Q4/

$$R = \frac{R_o}{M} = \frac{8.314}{44} = 0.189 \ kJ/kg.k$$

$$C_v = \frac{R}{\gamma - 1} = \frac{0.189}{1.3 - 1} = 0.63 \ kJ/kg.k$$

$$C_p = \frac{\gamma R}{\gamma - 1} = \frac{1.3(0.189)}{1.3 - 1} = 0.819 \ kJ/kg.k$$

Q5/

$$P_1 V_1 = R T_1 \Rightarrow T_1 = \frac{P_1 V_1}{R} = \frac{20 \times 10^5 \times 0.05}{0.287 \times 10^3} = 348.43 K$$

$$u_1 = C_v T_1 = 0.718 \times 348.43 = 250.17 \ kJ/kg$$

$$h_1 = u_1 + PV = 250.17 + 20 \times 10^2 \times 0.05 = 350.17 \ kJ/kg$$

$$u_2 = u_1 + 120 = 250.17 + 120 = 370.17 \ kJ/kg$$

$$u_2 = C_v T_2 \Rightarrow T_2 = \frac{u_2}{C_v} = \frac{370.17}{0.718} = 515.55 K$$

$$P_2 V_2 = R T_2$$

$$V_2 = \frac{R T_2}{P_2} = \frac{0.287 \times 10^3 \times 515.55}{50 \times 10^5} = 0.296 \ m^3$$

6- $V_1 = 0.085 m^3$, $V_2 = 0.034 m^3$

$P_1 = 1 bar$, $P_2 = 3.9 bar$

$C_v = 0.724$ kJ/kg.k , $C_p = 1.02$ kJ/kg.k

$\Delta T = 14.6 K$

$R = ?$

$m = ?$

$\Delta U = ?$

$R = C_p - C_v = 1.02 - 0.724 = 0.296$ kJ/kg.k

$P_1 V_1 = m R T_1$ --- ①

$P_2 V_2 = m R T_2$ --- ②

Subtract eq① from eq②

$P_2 V_2 - P_1 V_1 = mR (T_2 - T_1)$

$3.9 \times 10^2 \times 0.034 - 1 \times 10^2 \times 0.085 = m \times 0.296 \times 14.6$

$\therefore m = 0.11$ kg

$\Delta U = m C_v \Delta T$

$= 0.11 \times 0.724 \times 14.6$

$= 11.63$ kJ

INTERNAL COMBUSTION ENGINES

Engine Classifications تصنيف المحركات

اولاً - تصنيف المحركات على اساس الموقع الذي يحترق فيه الوقود ..الى نوعين:

1-محركات الاحتراق الخارجي EXTERNAL COMBUSTION ENGINES

2-محركات الاحتراق الداخلي INTERNAL COMBUSTION ENGINES

ثانياً - تصنيف المحركات حسب نوع الوقود الذي يستخدم لتشغيلها ..الى ثلاث انواع:

1-محركات الكيروسين (النفط الابيض) Kerosene Engines

2-محركات البنزين Petrol Engines

3-محركات الديزل (زيت الغاز) Diesel Engines

ثالثاً – تصنيف محركات الاحتراق الداخلي حسب طرق حرق الوقود.. الى نوعين:

1- محركات الاحتراق بالشرارة Spark Ignition Engine

2 - محركات الاحتراق بالضغط Compression Ignition Engines

Gasoline engine

Diesel engine

رابعاً – تصنيف المحركات حسب طبيعة حركة الاجزاء المنتجة للطاقة.. الى نوعين:

1- المحركات الترددية Reciprocating Engines

2- المحركات الدورانية Rotational Engines

Rotary Engine (Wankel Engine)

خامساً – تصنيف المحركات الاحتراق على اساس الدورة الحرارية ..الى نوعين:

1-محركات ثنائية الاشواط Engines Two Stroke

2-محركات رباعية الاشواط Engines Four Stroke

سادساً – تصنيف المحركات على اساس نوع التبريد ..الى نوعين:

1-محركات تبرد بالماء Engines Water Cooling

2-محركات تبرد بالهواء Engines Air Cooling

الفصل الاول (الثرموداينمك)

حل مسائل الفصل الاول

Problems:

Q1/

$$T_{^\circ F} = 1.8\, T_{^\circ C} + 32$$

$$T_{^\circ C} = \frac{(T_{^\circ F} - 32)}{1.8} \Rightarrow T_{^\circ C} = \frac{80 - 32}{1.8} = 26.6\ ^\circ C$$

$$T_K = T_{^\circ C} + 273 = 26.6 + 273 = 299.6\ K$$

$$T_{^\circ R} = T_{^\circ F} + 460 = 80 + 460 = 540\ ^\circ R$$

Q2/

$$T_{C^\circ} = \frac{T_{^\circ F} - 32}{1.8} = \frac{98.6 - 32}{1.8} = 37 C^\circ$$

$$T_{^\circ R} = T_{^\circ F} + 460 = 98.6 + 460 = 558.6\ ^\circ R$$

$$T_K = T_{C^\circ} + 273 = 37 + 273 = 310\ K$$

Q3/

$$\rho = \frac{m}{V}$$

$$V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(6.4 \times 10^6)^3$$

$$= 1.098 \times 10^{21}\ m^3$$

$$\therefore \quad \rho = \frac{6 \times 10^{24}}{1.098 \times 10^{21}} = 5464.48\ kg/m^3$$

Q4/

$$W = mg = 2000 = m \times 9.81 \Rightarrow m = \frac{2000}{9.81} = 203.87\,kg$$

$$\rho = \frac{m}{V} = \frac{203.87}{1} = 203.87\ kg/m^3$$

Q12/

$g = 9.81 - 3.32 \times 10^{-6} h \quad m/s^2$

$\therefore g = 9.81 - 3.32 \times 10^{-6} \times 10 \times 10^{3}$

$g = 9.77 \ m/s^2$

the mass of sea level

$m = \frac{W}{g} = \frac{40 \times 10^{3}}{9.81} = 4077.47 \ kg$

The weight of airplane at 10 km.

$W = m \times g$

$= [4077.47 \times 9.77] \times 10^{-3}$

$= 39.83 \ N$

Q13/

(a) Kinetic energy

$KE = \frac{1}{2} m c^2$

$W = 40 KN$

$g = 9.81 - 3.32 \times 10^{-6} h \quad [m/s^2]$

$\therefore g = 9.81 - 3.32 \times 10^{-6} \times 10 \times 10^{3}$

$= 9.77 \ m/s^2$

$m = \frac{W}{g} = \frac{40 \times 10^{3}}{9.77} = 4094.16 \ kg$

$\therefore KE = \frac{1}{2} (4094.16)(900 \times \frac{1000}{3600})^2$

$= 127942500 \ J \times 10^{-6}$

$= 127.94 \ MJ$.

(b) Potential energy.

$PE = mgz$

$\therefore PE = (4094.16)(9.77)(10 \times 10^{3}) \times 10^{-6}$

$= 400 \ MJ$.

