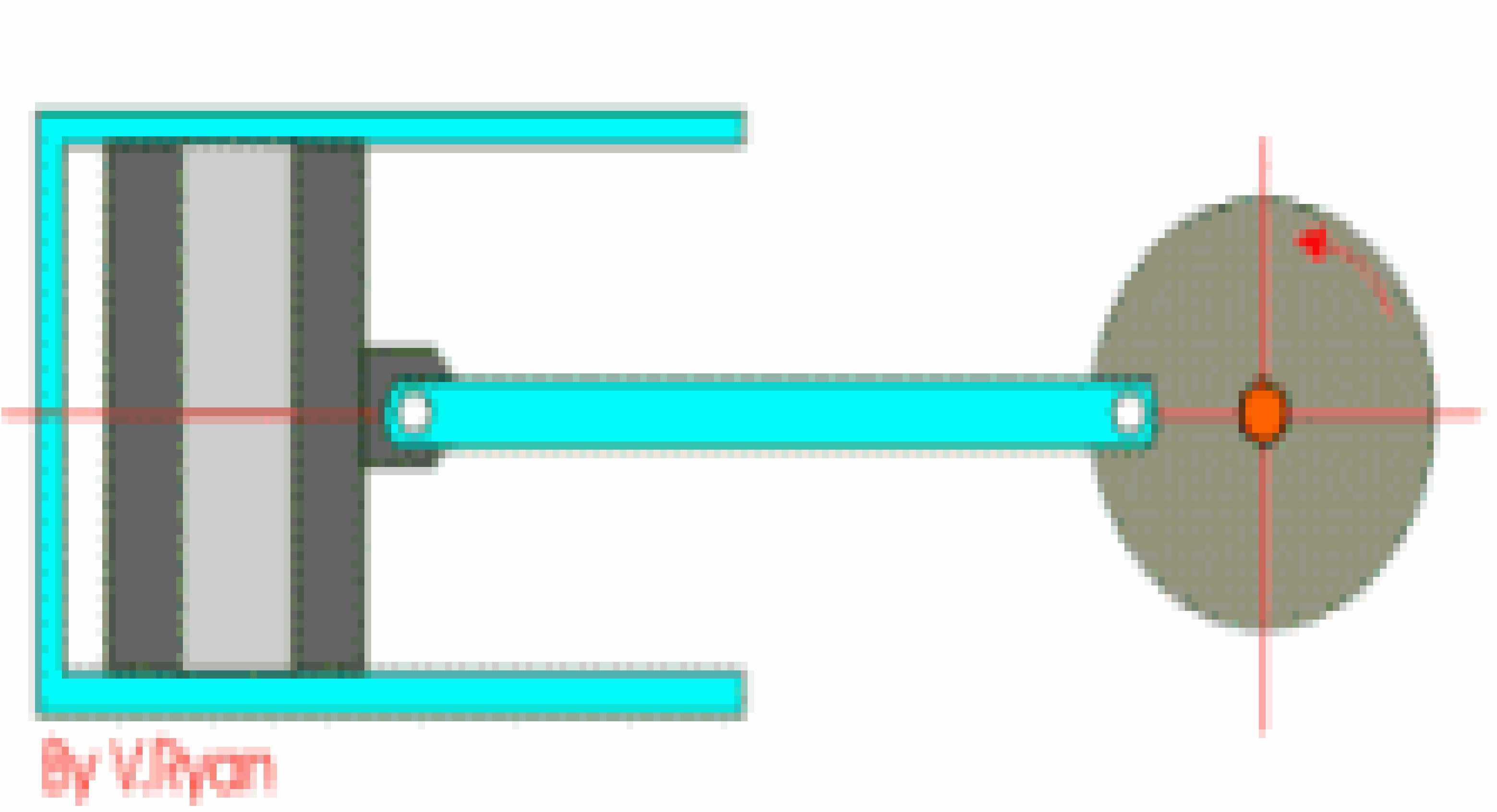
I.C. ENGINE

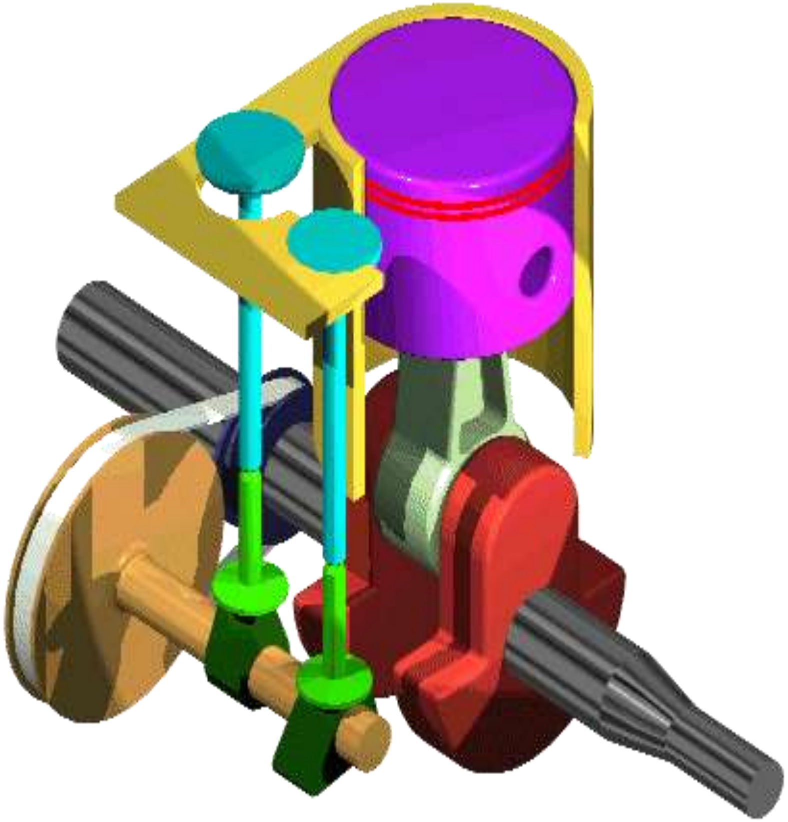
HEAT ENGINE

I. C. ENGINE	E. C. ENGINE
Combustion of fuel takes place inside the cylinder.	Combustion of fuel takes place outside the cylinder.
Compact in size.	Large in size.
Low initial Cost.	More initial cost.
Fuels are costly.	Cheaper fuels may be used.
Suitable for mobile application.	Less suitable for mobile applications.

WORKING OF RECIPROCATING ENGINE



WORKING OF RECIPROCATING ENGINE

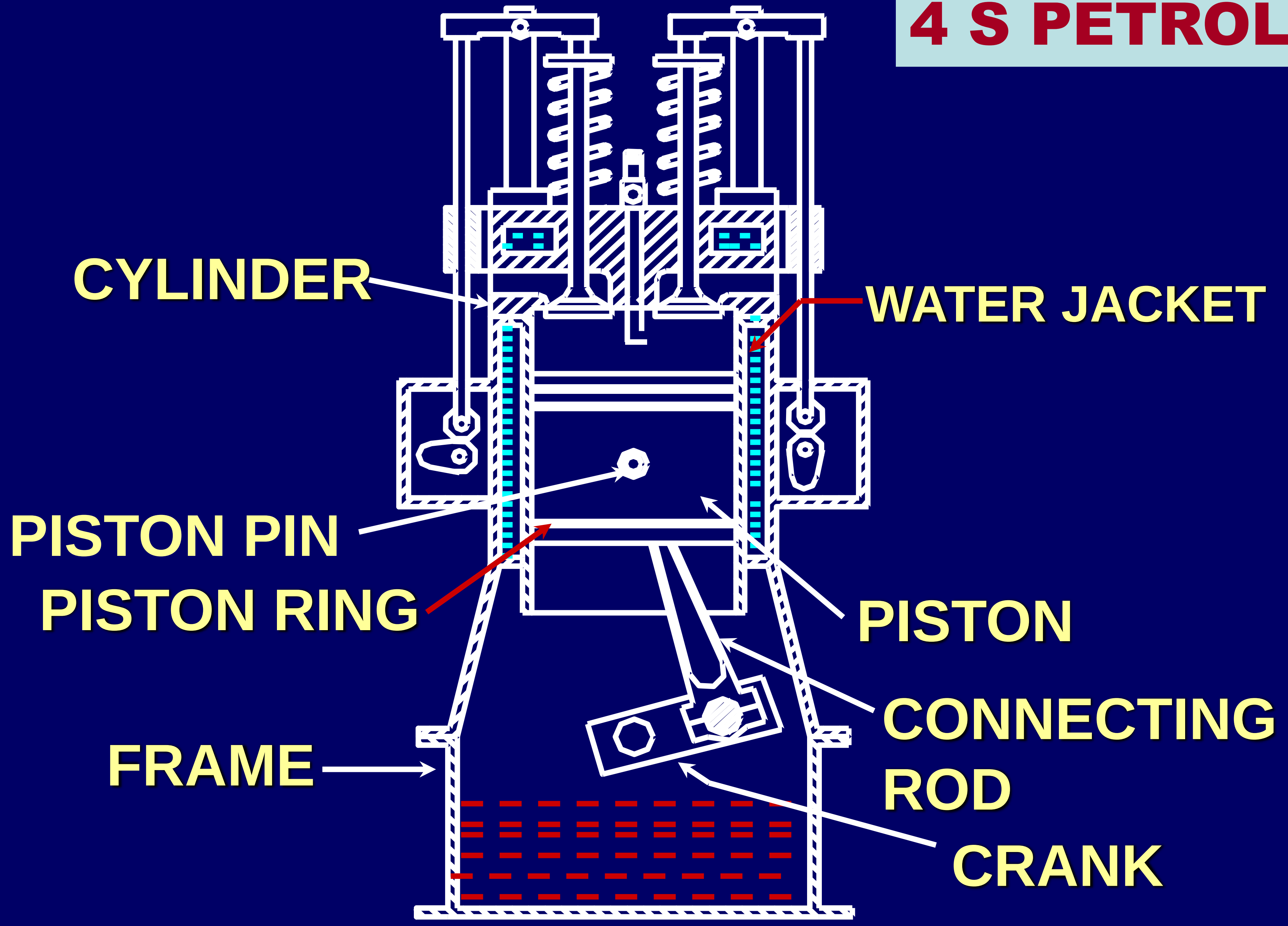


MAIN COMPONENTS

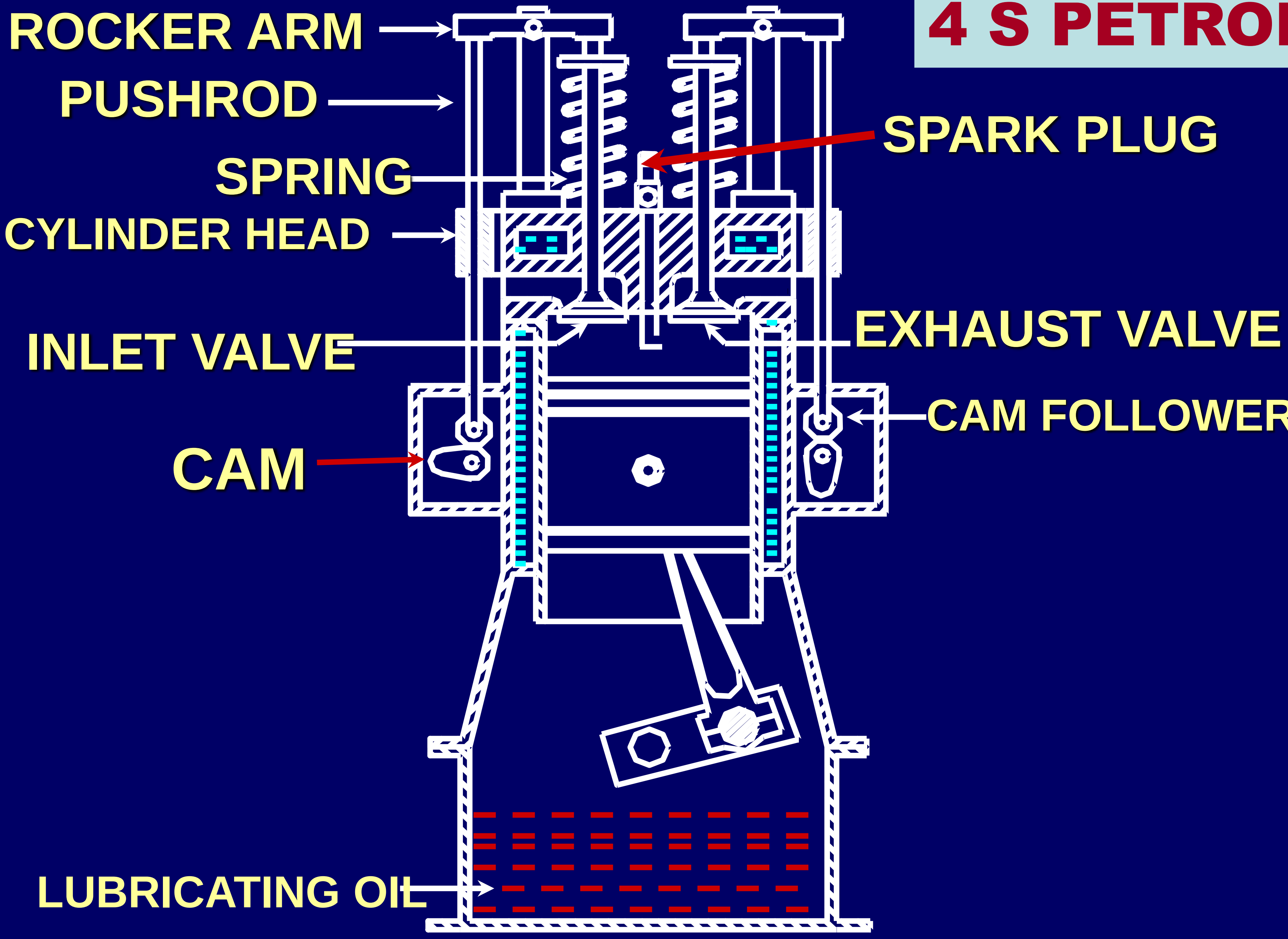
OF I. C. ENGINE AND

THEIR FUNCTIONS.

