INTERNAL COMBUSTION ENGINE (ICE)

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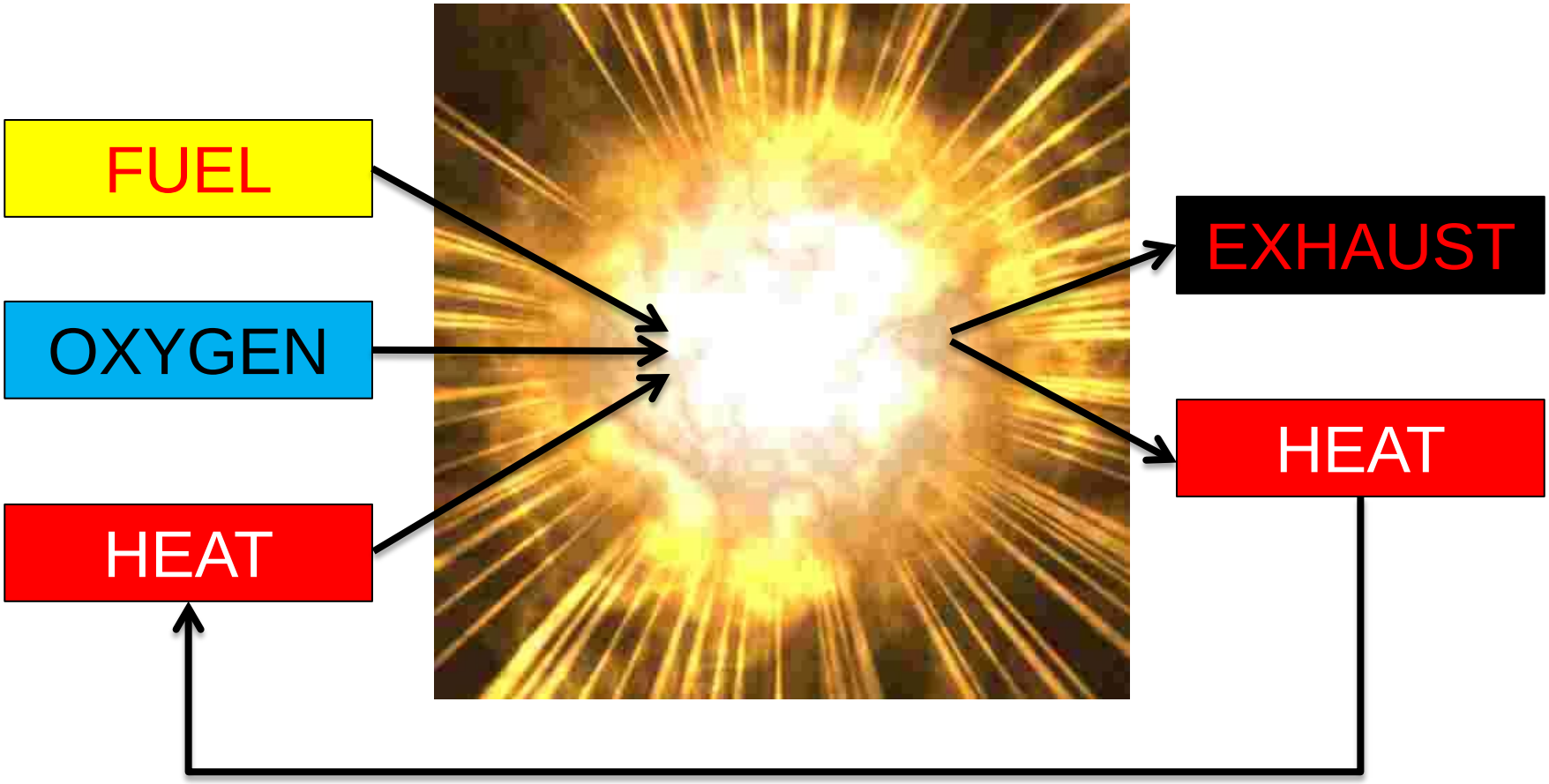
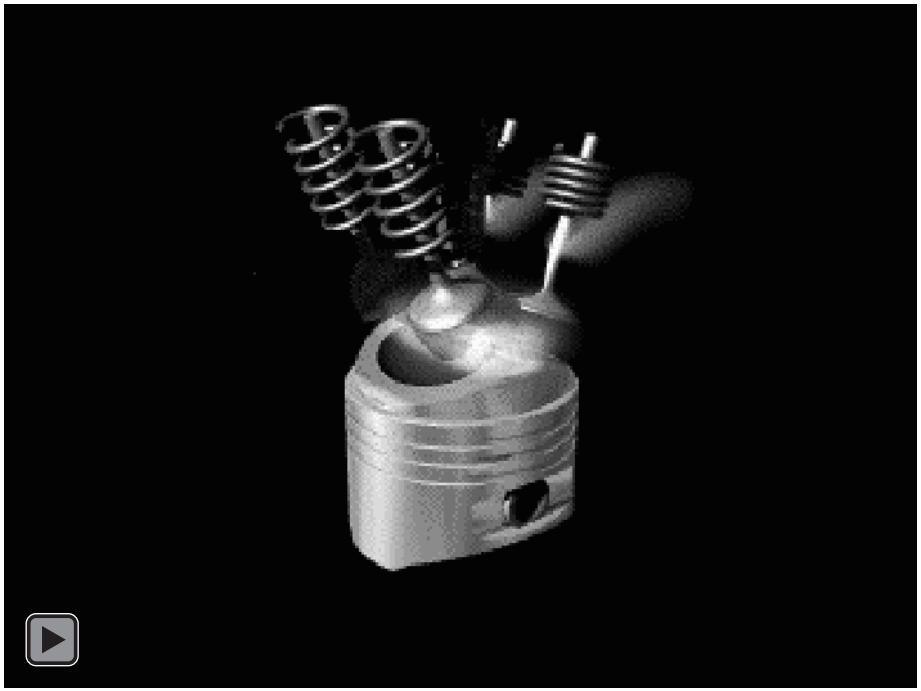
Internal Combustion Engine

What does *Combustion* signifies?



