1. An external combustion engine is an engine that generates heat energy from the combustion of a fuel outside the engine such as a steam engine. An internal combustion engine is an engine that generates heat energy from the combustion of a fuel inside the engine such as a gasoline engine.

2. A spark ignition engine is an engine that ignites an air-fuel mixture with an electrical spark. A compression ignition engine is an engine that ignites fuel by compression. Spark ignition engines commonly use gasoline. Compression ignition engines commonly use diesel fuel.

3. The five events of a small engine are the intake, compression, ignition, power, and exhaust events.

4. A slanted engine is used when the engine application requires an angled cylinder.

5. When fuel is oxidized (ignited providing combustion) in a typical small engine, approximately 30% of the energy released is converted into useful work. The remaining energy is lost in the form of heat to cooling air, exhaust system, radiation, and friction.

6. Potential energy is stored energy a body has due to its position, chemical state, or condition.

7. Kinetic energy is energy of motion. Kinetic energy is, in effect, released potential energy.

8. A Btu (British thermal unit) is the amount of heat energy required to raise the temperature of 1 pound (lb) of water 1°F (Fahrenheit). A calorie is the amount of heat energy required to change the temperature of one gram of water 1°C.

9. The only true difference between work and torque is that a torque does not always result in perceptible motion.

10. Through observation, it was determined that an average horse could move/lift 33,000 lb on a linear plane 1’ in 1 minute.

11. In an effort to establish a benchmark of small engine service technician competency, the Briggs & Stratton Corporation has instituted the Master Service Technician (MST) program. The MST program is based on the successful completion of the Briggs & Stratton MST exam. The MST exam is a comprehensive test of Briggs & Stratton Corporation product and service knowledge.

12. Small gasoline engines convert the potential energy in gasoline into the kinetic energy of a rotating shaft.

13. Engine shaft orientation is selected based on the efficiency required for driving components of the application.

14. The state of a substance as a solid, liquid, or gas, depends on the intensity of the vibration (movement) or energy of the molecules.

15. A body, when referring to force, is anything with mass.

16. Conduction is heat transfer that occurs atom to atom when molecules come in direct contact with each other, and through vibration, kinetic energy is passed from one to the other.

17. Radiation is heat transfer that occurs as radiant energy without a material carrier.

18. Convection is heat transfer that occurs when heat is transferred by currents in a fluid.

19. Torque is a force acting on a perpendicular radial distance from a point of rotation.

20. Horsepower is commonly used to rate and rank the power produced by an engine based on a finite engine speed. However, variation in some engine testing specifications has resulted in vague and inconsistent horsepower measurement.

This was the basis for the standard 550 lb-ft per second that is used today.

2. Orange is used to identify potentially dangerous parts of machines including exposed pulleys, gears, rollers, cutting devices, and power jaws in the workplace.

3. Yellow is used to identify radiation hazards in the workplace.

4. Purple is used to identify radiation hazards in the workplace.

5. Black and white are used to designate specific traffic and housekeeping areas in the workplace.

6. A code is a regulation or minimum requirement. A standard is an accepted reference or practice.

7. Private organizations are organizations that develop standards from an accumulation of knowledge and experience with materials, methods, and practices. Private organizations often impose stricter standards than other organizations. Trade associations are organizations that represent producers and distributors of specific products.

8. The number and type of fire extinguishers required are determined by the authority having jurisdiction (AHJ) based on how fast a fire may spread, potential heat intensity, and accessibility to the fire.

9. Water should never be used to extinguish a flammable liquid fire. Water disperses the flammable liquid and flames over a larger area.

10. A flammable liquid is a liquid that has a flash point below 100°F. A combustible liquid is a liquid that has a flash point at or above 100°F.

11. When transferring a flammable liquid from one metal container to another, bonding is used to prevent possible sparks caused by static electricity.

12. A lack of oxygen may lead to dizziness, headaches, blurred vision, and possibly death.

13. 4000 PPM of carbon monoxide is considered fatal.

14. Examples of a 110 dB to 140 dB hazard include a jet airplane taking off, municipal warning, locomotive horn, and/or a gasoline lawn mower engine.
15. Gloves should be snug fitting. Gloves that are too large can pose a safety hazard when working around moving parts because they can get caught on moving parts.

16. RTK stands for right to know and refers to the worker's right to know about the hazards involved when working with certain materials.

17. Back injuries are one of the most common injuries resulting in lost time in the workplace.

18. A cleaning tank is a tank used for cleaning parts in solvents with a lid that automatically closes to contain flames during a fire. A low-temperature solder joint on the safety prop is quickly melted from the heat of a fire. The prop breaks down, and gravity closes the lid.

19. Tools are commonly classified by function as measurement, fastening, cutting, striking/driving, test tools, and specialty tools.

20. Green is used to indicate safety devices and locations of first aid equipment.

21. An overhead valve (OHV) engine is an engine that has valves and related components located in the cylinder head. An L-head engine is an engine that has valves and related components located in the cylinder block.

22. Displacement (swept volume) is the volume that a piston displaces in an engine when it travels from TDC to BDC during the same piston stroke.

23. The cylinder block is the engine component which consists of the cylinder bore, cooling fins on air-cooled engines, and valve train components, depending on the engine design.

24. A head gasket is the filler material placed between the cylinder block and cylinder head to seal the combustion chamber. Head gaskets allow for even heat distribution between the cylinder block and cylinder head for efficient heat dissipation.

25. Antifriction bearings used for main bearings increase the radial and axial load capacity of the engine design.

Chapter Review 103

1. The compression ratio of most small gasoline engines ranges between 6:1 and 8.5:1.

2. The energy required to compress the charge before combustion is typically 25% of the energy released during combustion, or a 1:4 ratio.

3. Detonation is sometimes referred to as knocking, spark knock, or pinging.

4. Compression ratio is increased when a large volume of combustion chamber deposits accumulate in the engine.

5. Preignition decreases performance and results in an audible pinging or knocking sound in the engine.

6. Valve train components are commonly used on engines that drive lighter loads, have occasional use, or where economy is the main consideration.

7. Friction welding is a metal joining process in which heat and pressure cause fusion as one or both pieces are rotated and pressed against each other.

