



INTERNAL COMBUSTION ENGINE (ICE)

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Lecturer,

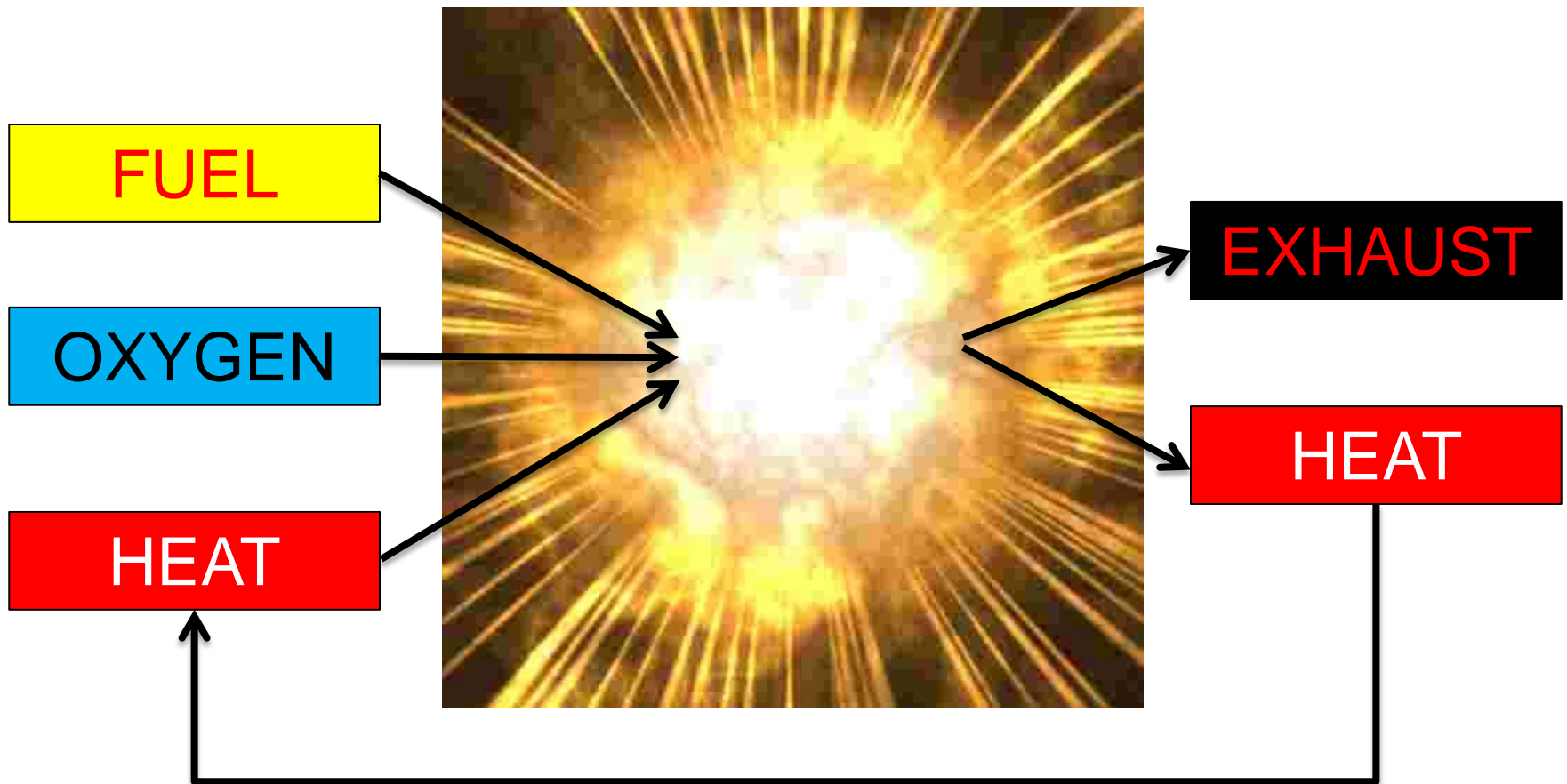
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Internal Combustion Engine

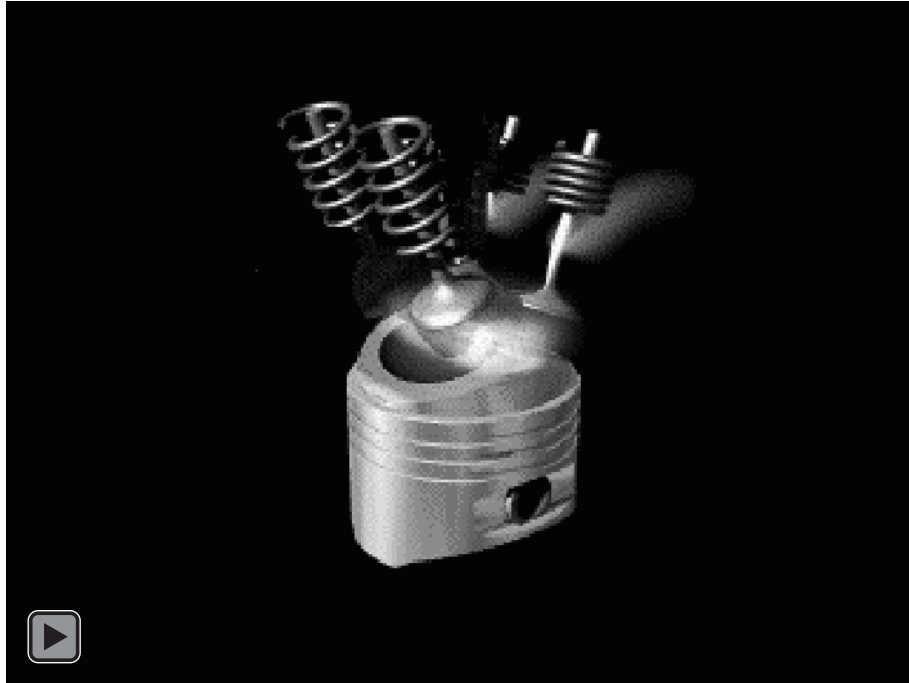
What does *Combustion* signifies?





