

# Course Topics

1. Introduction, what is the heat engine?
2. Classification of engines.
3. How internal combustion engines operate, operating cycles.
4. Main parts of the internal combustion engine.
5. Traditional Engine Systems :
  - Lubrication system**
  - Cooling system**
  - Fuel system**
  - Ignition system**
  - Fuel injection system**
  - Exhaust system**
  - System of towing and engine screening**

# *Heat engine:*

A heat engine is a device which transforms the chemical energy of a fuel into thermal energy and uses this energy to produce mechanical work.

**It is classified into two types-**

- (a) External combustion engine
- (b) Internal combustion engine

# *Definition of Heat Engine:*

**A heat engine is a device which transforms the chemical energy of a fuel into thermal energy and uses this energy to produce mechanical work.**

يعرف المحرك على أنه الآلة التي تقوم بتحويل أي شكل من أشكال الطاقة إلى طاقة ميكانيكية، والمحرك الحراري أو محرك الاحتراق يقوم بتحويل الطاقة الحرارية إلى طاقة ميكانيكية. وبغض النظر عن أنواع وتصنيفات تلك النوعية من المحركات، فإنها جميعاً تعمل على مبدأ أساسي واحد:

يشتعل الوقود المختلط بالهواء فتتولد حرارة يتم تحويلها إلى شكل آخر من أشكال الطاقة (طاقة ميكانيكية).

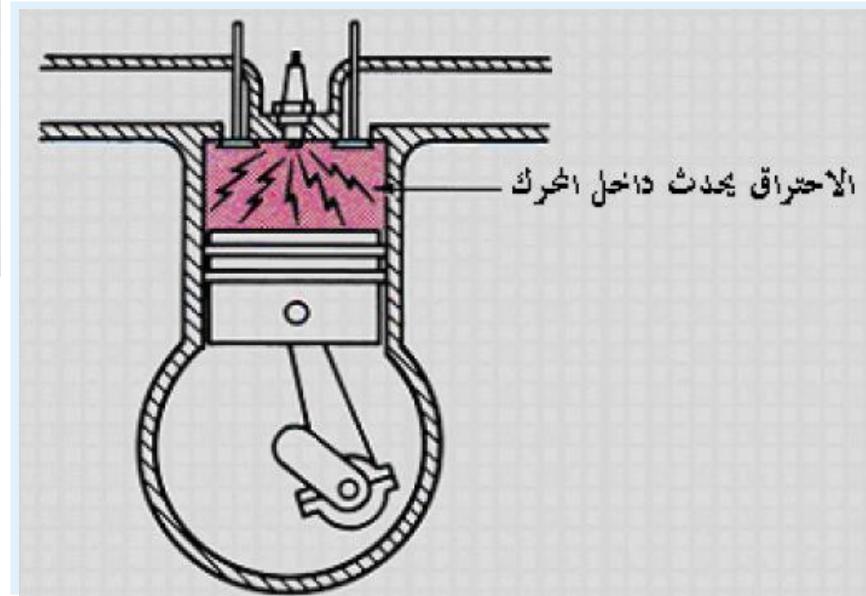
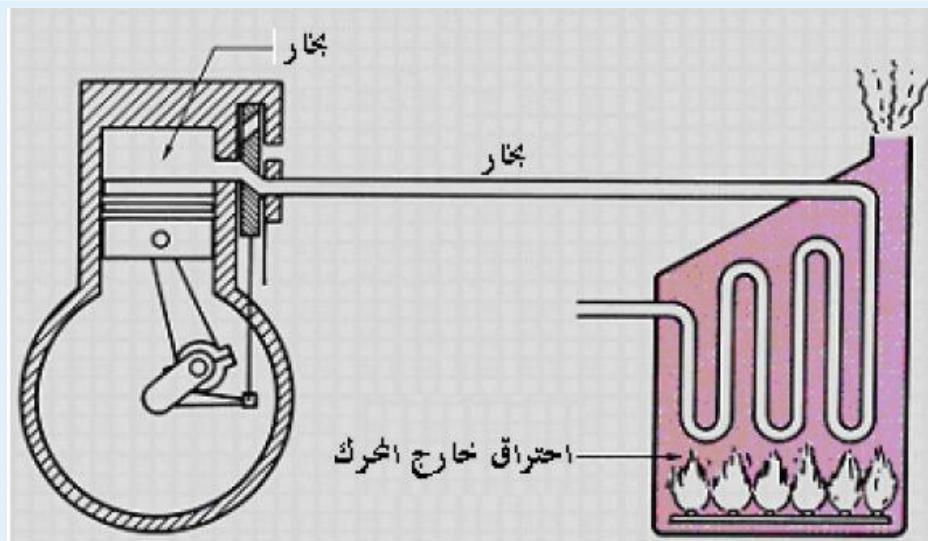
**It is classified into two types-**

**(a) External combustion engine**

محرك الاحتراق الخارجي

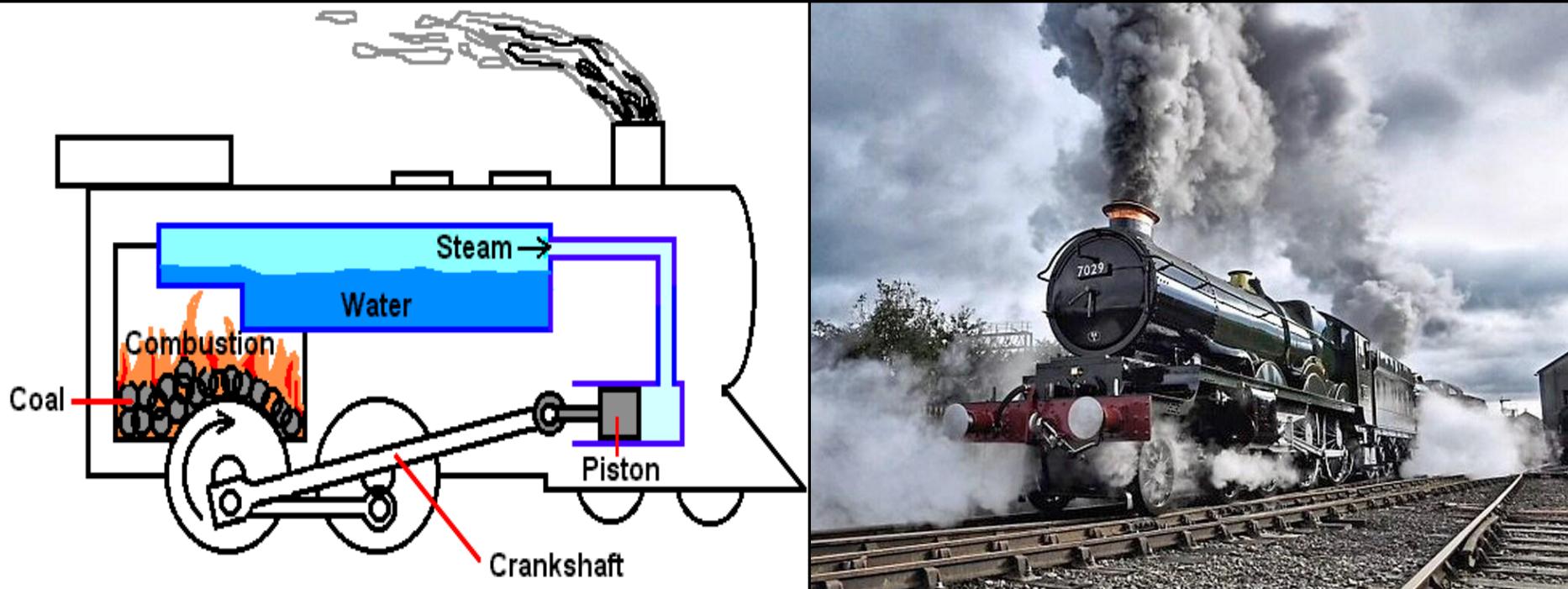
**(b) Internal combustion engine**

محرك الاحتراق الداخلي



## (a) External combustion engine, Steam Engine

**External combustion engine:** Here, the working medium, the steam, is generated in a boiler, located out side the engine and allowed in to the cylinder to operate the piston to do mechanical work.



## (b) Internal combustion engine, Vehicle Engine

**Internal combustion engine (I.C. Engine):** In internal combustion engine, the combustion of fuel takes place inside the engine cylinder and heat is generated within the cylinder. This heat is added to the air inside the cylinder and thus the pressure of the air is increased tremendously. This high pressure air moves the piston which rotates the crank shaft and thus mechanical work is done.



# Internal Combustion Engines

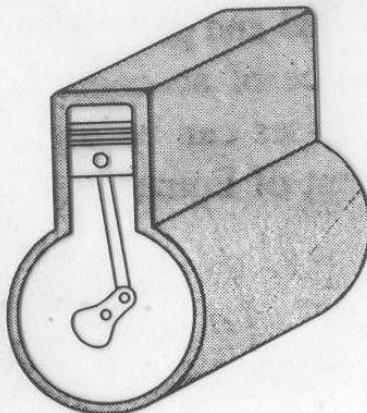
## Classification



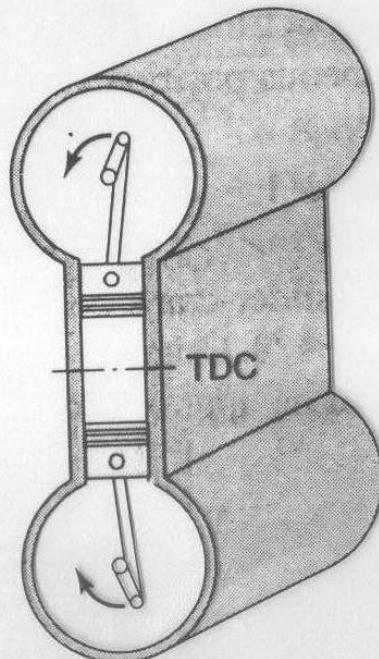
## **Engine Classifications can be drawn as the following:-**

- **Cylinder arrangement**
- **Operational cycles**
- **Type of fuel used**
- **Number of cylinders**
- **Cooling system type**
- **Camshaft location**
- **Type of ignition**
- **Type of aspiration**
- **Application**

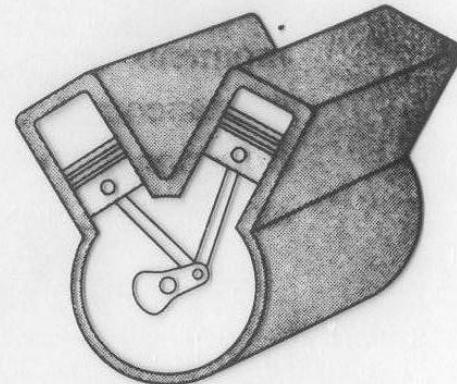
- Cylinder arrangement



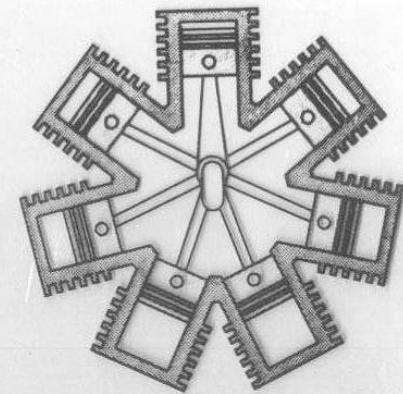
(a) In line



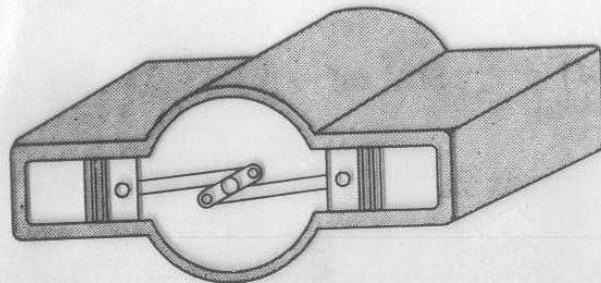
(c) Opposed piston  
(crankshafts geared together)



(d) V



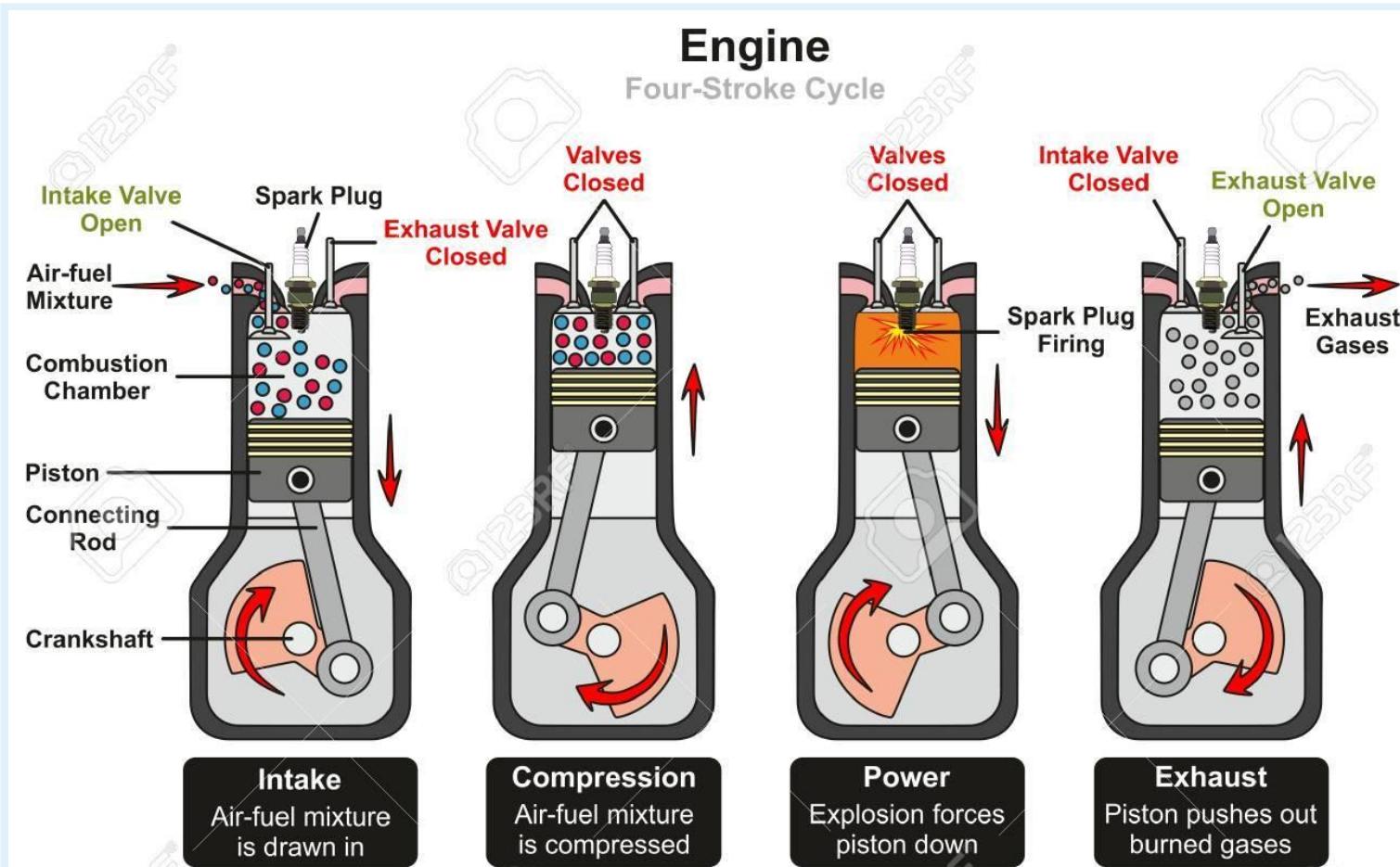
(e) Radial



(b) Horizontally opposed

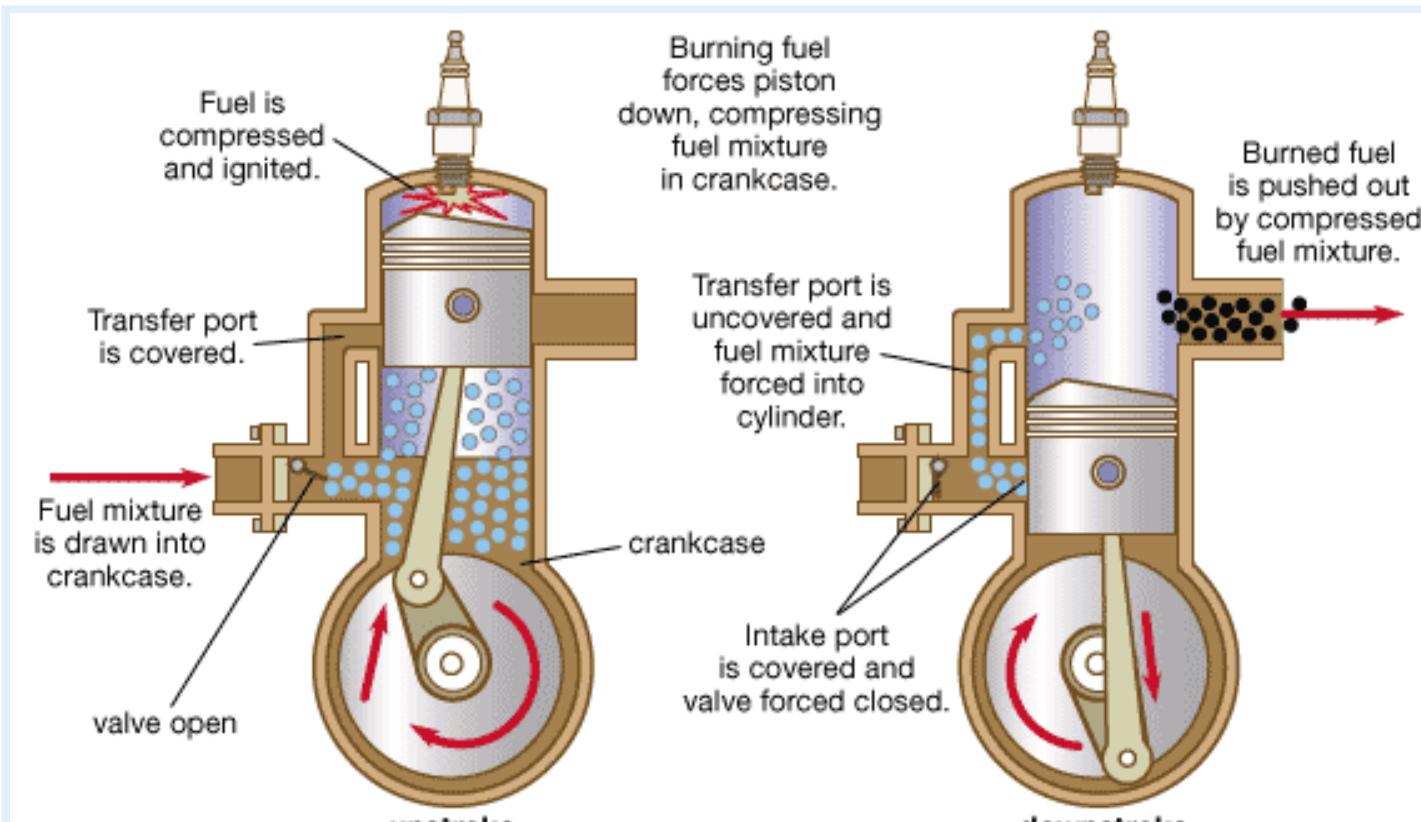
- Operational cycles

- Four-Stroke Cycle
- Two-Stroke Cycle



•Four-Stroke Cycle

## • Operational cycles

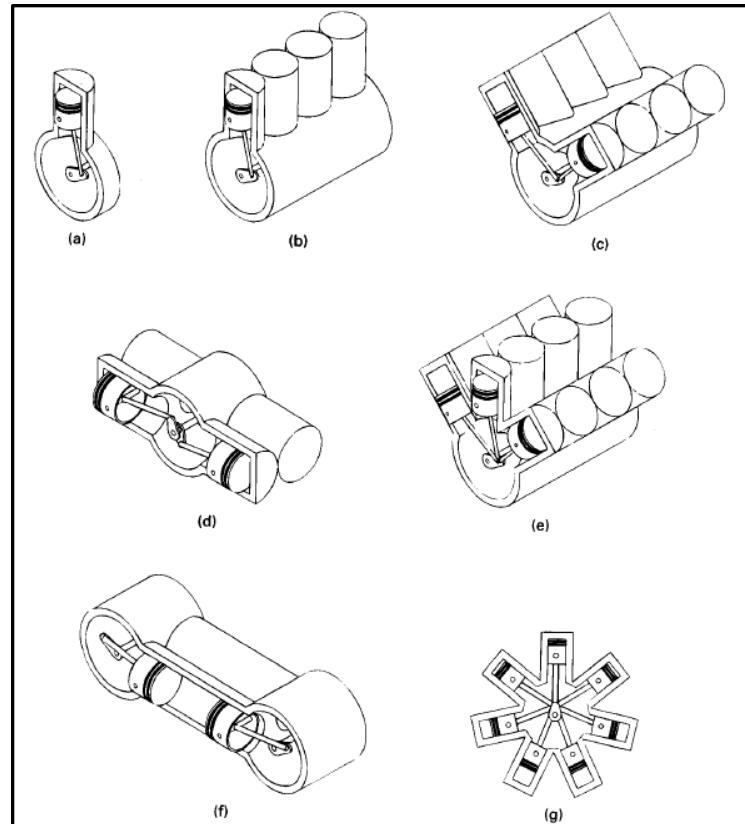


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## •Two-Stroke Cycle

# Number of Cylinders

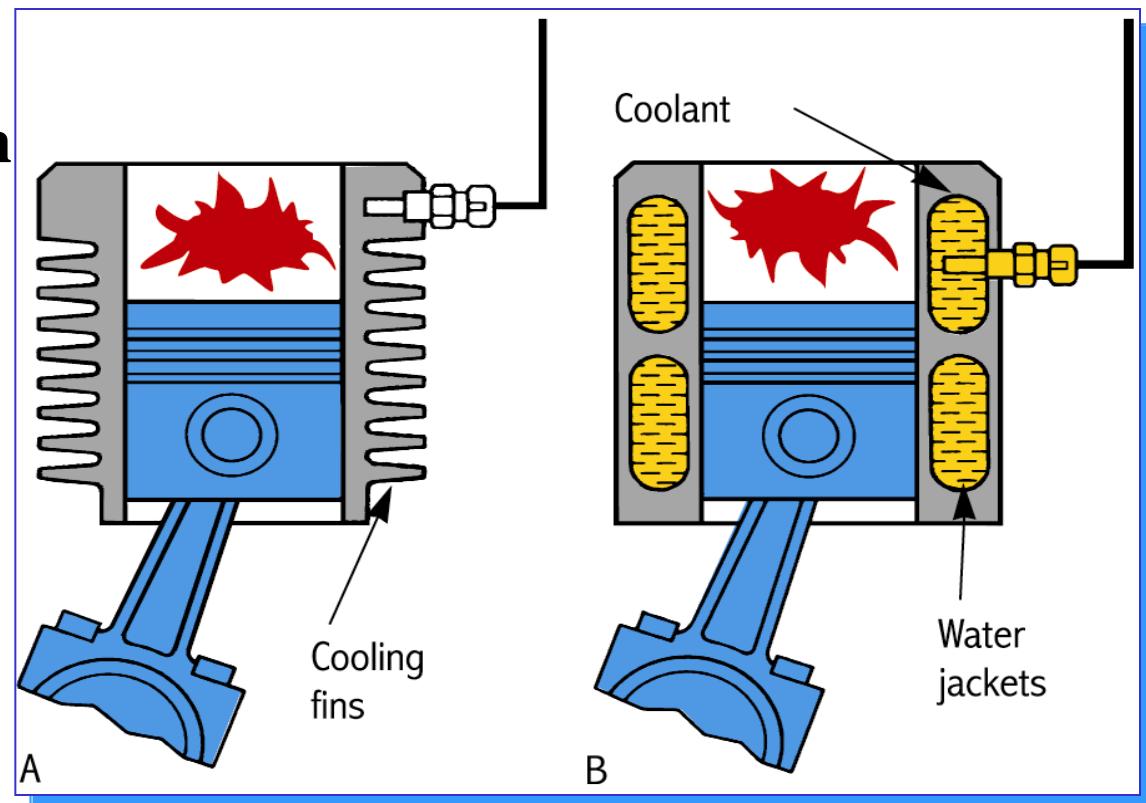
- Most vehicle and truck engines have either 4, 6, or 8 cylinders
  
- Some may have 3, 5, 10, 12, or 16 cylinders
  
- Engine power and smoothness are enhanced by using more cylinders



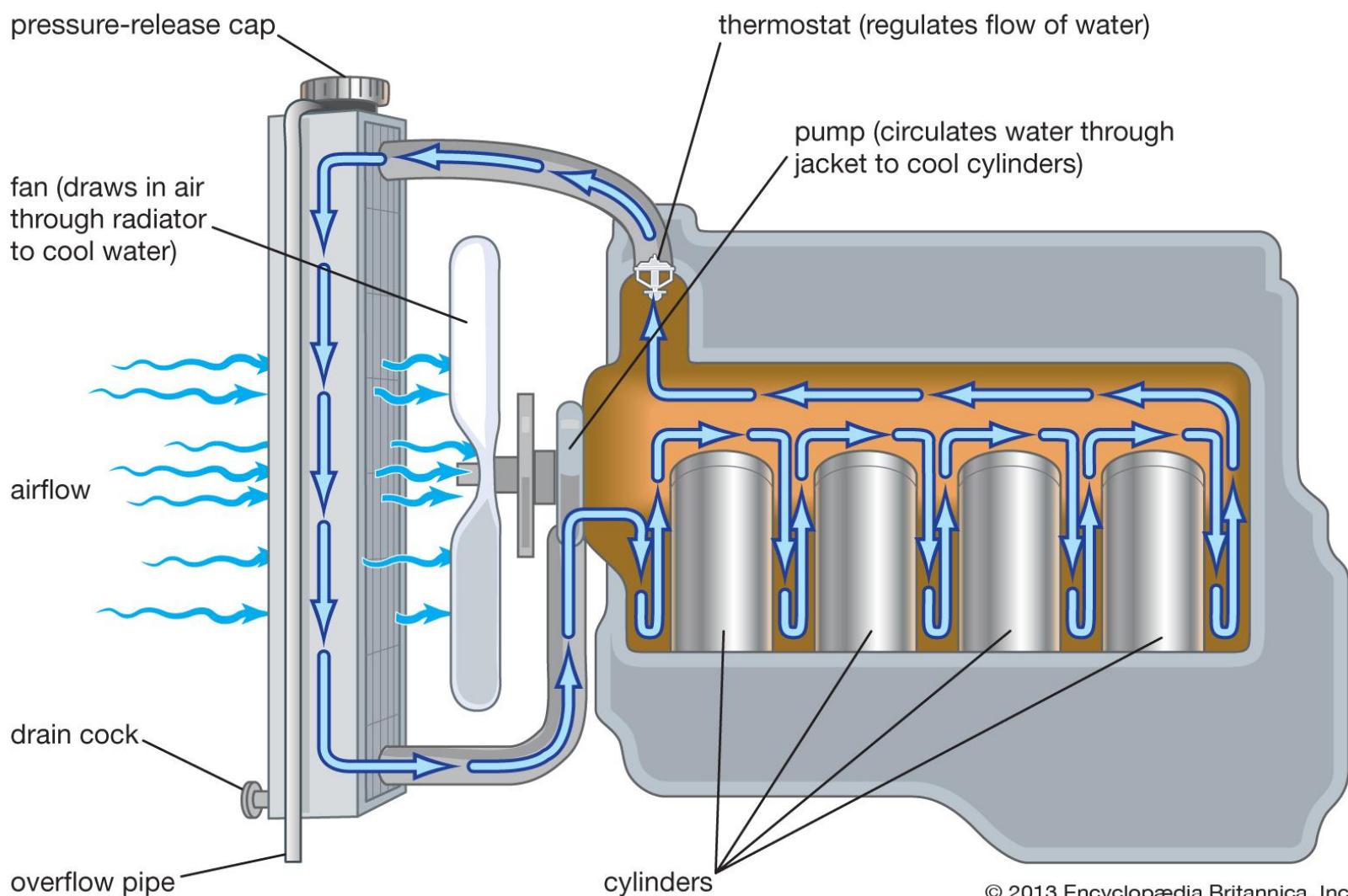
## Cooling System Type

There are two types of cooling systems:

