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Transportation

Curriculum Unit 87.06.02
by Joyce Bryant

This unit is designed for middle school students. Its purpose is to acquaint and increase students knowledge and understanding of the diesel and gasoline engines. It will provide an introduction to those students who may be interested in more specialized training in the automobile field and its scientific principles through math, science and chemistry. It will also help students realize the importance of transportation and the need in their daily lives.

It will help students to meet their needs in math through problem solving by dealing with materials in their world that they will become familiar with. They will develop skills and techniques through hands on experience. The unit will also aid in helping students to develop a positive attitude toward math and school work.

Transportation is the moving of people and materials from one place to another.

The automotive industry is growing at a rapid rate. Over seventy million cars and more are being constructed. Such rapid expansion offers unlimited opportunities to persons with varying educational backgrounds.

The engine in an automobile is a machine that changes one form of energy into another form that can produce mechanical work. The engine is made up of many different parts, each part having its own function.

Transport is so intimately connected with the various assets of modern life, and has become such a common place thing, that we seldom stay to consider what it is, how it arose, how it developed, or how it is carried on. From the beginning of life to the very end it attends upon us, and ministers to our necessities and our pleasures, almost as soon as thought commence to stir within us we realize that some sort of transport is moving us from place to place. There is not an hour of our lives in which transport is not doing something for us.

Our food, our clothing, our house and their contents, have all taken their toll of its service. In most of our pleasures it is called upon to minister to us, and in a very large percentage of cases it is wanted and needed to carry us to and from the places where we may earn our daily bread. Another aspect in Which transport must appeal to us when we think about it, is its relation to the world’s polices. In it long history it has been both a war-maker and a peace maker. It has brought people together so that they may know one another.

Because no other means of transportation offers its flexibility, the car has become a way of life. It is a

necessity. A full size car weighs about 3,300 pounds, it can carry a load of approximately a thousand pounds and reach speeds of up to one hundred miles an hour. The average car gets from 9 to 28 miles per gallon and only ten percent of the full energy is converted into motion. The average life span of a car is from three to six years.

The Gasoline Engine . The gasoline engine is a highly compact, convenient, and efficient source of power. The distinguishing feature of the internal combustion engine is the fact that the fuel is burned inside the engine.

The gasoline engine is very economical as an automobile power plant and after being started has great flexibility. It is adopted for long-distance driving and does not require any great attention from the operator. The average car carries enough fuel to run 150 to 300 miles. With proper care the engine will run as long as the fuel, the lubricating oil, and the cooling water hold out and the ignition system continues to function. The gasoline engine may appear to be complicated in construction and operation, when in fact it is quite simple.

There are several types of gasoline engines in use. For our purpose we will deal with the four cycle engine.

The Four Cycle Engine . A typical four-cycle engine consists of a cast-iron cylinder open at the lower end and closed at the top. Within the cylinder is a tight-fitting piston, free to move up and down. In the closed top, or cylinder head, are placed a spark plug and two valves-one for intake of fuel and the other for exhaust of used gases. Attached to the lower side of the piston by means of a wrist pin is a rod which connects the piston to the crankshaft. Because the connection to the shaft is off-center, the up-and-down motion of the piston is converted into a rotating motion of the shaft. The crankshaft rotates within a crankcase, which carries the oil supply for lubricating the engine. The rotation of the crankshaft supplies power to the machinery which the engine is designed to run.

The motion of the piston from one end of the cylinder to the other is called a stroke. There are four strokes to the complete cycle of operation in any one cylinder: intake, compression, power and exhaust. The explosion stroke is the power stroke. Let us consider What happens in one cylinder when we operate the starter of an automobile. The piston moves downward in the cylinder, drawing into the cylinder a mixture of gasoline vapor and air from the carburetor. At the end of this intake stroke, when the piston reaches the bottom of the cylinder, the intake valve closes. With both valves closed, the piston rises, compressing the charge of fuel and air. Near the top of this compression stroke, a hot spark jumps the gap between the points of the spark plug and ignites the mixture. With both valves still closed, the rapid burning of the mixture, produces a sudden expansion of the gaseous products that drives the piston forcibly downward.