8. Hardfacing is the application of material to an engine component to improve wear resistance from load, heat, and chemical corrosion.

9. A 45° valve face angle provides a smooth transitional flow from the carburetor to the combustion chamber and an unimpeded path during exhaust gas evacuation. In addition to gas flow characteristics, the 45° exhaust valve face angle provides sufficient valve seat pressure to crush and void small combustion deposit particles. This improves the performance and longevity of the entire valve train.

10. Excessive rotation can cause surface wear between the valve face and valve seat. The signature of excessive rotation is a wiping or smearing of metal on the valve face or valve seat. Another common signature of excessive rotation is a circular wear pattern on the end of the valve stem.

11. The valve guide length to valve stem ratio is typically 7:1.

12. Valve seat inserts are commonly 0.003″ to 0.005″ larger than the machined hole in the cylinder block.

13. Some Briggs & Stratton engines use a barrel-shaped piston skirt. The barrel shape provides a smoother transition
during directional changes of the piston. The piston rolls into the cylinder wall when changing direction at the end of a stroke. This reduces noise, spreads the force of the directional change across a greater surface, and reduces side loading on the piston skirt.

14. The proper orientation of the piston pin offset is marked by a notch or an arrow on the piston head.

15. Piston windows are a series of small holes machined into the oil ring groove surface of the piston and allow oil in the piston ring groove to drain into the oil reservoir.

16. Ring lands are the two parallel surfaces of the ring groove which function as the sealing surface for the piston ring.

17. Typically, the greater the free piston ring gap, the more force the piston ring applies when compressed in the cylinder bore.

18. Currently, most piston ring design improvements are dictated by stricter emission control standards.

19. The wiper ring provides a consistent thickness of oil film to lubricate the running surface of the compression ring.

20. Vibration in the engine is the primary cause of piston ring rotation.

21. Piston ring rotation is critical to engine durability. Without rotation, inherent gas pressures and inertia can cause piston ring ends to wear into the piston ring lands. This leads to rapid piston and piston ring failure due to uneven heating of the respective surfaces.

22. Under normal operating conditions, the wear ratio between the cylinder bore and the piston ring should be equal. The preferred wear ratio on a Briggs & Stratton engine is 1:1.

23. A peripheral coating is a coating that is applied only to the bearing surface of the piston ring. It is used to lengthen the service life and to provide maximum running surface protection to the piston ring and cylinder bore.

24. It is recommended that an engine not be operated continuously at full load during the initial hours of operation because this can lead to permanent deformation of the cylinder bore.

25. The crankcase breather system maintains pressure in the crankcase at less than ambient pressure to assist in the control of oil consumption.

Fuel System

Chapter Review 139

1. Gasoline is the most common fuel used for internal combustion engines and was originally an undesirable by-product of the crude oil refining process.

2. A power decrease occurs when an engine is operated with a stoichiometric ratio compared to the same engine operated with a slightly richer air-fuel mixture.

3. A small engine operated at or near a 1.0 \( \lambda \) factor overheats from the intense heat produced by complete combustion.

4. Metal deactivators minimize the effects of metals present in gasoline.

5. When an engine is operated at a 1.0 \( \lambda \) factor, CO emission is very low and independent of the air-fuel ratio. The CO produced is affected by the distribution efficiency of the charge in the combustion chamber. This includes crevices and dead areas that do not allow the flame front to spread efficiently throughout the combustion chamber. OHV engines, by design, have fewer dead areas. This increases overall engine combustion efficiency.

6. Hydrocarbon emissions are commonly caused by incomplete combustion.

7. Catalytic converters installed on most small engines have a muffler shell, an external air intake, and a catalytic element (catalyst).

8. Octane is the ability of a fuel sample to resist engine knock and/or ping.

9. The antiknock index (AKI) number is the numerical value assigned to gasoline that indicates the ability to eliminate knocking and/or pinging in an operating engine. The more stable the charge during combustion, the higher the AKI.

10. Industry standards for rating the volatility of any given fuel use the distillation test and the Reid vapor pressure test.

11. The initial boiling point of gasoline (accounting for seasonal ambient temperature variations) ranges from 85°F to 105°F.

12. Ambient temperature is the main factor in selecting the proper fuel volatility.

13. Briggs & Stratton engines can operate satisfactorily using a gasoline blend including up to 10% by volume of ethanol.

14. Alcohol blended in gasoline can cause two problems in two-stroke cycle engines. Alcohol can remove the lubricating qualities from the gasoline-oil mixture, causing lubrication-related failures. Also, a significant number of two-stroke cycle engine failures are caused by overheating due to lean air-fuel ratios (from alcohol additives) and the lack of lubrication.

15. A gas has very little cohesive force between its molecules. This allows a gas to assume the shape of a container and increase or decrease in pressure to fill a given (sealed) container.

16. Bernoulli’s principle is a principle in which air flowing through a narrowed portion of a tube increases in velocity and decreases in pressure.

17. A bowl vent is a passage drilled into the carburetor connecting the fuel bowl to the atmosphere. The bowl vent allows ambient atmospheric pressure to be continually applied on the fuel in the fuel bowl.

18. A primer system eliminates the need for a choke.

19. When the engine is under a light to moderately light load, the pilot jet orifice limits the amount of fuel that reaches the transitional holes in the carburetor body.

20. An internal vent carburetor is a carburetor that has the fuel bowl vent located between the air filter and the venturi of the carburetor. An external vent carburetor is a carburetor that has the fuel bowl vent located outside the air path of the carburetor.

21. Engine horsepower decreases by 3.5% for each 1000’ above sea level.

22. An updraft carburetor is a carburetor that has the air intake opening below the fuel bowl. A downdraft carburetor is a carburetor that has the air intake opening above the fuel bowl. A sidedraft carburetor is a carburetor that has an air intake opening above the fuel bowl and parallel to a horizontal plane. A multiple-barrel carburetor is a carburetor that contains more than one venturi.

23. The fuel cup is a reservoir located high inside the fuel tank. The fuel cup is a holding area for fuel to be delivered to the carburetor.

