

The Basics of Four-Stroke Engines

Description

Students will be introduced to basic engine parts, theory and terminology. Understanding how an engine works and knowing some key related parts and terminology is important for working on any vehicle. The information is broken down into three major sections: “Basic Engine Parts,” “Basic Engine Terminology” and “Basic Four-Stroke Cycle Engine Theory.”

Lesson Outcomes

The student will be able to:

- Identify and explain the function of basic engine parts
- Identify and explain basic engine terminology
- Identify the four piston strokes of a four-stroke cycle engine
- Describe the action and function of each piston stroke

Assumptions

- The students will have little or no prior knowledge of how engines work, terminology or parts.
- The teacher is familiar with the information being taught.

Note: This information is given as a guide to the minimum amount of material to be covered for a basic understanding of the engine and how it works. Much more can be added as the instructor sees fit.

Terminology

Valve train: all the parts that are used to open and close valves. This may include parts such as valve springs, keepers, lifters, cam followers, shims, rockers and push rods.

Any other terminology used will be explained as required during the activities.

Estimated time

90–120 minutes (including a question and answer session)

Recommended number of students

20, based on the *BC Technology Educators’ Best Practice Guide*

Facilities

A classroom, computer lab or workshop with tables and chairs sufficient for 20 students.



Materials

- Basic engine parts to show as examples, or images of them. A wide variety would be best (1, 4, 6 and 8 cylinders)
- Engine cutaway

Resources

Four Stroke Engine

Animation of four-stroke engine in motion. Other depicted engines can be found on the home page.

www.animatedengines.com/otto.html

Automobile Engine: Introduction

<https://auto.howstuffworks.com/engine1.htm>

How Car Engines Work

www.howstuffworks.com/engine.htm

World's Largest and Most Powerful Diesel Engine

General interest—description of the largest two-stroke diesel engine, designed for use in container ships.

<http://wonderfulengineering.com/worlds-largest-and-most-powerful-diesel-engine/>

Print Resources

Stockel, Martin. *Auto Mechanics Fundamentals*. Goodheart-Wilcox Co., 1990.

McGraw-Hill Education (author). *Automotive Excellence, Volume 1* (3rd Edition). Glencoe/McGraw-Hill, 2006.

Activity

This information can be presented in many different ways and formats: straight theory lessons, worksheets, computer research assignments or textbook assignments. This information is meant only to be the essential basics to build a foundation on how an engine functions.

1. Basic Engine Parts

Engine Block

The engine block is the foundation and centre of the engine. Blocks come in many different sizes, shapes and styles.

The engine block holds the cylinder, the crankshaft, connecting rods (“con rods”) and pistons. The large round holes in the block, called *cylinders*, are where the pistons slide up and down.



Figure 1—Cylinder block with head attached

Piston

A piston slides up and down a cylinder and pushes the crankshaft around. The piston connects to the crankshaft via the connecting rods.



Figure 2—Piston



Figure 3—Piston with connecting rod attached

Piston Rings

Each piston has two compression rings and one oil control ring to help seal the piston in the cylinder.

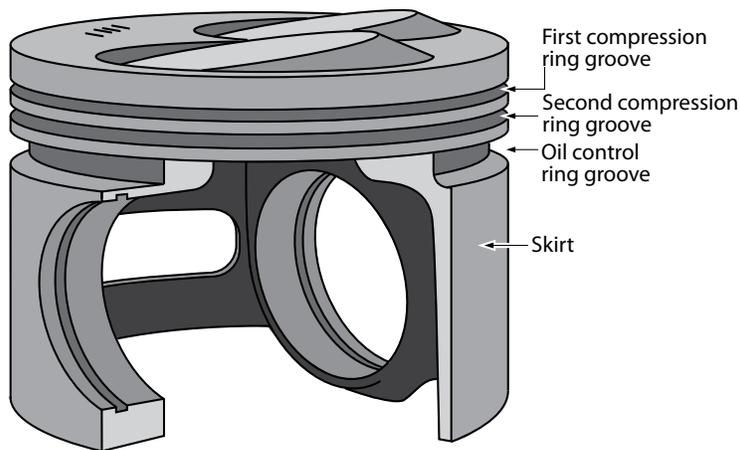


Figure 4—A piston with two compression rings and one oil control ring



Figure 5—Piston rings (compression rings and oil control ring, left to right)

Connecting Rods

Connecting rods connect the pistons to the crank. They utilize an I-beam construction for strength.