Q14/

$$KE = \frac{1}{2} m c^2 = \frac{1}{2} \frac{25 \times 10^3}{9.81} \times \left(\frac{400 \times 1000}{3600}\right)^2$$

$$= 15.73 \text{ MJ}$$

$$PE = mgz = \frac{25 \times 10^3}{9.81} \times 9.81 \times 5 \times 10^3$$

$$= 125 \text{ MJ}$$

Q15/

(a) $m = \frac{W}{g} = \frac{100{,}000}{9.81} = 10194 \text{ kg}.$

(b) The value for gravity on the plant's surface, with $h=0$, is $g = 4 \, m/s^2$,

The weight is then

$$W = mg = (10194)(4) = 40780 \text{ N}$$

(c) At $h = 200000 m$, gravity is

$$g = 4 - (1.6 \times 10^{-6})(2 \times 10^5)$$

$$= 3.68 \, m/s^2$$

The probe's weight at 200km is

$$W = mg = (10194)(3.68) = 37510$$

open system حل أسئلة

Q1/

a)

$c_1 = 30\ km/h = \frac{30}{3.6} = 8.333\ m/s$

$c_2 = 50\ km/h = \frac{50}{3.6} = 13.888\ m/s$

$m = 1200\ kg$

$W = \Delta KE = \frac{1}{2} m (c_2^2 - c_1^2)$

$= \frac{1}{2} * 1200 (13.888^2 - 8.333^2)$

$= 74077\ J = 74.1\ kJ$

b)

$c_1 = 50\ km/h = \frac{50}{3.6} = 13.888\ m/s$

$c_2 = 70\ km/h = \frac{70}{3.6} = 19.444\ m/s$

$W = \Delta K.E = \frac{1}{2} m (c_2^2 - c_1^2)$

$= \frac{1}{2} * 1200 (19.444^2 - 13.888^2)$

$= 111112 J = 111.112\ kJ$.

Q2/

$m = 1750\ kg$

$z = 1.8\ m$

$P = 800\ kPa$

$\Delta P.E = m \cdot g \cdot z = 1750 * 9.81 * 1.8$

$\Delta P.E = 30901\ J$

$W = P(V_2 - V_1) = P \Delta V$

$30.901 = 800 \Delta V$

$\Delta V = 0.0386\ m^3$

Q3/ $T = 15^{\circ}C$ $z = 15\,m$ $C_2 = ?$ $C_1 = 0$

$$\cancel{Q_{12}}^{0} - \cancel{W_{12}}^{0} = \Delta P.E + \Delta KE_{12} + \cancel{\Delta H_{12}}^{0}$$

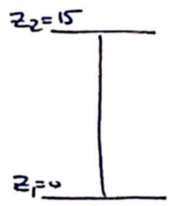
neg (No change of water temp.)

$$\Delta KE_{12} = -\Delta P.E$$

$$\frac{1}{2}\cancel{m}(c_2^2 - c_1^2) = -\cancel{m}\cdot g \cdot z$$

$$\frac{c_2^2}{2} = -g.z \Rightarrow c_2 = -\sqrt{2gz}$$

$$C_2 = -\sqrt{2 * (9.81) * 15} = 17.15\ m/s$$



Q4/

$$\Delta KE = -\Delta H$$

$$\frac{1}{2}m(c_2^2 - c_1^2) = -m\,\Delta h = -cp(T_2 - T_1) = cp(T_1 - T_2)$$

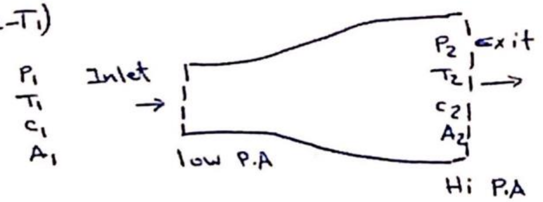
$$\frac{c_2^2 - c_1^2}{2} = cp\,(T_1 - T_2)$$

$$\frac{500^2 - 40^2}{2} * 10^{-3} = 1.005(1000 - T_2)$$

$\therefore T_2 = 880\ K$.

Q5/ $P_1 = 100\,kPa$ $A_1 = 100\,mm^2$ $T_2 = ?$
$T_1 = 300\,K$ $A_2 = 860\,mm^2$ $P_2 = ?$
$c_1 = 200\,m/s$ $c_2 = 20\,m/s$

$\Delta KE = -\Delta H = -\dot{m}\,c_p\,(T_2 - T_1)$



$$\tfrac{1}{2}\dot{m}\,(c_2^2 - c_1^2) = \dot{m}\,c_p\,(T_1 - T_2)$$

$$\frac{20^2 - 200^2}{2} \times 10^{-3} = 1.005\,(300 - T_2)$$

$T_2 = 319\,K$

$P_1 v_1 = R T_1$

$100 \times v_1 = 0.287 \times 300$

$v_1 = 0.861\,m^3/kg$

$$\dot{m} = \frac{c_1 A_1}{v_1} = \frac{200 \times 100 \times 10^{-6}}{0.861} = 0.0232\,kg/s$$

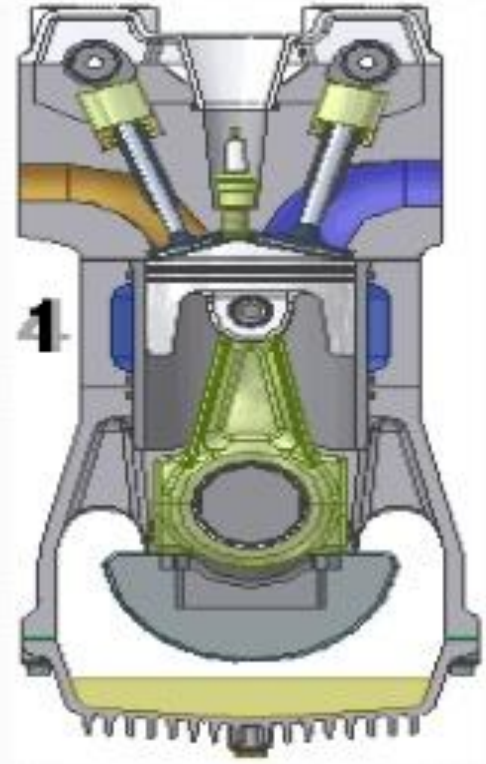
$$\dot{m} = \frac{c_2 A_2}{v_2} \Rightarrow v_2 = 0.741\,m^3/kg$$

$P_2 v_2 = R T_2$

$$P_2 = \frac{0.287 \times 319}{0.741} = 123.8\,kPa$$

RECIPROCATING

Engine has one or more cylinders in which pistons reciprocating back and forth. The combustion chamber is located in the closed end of each cylinder. Power is delivered to a rotating shaft output crankshaft by mechanical linkage with the pistons.



AIR INTAKE PROCESS

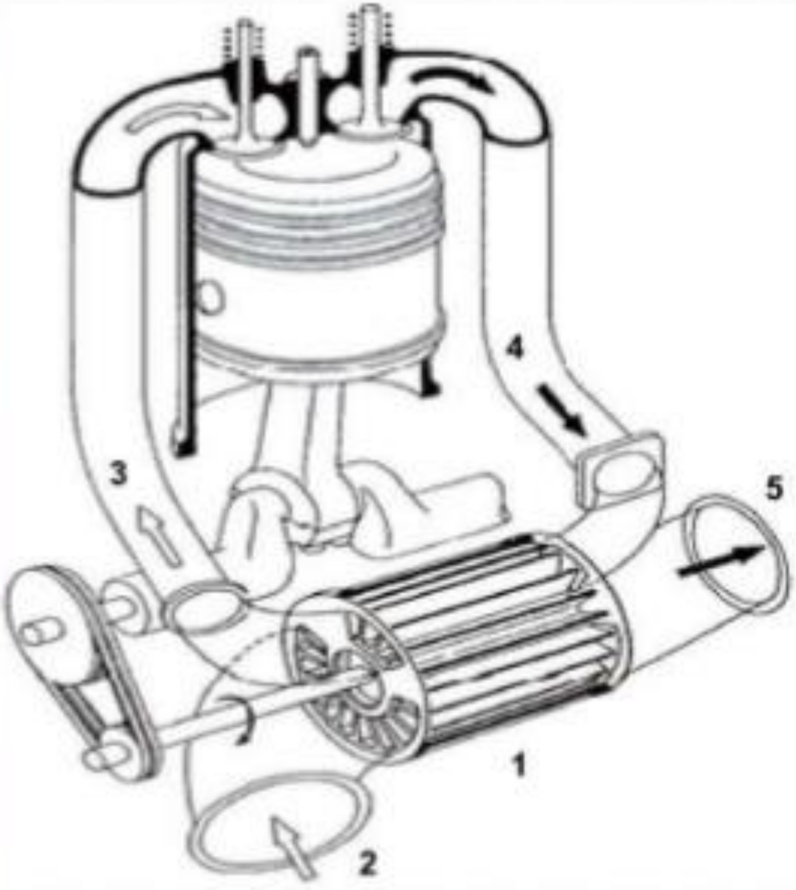
- Naturally Aspirated
- Supercharged
- Turbocharged
- Crankcase Compressed