Internal Combustion Engine

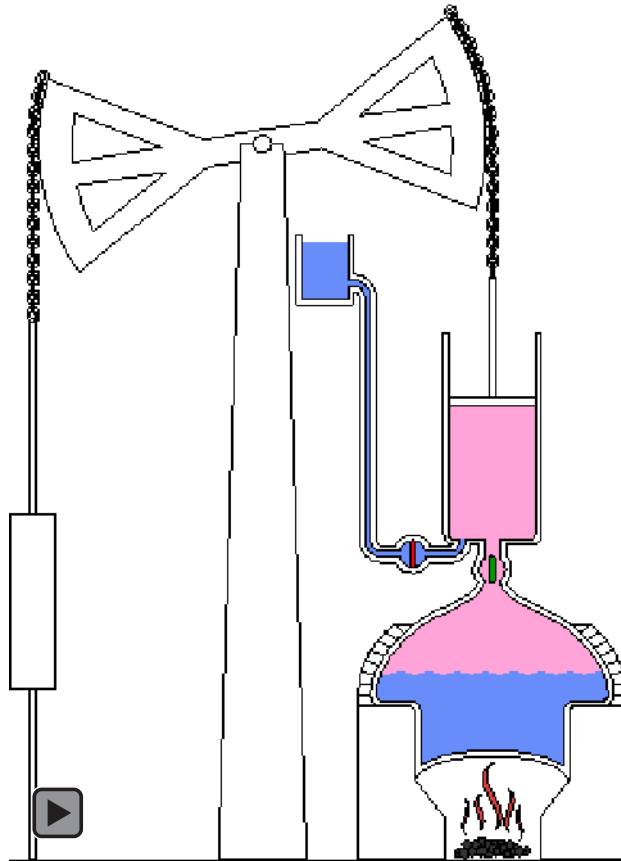
Internal Combustion Engine





Internal Combustion Engine

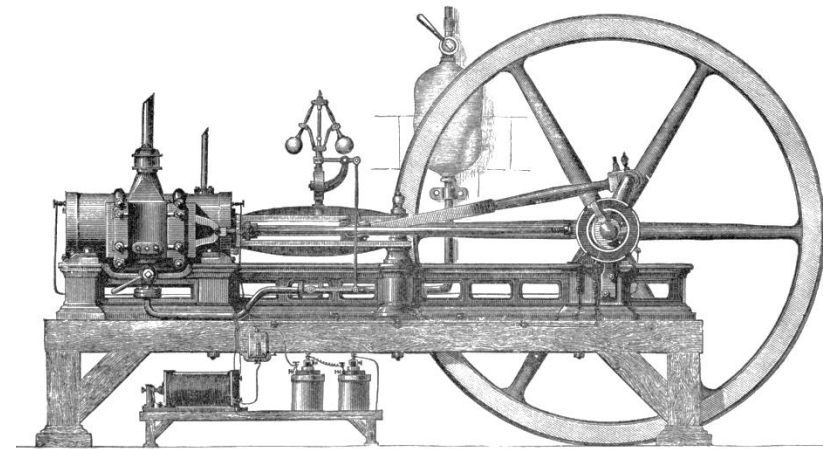
External Combustion Engine





History of ICE

- Most of the very earliest internal combustion engines of the 17th and 18th centuries can be classified as atmospheric engines
 - A single large piston and cylinder
- The first fairly practical engine was invented by J. J. E. Lenoir on about 1860
 - Power up to about 4.5 kW (6 hp)
 - Efficiency up to 5%
- In 1867 the Otto-Langen engine with efficiency improved to about 11% was introduced
- In the 1880s the internal combustion engine first appeared in automobiles
- By 1892, Rudolf Diesel had perfected his compression ignition engine



Lenoir Engine



Otto-Langen Engine



Applications of ICE

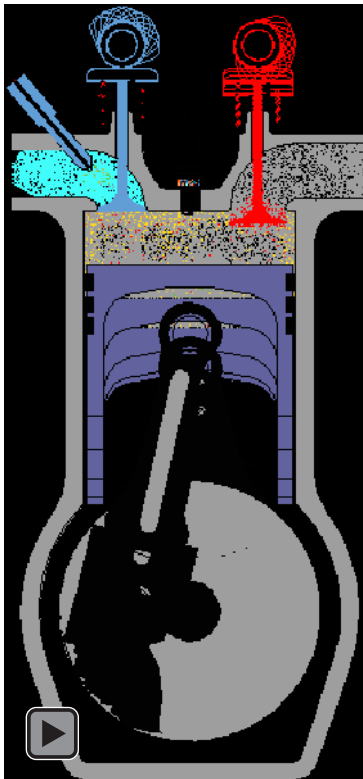
- Automobiles
- Trucks
- Locomotive
- Aircraft
- Marine
- Power Generation