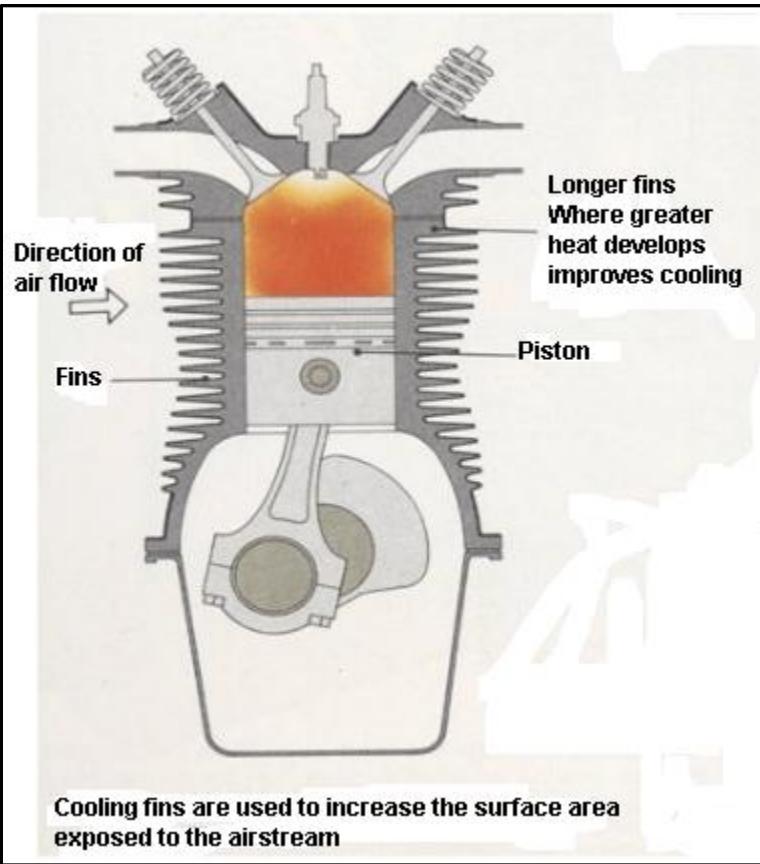
- Liquid cooling system
- Air cooling system



# Water cooling system of a 4-cylinder



# Air cooling system



- Type of fuel used

**1. Conventional:**

- (i) Gasoline
- (ii) Diesel

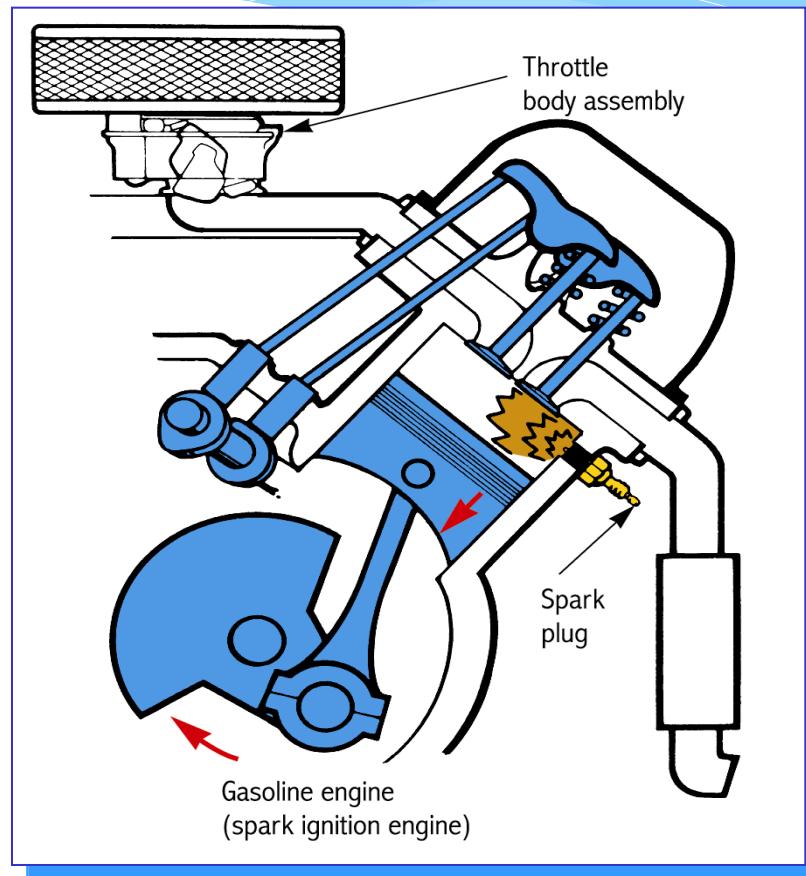
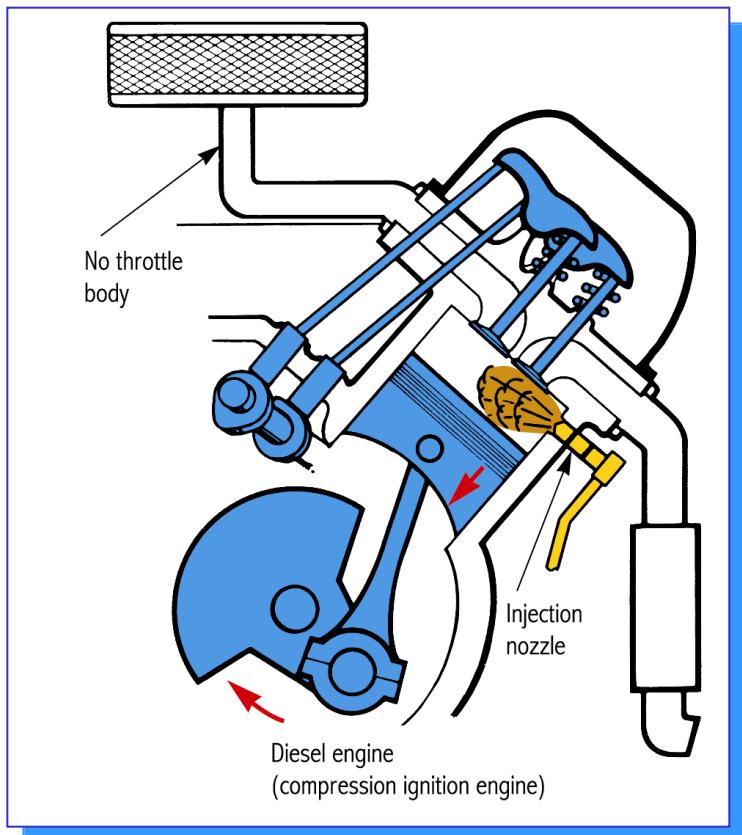
**2. Alternate:**

- (i) CNG
- (ii) LPG
- (iii) Ethanol and Methanol
- (iv) Bio-Fuel
- (v) Propane
- (vi) Hydrogen

**3. Blending fuel engines**

**4. Dual fueling engines**

## • Ignition Type



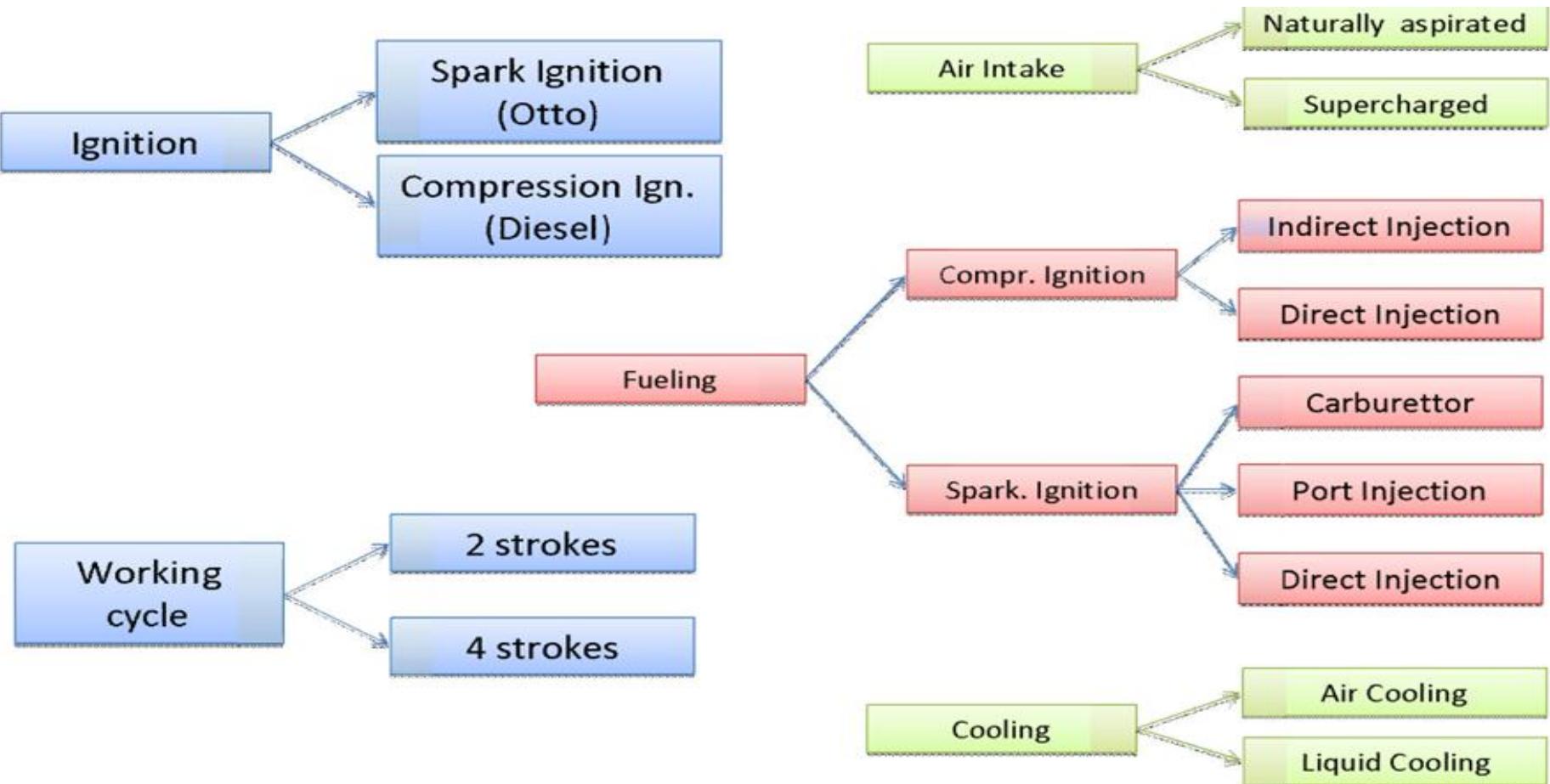
**Compression Ignition Engine  
(Diesel Engines)**

**Spark Ignition Engine  
(Petrol Engines)**

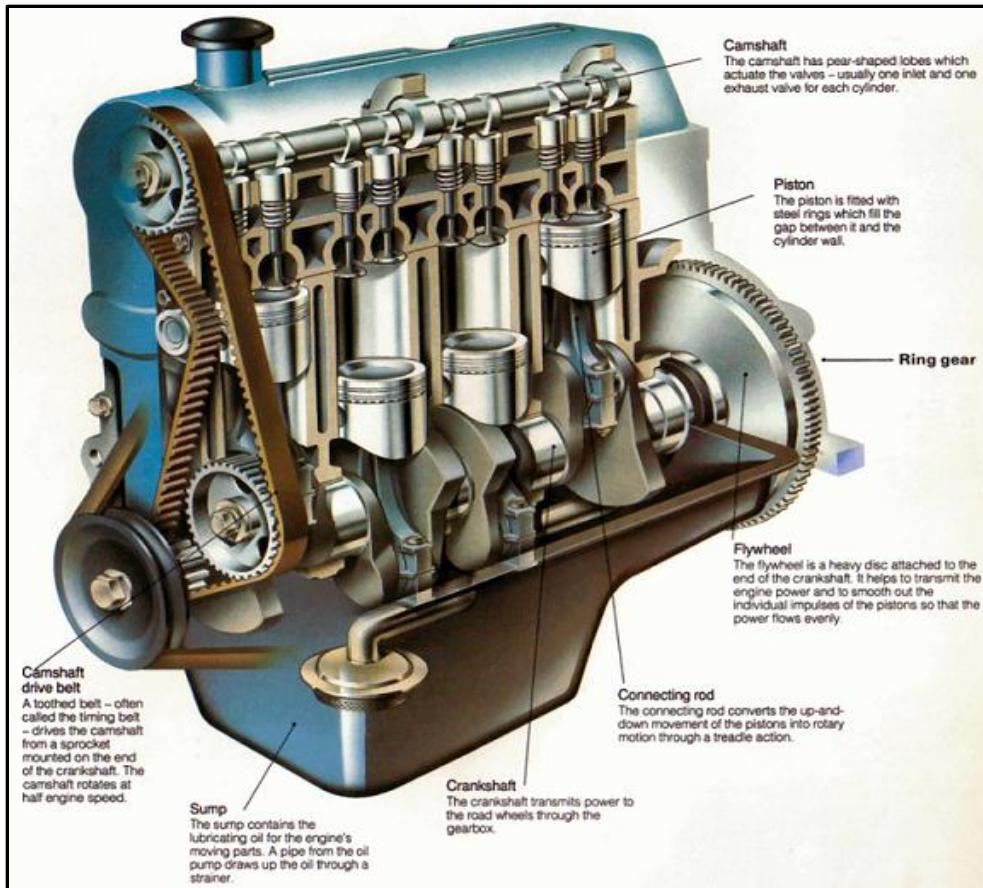
- **Application**

- **Automotive.**
- **Light Aircraft.**
- **Marine.**
- **Power Generation.**
- **Agricultural.**
- **Earthmoving.**
- **Home Use.**

# Internal combustion engine classification



# Engine Construction



# Internal Combustion Engine Components

## ١- مقدمة :

يتكون محرك السيارة من مجموعة أجزاء تتصل بعضها ببعض بطريقة منتظمة بهدف أداء وظيفته المتمثلة في تحويل الطاقة الحرارية الناتجة من احتراق الوقود إلى طاقة ميكانيكية يستفاد منها في تحرير السيارة. ويتكون المحرك من الأجزاء الرئيسية التالية:

### ١- الجزء الأسفل من المحرك:

العناصر الأساسية لهذا الجزء تشمل على جسم المحرك (كتلة الأسطوانات)، والماكبس وأذرع التوصيل وعمود المرفق، والحدافة، وحوض الزيت والزيت ومضخة الزيت.

### ٢- الجزء العلوي للمحرك:

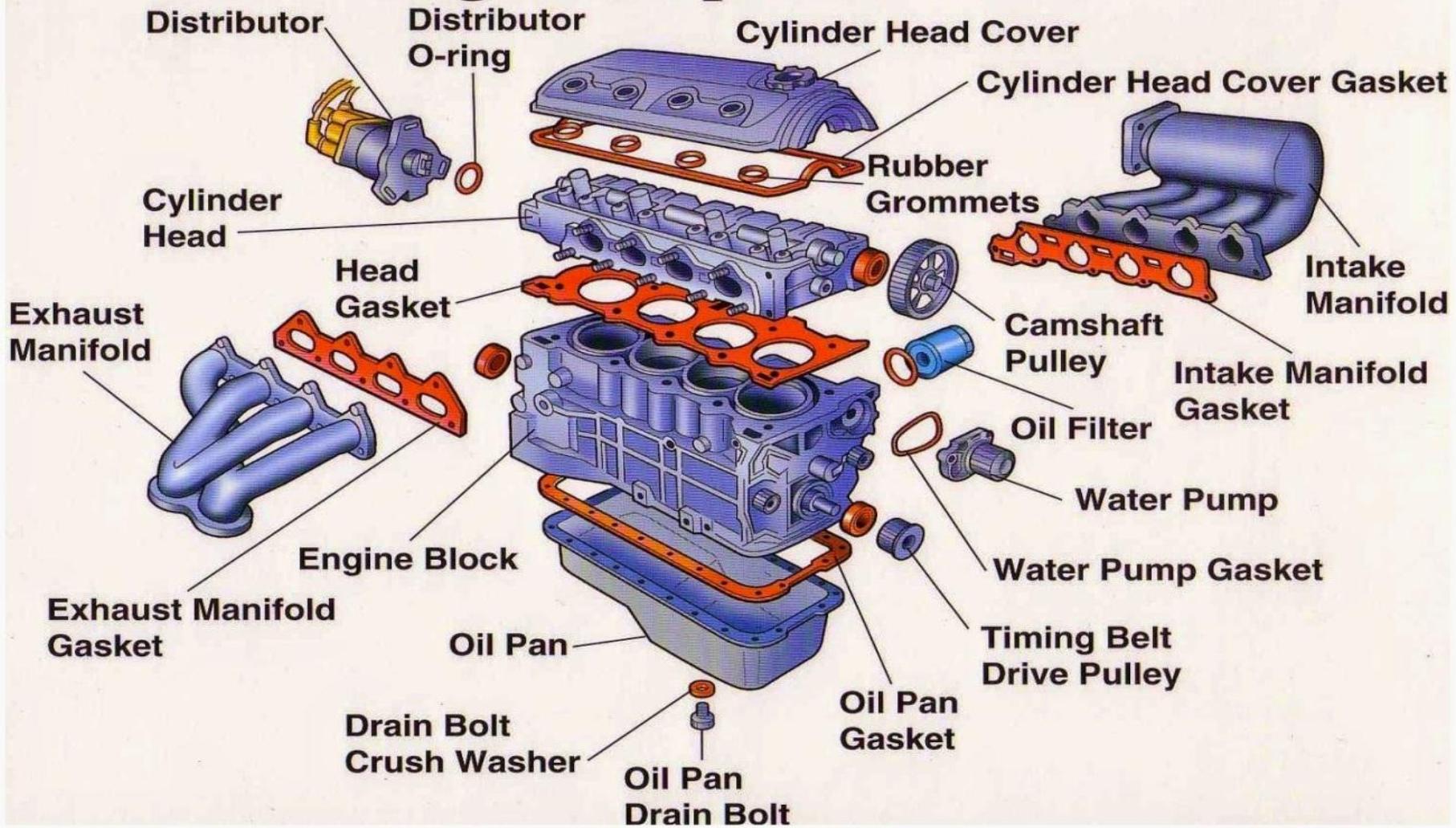
تشتمل العناصر الأساسية للجزء العلوي بالمحرك على رأس الأسطوانات، ومجموعة الصمامات، وغطاء الصمامات، ومجموعات السحب والعادم.

### ٣- مقدمة المحرك:

هي مجموعة الأجزاء التي تشكل مقدمة المحرك، وتتكون من تروس وجنزير التوقيت وهي في السيارات الحديثة سيور التوقيت وغطاء مقدمة المحرك وبعض الأجزاء الأخرى.

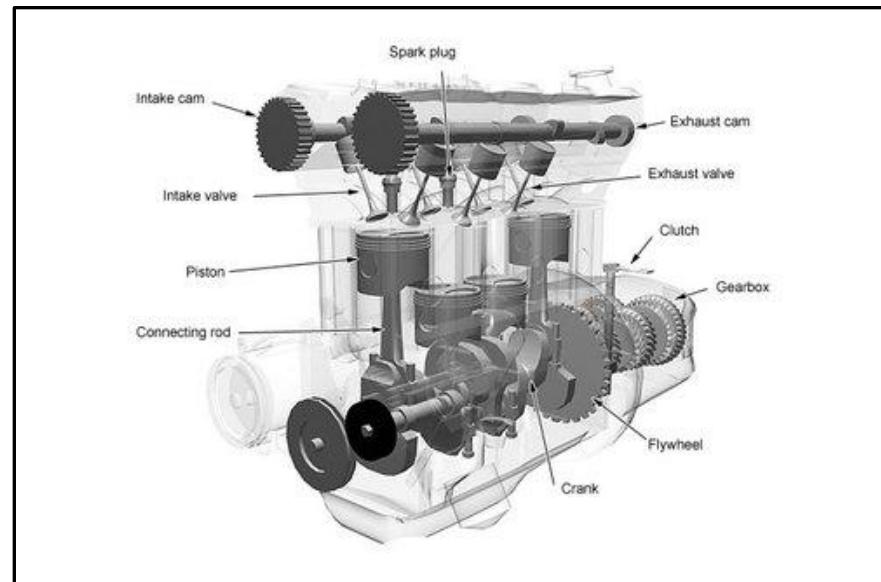
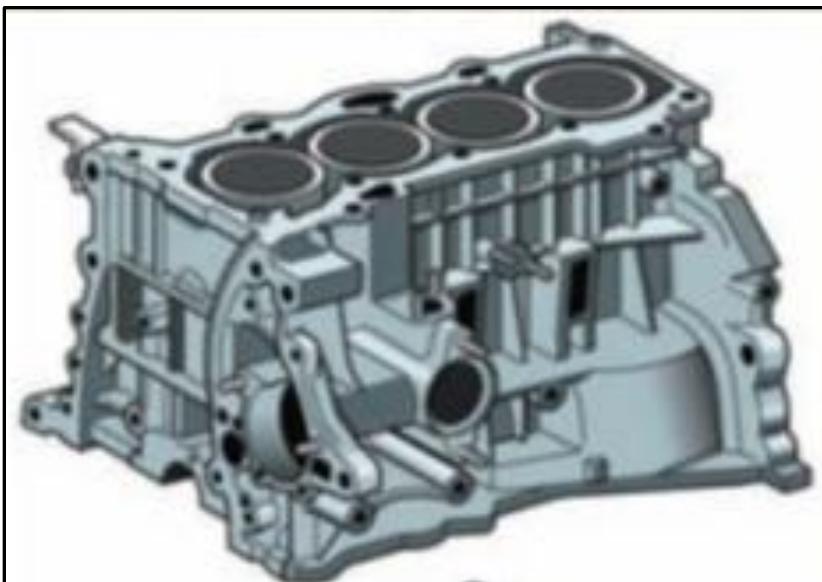
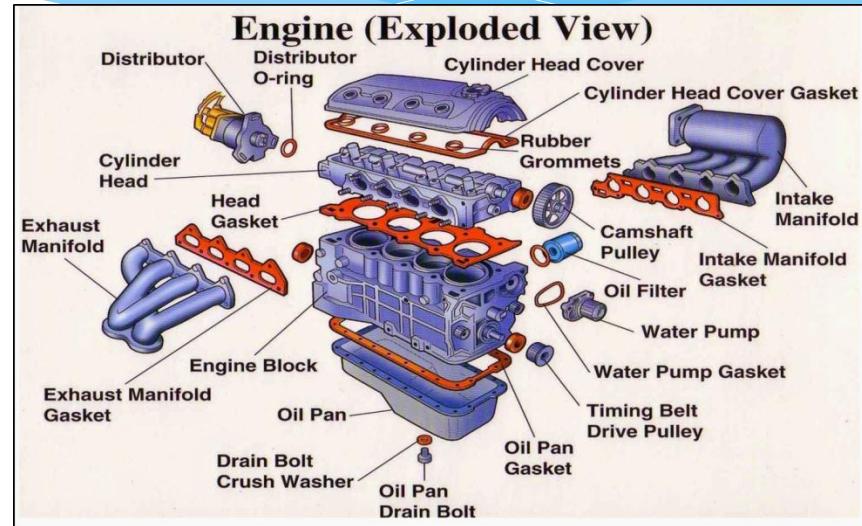
# Construction Overview of an ICE

## Engine (Exploded View)



# Internal Combustion Engine Components

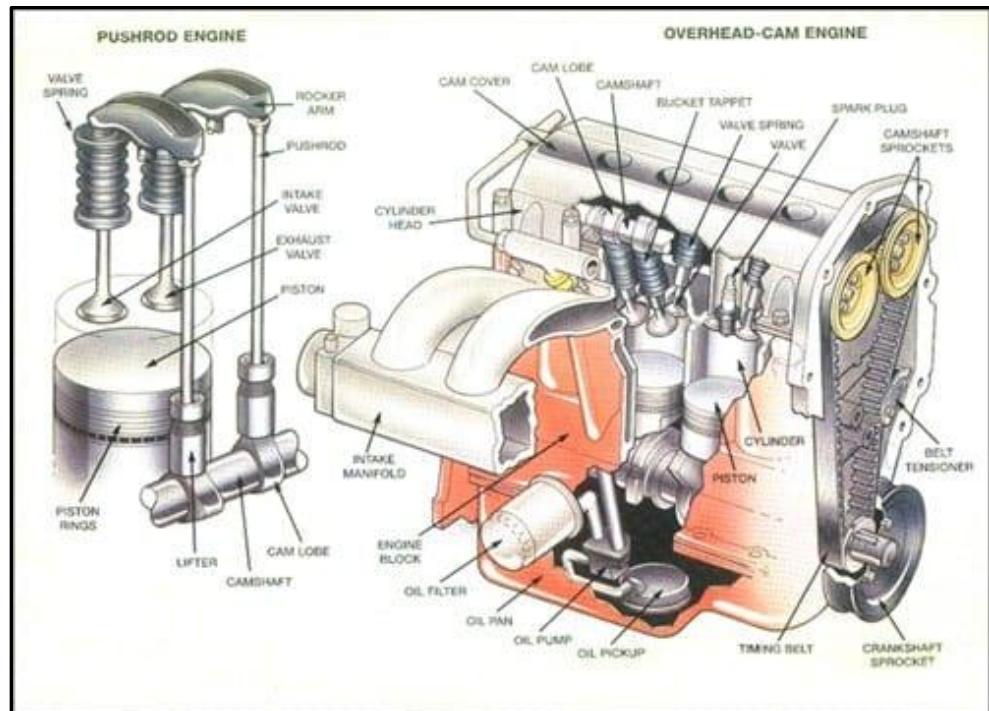
- Main parts
  - Stationary Parts
  - Running Parts
- Auxiliary Systems



# Stationary Parts

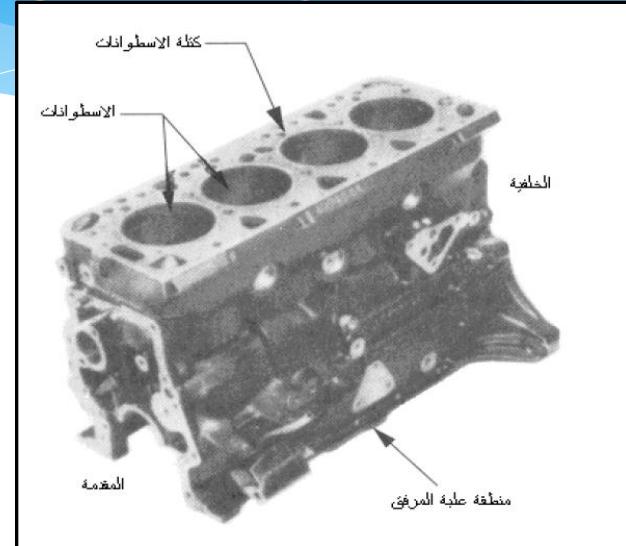
## PURPOSE:

- To Support Running Parts.
- To Provide Jackets and Passages for Cooling water and Lubrication oil.
- To Support Auxiliaries.



