehicles, and service information to aid the technician. A number of basic service procedures will be covered. This chapter will briefly cover a number of vehicle systems from a maintenance point of view.

## LEARNING OUTCOMES

- Describe the information that should be included on a repair order.
- Explain how repair costs can be estimated.
- Explain how the vehicle and its systems can be defined by deciphering its VIN.
- Explain the importance of preventive maintenance, and list at least six examples of typical preventive maintenance services.
- Understand the differences between the types of fluids required for preventive maintenance and know how to select the correct one for a particular vehicle.
- Explain how the design of a vehicle determines what preventive maintenance procedures must be followed.

## INSTRUCTIONAL OUTLINE WITH TEACHING HINTS

**I.** Repair Orders
- A. Computerized Shop Management Systems
- B. Parts Replacement
- C. Sublet Repairs
- D. Estimating Repair or Service Costs

**II.** Vehicle Identification

**III.** Preventive Maintenance
- A. Maintenance Schedules and Reminders
- B. Safety Inspections

**IV.** Basic Services
- A. Engine Oil
- B. ILSAC Oil Ratings
- C. ACEA Oil Ratings
- D. Manufacturers' Oil Ratings
  1. Synthetic Oils
  2. Maintenance
  3. Oil Filter
- E. Cooling System

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1. Coolant
2. Coolant Condition

F. Drive Belts
1. Drive Belt Inspection
2. V-Ribbed Belts
3. V-Ribbed Belt Inspection
4. Belt Replacement

G. Stretch-Fit Belts
H. Air Filters
I. Battery
J. Transmission Fluid
1. Manual Transmissions

K. Power-Steering Fluid
L. Brake Fluid
M. Clutch Fluid
N. Diesel Exhaust Fluid
O. Windshield Wipers
1. Windshield Washer Fluid

P. Tires
1. Inflation
2. Tire Rotation
3. Lug Nut Torque

Q. Chassis Lubrication
1. Greases

**V.** Hybrid and Electric Vehicles
A. Maintenance

**VI.** Additional PM Checks

## ADDITIONAL TEACHING HINTS

- Have the students pick two or three vehicles, record and decipher the VIN, and create a list of all of the fluids used for that vehicle's maintenance.
- Using the information in this chapter have the students create a list comparing the differences in maintenance items for a typical RWD passenger car, a pickup, a hybrid, and a typical FWD passenger car.

## WHAT ARE COMMON STUDENT MISCONCEPTIONS AND STUMBLING BLOCKS?

- A stumbling block for beginning technicians is understanding the differences between engine oils due to the fact that they all look the same. Possibly show the students two extreme viscosities and how they flow. See page 195 of Chapter 8 for reference.
- Students may struggle with preventive maintenance due to the fact that in most cases nothing is actually in need of repair. Attempt to locate components that will show good examples of a component that failed earlier than normal due to a lack of maintenance.

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## SHOP ACTIVITIES AND CASE STUDIES

Here are some activities you can review in-class as a group, or ask students to complete individually or in pairs:

1. Using the shop manual, identify the most up-to-date lubricant classification and the viscosity of engine oil, automatic transmission fluid, and power-steering fluid for the current year of three different manufacturers' vehicles.

2. Have the students create a Repair Order template individually and then as a group decide on a RO template that can be used for each vehicle that enters the shop.

3. Have the students, on a continual basis, record the actual time, flat-rate time, and estimated cost of each repair that they are asked to perform during shop time in the course.

## ANSWERS TO TEXTBOOK REVIEW QUESTIONS

**1.** The information found in the vehicle identification number (VIN) includes the country of manufacture, the make and type of vehicle, the year of manufacture, engine type, and the body style.
**2.** A battery inspection should include the following: Visually inspect the battery cover and case for dirt and grease, check the electrolyte level (if possible), inspect the battery for cracks, loose terminal posts, and other signs of damage, check for missing cell plug covers and caps, inspect all cables for broken or corroded wires, frayed insulation, or loose or damaged connectors, check the battery terminals, cable connectors, metal parts, hold-downs, and trays for corrosion damage or buildup—a bad connection can cause reduced current flow, check the heat shield for proper installation on vehicles so equipped.
**3.** Five different types of oil ratings are API (American Petroleum Institute), SAE (Society of Automotive Engineers), ILSAC (International Lubricant Specification Advisory Committee), ACEA (Association of Constructors of European Automobiles), and Manufacturer's Ratings.
**4.** Cleaning off the outside of a zerk fitting before injecting grease prevents foreign materials such as dirt or water from being pushed into the joint.
**5.** The correct tire pressure is listed in the vehicle's owner's manual or on a decal (placard) stuck on the driver's doorjamb.
**6.** d. The right to impose a mechanic's lien can be exercised by a shop 90 days after the completion of the agreed-upon services is the correct statement regarding a mechanic's lien.
**7.** d. GC is the grease classification best suited for wheel bearings.
**8.** a. 0W-20 is the engine oil best suited for use in a hybrid electric vehicle.
**9.** d. A repair quote should show the total cost of parts and shop labour, plus any shop consumables.
**10.** b. Checking the hybrid system's coolant system is an additional task that should be performed when servicing a hybrid vehicle.
**11.** a. Viscosity measures the ability of oil to resist flow.
**12.** b. The VIN shown in option b represents a 2020 Canadian-made Dodge vehicle.
**13.** c. 0 at –18°C and 20 at 100°C represents a 0W-20 oil.
**14.** b. Ethylene glycol is a coolant that is green in colour.
**15.** b. EPDM belts resist cracking, so checking the belt for a loss of material with a wear gauge is best.
**16.** a. Dark particles found on a rag after checking automatic transmission oil indicates worn clutch discs.

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**17.** d. When replacing a paper air filter element, the technician should also clean out the air filter housing.
**18.** b. Changes to seal and gasket technology is the reason for newer manufacturer oil ratings.
**19.** c. Checking engine oil is the PM check that should be performed most often.
**20.** a. 1.6 mm (1/16 inch) is the minimum amount of tire tread allowed before replacement.

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