

# Diesel Engine Piston Demonstrator Instructions



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## Introduction

Learn firsthand about a unique relationship between gas pressure and temperature with this kit.

The following materials are included:

- piston apparatus
- cotton for ignition
- package of lubricant
- two extra rubber o-rings

## Scientific Principles

When it is compressed rapidly, gas undergoes an *adiabatic* thermodynamic process, one that occurs without loss or gain of heat. As the volume is reduced, pressure increases very quickly. The temperature of the gas also rises, because there is not time for the heat energy to transfer to its surroundings as would normally happen. This increase in temperature can cause flammable substances to ignite with "hot air" alone!

How does it work? A diesel engine compresses air inside a cylinder (which leads to an adiabatic temperature increase) and then injects fuel at just the right moment so that it combusts from the heat. The fuel combustion forces the piston down, producing the engine's power.

This design, where fuel is directly injected into the cylinder at the top of the engine's compression stroke, prevents engine knock, unlike a gasoline engine that uses a spark plug for ignition. (The fuel in a diesel engine combusts spontaneously from the heat, rather than requiring a spark to ignite it.) Since there's no danger of causing knock, the diesel engine can use higher compression ratios than gasoline engines.

Diesel engines with high compression ratios are more efficient than gasoline engines, which is why large trucks and ships use diesel engines. When it was invented in the 1890s by Rudolf Diesel, though, the engine was sneered at.

A diesel engine starts with an *intake* stroke, where air is sucked into the cylinder as the piston moves down. The next *compression* stroke occurs when the piston moves back up, compressing air rapidly in an adiabatic process. In the *power* stroke, the fuel is injected and ignites, pushing the piston down and powering the engine with the energy produced. In the *exhaust* stroke, the piston moves back up, pushing the burned gases out.

The more flammable the fuel, the lower the temperature required to cause ignition. Cotton is used in this experiment, since it's much more flammable than a heavier fuel (such as wood). When the oxygen gas in the air surrounding the piece of cotton heats up quickly, it can ignite the cotton.

## Set Up

1. Unscrew the cylinder cap and remove the piston assembly from the cylinder. Spread a little dab of the lubricant onto each of the rubber o-rings on the piston, to work as a seal.
2. Insert the piston rod into the cylinder and then move the piston up and down a few times until the inside wall of the cylinder is lubricated.
3. Pull the piston all the way up and then screw the cap tightly on the cylinder.
4. Set the apparatus on a table and push the piston down hard. The piston should be about 1cm (1/2 inch) from the bottom of the cylinder. When you release the handle, the piston should snap back up to the middle of the cylinder.



**Troubleshooting Tip:** If the piston does not bounce back high enough, use more lubricant or Vaseline on the o-rings. If the problem continues, replace the rubber o-rings.

## Experiment

1. Unscrew the cylinder cap and remove the piston from the tube.
2. Tear off a small piece of the cotton, making sure not to wad it up--the fibers should be loose and exposed in order for it to ignite. Drop the cotton into the bottom of the cylinder.
3. Replace the cap with the piston just below the opening, and screw it on tightly.
4. Push the handle down hard. The cotton will ignite as the rapid increase in gas (air) pressure causes a corresponding increase in temperature. You should see a flash, if not an actual flame.

**Note:** You can repeat the experiment, using a fresh piece of cotton. Just tap the burned cotton out of the cylinder and repeat steps 1-4. If you use up all of the provided cotton, you can use a piece of a regular cotton ball. If the regular cotton doesn't ignite, try dabbing it in denatured alcohol or rubbing alcohol to increase its flammability.