# Cylinder Block

# كتلة الاسطوانات



- A metal casting containing the cylinders and cooling ducts of an engine
- All other sub-systems are bolted to the block.
- Cast Iron or Aluminum alloys are used to build the blocks.

كتلة الأسطوانات (جسم المحرك) هي ذلك المنشأ الرئيس الداعم الذي يركب به جميع الأجزاء الأخرى للمحرك. وتصنع كتلة الأسطوانات بالسبك، ويستخدم الحديد الصلب لقدرته على امتصاص الصدمات الناتج عن احتراق الوقود ولسهولة صبها في المسابك. وحيث إن النواحي الاقتصادية تتطلب تقليل وزن المحرك، فقد أصبحت سبيكة الألミニوم الأكثـر شيوعاً الآن في تصنيع محركات سيارات الركوب.

# Cylinder Sleeves or Liners

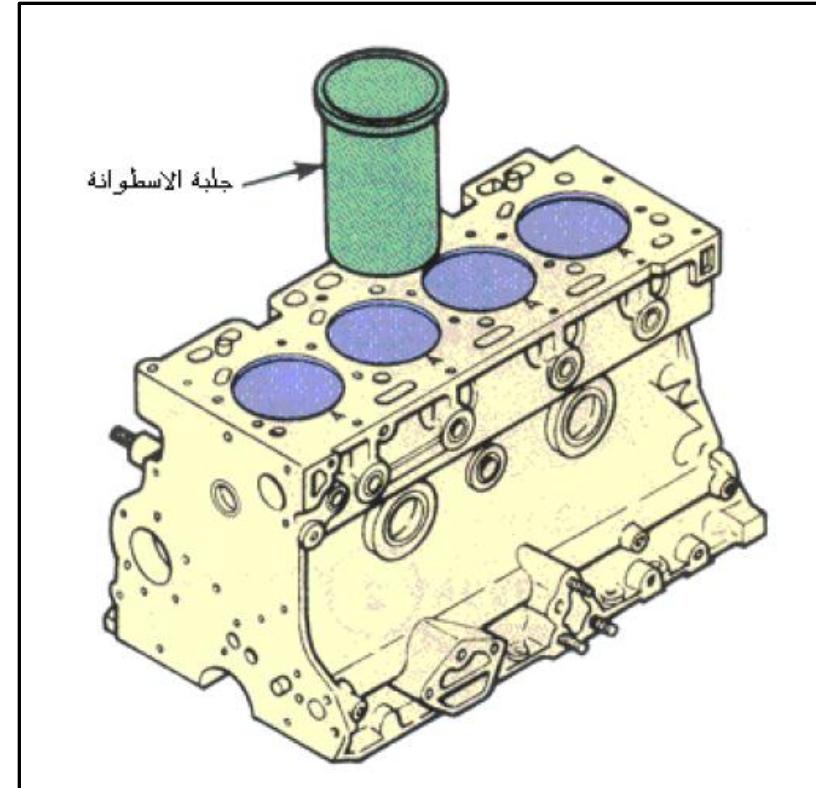
جلبة الاسطوانة

- They are inserts into the cylinder block
- They act as cylinder walls for the piston
- Sleeves made from Cast iron alloys



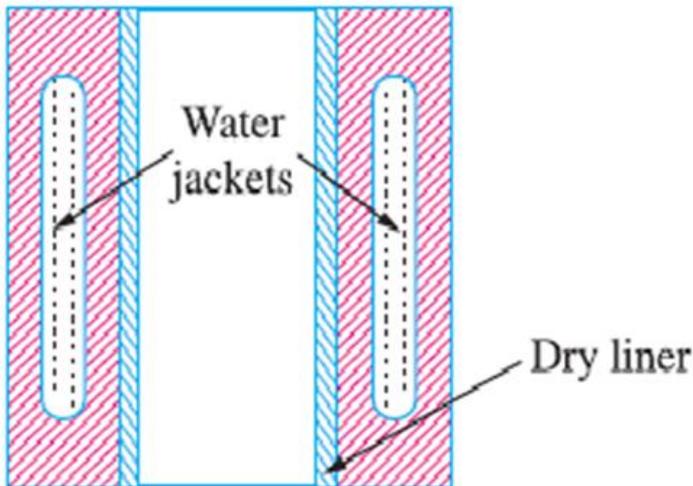
الشروط الواجب توافرها في معدن الاسطوانة :

مقاومة اجهادات كبيرة مثل درجة الحرارة العالية  
خواص انزلاق جيدة  
مقاومة عالية للتآكل  
موصلية حرارة عالية  
خفة الوزن  
مقاومة عالية للصدأ  
قدرة تلاصق جيدة مع وسيط التزليق  
امكانية انتاج رخيصة

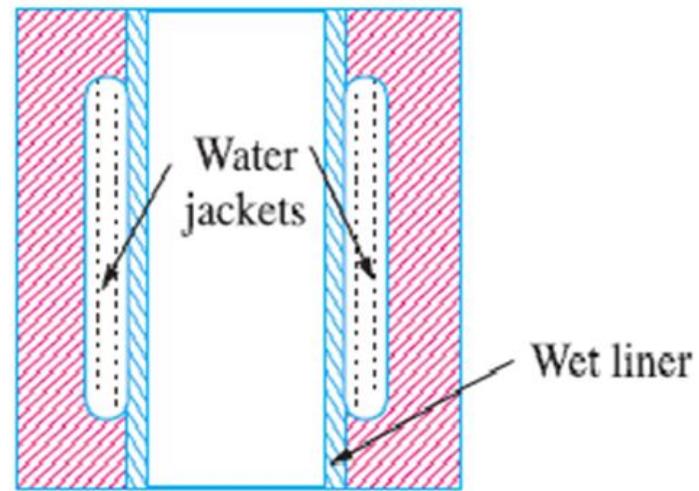


يوجد نوعان من الجلب: الجلب الجافة والجلب المبللة.

1. Dry liner, and 2. Wet liner.



(a) Dry liner.



(b) Wet liner.

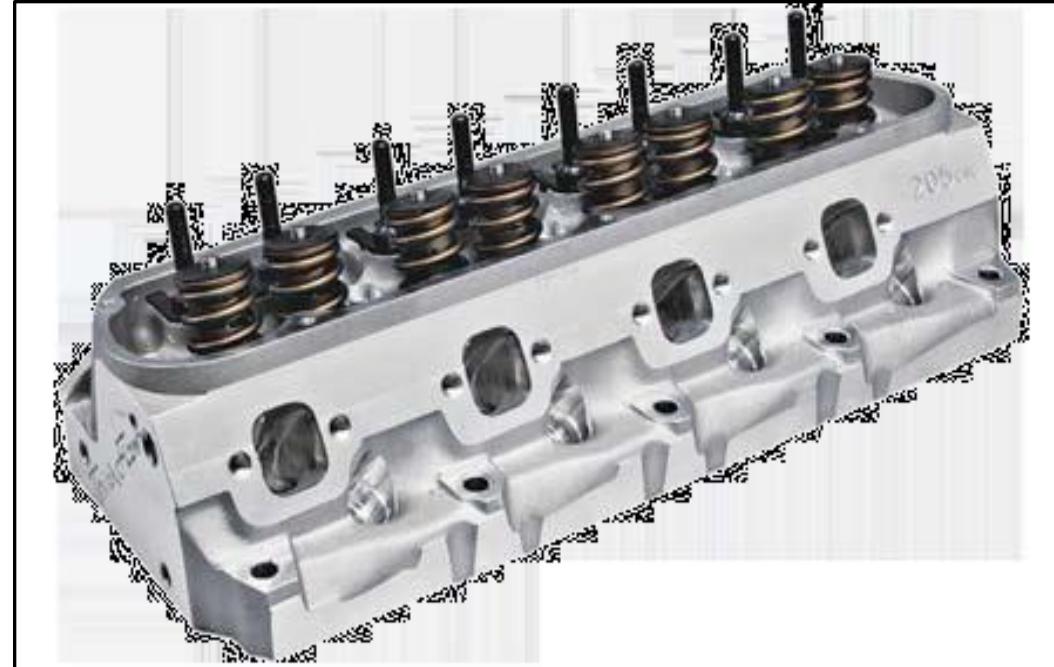
النوع الاول : الجلبة الجافة الغير معرضة لماء التبريد.

النوع الثاني : الجلب المبللة والتي تحاط مباشرة بمياه التبريد ، ويتم منع تسرب المياه بواسطة حلقات مطاطية.

# Cylinder Head غطاء الاسطوانات

وهو غطاء كتلة الاسطوانات للمحرك  
ويحتوي على:-

- الصمامات التي تتحكم بدخول خليط البنزين والهواء وخروج العادم.
- مجمع السحب ومجمع العادم
- عمود الكامات
- غرف الاحتراق ومسارات التبريد



- **The cylinder head is the metal part of the engine that encloses and covers the cylinders.**
- **Bolted on to the top of the block, the cylinder head contains combustion chambers, water jackets and valves**
- **The head gasket seals the passages within the head-block connection, and seals the cylinders as well.**

# غطاء الأسطوانات Cylinder Head

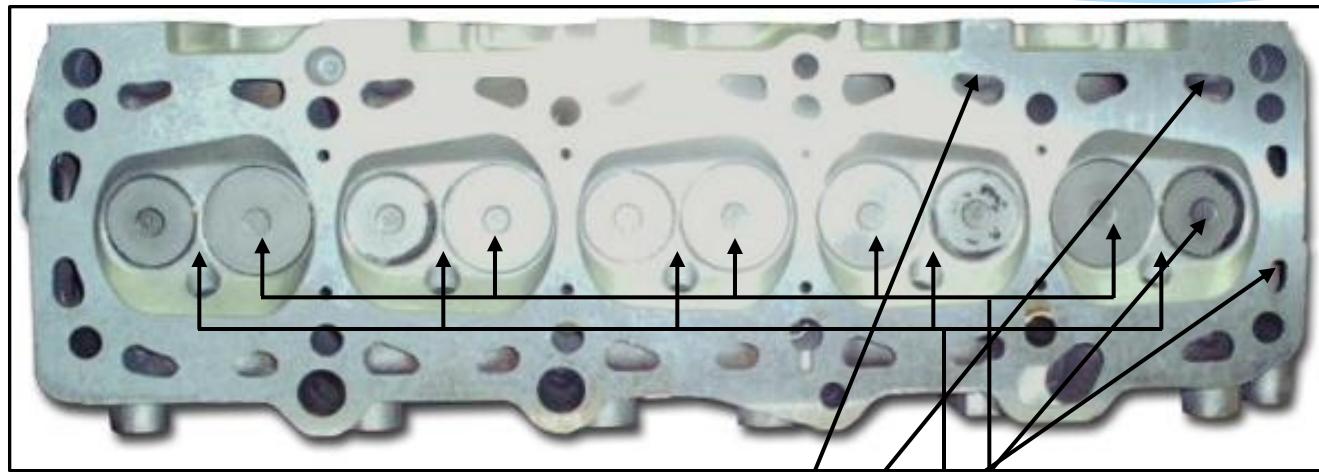
## ٤ - رأس الأسطوانات :

تستخدم جميع محركات السيارات رأس أسطوانات ومجموعة من الصمامات لتشغيل المحرك بالطريقة الصحيحة. رأس الأسطوانات تعمل كغطاء للمحرك من الأعلى، وتسمح الصمامات لشحنة الوقود والهواء بالدخول وللعادم بالخروج من المحرك في الأوقات الصحيحة.

رأس الأسطوانات بالمحرك، لها وظائف متعددة:

- ١ تعمل كحابك أو غطاء للأسطوانات في أعلى المحرك
- ٢ تحتوي على مجموعة الصمامات (في المحركات الحديثة)
- ٣ تشتمل على فتحات دخول الشحنة إلى الأسطوانات وخروج العادم منها
- ٤ تحتوي رأس الأسطوانات في العديد من المحركات على غرف الاحتراق لكل أسطوانة
- ٥ يثبت برأس الأسطوانات شمعات الإشعال في محركات البنزين أو البخاريات في محركات الديزل

# Cylinder Head (2 Valve)



Water jacket holes match Cylinder Block.

Combustion chamber for each cylinder.

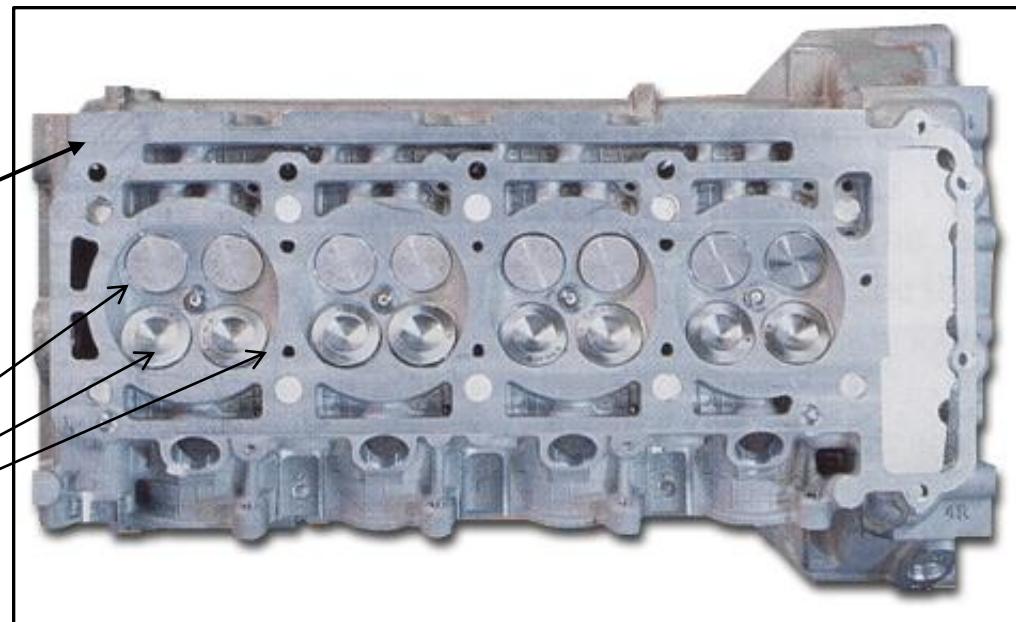
Intake valves.

Exhaust valves slightly smaller.

# Cylinder Head (4 Valve)

*Many different engine designs.*

Aluminum type  
cylinder head.



Four-valve design.  
Differing combustion  
chamber designs.

## Crank Case      علبة المرفق

### OIL CASE      حوض الزيت

تستخدم كمستودع لحفظ الزيت ومنه يسحب الزيت بواسطة مضخات خاصة  
ويوزع على اجزاء المحرك



- That encloses and covers the bottom of cylinder block.
- Contains the lubricant oil and oil lubrication pump.
- Contains the oil drain hole for changing engine lube oil.

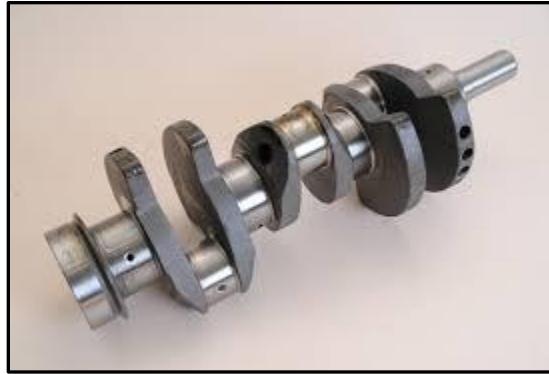
# Running parts

## PURPOSE

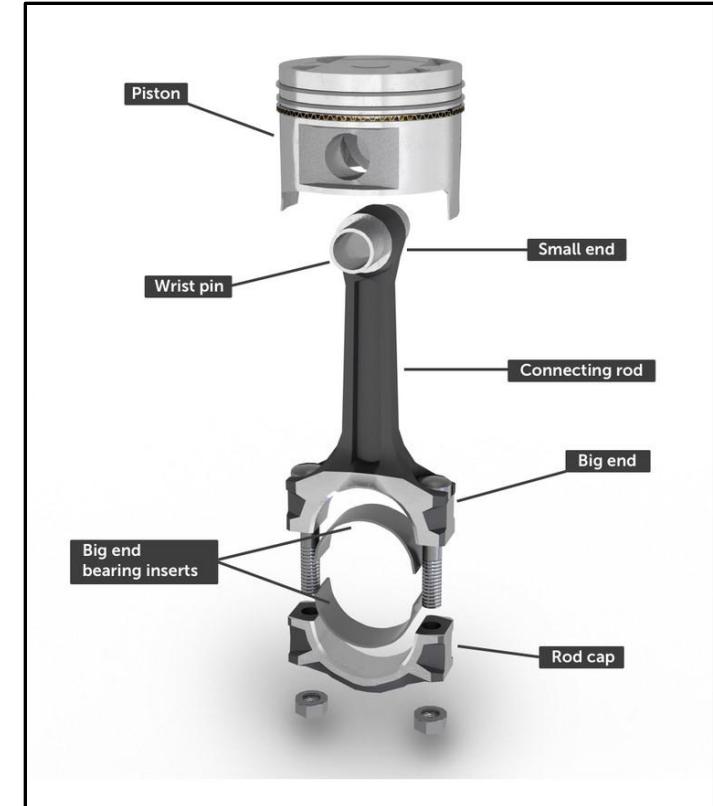
- To convert the power of combustion in the cylinders to mechanical work



Flywheel



Crank shaft

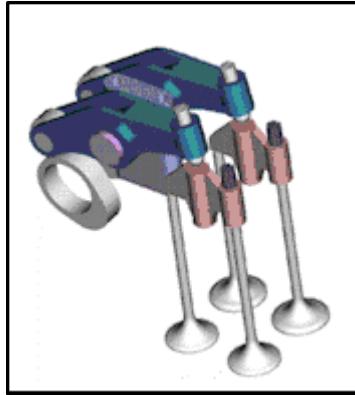


Piston and con-rod

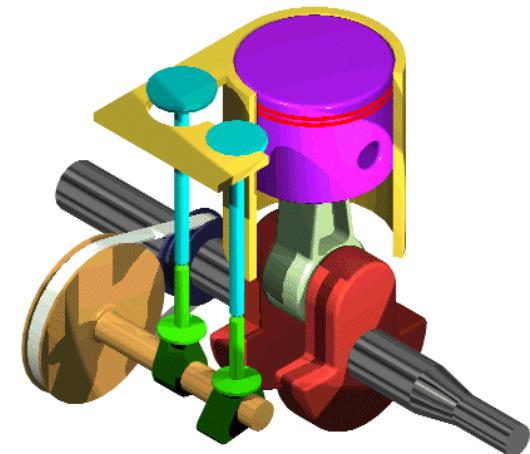
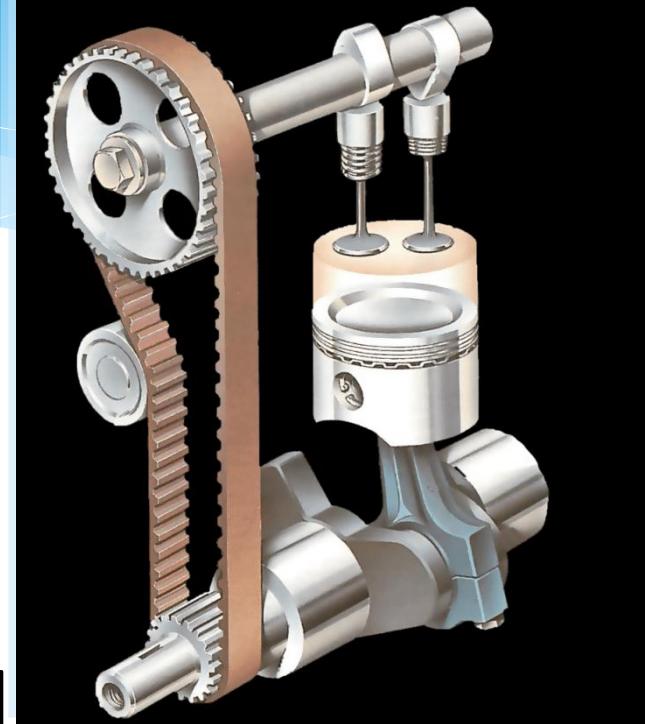
# Running parts