NATURALLY ASPIRATED

No intake air pressure boost system

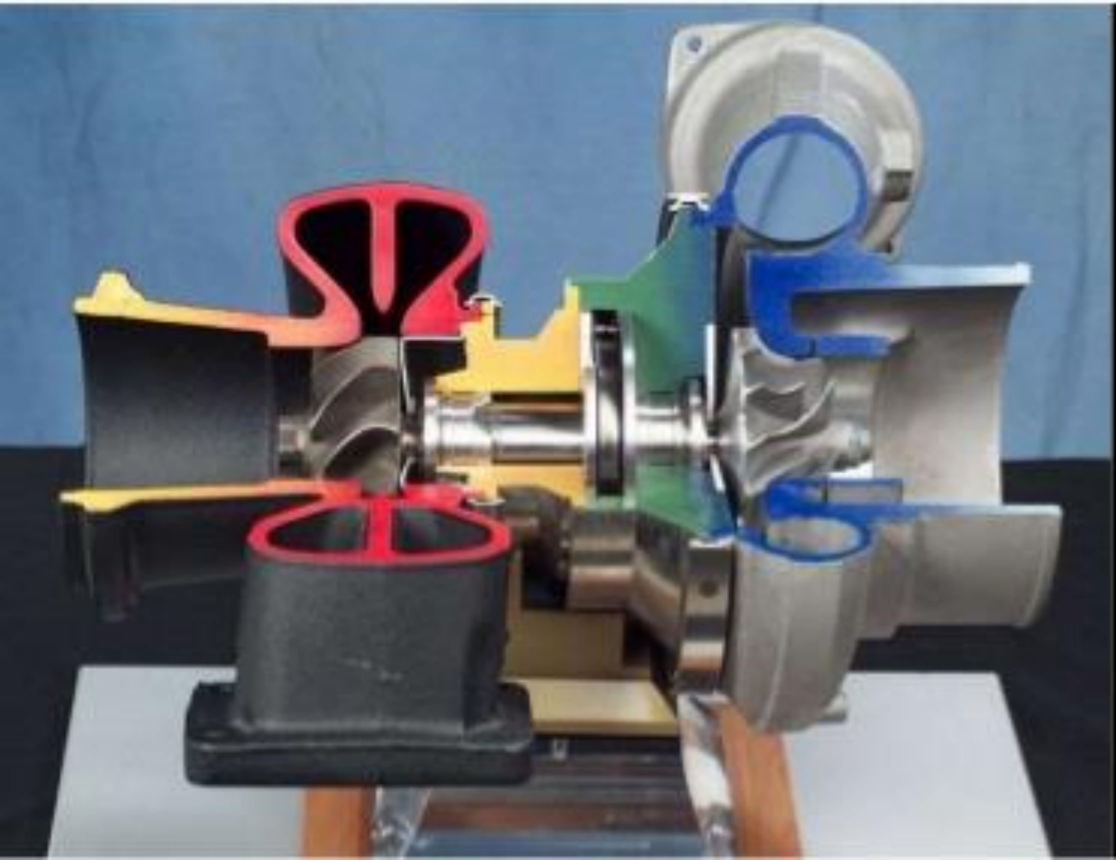
SUPERCHARGER

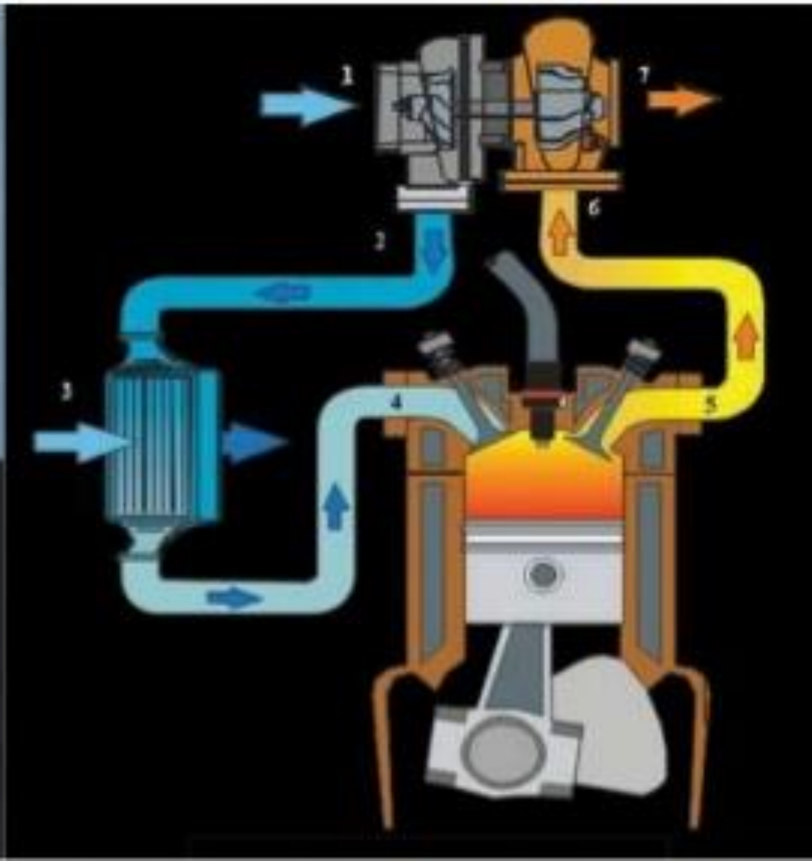
Intake air pressure increased with the compressor driven off of the engine crankshaft.