At the end of the power stroke, the exhaust valve opens and remains open during the ensuing exhaust stroke. The piston rises, forcing the waste products out of the cylinder through the exhaust valve and into the exhaust pipe, which leads to the muffler and the open air. Then a new cycle begins.

Most gasoline engines have more than one cylinder. In engines with more than one cylinder, the sequence of action just described takes place in the several cylinders at evenly spaced periods.

The Flywheel . Since one up-and-down motion of the piston causes one revolution of the crankshaft, the complete cycle of four strokes causes two revolutions of the crankshaft. In single-cylinder engines, a heavy flywheel attached to the crankshaft stores up enough kinetic energy during the power stroke to keep the moving parts in operation during the other three strokes of the cycle. In a four-cylinder engine there is one power stroke for every one-half revolution.

The Camshaft . Since both the opening and the closing of the intake valve and the opening and the closing of the exhaust valve occur but once in the complete cycle, their operation is accomplished by means of cams or projections, on a camshaft that rotates once, for every two revolutions of the crankshaft. The camshaft is accordingly driven by a one-to-two reduction gear from the crankshaft. (See diagram 1-1-5).

Ignition . In the ordinary gasoline engine the firing spark is produced by the discharge of the secondary, or high-voltage, circuit of an induction coil. Current from a battery flows through the primary, or low-voltage, circuit of the induction coil. At the moment when the spark is needed to fire the charge in the cylinder, the primary current is suddenly interrupted by the separation of the contact points in a cam-operated timer. The sudden flash of high voltage thus produced in the secondary coil is directed to the proper spark plug by a conductor, which rotates in time with the operation of the various cylinders. Here a current jumps across the gap between the contact points, producing a spark which ignites the explosive mixture. In order to produce a high flash of voltage in the secondary circuit, a very sharp break in the primary current is essential. AS an aid in procuring this sharp break, a condenser connected with the contact points in the primary circuit is an important feature of the ignition system.

Since it requires a little time-probably 1/350 of a second for the flame to spread through the entire charge of fuel, the spark is generally timed to occur just before the piston reaches top dead center. IF the spark comes too late, the action of the engine is apt to be sluggish; if it comes to soon, the engine is apt to “knock.” However, the spark should occur a little sooner in the cycle when the engine is running at high speed than when it is running slowly.

Gasoline . Gasoline is a liquid fuel, that evaporates readily and burns rapidly When mixed with oxygen. It is a hydrocarbon, complex union of hydrogen and carbon atoms which is derived from crude oil through distillation process at a petroleum refinery. Gasoline is the energy that is used in gasoline engines found in some modern cars, buses and trucks.

Gasoline is a very explosive material. If a match or spark touches even a little gasoline, it will burn with a huge flame an heat. This explosive energy is used in gasoline engines. A fuel pump is used to draw the gasoline from the tank to the carburetor where it is mixed with air and drawn into the combustion chamber by the piston. The carburetor mixes the gas with air and the burning takes place inside a cylinder, touched off by an electric spark. The pressure from the burning gas pushes down the piston. There are several explosions every second.

Cooling and Lubrication . The heat within an internal-combustion engine soars momentarily above 4500°F. Since such a temperature if sustained would wreck the motor, a cooling system is necessary. Cooling in an engine is commonly accomplished by having water circulate through spaces in the block surrounding the cylinders. The heated water then passes through a radiator, where it is cooled by a strong current of air from a fan. In winter an antifreeze solution is added to the water to prevent freezing.

Oil must be supplied to the cylinder walls, valve stems, wrist pins, and connecting rods and crankshaft bearings to maintain a protective film between rubbing surfaces. This oil supply must be kept in circulation so that it will remain cool and replace any oil that may break down under heat and pressure in a particular spot. Circulation is accomplished by the “splash system,” in which small dippers attached to the connecting-rod bearings dip into the reservoir of oil in the crankcase and splash it about, or by means of pressure from a gear-driven pump, which moves the oil through channels drilled in the crankshaft and connecting rods.

The Diesel Engine . When the diesel engine was first built, it was believed that it would be the world’s most

efficient. It delivered more power per pound of fuel than the gas. It is a self contained unit that closely resembles the gasoline engine, having fewer parts requiring care. Diesel engines are available in up to 55, 000 horsepower.