24. Water present in the fuel bowl is most commonly the result of using gasoline blended with alcohol, such as ethanol.


Governor System

Chapter Review 161

1. A governor system is a system that maintains a desired engine speed regardless of the load applied to the engine. Most small air-cooled engines have a governor system to control engine speed and torque for maximum performance and safety.

2. Like cruise control on an automobile, governor systems on small engines use a movable throttle plate to vary the volume of the air-fuel mixture supplied to the combustion chamber in response to an increase or decrease in applied load.

3. If the applied load is small, the engine produces just enough torque to overcome the load. For this reason, the
throttle plate of the engine is set for a slightly open position to allow a small amount of air into the carburetor.

4. Governor system components commonly consist of a speed-sensing device and a governor spring.

5. Governor systems used on small air-cooled engines are the pneumatic governor system, mechanical governor system, and electronic governor system.

6. Governor blade material, mass, or angle of air deflection affects overall governor performance on the engine.

7. Mechanical governor systems are the most common governor systems used on small air-cooled engines built in the last decade.

8. A limited angle torque (LAT) motor is a direct current (DC) motor used to control governor system components in an electronic governor system.

9. Governor return springs provide a fail-safe function to prevent overspeeding during an electrical failure by returning the throttle plate to idle position.

10. When a snow thrower is moved from a clean sidewalk to a large snow drift, there is a decrease in engine speed. This decrease is governor droop.

11. Hunting is the undesirable quick changing of engine rpm when set at a desired speed. Surging is the undesirable slow changing of engine rpm in a cyclical pattern when set at a desired speed. Hunting and surging are similar malfunctions and are commonly used together when describing undesirable engine rpm variation.

12. Elastic limit is the last point at which a material can be deformed and still return to its original physical dimensions.

13. Hysteresis is the undesirable motion of governor system components caused by engine vibration and governor system friction characteristics.

14. Resonance is the state of the vibration wave frequency being equal to the natural vibration wave frequency of the component.

15. Governor system replacement parts are chosen by engine type number.
3. Desirable properties of cast aluminum alloy include:
   • high strength-to-weight ratio
   • ease of manufacture
   • lower production cost than cast iron alloy
   • excellent heat dissipation

4. Desirable properties of cast iron alloy include:
   • greater density resulting in higher compressive strength compared to cast aluminum alloy
   • structural integrity when mechanically or thermally stressed
   • a porous surface providing small oil reservoirs
   • excellent lubrication provided by graphite commonly contained in cast iron
   • reduced dimensional changes when placed under thermal stress compared to cast aluminum alloy

5. Thermal distortion primarily affects the operation and durability of the cylinder bore and valve seat inserts.

6. Cylinder wall temperature is considerably lower because a thin layer of gasoline adheres to the cylinder wall and acts as an insulator. Heat flows from the combustion chamber through a gasoline and oil film, through the cylinder wall, to the coolest portion of the engine block at the cooling fin tips.

7. A rotating screen is an engine component attached to the outer side of the flywheel that prevents harmful foreign matter from entering the path of cooling air to the engine. The rotating screen spins with the flywheel when the engine is operating to block sticks, stones, paper, and other debris from entering the cooling air path. The rotating screen also serves as a cutting device for any grass or weeds discharged from a lawn mowing application.

8. A cooling air plenum is required when the air flow source and/or direction are not sufficient to meet engine cooling needs.

9. Hot soak back is the period immediately following the initial shutdown of an engine when cooling air flow has stopped and the engine enclosure temperature increases for a brief time.

10. The cooling system in Briggs & Stratton liquid-cooled engines is pressurized at 11 psi to 13 psi.

11. The thermostat is used to control engine temperature and to reduce the engine warm-up period.

12. Most small air-cooled engines operate with oil temperatures that can exceed 275°F.

13. A slinger is a splash lubrication system component used on vertical crankshaft engines consisting of a spinning gear with multiple paddles cast into the plastic gear body.

14. A pressure lubrication system consists of a gerotor oil pump, a pick-up screen, an oil filter, and oil passages throughout the engine.

15. Cooling fins should be cleaned every 100 hours of engine operation.

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11. Air-cooled engines are more compact in size and weigh less than liquid-cooled engines. Liquid-cooled engines require a radiator, radiator cooling fan, water pump, thermostat, and hoses. These components are not required on an air-cooled engine.

12. Exhaust flow restriction causes unnecessary back pressure and reduces volumetric efficiency, resulting in a loss of horsepower.

13. Diesel engines often produce more torque than gasoline engines due to a relatively longer stroke and higher compression ratio.

14. Advantages of a diesel engine include:
   • greater fuel economy
   • lower fuel volatility
   • lower exhaust gas emissions
   • longer life span

15. Disadvantages of a diesel engine include:
   • more difficult cold weather starting
   • higher engine noise
   • greater manufacturing costs
   • exhaust gas particulates (soot) and odor
   • variable diesel fuel quality and availability
   • heavier engine components
by terminating the fuel injected into the cylinder.
6. Most small engines follow a typical life expectancy curve, including a break-in period, useful life, and wear-out period.
7. Break-in period is the period of time required for the running surfaces of piston rings and the surface of the cylinder bore to conform to one another after initial startup.
8. The rebound compression test has limited effectiveness when determining engine compression. The amount of rebound force is not quantified and varies greatly with a warm engine and a cold engine.
9. Carburetor leakage in float-style carburetors is most commonly caused by dirt or debris in the fuel system.
10. A static leak in a small engine is an undesirable discharge of gasoline which occurs when the engine is not operating.
11. Dirt is the most common cause of leakage after an engine has been idle for an extended period of time.
12. When a fuel filter is removed, a small amount of the inner rubber hose is removed as the barbed end of the filter is pulled out. Small rubber particles can enter into the carburetor and cause obstructions as well as leaks. These rubber particles are very small and difficult to see with the naked eye and can also enter the fuel line. When a fuel filter is removed, the fuel line should be replaced.
13. Internal leaks can be caused by:
   • loose or damaged emulsion tube
   • clogged air filter element (externally vented carburetors only)
   • excessive vibration
   • incorrect fuel inlet seat size
   • improper float level
   • clogged muffler
   • porosity in the carburetor casting
   • improper valve clearance
   • loose intake valve seat
14. Ignition system components include the ignition armature, spark plugs, spark plug wires, and Magneton® ignition module (or breaker points and condenser).
15. Cooling system problems are commonly caused by recirculation of hot exhaust gases and inadequate coolant flow.  