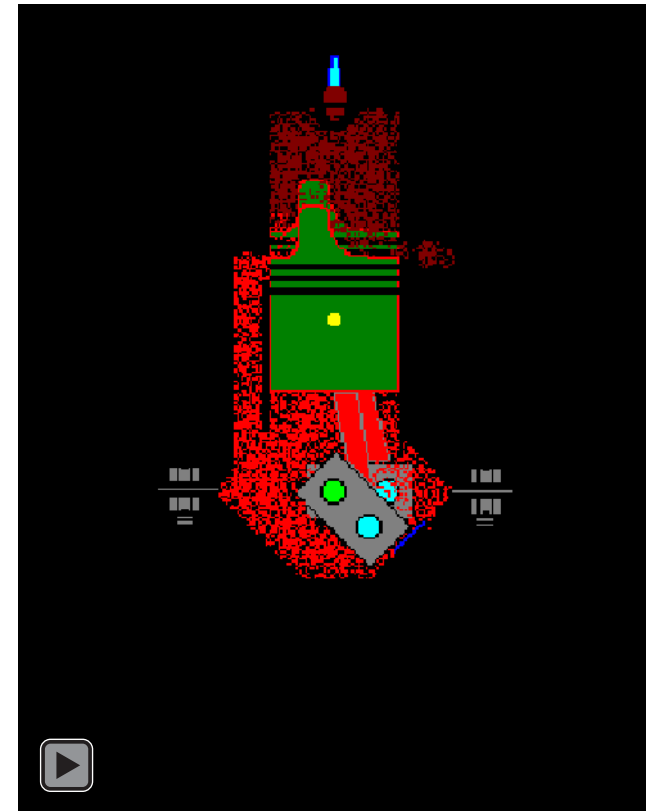


Classifications

Four Stroke Engine



Two Stroke Engine



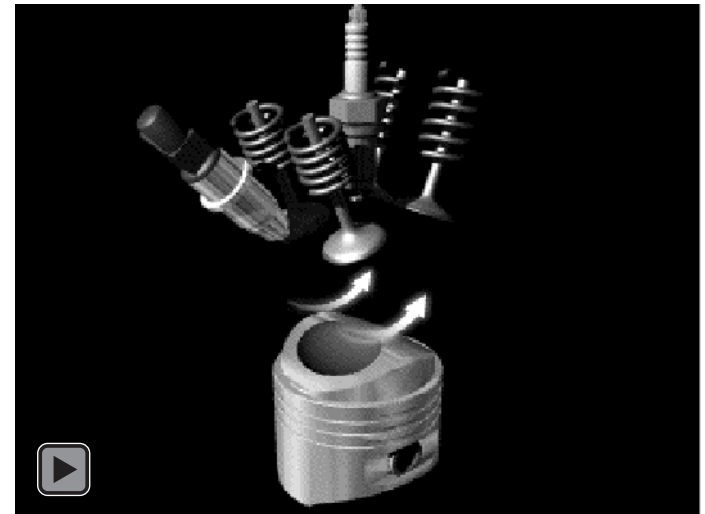


Classifications (contd.)

Spark Ignition Engine

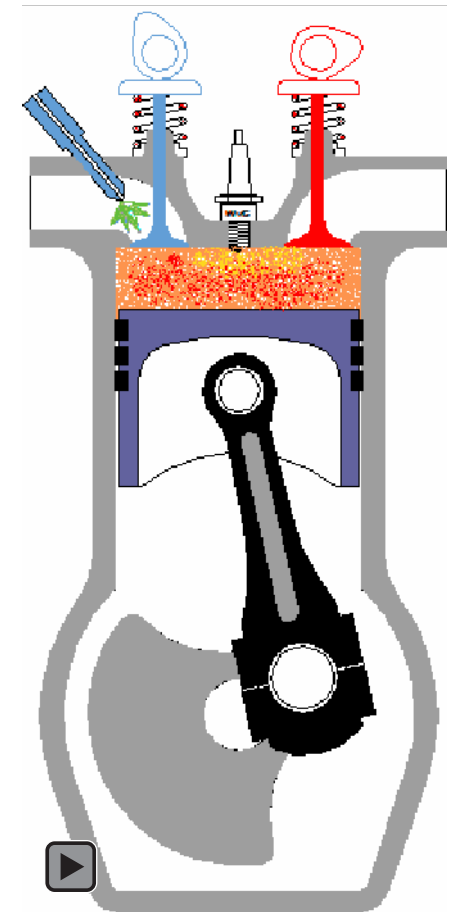
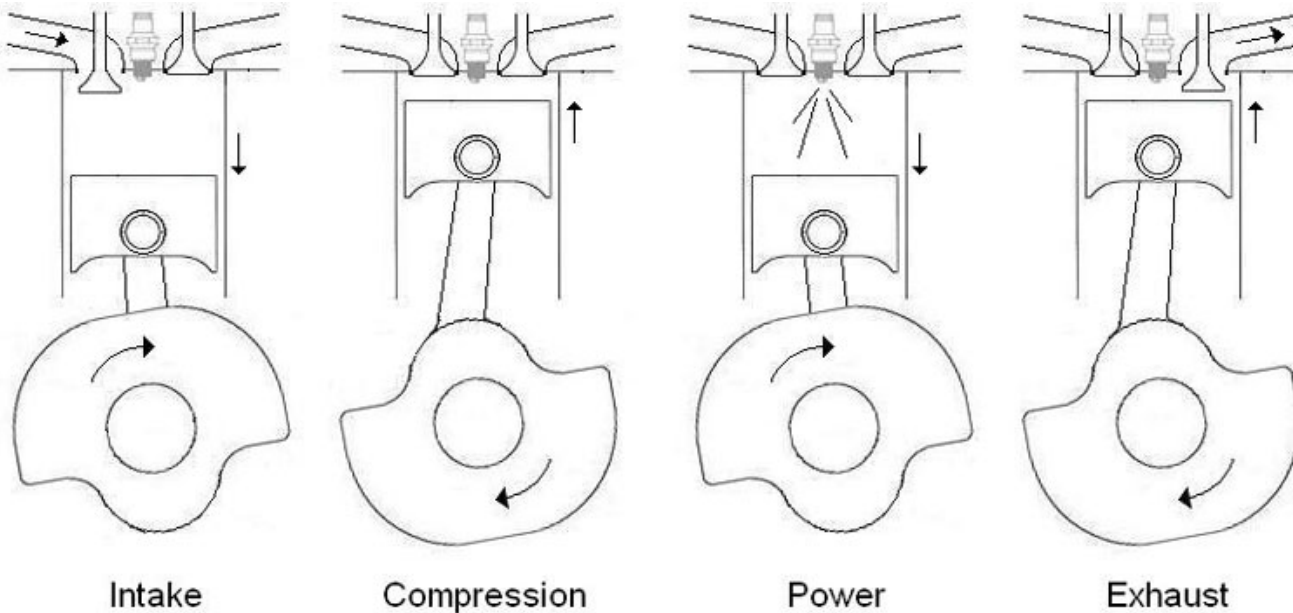