Figure 6—Connecting rod

Crankshaft

The crankshaft is bolted to the bottom of the engine block through bearings so it can rotate freely. It is sometimes referred to as the *crank*. The crankshaft converts the vertical motion of the pistons and connecting rods to rotational motion. One end of the crankshaft is connected to a flywheel that transfers the engine power to the wheels through a transmission (manual or automatic).



Figure 7—Crankshaft with pistons and connecting rods attached



Figure 8—Crankshaft of a 1-cylinder engine with connecting rod attached

Cylinder Head

The cylinder head is bolted to the top of the cylinder block. It serves as a cover for the cylinders and pistons. The cylinder head helps to create the top part of the combustion chamber. An engine “breathes” through the cylinder head. It lets an air/gas mixture into the engine and exhaust out of the engine. The valves and valve train control the breathing of the engine by opening and closing the valves at the appropriate time.



Figure 9—Top view of cylinder head with camshafts attached



Figure 10—Bottom view of cylinder head showing where the valves sit
Note: This has four valves per cylinder (two intake and two exhaust).



Figure 11—Cylinder head being attached to engine block

Valves

Valves can be divided into two groups:

- Intake valves control the flow of the air/gas mixture into the engine.
- Exhaust valves control the flow of exhaust out of the engine.



Figure 12—Exhaust and intake valves



Figure 13—Valve

Camshaft

The camshaft controls the opening and closing of the valves. There is one lobe on the camshaft for each valve in the engine. Camshaft lobe design dictates three things:

- How far the valve opens
- How fast the valve opens
- How long the valve opens

Depending on the engine type, the camshaft can be located either in the engine block or over the head (OHC) or double OHC (DOHC).



Figure 14—Cam lobe profile showing the opening and closing angles



Figure 15—Camshaft



Figure 16—In-the-block camshaft



Figure 17—Camshaft located over the head

Lifters (Tapetts)

Lifters are the link between the cam and valves. They are so named because they actually lift as the cam lobe rotates and open the valves. There are two basic types of lifters:

- The hydraulic lifter
- The solid lifter

Timing Chain/Belt/Gears

These parts are used in different combinations and configurations to connect the crankshaft to the camshaft. They keep the valves' opening and closing timed with the piston movement. Timing belts should be replaced every 100,000 km or every five years.

Valve Train

The valve train includes all the parts that are used to open and close valves. This may include parts like valve springs, keepers, lifters, cam followers, shims, rockers and push rods.



Figure 18—Diagram of an engine with overhead camshafts, demonstrating valve train components

Flywheel

The flywheel attaches to the crankshaft, and uses its momentum to power the engine through the three non-power strokes (intake, compression and exhaust). Because an 8-cylinder car has more power strokes than a 4-cylinder car, the flywheel will be smaller and lighter as there is less need for the momentum carry capabilities.

- Flywheels are used in standard transmissions.
- Flexplates are used in automatic transmissions.

Flywheels and flexplates have a ring gear for the starter.

2. Basic Engine Terminology

Bore: the distance across the cylinder (or the diameter).

Bottom dead centre (BDC): the lowest point in the cylinder that the piston reaches.

Combustion chamber: the space left at the top of the cylinder when the piston is at top dead centre (TDC). This also includes any space in the cylinder head.

Compression: the squishing or squeezing of the air/fuel mixture from BDC to TDC. The more the mixture is compressed, the more power it can produce.

Compression ratio: the difference as expressed through a ratio of the space left in the cylinder when the piston is at TDC versus BDC. For example, 8:1 means that the space when the piston is at BDC is 8 times bigger than when the piston is at TDC.

Cubic inch displacement (CID): the engine size. For example, Chevy 350 (cubic inches), Mustang 5.0 (cubic litres) or Honda 1800 cc (cubic centimetres). Even though 5.0 L and 1800 cc are metric measurements, they are often referred to as the CID of an engine.