TURBOCHARGER

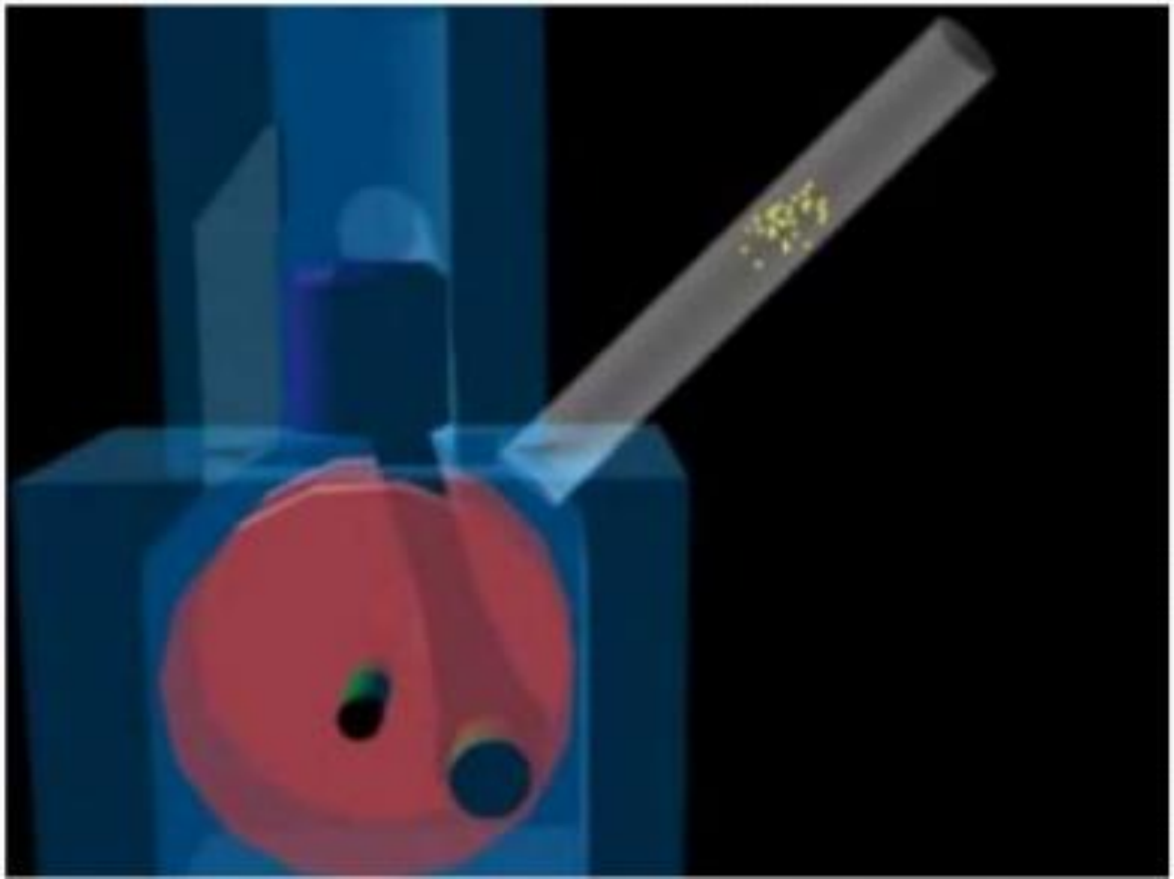
Intake air pressure increased with the turbine-compressor driven by the engine exhaust gas.





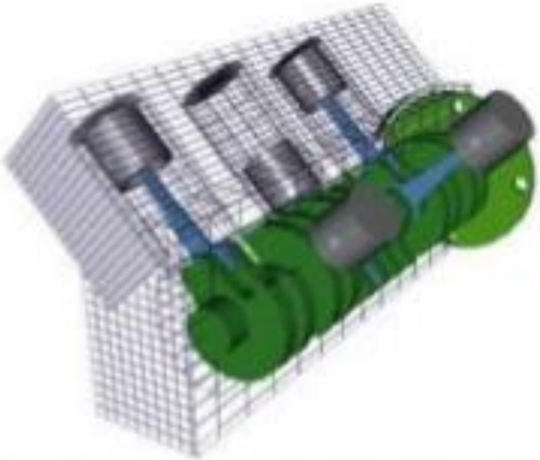
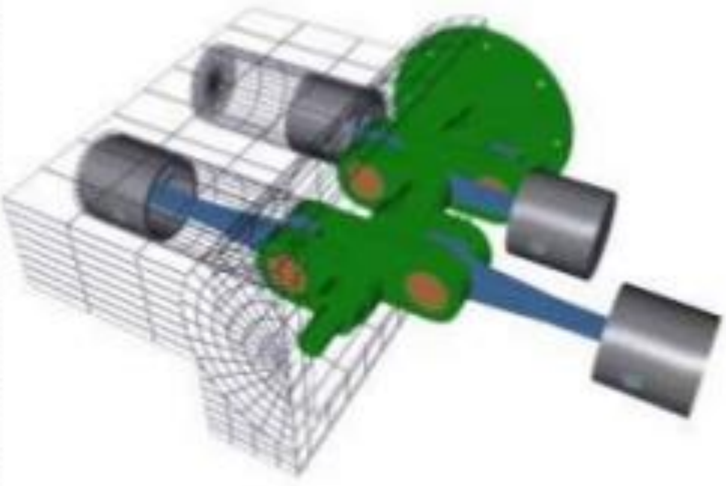
CRANKCASE COMPRESSED

Two-stroke cycle engine which uses the crankcase as the intake air compressor.



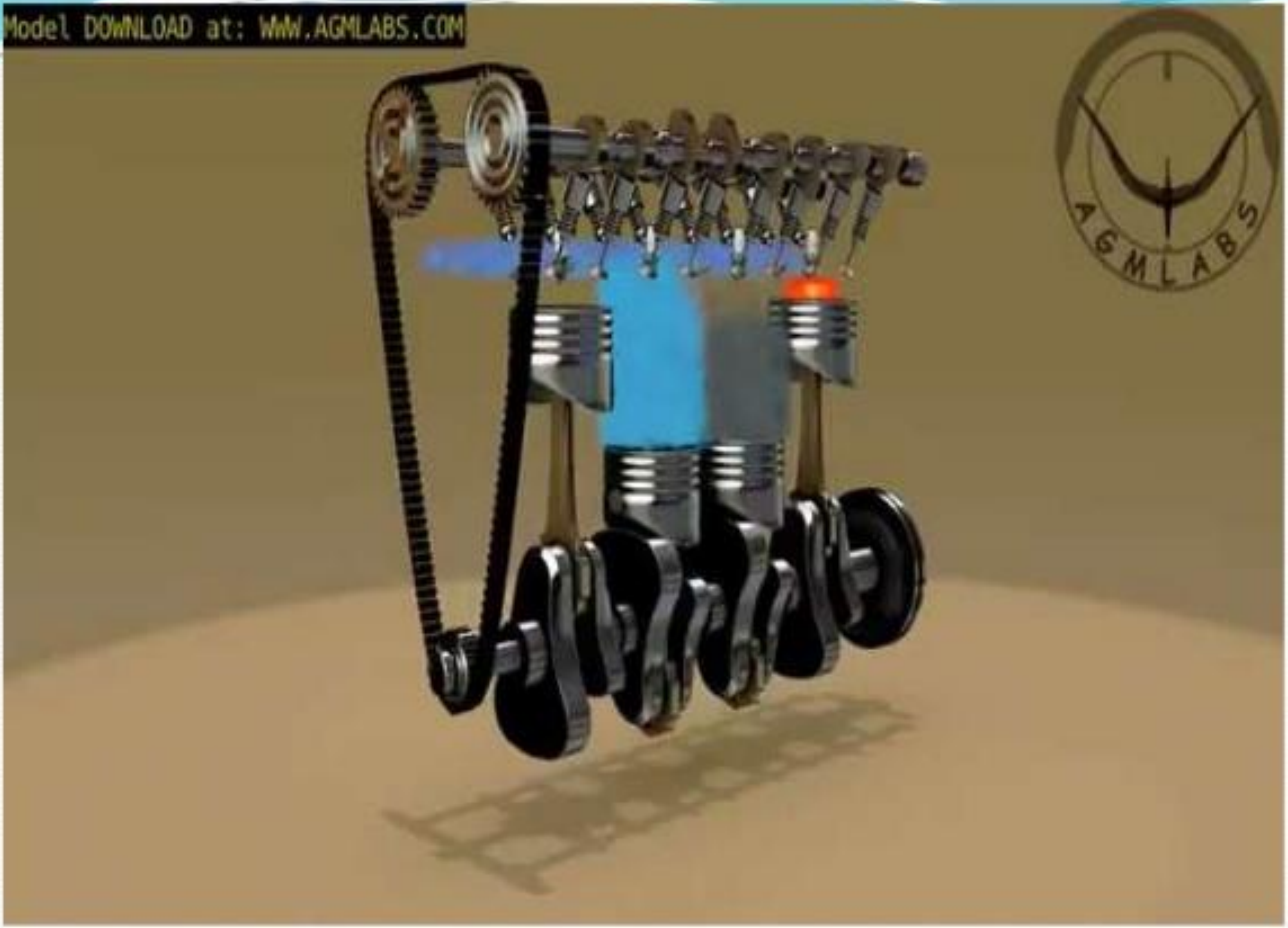
POSITION & NUMBER OF CYLINDERS OF RECIPROCATING ENGINES

- Single Cylinder
- In-Line
- V Engine
- Opposed Cylinder Engine
- Opposed Piston Engine