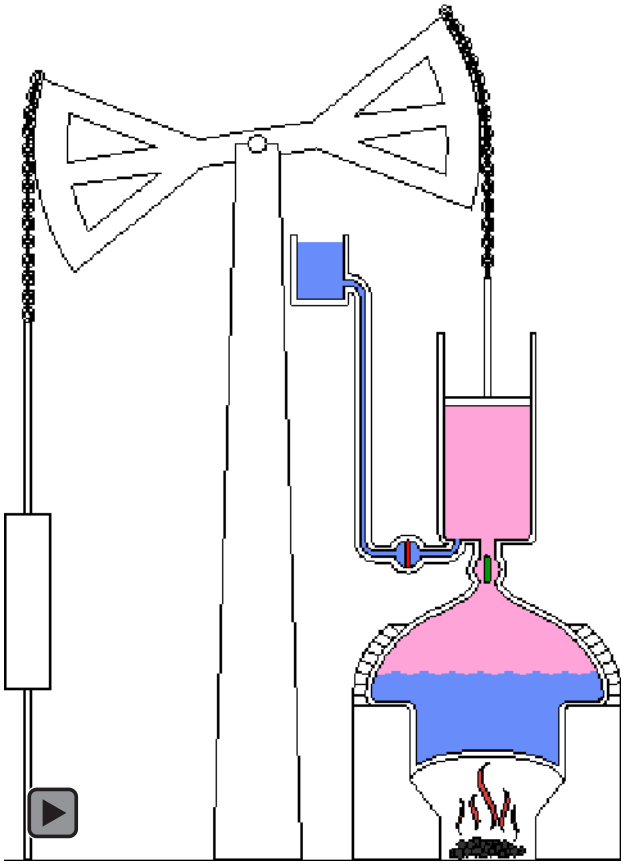
Internal Combustion Engine

Internal Combustion Engine



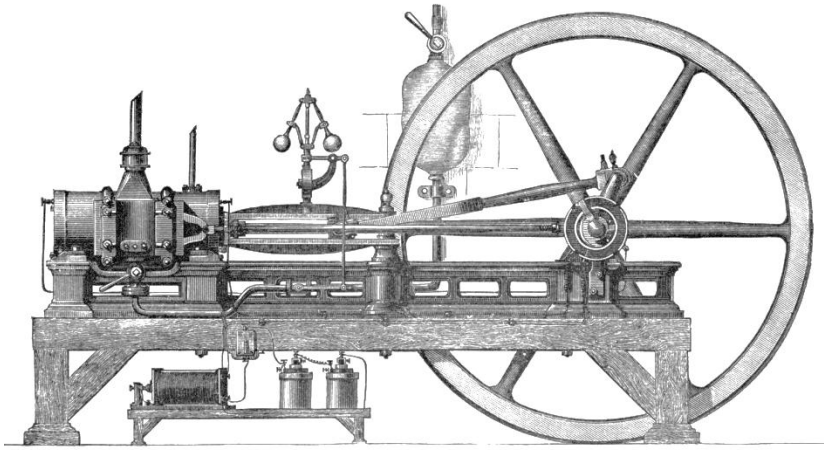
Internal Combustion Engine

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

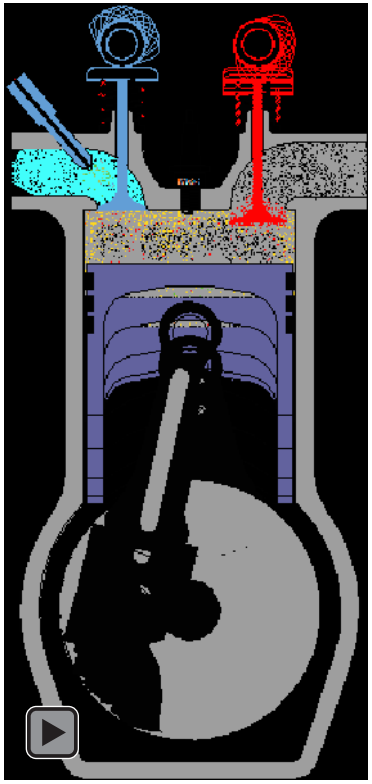
Otto-Langen Engine

Applications of ICE