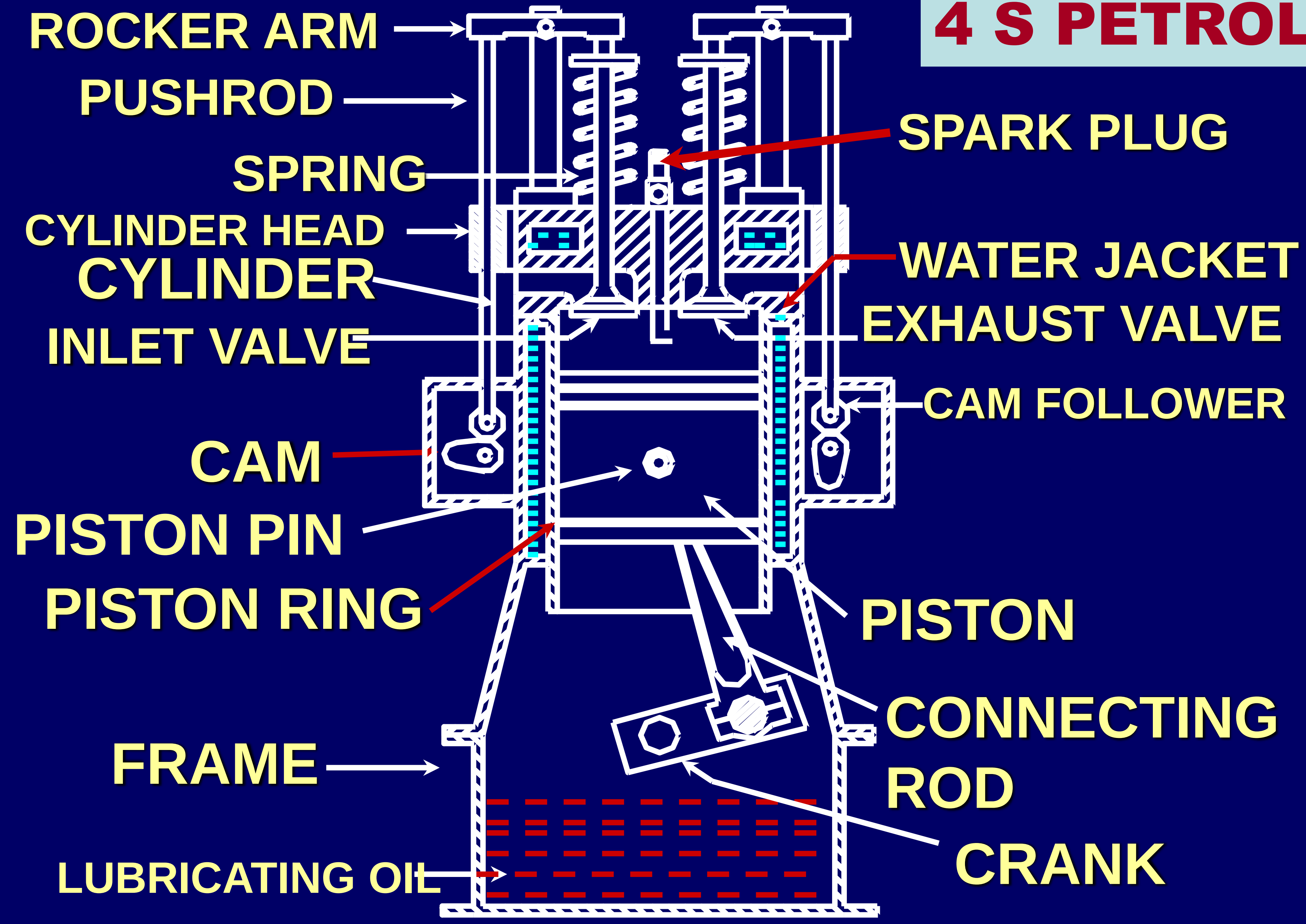
4 S PETROL


CYLINDER
WATER JACKET
PISTON PIN
PISTON RING
PISTON
CONNECTING ROD
FRAME
CRANK

4 S PETROL


ROCKER ARM
PUSHROD
SPRING
CYLINDER HEAD
INLET VALVE
CAM
SPARK PLUG
EXHAUST VALVE
CAM FOLLOWER
LUBRICATING OIL

4 S PETROL



ROCKER ARM
PUSHROD
SPRING
CYLINDER HEAD
CYLINDER
INLET VALVE
CAM
PISTON PIN
PISTON RING
FRAME
LUBRICATING OIL
SPARK PLUG
WATER JACKET
EXHAUST VALVE
CAM FOLLOWER
PISTON
CONNECTING ROD
CRANK

Engine parts and their functions

(1) Frame:- Consists of bed plate, crank case, also supports the different movable ports.

Bed plates are rigidly fix up with the foundations.

Lower parts of the crank case contains oil for the lubrication purpose.

(2) Cylinder :- Single cylinder engine has a single cylinder. Cylinder contains cylindrical bores, opening for valve mechanisam, passage for cooling water known as water jackets.

(3) Cylinder Block:- Multiple cylinder engine has cylinder block. Separate cylinder head is fit over the cylinder block with stud and nuts. Cylinder block is made up from the cast iron.

(4) Cylinder Head:- Top of the engine cylinder is close by a cover known as cylinder head.
It contain inlet and exhaust valves.
(5) Piston: Gas tight movable cylindrical part which Reciprocate in the cylinder. Piston rings are provide around the piston to prevent the leakage of the hot High pressure gases. Made up from aluminium alloy.
(6) Connecting Rod:- Connects the piston and crank Shaft. Small end of the connecting rod is fit with the Piston pin or gudgeon pin. Big end of the connecting rod is fit with the crank shaft by crank pin.
Main function is to convert the reciprocating motion of piston in to rotary motion of the crank shaft.

(7)Crank Shaft:- Principal rotating part of the engine. Crank shaft is support on to main bearings. Mechanical work is available at the crank shaft of the I C engine. Drives various accessories of the I C engine like as lubricating oil pump, Cooling water pump, dynamo, cam shaft, spark distributer etc. Fly Wheel is mount on to the crank shaft made up from Forge steel.

(8) Valve Gear:- Combination of the parts which control the Admission of fresh charge into cylinder and discharge of Exhaust gases from the cylinder is term as valve gear. Consists of cam shaft, cams, followers, push rods, rocker arms, springs, valves. Valves are made up from nickel steel Or the chrome steel.

(9) Cam Shaft:- operates the valve gear mechanisam. Driven by the crank shaft through timing gear. Rotates at the half of the crank shaft speed because each valves needs to be Operate once in two revolution of the crank shaft.

(10) Fly Wheel:- Heavy Wheel which is fit on to crank shaft. Minimize the fluctuation of cyclic variation in the speed by storing the energy during expansion stroke and by realizing the energy during the other stroke.

(11) Carburetor:- Provide in to the petrol engine for proper mixing of the air and petrol.

(12) Spark Plug:- Provide in to the petrol engine to provide spark to ignite air-fuel mixture. Fit in to the cylinder head.

(13) Fuel Injector:- Provide in to the diesel engines. Use to inject diesel in the form of fine Atomize spray under the pressure.

Fuel Pump:- Pumps the fuel from storage tank to injector at the high pressure in to the diesel engine. Pumps the petrol from storage tank to carburetor if the storage tank is below the carburetor level in to the petrol engine.

Important Terminology:-

(1) Dead center:- Define as positions occupy by the piston at the end of the stroke where crank and center line of the connecting rod is in a straight line.

(2) Top Dead Centre (TDC):- Top most position of the piston on cylinder head side in to the vertical engines.

(3) Bottom Dead Centre (BDC):- Bottom most position of the piston on to the crank shaft side in to the vertical engines.

(4) Inner Dead Centre (IDC):- Inner most position of the piston on to the cylinder head side in to the horizontal engines.

(5) Outer Dead Centre (ODC):- Outer most position of the piston on crank shaft side in to the horizontal engine.

(6) Stroke:- Traveling of the piston from one dead center to the second dead center is term as the stroke.

(7) Swept Volume:- Volume swept away by the piston in one stroke. D is the diameter of the cylinder or the bore and L is the stroke length then swept volume Vs can be write like as

In the Equation form as below:

$$V_s = \frac{\prod}{4} D^2 . L$$

(8) Clearance Volume:- Volume entrap between piston and the cylinder head when piston is at TDC or IDC is known to be as clearance volume denote by Vc.

(9) Stroke length:- Distance travel by a piston from one dead center to second dead centre is called stroke length. Equal to twice the crank radius or crank throw.

Stroke Length (L) = 2 x crank radius

(10) Piston Speed:- During one stroke piston travels a distance equal to stroke length and in one revolution of crank shaft piston completes two stroke.

Piston speed is to be written as

Piston speed = 2LN

N is the speed of the engine.

(11) Compression Ratio:- Ratio of the volume at the beginning of the compression stroke to the volume at the end of the stroke.

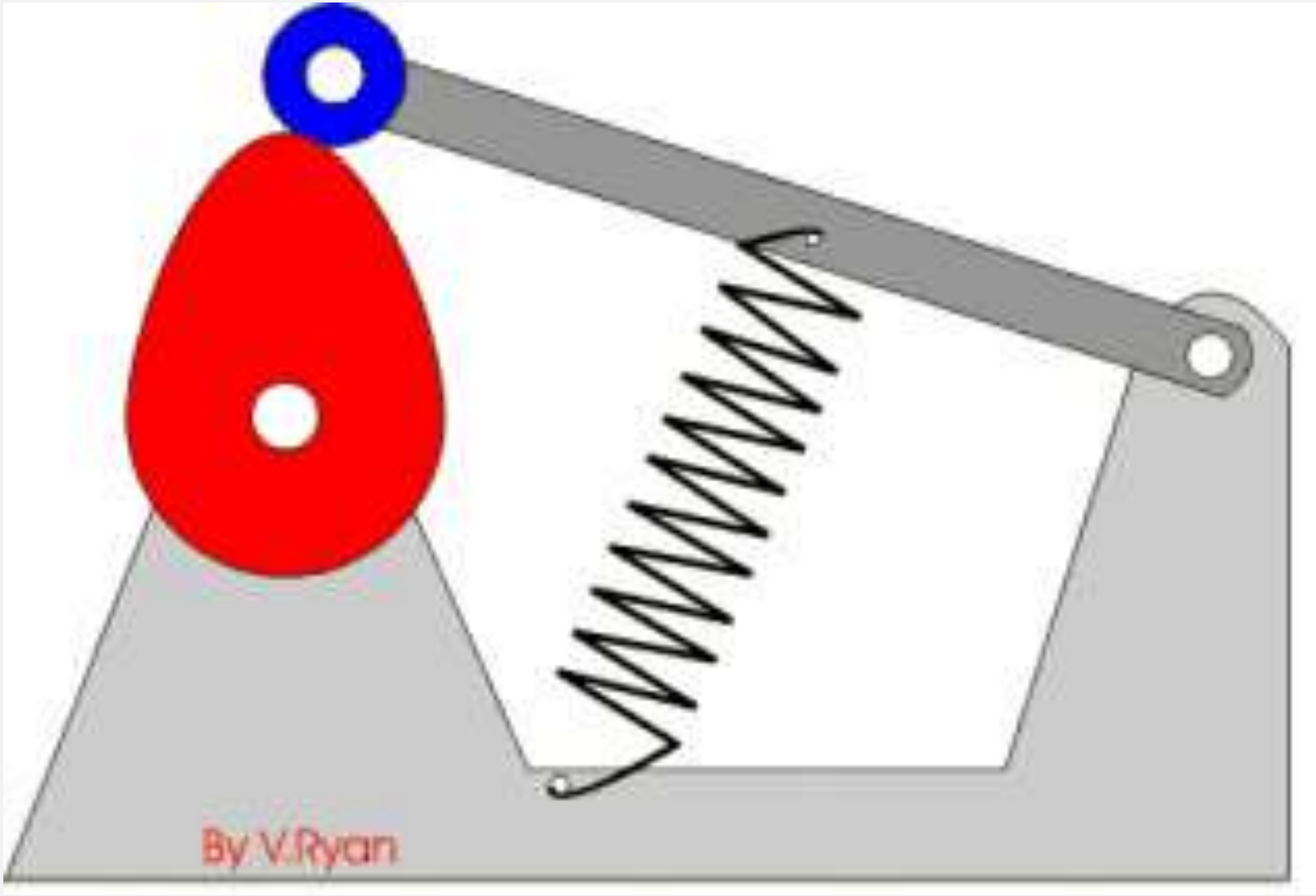
Volume at the beginning of the compression stroke will be : Vs + Vc

