How Car Engines Work

by Marshall Brain

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Have you ever opened the hood of your car and wondered what was going on in there? A car engine can look like a big confusing jumble of metal, tubes and wires to the uninitiated.

Photo courtesy DaimlerChrysler
2003 Jeep® Grand Cherokee Engine

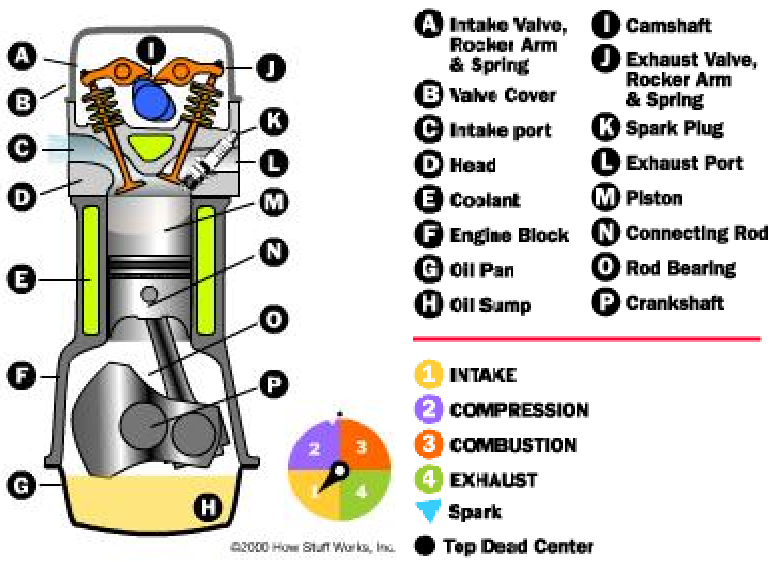
You might want to know what's going on simply out of curiosity. Or perhaps you are buying a new car, and you hear things like "3.0 liter V-6" and "dual overhead cams" and "tuned port fuel injection." What does all of that mean?

If you have ever wondered about this kind of stuff, then read on -- In this article, we'll discuss the basic idea behind an engine and then go into detail about how all the pieces fit together, what can go wrong and how to increase performance.

The purpose of a gasoline car engine is to convert gasoline into motion so that your car can move. Currently the easiest way to create motion from gasoline is to burn the gasoline inside an engine. Therefore, a car engine is an **internal combustion engine** -- combustion takes place internally. Two things to note:

- There are different kinds of internal combustion engines. Diesel engines are one form and gas turbine engines are another. See also the articles on HEMI engines, rotary engines and two-stroke engines. Each has its own advantages and disadvantages.

- There is such a thing as an **external** combustion engine. A steam engine in old-fashioned trains and steam boats is the best example of an external combustion engine. The fuel (coal, wood, oil, whatever) in a steam engine burns outside the engine to create steam, and the steam creates motion inside the engine. Internal combustion is a lot more efficient (takes less fuel per mile) than external combustion, plus an internal combustion engine is a lot smaller than an equivalent external combustion engine. This explains why we don't see any cars from Ford and GM using steam engines.



Inside a typical car engine

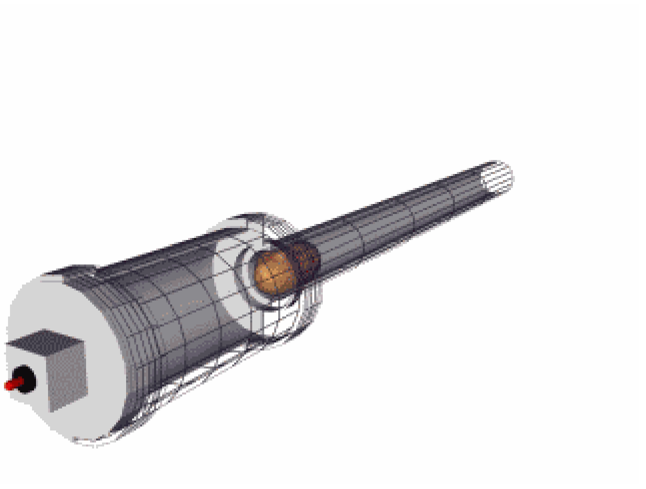
Almost all cars today use a reciprocating internal combustion engine because this engine is:

- **Relatively efficient** (compared to an external combustion engine)
- **Relatively inexpensive** (compared to a gas turbine)
- **Relatively easy to refuel** (compared to an electric car)

These advantages beat any other existing technology for moving a car around.

To understand the basic idea behind how a reciprocating internal combustion engine works, it is helpful to have a good mental image of how "internal combustion" works. One good example is an old Revolutionary War cannon. You have probably seen these in movies, where the soldiers load the cannon with gun powder and a cannon ball and light it. That is internal combustion, but it is hard to imagine that having anything to do with engines.

A more relevant example might be this: Say that you took a big piece of plastic sewer pipe, maybe 3 inches in diameter and 3 feet long, and you put a cap on one end of it. Then say that you sprayed a little WD-40 into the pipe, or put in a tiny drop of gasoline. Then say that you stuffed a potato down the pipe. Like this:



I am not recommending that you do this! But say you did... What we have here is a device commonly known as a **potato cannon**. When you introduce a spark, you can ignite the fuel.

What is interesting, and the reason we are talking about such a device, is that a potato cannon can launch a potato about 500 feet through the air! There is a huge amount of energy in a tiny drop of gasoline.

Internal Combustion

The potato cannon uses the basic principle behind any reciprocating internal combustion engine: If you put a tiny amount of high-energy fuel (like gasoline) in a small, enclosed space and ignite it, an incredible amount of energy is released in the form of expanding gas. You can use that energy to propel a potato 500 feet. In this case, the energy is translated into potato motion. You can also use it for more interesting purposes. For example, if you can create a cycle that allows you to set off explosions like this hundreds of times per minute, and if you can harness that energy in a useful way, what you have is the core of a car engine!