CID is a mathematical calculation that takes into account the bore and stroke of the cylinder times the number of cylinders in the engine. It basically measures how much volume or air a cylinder can displace or push out from BDC to TDC.

Engine types: engines can be classified in many different ways, but three basic engine types likely to be encountered in an automotive shop are:

- Four-stroke cycle engine—takes four strokes of the piston to complete a cycle
- Two-stroke cycle engine—takes two strokes of the piston to complete a cycle
- Diesel—(two or four stroke) uses heat of compression rather than a spark plug to ignite the fuel that is directly injected into the cylinder

Each of these engines can come in several different configurations.

Four-stroke cycle: four movements of the piston equals one cycle.

Stroke: the distance the piston travels from TDC to BDC or from BDC to TDC.

Top dead centre (TDC): the highest point in the cylinder that the piston reaches.

3. Basic Four-Stroke Engine Theory

Regardless of its design, an engine needs four things in order to deliver a substantial amount of useful energy or work:

1. Air
2. Fuel to burn
3. Ignition source to ignite the fuel
4. Compression of the air/fuel mixture to maximize the power potential of the fuel

Take away any of these items and an engine will not run. Therefore all engine designs are based on allowing these key factors to work in harmony for a smooth, powerful and efficiently running engine.

Example: You could pour out some gas on a small plate and light it on fire. Although it would produce some light and heat, it would not be a great source of power. However, taking that same plate of gas and compressing the air around it by placing a bowl over it and igniting the gas would produce enough power to blow the bowl off the plate. This is the basics of how an engine works.

The Four-Stroke Cycle

Nickolaus Otto is credited with building the first four-stroke cycle engine in 1867, considered the basis of our modern engines. In his honour it is often called the *Otto cycle engine*.

1. Intake stroke

- The piston moves from TDC to BDC (down).
- The intake valve is open.
- The exhaust valve is closed.
- The piston creates a suction (vacuum) and air and fuel are sucked into the cylinder.

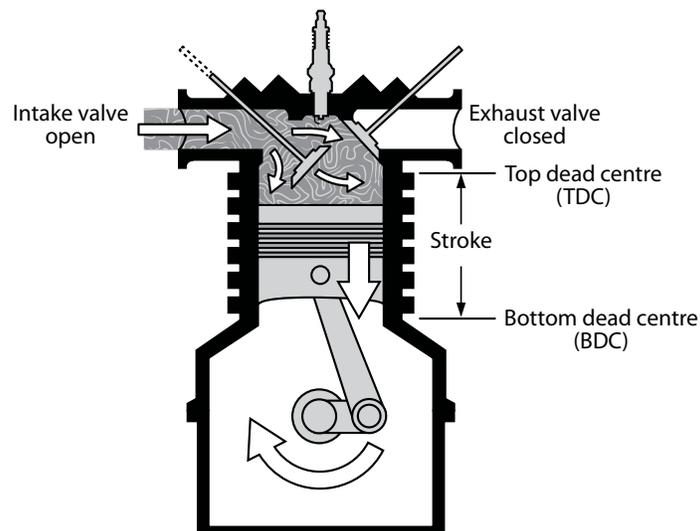


Figure 19—Intake stroke

2. Compression stroke

- The piston moves from BDC to TDC (up).
- Both valves are closed.
- The piston compresses the air and fuel mixture.