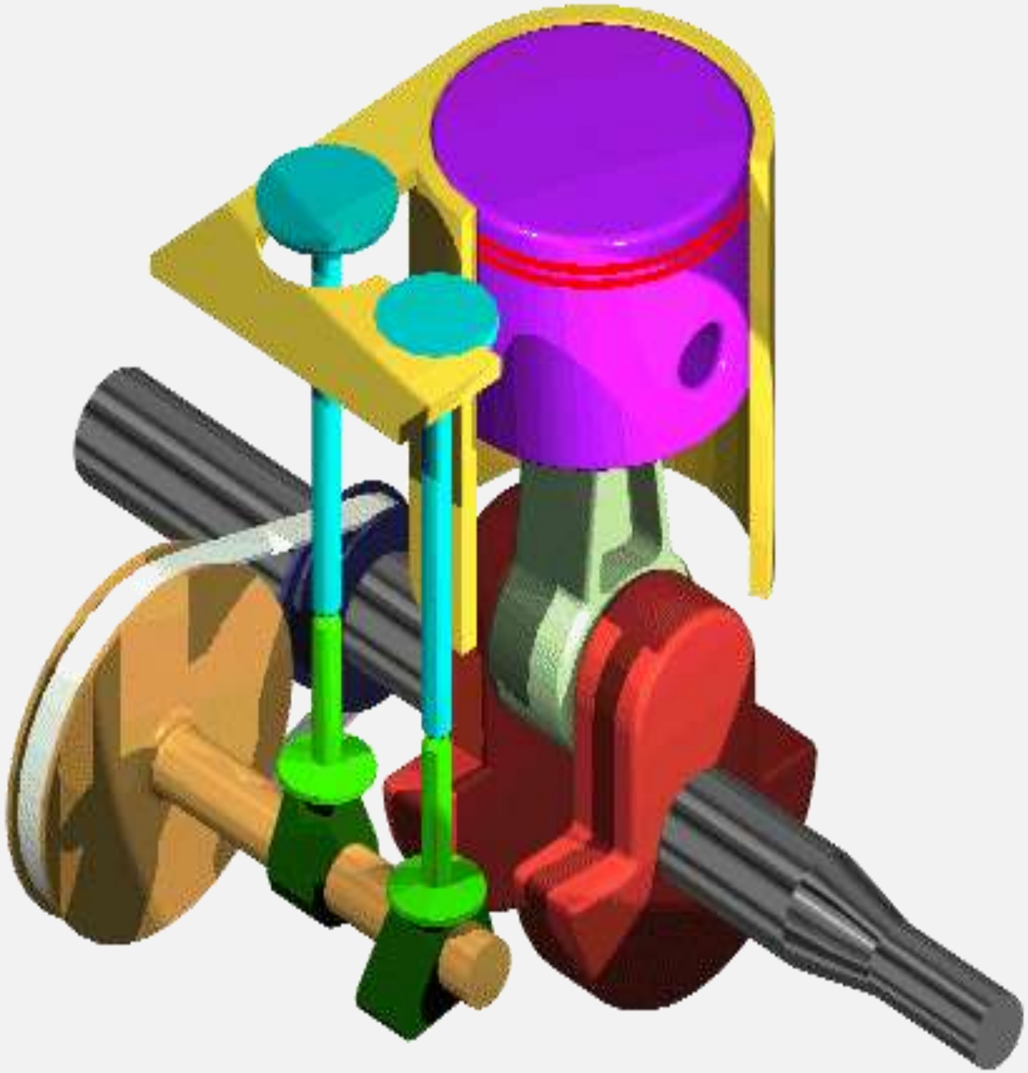
Volume at the completing of the compression stroke will be : Vc

So that Compression ratio is equal to $\frac{V_S+V_C}{V_C}$

Petrol Engine Compression ratio value vary from 5 to 8

Diesel Engine Compression ratio value vary from 16 to 22.