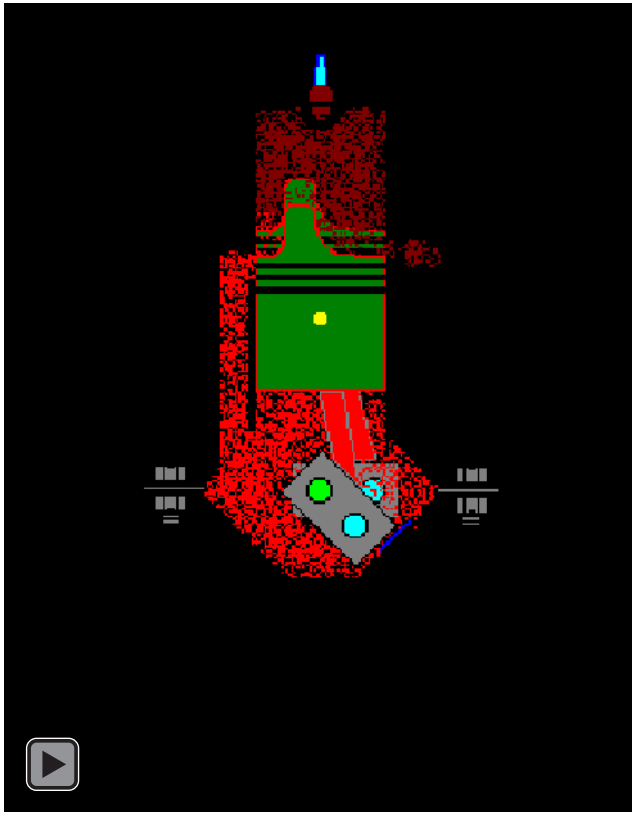
- Automobiles
- Trucks
- Locomotive
- Aircraft
- Marine
- Power Generation

Classifications

Four Stroke Engine



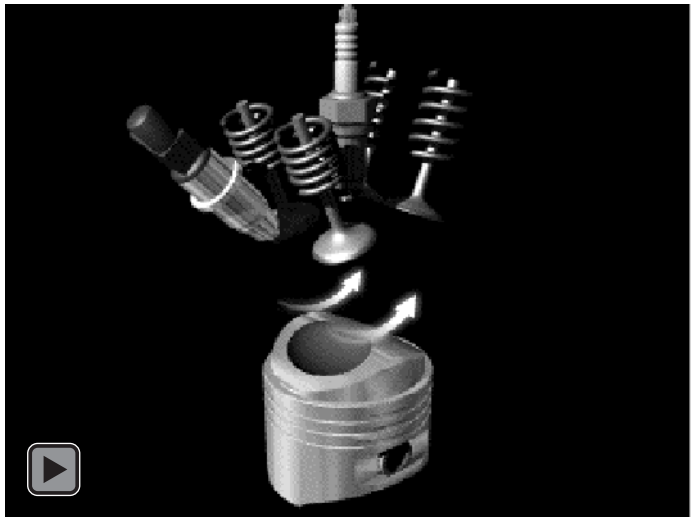
Two Stroke Engine



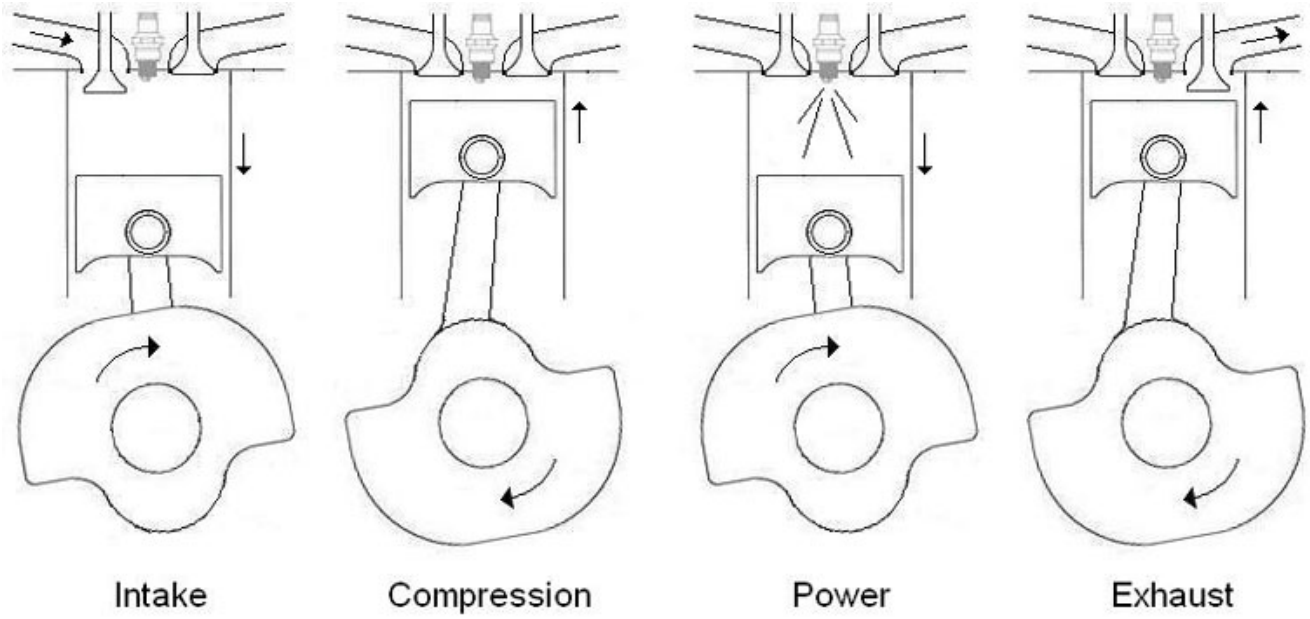
Classifications (contd.)