COMPARISON

Two-Stroke Cycle Engines	Four-Stroke Cycle Engines
Lighter weight	Heavier weight
Operates in many positions	Operates in limited positions
Higher power to weight ratio	Lower power to weight ratio
Engine oil usually mixed with fuel	Engine oil in a reservoir
Louder operation	Quieter operation
Higher engine speeds	Slower engine speeds
More vibration	Smoother operation
Rough idling operation	Smoother Idling operation


Model DOWNLOAD at: WWW.AGMLABS.COM
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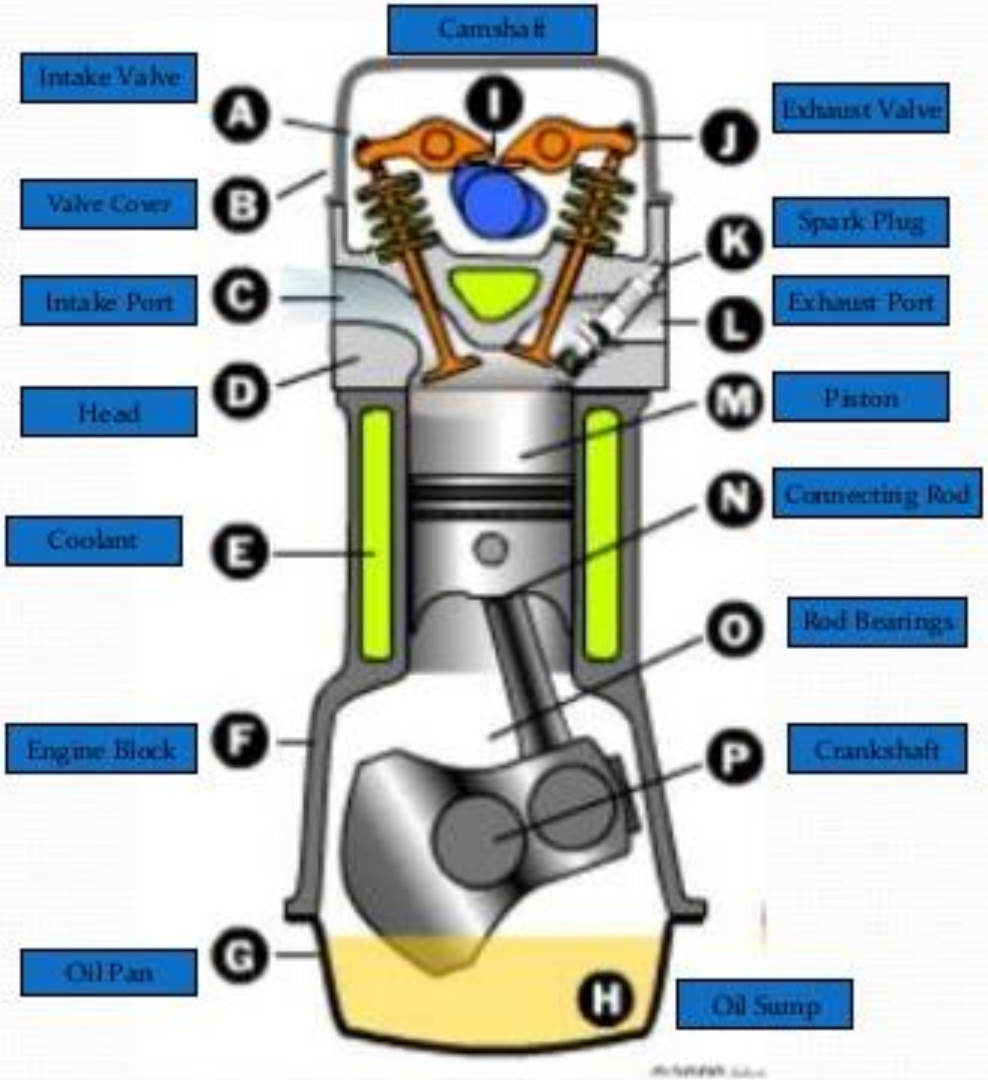
BASIC PARTS OF THE ENGINE

- Cylinder block
- Piston
- Piston rings
- Piston pin
- Connecting rod
- Crankshaft
- Cylinder head
- Intake valve
- Exhaust valve
- Camshaft
- Spark plug

BASIC COMPONENTS



Principal Engine parts?

Components of engine framework

1. Cylinder/cylinder block
2. Cylinder head
3. Piston
4. Piston rings
5. Piston pin
6. Connecting rod
7. Crankshaft
8. Flywheel
9. Valve system
10. Fuel supply and carburetion system
11. Ignition System
12. Cooling system
13. Lubrication System
14. Governing System

Roger C. Montepio

Internal Combustion Engine

- Function - Converts potential chemical energy in fuel into heat energy then to mechanical energy to perform useful work.

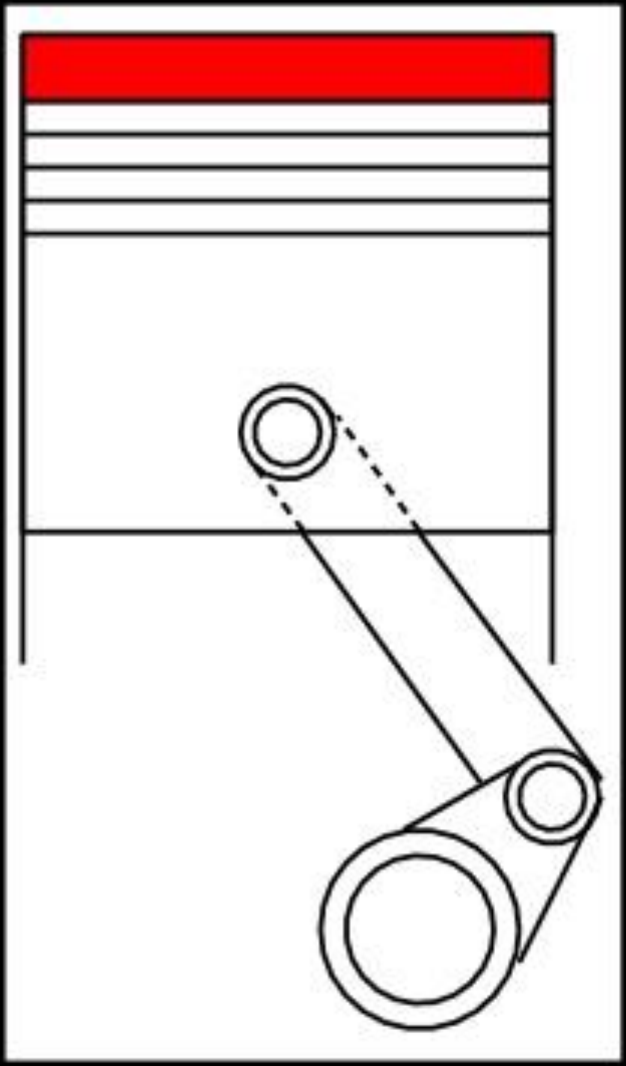
.Chemical

Heat

Mechanical

Fig. 1 IC Engine [1]

Requirements for I.C. Engine Operation



- All Internal combustion engines must carry out five events:
  - Air-fuel mixture must be brought into the combustion chamber.
  - Mixture must be compressed.
  - Mixture must be ignited.
  - Burning mixture must expand into increasing combustion chamber volume.
  - Exhaust gasses must be removed.