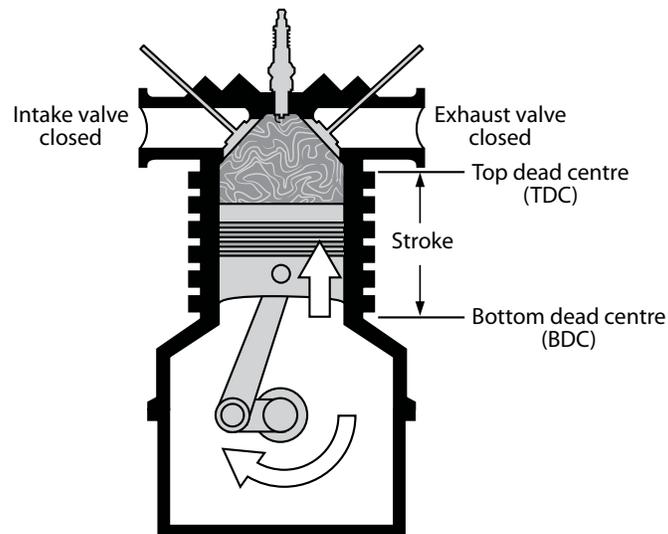


Figure 20—Compression stroke

3. Power stroke

- The piston moves from TDC to BDC (down).
- Both valves are closed.
- The spark plug fires.
- The fuel mixture burns rapidly. This expanding heated mixture forces the piston down.

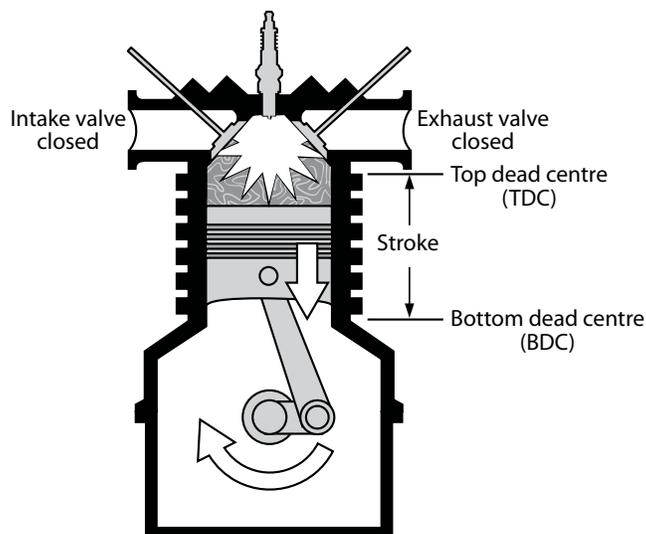


Figure 21—Power stroke

4. Exhaust stroke

- Piston moves from BDC to TDC (up).
- The intake valve is closed.
- The exhaust valve is open.
- The piston pushes the exhaust out.

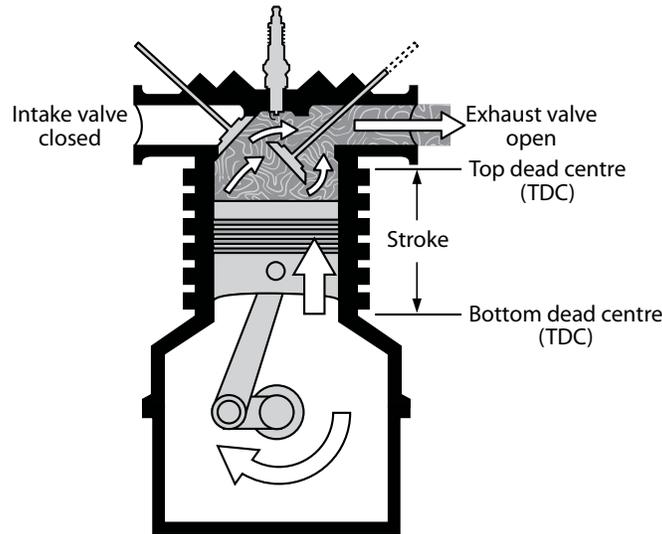


Figure 22—Exhaust stroke

The cycle repeats itself.

The four-stroke cycle is presented in chart form below. Note the following:

- The piston direction has a distinct pattern.
- The intake valve is only open during the intake stroke.
- The exhaust valve is only open during the exhaust stroke.

	Intake	Compression	Power	Exhaust
Piston Direction	Down	Up	Down	Up
Intake Valve	Open	Closed	Closed	Closed
Exhaust Valve	Closed	Closed	Closed	Open
Mixture Action	Sucked In	Being Squished	Ignited	Pushed Out

Remember **ICPE**: intake, compression, power, exhaust.

The cycle repeats itself. This order cannot change!