Compression Ignition Engine





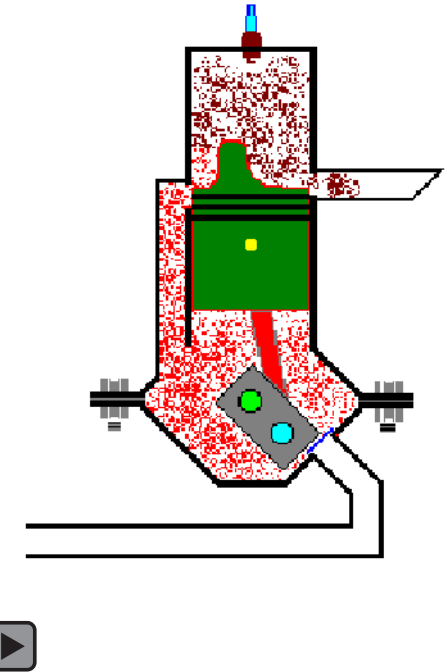
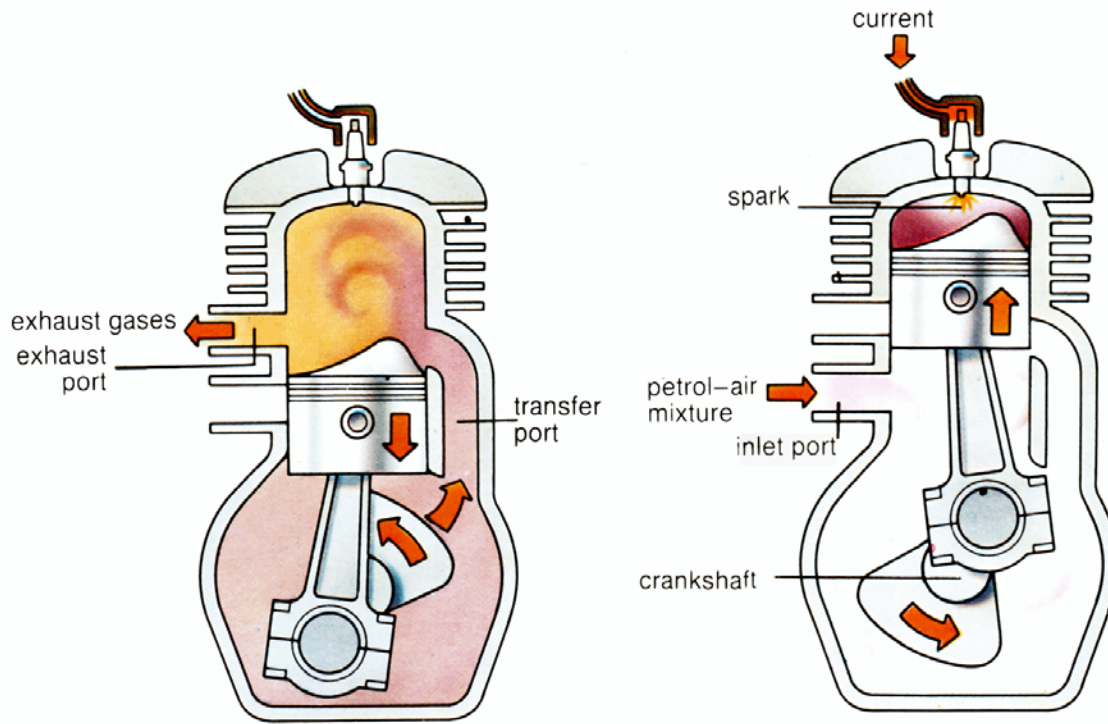
Four Stroke SI Engine



