Fuel Segment

1. Gasoline
   • Is a refined _____________ used as fuel in four-stroke engines
   • Should always be used according to the manufacturer’s recommendations
   • Is reformulated and refined to meet requirements of the Clean Air Act
     – exact specifications will vary in different areas to meet air quality needs, _____________conditions and seasonal temperature changes

2. Octane Rating
   • Determines gasoline’s ability to resist detonation caused by excessive heat and/or pressure
   • Indicates how much a fuel can be compressed or heated before it spontaneously ignites
     Four-Stroke Fact: _____________octane fuel does not burn hotter or colder, faster or slower.

3. Octane Ratings
   • Are as follows:
     – regular gasoline
       • octane rating equal to _____________ and less than 88
     – mid-grade gasoline
       • octane rating equal to _____________ and less than or equal to 90
     – premium gasoline
       • octane rating greater than 90
     Four-Stroke Fact: Lower octane gasoline will explode (detonate) at lower temperatures and pressures. Higher octane gasoline can spontaneously ignite (detonate) when exposed too much higher temperatures and pressures than lower octane gasoline.
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4. Octane Ratings
• Were significantly increased in the past by using _____________lead in gasoline
  – lead has since been _____________from gasoline because it is extremely toxic and is not compatible with catalytic converters
  • lead will quickly destroy a catalytic converter
• Have also been boosted by using alcohol and methyl tertiary butyl ether (MTBE)
  – MTBE has been found to contaminate ground water, so has been removed from gasoline sold in the U.S.

5. Volatility
• Refers to the gasoline’s ability to become a _____________
  – in order for quality combustion, gasoline must become vapor before being introduced to the _____________
  – poor quality gasoline may have too much or not enough volatility to deliver quality combustion

6. Volatility
• Should vary in different conditions for best results
• Is measured by the following:
  – vapor _____________
  – distillation profile
  – vapor-liquid _____________

7. Vapor Pressure
• Refers to the pressure exerted by vapor above the surface of a _____________in a closed container
  – an increase in pressure will make it _____________to start an engine at ambient temperature
  – a decrease in pressure is better for preventing vapor lock and other problems related to the handling of hot fuel
8. Distillation Profile
- Is engineered to give gasoline the following characteristics:
  - easy _____________starting
  - easy hot starting
  - avoiding vapor lock
  - good fuel economy
  - low engine _____________
  - good power
  - low emissions

9. Vapor-Liquid Ratio
- Relates to the _____________at which gasoline creates a vapor
- Is relative to the ____________conditions which the fuel will be used in

10. Fuel Chemical Makeup
- Is modified as the seasons change, especially where the climate has extreme change throughout the year
  - fuel refined for winter use will be _____________resistant to vapor lock
  - fuel which has a summer blend will have lower _______emissions

11. Fuel Issues
- Include:
  - vapor _____________
  - engine _____________
  - contaminants

12. Vapor Lock
- Occurs when a fuel _____________from excessive heat
- Can happen in the _____________, fuel pump or carburetor

13. Engine Detonation
- Refers to the _____________of a significant portion of the charge before the spark-induced flame front reaches it
- Is the collision of two flame fronts in the combustion chamber
  - one is the result of the _____________and the other is the result of the undesired combustion
- Can also be caused by ignition timing, being incorrectly set or by excess carbon deposits in the combustion chamber
14. Fuel Contaminants
- Can be anything from liquid to ___________
  - solids in fuel should be captured by a fuel filter and can cause fuel starvation if the fuel filter gets plugged
    - some dissolved solids can flow through the fuel filter and accumulate in the fuel bowl
  - liquid contaminants tend to create poor performance issues

Four-Stroke Fact: Water is ____________ than gasoline and will fall to the bottom of the tank and migrate to the carburetor. Just a few drops can cause intermittent stalling and no-start issues. Stale gas will not support good combustion because of its inability to vaporize properly.