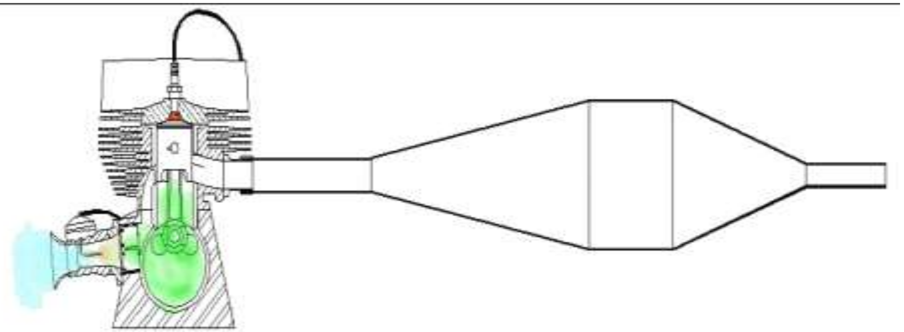

By V.Ryan



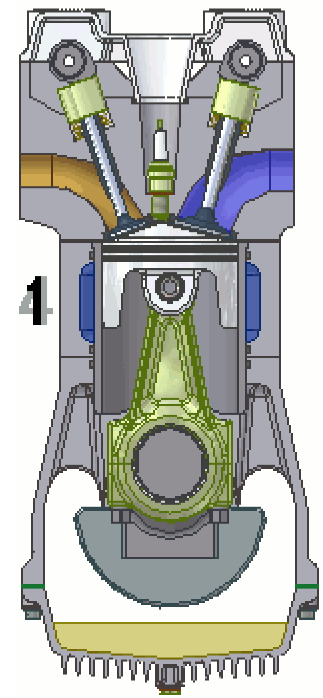
Classification Of I.C. Engine

1. Cycle Of Operation

Two Stroke
Cycle Engine



Four Stroke
Cycle Engine



Classification Of I.C. Engine

2. Thermodynamic Cycle Of Combustion

Otto Cycle Engine

Diesel Cycle Engine

Duel Cycle Engine

Classification Of I.C. Engine

3. Arrangement Of Cylinder/ piston

Horizontal Engine

Vertical Engine

V-Type Engine

Y- type engine

Radial Engine

Classification Of I.C. Engine

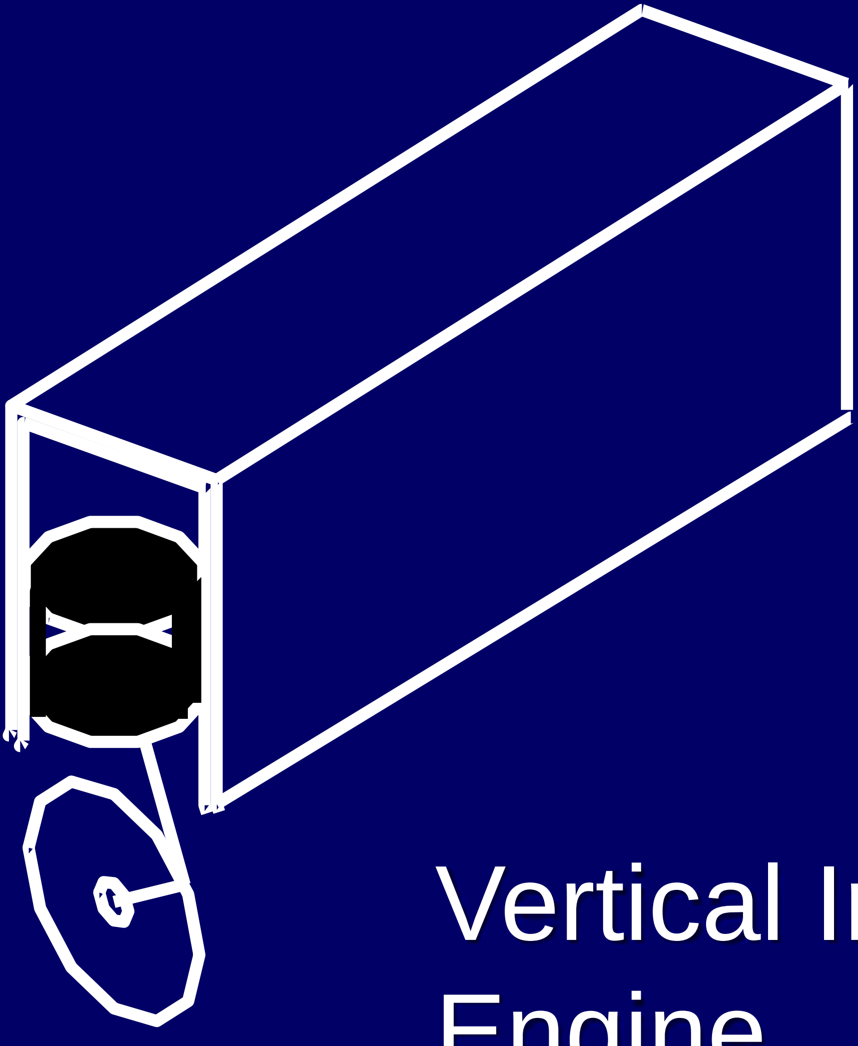
4. Arrangement Of Cylinder/ piston

Opposed cylinder engine

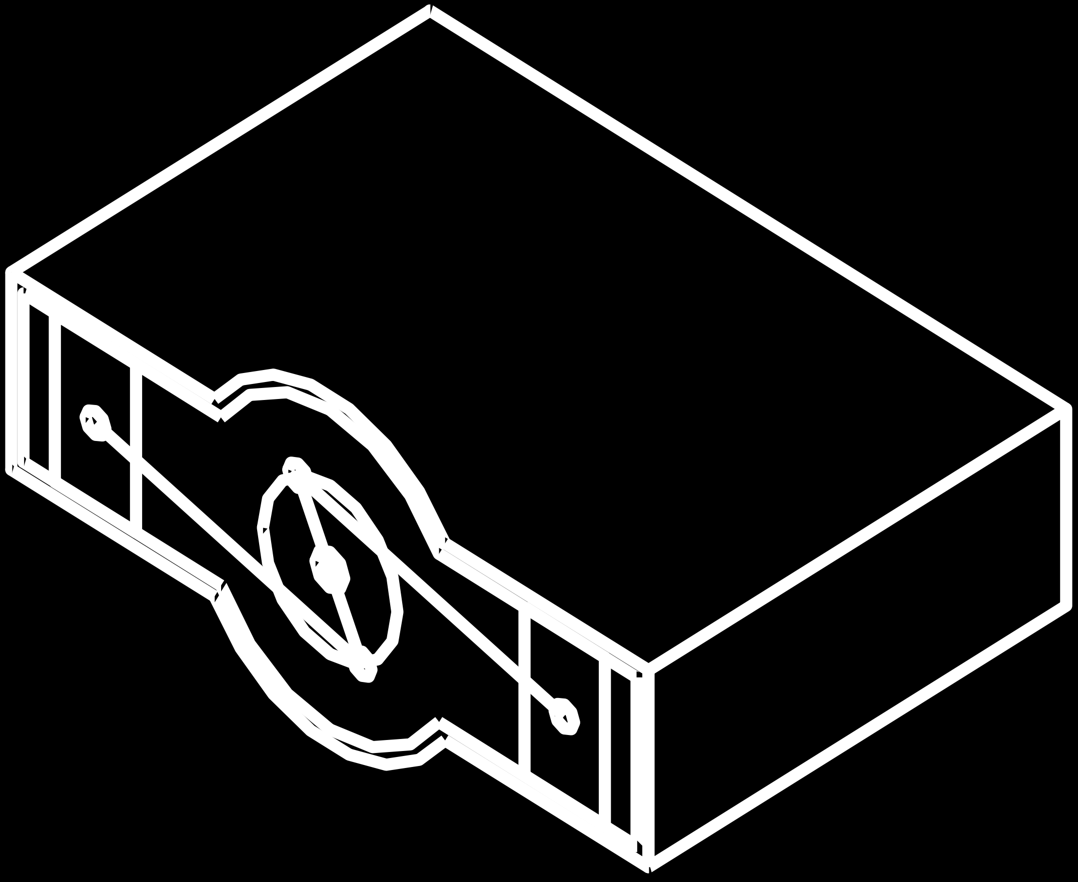
Opposed piston engine

In-line engine

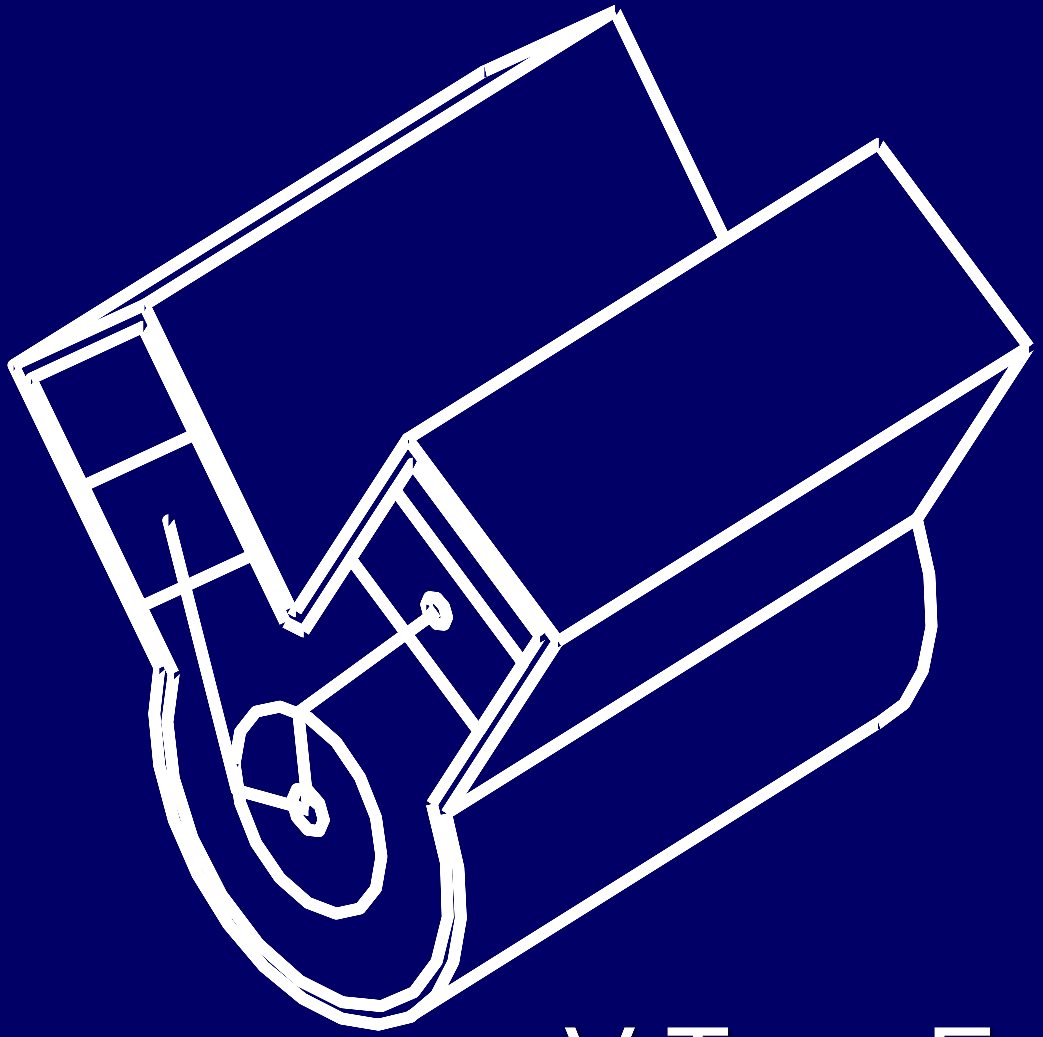
Deltic Engine



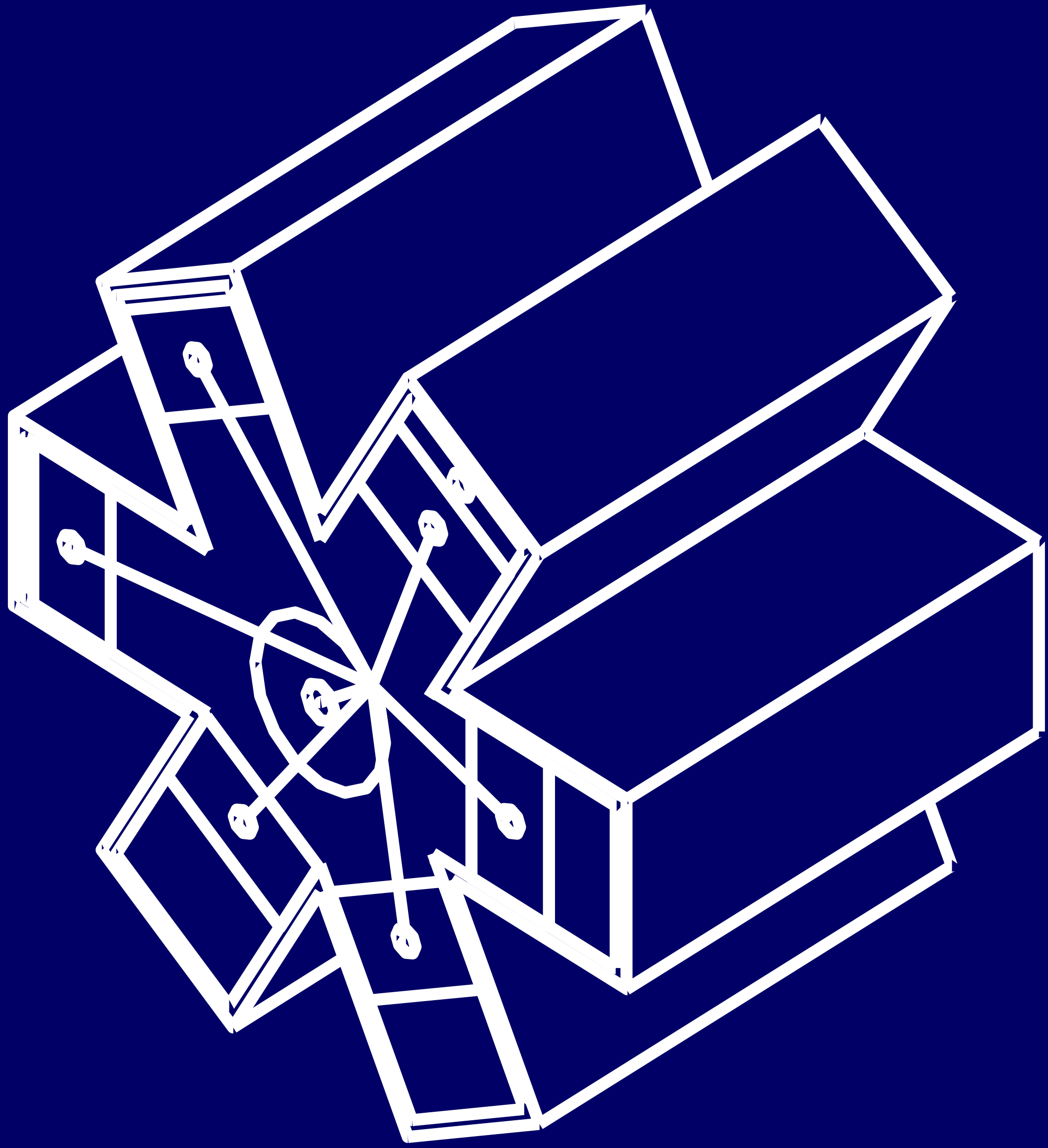
Vertical In line Engine



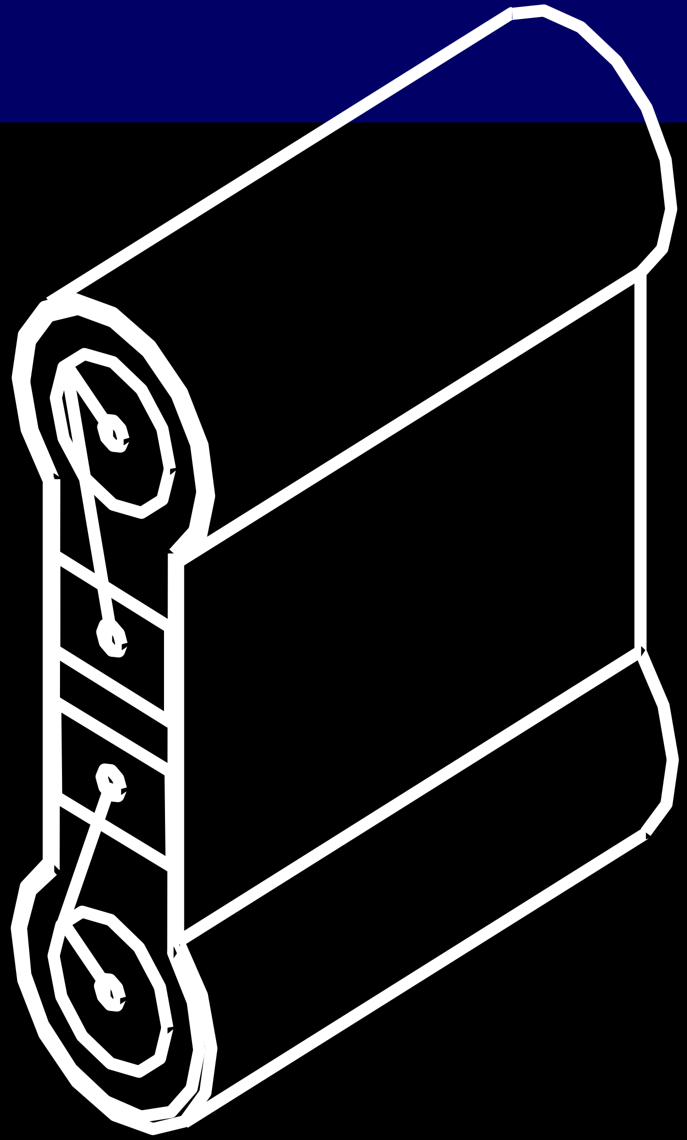
Horizontal Opposed cylinder engine



V-Type Engine



Radial Engine



Vertical Opposed piston engine

Classification Of I.C. Engine

4. Number Of Cylinders

Single Cylinder Engine

Multi Cylinder Engine

Classification Of I.C. Engine

5. Action Of Product Of Combustion Upon The Piston

Single Acting Engine

Double Acting Engine

Classification Of I.C. Engine

6. Speed Of The Engine

Low Speed Engine

Medium Speed Engine

High Speed Engine

Classification Of I.C. Engine