Chapter Review

6. Adjustable fixed speed controls are commonly used on generators, pumps, and air compressors.
7. Maximum safe engine speed is determined by the engine manufacturer based on engine design, material, and operating characteristics.
8. Small engine sound commonly ranges from 70 dBA to 85 dBA at an average distance of 10 meters (m).
9. Fretting commonly occurs on drive pulleys and centrifugal clutches.
10. Power taken from the booster fan generally should not exceed 50% of rated horsepower.
11. An oversized engine is an engine that is typically capable of producing 20% to 30% more power than required by the application at full load.
12. Engine horsepower decreases by 3.5% for each 100’ above sea level.
13. The standard angle of operation limit for most small engines is a constant 15° angle under normal operation.
14. The fuel tank outlet for a gravity feed system must be at least 1” above the fuel inlet fitting of the carburetor to ensure proper and consistent fuel delivery.
15. A 75 micron (μm) or finer fuel filter should be used on engines equipped with a fuel pump.
16. The starter motor should be capable of cranking the engine a minimum speed of 350 rpm with any parasitic load attached.
17. Generally, No. 14 wire is used for battery charging and headlight circuits, and No. 16 and/or No. 18 wire is used for all other wiring.
18. Operating characteristics are checked using touch, sight, and sound. If all three characteristics are satisfactory, the installation should be satisfactory.
19. Examples of synchronous drive systems include timing belt and power take-off (PTO) couplings or shaft drives.
20. The two most common types of rigid PTO couplings used on outdoor power equipment are flange couplings and sleeve couplings.
21. Flexible belt drives are one of the most common types of drive systems used with outdoor power equipment because they are inexpensive, quiet, easy to maintain, and can accommodate a wide range of speed and power capacity.
22. Most V-belts used with OPE can be classical, double, or notched.
23. The optimum belt wrap of a pulley and V-belt combination is 180° (100%), which means that the belt is in contact with the pulley for one half of the outer diameter of the pulley.
24. One advantage of slip is that it provides a certain degree of safety within the drive system.
25. The travel of the friction disc is limited to a short distance from the centerline.
of the drive disc. This limited movement prevents high ground speed in reverse.

26. The four most common styles of belt guides are fully enclosed, semi-enclosed, stationary pin, and L-bracket.

27. Most chainsaws and some walk-behind lawnmowers use a centrifugal clutch to allow the operator to bring the cutting chain or mower blade to a stop when the engine is at idle.

28. Electromagnetic clutches are typically used to engage the mower deck on lawn tractors.

29. A Consumer Product Safety Commission (CPSC) requirement on walk-behind lawn mowers states that the rewind starter rope grip must be positioned a minimum distance of 24" from the engine.

30. Spark arrester designs vary with engine type and size, and all must be U.S. Forestry Service approved.
1 Internal Combustion Engines

Test 1

True-False ______________________ 1
1. T
2. T
3. F
4. T
5. T
6. F
7. T
8. F
9. F
10. T

Multiple Choice __________________ 1
1. B
2. C
3. D
4. B
5. C
6. A
7. C
8. A

Completion _____________________ 2
1. 30
2. British thermal unit (Btu)
3. calorie
4. Convention
5. Area
6. pounds (lb)
7. Torque
8. lever
9. throw
10. Work
11. steam
12. radiator
13. 212
14. 550
15. piston

Temperature ______________________ 3
1. 26.67
°C = °F − 32

°C = 80 − 32
1.8
°C = 48
1.8
°C = 26.66°C
2. 35.56
°C = °F − 32
1.8
°C = 96 − 32
1.8
°C = 64
1.8
°C = 35.55°C
3. 82.4
°F = (1.8 °C) + 32
°F = (1.8 × 28) + 32
°F = 50.4 + 32
°F = 82.4 °F
°F = (1.8 × 16) + 32
°F = 28.8 + 32
°F = 60.8 °F

Horsepower ______________________ 4
1. 2.5
HP = \frac{W}{T \times 33,000}
HP = \frac{412,500}{5 \times 33,000}
HP = \frac{412,500}{165,000}
HP = 2.5 HP
2. 5.5
HP = \frac{W}{T \times 33,000}
HP = \frac{360,000}{2 \times 33,000}
HP = \frac{360,000}{66,000}
HP = 5.45 HP = 5.5 HP
3. 3.0
HP = \frac{W}{T \times 33,000}
HP = \frac{564,000}{6 \times 33,000}

Two-Stroke _____________________ 4
1. intake/compression
2. power/exhaust

Four-Stroke _____________________ 4
1. exhaust
2. compression
3. intake
4. power

Cylinder Design _________________ 5
1. horizontal
2. slanted
3. vertical
4. V
5. horizontally-opposed
6. in-line

Test 2

True–False _____________________ 7
1. T
2. T
3. F
4. T
5. T
6. T
7. T
8. F
9. T
10. T

Multiple Choice _________________ 7
1. B
2. C
3. D
4. B
5. C
6. A
7. B
8. D

Completion 8
1. 1967
2. Temperature
3. gram (g)
4. Radiation
5. Pressure
6. newtons (N)
7. body
8. stroke
9. Work
10. Power
11. water
12. temperature
13. thermometer
14. 100
15. Master Service Technician (MST)

Work 9
1. $3000 = F \times D$
   $W = 3000 \text{ lb-ft}$
2. $7200 = F \times D$
   $W = 7200 \text{ lb-ft}$
3. $745 = F \times D$
   $W = 745 \text{ lb-ft}$
4. $4000 = F \times D$
   $W = 4000 \text{ lb-ft}$

Cooling System 10
1. air
2. liquid

Shaft Orientation 10
1. vertical
2. horizontal

Torque 10
1. $180 = F \times D$
   $T = 180 \text{ lb-ft}$
2. $150 = F \times D$
   $T = 150 \text{ lb-ft}$
3. $84 = F \times D$
   $T = 84 \text{ lb-ft}$