Almost all cars currently use what is called a **four-stroke combustion cycle** to convert gasoline into motion. The four-stroke approach is also known as the **Otto cycle**, in honor of Nikolaus Otto, who invented it in 1867. The four strokes are illustrated in **Figure 1**. They are:

- Intake stroke
- Compression stroke
- Combustion stroke
- Exhaust stroke

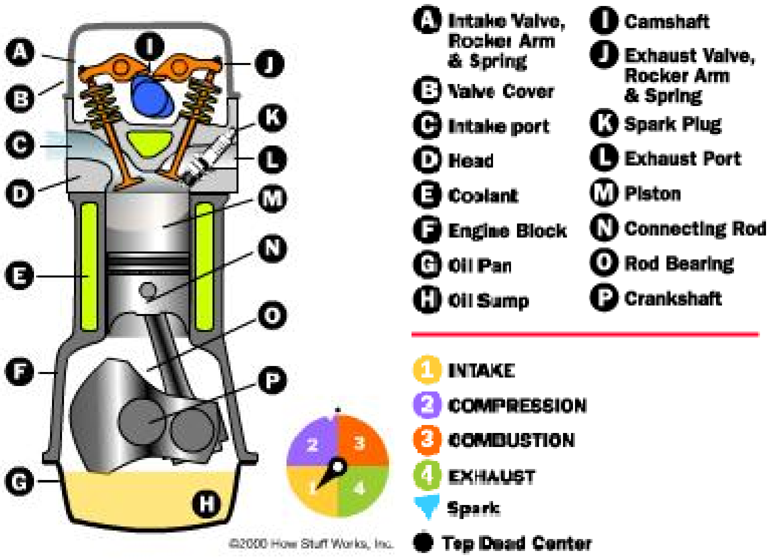


Figure 1

Understanding the Cycles

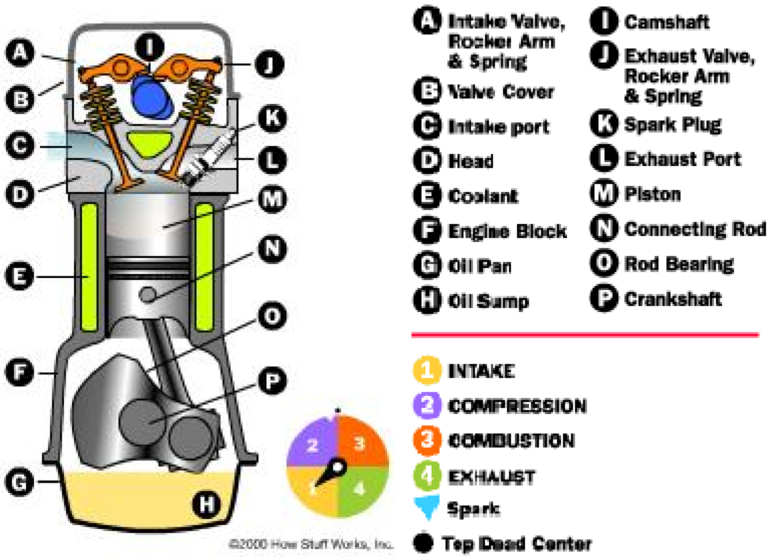
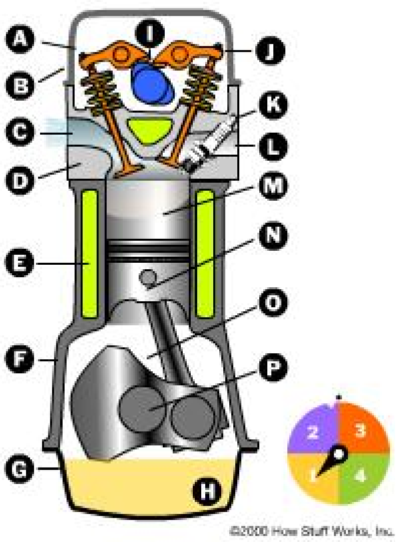


Figure 1

You can see in the figure that a device called a **piston** replaces the potato in the potato cannon. The piston is connected to the **crank shaft** by a **connecting rod**. As the crankshaft revolves, it has the effect of "resetting the cannon." Here's what happens as the engine goes through its cycle:



1. The piston starts at the top, the intake valve opens, and the piston moves down to let the engine take in a cylinder-full of air and gasoline. This is the **intake stroke**. Only the tiniest drop of gasoline needs to be mixed into the air for this to work. (Part 1 of the figure)
2. Then the piston moves back up to compress this fuel/air mixture. **Compression** makes the explosion more powerful. (Part 2 of the figure)
3. When the piston reaches the top of its stroke, the spark plug emits a spark to ignite the gasoline. The gasoline charge in the cylinder **explodes**, driving the piston down. (Part 3 of the figure)
4. Once the piston hits the bottom of its stroke, the exhaust valve opens and the **exhaust** leaves the cylinder to go out the tail pipe. (Part 4 of the figure)

Now the engine is ready for the next cycle, so it intakes another charge of air and gas.

Notice that the motion that comes out of an internal combustion engine is **rotational**, while the motion produced by a potato cannon is **linear** (straight line). In an engine the linear motion of the pistons is converted into rotational motion by the crank shaft. The rotational motion is nice because we plan to turn (rotate) the car's wheels with it anyway.

Now let's look at all the parts that work together to make this happen.

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It's hard to believe that the good old internal combustion engine may be seeing its final era of dominance. What would like to see in the Engine of the Future? Give us your wish list!

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