Fig..2 IC Engine [1]

Engine Components and Functions

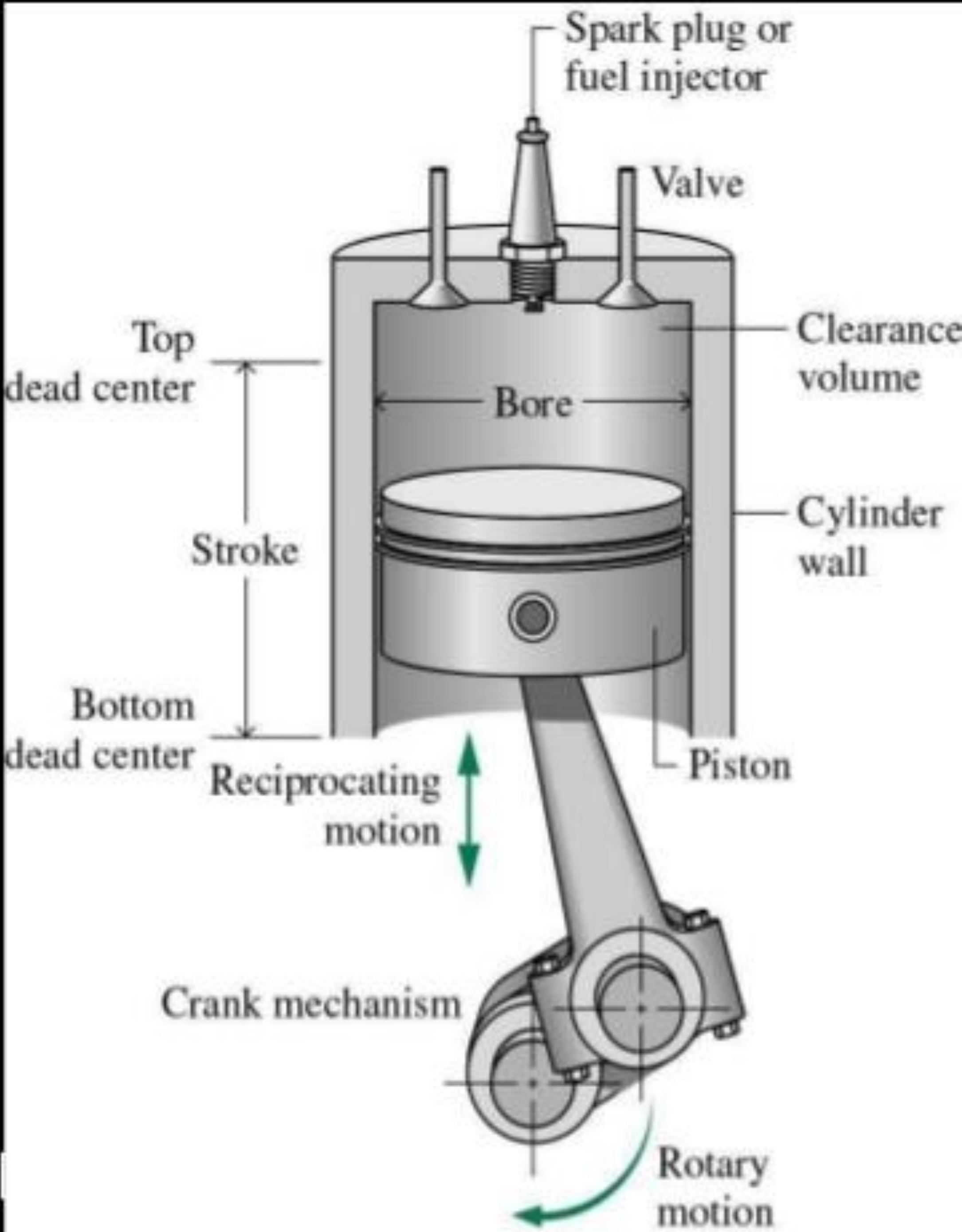


Fig. 3 IC ENGINE

Stroke

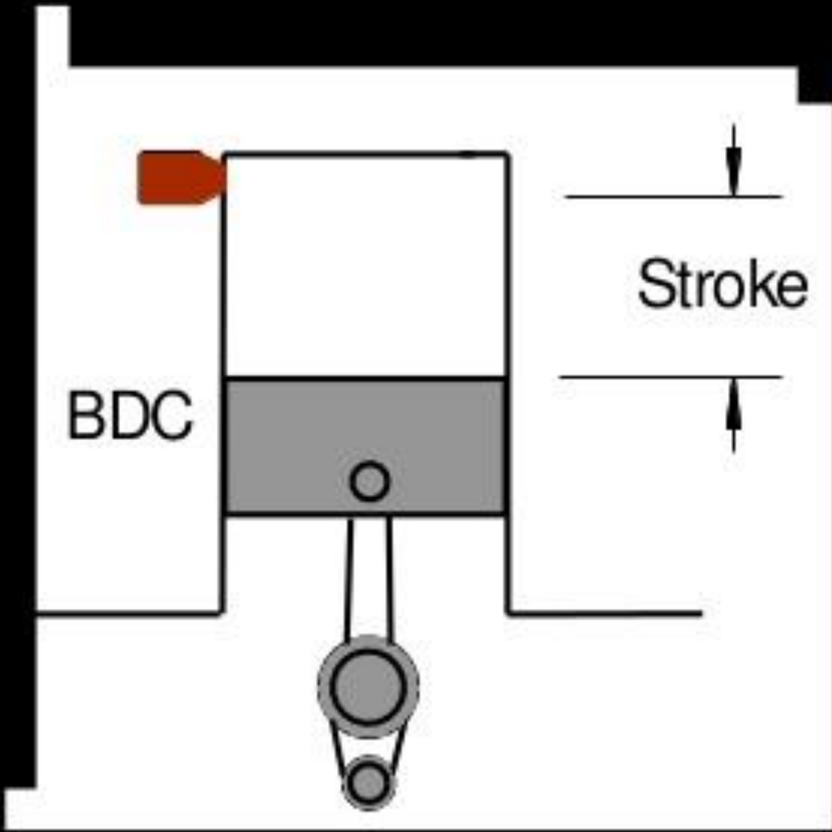
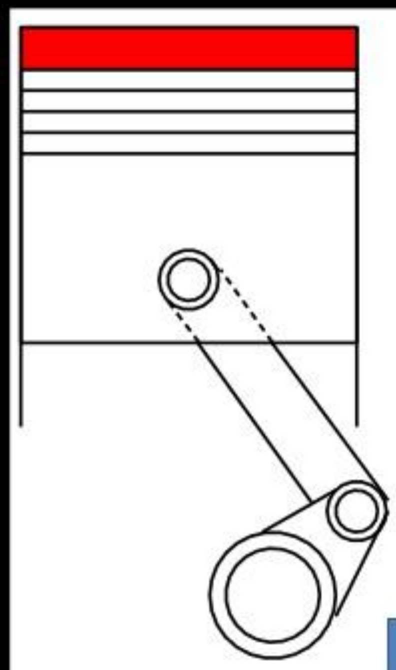


Fig. 8 IC Engine [1]

- Linear distance piston travels from Top Dead Center (TDC) to Bottom Dead Center (BDC).