Fire Extinguisher Classes 17
1. ordinary combustibles
2. flammable liquids
3. electrical equipment
4. combustible metals

Tools 18
1. D
2. C
3. A
4. B
5. E
6. H
7. F
8. G
9. J
10. I

Hazardous Material
Container Labeling 19
1. fire
2. reactivity
3. specific
4. health

Safety Color Coding 19
1. D
2. B
3. F
4. E
5. A
6. C

Test 1

True-False 15
1. T
2. T
3. F
4. T
5. T
6. T
7. T
8. F
9. T
10. T
11. T
12. T

Multiple Choice 15
1. A
2. D
3. B
4. C
5. D
6. B
7. A
8. B

Completion 16
1. code
2. societies
3. American National Standards Institute (ANSI)
4. ASTM International
5. flammable
6. S
7. surface
8. hazardous
9. Hand
10. flammability
11. emergency
12. test

Test 2

True-False 21
1. F
2. T
3. T
4. F
5. T
6. F
7. F
8. T
9. T
10. F
11. T
12. F

Multiple Choice 21
1. B
2. A
3. D
4. B
5. B
6. C
7. D
8. A

Completion 22
1. standard
2. American Society of Agricultural and Biological Engineers (ASABE)
3. Society of Automotive Engineers (SAE)
4. Canadian Standards Association (CSA)
5. authority having jurisdiction (AHJ)
6. combustible
7. Bonding
8. Spontaneous
9. hazard
10. safety data sheet (SDS)
11. accident
12. specific

Sound Levels ___________________ 23
1. C
2. E
3. A
4. B
5. D

Tools __________________________ 24
1. E
2. A
3. B
4. H
5. C
6. J
7. F
8. I
9. G
10. D

Digital Multimeter Tests __________ 25
1. resistance
2. continuity
3. voltage
4. current

MST Sample Exam _____________ 27
1. D
2. False
3. True
4. D
5. C
6. C

Test 1
True-False _____________________ 29
1. T
2. F
3. T
4. F
5. F
6. T

Multiple Choice _________________ 30
1. B
2. C
3. B
4. A
5. B
6. C
7. C
8. D
9. B
10. C

Completion ____________________ 31
1. engine block
2. stroke
3. bore
4. crankcase
5. sump
6. head gasket
7. overhead valve
8. throw
9. bearing
10. crankgear
11. piston
12. skirt
13. connecting rod
14. road cap
15. charge
16. power
17. overlap
18. face
19. glow plug
20. Brake
21. prony brake
22. Thermal
23. race
24. Transesterification
25. turbine
26. piston head
27. cam lobe
28. valving system
29. two
30. rocker arm

Displacement ___________________ 33
1. 28.27
   \[ D = 0.7854 \times B^2 \times S \]
   \[ D = 0.7854 \times (3 \times 3) \times 4.00 \]
   \[ D = 0.7854 \times 9 \times 4.00 \]
   \[ D = 28.2744 = 28.27 \text{ cu in.} \]
2. 38.48
   \[ D = 0.7854 \times B^2 \times S \]
   \[ D = 0.7854 \times (3.5 \times 3.5) \times 4.00 \]
   \[ D = 0.7854 \times 12.25 \times 4.00 \]
   \[ D = 38.4846 = 38.48 \text{ cu in.} \]

Connecting Rod ________________ 33
1. B
2. C
3. B
4. H
5. G
6. B
7. D
8. E

Diesels ________________________ 34
1. C
2. F
3. E
4. D
5. A
6. B

Crankshaft _____________________ 34
1. B
2. A
3. E
4. F
5. D
6. C
7. G

Test 2
True-False _____________________ 35
1. F
2. T
3. T
4. F
5. T
6. F
7. F
8. T
9. T
10. F
11. T
12. F
13. F
14. F
15. T

Multiple Choice _________________ 36
1. A
2. C
3. D
4. C
5. D
6. A
Completion ____________________ 37
1. cylinder block
2. cylinder bore
3. cooling fin
4. breather
5. cylinder head
6. jug
7. L-head
8. crankshaft
9. crankpin
10. counterweight
11. conductivity
12. bearing
13. flywheel
14. Compression
15. Combustion
16. exhaust
17. seat
18. diesel
19. Long-stroke
20. dynamometer
21. Volumetric
22. injector
23. separator
24. Scavenging
25. intake event
26. direct overhead value (DOV)
27. wastegate
28. piston pin
29. flame front
30. power

Pistons ________________________ 38
1. D
2. A
3. B
4. C

Bears ________________________ 39
1. C
2. A
3. B
4. D
5. E
6. F

Ignition Event ____________________ 39
1. B
2. C
3. D
4. A

MST Sample Exam ____________ 41
1. True
2. B
3. B
4. C
5. True
6. A
7. False

Piston Rings ____________________ 46
1. A
2. B
3. C
4. D
5. E

Interference Angle ______________ 47
1. A
2. E
3. C
4. B
5. D

Test 1

True-False ________________ 43
1. F
2. T
3. F
4. F
5. F
6. T
7. T
8. F
9. F
10. T

Multiple Choice ________________ 43
1. B
2. D
3. C
4. B
5. A

Completion ____________________ 44
1. piston
2. reduced
3. Cohesion
4. vapor
5. Preignition
6. Austenitic
7. Diamond Bore™
8. Hardfacing
9. interference
10. Side
11. Thermal
12. insert
13. windows
14. Thermal
15. Inherent
16. Break-in
17. ingetion
18. ring

Valves ________________________ 45
1. A
2. B
3. E
4. D
5. C

Adiabatic Process ____________ 46
1. A
2. B
3. C

Test 2

True-False ________________ 49
1. T
2. T
3. T
4. F
5. T
6. T
7. T
8. T
9. T
10. T
11. T
12. F

Multiple Choice ________________ 49
1. C
2. B
3. B
4. C
5. D

Completion ____________________ 50
1. adiabatic
2. 25
3. Detonation
4. austenitic
5. Stainless
6. running
7. 0.03
8. interface
9. Thermal
10. sintered
11. Cobalite™
12. lands
13. Applied
14. T
15. Honing