7. Method Of Igniting Fuel

Spark Ignition System

Compression Ignition System

Electronics Ignition System

Classification Of I.C. Engine

8. Method Of Cooling The Cylinder

Air Cooled Engine

Water Cooled Engine

Classification Of I.C. Engine

9. Method Of Governing The Engine

Hit And Miss Governing Engine

Quantity Governing Engine

Quality Governing Engine

Classification Of I.C. Engine

10. Method Of Fuel Supply To The Engine Cylinder

Carburettor Engine

Air Injection Engine

Solid Or Airless Injection Engine

Classification Of I.C. Engine

11. Suction Pressure

Naturally Aspirated Engine

Super Charged Engine

Classification Of I.C. Engine

12. Uses/ application

Stationary Engine

Portable Engine

Automobile Engine

Tractor Engine

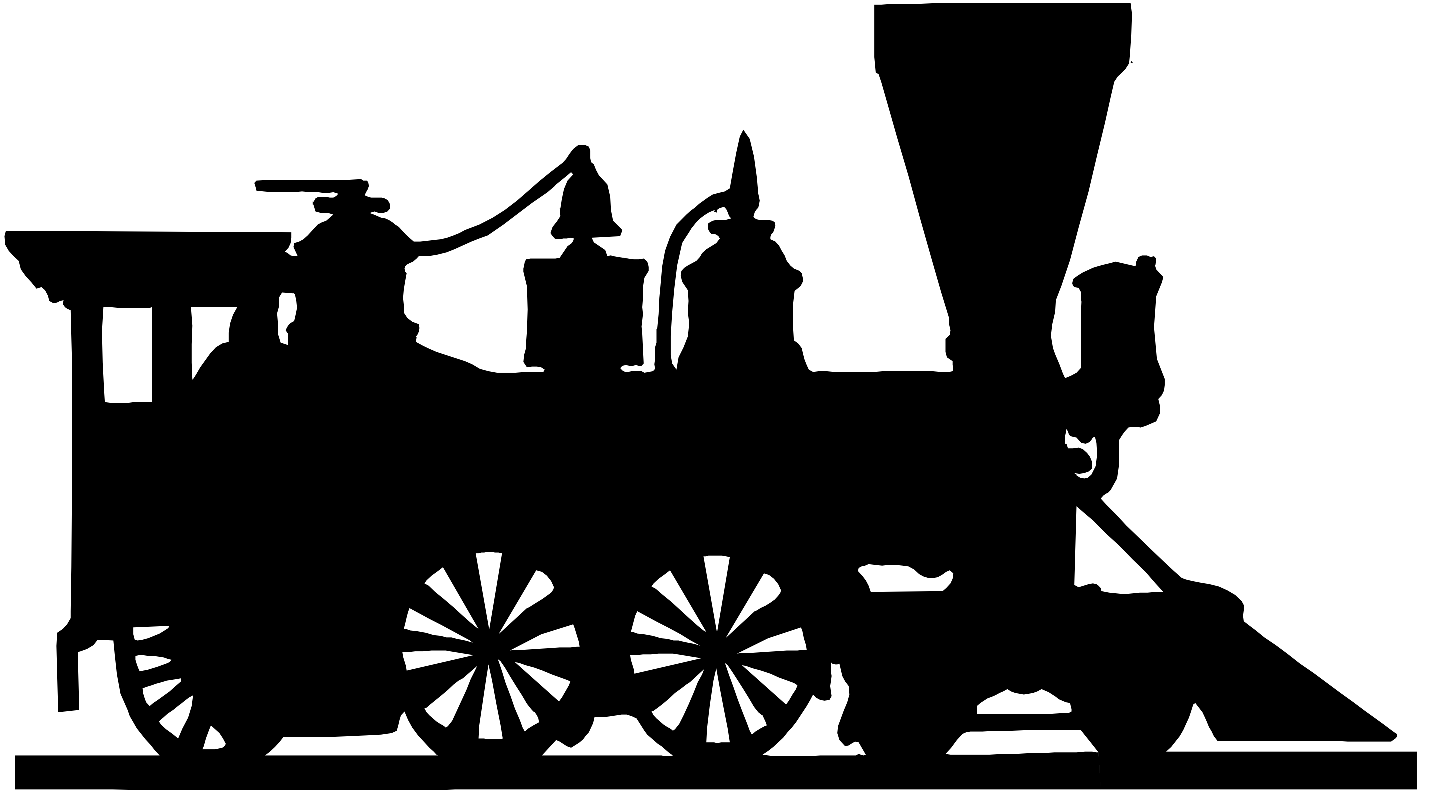
Aero Engine

Marine Engine

Automobile engine

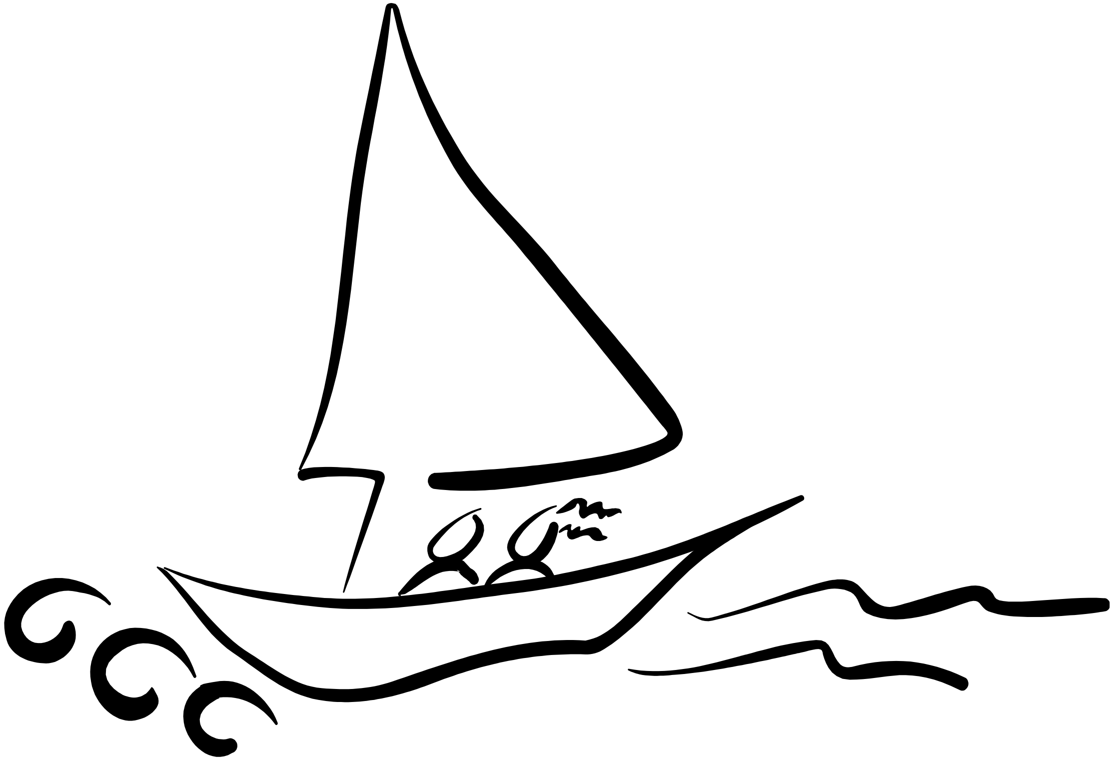
Automobile engine

Aero engine

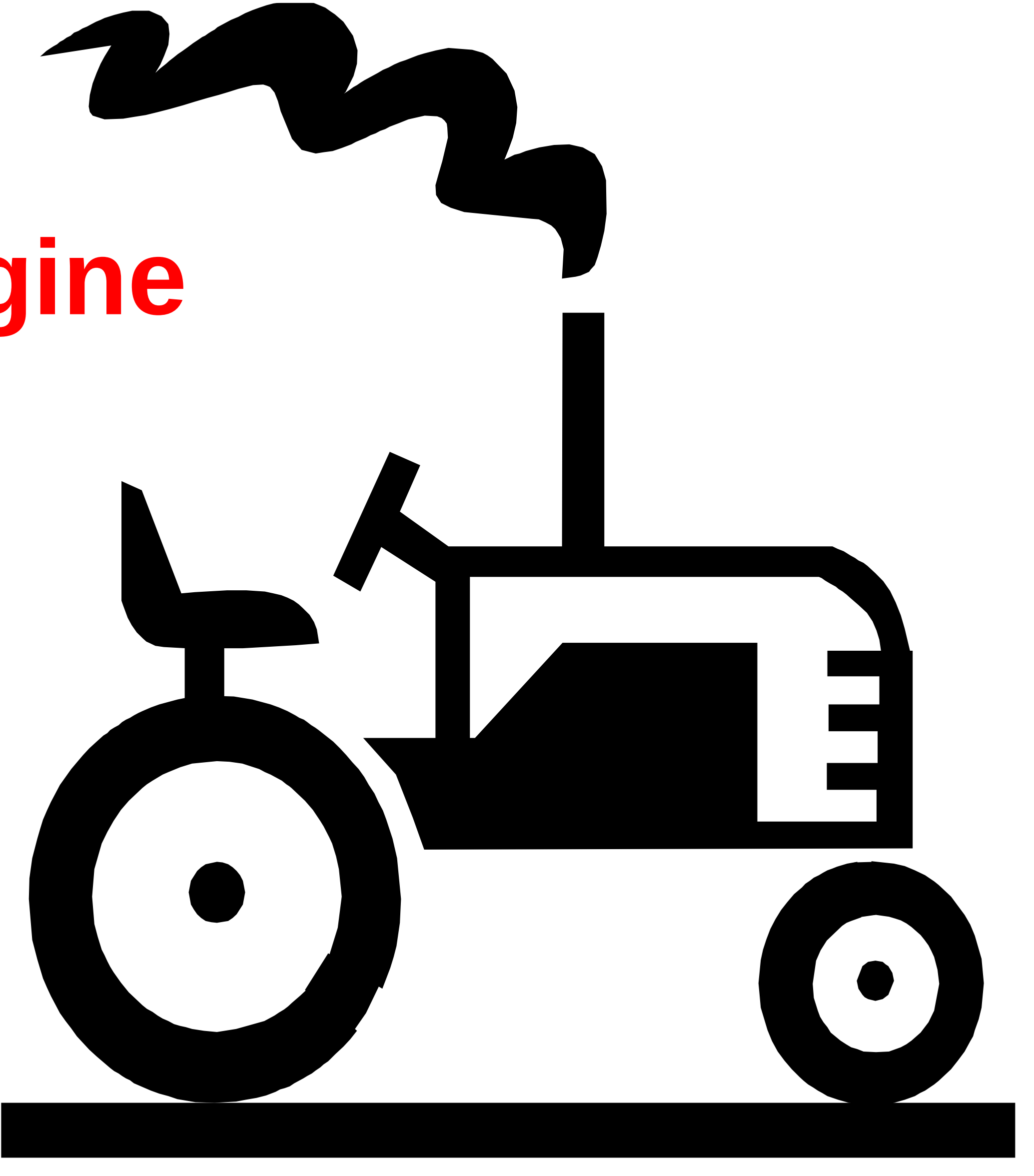


Railway/ locomotive engine

Marine engine

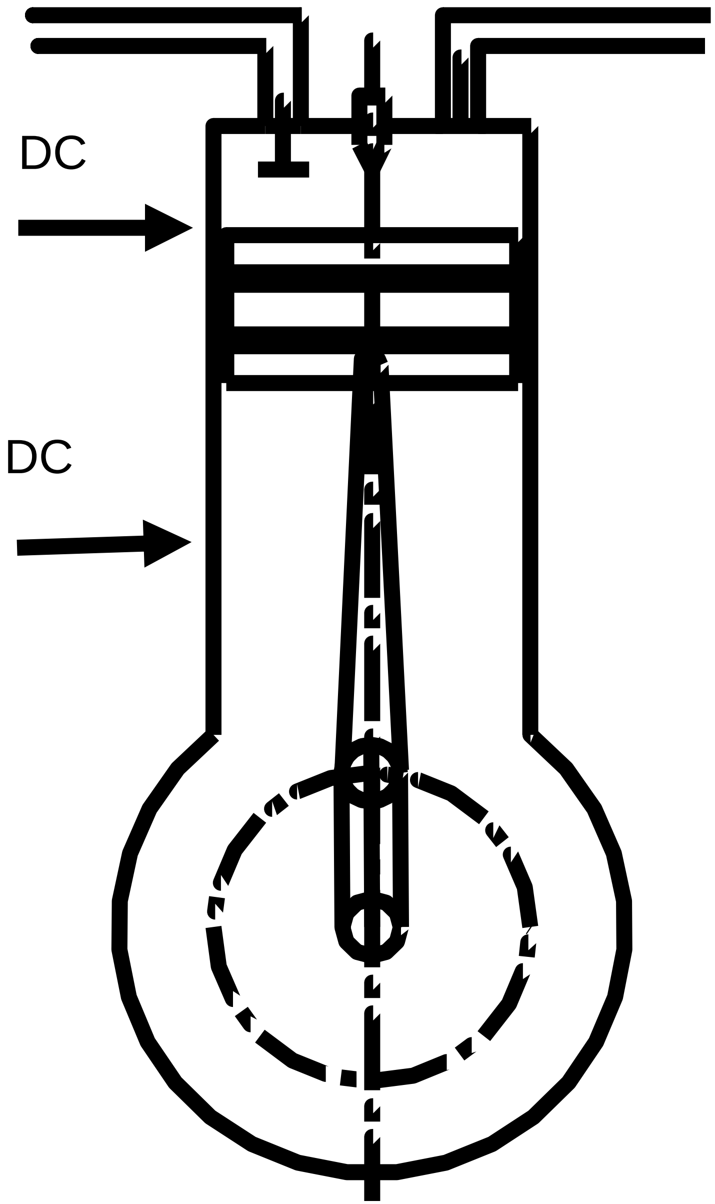


Tractor engine



TERMINOLOGY
OF
I.C. ENGINE

WHAT IS DEAD CENTER?

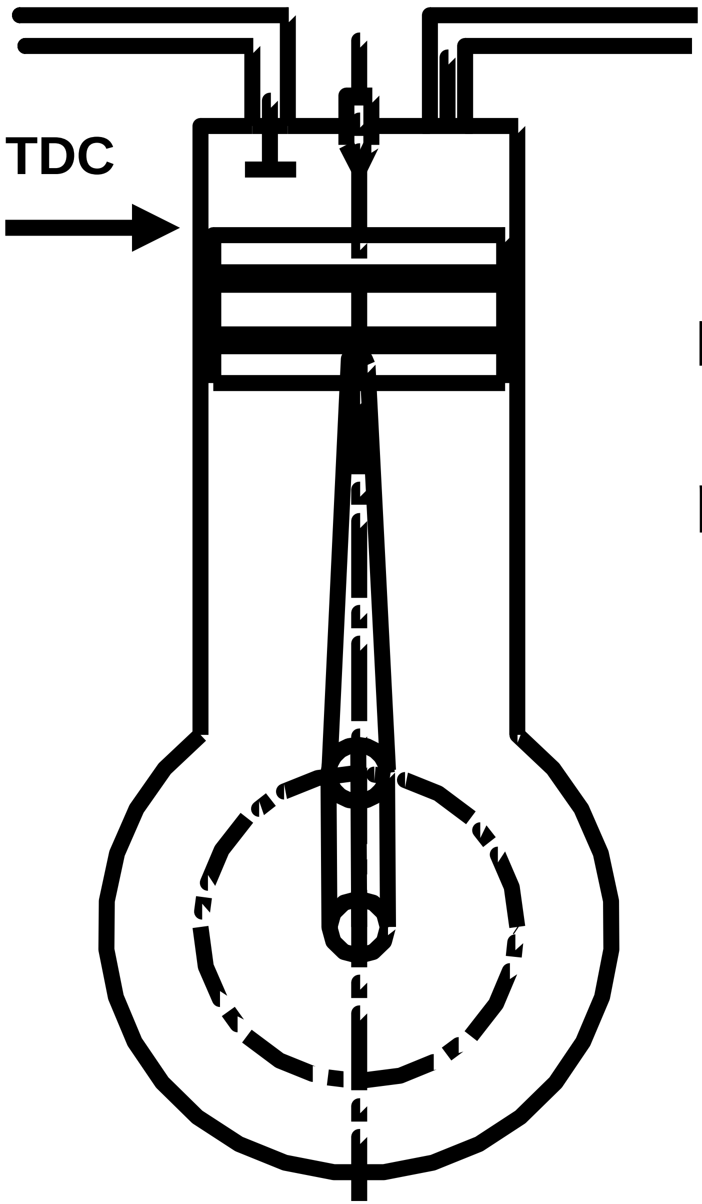


Dead center:

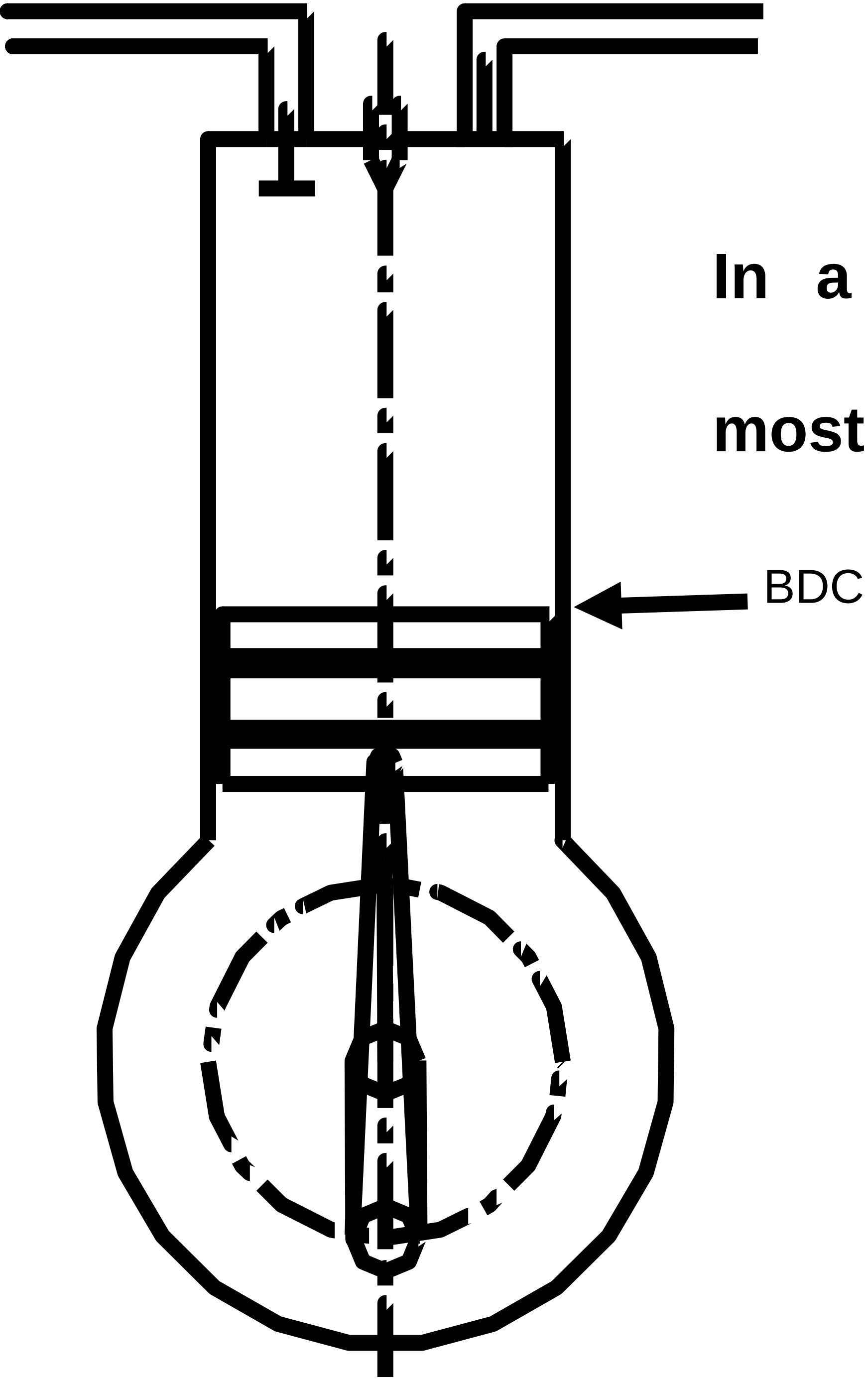
Extreme position of the piston

Piston stops for fraction of second

Piston changes the direction of movement.