15. Oxygenated Fuels
- Have oxygen added to burn more efficiently and reduce ____________ emissions
  - oxygen is usually in the form of ____________

16. Alcohol-Based Fuels/Ethanol Blends
- Are used to:
  - improve ____________
  - boost octane
  - decrease U.S. ____________ on imported oil

17. Alcohol Types
- Include:
  - methanol
    - derived from ____________ or petroleum products
  - ethanol
    - comes from grain, corn and agricultural products

Four-Stroke Fact: Today, ethanol is the primary ____________ blended with gasoline.
18. Alcohol Percentages
• Are regulated in most states
• Are posted on gasoline pumps to show the _____________ethanol content in gasoline
  – E10 (10 percent)
  – E15 (15 percent)
  – E20 (20 percent)

Four-Stroke Fact: Several states have pushed for an overall usage of 20 percent alcohol to reduce gasoline imports.
Four-Stroke Fact: Currently, all _____________engine manufacturers recommend using a fuel with a maximum rating of E10.

19. E85 (85% Ethanol)
• Is a fuel blended for vehicles designed for higher alcohol ratios
  – these vehicles contain chemical-resistant gaskets, _____________, etc., as well as stainless steel components, impervious to the effect of sustained use of _____________fuel

20. E85 (85% Ethanol)
• Is not meant to be used in typical _____________small engines used in outdoor power equipment
  – running an engine on E85 can cause a lean condition, leading to hard starting, _____________and can greatly affect engine performance

21. Alcohol Problems
• Include:
  – enleanment
  – phase _____________
  – degreasing _____________
  – corrosion

22. Enleanment
• Is altering the _____________ratio due to an increase in alcohol
  – unlike gasoline, alcohol contains a significant amount of oxygen and using a significant percentage of alcohol (above 10 percent), has the same effect as leaning out the carburetor further or using a much smaller jet size

Four-Stroke Fact: Ethanol is _____________percent oxygen.
23. Phase Separation
• Causes the octane of the gasoline to _____________two to three points
  – water and alcohol will combine and, being a heavier mixture than gasoline, will sink to the bottom of the tank
  • alcohol is not chemically stable in gasoline when water is present and is highly _____________, meaning it attracts water or moisture

24. Degreasing Agent
• Will dissolve protective oils
  – alcohol is a very effective _____________and dissolves the protective film of oil found on _____________walls, piston surfaces, bearings, bearing cages, etc.

25. Corrosion
• Is breaking down or _____________materials
  – a high concentration of alcohol can cause corrosion if left on unprotected surfaces
  • it can attack _____________aluminum components
  • it can combine with water and, once the protective film of oil is gone, will oxidize or rust ferrous metal components of left for long periods, particularly in carburetors

26. Testing for Alcohol
• Can be effective to determine the approximate _____________of alcohol present
  – providing water has not contaminated the gasoline sample
  • alcohol has a tendency to separate from gasoline when water is present
  • Is competted by performing a “___________”
27. “Shaker Test”
- Is performed in the following manner:
  - using a clear glass cylinder, with ____________graduations and
    a sealed cap, water is added to the level of the first mark from the
    bottom
  - the fuel is added until the total reaches the top mark on the
    cylinder
  - after vigorous _____________, the mixture should sit for three to
    five minutes
  - the percentage of alcohol can be read above the first mark

28. Fuel Shelf Life
- Is the recommended length of time a fuel can sit without being used
  - with the addition of alcohol to gasoline and changes to the
    refinery process, manufacturers do not recommend storing fuel
    for more than ____________days
    - this period can be even shorter in hot and humid climates
  - fuel which exceeds its shelf life will become ____________

29. Oxidized Fuel
- Will form ____________, varnish and deposits inside the carburetor
  and fuel system components
  - this is a common issue found after ____________storage of
    equipment

30. Fuel Stabilizer
- Can help ____________fuel shelf life when used per the
  manufacturer’s recommendations

Four-Stroke Fact: There is not a treatment available to rejuvenate fuel
which has already ____________.
31. Elevation
• Has the ability to effect engine _____________
  – horsepower will degrade as elevation increases
    • as the density of air diminishes, engines develop a fuel-rich condition
  – _____________the amount of fuel by adjusting the carburetor’s settings or changing jet sizes within the carburetor will bring the air/fuel ratio closer to the optimum 14.7:1 ratio and restore engine performance