Thermal Expansion ____________ 51
1. 4.00524000
\[ L_n = L_o + (C \times \Delta T \times L_o) \]
\[ L_n = 4 + (0.00000655 \times 200 \times 4) \]
\[ L_n = 4 + 0.00524000 \]
\[ L_n = 4.00524000 \]
2. 3.5199675
   \[ L_n = L_o + (C \times \Delta T \times L_o) \]
   \[ L_n = 3.5 + (0.0000163 \times 350 \times 3.5) \]
   \[ L_n = 3.5 + 0.0199675 \]
   \[ L_n = 3.5199675^\circ \]
3. 4.00700
   \[ L_n = L_o + (C \times \Delta T \times L_o) \]
   \[ L_n = 4 + (0.00001 \times 175 \times 4) \]
   \[ L_n = 4 + 0.00700 \]
   \[ L_n = 4.00700^\circ \]
4. 3.00839700
   \[ L_n = L_o + (C \times \Delta T \times L_o) \]
   \[ L_n = 3 + (0.00001244 \times 225 \times 3) \]
   \[ L_n = 3 + 0.00839700 \]
   \[ L_n = 3.00839700^\circ \]

Detonation _______________ 52
1. C
2. A
3. B
4. D

Preignition _______________ 52
1. D
2. C
3. B
4. A

Leaking Exhaust Valve ___________ 53
1. A
2. D
3. C
4. E
5. F
6. B

MST Sample Exam _______________ 55
1. D
2. True
3. True
4. D
5. False
6. False
7. False
8. D
9. C
10. B
11. B
12. B

Multiple Choice _______________ 59
1. C
2. B
3. C
4. D
5. A

Completion _______________ 60
1. fossil
2. Stoichiometric
3. Carbon monoxide
4. Autoignition
5. research octane number
6. 85
7. Methanol
8. carburetor
9. venturi
10. primer
11. WOT
12. diaphragm
13. micron
14. pump
15. Catalysis
16. catalytic converter
17. laughing
18. honeycomb

Carburetor Operation _______________ 62
1. D
2. A
3. E
4. F
5. B
6. C

Test 2

True-False _______________ 63
1. F
2. T
3. T
4. T
5. F
6. F
7. F
8. F
9. T
10. F
11. F
12. T
13. F
14. F
15. F

Multiple Choice _______________ 64
1. C
2. B
3. C
4. D
5. A

Completion _______________ 64
1. Combustion
2. Lambda
3. Octane
4. antiknock index
5. market octane number
6. Vapor lock
7. 14.7
8. Bernoulli's
9. throat
10. air bleed
11. pilot
12. filter
13. Head
14. distillation
15. compression ratio
16. monolithic converter
17. Ambient
18. Liquefied petroleum gas (LPG)
19. Reid vapor pressure (RVP)
20. speed

Carburetor Design _______________ 65
1. downdraft
2. multiple-barrel
3. sidedraft
4. updraft

MST Sample Exam _______________ 67
1. False
2. D
3. False
4. D
5. True
6. True
7. False
8. A
9. C
10. A
11. False
12. A

Test 1

True-False _______________ 69
1. T
2. F
3. T
4. T
5. F
Small Engines Answer Key

Multiple Choice _________________ 69
1. B
2. C
3. D
4. B
5. C

Completion _________________ 70
1. governor
2. no-load
3. speed-sensing
4. Free
5. mechanical
6. electronic
7. armature
8. return
9. droop
10. idle
11. Hysteresis

Throttle Plate Position ____________ 71
1. C
2. B
3. A

Test 2

Test 1

Test 2

Circuits _________________ 82
1. series
2. series/parallel
3. parallel

Breaker Point Ignition System ___ 83
1. secondary
2. armature
3. windings
4. magnetic
5. flat
6. condenser
7. spring
8. plunger
9. breaker point
10. spark plug

Breaker Points ___________________ 83
1. spark plug
2. air gap
3. armature
4. stack
5. magnet
6. magnetic field
7. condenser
8. breaker points
9. primary
10. secondary

Test 2

True-False ______________________ 85
1. T
2. T
3. T
4. T
5. T
6. T
7. T
8. T
9. F
10. F
11. F
12. F
13. T
14. T
15. T
16. T
17. T
18. T
19. T
20. T

Multiple Choice _________________ 79
1. B
2. C
3. A
4. A
5. D

Completion _________________ 74
1. applied
2. parasitic
3. governor
4. rate
5. limited angle torque
6. inductive
7. dither
8. droop
9. elastic
10. Hysteresis

LAT Motor _________________ 75
1. E
2. D
3. B

Multiple Choice _________________ 79
1. B
2. C
3. A
4. A
5. C
6. C
7. A
8. D

Completion _________________ 81
1. Electricity
2. free
3. circuit
4. load
5. 12
6. Polarity
7. short circuit
8. pulse

MST Sample Exam _________77
1. B
2. False
3. B
4. True
5. C
6. True
7. C
8. D

Fixed Throttle Plate Carburetor ___ 75
1. B
2. A
3. C
4. D

Completion _________________ 70
1. governor
2. no-load
3. speed-sensing
4. Free
5. mechanical
6. electronic
7. armature
8. return
9. droop
10. speed
11. idle
12. Hysteresis

Test 1

True-False ______________________ 79
1. F
2. T
3. F
4. T
5. F
6. F
7. T
8. T
9. T
10. F
11. F
12. T
13. T
14. T
15. T
16. T
17. T
18. T
19. T
20. T
21. False
22. True
23. True
24. True
25. True
26. True
27. True
28. True
29. True
30. True
31. True
32. True
33. True
34. True
35. True
36. True
37. True
38. True
39. True
40. True
41. True
42. True
43. True
44. True
45. True
46. True
47. True
48. True
49. True
50. True
51. True
52. True
53. True
54. True
55. True
56. True
57. True
58. True
59. True
60. True
61. True
62. True
63. True
64. True
65. True
66. True
67. True
68. True
69. True
70. True
71. True
72. True
73. True
74. True
75. True
76. True
77. True
78. True
79. True
80. True
81. True
82. True
83. True
84. True
85. True
86. True
87. True
88. True
89. True
90. True
91. True
92. True
93. True
94. True
95. True
96. True
97. True
98. True
99. True
100. True