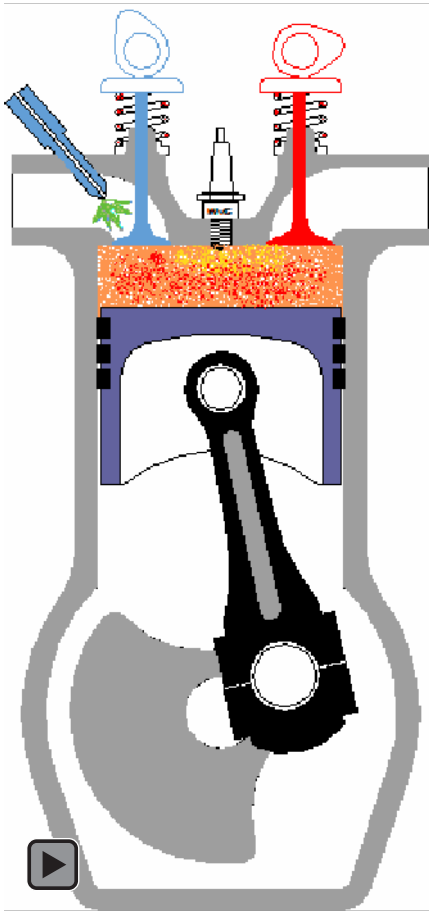
Spark Ignition Engine

Compression Ignition Engine



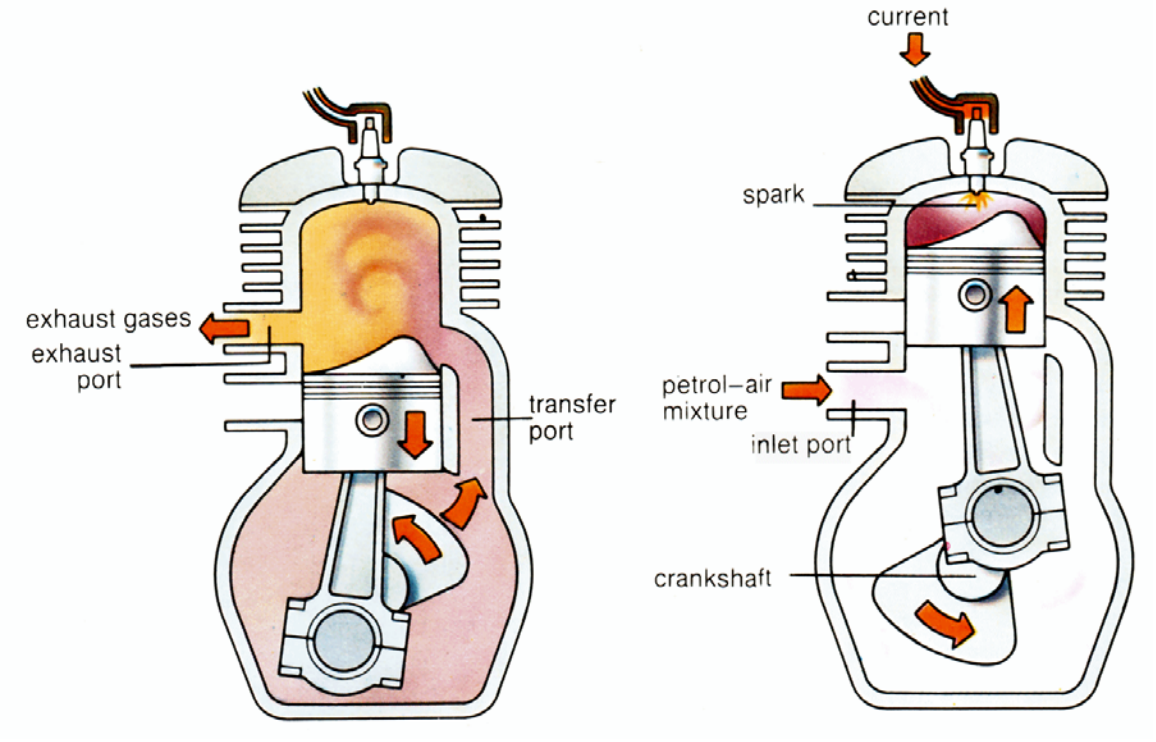
Four Stroke SI Engine

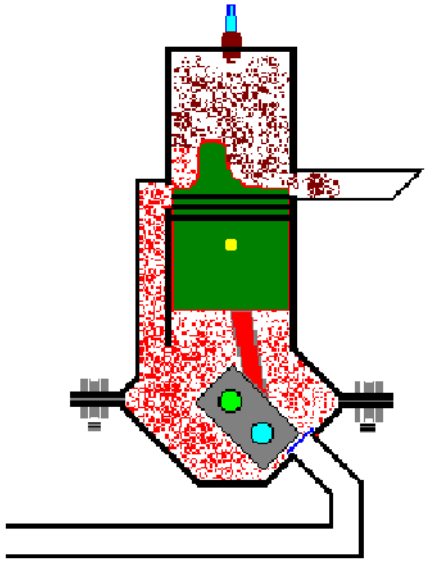