Cam shaft



Valves

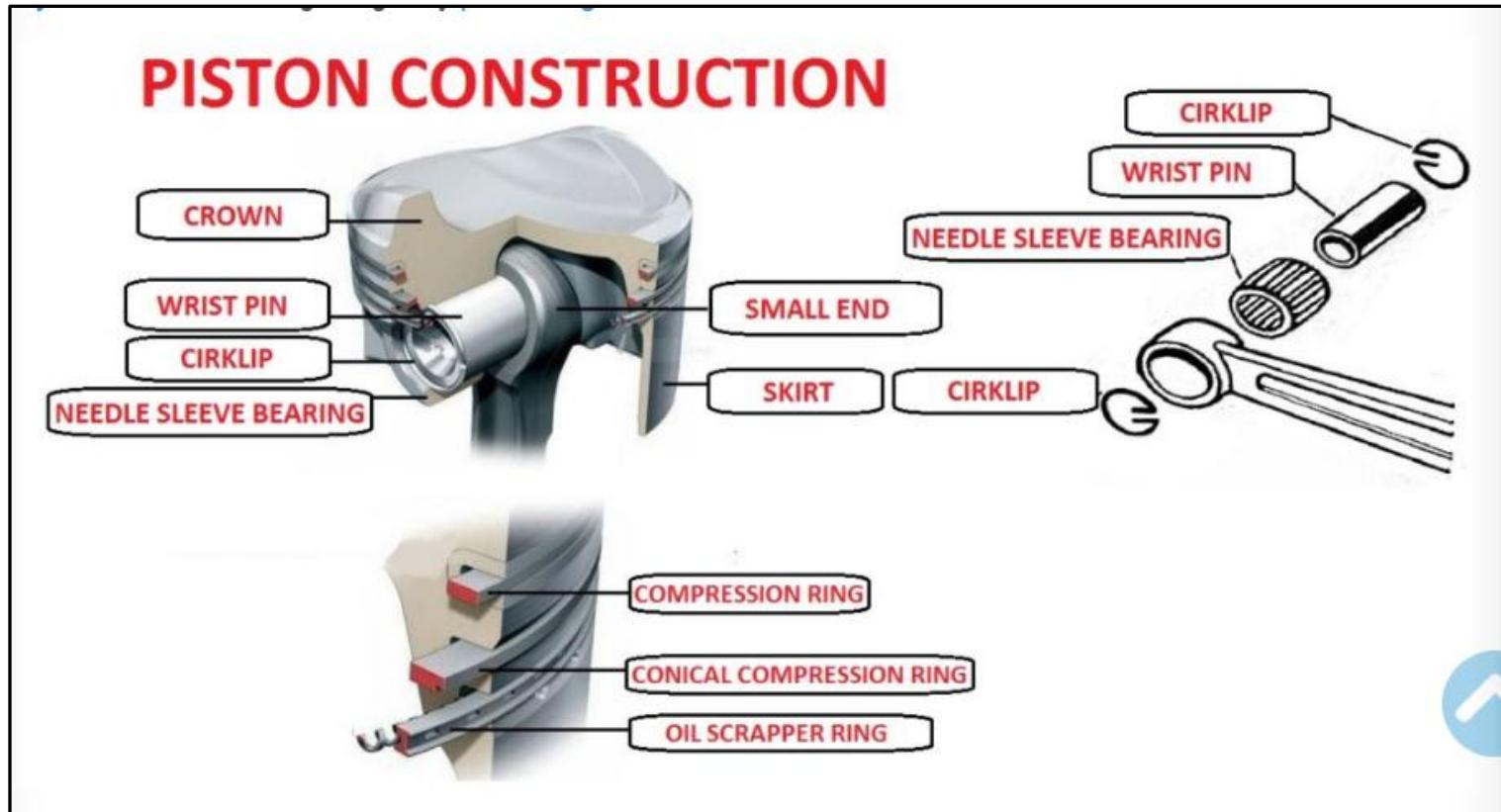




**Question?**

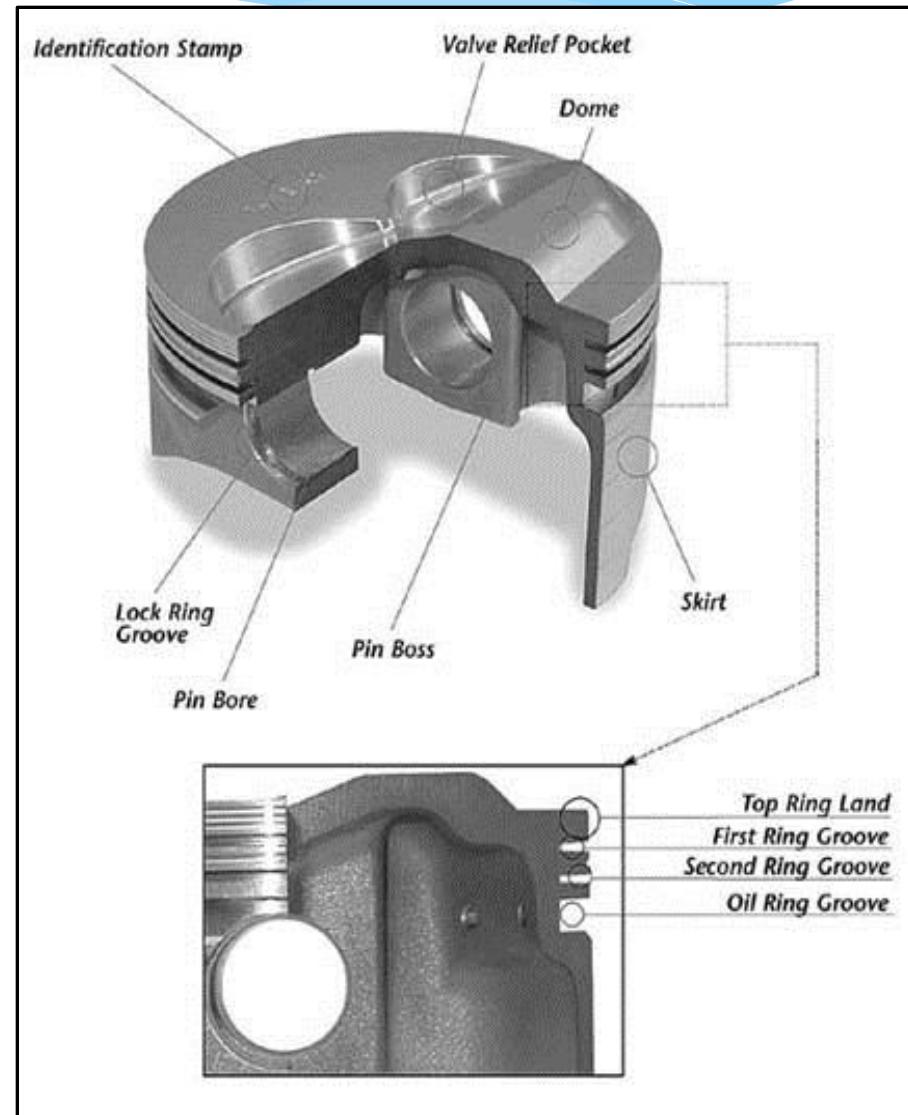
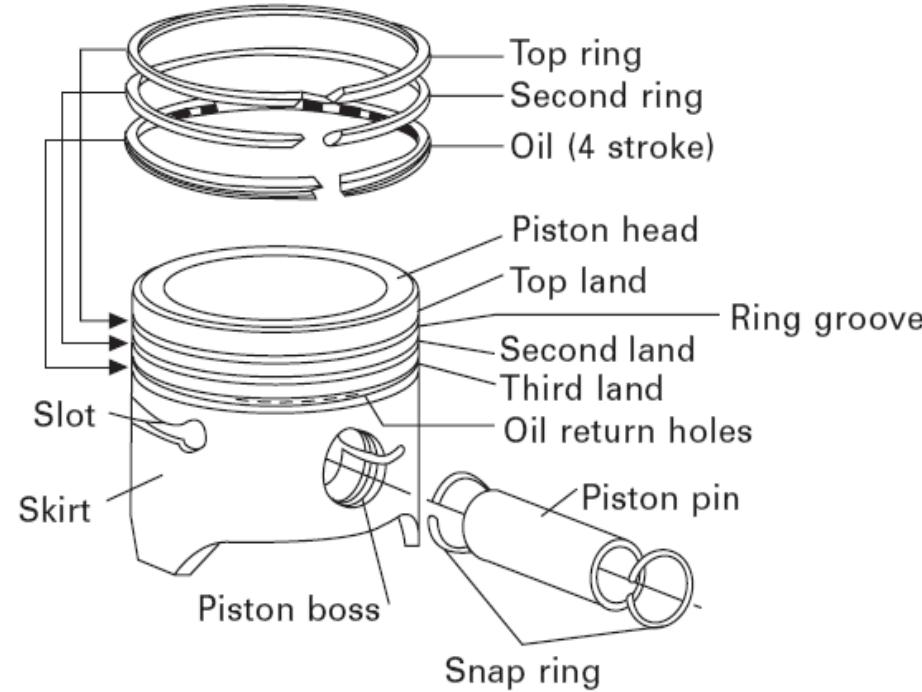
# Piston construction

A **piston** – is a component of engine. **Purpose of piston** is to transfer force from expanding gas in the cylinder to the crankshaft via a connecting rod. Piston has cylinder form. It is moving component, which contained by a cylinder and is made gas-tight by piston rings.

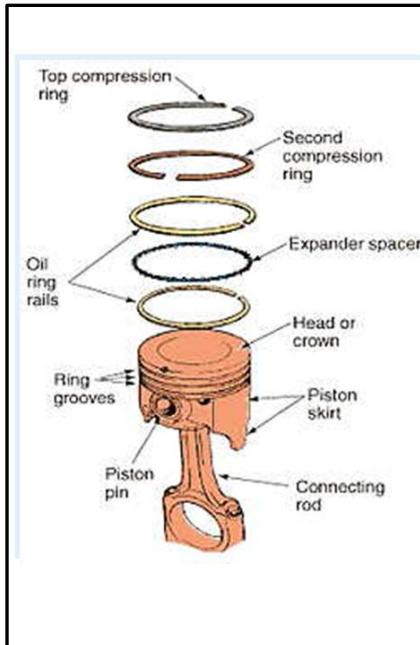
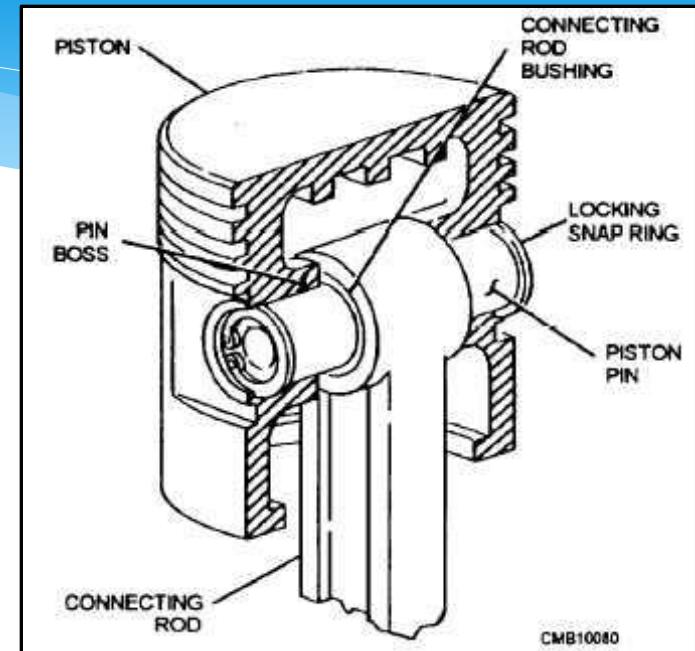
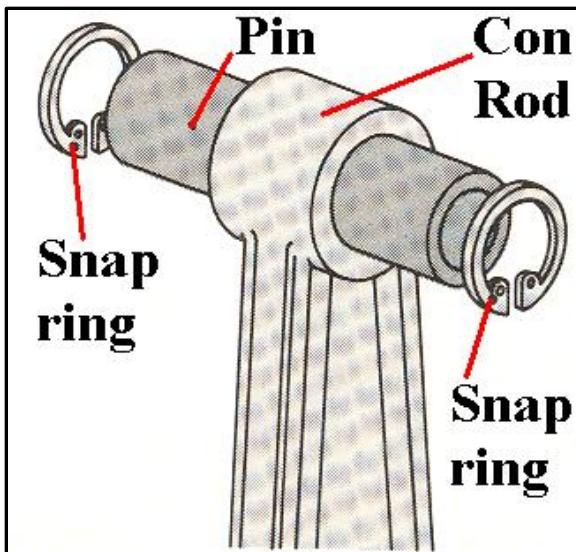


**Piston consist of:** 1 – crown; 2 – piston pin; 3 – ring belt; 4 – pin holes; 5 – skirt.

# Piston construction



# Piston Pin connections



# Piston Functions

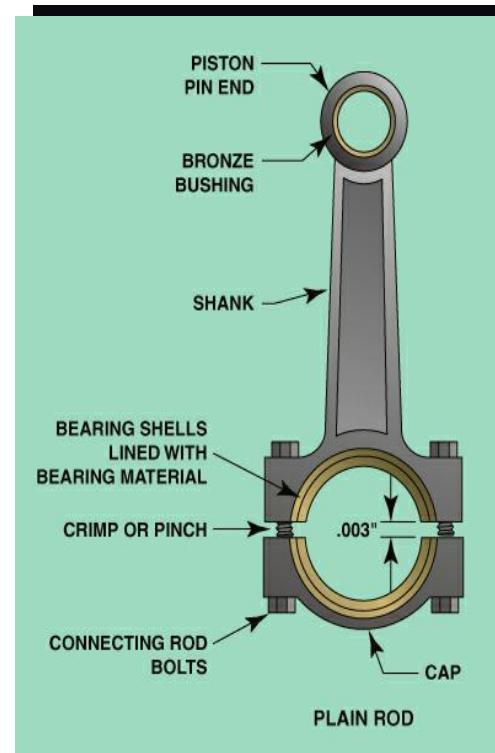
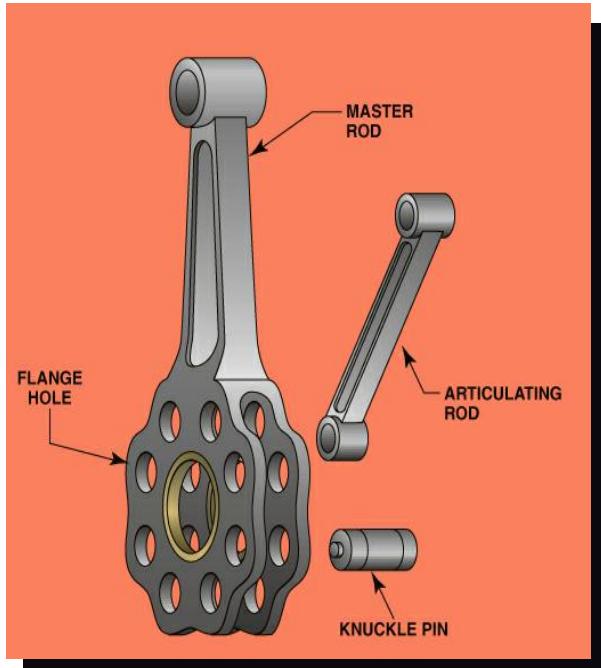
المكبس هو: عضو انزلاقي يتحرك إلى أعلى وأسفل داخل الأسطوانة ويقوم بعده وظائف في تتابع منتظم.  
الوظائف الرئيسية للمكبس هي:

- ١ - توليد التخلخل اللازم لسحب شحنة الوقود والهواء (أو شحنة الهواء في محركات الديزل) أثناء تحركه للأسفل في شوط السحب
- ٢ - ضغط الشحنة أثناء تحركه للأعلى في شوط الضغط لتهيئة عملية الاحتراق
- ٣ - تلقي القوى المترددة من غازات الاحتراق ونقلها إلى عمود المرفق من خلال بنز المكبس وذراع التوصيل،
- ٤ - طرد غازات العادم أثناء تحركه للأعلى في شوط العادم
- ٥ - المكبس أيضاً يجب أن تكون له القدرة على تسريب جزء كبير من الحرارة التي تنتج من الاحتراق داخل الأسطوانة والتي يتسرّب معظمها من خلال المكبس إلى الشناير وزيت التزييت،
- ٦ - المكبس يحمل الشناير ويساعد في تكوين إثارة للخلط أثناء شوط الضغط

# Different Types Connection Rods

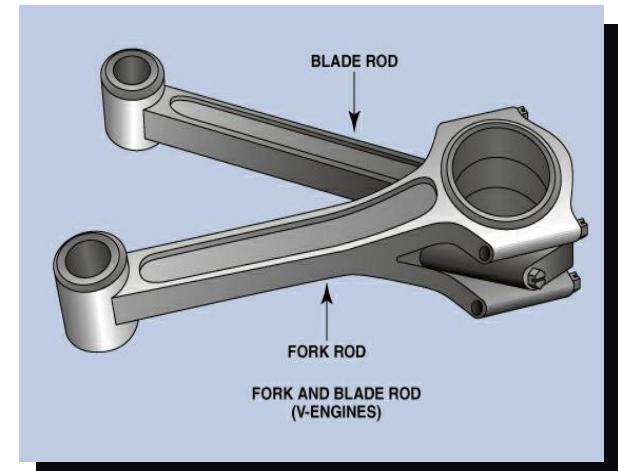
هو ذراع يتصل بين المكبس وعمود المرفق. يتحرك المكبس من أعلى إلى أسفل في حركة خطية ترددية وعن طريق اتصال ذراع التوصيل بالعمود المرقفي تحول الحركة الخطية إلى حركة دورانية للعمود المرقفي

## Master and Articulated



Plain

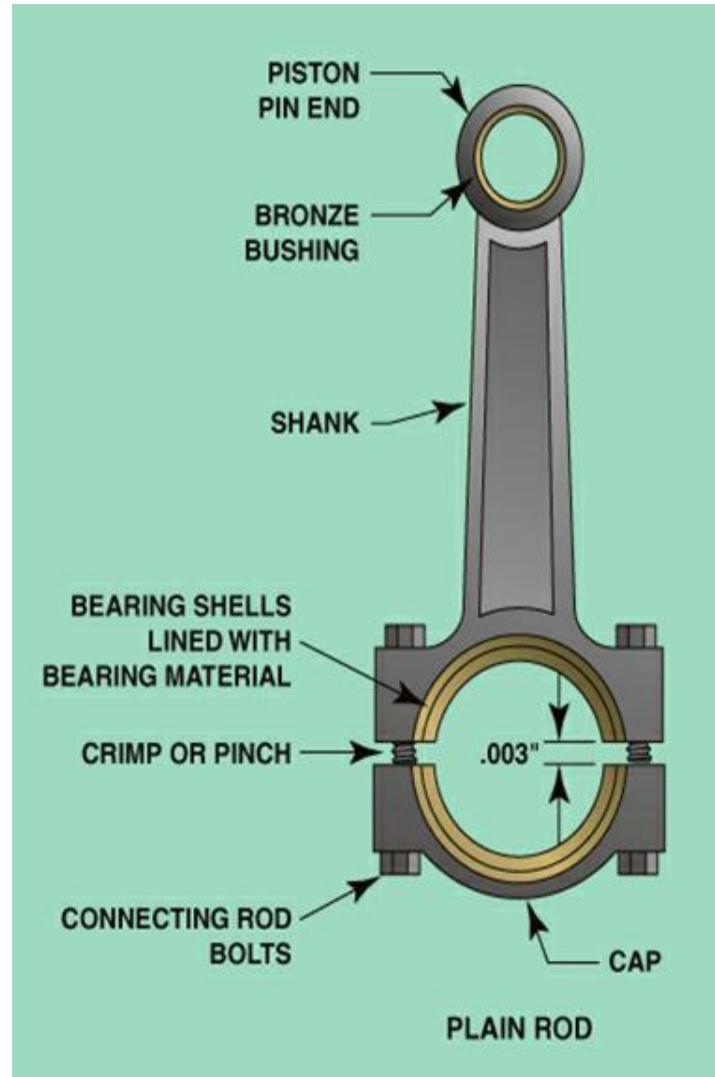
## Fork and Blade



## Plain Type .

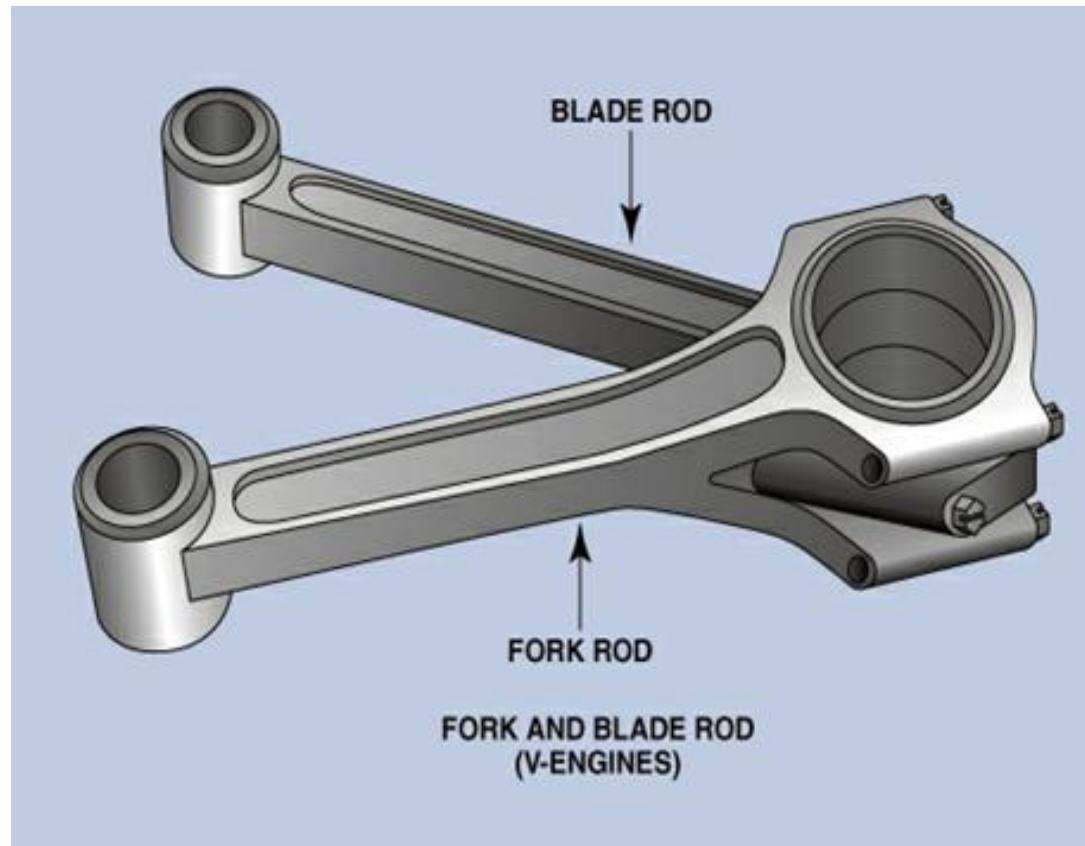
### Plain Type Connecting Rod

Used in in-line, V -engine and opposed engines.



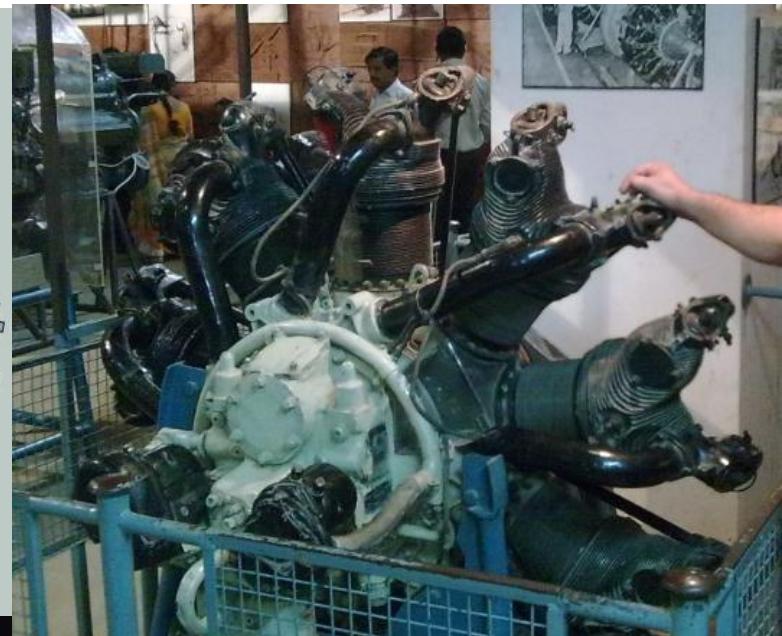
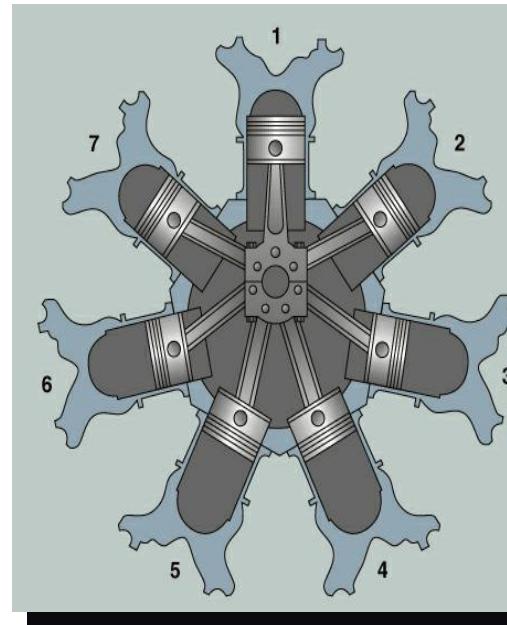
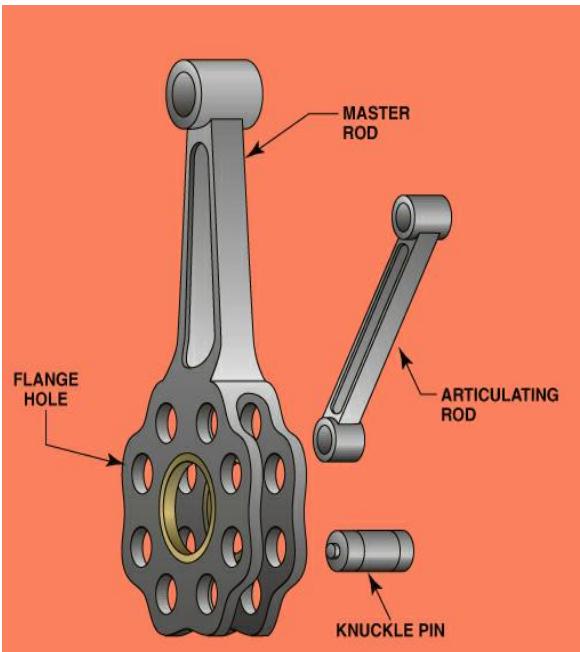
## Fork and Blade Type.

- **Fork And Blade Assembly**
- **Used primarily in V-type engines.**



## Master and Articulated Type

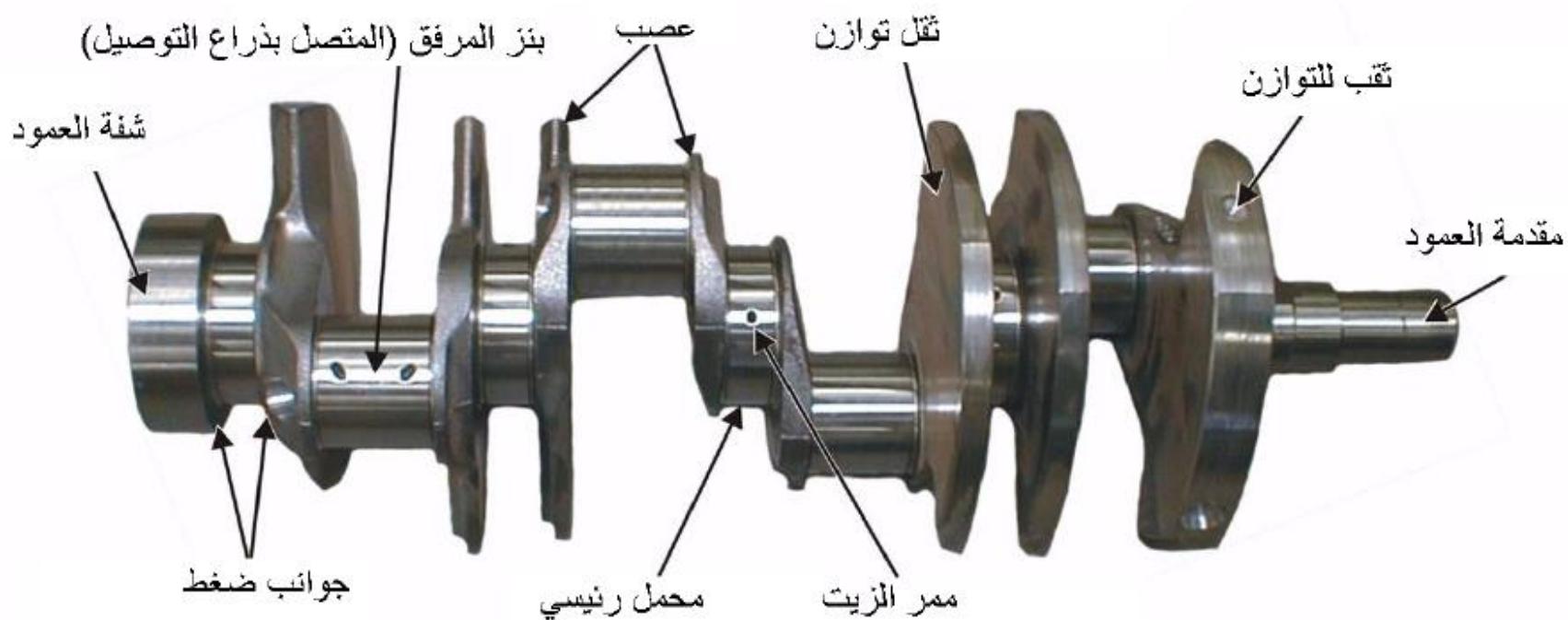
- Commonly used in radial engines.
- One piston in each row is connected to the master rod.  
Others are connected to the master rod by articulated rods.