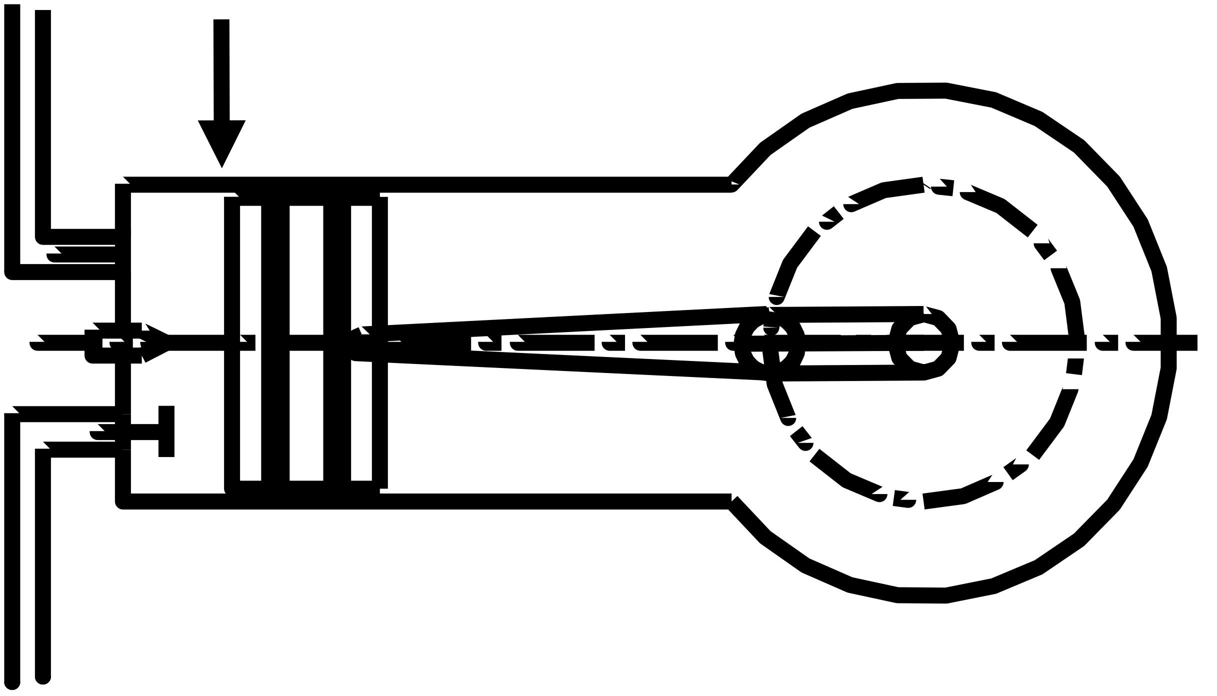


In a vertical axis engine top most position of the piston is T.D.C.

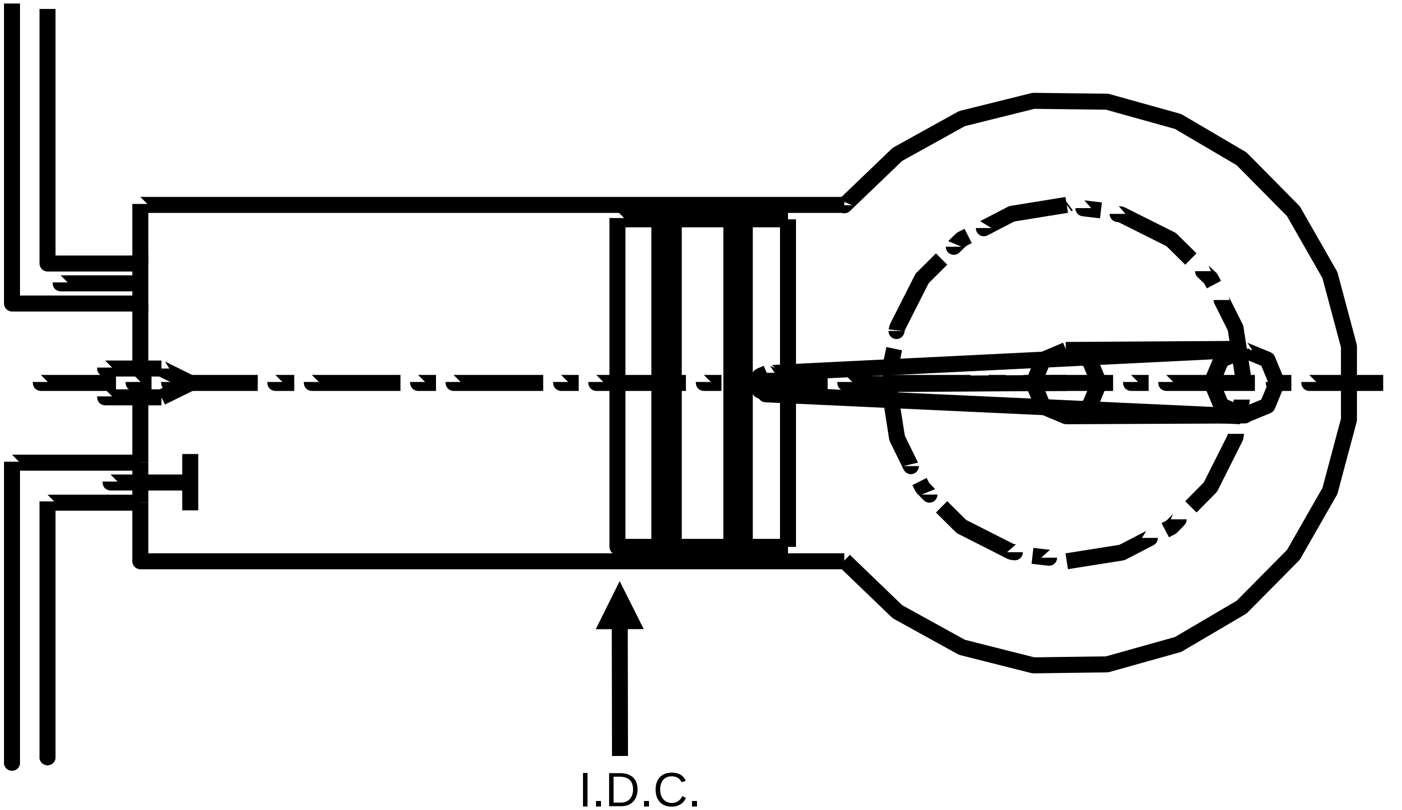


In a vertical axis engine bottom most position of piston is B.D.C.

Outer Dead Center:



- In a horizontal axis engine the outer most position (towards head) of the piston is O.D.C.



In a horizontal axis engine inner most position (towards crank) of piston is I.D.C.

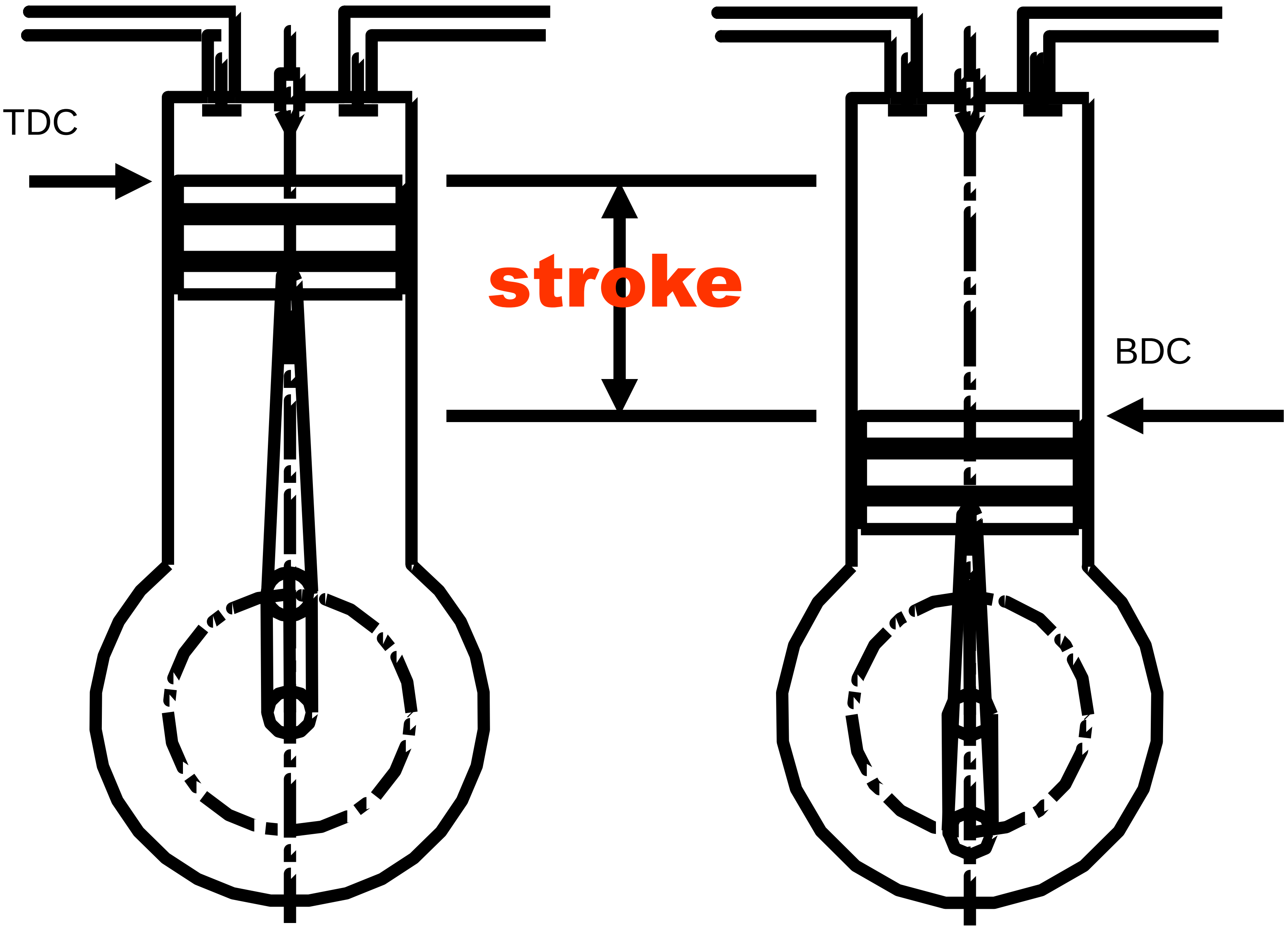
What is Stroke (Stroke Length), L?

Distance traveled by piston, from one dead center to other dead center, is called STROKE.

stroke = distance from TDC to BDC or BDC to TDC
(for Vertical engine)

stroke = distance from ODC to IDC or IDC to ODC
(for Horizontal engine)

stroke (L) = 2 x crank radius (r)


TDC
stroke
BDC

AREA OF CYLINDER (AREA OF PISTON)

$$AREA = \frac{\pi}{4} D^2$$

Where,

D = Inside Diameter of Cylinder.
= Outside Diameter of Piston.
= Cylinder Bore.

Swept Volume (Stroke Volume) = Area of Cylinder * Stroke Length.

Clearance Volume = Area of Cylinder * Clearance Length.