The diesel engine is an internal combustion engine, it operates on diesel liquid fuel. To obtain, maximum efficiency and power the engine depends upon heat developed by compressing air to ignite the fuel, which is forced into the combustion chamber at the proper time. These engines are available in two, four, six and eight cycles types. Diesel engines are used as a source power in automobile vehicles, both passenger car and commercial.

The diesel engine is very reliable and it offers many advantages such as: low fuel cost, low fire hazard, high power per pound of engine, low fuel consumption and a high sustained torque. A diesel engine that is supplied with clean fuel can operate continuously for long periods of time with minor repairs. Diesel fuel cost less per gallon than gasoline and in the passenger car the saving is apparent. Diesel fuel has a heat value of 139,500 heat units per gallon, compared to 124,500 heat units for gasoline.

Diesel fuel is safer because of its difficulty to ignite. Another feature is that diesel exhaust gases are not as toxic as exhaust fumes from gasoline engines. The odor of the diesel is very unpleasant, but carbon monoxide and hydrocarbons are less in the diesel engine than in the gasoline engine. Diesel fuel is obtained from crude oil which is a mixture of hydrocarbons. The properties of diesel fuel are, heat value, specific gravity, flash point, pour point, viscosity, volatility, ignition quality, carbon residue, sulphur content, oxidation and water. The heat value of a fuel is of primary importance as it is an indication of how much power the fuel will provide when burned.

The diesel engine is referred to as a compression ignition engine because it does not use a spark to ignite the fuel mixture. Because of the higher compression ratio used by the diesel engine, and the accurate injection of fuel into each cylinder, the combustion of fuel is more complete and the efficiency is higher than in the gasoline engine.

The diesel engine, be it two, four, six or eight cylinder operates on the same principle. In a four cycle engine, four strokes of the piston are required to complete one sequence of events: intake stroke, as the piston moves down, a mixture of fuel and air flows into the cylinder, compression stroke, the piston moves upward to squeeze a fuel air mixture into a tiny space, the power stroke is the rapid burning gases in the cylinder forcing the piston down. When the piston reaches the bottom of its stroke, the cylinder is filled with burned gases and the piston moves upward to push them out and this is called the exhaust stroke. This four-stroke cycle has been completed and repeated. See diagram 2.

The valve system which is important open and close the fuel and exhaust passageways. On the first stroke the intake valve is open and the exhaust valve is closed and the fuel-air mixture flows into the cylinder, during the second stroke both valves are closed and pressure of gases within the cylinder keep the valves closed, on the power stroke both valves are closed and the fuel-air mixture is ignited, and the pistons moves downward, finally the exhaust valves opens and the pistons moves upward to remove the burned gases and the intake valve is closed.

The crankshaft which is a part of the diesel engine has cylinders connected to it for the purpose of delivering one power stroke during a complete cycle. For each cycle the crankshaft must make two turns and during the first turn the inlet is open on the intake stroke and on the second turn, the exhaust valve is open on the exhaust stroke. During the power and compression strokes both valves are closed. Engines valves are closed

by springs and are open by cam lobes on a rotating camshaft. As the camshaft turns the cams push down on the valves to open them. On four cycle engines, the small gear on the crankshaft goes around twice every time the larger gear on the camshaft turns once. Lobes on the camshaft operates both the intake and the exhaust valves. (See diagram 3).

The diesel engine gets its power from the expansion of burning gases. The diesel engine depends upon the heat of compression of the air to ignite the fuel, instead of an electric spark Which is used in the gasoline engines. On the compression stroke, air is compressed until it reaches 1000°C so that liquid diesel fuel forced into the cylinder burns instantly. The piston in the fuel pump forces the fuel under high pressure though the full line and nozzle, and the fuel pump piston is pushed upward by a cam on the camshaft. The fuel injection stops when the nozzle valve closes. Each cylinder has its own fuel pump, and each pump is operated by a cam on the camshaft. (See diagram 4).