Carburetors Segment
1. Carburetors
• Are a type of metering device which mix fuel and air
  – the correct mixture which flows into the combustion chamber is _____________for the engine to run properly
• Are mounted to the _____________of the engine

2. Carburetors
• Ensure the following:
  – the fuel is introduced to the _____________air stream
  – the fuel is _____________
    • liquid gasoline will not support rapid combustion without first being atomized into a mist

3. Carburetors
• Work in the following manner:
  – pre-atomized gasoline is introduced into the air stream inside the _____________
  – there the air/fuel mixture becomes an atomized mist
  – the atomized mist then flows to the intake manifold because the intake stroke creates vacuum pressure in the combustion chamber and intake _____________area of the engine

4. Float Carburetors
• Are used on products which run in a fixed or _____________position
  – such as _____________, motorcycles, marine inboard engines and snowmobiles
• Use a fuel bowl to hold the supply of fuel for the carburetor before it is processed and mixed with air
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5. Float Carburetor
1. _____________
2. Float (side view)
3. Float
4. Fuel Bowl
5. Inlet Needle
6. _____________

6. Float Carburetor
1. _____________
2. Carburetor Body
3. Idle Circuit/Jet
4. Plug
5. Float
6. Fuel Bowl
7. Fuel Solenoid
8. Main Circuit/Jet
9. _____________

7. Carburetor Parts
• Include:
  – fuel supply _____________
  – fuel bowl
  – fuel bowl _____________
  – float assembly
  – inlet needle
  – pickup tube

8. Fuel Supply Inlet
• Is where fuel _____________ the _____________ from the engine’s fuel tank
9. Fuel Bowl
• Holds fuel for use by the ____________metering circuits which are built into the ____________

10. Fuel Bowl Vent
• Allows atmospheric air pressure to enter the ____________system
  – the difference in ____________pressure (relatively high) and the venturi pressure (relatively low) pushes the fuel from the fuel container into the carburetor venturi while the engine is operating

11. Fuel Bowl Vent
• Maintains the air pressure above the surface of the fuel in the bowl at ____________levels
• May be external or internal
  – an external vent can be found on the outside of the carburetor body
  – most ____________ carburetors feature an internal type of bowl vent

12. Float Assembly
• Is used to ____________the level of fuel in the fuel bowl
  – an essentially ____________level of fuel must be maintained
    • proper metering of air/fuel ratio is dependent on a constant distance from the venturi to the surface of the fuel in the bowl

13. Inlet Needle
• Allows fuel to enter the float bowl as fuel is consumed by the engine
  – the amount of fuel in the float bowl is ____________during consumption, causing the float and inlet needle to fall, opening the inlet
    • as the fuel level rises, the float and inlet needle rise, pushing the inlet needle into its seat, ____________the flow of incoming fuel

14. Pickup Tube
• Delivers fuel to the ____________of the carburetor using the principles of the ____________effect
15. Venturi Effect
• Is the _____________in pressure which results when fluid (liquid or gas) flows through a _____________passage

16. Carburetor Operation
• Includes:
  – fixed speed
    • occurs during carburetor _____________
      – carburetors have main jets with predetermined opening sizes (no adjustment system is provided) which control the _____________of fuel allowed to enter the engine at wide open throttle
  – idle circuit
    • allows just enough fuel to keep the engine idling and controls the idle revolutions per minute (RPM)

17. Carburetor Operation
• Includes:
  – idle _____________air bleed
    • mixes air with fuel in the low idle stage of the carburetor
  – main _____________
    • meters fuel for the engine when the RPM range is high idle
    • is also known as the main jet

18. Choking Systems
• Are installed on a carburetor to _____________the flow of air to make the air/fuel mixture rich while starting
• Are operated by a choke valve
  – manually by a lever or pull handle
  – automatically by a _____________element

19. Manual Choke
• Is actuated by the operator with a lever which is attached directly to the carburetor or mounted remotely with the equipment controls
  – when the choke is _____________, the airflow is restricted to the carburetor, making the air/fuel mixture rich (more fuel than air)
  – as the choke valve is _____________, more air is introduced to the carburetor, making the air/fuel mixture more balanced for idling and faster engine operation
20. Automatic Choke
- Uses a vacuum choking system to close the choke plate when the engine is not running
  - to ease starting, the choke plate is closed by __________ pressure
  - when the engine creates enough vacuum to overcome the spring pressure, the choke plate __________ opens, allowing the correct air/fuel ratio into the carburetor