Multiple Choice _________________ 73
1. B
2. C
3. A
4. A
5. F
6. F
7. T
8. T
9. F
10. F

Completion _________________ 74
1. applied
2. parasitic
3. governor
4. rate
5. limited angle torque
6. inductive
7. dither
8. droop
9. elastic
10. Hysteresis
Workbook Answers 15

7. T
8. F
9. T
10. T
11. F
12. F
13. T
14. T
15. F

Multiple Choice ___________ 86
1. A
2. B
3. B
4. C
5. B
6. D

Completion ___________ 86
1. conductor
2. Voltage
3. pathway
4. volt
5. Current
6. amperes
7. cycle
8. Frequency
9. 60
10. switch
11. series/parallel
12. parallel
13. overcurrent
14. symbols
15. flux
16. diode
17. battery
18. Specific
19. primary
20. gap
21. Self-inductance
22. Magnetron®
23. rewind
24. flywheel
25. break-away
26. commutator
27. ringing out
28. truth table
29. Actuation
30. lamination stack

AC Voltage ___________ 88
1. Time
2. positive
3. positive
4. negative
5. pulse
6. cycle

Current ___________ 88
1. A
2. B

Starter Motor ___________ 89
1. housing
2. pinion gear

3. drive end cap
4. spring washer
5. thrust washer
6. spring retainer
7. clutch retainer
8. return spring
9. commutator
10. thru bolt
11. roll pin
12. end cap
13. armature
14. helix and drive assembly
15. brushes
16. magnets

MST Sample Exam ___________ 91
1. A
2. False
3. False
4. D
5. D
6. True
7. B
8. True
9. A
10. False

Test 1

True-False ___________ 93
1. T
2. T
3. T
4. T
5. F
6. T
7. F
8. T

Multiple Choice ___________ 93
1. C
2. A
3. B
4. D
5. A

Completion ___________ 94
1. temperature
2. Thermal
3. radiator fins
4. growth
5. Conduction
6. Radiation
7. conduction
8. rotating screen

8 Cooling and Lubrication Systems

Test 2

True-False ___________ 99
1. F
2. T
3. T
4. F
5. T
6. F
7. F
8. F

9. phase modulated
10. plenum
11. Hot soak back
12. water pump
13. Friction
14. viscosity
15. multi-viscosity
16. splash
17. slinger
18. fully-ducted
19. water jacket
20. S
21. filtration lubrication
22. Antifreeze
23. Phase lubrication
24. Coolant
25. Increases

API Certification Mark ___________ 95
1. A
2. B
3. C

Water Pump ___________ 96
1. E
2. F
3. A
4. G
5. H
6. B
7. J
8. I
9. C
10. D

Cast Iron Alloy ___________ 96
1. D
2. D
3. U
4. U
5. D

Liquid-Cooled Engine Cooling System ___________ 97
1. D
2. E
3. F
4. A
5. B
6. C
7. G

Test 2

True-False ___________ 99
1. F
2. T
3. T
4. F
5. T
6. F
7. F
8. F
### Multiple Choice ____________ 99
1. C  
2. C  
3. D  
4. B  
5. A

### Completion _____________ 100
1. Internal  
2. Thermal  
3. coefficient  
4. distortion  
5. Convection  
6. air-cooled  
7. convection  
8. fan  
9. blower housing  
10. 1
11. liquid  
12. Antifreeze  
13. thermostat  
14. Viscosity  
15. 50  
16. polymer  
17. dipper  
18. gerotor  
19. partially-ducted  
20. cooling fan  
21. C  
22. lubrication  
23. heat  
24. Oil Gard®  
25. gear drive

### Radiator ________________ 101
1. A  
2. E  
3. B  
4. D  
5. C

### Recommended SAE Viscosity Grades ____________ 102
1. 30  
2. 5W-30; 10W-30  
3. 5W-20; 5W-30

### API Service Symbol ____________ 102
1. B  
2. C  
3. A  
4. D  
5. E

### Oil Pressure ________________ 102
1. G  
2. E  
3. D  
4. A  
5. C  
6. B  
7. F

### Combustion Gas Temperatures ___ 103
1. A  
2. C  
3. D  
4. E  
5. B

### Liquid-Cooled Engines_________ 108
1. E  
2. C  
3. B  
4. D  
5. A

### Electronic Governor System ______ 109
1. E  
2. C  
3. A  
4. D  
5. B

### Multiple Choice ________________ 107
1. A  
2. C  
3. C  
4. B  
5. D

### Completion _____________________ 108
1. multiple  
2. in-line  
3. bowl-style  
4. Afterfire  
5. trigger  
6. Parasitic  
7. Duty  
8. freeze plug  
9. header pipe  
10. fuel solenoid  
11. 140,000  
12. Compression

### Test 1

#### True-False _____________ 107
1. F  
2. T  
3. T  
4. T  
5. F  
6. T

#### Multiple Choice ________________ 107
1. A  
2. C  
3. C  
4. B  
5. D

### MST Sample Exam ________105
1. True  
2. B  
3. D  
4. False  
5. C  
6. False  
7. False  
8. A  
9. False  
10. False

### Test 2

#### True-False _____________ 111
1. T  
2. T  
3. F  
4. T  
5. F  
6. T  
7. T  
8. F

#### Multiple Choice ________________ 111
1. C  
2. C  
3. C  
4. A  
5. A

### Liquid-Cooled Engines_________ 108
1. E  
2. C  
3. B  
4. D  
5. A

### Electronic Governor System ______ 109
1. E  
2. C  
3. A  
4. D  
5. B

### Test 2

#### True-False _____________ 111
1. T  
2. T  
3. F  
4. T  
5. F  
6. T  
7. T  
8. F

#### Multiple Choice ________________ 111
1. C  
2. C  
3. C  
4. A  
5. A

### Compression System Components ____________ 113
1. J  
2. A  
3. I  
4. F
12. AC voltage
13. ionization
14. choke
15. pressure lubrication system