# Description of crank shaft.

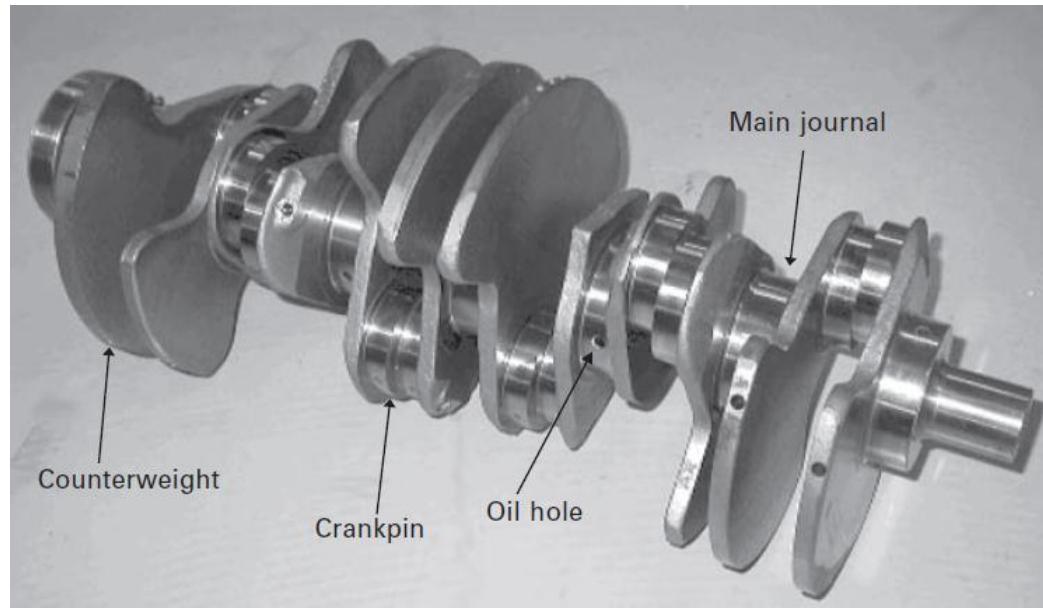
- Crankshaft converts the reciprocating displacement of the piston to a rotary motion.

من أهم أجزاء محرك السيارة هو العمود المرفق أو عمود الكرنك وهو يحول الحركة الخطية الترددية للمكبس إلى حركة دورانية. ويكون من بنوز المرفق ويثبت عليها النهاية الكبيرة لذراع التوصيل كراسى تحميل واثقال توازن ومسارات لزيت التزييت.



# Description of crank shaft.

- Crankshaft **converts the reciprocating displacement of the piston to a rotary motion.**



The crankshafts are generally made of:-

- **carbon steel,**
- **special steel or**
- **special cast iron.**

# Flywheels

The Flywheel has 3 main functions.

- **The first is to maintain a rotating mass (inertia) to assist the engine rotation.**
- **The second is to provide a ring gear for the starter motor to engage on.**
- **The third is to provide one of the driving friction surfaces for the friction disc.**



## ٦- الحداقة : Flywheel

تحصل حداقة ثقيلة \_\_\_\_\_ بالجزء الخلفي لعمود مرفق المحرك وتصنع من الحديد الصلب أو حديد الزهر الرمادي. وتمتص الحداقة الطاقة في أشواط القدرة ثم تقوم بإرجاعها بين تلك الأشواط، وهذا يؤدي إلى الحفاظ على دوران عمود المرفق عند سرعة منتظمة. إذن فالوظيفة الرئيسية للحداقة هي الحفاظ على استمرارية دوران عمود المرفق بسلاسة، وذلك بتخزين الطاقة من شوط القدرة وإرجاعها إلى الأشواط غير الفعالة (السحب والضغط والعادم). وهناك وظائف ثانوية أخرى للحداقة تتمثل في:

- توفير سطح الاحتكاك اللازم لقرص الاحتكاك بالقابض (بالسيارات ذات ناقل الحركة العادي)
- إدارة محول العزم في السيارات ذات ناقل الحركة الذاتي.
- تركيب الترس الحلقي اللازم للتعشيق مع ترس بادئ الحركة بهدف تسهيل بدء إدارة المحرك.

# Camshaft Construction

The main purpose of camshaft is transmits move from crankshaft to valves through camshaft cams. It is provides by opening and closing of inlet and outlet valves. Cams provide opening and closing of inlet and outlet valves in time.



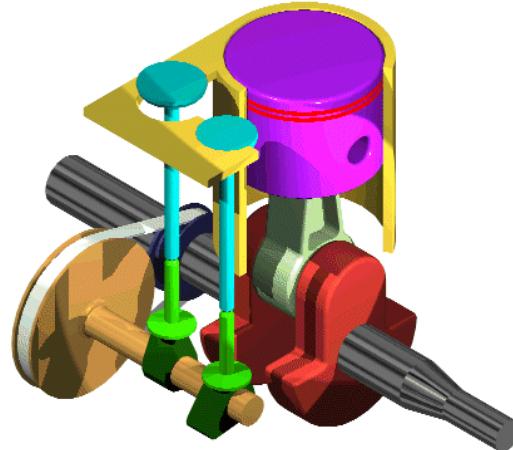
يُعد عمود الكامات أو ما يسمى بعمود الحدبات من الأجزاء المهمة في المحرك، يستعمل عمود الكامات لفتح وإغلاق الصمامات، وتستعمل كامة واحدة من العمود لكل صمام موجود في المحرك، حيث يستعمل عمود كامات واحد بالمحرك، ولكن أصبحت [المحركات الحديثة](#) تستعمل عمودين أو أكثر من أعمدة الكامات.

# Engine Valves

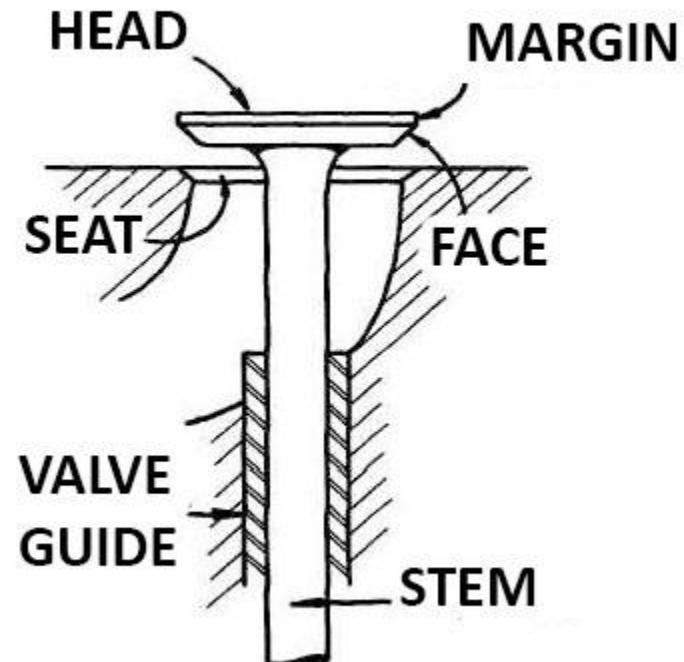
The main purpose of engine valves is opening and closing intake and exhaust holes. When intake valve is opening the fuel air mixture enters to the [cylinders](#) and when exhaust valve is opening burned gases are ejected. Valve is an element of [Valve mechanism](#).

توجد الصمامات في رأس المحرك . وتمثل المهمة الرئيسية لصمامات المحرك في السماح بدخول وخروج الهواء من وإلى الأسطوانات بشكل منظم وفي وقت محدد ودقيق .

وتعمل الصمامات في السيارات كذلك على منع أي تسرب محتمل من غرفة الاحتراق عن طريق إغلاقها بإحكام



## VALVE CONSTRUCTION



# Auxiliary Systems

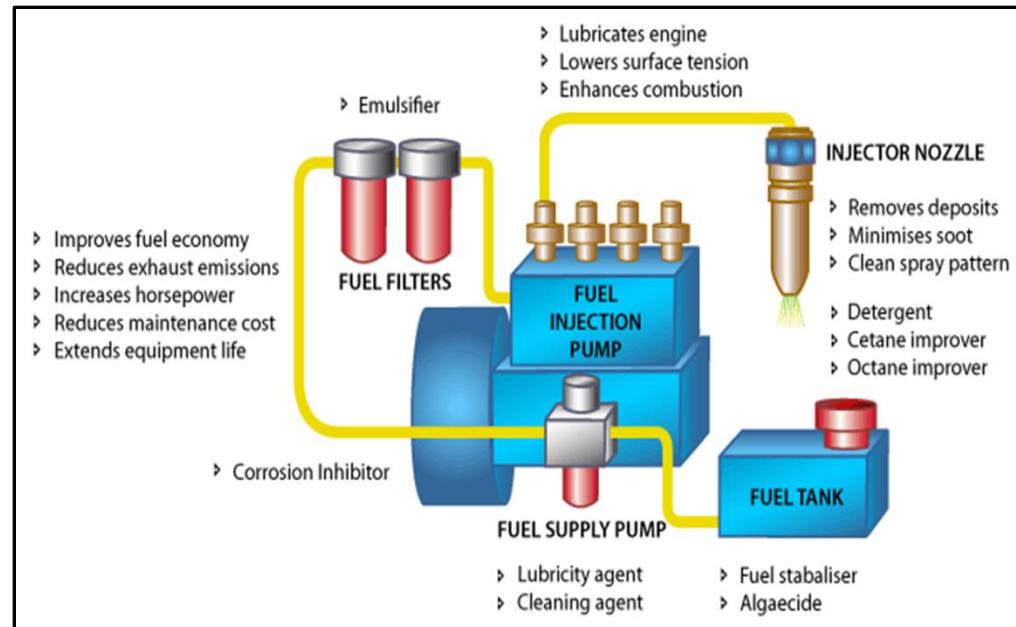
## PURPOSE

- Supply of Air
- Turbocharging
- Lubrication

Air intake system

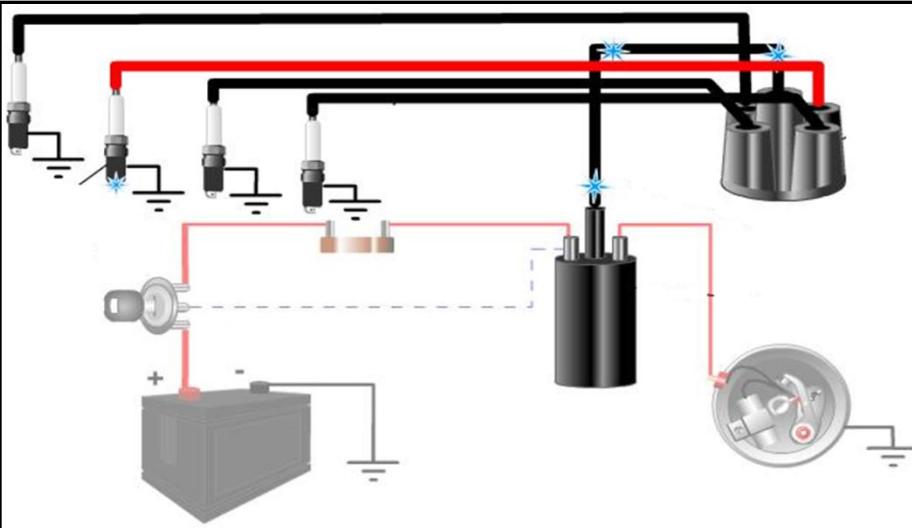


Exhaust Removal  
Fuel Injection  
Cooling System

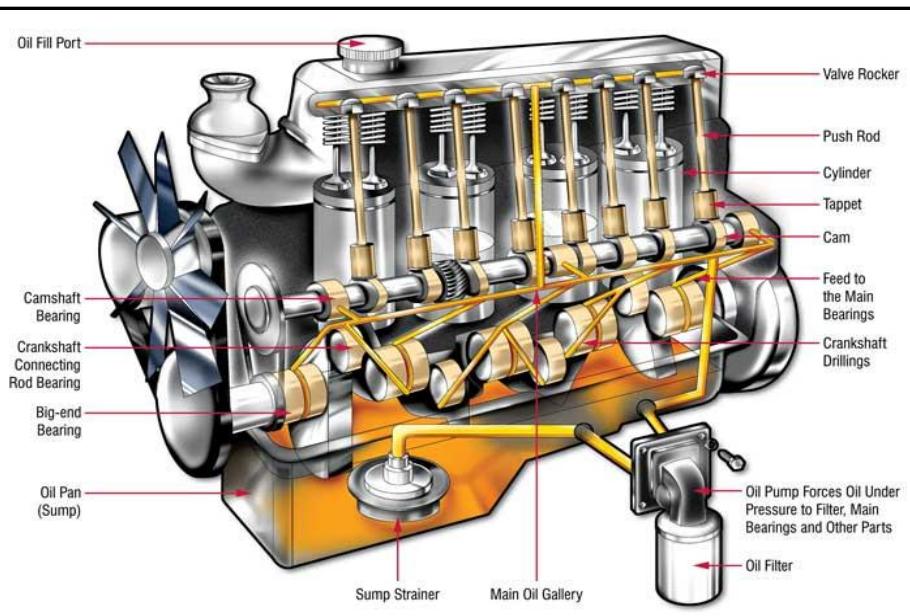
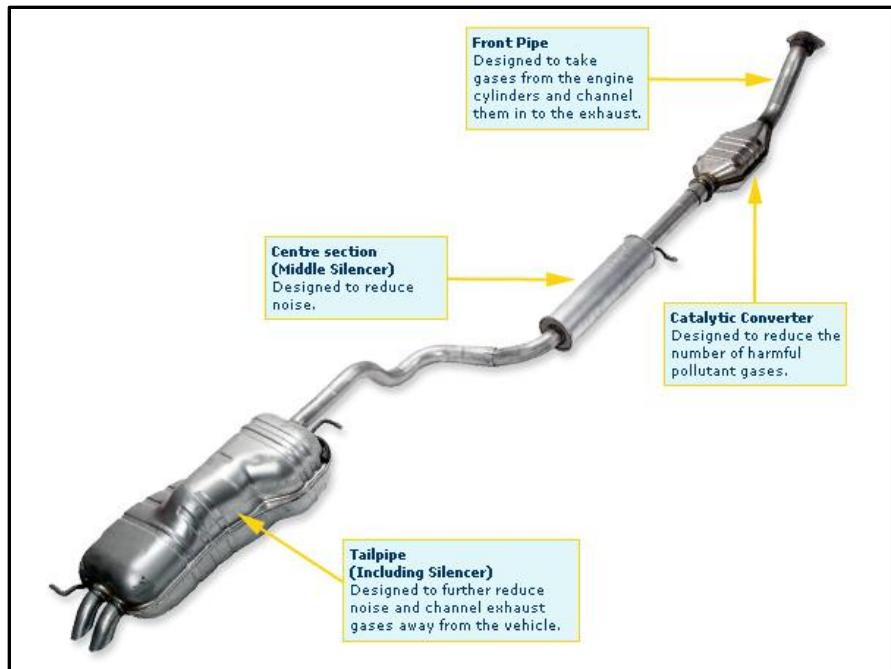


Fuel System

## Ignition System



## Exhaust system



## Lubrication System



Question?

# Engine Parameters

- |                                    |                         |
|------------------------------------|-------------------------|
| • Cylinder bore                    | Mechanical efficiency   |
| • Stroke                           | Thermal efficiency      |
| • Engine speed                     | S.F.C                   |
| • Displacement                     | A:F ratio               |
| • Compression ratio                | Indicated power         |
| • Swept Volume/cylinder            | Brake power             |
| • crank radius                     | Mean effective pressure |
| • Stroke to Bore (L/D) Ratio ..... | .....                   |

# Internal Combustion Engines

## Engine Parameters

- |                            |                                     |
|----------------------------|-------------------------------------|
| • Cylinder Diameter (Bore) | قطر إسطوانة المحرك                  |
| • Stroke                   | المشوار                             |
| • Engine speed (rpm)       | سرعة دوران المحرك (عدد لفات المرفق) |
| • Compression ratio        | نسبة الانضغاط                       |
| • Swept Volume             | الإزاحة (الحجم المكتسح)             |
| • crank radius (r)         | نصف قطر دوران عمود المرفق           |
| • Stroke to Bore Ratio     | نسبة طول المشوار إلى قطر الاسطوانة  |

# Engine Parameters, Cont.....

- Mechanical efficiency

الكفاءة الميكانيكية

- Thermal efficiency

الكفاءة الحرارية

- Specific Fuel Consumption (S.F.C)

الاستهلاك النوعي للوقود

- A:F ratio

نسبة الهواء الى الوقود

- Indicated power

القدرة البيانية للمحرك

- Brake power

القدرة الفرمالية للمحرك

- Friction power

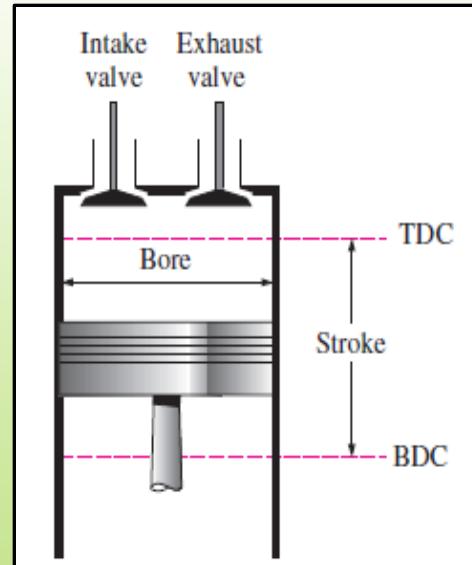
القدرة الاحتاكية

- Mean effective pressure

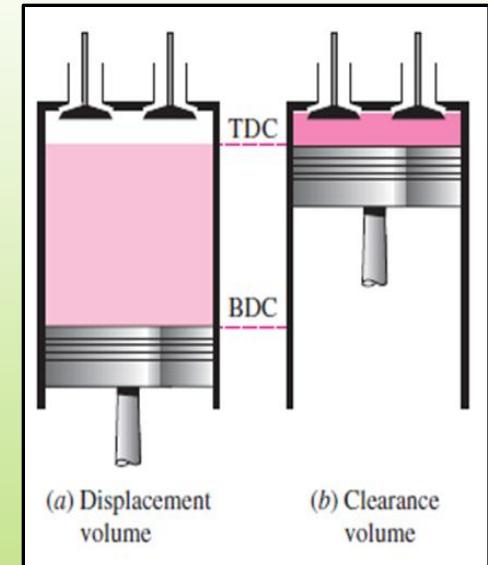
الضغط المتوسط الفعال

# Terminology used in IC engine:

1. Cylinder bore (D):



2. Piston area (A):



3. Stroke (L):

4. Bottom dead centre (BDC):

5. Top dead centre (TDC):

6. Displacement volume or swept volume (Vs):  $V_s = A \times L$

7. Clearance volume (Vc):

8. Cylinder volume (V):  $V = V_s + V_c$

9. Compression ratio (r):  $r = (V_s + V_c) / V_c$



# Definition of IC engine Terminology

## تعريفات هامة لبعض المصطلحات في محركات الاحتراق الداخلي

**شوط المكبس:** هو المسافة المحصورة بين النقطة الميّة العلّى والنقطة الميّة السفّل.

**النقطة الميّة العلّى TDC:** هي أعلى نقطة يصل إليها المكبس في أثناء صعوده للأعلى داخل الاسطوانة.

**غرفة الاحتراق:** هي حيز مغلق محصور بين نهاية شوط المكبس في أثناء حركته للأعلى وبين رأس المحرك ويتم فيها ضغط مزيج الوقود واحتراقه.

**النقطة الميّة السفّل BDC:** هي أدنى نقطة يصل إليها المكبس في أثناء نزوله إلى الأسفل.

تابع.....

## Definition of IC engine Terminology

تعريفات هامة لبعض المصطلحات في محركات الاحتراق الداخلي

**القدرة الحصانية الفرمولية (B.H.P):** وتعُرف بالقدرة الفعالة على عمود الإدارة (المرفق).

**القدرة الحصانية البيانية (I.H.P):** وهي قدرة المكبس المكتسبة من الغازات العاملة في المحرك نتيجة للاحتراق، وهي الخطوة الأولى التي يتم عندها تحويل طاقة الوقود الحرارية إلى طاقة ميكانيكية.

**القدرة الحصانية الاحتاكية (f.h.p):** وهي القدرة الضرورية للتغلب على قوى الاحتاك بين أجزاء المحرك في أثناء العمل وتساوي الفرق بين القدرة الحصانية الفرمولية والقدرة الحصانية البيانية.

تابع.....

## Definition of IC engine Terminology

### تعريفات هامة لبعض المصطلحات في محركات الاحتراق الداخلي

**معدل استهلاك الوقود النوعي (s.f.c):** ويعرف بالنسبة بين معدل استهلاك الوقود في الساعة والقدرة الحصانية.

$$b.s.f.c = \frac{\text{معدل استهلاك الوقود}}{\text{القدرة الحصانية}} \text{ (kg/kwh)}$$

**كفاءة المحرك الميكانيكية ( $\eta_{\text{mech.}}$ ):** وتعتبر بالنسبة ما بين القدرة الحصانية الفعلية والقدرة الحصانية البينية للمحرك.

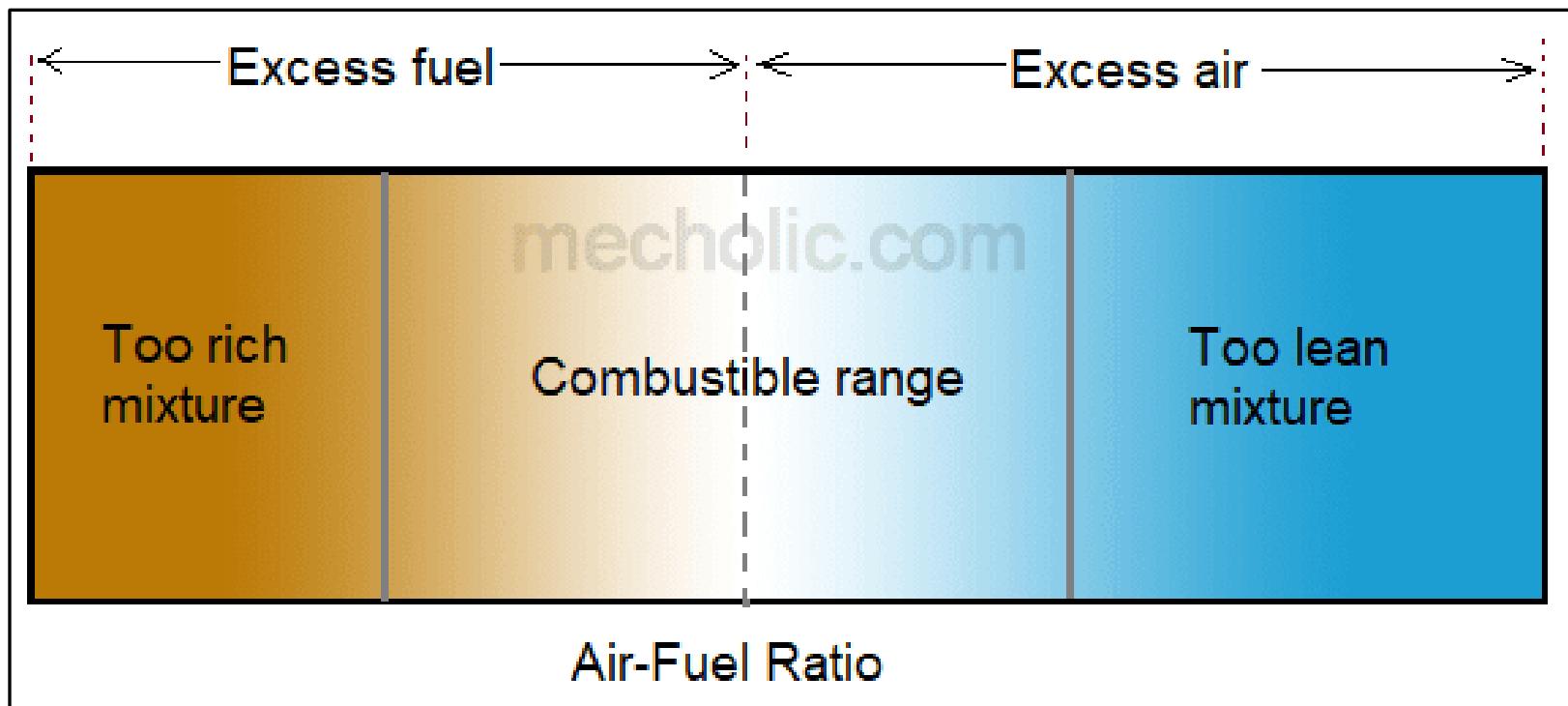
**نسبة الانضغاط (Compression ratio):** وتساوي نسبة حجم الاسطوانة إلى حجم غرفة الاحتراق، وحجم الاسطوانة يساوي حجم الشوط زائد حجم غرفة الاحتراق.

## Terms and abbreviations are commonly used in engines to

- **Top-Dead-Center (TDC)** Position of the piston when it stops at the furthest point away from the crankshaft.
- **Bottom-Dead-Center (BDC)** Position of the piston when it stops at the point closest to the crankshaft.
- **Bore (D)** Diameter of the cylinder or diameter of the piston face, which is the same minus a very small clearance.
- **Stroke** Movement distance of the piston from one extreme position to the other:  
TDC to BDC or BDC to TDC.
- **Clearance Volume** Minimum volume in the combustion chamber with piston at TDC.
- **Displacement or Displacement Volume** Volume displaced by the piston as it travels through one stroke.

- **Air-Fuel Ratio (AF)** Ratio of mass of air to mass of fuel input into engine.
- **Fuel-Air Ratio (FA)** Ratio of mass of fuel to mass of air input into engine.

هي النسبة الفعلية بين الوقود إلى الهواء التي تدخل المحرك واللزمرة لاتمام عملية الاحتراق.