Almost all automobile type diesel engines use liquid petroleum fuels. There are eight major types of gaseous fuels used in diesel engines: natural gas, producer gas, blast furnace gas, blue water gas, from coke, carbureted water gas, coal gas, coke oven gas and refinery gas. Natural gas is found in commercial quantities throughout the United States and Canada. Other gaseous fuels may be classified as either manufactured or by-product gases.

The car is powered by an internal combustion engine using the four cycle principle. This principle has not changed, but improved in design and production methods having increased its efficiency. This combustion engine converts a fuel call gas into energy, thus causing it to function. There are differences in design, such as the six and eight cylinder engines but they are operated using the four cycle principle.

The cylinder block which is the main body of the engine has cylindrical holes in which pistons move up and down. A water jacket is used to carry away engine heat. The crankcase supports the crankshaft and camshaft in bearings along with other engine parts. An oil pan is attached to the crankshaft to hold the oil necessary for lubrication of the engine parts. An oil pump circulates the oil. The cylinder head bolted to the block is pressure tight, sealed with a head gasket. The burning of gases takes place in the combustion chamber.

The operation of the four-stroke-cycle internal combustion may be defined as the complete series of events that occurs up to the time these events are repeated. This engine requires four strokes of each piston, two up, two down and two revolutions of the crankshaft to complete the cycle. The intake stroke begins its function with the piston at the top of the cylinder. The piston moves downward on the intake stroke with the exhaust valve being closed and the intake valve open. The pressure of the air outside the engine being greater than the pressure within the cylinder causes air to move through the carburetor Where a air fuel mixture is formed and this passes through the intake manifold into the cylinder. When the piston reaches bottom center the pressure within the cylinder is below outside atmosphere pressure and the charge fuel continues to enter the cylinder. The intake valve is held open while the piston moves upward on its stroke until the position of the cam permits the valve to close.

The compression stroke follows the intake stroke. During the intake stroke both valves are closed and the air fuel mixture is contained in a sealed cylinder. The piston travels upward in the cylinder, compressing the air fuel mixture. At this point the piston has completed two strokes, one up and one down, and the crankshaft has revolved 360°F. When the piston has reached top center, the fuel charge taken in during the intake has been compressed and at this point in the cycle the fuel mixture is ignited by a spark at the spark plug and combustion takes place. Due to temperature of 5,000°F to 5,500°F developed by combustion the gases charge expands and builds up a high pressure within the cylinder. This pressure push against the head of the

piston, forcing it downward on its power stroke resulting in the transmission of power to the crankshaft in the form of torque. As the pistons nears the bottom center on the power stroke, the exhaust valve opens, relieving the pressure within the cylinder and the exhaust valve remains open while the piston moves upward forcing the burned gases out of the cylinder through an exhaust valve part (see diagram 4).

The fuel in the diesel engine is sprayed directly into the cylinder and ignited by the heat of air that has been highly compressed by the piston. There are two types of fuel injection systems in the diesel engine: the air or blast-injection system and the solid or mechanical-injection system. In the air injection system, fuel is forced into the cylinder by a jet of high pressure air. A compressor, which may be either engine or independently driven, is used to provide the compressed air. Air injection has been superseded by mechanical or solid injection. (See diagram 5).

LESSON PLANS

I.

a. Make arrangements for an experienced diesel and gasoline mechanic to speak to your class. Plan for a question and answer session on job opportunities, educational requirements, working conditions, and how to seek employment.
b. Plan a visit to a vocational school or college, such as Eli Whitney, Platt Technical or High School.
c. Write to companies, vocational schools and technical training programs for information on educational requirement necessary to become employable in the diesel and gasoline industry.
d. Prepare a written report on the specific training necessary for each job classification.

II.

a. Research diesel fuel and gasoline.
b. Where gas is found and how it is processed.
c. List and describe three out of four types of fuels.
d. What causes gases to form underground?

III.

a. Have the students write an essay on the diesel an gasoline engines.
b. Invite a speaker from the public transportation system of the city.
c. If possible plan a field trip to the company, so the students may see first hand a diesel and gasoline engine.