4-Stroke Cycle Engine Operation



- 4-stroke cycle engines require four strokes of the piston to complete the five events necessary for engine operation.
  - 1 piston stroke = ½ crankshaft revolution.
  - 4 piston strokes = 2 crankshaft revolutions.

Fig. 9 IC Engine [1]

4-Stroke Cycle Engine Operation

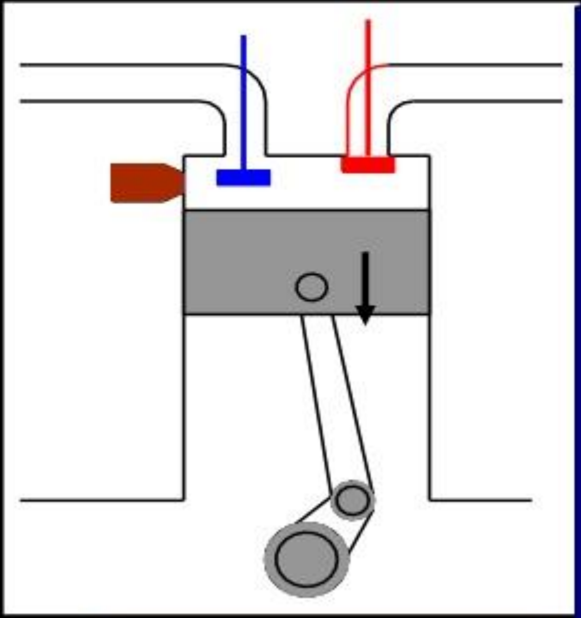


Fig.10 IC Engine [1]

- Intake Stroke
  - Intake valve open.
  - Piston moves down (TDC to BDC) in cylinder.
  - Low pressure is created in cylinder.
  - Air is brought into the combustion chamber due to pressure differences.

4-Stroke Cycle Engine Operation

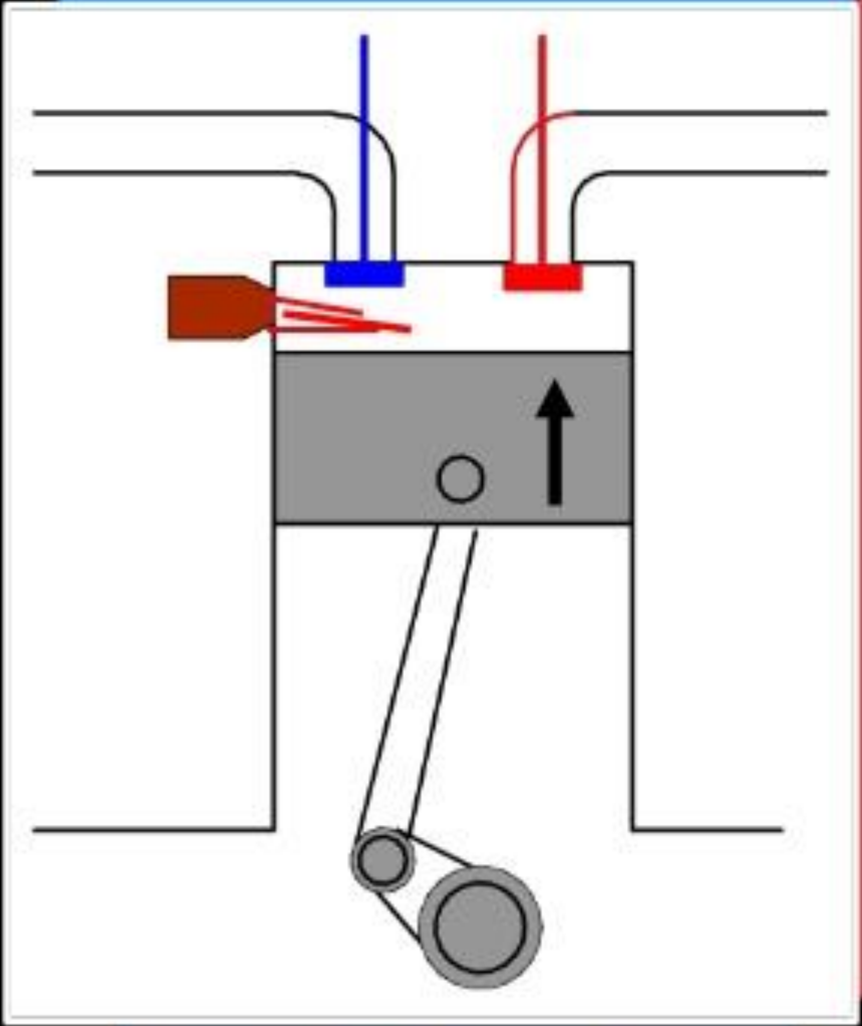


Fig. 11 IC Engine [1]

- Compression Stroke
  - **Both valves closed.**
  - **Piston moves from BDC to TDC**
  - **Air in combustion chamber is compressed, raising its temperature.**
  - **Near TDC of Compression stroke, diesel fuel is injected into the combustion chamber.**

4-Stroke Cycle Engine Operation

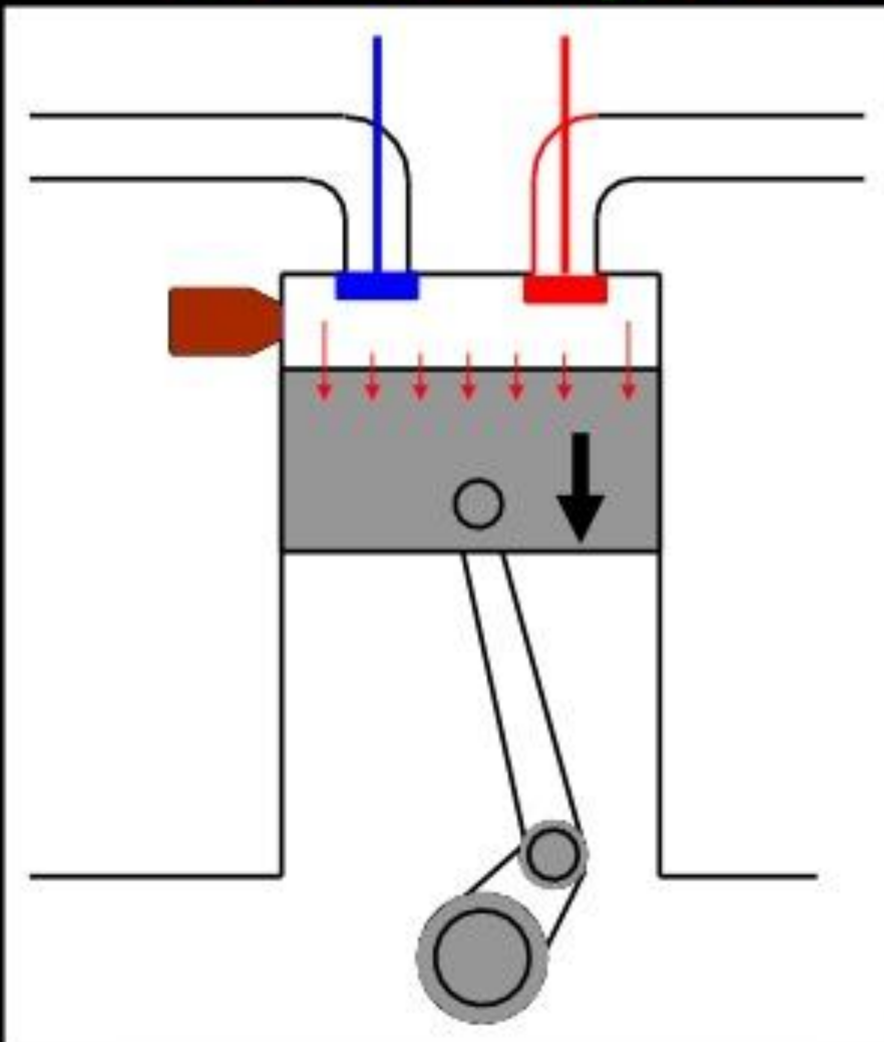


Fig. 12 IC Engine [1]

- Power Stroke
  - Both valves are closed
  - Air-fuel mixture burns rapidly
  - Expansion of the burning air-fuel mix applies force to the head of the piston
  - Piston is driven down in the cylinder.