Total Volume of Cylinder = Swept Volume + Clearance Volume.

$$CompressionRatio(r) = \frac{TotalVoulumeofCylinder}{ClearanceVolume}$$

Working of 4 Stroke Cycle Petrol Engine

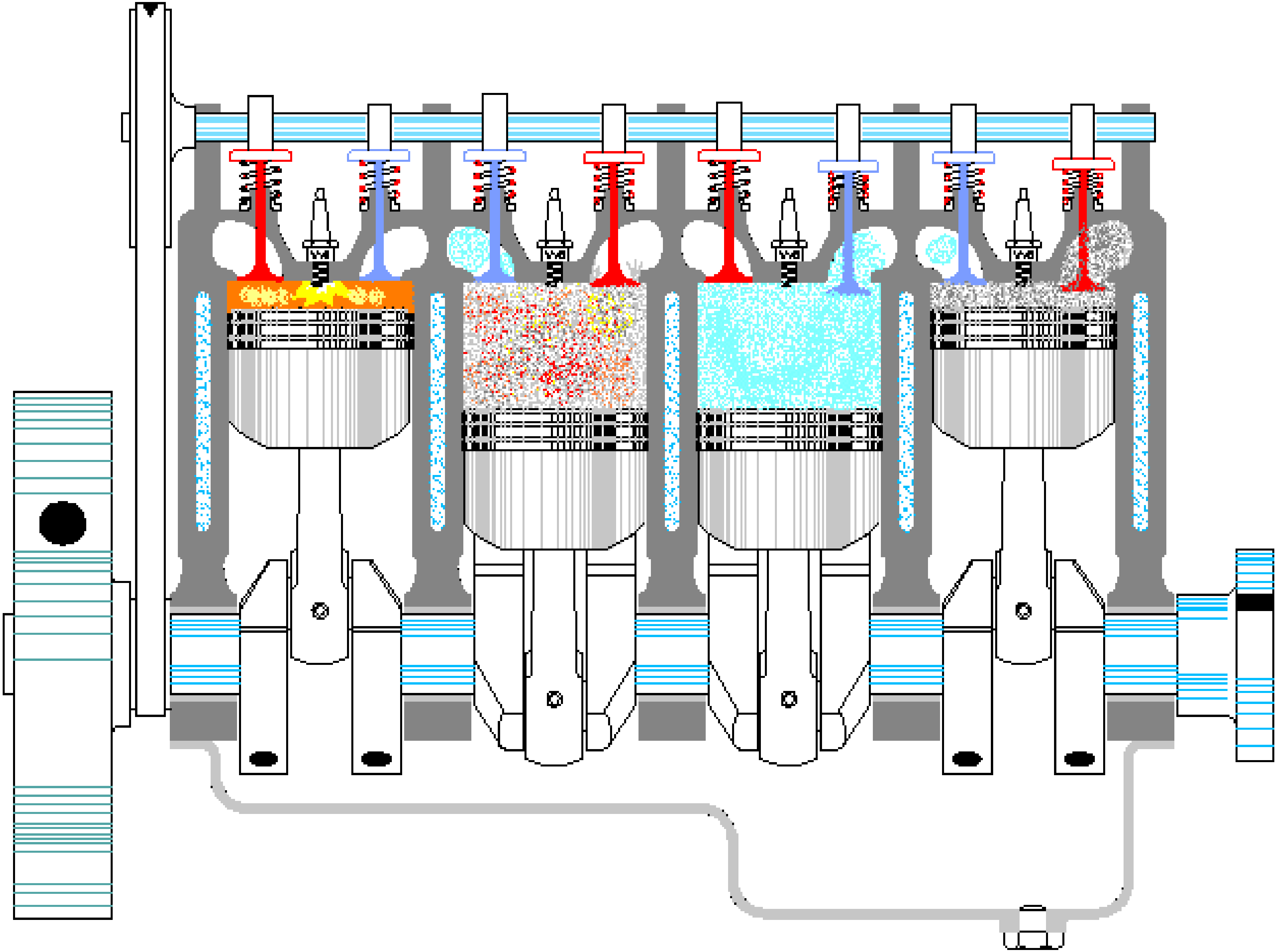
SR NO	STROKE	INLET VALVE	EXHAUST VALVE	REMARK
1	**SUCTION**	**OPEN**	**CLOSE**	**Crank rotated by external force F. piston moves from TDC to BDC. charge taken inside the cylinder**

SR NO	STROKE	INLET VALVE	EXHAUST VALVE	REMARK
2	**COMP.$^{\underline{N}}$**	**CLOSE**	**CLOSE**	**Crank rotated by external force F. piston moves from BDC to TDC. charge compressed inside the cylinder**

SR NO	STROKE	INLET VALVE	EXHAUST VALVE	REMARK
	At the end of comp$^{\underline{n}}$ stroke	**CLOSE**	**CLOSE**	**High pr. high temp. charge is ignited by spark. Combustion will produce high pressure high temp. hot gases**

SR NO	STROKE	INLET VALVE	EXHAUST VALVE	REMARK
3	**Power or Expa.$^{\underline{n}}$**	**CLOSE**	**CLOSE**	**High pr. high temp. hot gases will do work on piston. hence power P will be available at crank shaft.**

SR NO	STROKE	INLET VALVE	EXHAUST VALVE	REMARK
4	**Exhaust or scavenging**	**CLOSE**	**OPEN**	**crank rotated by external force F. Piston moves from BDC to TDC. Waste gases or weak hot gases is exhausted by piston.**



Working of 4 Stroke Cycle Diesel Engine

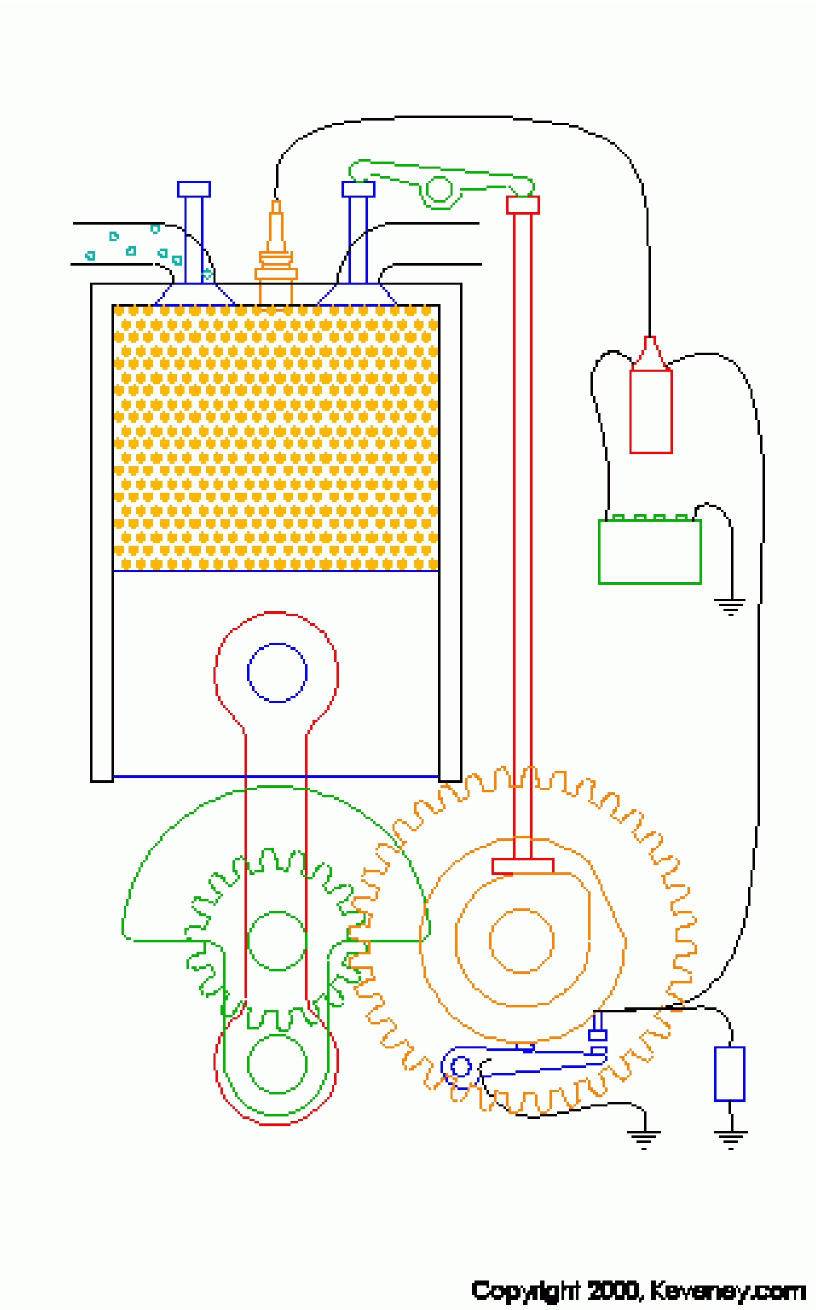
SR NO	STROKE	INLET VALVE	EXHAUST VALVE	REMARK
1	**SUCTION**	**OPEN**	**CLOSE**	**Crank rotated by external force F. piston moves from TDC to BDC. only air taken inside the cylinder**

SR NO	STROKE	INLET VALVE	EXHAUST VALVE	REMARK
2	**COMP.$^{\underline{N}}$**	**CLOSE**	**CLOSE**	**Crank rotated by external force F. piston moves from BDC to TDC. air compressed inside the cylinder**

SR NO	STROKE	INLET VALVE	EXHAUST VALVE	REMARK
	At the end of comp$^{\underline{n}}$ stroke	**CLOSE**	**CLOSE**	**Diesel, in atomized form is injected, in high pr high temp. air, is ignited due to high temp. Combustion will produce high pressure high temp. hot gases**

SR NO	STROKE	INLET VALVE	EXHAUST VALVE	REMARK
3	**Power or expa.$\underline{^{n}}$**	**CLOSE**	**CLOSE**	**High pr. high temp. hot gases will do work on piston. hence power P will be available at crank shaft.**

SR NO	STROKE	INLET VALVE	EXHAUST VALVE	REMARK
4	**Exhaust or scavenging**	**CLOSE**	**OPEN**	**crank rotated by external force F. Piston moves from BDC to TDC. Waste gases or weak hot gases is exhausted by piston.**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Working of 2 Stroke Petrol Engine

Two stroke engine requires two strokes of the piston or one revolution of the crank shaft to complete the cycle.

Ports are used instead of valves in the two stroke engines.

Scavenging Process:- Exhaust gases are expelled out from the engine cylinder by fresh charge of the fuel enter in to the Cylinder. This process is known as Scavenging.

First Stroke:-

During this stroke the piston moves from BDC to TDC.

During upward motion piston close the transfer port and exhaust port.

The fuel mixture which is there in the cylinder is compressed.

Due to piston moving upward direction, pressure and temperature of the air-petrol mixture is increasing.

During upward movement piston open the inlet port.

Due to opening of the inlet port, partial vacuum is created in the crank case and fresh mixture of air-petrol is suck in to the crank case through the inlet port.

Stroke is completed when piston reaches to the TDC.

Second Stroke:-
During this stroke piston moves from TDC to BDC.

The compressed charge which is there in the cylinder is ignited by spark provided by spark plug.

Pressure and temperature of the combustion product increases rapidly and it directly create pressure on piston.

Due to this, piston pushes towards the downward direction and producing useful work.

During downward motion, piston close the inlet port and fresh charge is compressed in the crank case.

During more downward motion of the piston, piston open first exhaust port and then transfer port.

The exhaust gases start to escaping through the exhaust port.

During that same time fresh charge is compressed in the crank case is force towards the cylinder through transfer port.

The fresh charge strikes the deflector on the piston crown, rises to the top part of the cylinder and pushes outside the exhaust gases.

During the more downward motion of the piston (BDC), the cylinder is completely filled with fresh charge by opening the inlet port and thus cycle is completed.

https://youtu.be/33xFSCQaVvk

Working of 2 Stroke Diesel Engine

First Stroke:-
During this stroke the piston moves from BDC to TDC.

During upward motion piston close the transfer port and exhaust port.

The air is compressed in the cylinder and also increases the pressure and temperature of air.

During the same time upward movement of piston open the inlet port.

Due to opening of the inlet port, partial vacuum is created in the crank case and fresh air is suck in to the crank case through the inlet port.

Stroke is completed when piston reaches to the TDC.

Second Stroke:-
During this stroke piston moves from TDC to BDC.

Air is present in the cylinder at the end of the first stroke with high pressure and temperature.

Diesel is injected by diesel injector in to the cylinder just before the end of the first stroke.

The temperature of the compressed air is high to ignite the fuel.

The rate of the fuel (Diesel) injection is kept in such a way to maintain constant pressure during the combustion.

Combustion product acts on the piston pushing it to downward producing useful work.

During more downward motion of the piston, piston open first exhaust port and then transfer port.

The exhaust gases start to escaping through the exhaust port.

During that same time fresh charge is compressed in the crank case is force towards the cylinder through transfer port.

The fresh charge strikes the deflector on the piston crown, rises
to the top part of the cylinder and pushes outside the exhaust
gases.

During the more downward motion of the piston (BDC), the

After some time later the stroke , piston close the inlet port and fresh air is compressed in to the crank case.

During more downward motion of the piston, it open the exhaust port and then transfer port.

Due to open the exhaust port, exhaust gases start to escaping through exhaust port.

Fresh air is compressed in the crank case is forced towards the in to the cylinder through transfer port at the same time.

The air striking the deflector provided on the piston.

Due to this the air rises to wards upward side in to the cylinder and pushes exhaust gases to out side in the atmosphere.

During the downward motion of the piston, the cylinder is completely fill up with the fresh air and thus the cycle is completed.

https://youtu.be/HQk1u_kvQSA

Various Efficiency Equation for I C Engine:

Indicated Power:- Power develop by the engine given by the equation as below:

$$IP = \text{Indicated Power} = \frac{\mathbf{p_m\, LnA}}{\mathbf{60}}$$

For the Four Stroke Engine $n = \frac{N}{2}$

For the Two Stroke Engine n = N

Brake Power:- Power available at the engine shaft.
Lesser value then indicated power because of the friction of the Various moving engine parts.

$$BP = \text{Break Power} = \frac{2\prod nT}{60} = \frac{\mathbf{p_{mb}\, LnA}}{\mathbf{60}}$$

Friction Power:- Power lost due to the friction

$$FP = IP – BP$$

Mechanical Efficiency:-

Ratio of the power available at crank shaft (BP) to that the power developing by the engine cylinder (IP).
Denote by the symbol of $\eta_{\mathbf{mechanical}}$

$$\eta_{\mathbf{mechanical}} = \frac{\mathrm{BP}}{\mathrm{IP}}$$

Thermal Efficiency:-
Ratio of work output of the engine to that of the heat supplied by the fuel.

$$\eta_{thermal} = \frac{\text{work output of the engine}}{\text{heat supply by the fuel}}$$

Indicated Thermal Efficiency:-
Ratio of the indicated power to that of the heat supply by the Fuel per second.
Denote by the symbol $\eta_{\textbf{indicated thermal}}$

$$\eta_{\textbf{indicated thermal}} = \frac{\text{Indicated power}}{\text{Fuel Suppied x C.V}}$$

Brake Thermal Efficiency:-
Ratio of the brake power to that of the heat supplied by the fuel per second.