ACTIVITIES FOR STUDENTS

EXPANSION OF LIQUIDS

Fit two or three medicine bottles or test tubes with corks and tubes. Fill them with a variety of liquids and immerse them in a pan of hot water. The air rise inside the tubes indicates difference in expansion.

EXPANSION OF GASES

The medicine bottles can also show the expansion of air or other gases. Push the glass tube through the cork and trap some air. A hand placed on the bottle drives liquid up the tube. Warming the bottle causes air to be expelled. This reduces pressure inside. When the bottle cools, liquid is forced up the tube.

Stretch a rubber balloon over the neck of a flask which has been made from a used electric bulb. Heat the flask gently with a small flame and watch the difference.

Partially inflate a balloon and hold it over a hot plate or place it in the warm sun for a while and observe the results.

Have students take a look at the family car with their parent and observe the following:

a) Tires for air
b) Start the car and observe the dashboard for lights, and fuel gauge, also take a look at the engine while it is running.
c) Make notation of their parts and functions based upon information received.

VOCABULARY ACTIVITIES FOR STUDENTS

Have students look up definitions of words. Use the words in sentences. Write a report Where applicable.

Intake

Compression

Power

Exhaust

Combustion Chamber

Atmospheric Cycle

Crankshaft

Cylinder

Cycle

Displacement

Piston

Revolutions Per Minute

Stroke

Gasoline

Diesel Fuel

Camshaft

Combustion

Spark Plug

Carburetor

Fuel Mixture

Engine

Exhaust Valve

Engine Block

Fuel Injection

QUESTIONS

1. Name five applications of diesel engines as a source of power.
2. Five advantages that the diesel engines offers are: _____ , _____ , _____ , _____ , _____ .
3. Diesel engines are available in _____ , _____ , _____ , and cylinders.
4. Discuss the difference between diesel and gasoline fuel.
5. In a four cylinder engine, the strokes of the piston required to complete one cycle are: _____ , _____ , _____ , _____ .
6. Lobes on the camshaft operate both the _____ and valves.
7. Air in the diesel engine reaches _____ degrees so that the fuel forced into the cylinder burns instantly.
8. Describe a four-stroke cycle engine. Explain one complete action.
9. Why is the water jacket necessary in the cylinders and cylinder heads of an internal combustion engine?
10. Does the fuel explode in a diesel engine the same as in a gasoline engine? Explain.
11. Name two parts of a gasoline engine not needed by the diesel engine.
12. In your own words, explain how a diesel engine works.
13. List in order the strokes of a four cycle engine. After each one, tell briefly What happens during the stroke.
14. In a gasoline or diesel engine, why is there greater pressure on the piston during the power stroke than during the compression stroke?
15. What is meant by an internal combustion engine and how does this kind of engine run?

PROBLEMS

1. Name the capacity in kilowatts of a generator delivering current at 220 volts and 1450 amperes.
2. One truck averages 8 km per liter of gasoline, while another truck averages 15 mi per gallon. Which truck will go the greater distance on a fuel tank of gasoline if both tanks hold the same amount of gasoline?
3. A column of mercury 76 cm high is used to determine the standard atmospheric pressure at sea level. Find the height in inches.
4. An automobile wheel makes 432 revolutions in traveling 0.5 miles. How many revolutions will it make in traveling 0.9 miles?
5. Gas is flowing through a pipe at the rate of 78 gallons each 6 seconds. How long will it take for 1112 gallons to flow through the pipe?
8. An automobile traveled 50 miles on 4 gallons of gasoline. How far should the vehicle travel on a full tank of 25 gallons?
7. A bus driver took 1.5 hours to drive 72 miles. At that rate, how long will it take her to drive 420 miles?
8. An automobile wheel makes 49 revolutions in traveling 375 ft. How many revolutions per mile does it make?
9. Gasoline is selling for $1.06.9 per gallon. It cost Jermaine $21.38 to fill the gas tank in his car. How many gallons did he buy?
10. The distance from Justine's house to the park is 810 meters and the distance from the park to school is 880 meters. If she walked from her house to the park and then to school, how far did she walk? Did she walk more than kilometer? How much farther than a kilometer did she walk?
11. Shantel's father purchased a new car and kept it for four years. At the end of the first year the odometer read 8,425 miles, at the end of the second year 20,132 miles, at the end of the third year 34,142 miles, and at the end of the fourth year 45,366 miles. How many miles did Shantel's father drive the second year, the third year, the fourth year?
12. At a speed of 55 miles per hour, how many minutes will it take to go a distance of 45 miles?
13. The family car averages 18 miles per gallon of gasoline. How many gallons will the family car use to go 300 miles?
14. Joe's family started on an automobile trip, filled the gasoline tank and set the odometer at zero. When the family reached Dallas it registered 149 miles. It took 9.5 gallons to refill the tank. How many miles per gallon of gasoline did the family get?
15. What distance in feet does the tip of a propeller travel in one revolution if its length (diameter) is 12 feet?
16. If the diameter of each Wheel is 35 inches, how far does a car go when the wheels revolve once? How many times do the wheels revolve in a distance of 2 miles?
Heating or cooling a gas at constant volume
(figure available in print form)
Heating or cooling a gas at constant pressure
(figure available in print form)
17. Consider a fuel air mixture in a closed vessel. This gas is at an initial temperature of 110°C and a pressure of 6 atmospheres. The fuel is ignited by a spark, resulting in a temperature of