1. Intake Stroke
2. Compression Stroke
3. Power Stroke
4. Exhaust Stroke



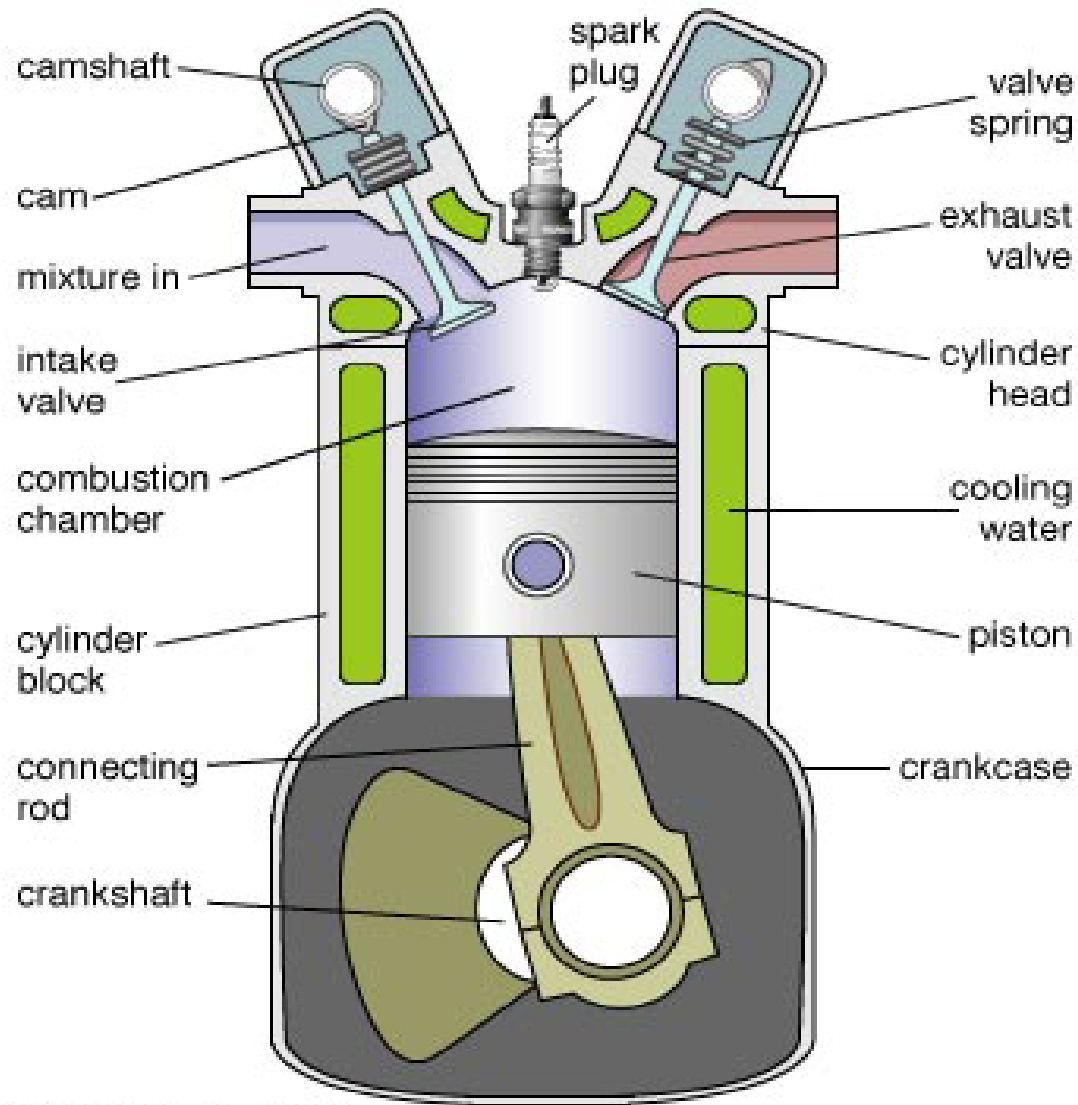
Two Stroke SI Engine



1. Compression Stroke
2. Power Stroke