Denote by the symbol of $\eta_{\textbf{brake thermal}}$

$$\eta_{\textbf{brake thermal}} = \frac{\text{Brake power}}{\text{Fuel Suppied x C.V}}$$

$$\eta_{\textbf{mechanical}} = \frac{\eta_{\textbf{brake thermal}}}{\eta_{\textbf{indicated thermal}}}$$

Relative Efficiency:-

Ratio of the actual thermal efficiency to its corresponding air standard cycle efficiency.

Denote by the symbol of $\eta_{\mathbf{relative}}$

$$\eta_{\mathbf{relative}} = \frac{\mathbf{Actual\ Thermal\ Efficiency}}{\mathbf{Air\ Standard\ Cycle\ Efficiency}}$$

Numerical Base on the I C Engine

(1)Four stroke petrol engine has a stroke volume of 10 liters. Its mean effective pressure is 600 kpa and speed of 300 RPM. Calculate the indicated power of the engine.

Given Data:-

Vs = A.L = 10 Litres = 0.01 m^3

p_m = 600 kpa

N = 300 rpm

n = $\frac{\mathrm{N}}{2}$ = $\frac{300}{2}$ =150, Due to the engine is four stroke type.

Indicated Power = $\frac{\mathbf{p_m\,LA\,n}}{\mathbf{60}}$

= $\frac{600 \text{ x } 0.01 \text{ x } 150}{\mathbf{60}}$

= 15 kW

(2) Six cylinder 4 stroke I C Engines to develop 90 Kw. Indicated Power at 800 rpm. The stroke to bore ratio is 1.5. Assume $\eta_{\mathbf{mechanical}}$ = 0.85. Brake mean effective pressure is 5 bar. Calculate bore and stroke of an engine.

Given Data:-

Indicated Power = 90 kW.

$\eta_{\mathbf{mechanical}}$ = 0.85

p_{mb}= 5 bar

$\frac{L}{D}$ = 1.5

$$\eta_{\mathbf{mechanical}} = \frac{\mathbf{p_{mb}}}{\mathbf{p_m}}$$

$$= \frac{\mathbf{5}}{\mathbf{p_m}}$$

$$\eta_{\mathbf{mechanical}} = \frac{\mathbf{p_{mb}}}{\mathbf{p_m}} = \frac{\mathbf{5}}{\mathbf{p_m}}$$

So that p_m = $\frac{\mathbf{5}}{\eta_{\mathbf{mechanical}}} = \frac{\mathbf{5}}{\mathbf{0.85}}$ = 5.88 bar

Area (A) = $\frac{\Pi}{\mathbf{4}}\mathbf{D^2}$

$\frac{L}{D}$ = 1.5 , So that L = 1.5 x D

n = $\frac{\mathbf{N}}{\mathbf{2}}$

Because Engine is four stroke type.

Apply all the value in the Indicated Power Equation.

We get

Now Indicated Power (IP) = $\frac{\mathbf{p_m\ LA}n}{\mathbf{60}}$

$$90 = \frac{5.88 \text{ x} 1.5 \text{ x D x } \frac{\Pi}{4}\mathbf{D^2}\ x\ \frac{\mathbf{N}}{\mathbf{2}}}{\mathbf{60}}$$

So that We can get the value for Bore and Stroke

Bore Diameter (D) = 269 mm

Stroke Length (L) = 1.5 x D

= 1.5 x 269

= 405 mm

(3) A four cylinder four stroke petrol engine develops 200 kW, of Brake power at 2500 rpm. The stroke to bore ratio is 1.2. If the mean effective pressure is 10 bar and the mechanical efficiency is 81 % . Calculate bore and stroke of the engine. Also calculate indicated thermal efficiency and brake thermal efficiency if 65 $\frac{\mathbf{kg}}{\mathbf{hour}}$ of the petrol is consume having C.V =42000 $\frac{\mathbf{KJ}}{\mathbf{KG}}$.

Given Data:

No of Cylinder = 4

Brake Power = 200 Kw

$\frac{L}{D}$ = 1.2

η_m = 81%

C.V = 42000 $\frac{\mathbf{KJ}}{\mathbf{KG}}$

n= $\frac{N}{2}$

N = 2500 rpm

p_m = 10 bar

m_f = 65 $\frac{\mathbf{kg}}{\mathbf{hour}}$

$$\eta_m = \frac{\mathrm{BP}}{\mathrm{IP}}$$

So that IP = $\frac{\mathrm{BP}}{\eta_m}$

$$= \frac{200}{0.81} = 246.91\ kW$$

Now IP = $\frac{\mathbf{p_m\ LA}\boldsymbol{n}}{\mathbf{60}}$ x No of Cylinder

246.91 = $\frac{10\ x\ 100\ x\ \frac{\Pi}{4}\ x\ D^2\ X\ (1.2\ X\ D)\ X\ 2500}{60\ X\ 2}$ x 4

So that By simplify the above Equation we get

D = 147 mm

L = 1.2 x D = 1.2 x 147 = 176 mm

$$\eta_{ith} = \frac{\mathrm{IP}}{\mathrm{m_f \; X \; C.V}}$$

$$= \frac{246.91}{\frac{65}{3600} X \; 42000}$$

$$= 32.56 \; \%$$

$$\eta_{bth} = \eta_{ith} \times \eta_m$$

$$= 0.3256 \times 0.81$$

$$= 26.37 \; \%$$

(4) The following results refers to a test on the IC Engine.

Indicated Power = 42 Kw

Frictional Power = 7 kw

Engine Speed = 1800 rpm

Specific fuel consumption per B.P = 0.30 $\frac{KG}{KW.h}$

Calorific value of fuel used = 43000 $\frac{kJ}{kg}$

Calculate the following Values:

(i) Mechanical Efficiency

(ii) Brake Thermal Efficiency

(iii) Indicated Thermal Efficiency

Solution:

IP = 42 kW,

FP = 7 kW,

BP = IP – FP

= 42 – 7

= 35 Kw,

(i) Mechanical Efficiency

$$\eta_m = \frac{\mathrm{BP}}{\mathrm{IP}} = \frac{35}{42}$$

=0.83

= 83 %

(ii) Brake Thermal Efficiency

$$\eta_{bth} = \frac{\mathrm{BP}}{\mathrm{m_f\ X\ CV}}$$

$$= \frac{1}{\frac{m_f}{BP}\ \mathrm{X\ CV}}$$

$$= \frac{1}{\frac{m_f\ in\ \frac{kg}{hr}}{BP}\ \mathrm{X\ CV}}$$

$$= \frac{1}{\frac{m_f}{BP\ x\ 3600}\ \mathrm{X\ CV}}$$

$$= \frac{1}{\frac{m_f}{BP\ x\ 3600}\ \mathrm{X\ CV}}$$

$$= \frac{3600}{\frac{m_f}{BP}\ \mathrm{X\ CV}} = \frac{3600}{\mathrm{BSFC\ X\ CV}}$$

Here BSFC = 0.3 $\frac{\text{KG}}{\text{KW h}}$

CV = 43000 $\frac{KJ}{KG}$

$$\eta_{bth} = \frac{3600}{\text{BSFC X CV}}$$

$$= \frac{3600}{0.3 \text{ X } 43000}$$

$$= 0.2790$$

= 27.90 %

(iii) Indicated Thermal Efficiency

$$\eta_m = \frac{\eta_{bth}}{\eta_{ith}}$$

So That $\eta_{ith} = \dfrac{\eta_{bth}}{\eta_m}$

$$= \frac{0.279}{0.83}$$

$$= 0.3361$$

$$= 33.61\%$$

(5) Following observations were record during a test on a single cylinder oil engine.

Bore = 300 mm

Stroke = 450 mm

Speed = 300 rpm

indicated mean effective pressure = 6 bar

Net break load = 1.5 kN

Brake drum diameter = 1.8 m

Brake rope diameter = 2 cm

Calculate the following values:

(1) Indicated Power

(2) Brake Power

(3) Mechanical Efficiency

D = 300 mm

L = 450 mm

N = 300 rpm

P_{imep} = 6 bar

F = 1.5 Kn

R_{eff} = $\frac{D+(2X2)}{2}$

= $\frac{180+(2X2)}{2}$

= 92 cm

(i) Indicated Power

$$IP = \frac{\mathbf{p_{imep}\,LAN}}{\mathbf{60}}$$

$$= \frac{\mathbf{p_{imep}\,L\,X\,\frac{\prod}{4}}\boldsymbol{D^2}\,\mathbf{X\,N}}{\mathbf{60}}$$

Consider that the engine is 4 stroke type.

$$= \frac{\mathbf{600\,X\,0.450\;\;X\,\frac{\prod}{4}\,x\,0.3^2\,X\,300}}{\mathbf{2}\;\boldsymbol{x}\;\mathbf{60}}$$

IP = 47.68 kw

(ii) Brake Power

$$BP = \frac{2 \, X \, \pi \, X \, N \, X \, T}{60}$$

$$= \frac{2 \, X \, \pi \, X \, 300 \, X \, (F \, X \, R_{eff})}{60}$$

$$= \frac{2 \, X \, \pi \, X \, 300 \, X \, (1.5 \, X \, 0.92)}{60}$$

= 43.33 Kw,

(iii) Mechanical Efficiency

$$\eta_m = \frac{43.33}{47.68}$$

$$= 0.9087$$

$$= 90.87\ \%$$

(6) The following results refers to a test on the C.I engine.

Indicated Power = 37 kW

Frictional Power = 06 kW

Brake Specific Fuel Consumption = 0.28 $\frac{kg}{kW.h}$

Calorific value of the fuel = 44300 $\frac{kJ}{kg}$

Calculate:

(i) Mechanical Effciency

(ii) Brake Thermal Effciency

(iii) Indicated Thermal Effciency

Given :

IP = 37 Kw

FP = 6 KW

BSFC = 0.28 $\frac{kg}{kW.h}$

C.V = 44300 $\frac{kJ}{kg}$

η_m = ?

$\eta_{ith} = ?$

η_{bth} = ?

$$\eta_m = \frac{\mathrm{BP}}{\mathrm{IP}}$$

$$= \frac{\mathrm{IP} - \mathrm{FP}}{\mathrm{IP}}$$

$$= \frac{37-6}{37}$$

= 83.78 %

$$\text{BSFC} = \frac{m_f}{\mathrm{BP}}$$

M_f = BSFC x BP

$$= 0.28 \text{ X } 31 = 8.68 \frac{kg}{hr}$$

$$\eta_{bth} = \frac{\mathrm{BP}}{\mathrm{m_f} \; \mathrm{X} \; \mathrm{C.V}}$$

$$= \frac{31}{\frac{8.68}{3600} \mathrm{X} \; 44300}$$

$$= 29.02 \;\%$$

$$\eta_{ith} = \frac{\boldsymbol{\eta_{bth}}}{\eta_{\mathrm{m}}}$$

$$= \frac{\mathbf{29.02}}{83.78}$$

$$= 34.64 \;\%$$

(7) During a test on the single cylinder four stroke engine having a compression ratio of 6, the following data is record.

Bore = 10 cm

Stroke = 12.5 cm

imep = 2.6 bar

dead load on dynamometer = 60 N

Spring balance reading = 19 N

Effective radius of the flywheel = 40 cm

Fuel consumption = 1 kg/hr

Calorific Value of fuel = 42000 kj/kg

Speed =2000 RPM

Determine its indicated power, brake power, mechanical efficiency, over all efficiency, air standard cycle efficiency, relative effeciency

Given Parameter:-

d = 10 cm,

L = 12.5 cm

Imep = 2.6 bar = Pm

W = 60 N

S = 19 N

Reff = 40 cm

r= 6

N = 200 RPM

Single cylinder four stroke engine

IP = ?

BP = ?

$\eta_m = ?$

η_{bth} = ?

η_r = ?

For the four stroke engine

$$IP = \frac{P_m \text{ X } A \text{ X } L \text{ X } N}{60 \text{ X } 2}$$

$$= \frac{2.6 \text{ x } 100 \text{ X } \frac{\pi}{4} \text{ X } 0.1^2 \text{ X } 2000}{60 \text{ X } 2}$$

= 4.25 Kw

$$BP = \frac{2 \text{ X } \pi \text{ X } N \text{ X } T}{60}$$

$$= \frac{2 \text{ X } \pi \text{ X } N \text{ X } (W - S) \; X \; R_{eff}}{60}$$

$$= \frac{2 \text{ X } 3.14 \text{ X } 2000 \text{ X } (60-19) \; X \; 0.4}{60}$$

= 3.44 kW

$$\eta_m = \frac{\mathrm{BP}}{\mathrm{IP}} = \frac{3.44}{4.25} = 80.94\ \%$$

$$\eta_{bth} = \frac{BP}{m_f\ X\ \ C\,V}$$

$$= \frac{3.44}{\frac{1}{3600} X\ \ 42000}$$

$$= 29.5\ \%$$

$$\eta_{ith} = \frac{\eta_{bth}}{\eta_m}$$

$$= \frac{29.5}{0.8094}$$

$$= 36.45\ \%$$

Assuming Petrol Engine working on to the otto cycle

$$\eta_a = 1 - \frac{1}{r^{\Upsilon-1}}$$

$$= 1 - \frac{1}{6^{1.4-1}}$$

$$= 1 - \frac{1}{6^{0.4}}$$

$$= 51.16\ \%$$

$$\eta_a = \frac{\eta_{\mathrm{bth}}}{\eta_{\mathrm{a}}}$$

(Base on the Brake Thermal Effciency)

$$= \frac{\eta_{\mathrm{bth}}}{\eta_{\mathrm{a}}} = \frac{29.5}{0.5116} = 57.66\%$$