**The Mean Effective Pressure (MEP)** is a theoretical parameter used to measure the performance of an internal combustion engine (ICE).

$$\text{Brake Mean Effective Pressure (BMEP)} = \frac{\text{Work done per cycle}}{\text{Stroke volume}}$$

$$BMEP = \frac{\text{Work done per cycle} \times \text{number of cycles per second}}{\text{stroke volume} \times \text{number of cycles per second}}$$

$$BMEP = \frac{\text{Brake power}}{ALn \times N/\tau}$$

$$BMEP = \frac{B \times \tau}{A \times L \times n \times N}$$

الضغط المتوسط الفعال  
هو متوسط الضغط داخل إسطوانة محركات الاحتراق  
الداخلي و يعتبر مؤشر على قدرة المحرك حيث ترتفع  
القدرة بارتفاعه

**Mechanical Efficiency** : It is defined as the ratio of the break power and the Indicated power .

$$\eta_{mech} = \frac{B.P.}{I.P.}$$

- ▶ **Thermal Efficiency** : It is the efficiency of conversion of the heat energy produced by the actual combustion of the fuel into the power output of the engine . It is the ratio of work done to heat supplied by fuel .

- ▶ (1) **Indicated Thermal Efficiency**

where ,  $m_f$  = mass of fuel supplied ,  $C.V$  = calorific value of fuel , J/kg

- (2) **Break Thermal Efficiency**

$$\eta_{bt} = \frac{B.P.}{m_f \times C.V}$$

- **Relative Efficiency** : It is the ratio of Indicated Thermal Efficiency of an engine to air standard cycle Efficiency cycle Efficiency .

$$\eta_{rel} = \frac{\eta_{it}}{\eta_{air}}$$

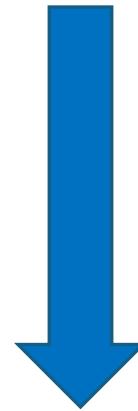
- **Air standard Efficiency** : It is

*Thank You  
For Your Attention*



# Internal Combustion Engines Operating Cycles

دورات التشغيل لمحركات الاحتراق الداخلي



**Four Stroke  
Operating Cycle**

دورة التشغيل رباعية الأشواط  
( الدورة الرباعية )

**Two Stroke  
Operating Cycle**

دورة التشغيل ثنائية الأشواط  
( الدورة الثنائية )

# What is Operating cycle?

**Operating cycle of engine:-** is assembly of processes, it repeats in timely manner in certain sequence.

**The result of this processes** are work of engine. If operating cycle makes for 2 crankshaft rotation is four-stroke engine. If operating cycle makes for one crankshaft rotation is two-stroke engine.

هي مجموعة من الاجراءات تتكرر في وقت معين وبتسلسل محدد ويكون نتيبة ذلك هو عمل المحرك .... اذا تمت الدورة في لفتين من لفات عمود المرفق فان المحرك يعمل طبقا للدورة الرباعية ...  
و اذا تمت الدورة في لفة واحدة من لفات عمود المرفق فان المحرك يتبع الدورة الثانية

# Four Stroke Operating Cycle

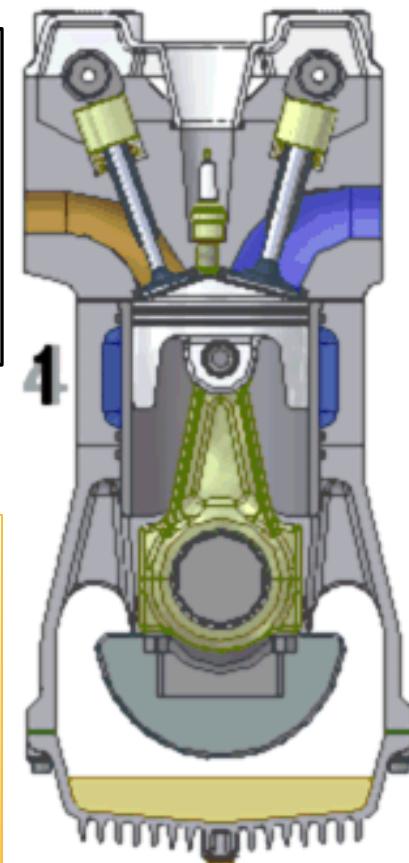
## الدورة الرباعية

A four-stroke cycle engine is a cycle in which the piston completes four separate strokes while turning the crankshaft. A stroke refers to the full travel of the piston along the cylinder, in either direction

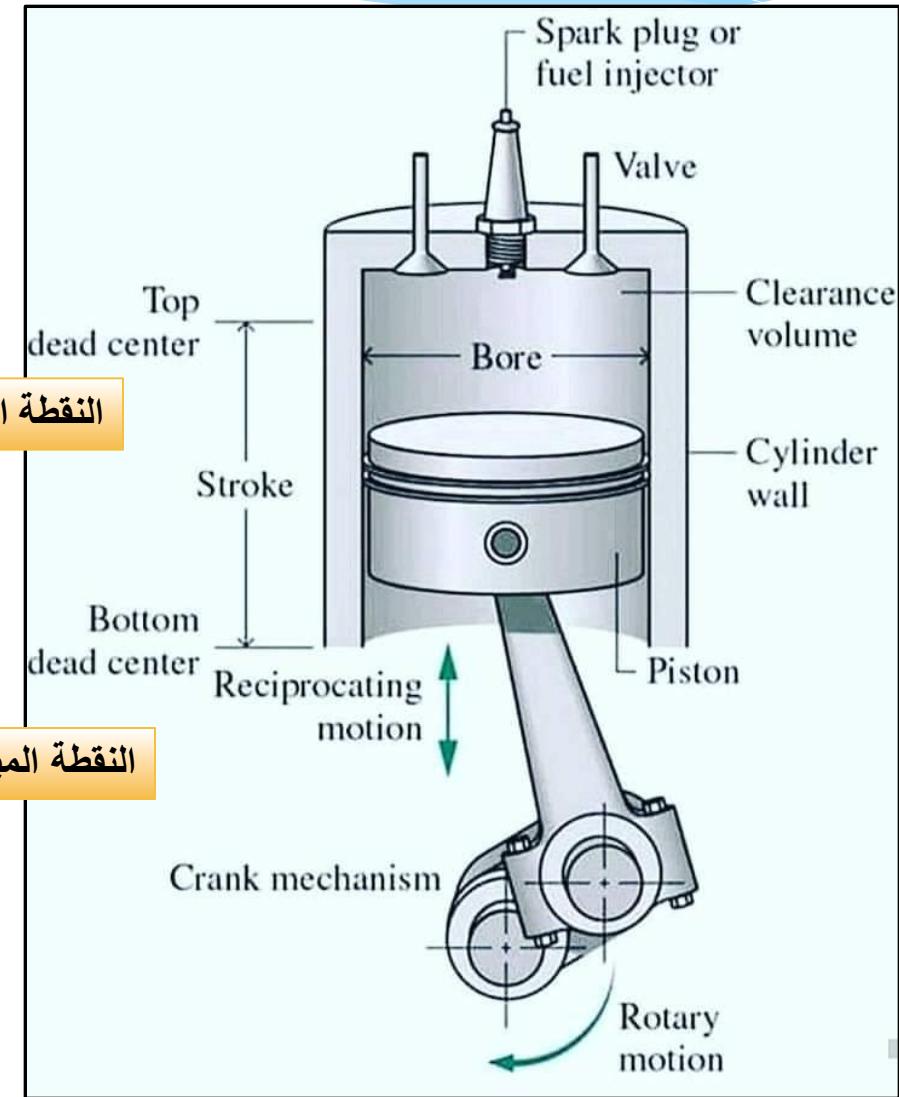
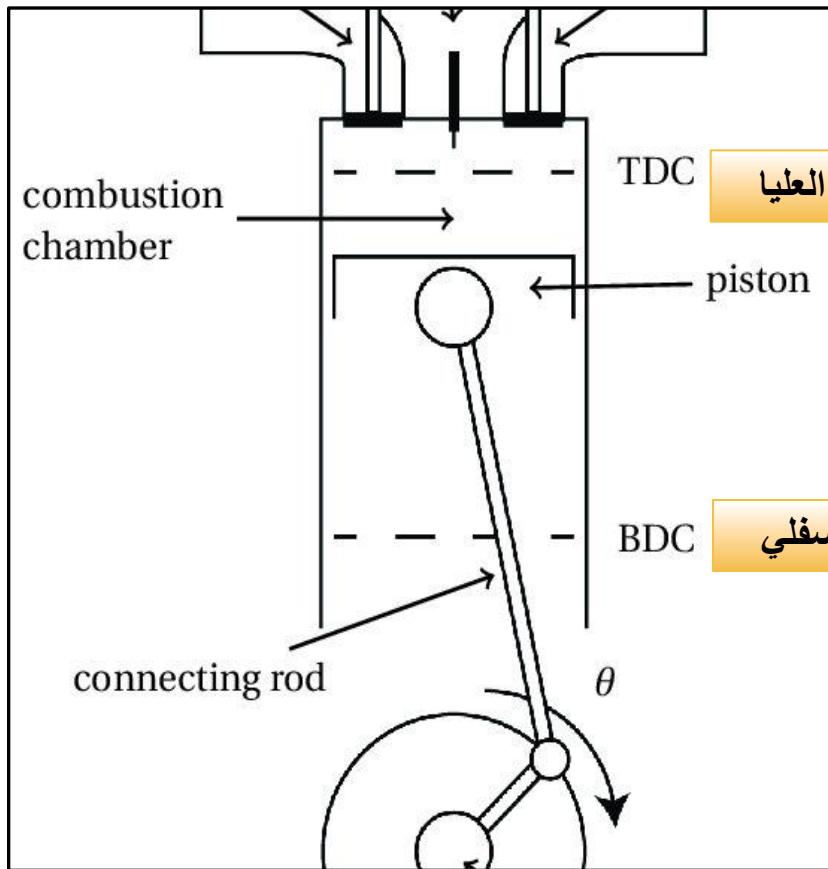
**Intake – Compression – Combustion - Exhaust**

الدورة الرباعية أو الأشواط الأربع في محرك الاحتراق الداخلي هي مجموعة من الإجراءات تتكرر مع دوران المحرك..

والدورة الرباعية تتكون من أربعة أشواط وهي:-  
**شوط السحب - شوط الضغط - شوط الاحتراق أو القدرة - شوط العادم**

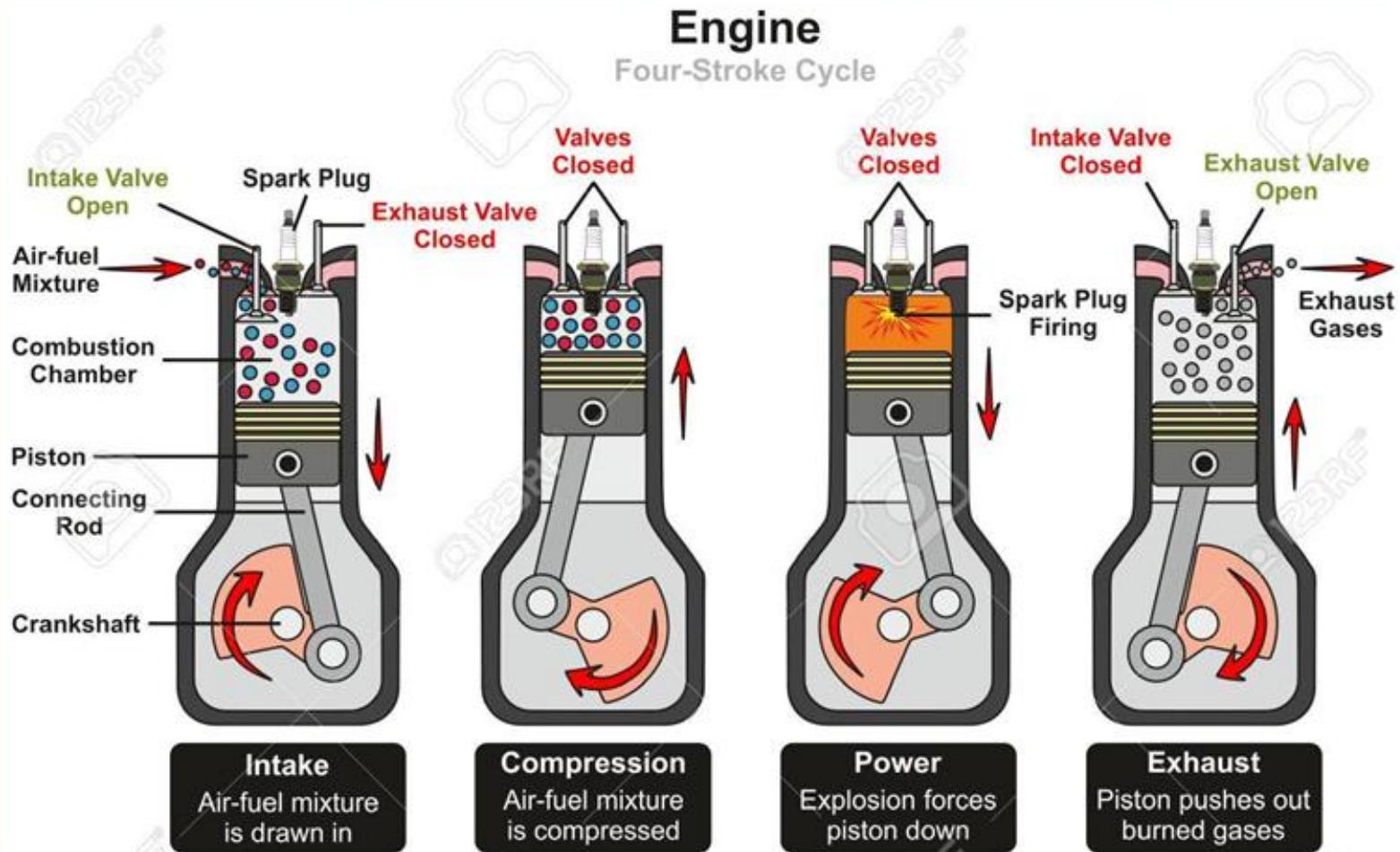


# Internal Combustion Engine Geometry



# الدورة الرباعية

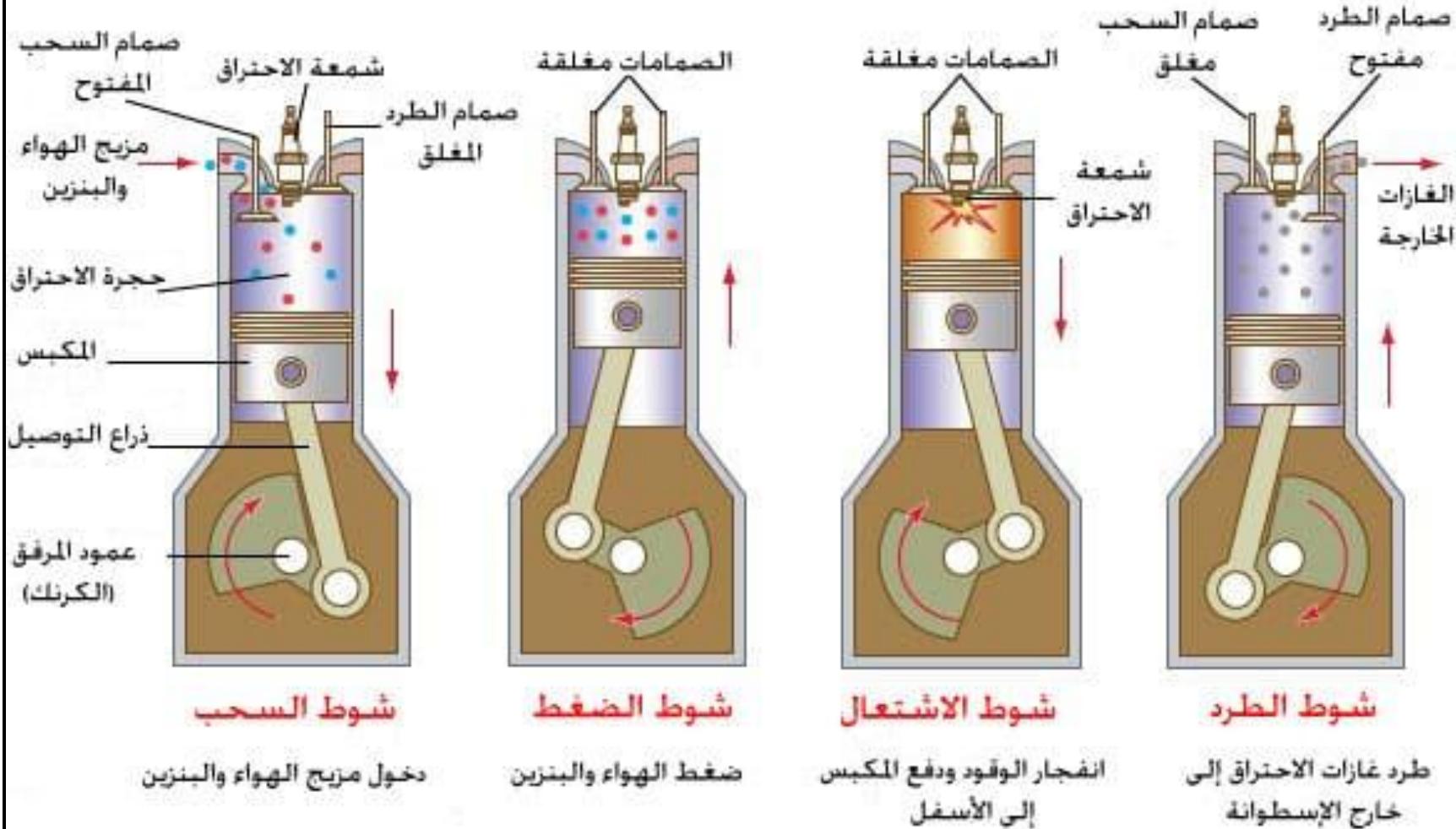
# Four Stroke Operating Cycle



Cycle of operation completed in four strokes of the piston or two revolution of the crankshaft.

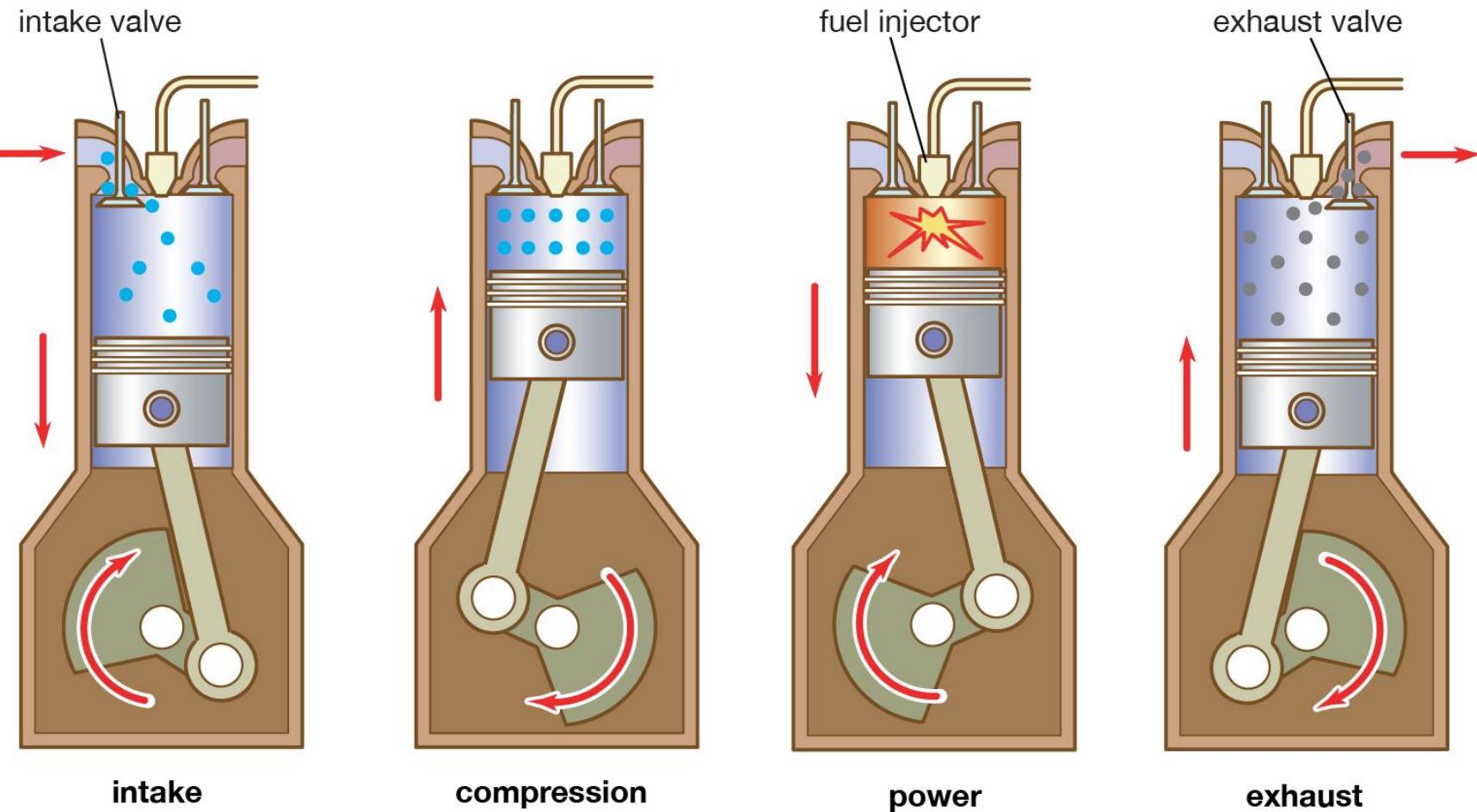
# الدورة الرباعية لمحركات الإشعال بالشارة (البنزين)

نلاحظ وجود شمعات الشرر Spark Plugs



# الدورة الرباعية لمحركات الإشعال بالضغط (الديزل)

نلاحظ وجود الرشاشات Injectors



# Four Stroke Operating Cycle

## **Suction stroke** (suction valve open, exhaust valve closed)

charge consisting of fresh air mixed with the fuel is drawn into the cylinder due to the vacuum pressure created by the movement of the piston from TDC to BDC.

١- شوط السحب : يبدأ شوط السحب عندما يتحرك المكبس من النقطة الميّتة العليا الى النقطة الميّتة السفلية ويحدث أثناء ذلك ما يلي:- ينخفض الضغط داخل الأسطوانة وينفتح صمام السحب ويندفع منه مزيج الهواء والوقود الى داخل الأسطوانة

## Four Stroke Operating Cycle..... Cont.

### **Compression stroke** (both valves closed)

fresh charge is compressed into clearance volume by the return stroke of the piston and ignited by the spark for combustion. Hence pressure and temperature is increased due to the combustion of fuel

٢- شوط الانضغاط وفيه يغلق صمام السحب ويتحرك المكبس من النقطة م سفلی نحو ن م العلیا ضاغطا المزدوج في حيز ضيق جدا في أعلى الأسطوانة

## Four Stroke Operating Cycle..... Cont.

### **Expansion stroke** (both valves closed)

high pressure of the burnt gases force the piston towards BDC and hence power is obtained at the crankshaft.

٣- شوط القدرة ويبدأ شوط القدرة عند اشعال المزيج المضغوط عن طريق شراراة شمعة الاشتعال اي البواجي والتي تعمل على اشعال المزيج بسرعة وبقوة فتعمل على دفع المكبس بقوة الى اسفل ويستفاد من هذه القدرة في ادارة عمود المرفق

## Four Stroke Operating Cycle..... Cont.

**Exhaust stroke** (exhaust valve open, suction valve closed)

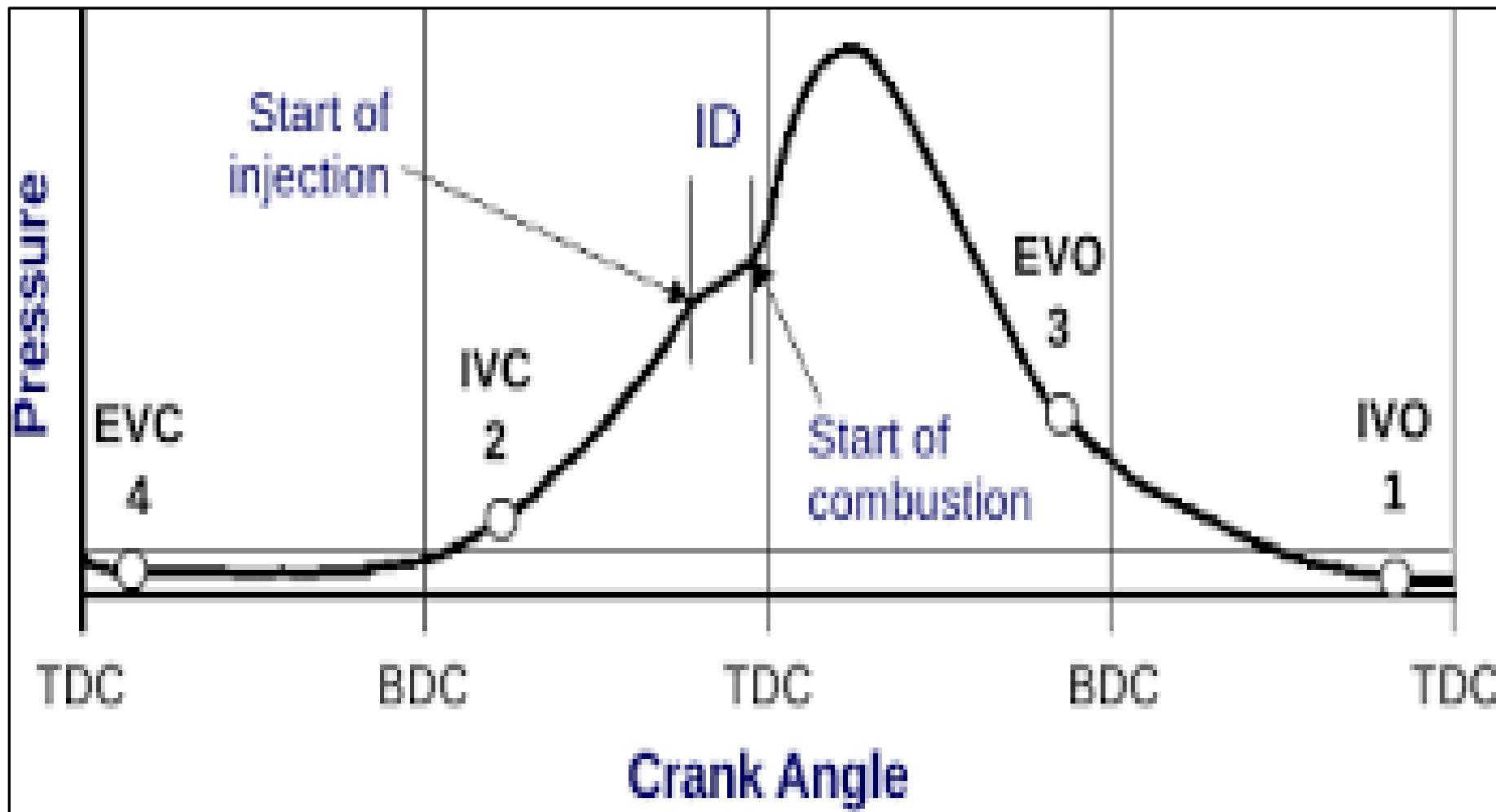
burned gases eject out due to the movement of piston from BDC to TDC.