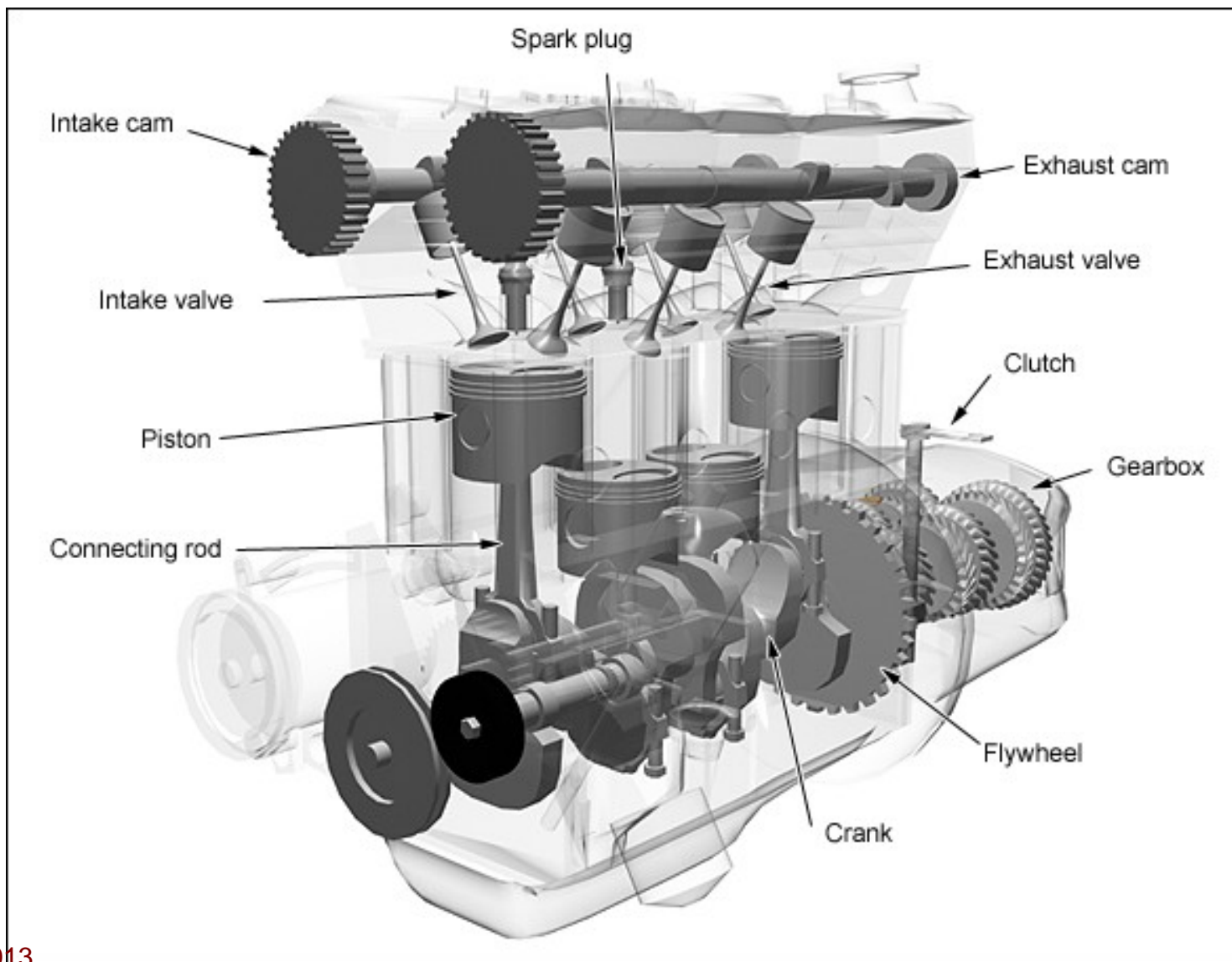


Basic Engine Component





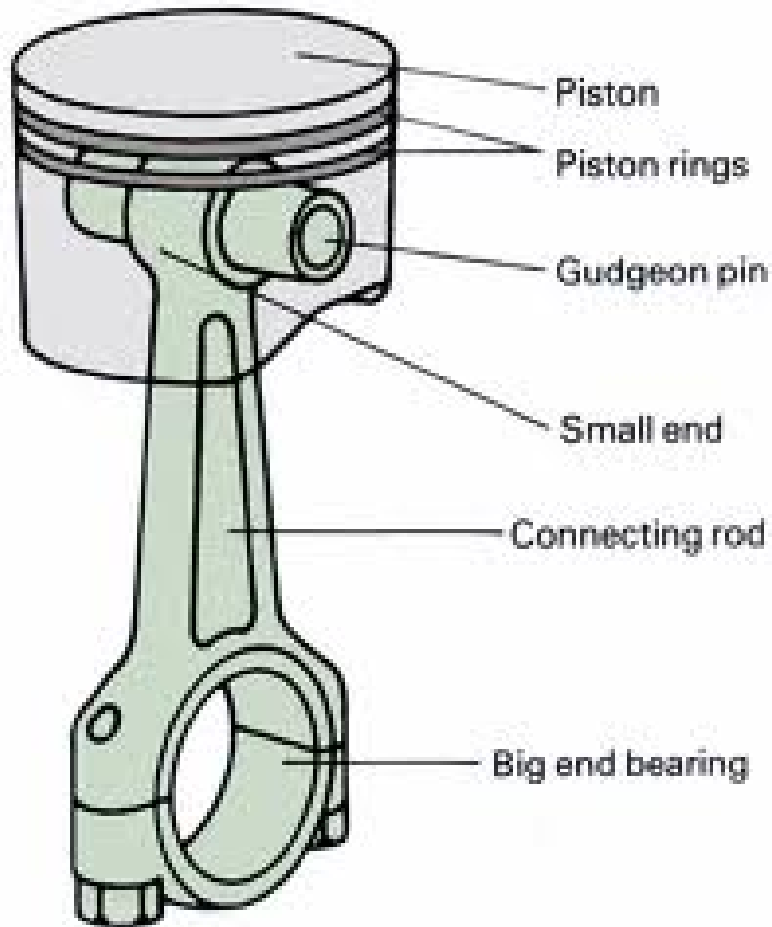
Basic Engine Component (contd.)





Basic Engine Component (contd.)