1. Intake Stroke
2. Compression Stroke
3. Power Stroke
4. Exhaust Stroke

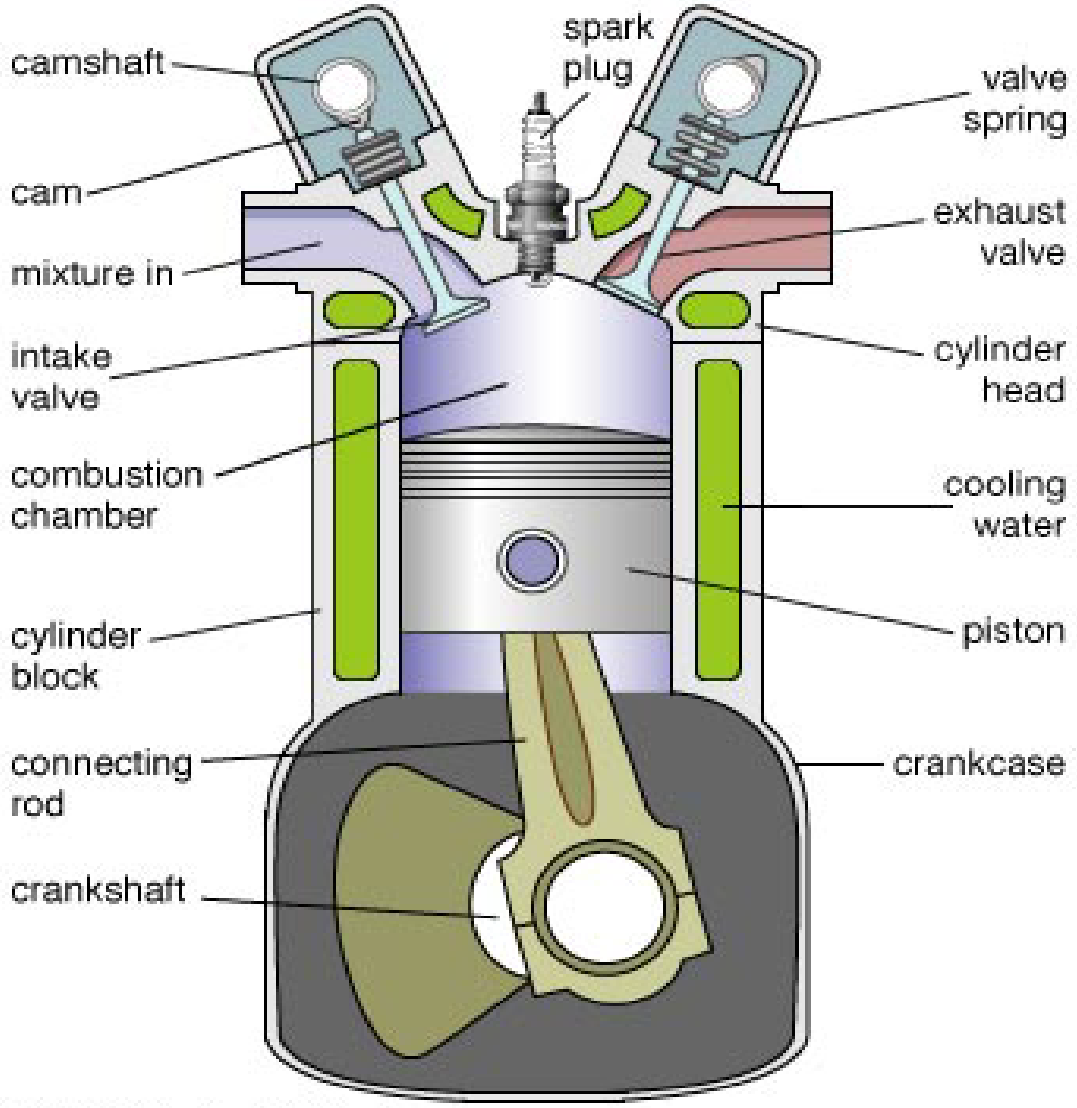
Two Stroke SI Engine



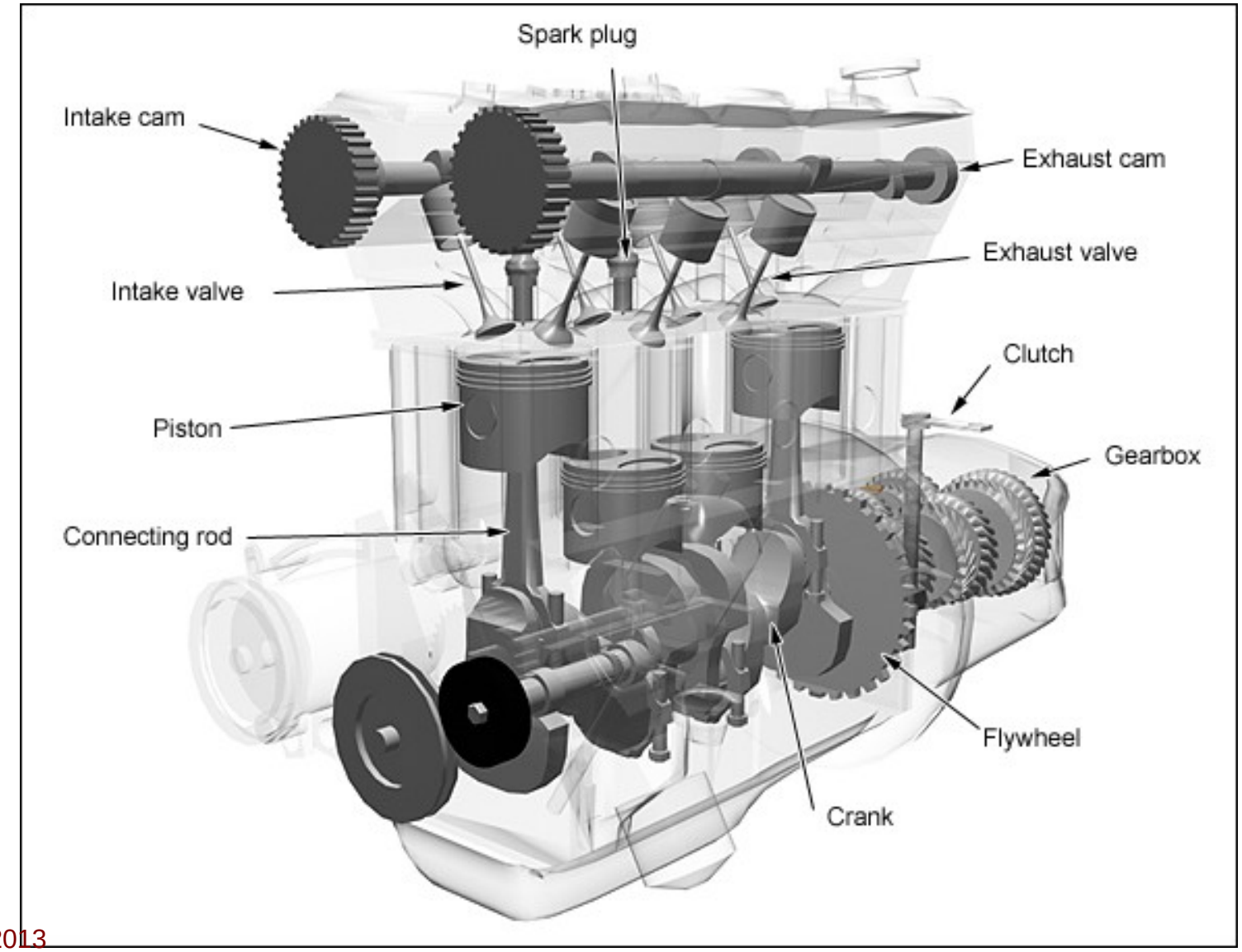


1. Compression Stroke