٤- شوط العادم وفيه يفتح صمام العادم ويتحرك المكبس من النقطة الميّة السفلّى إلى النقطة الميّة العليا دافعاً أي طارداً الغازات والشوائب الناتجة عن الاحتراق إلى خارج الأسطوانة لخروج مع عادم السيارة

وبهذا تكون قد تمت دورة رباعية كاملة وتتكرر من جديد في كل أسطوانة من أسطوانات المحرك وهكذا تنتج الحركة

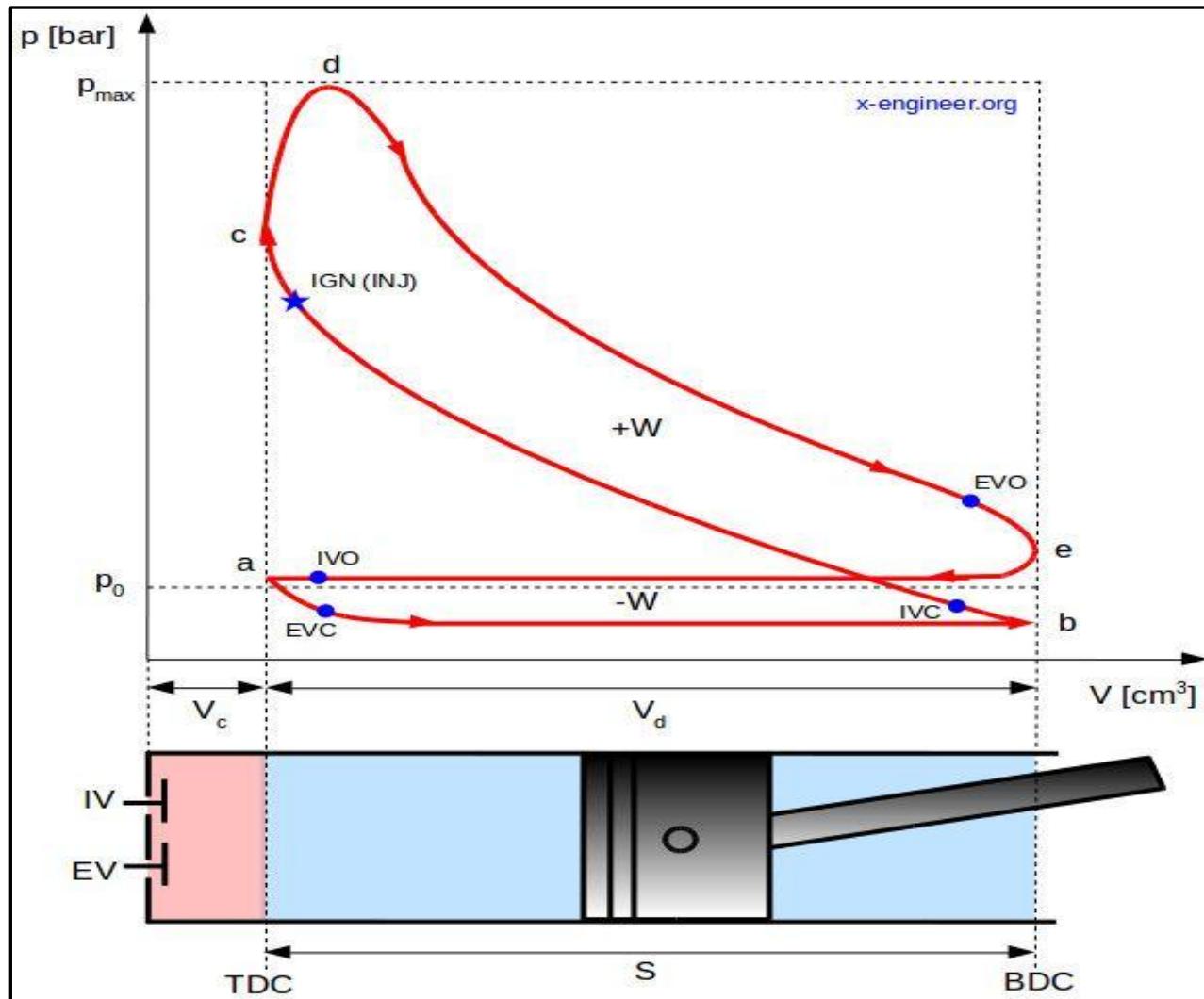
# Pressure – Crank angles Diagram

منحنى تغير الضغط داخل الاسطوانة مع درجات عمود المرفق  
أثناء الاشواط الاربعة



# Pressure – Volume Diagram for ICE

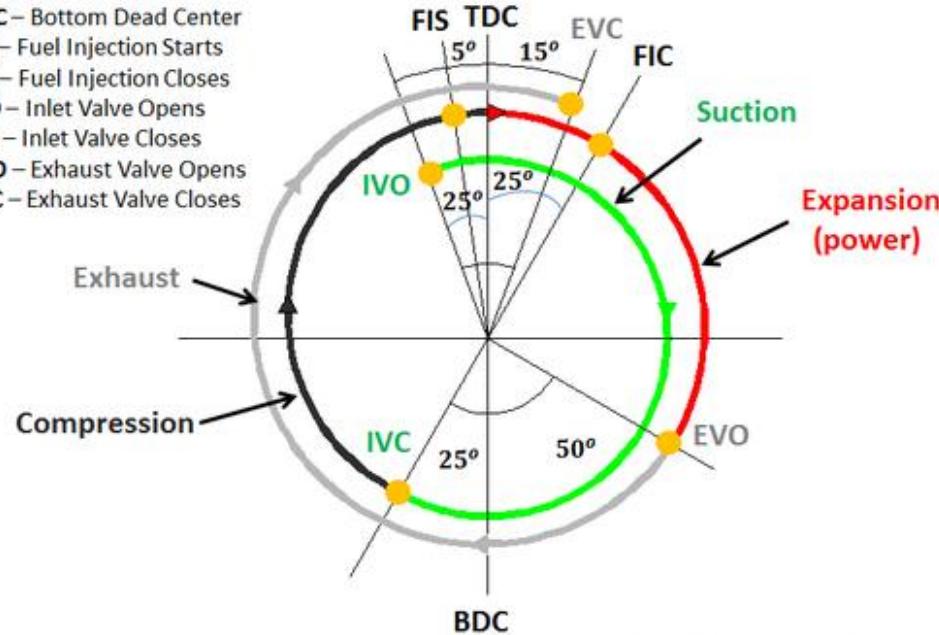
منحنى تغير الضغط مع الحجم داخل الاسطوانة  
أثناء الاشواط الاربعة



# Valve Timing Diagram of a Four Stroke IC Engine

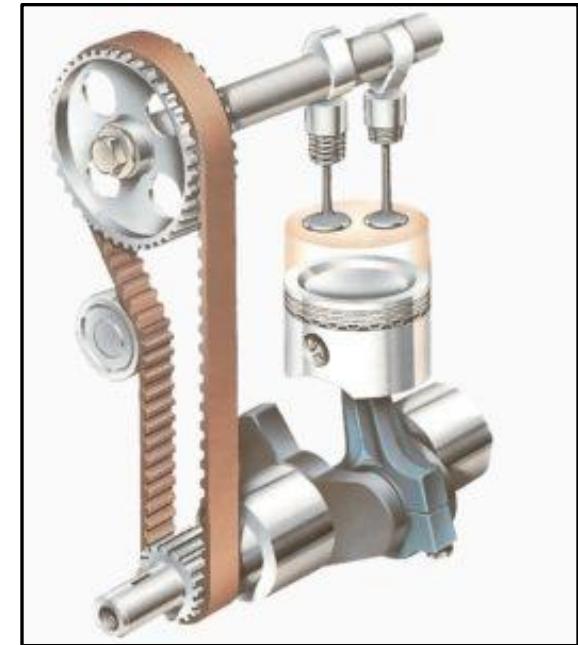
## منحنى توقيت الصمامات (فتح وغلق الصمامات) خلال الاشواط الاربعة

TDC - Top Dead Center  
BDC - Bottom Dead Center  
FIS - Fuel Injection Starts  
FIC - Fuel Injection Closes  
IVO - Inlet Valve Opens  
IVC - Inlet Valve Closes  
EVO - Exhaust Valve Opens  
EVC - Exhaust Valve Closes



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Valve Timing Diagram of 4 Stroke Diesel Engine



A valve timing diagram is a graphical representation of the opening and closing of the intake and exhaust valve of the engine. The opening and closing of the valves of the engine depend upon the movement of piston from TDC to BDC.



THANK YOU

# Two Stroke Operating Cycle

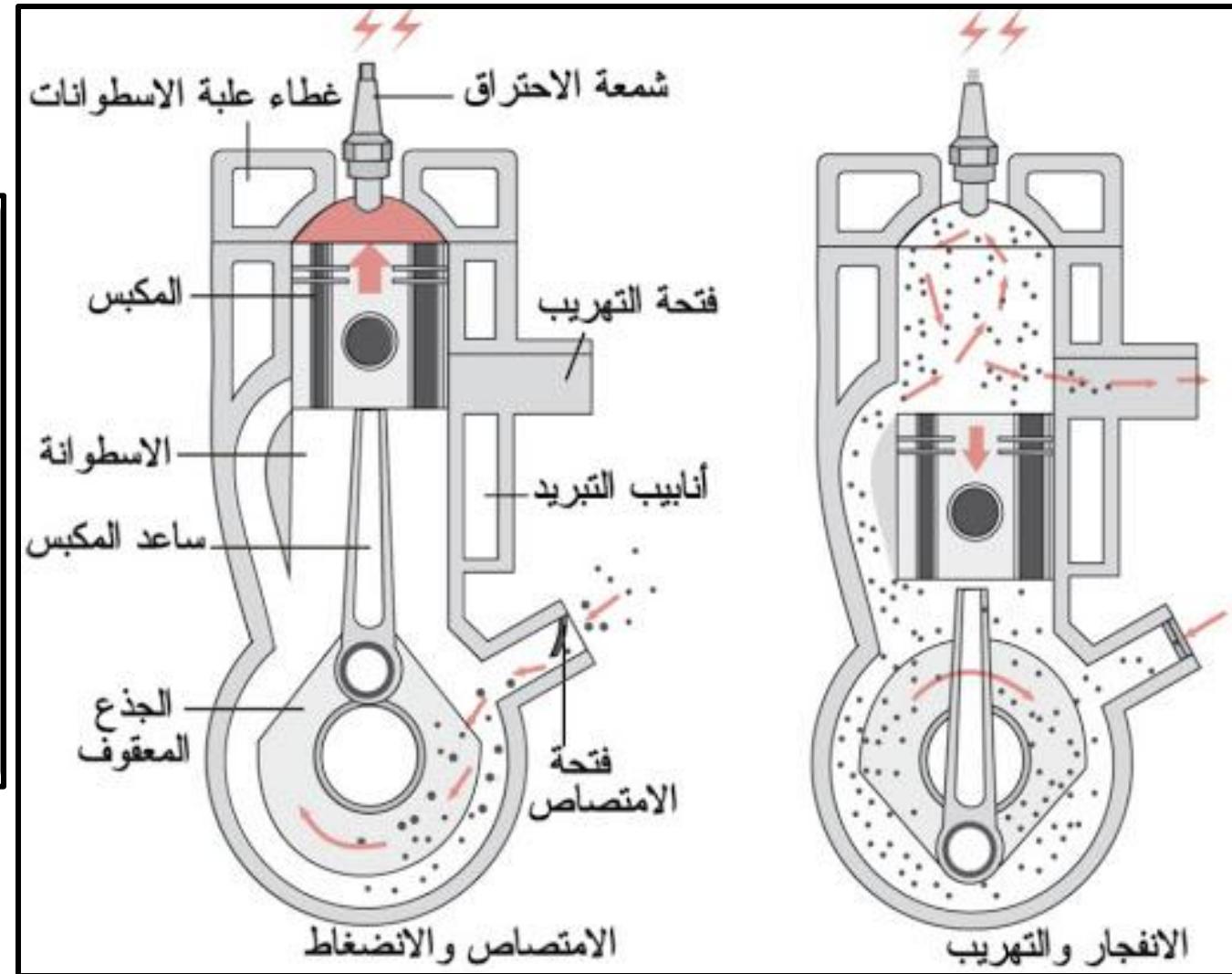
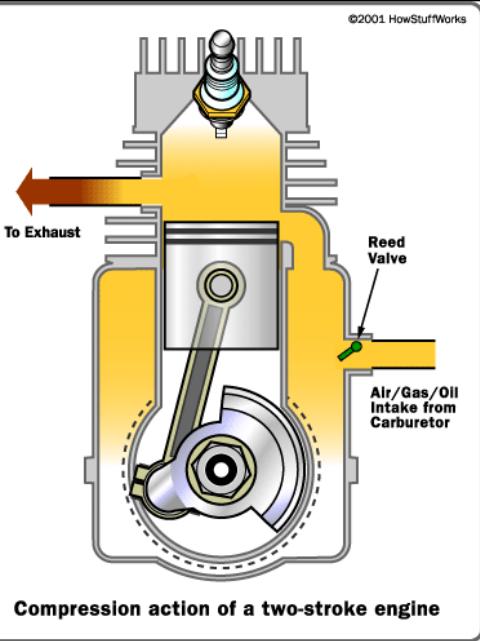
## الدورة الثانية

المحرك ثائي الأشواط:- هو محرك احتراق داخلي يعمل بشوطين اثنين فقط للمكبس ويقتصر شوطي ذلك المحرك على شوط الانضغاط وشوط الإشعال. ويمكنه في نفس الوقت أداء شوط سحب الشحنة وطرد غازات العادم عن طريق فتحات جانبية موجودة في الاسطوانه.  
يستعمل هذا النوع من المحركات بصفة خاصة في الدراجات النارية، والمنشار الآلي اليدوي.

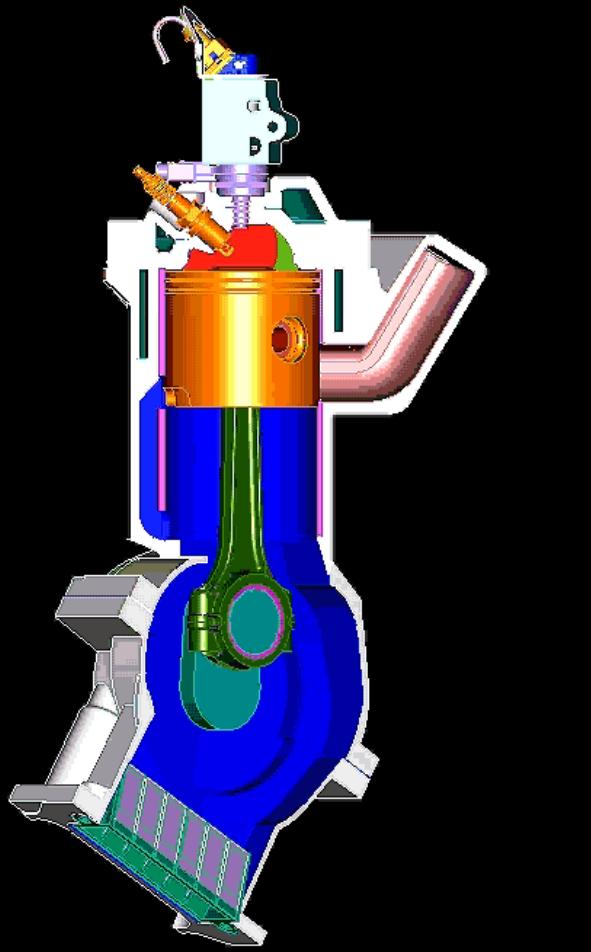
In two stroke cycle engines, the whole sequence of events i.e., suction, compression, power and exhaust are completed in two strokes of the piston i.e. one revolution of the crankshaft. There is no valve in this type of engine. Gas movement takes place through holes called ports in the cylinder.

# Simplified Drawing for Two Stroke Engine

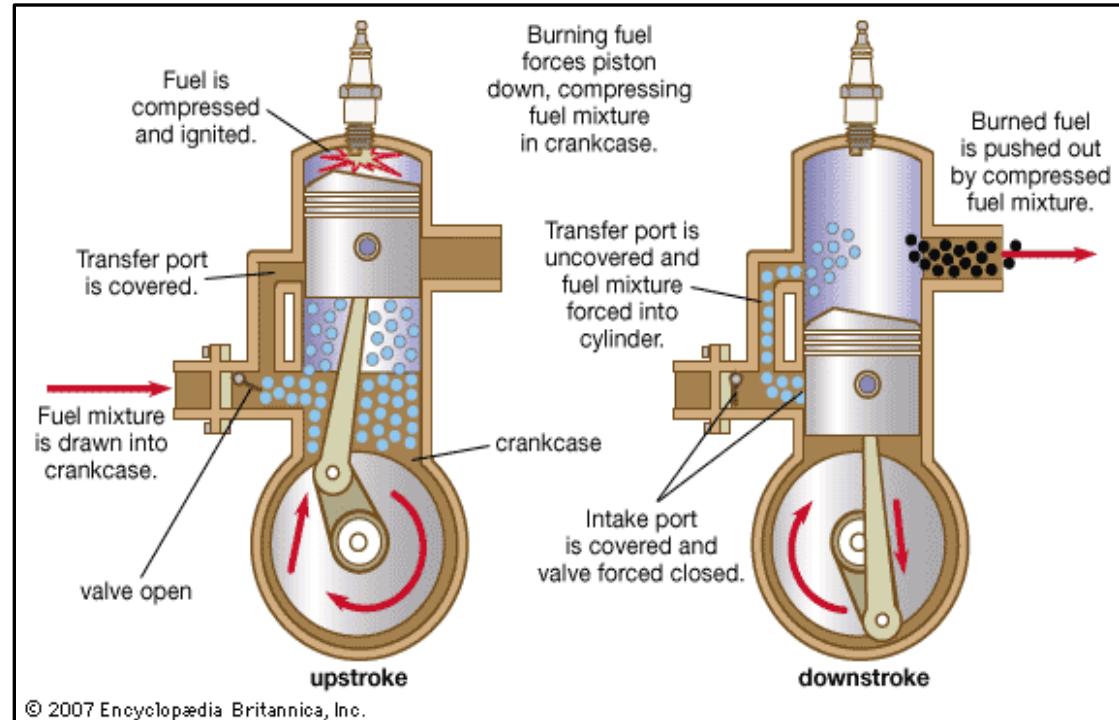
رسم مبسط لمحرك الورقة الثانية



# Two Stroke Engine Working Animation



[https://www.google.com/url?sa=i&url=https%3A%2F%2Fdragonmotorbikes.co.uk%2Fservices%2F2-stroke-tuning%2F&psig=AOvVaw0f\\_2xFHqqqcQNhjhmmvdVYd&ust=1615641140540000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCIj5w7rqqu8CFQAAAAAAAdAAAAABAV](https://www.google.com/url?sa=i&url=https%3A%2F%2Fdragonmotorbikes.co.uk%2Fservices%2F2-stroke-tuning%2F&psig=AOvVaw0f_2xFHqqqcQNhjhmmvdVYd&ust=1615641140540000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCIj5w7rqqu8CFQAAAAAAAdAAAAABAV)



## **Upward stroke of the piston (Suction + Compression)**

When the piston moves upward it covers two of the ports, the exhaust port and transfer port. This traps the charge of air- fuel mixture drawn already in to the cylinder. Further upward movement of the piston compresses the charge and also uncovers the suction port. Now fresh mixture is drawn through this port into the crankcase. Just before the end of this stroke, the mixture in the cylinder is ignited by a spark plug. Thus, during this stroke both suction and compression events are completed.

## **Downward stroke (Power + Exhaust)**

Burning of the fuel rises the temperature and pressure of the gases which forces the piston to move down the cylinder. When the piston moves down, it closes the suction port. Further downward movement of the piston uncovers first the exhaust port and then the transfer port. Now fresh charge in the crankcase moves in to the cylinder through the transfer port driving out the burnt gases through the exhaust port. During the downward stroke of the piston power and exhaust events are completed.

# Upstroke (compression + Suction )

- \* Intake Port opens and fuel mixture is drawn into crankcase كشف فتحة الدخول
- \* Transfer port is covered تغطية فتحة التحويل
- \* Fuel mixture is compressed and ignited ضغط الشحنة واحتراقها
- \* Piston covers exhaust port during compression تغطية فتحة خروج العادم

# Downstroke (Combustion + Exhaust)

- \* Combustion forces piston down دفع المكبس لأسفل نتيجة الاحتراق
- \* Intake port is covered تغطية فتحة الدخول
- \* Transfer port is uncovered forcing fuel mixture into cylinder كشف فتحة التحويل
- \* This fuel mixture pushes the exhaust out الشحنة الجديدة تساعد على طرد العادم

## طريقة عمل المحرك شاثي الأشواط:

إذا تخيلنا وجود شحنة من الوقود والهواء داخل الأسطوانة، وكان المكبس عند وضعه الأسفل بالأسطوانة، فعند تحرك المكبس إلى أعلى فإنه يقوم بضغط شحنة الوقود والهواء وفي نفس الوقت يقوم بتوليد خلخلة داخل علبة المرفق المحكمة. هذا التخلخل يقوم بفتح صمام صغير "صمام ريد" ومن ثم يسمح بدخول خليط الوقود والهواء إلى علبة المرفق.

عندما يصل المكبس إلى أعلى الأسطوانة في مشواره فإنه عندئذ يكون قد قام بضغط الشحنة في الأسطوانة وقام بتباعتها علبة المرفق بخليط الوقود والهواء. يحدث هذا كله في شوط واحد أي نصف دورة لعمود المرفق.

تطلق شمعة الإشعال شرارة كهربائية بالشحنة داخل الأسطوانة في نهاية الشوط ويؤدي ذلك إلى الاحتراق ومن ثم دفع المكبس إلى الأسفل والحصول على القدرة الميكانيكية. عند تحرك المكبس للأسفل يحدث عدة أشياء: يتم ضغط خليط الوقود والهواء في علبة المرفق ويغلق صمام ريد في نفس الوقت الذي يحدث فيه شوط القدرة. وعندما يكشف المكبس مع نزوله للأسفل عن فتحة العادم، فإنفازات الاحتراق تتساب إلى الخارج من خلال تلك الفتحة فيحدث طرد العادم. ومع استمرار حركة المكبس للأسفل فإنه يكشف عن فتحة الدخول فيدفع الخليط المضغوط بعلبة المرفق إلى الدخول للأسطوانة من خلال الممر وفتحة الدخول.

# Advantages

- \* Less parts = Lighter خفيف الوزن واجزاء قليلة
- \* 2x power of four stroke ضعف قدرة الورقة الرباعية
- \* Cheaper, less complex and easier to work on رخيص وبسيط
- \* Can work in any orientation - upside down يمكنه العمل على اي وضع

# Disadvantages

- \* No dedicated lubrication system لا يحتاج نظام تزييت
- \* Require expensive oil to be mixed with fuel يحتاج زيت غالى الثمن
- \* Produce a lot of pollution due to burning of gas and oil. ينتج ملوثات كثيرة بسبب احتراق الزيت مع الوقود

# Applications

- \* Two stroke engines are found on:
  - \* Weed trimmers معدات قص الحشائش
  - \* Snowmobiles عربات الثلوج
  - \* Older dirt bikes الدراجات الترابية القديمة
  - \* Chainsaws مناشير
  - \* Nitro R/C Cars سيارات نيترو



# Comparison between four-stroke engine and two-stroke engine

Four-stroke engine	Two-stroke engine
<ul style="list-style-type: none"><li>• Four stroke of the piston and two revolution of crankshaft</li></ul>	<ul style="list-style-type: none"><li>• Two stroke of the piston and one revolution of crankshaft</li></ul>
<ul style="list-style-type: none"><li>• One power stroke in every two revolution of crankshaft</li></ul>	<ul style="list-style-type: none"><li>• One power stroke in each revolution of crankshaft</li></ul>
<ul style="list-style-type: none"><li>• Heavy in weight</li></ul>	<ul style="list-style-type: none"><li>• Light and compact</li></ul>
<ul style="list-style-type: none"><li>• Contains valve and valve mechanism</li></ul>	<ul style="list-style-type: none"><li>• Contains ports arrangement</li></ul>
<ul style="list-style-type: none"><li>• Higher initial cost</li></ul>	<ul style="list-style-type: none"><li>• Cheaper initial cost</li></ul>
<ul style="list-style-type: none"><li>• Volumetric efficiency is more due to greater time of induction</li></ul>	<ul style="list-style-type: none"><li>• Volumetric efficiency less due to lesser time of induction</li></ul>
<ul style="list-style-type: none"><li>• Thermal efficiency is high</li></ul>	<ul style="list-style-type: none"><li>• Thermal efficiency is low</li></ul>
<ul style="list-style-type: none"><li>• Ex-cars, buses, trucks, tractors, industrial engines, aero planes, power generation etc.</li></ul>	<ul style="list-style-type: none"><li>• Ex- scooters, motor cycles</li></ul>

# Comparison of SI and CI engine

SI engine	CI engine
<ul style="list-style-type: none"><li>Working cycle is Otto cycle.</li></ul>	<ul style="list-style-type: none"><li>Working cycle is diesel cycle.</li></ul>
<ul style="list-style-type: none"><li>Petrol or gasoline or high octane fuel is used.</li></ul>	<ul style="list-style-type: none"><li>Diesel or high Cetane fuel is used.</li></ul>
<ul style="list-style-type: none"><li>Fuel and air introduced as a gaseous mixture in the suction stroke.</li></ul>	<ul style="list-style-type: none"><li>Fuel is injected directly into the combustion chamber at high pressure at the end of compression stroke.</li></ul>
<ul style="list-style-type: none"><li>Carburetor used to provide the mixture.</li></ul>	<ul style="list-style-type: none"><li>Injector and high pressure pump used to supply of fuel.</li></ul>
<ul style="list-style-type: none"><li>Use of spark plug for ignition system</li></ul>	<ul style="list-style-type: none"><li>Self-ignition by the compression of air which increased the temperature required for combustion</li></ul>
<ul style="list-style-type: none"><li>Volumetric efficiency is more due to greater time of induction</li></ul>	<ul style="list-style-type: none"><li>Volumetric efficiency less due to lesser time of induction</li></ul>
<ul style="list-style-type: none"><li>Compression ratio is 6 to 10.5</li></ul>	<ul style="list-style-type: none"><li>Compression ratio is 14 to 22</li></ul>
<ul style="list-style-type: none"><li>Higher maximum RPM due to lower weight</li></ul>	<ul style="list-style-type: none"><li>Lower maximum RPM</li></ul>

# Engine Traditional Systems

- Cooling System منظومة التبريد في المحرك
- Lubrication System منظومة التزييت في المحرك
- Fuel System منظومة الوقود في المحرك
- Ignition System منظومة الالشعال
- Exhaust System نظام طرد غازات العادم
- Air Intake System منظومة دخول الهواء للمحرك

# Engine Traditional Systems, cont....

## • Cooling System

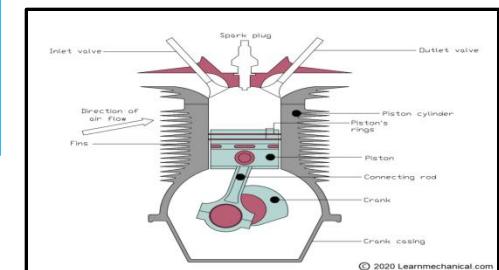
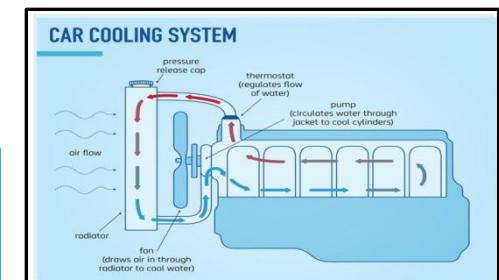
There are two types of cooling systems:

- (i) Air cooling system.
- (ii) Water-cooling system.