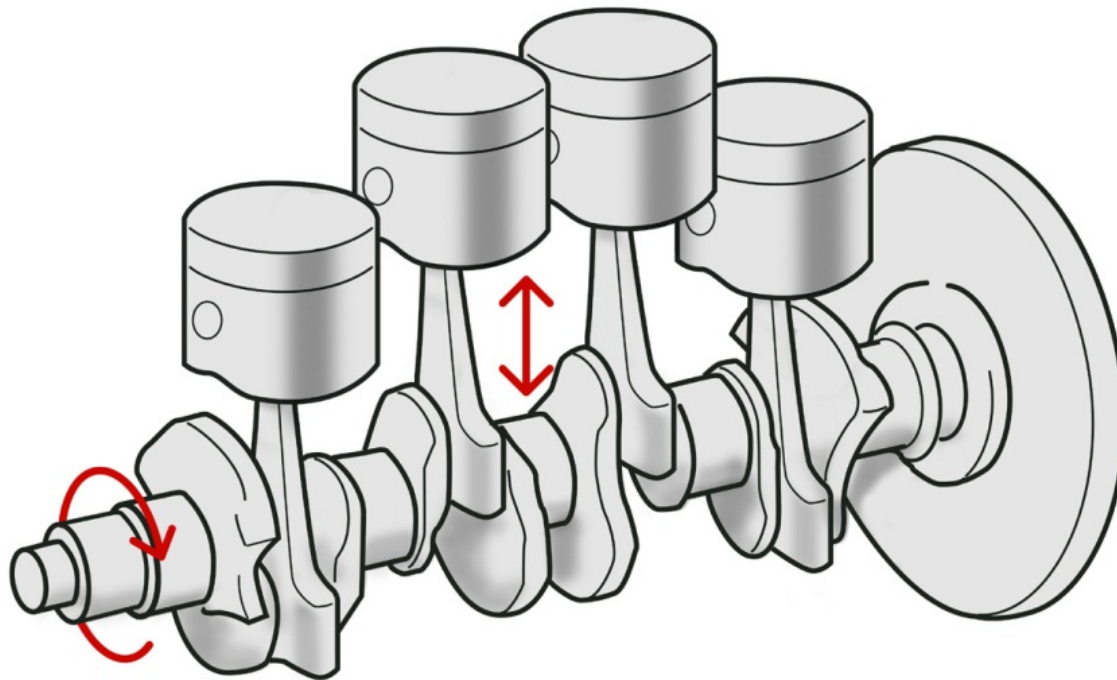
Piston and Connecting Rod





Basic Engine Component (contd.)

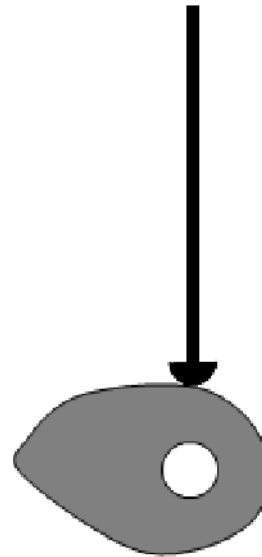
Crankshaft





Basic Engine Component (contd.)