21. Electronic Choke
- Uses a processor to __________ engine speed and control stepper motor operations, which moves the choke plate as required based on engine __________ and ambient temperature

22. Electronic Fuel Enrichment
- Is used with electronic fuel injection (__________) systems
  - through the engine sensors associated with the EFI, the engine control unit calls for more fuel to be delivered from the fuel injectors when cold starting or warming the engine to operating __________

23. Carburetor Fuel Solenoids
- Are __________ plunger used to stop fuel flow through the carburetor
  - the __________ closes, using mechanical (spring) power
  - when energized, the solenoid retracts the plunger, allowing fuel to flow
- Exist to limit afterbang after the engine is turned off

Fuel Delivery Segment
1. Fuel Delivery Methods
- Include:
  - __________ feed systems
  - __________ feed systems

2. Gravity Feed Systems
- Consist of a fuel tank positioned above the __________ and uses the force of __________ to feed the carburetor fuel
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3. Pressure Feed Systems
• Consist of a fuel tank placed _____________ the carburetor
• Require the use of a fuel pump to raise the fuel from the tank to the carburetor
  – electric fuel pumps are most commonly found in use with fuel injection systems and are used in conjunction with a pressure regulator
  – vacuum or “___________” fuel pumps are operated using a vacuum provided by negative crankcase pressure; the pulse line operates a diaphragm fuel pump which provides lift and/or feed, depending on the location of the fuel tank

4. Fuel Tanks
• Have been improved since 2007 to limit the escape of _____________ (HC) vapor (evaporative emission) through tank walls
  – like other emission parts, tanks will have an ID number
  – prior to regulation, handheld fuel tanks would emit 11 grams of evaporative emissions per day
    • regulated tanks can only emit 1.5 grams per day
• Are either multi-layer or _____________

5. Fuel Lines
• Are the lines _____________ the fuel tank which go to the carburetor
• Have been required to meet permeation requirements since January 2012
  Four-Stroke Fact: Pre-regulation fuel feed lines emit _____________ grams of hydrocarbons per day while regulated lines emit only 15 grams per day.
  Four-Stroke Fact: The fuel cap gasket must meet permeation requirements as well.

6. Fuel Line Regulations
• Require manufacturers to update their fuel feed lines to new materials such as _____________ and special rubber blends
  – fuel lines should also have an ID mark to indicate it is a _____________ fuel line
  Low-Permeation Fuel Line ID Number
7. Fuel Filters
- Protect the fuel _____________ system
- Should be replaced according to manufacturer’s recommendations
- Include:
  - inline _____________
  - pre-tank filters

8. Inline Filters
- Are often simple, _____________ filters in line between the fuel tank and carburetor or fuel injection
- Require very little service
  - other than removing the element periodically and _____________ it with a new filter

9. Pre-Tank Filters
- May be located in the fuel tank filler _____________ and are usually in the form of a screen basket
- Are easily _____________ to facilitate cleaning in solvent per the manufacturer’s recommendations

10. Electronic Fuel Injection (EFI)
- Is a system for introducing fuel into _____________ combustion engines
- Is designed to be a fuel and ignition management system controlled by an engine control unit
- Provides _____________ fuel economy characteristics with benefits of enhanced engine performance
11. Electronic Fuel Injection (EFI) System

- Fuel pump
  - provides high fuel pressure for the _____________ systems
  - some models utilize dual fuel pumps; one mechanical and
    one pulse pump to draw fuel from the tank and deliver it to
    the high pressure fuel pump module

- Fuel filter
  - removes particles in the fuel to _____________ damage to
    components

- Fuel lines
  - made of stainless steel or hose rated for EFI fuel delivery
    from the tank to the fuel injectors
13. Electronic Fuel Injection (EFI) System
- Incorporates the following components:
  - fuel pressure
    - controls the fuel pressure for the injectors and returns excess fuel to the tank
  - fuel injectors
    - atomize the fuel into a mist for better combustion
  - throttle body/intake
    - distributes the air/fuel mixture from the carburetor to the cylinder(s)
  - sensors
    - provide the engine control unit with information about engine operating conditions to allow the unit to react and adjust as needed