Anti-Afterfire Solenoid Testing _______ 123
1. D
2. A
3. B
4. C

AC Voltage Test _________________ 124
1. 3600
2. red
3. black
4. VAC

Flow Chart ________________ 124
1. A
2. C
3. B
4. D

Engine Life Expectancy _______ 124
1. B
2. A
3. C

Split-Half Troubleshooting Method __ 125
1. D
2. E
3. A
4. C
5. B
6. C

MST Sample Exam ________ 127
1. True
2. A
3. B
4. False
5. True
6. C
7. C
8. True
9. B
10. False

Test 1
True-False __________________ 129
1. T
2. T
3. T
4. F
5. F
6. F
7. T
8. T

Multiple Choice _______________ 117
1. C
2. D
3. A
4. A
5. B

Completion ________________ 118
1. Troubleshooting
2. malfunction
3. split-half
4. systems approach
5. Startup
6. Shutdown
7. troubleshooting
8. static
9. loading
10. hydrometer
11. 0.166
12. rebound compression

Test 2
True-False __________________ 121
1. T
2. F
3. T
4. F
5. T
6. T
7. T
8. T
9. F
10. T

Multiple Choice _______________ 121
1. B
2. D
3. B
4. A
5. A

Completion ________________ 122
1. process
2. easy-likely
3. quick-check
4. sequential
5. Operation
6. Maverick
7. flow
8. Useful
9. Harmonic
10. dynamic
11. Specific gravity
Multiple Choice _________________ 129
1. C  
2. A  
3. C  
4. B  
5. A

Completion ________________ 130
1. failure  
2. ingestion  
3. 35  
4. Maverick  
5. Friction  
6. Sludge  
7. blown  
8. ambient  
9. hot spot  
10. Overspeeding  
11. Abrasive  
12. Piston rings

Low-Oil Conditions ________________ 131
1. C  
2. B  
3. A

Test 2
True-False _____________________ 133
1. F  
2. F  
3. T  
4. T  
5. T  
6. T  
7. F  
8. T  
9. F  
10. F

Multiple Choice _________________ 133
1. B  
2. B  
3. C  
4. C  
5. A

Completion ____________________ 134
1. Troubleshooting  
2. particle  
3. signature  
4. port  
5. Insufficient  
6. failure  
7. Overheating  
8. distortion  
9. press  
10. combination

11. Adhesive  
12. Boundary

Boundary Lubrication ________________ 135
1. A  
2. D  
3. B  
4. C

MST Sample Exam ________________ 137
1. False  
2. C  
3. A  
4. True  
5. C  
6. D  
7. False  
8. True  
9. A  
10. False

Short Answer __________________ 142
1. Fully enclosed  
2. Semienclosed  
3. Stationary pin  
4. L-bracket

Test 2
True-False _____________________ 143
1. T  
2. T  
3. F  
4. T  
5. T  
6. F  
7. F  
8. T  
9. T  
10. F  
11. T  
12. T

Multiple Choice _________________ 143
1. C  
2. C  
3. C  
4. B  
5. A  
6. D  
7. C  
8. D  
9. C  
10. A

Completion ____________________ 145
1. Repowering  
2. service  
3. envelope  
4. torque  
5. governor droop  
6. adjustable fixed  
7. manual friction  
8. muffler  
9. Frequency  
10. Fretting  
11. axial  
12. booster
13. high-inertia
14. Environmental
15. 75
16. 10
17. Resonance
18. 1
19. Belt wrap
20. pulley
21. Wedge effect
22. sleeve
23. shock load
24. belt guard
25. Belt tension

Power Curve

1. A
2. B
3. C

CPSC Requirements

1. rewind starter
2. 24
3. engine
4. grip
5. remote
6. handle bar

Horsepower

1. 4.79 HP
   \[ HP = kW \times \frac{1.34}{E} \]
   \[ HP = 2.5 \times \frac{1.34}{0.70} \]
   \[ HP = 3.35 \times \frac{1.34}{0.70} \]
   \[ HP = 4.79 \text{ HP (5 HP motor)} \]
2. 4.69 HP
   \[ HP = kW \times \frac{1.34}{E} \]
   \[ HP = 1.75 \times \frac{1.34}{0.50} \]
   \[ HP = 2.345 \times \frac{1.34}{0.50} \]
   \[ HP = 4.69 \text{ HP (5 HP motor)} \]
3. 8.38 HP
   \[ HP = kW \times \frac{1.34}{E} \]
   \[ HP = 6.7 \times \frac{1.34}{0.80} \]
   \[ HP = 8.38 \text{ HP (8.5 HP motor)} \]
4. 9.57 HP
   \[ HP = kW \times \frac{1.34}{E} \]
   \[ HP = 5 \times \frac{1.34}{0.70} \]

Fuel Line Routing

1. A
2. B
3. C

Speed Controls

1. B
2. C
3. A

MST Sample Exam

1. C
2. False
3. B
4. D
5. True
6. A
7. True
8. False
9. D
10. True

Horsepower

1. \[ HP = \text{6.7} \times \frac{1.34}{0.70} \]
   \[ HP = 9.57 \text{ HP (10 HP motor)} \]

True-False

1. T
2. T
3. T
4. F
5. T
6. T
7. T
8. F
9. F
10. T

Multiple Choice

1. D
2. B
3. C
4. C
5. C
6. A
7. C
8. B
9. B
10. C
11. B
12. B

Completion

1. American National Standards Institute (ANSI)
2. venturi

Four-Stroke

1. exhaust
2. compression
3. intake
4. power

Cooling System

1. air
2. liquid

Combustion Gas Temperatures

1. A
2. C
3. D
4. E
5. B

Detonation

1. C
2. A
3. B
4. D

Compression System Components

1. J
2. A
3. I
4. F
5. E
6. D
7. B
8. G
9. H
10. C

Horsepower

13. high-inertia
14. Environmental
15. 75
16. 10
17. Resonance
18. 1
19. Belt wrap
20. pulley
21. Wedge effect
22. sleeve
23. shock load
24. belt guard
25. Belt tension