2. Power Stroke

Basic Engine Component

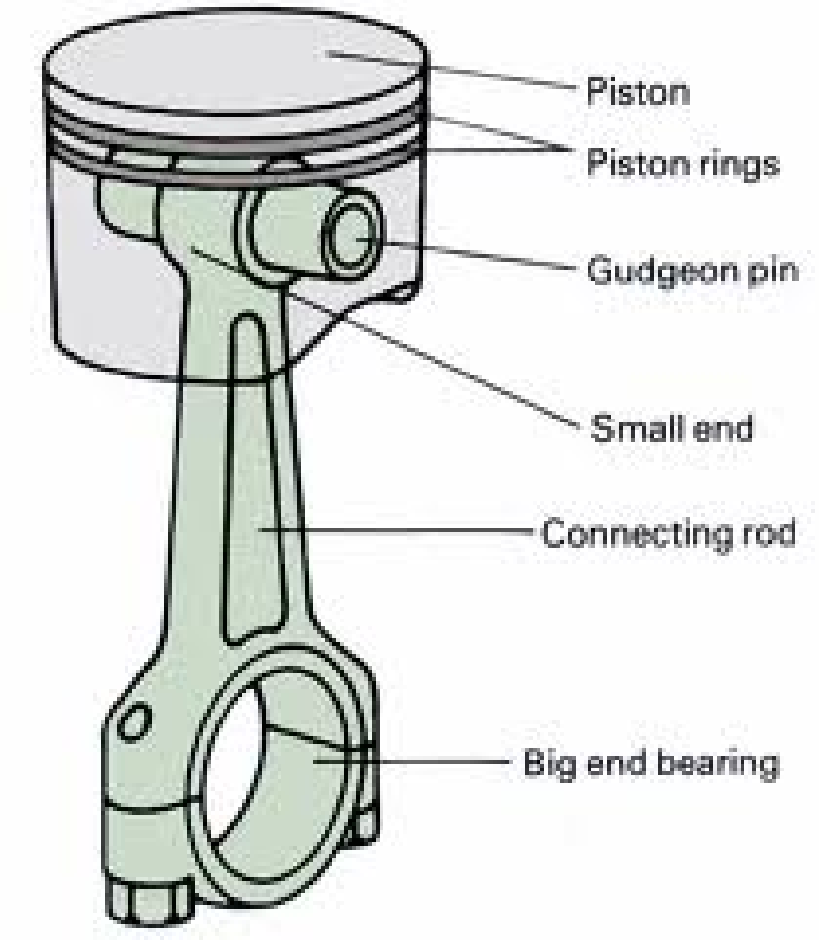


Basic Engine Component (contd.)



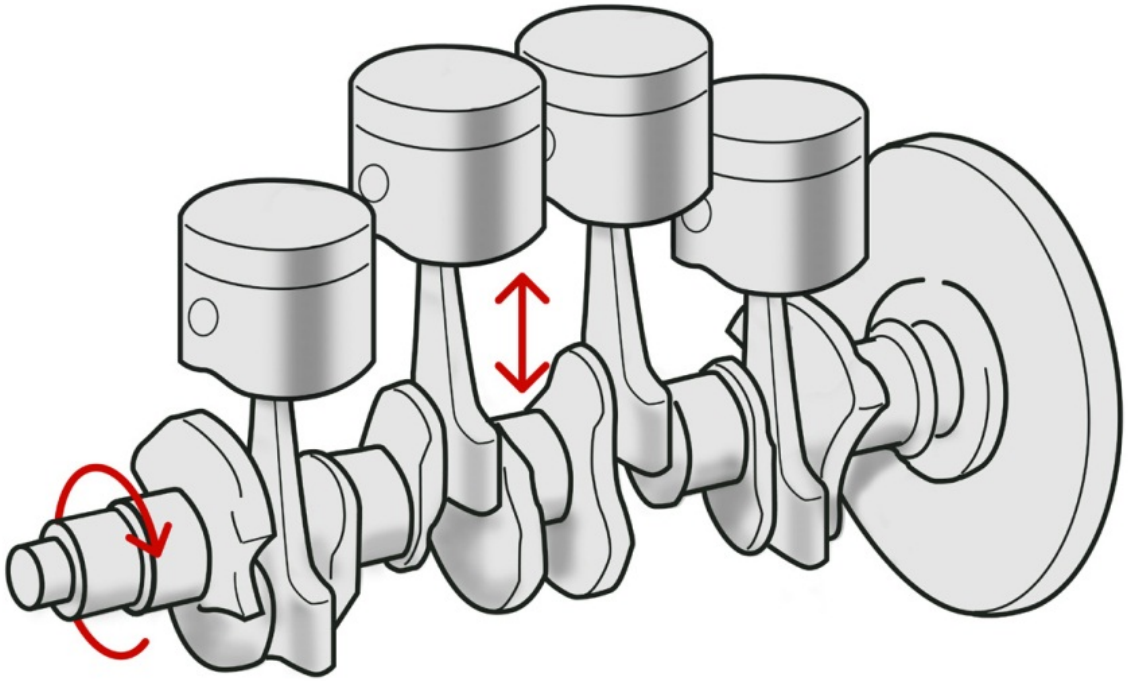
Basic Engine Component (contd.)