800°C. What is the pressure per pound ignition?
18. Consider a gas contained in a circular tube 8 inches in diameter. The tube has in it a sliding piston with a very small mass.
(figure available in print form)
The gas in the piston is at 20°C, at atmospheric temperature, and the piston is 15 inches from the bottom of the cylinder.
a. Calculate the cross-sectional area of the cylinder
(figure available in print form)
b. Calculate the volume of the gas initially in the cylinder.
(figure available in print form)
c. Calculate the distance of the piston from the bottom of the cylinder when the gas is heated to 300°C.
(figure available in print form)
19. The Goins family drove 420 miles between 7:15 A.M. and 5:30 P.M. Round off the distance to the nearest hundred miles; the time to the nearest hour. Estimate the average speed. Find their speed to the nearest mile per hour.
20. The value of n is 3.14. The formula for the circumference C of a circle with diameter d is C =nd. Estimate the circumference of a wheel with a diameter 38-1/2 inches. Find the correct solution to the nearest 0.1 inch.
21. The Dee club drove X miles on Thursday and Y miles on Friday. They drove 350 miles during the two days. The club drove 50 miles farther on Friday than on Thursday. How far did they drive each day?

DIAGRAM 1-1-5

Intake Stroke : The piston begins its cycle at the top of the cylinder, with the exhaust valve closed and the intake valve open. A vacuum is created as the piston moves downward drawing a vaporized fuel mixture into the cylinder.

(figure available in print form)

Compression Stroke : After drawing in the fuel mixture the piston is forced upward by the crankshaft; the intake valve is closed by linkage of valve lifters, pusrods, and rocker arms driven by a camshaft.

(figure available in print form)

Power Stroke : Combustion takes place when the compressed fuel-air mixture is ignited by the spark plug.

(figure available in print form)

Exhaust : The exhaust valve is open as the piston reaches bottom and move upward again, forcing the burn gases out of the cylinder.

(figure available in print form)

DIAGRAM 1-1-5

(figure available in print form)

DIAGRAM 2

(figure available in print form)

DIAGRAM 3

(figure available in print form)

(figure available in print form)

(figure available in print form)

DIAGRAM 4

(figure available in print form)

DIAGRAM 5

(figure available in print form)

RESOURCE LIST

International Association of Machinists and Aerospace Workers

Washington, DC 20036

Internal Union, United Automobile Aerospace and Agricultural Implement Workers of America

8000 East Jefferson Avenue

Detroit, Michigan 48214

U.S. Department of Labor

Bureau of Apprenticeship and Training

Washington, DC

Pratt and Whitney

415 Washington Avenue

North Haven, CT (203) 234-4200

Sikorsky Air Craft

Stratford, CT (203) 386-4000

Eli Whitney Regional Vocational Technical School

71 Jones Road

Hamden, CT (203) 397-4027

Platt Technical Training School

Milford, CT (203) 877-2771

SUGGESTED READING LIST FOR TEACHERS

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*These books are recommended highly.