4-Stroke Cycle Engine Operation

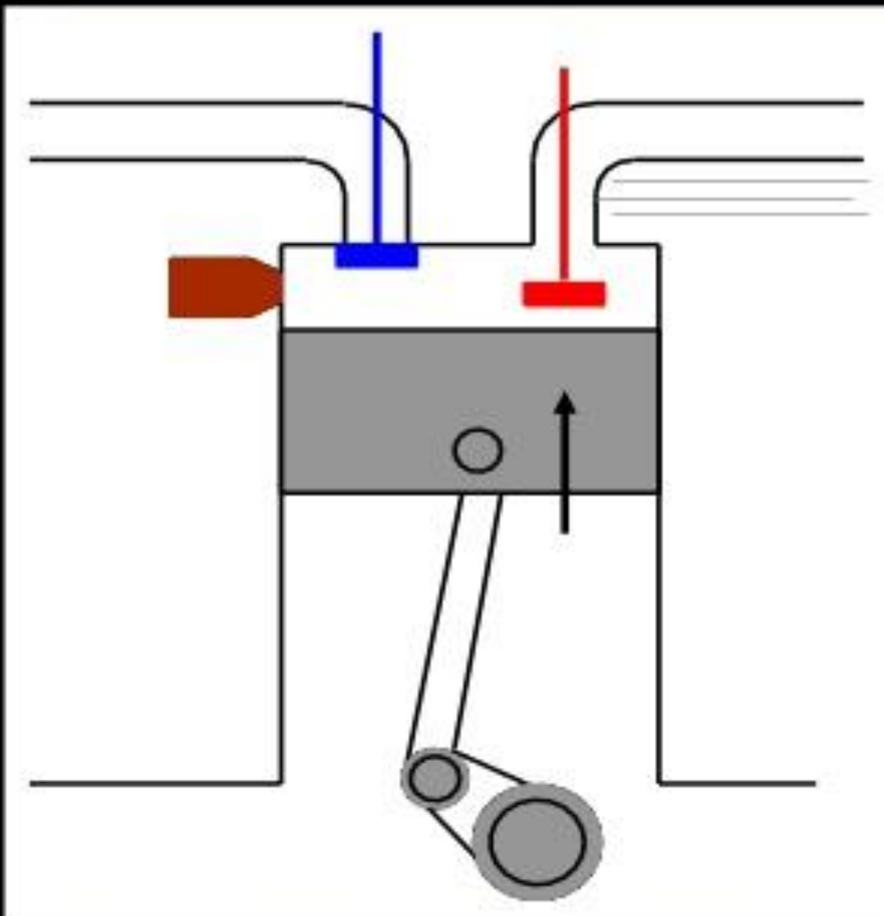


Fig. 13 IC Engine [1]

- Exhaust Stroke
  - Piston moves from BDC to TDC.
  - Exhaust valve is open.
  - Burnt air-fuel mixture is scavenged from combustion chamber.

Two-Stroke Cycle Engines

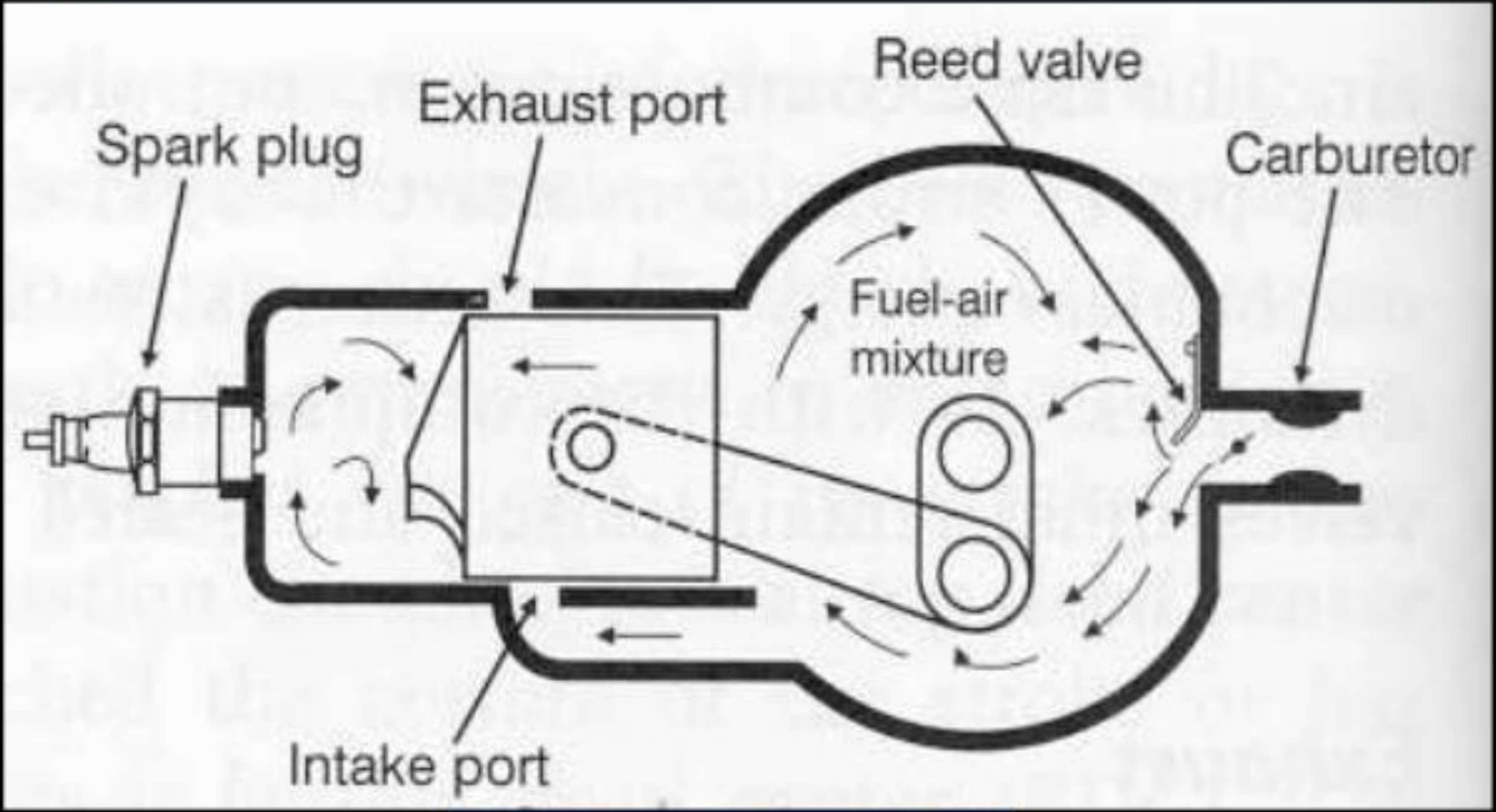


Fig. 14 IC Engine [3]

- STROKE 1 - Fuel - air mixture is enter in to the cylinder and is then compressed , combustion initiated at the end of stroke.

n

- STROKE 2 - combination products expend doing work and then exhaust
- .power are delivered to crankshaft on every revolution.