Piston and Connecting Rod



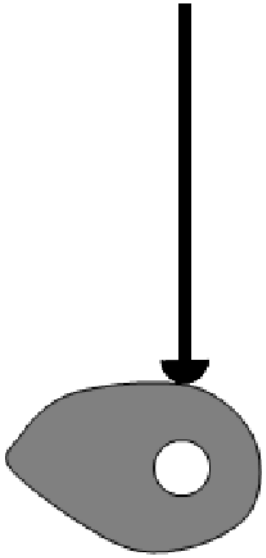
Basic Engine Component (contd.)

Crankshaft



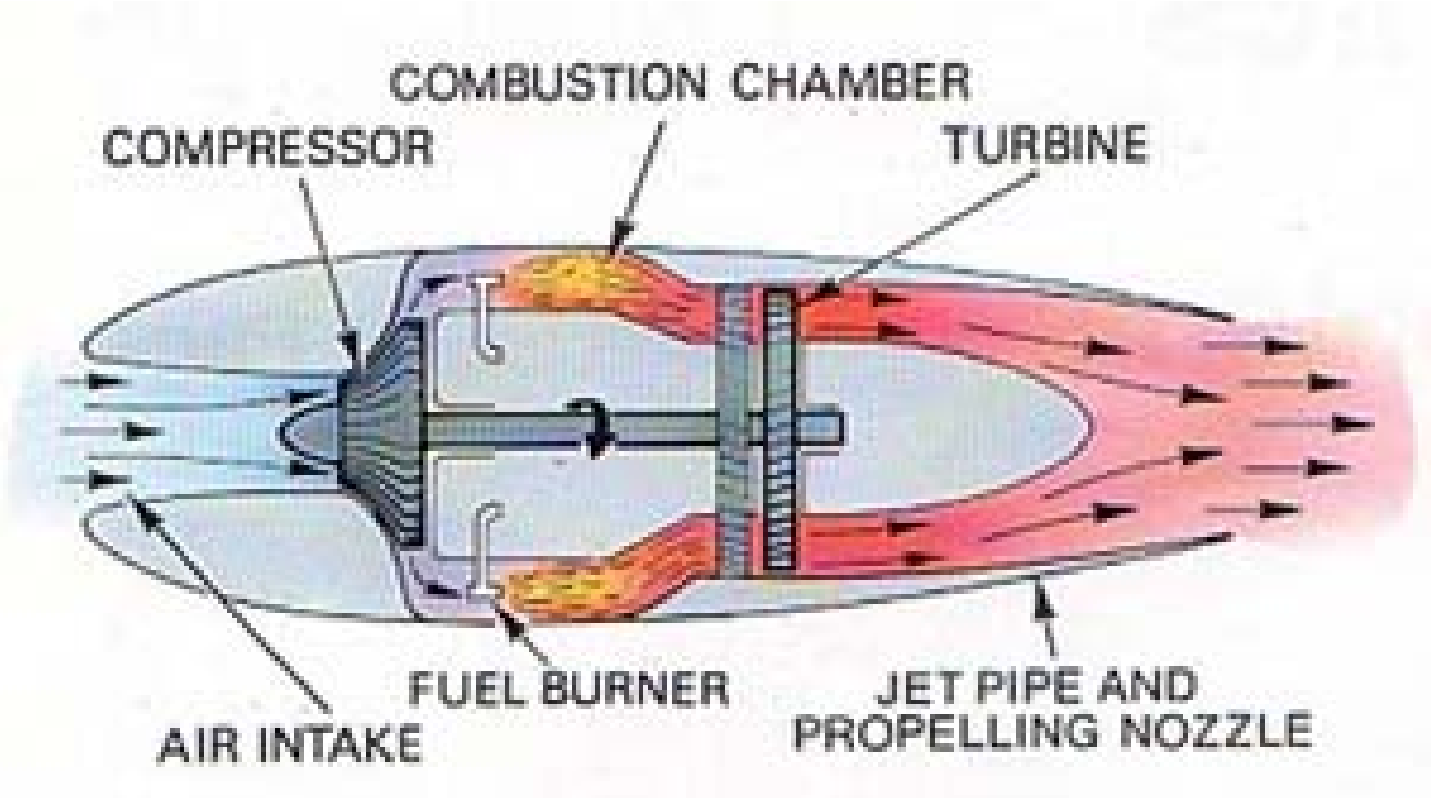
Basic Engine Component (contd.)