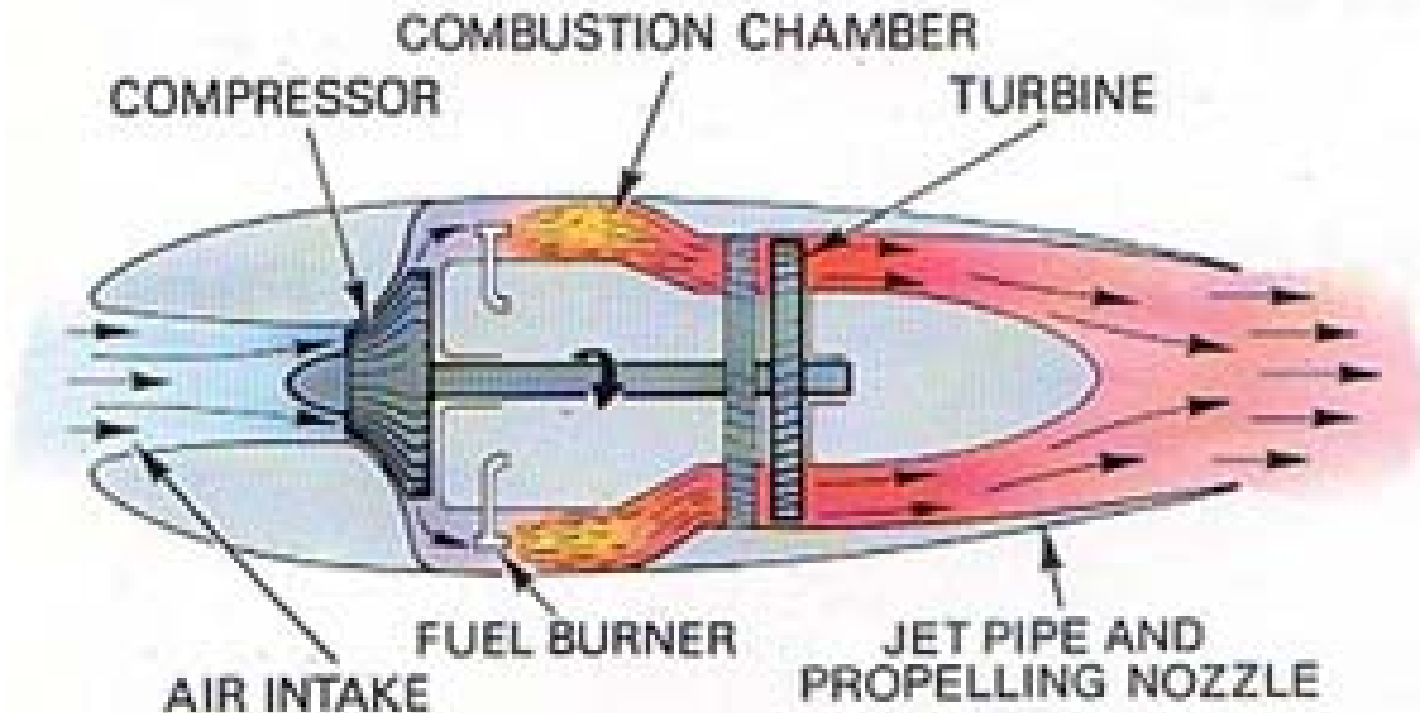
Cam, Rocker Arm & Valve





Other Type of ICEs

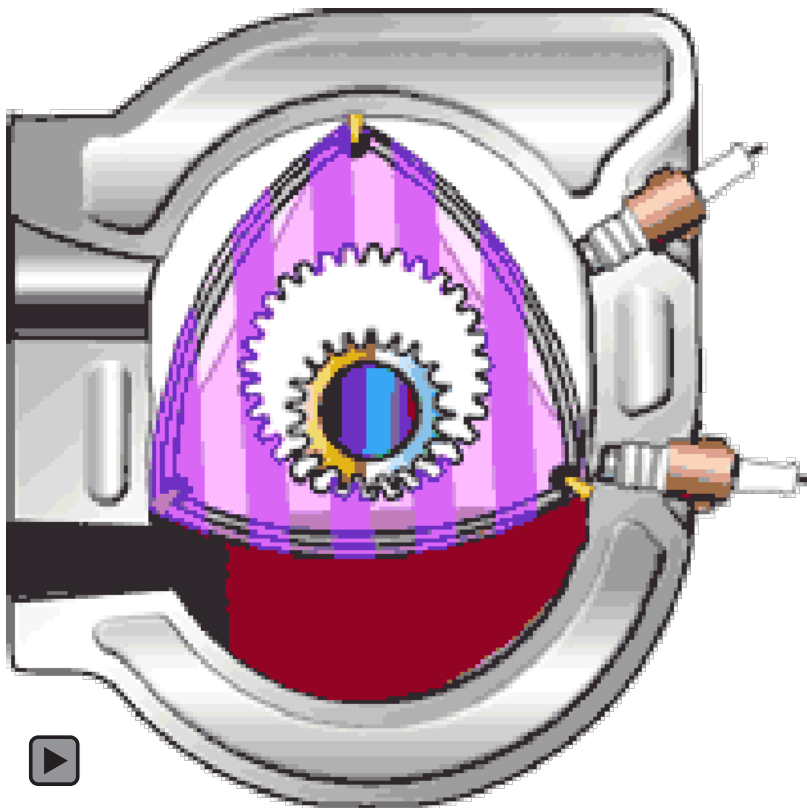
Gas Turbine





Other Type of ICEs

Rotary Engine (Wankel Engine)



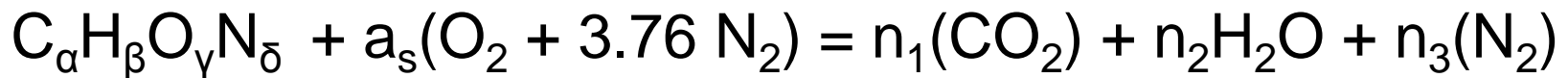


Thermochemistry of Combustion

Fuel \rightarrow Hydrocarbon $\rightarrow C_\alpha H_\beta O_\gamma N_\delta$

Air \rightarrow Oxygen + Nitrogen + Other Gases $\rightarrow O_2 + 3.76 N_2$

Reaction:



a_s = stoichiometric *molar* air-fuel ratio

A_s = stoichiometric air-fuel ratio = $\frac{\text{mass of air}}{\text{mass of fuel}}$

$$= \frac{28.85(4.76 a_s)}{(12\alpha + 1.008\beta + 16\gamma + 14\delta)}$$



Combustion (contd.)

Fuel	Chemical Formula	M	A_s	a_s
Methane	CH_4	16.04	17.12	2
Propane	C_3H_8	44.09	15.57	5
Gasoline	C_7H_{17}	101.21	15.27	11.25
Diesel	$\text{C}_{14.4}\text{H}_{24.9}$	198.04	14.30	20.63
Methanol	CH_4O	32.04	6.43	1.5
Hydrogen	H_2	2.02	34.06	0.5



Combustion (contd.)

The fuel-air equivalence ratio

$$\Phi = \frac{A_s}{A}$$

If

- $\Phi < 1 \rightarrow$ Lean Mixture
- $\Phi = 1 \rightarrow$ Stoichiometric Mixture
- $\Phi > 1 \rightarrow$ Rich Mixture



Resources

Websites:

<http://www.animatedengines.com/>

The screenshot shows the homepage of the website "Animated Engines". At the top, there is a dark blue header with a red and green wrench icon on the left and the text "Animated Engines" in white. Below the header is a light green bar with the word "Home" in black. The main content area has a white background and begins with the text "Welcome!" in blue, followed by "Click an engine to see how it works." in black. There are six engine diagrams arranged in two rows of three. Each diagram is accompanied by a caption in blue text: "Four stroke", "Diesel", "Two stroke", "Atkinson", and another unlabeled diagram. The diagrams are colorful and show the internal components of various engine types.



THANK YOU