14. Electronic Fuel Injection (EFI) System
- Operate in the following manner:
  - an electric fuel pump moves the fuel from the tank through fuel lines and an inline filter
  - fuel flows into the ____________ and into the intake manifold or throttle body
  - when the intake valve opens, the air/fuel mixture is drawn into the combustion chamber, compressed, ignited and burned

Four-Stroke Fact: The ignition and injection performance is ____________ controlled, monitored and updated to maintain the best air/fuel ratio possible based on information provided by the sensors.

15. Fuel Delivery
- Is accomplished in a variety of methods
  - ____________ injection uses a single injector at the throttle body similar to the same location as conventional carburetors
  - in continuous injection, fuel will flow at all times from the injectors, but at a changing flow rate; this is different from most fuel injection systems, which provide fuel during ____________ bursts of varying times with a constant rate of flow during each pulse
    - continuous injection systems can be multi-point or single-point
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Engine Management Segment

1. Engine Control Unit (ECU)
   • Uses _____________ received from various sensors to determine the correct amount of fuel and injection timing based on load, temperature and operator input
   • Detects malfunctions or _____________ operating conditions in the sensors and sensor circuits
     – when this occurs, the ECU generates a diagnostic trouble code (DTC)

2. Wiring Harness & Connectors
   • Should be _____________ and free of rust, corrosion and debris in order to deliver accurate electrical signals to the ECU and each other
     – this can be _____________, amperage or resistance
     – wiring and connectors which are not pliable are more likely to break, increasing the possibility of a short, an open circuit or inaccurate data delivered to the ECU, causing performance problems

Four-Stroke Fact: Short circuit can cause costly damage to components related to the EFI system.

3. Sensors
   • Are key components on many modern four-stroke engines
   • Provide necessary _____________ required by machines and their operational systems
   • Relay _____________ regarding temperature, pressures and positions of components

4. Sensors
   • Include the following common types:
     – crankshaft _____________ sensor
     – inlet air temperature (IAT) sensor
     – manifold absolute pressure (MAP) sensor
     – temperature/__________ absolute pressure (TMAP) sensor
     – throttle position (TPS) sensor
     – engine temperature (ET) sensor
     – Oxygen (O₂) sensor
5. Crankshaft Position Sensor
- Monitors the _____________per minute (RPM) of the crankshaft and its relative position in degrees of rotation
  - the signal sent to the ECU helps coordinate the EFI and the engine’s ignition _____________

6. Inlet Air Temperature (IAT) Sensor
- Provides a signal indicating the temperature of the incoming air change
- Is located in the _____________ housing or throttle body
- Works with the _____________ absolute pressure (MAP) sensor to allow the ECU to adjust the air/fuel ratio for ambient temperature differences

7. Manifold Absolute Pressure (MAP) Sensor
- Reads absolute _____________ of the intake air at the manifold and provides the ECU with a signal for determining engine load
  - this information coupled with the IAT sensor signal and the crankshaft position sensor allows the ECU to _____________ the proper fuel charge

8. Temperature/Manifold Absolute Pressure (TMAP) Sensor
- Is a _____________ of the IAT and the MAP in one sensor
- Is not found in all _____________

9. Throttle Position (TPS) Sensor
- Indicates the throttle valve _____________ so the ECU can increase or decrease the fuel mixture and spark timing to adjust for _____________, acceleration and changes in load

10. Engine Temperature (ET) Sensor
- Provides a signal to the ECU, indicating the engine temperature
- Can be _____________ in the cylinder head, engine oil pan or coolant system
- Allows the ECU to adjust _____________ to keep the engine operating within its own safe zone
- Is not found in all engines
11. Oxygen (O$_2$) Sensor

- Monitors the ___________ of oxygen in the exhaust and determines fuel burn efficiency to determine if the fuel injector should be open more or less time
- May be installed in the _____________ or exhaust manifold
- Functions effectively only after warming up to the operating temperature
- Is not found in all engines