Cam, Rocker Arm & Valve



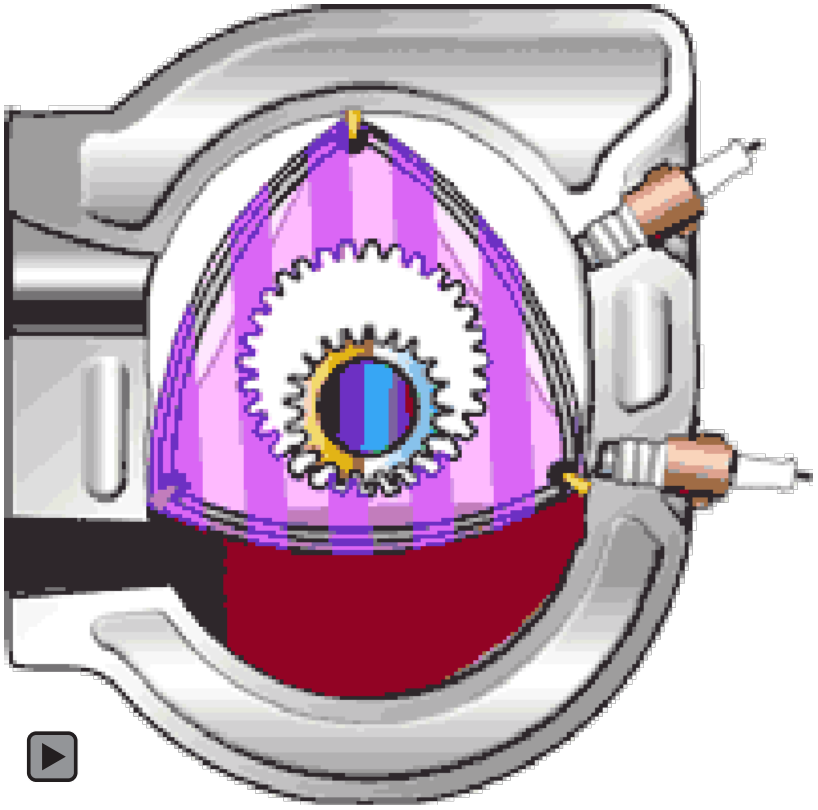
Other Type of ICEs

Gas Turbine



Other Type of ICEs

Rotary Engine (Wankel Engine)



Thermochemistry of Combustion

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

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

Reaction:

$$C_\alpha H_\beta O_\gamma N_\delta + a_s(O_2 + 3.76\ N_2) = n_1(CO_2) + n_2 H_2O + n_3(N_2)$$

a_s = stoichiometric *molar* air-fuel ratio

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

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

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	$C_{14.4}H_{24.9}$	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

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

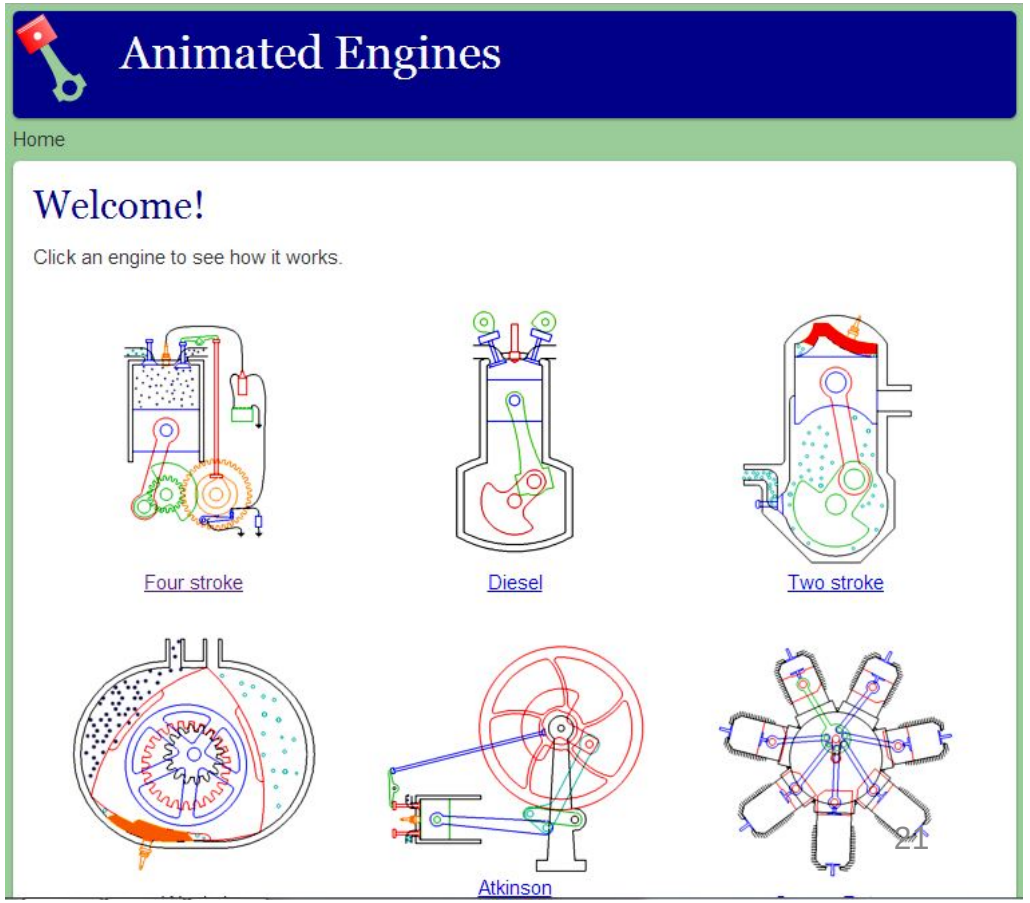
If

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

Resources

Websites:

http://www.animatedengines.com/



THANK YOU