The cooling system serves three important functions.

- it removes excess heat from the engine.
- it maintains the engine operating temperature during working.  
it brings the engine up to the right operating temperature as quickly as possible.

نظام تبريد المحرك Cooling system من أهم الأجزاء في السيارة، وهو أحد أهم مكونات المحرك المسئولة عن الحفاظ على درجة الحرارة طبيعية والتي تبلغ حوالي ٨٠ درجة مئوية، كما أنه مسؤول عن نقل حرارة غرفة الاحتراق إلى كل أجزاء المحرك، مما يحسن من كفاءة عمل المحرك، إضافة إلى أنه يحول دون ارتفاع درجة حرارة المحرك أكثر من اللازم



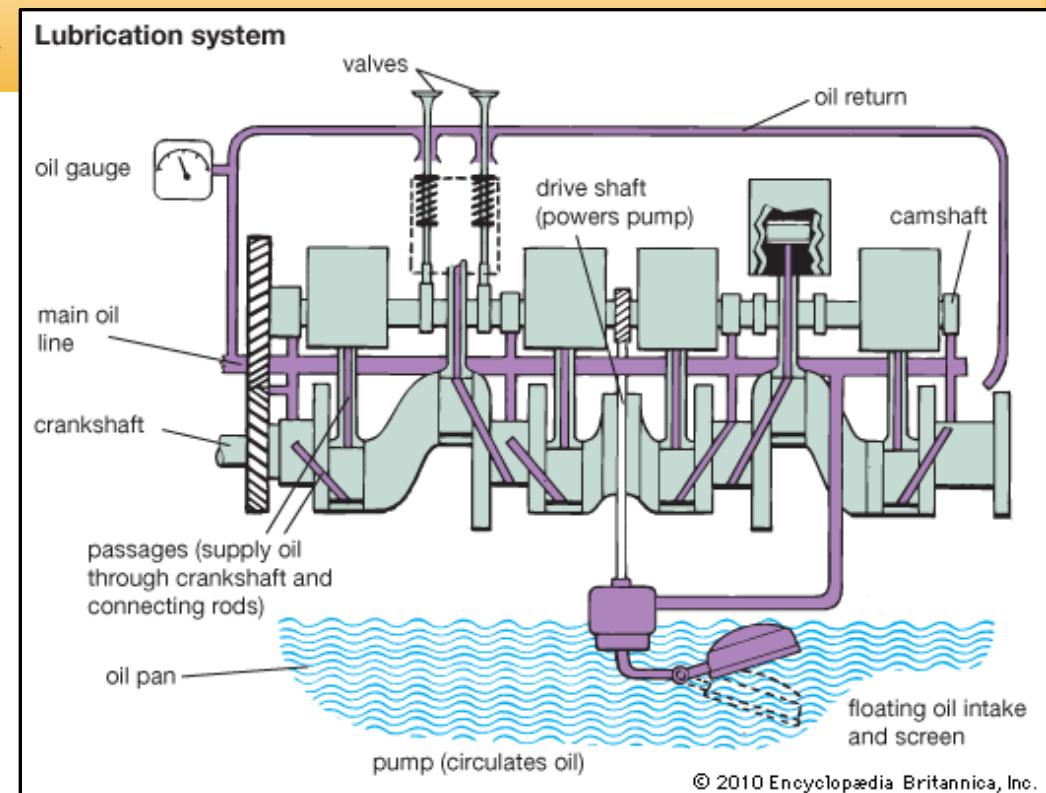
# Engine Traditional Systems, cont....

## • Lubrication System

The function of the lubrication system is:-

Distribute oil to the moving parts to reduce friction between surfaces which rub against each other.

يهدف نظام تزييت المحرك إلى توزيع الزيت على الأجزاء المتحركة لقليل الاحتكاك بين الأسطح. يلعب التزييت دوراً رئيسياً في العمر المتوقع للمحرك. في حالة تعطل نظام التزييت ترتفع درجة حرارة المحرك بشدة و ينهار بسرعة كبيرة.



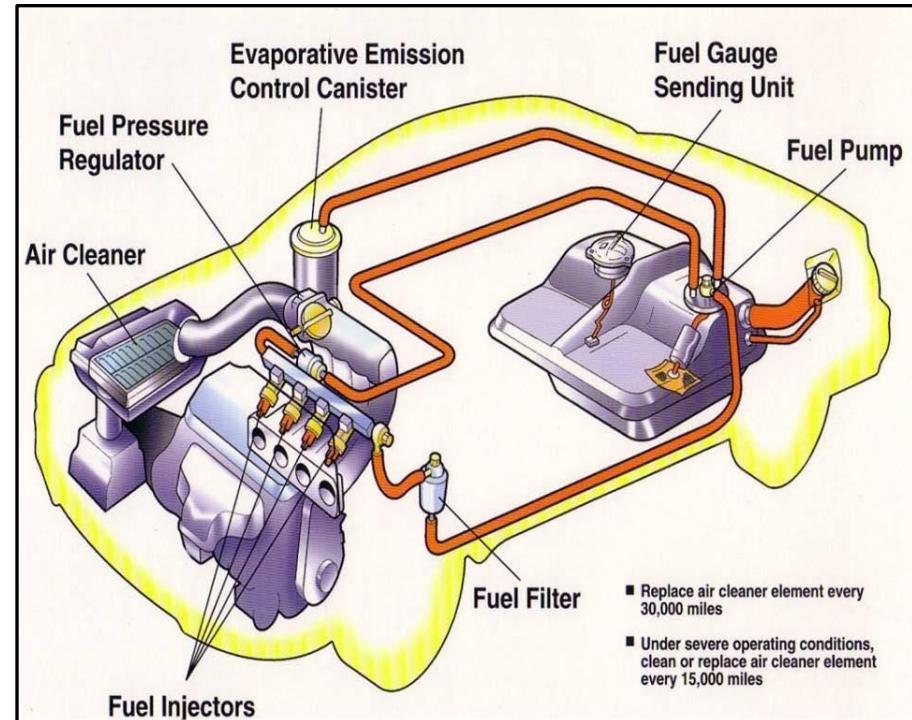
# Engine Traditional Systems, cont....

## • Fuel System

The function of the fuel system is to store and supply fuel to the engine where it can be mixed with air, vaporized, and burned to produce energy.

نظام وقود المحرك هو اسم آخر لنظام تزويد الوقود. وهو مخصص لتزويد محرك السيارة بالوقود ، وكذلك لتخزينه وتنظيفه. يشتمل تصميم نظام الوقود في السيارة على خزان وقود ، ومضخة وقود ، وفلتر وقود ، ونظام حقن متصل على التوالي بخطوط الوقود.

Fuel System

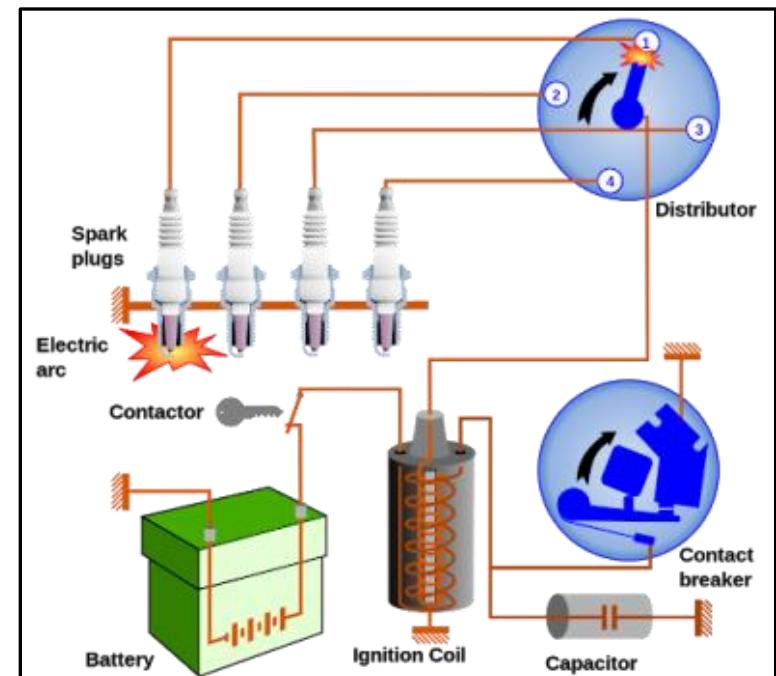


# Engine Traditional Systems, cont....

## • Ignition System

The purpose of the ignition system is to create an electric spark in the engine combustion chamber, at exactly the right time, which will ignite the mixture of fuel and air.

نظام الإشعال في المحرك ignition system، هو عملية إطلاق شرارة على كهربائية بين قطبي شمعة الإشعال spark plug في غرفة احتراق المحرك، تسبب في اشتعال مزيج الوقود والهواء المضغوط واحتراقه ومن ثم في دوران المحرك. ويستخدم الإشعال بالشرارة الكهربائية في محركات الاحتراق الداخلي العاملة بالوقود الخفيف السائل أو الغازي.

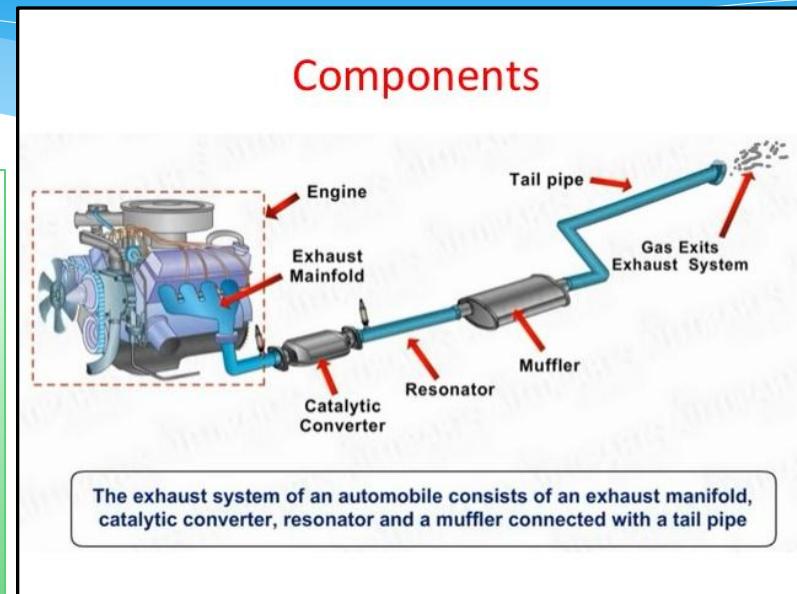


# Engine Traditional Systems, cont....

## • Exhaust System

Exhaust system has four main functions:

- Control noise,
- Direct exhaust gases away from passengers,
- Improve the performance of the engine and
- Improve fuel consumption.



ما هو نظام العادم في السيارة؟

يقوم نظام العادم بالعديد من الوظائف، منها طرد الغازات التي تنتج من احتراق الوقود من [المحرك](#) إلى مؤخرة السيارة للتخلص منها وإخراجها للهواء الجوي، وتقليل الضوضاء التي تنتج أثناء خروج العادم من المحرك، بالإضافة إلى معالجة الانبعاثات الضارة التي تخرج من المحرك قبل خروجها للهواء الجوي، وتقليل الضغط العكسي للحصول على أعلى قدرة وحماية مجموعة الصمامات بالمحرك، كذلك حماية كابينة السيارة الداخلية بالعمل على منع غازات العادم بالدخول إليها.

# Engine Traditional Systems, cont....

## • Air Intake System

### Air intake system



The air intake system's purpose is to let air travel to your engine. Oxygen within the air is one of the prime components for engine combustion.

### أنظمة سحب الهواء للمحرك:



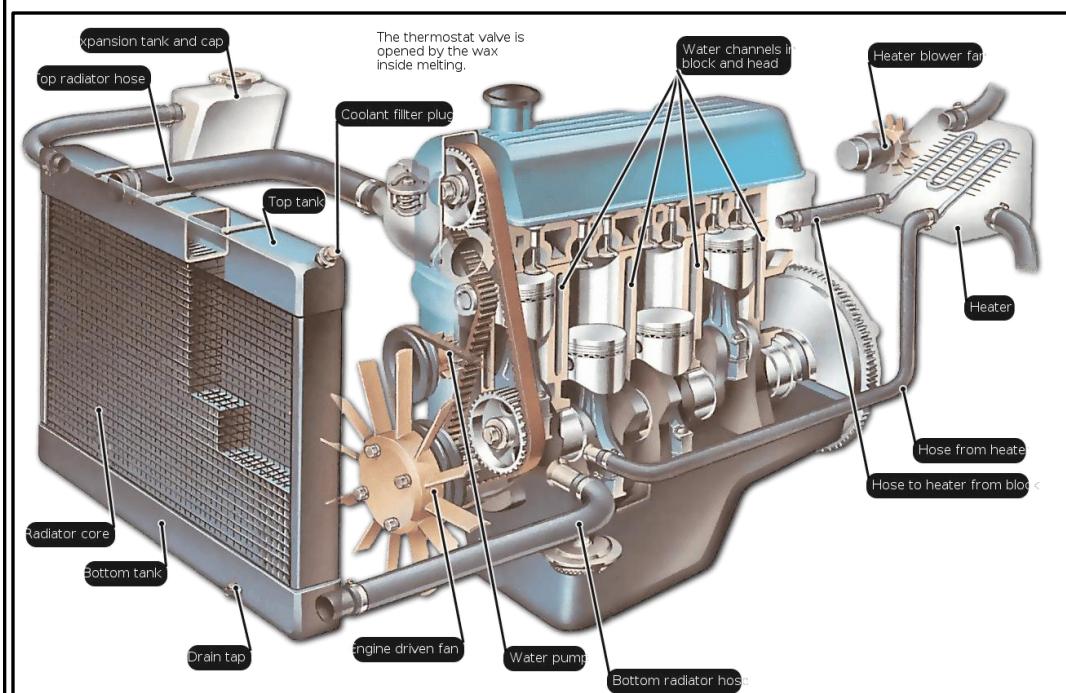
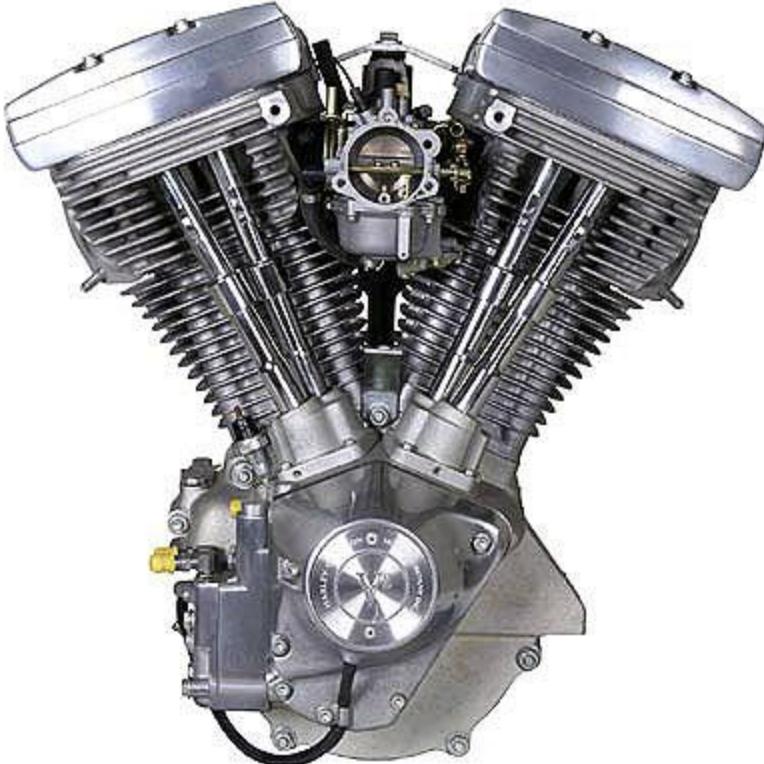
أيضاً يعمل نظام السحب على تنقية الهواء من أي شوائب قبل أن يدخل إلى **اسطوانات المحرك**، وأيضاً يقوم بتنحيف الضوضاء التي تنتج عن عملية سحب الهواء، حيث يدخل الهواء إلى المحرك بالسحب عن طريق الخلخلة التي تتولد خلال شوط سحب **المكبس**، حيث يخلط الهواء مع الوقود ويتم توريده إلى اسطوانات المحرك، التحكم في سريان الهواء وسريان خليط الوقود والهواء هو الوظيفة الرئيسية لنظام السحب.



**Question?**

# Cooling Systems

A system, which controls the engine temperature, is known as a cooling system.



# • **Necessity of Cooling System**

➤ **The cooling system is provided in the IC engine for the following reasons:**

1. The temperature of the burning gases in the engine cylinder reaches up to 1500 to 2000°C, which is above the melting point of the material of the cylinder body and head of the engine.
2. Due to very high temperatures, the film of the lubricating oil will get oxidized, thus producing carbon deposits on the surface.
3. Due to overheating, large temperature differences may lead to a distortion of the engine components due to the thermal stresses set up.
4. Higher temperatures also lower the volumetric efficiency of the engine.

# Requirements of Efficient Cooling System

➤ **The main requirements of an efficient cooling system are:**

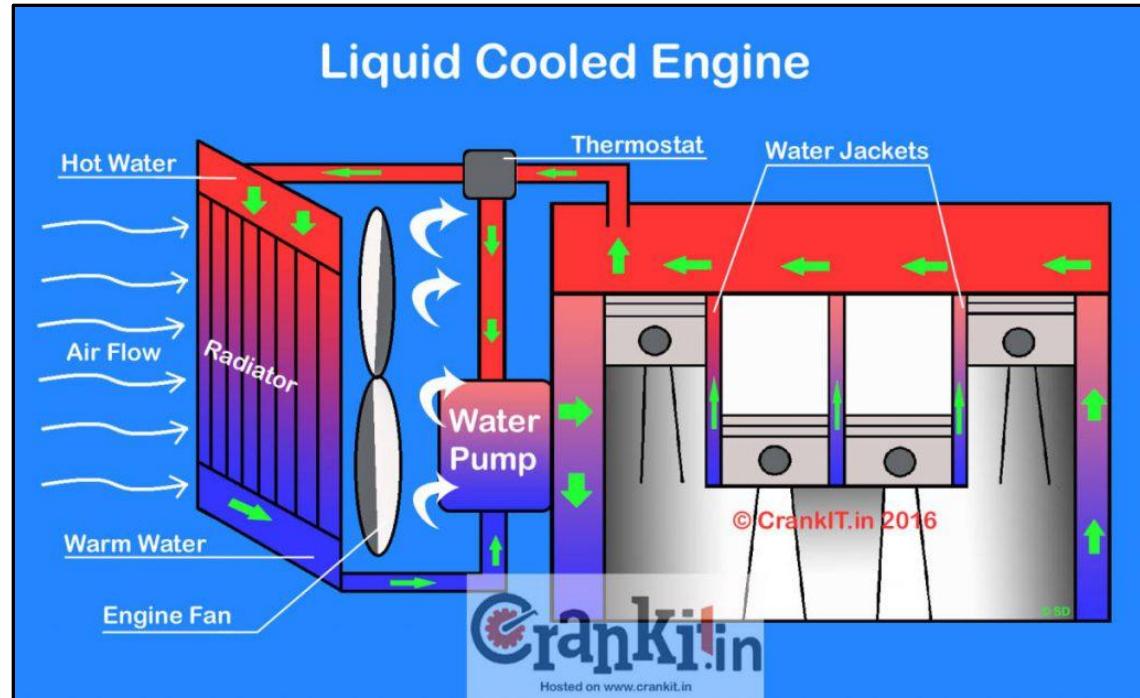
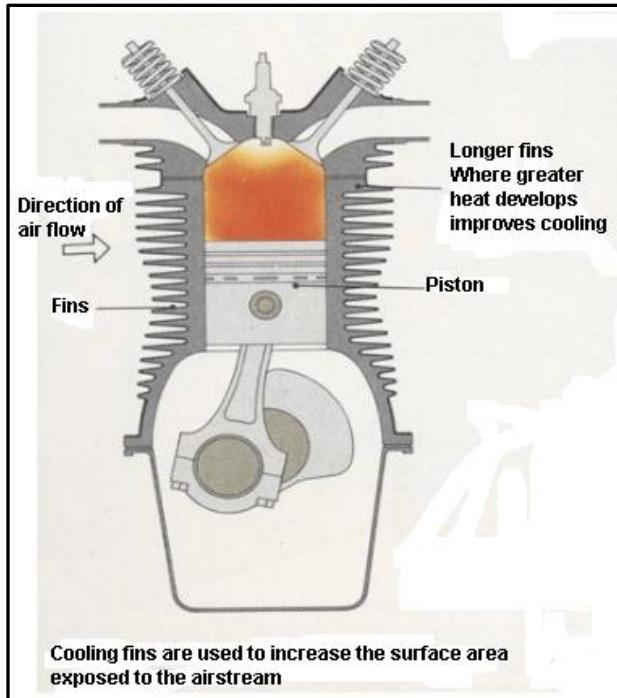
- It must be capable of removing only about 30% of the heat generated in the combustion chamber. Too much removal of heat lowers the thermal efficiency of the engine.
- It should remove heat at a fast rate when the engine is hot.
- During the starting of the engine, the cooling should be very slow so that the different working parts reach their operating temperatures in a short time.

# Types of Cooling System

There are two types of cooling systems:

**(i) Air cooling system.**

**(ii) Water-cooling system.**



# Air cooling system

Air-cooling is mostly tractors of less horsepower, motorcycles, scooters, small car engines where the forward motion of the machine gives good velocity to cool the engine.



**The amount of heat carried off by the air-cooling depends upon the following factors:**

- (i) The total area of the fin surfaces,
- (ii) The velocity and amount of the cooling air and
- (iii) The temperature of the fins and of the cooling air.

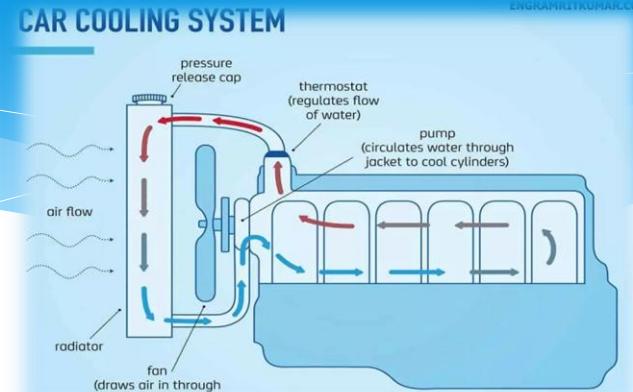
# **Advantages of Air Cooled Engines**

- 1. Its design of air-cooled engine is simple.**
- 2. It is lighter in weight than water-cooled engines.**
- 3. It is cheaper to manufacture.**
- 4. It needs less care and maintenance.**
- 5. This system of cooling is particularly advantageous where there is scarcity of water as in deserts.**
- 6. No risk of damage such as cracking of cylinder jackets or radiator water tubes.**

# Water cooling system

**It serves two purposes in the working of an engine:**

- It takes away the excessive heat generated in the engine and saves it from over heating.
- It keeps the engine at working temperature for efficient and economical working.

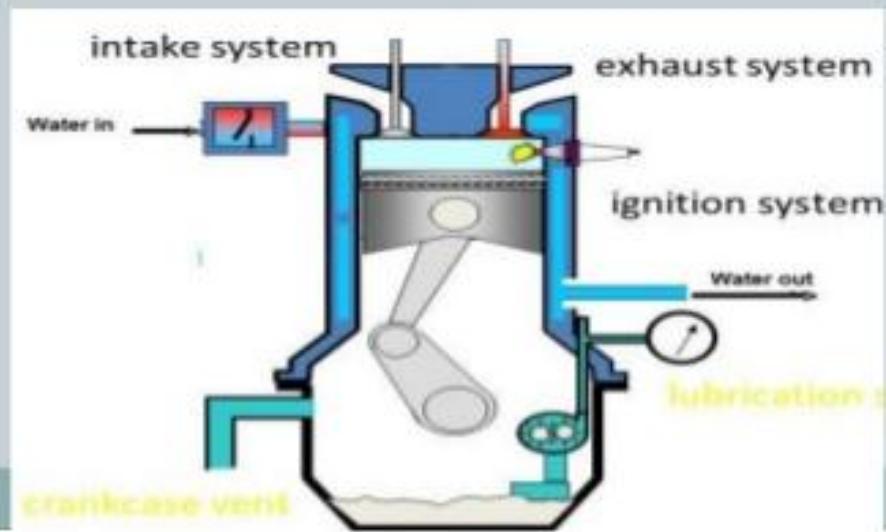


**This cooling system has four types of systems:**

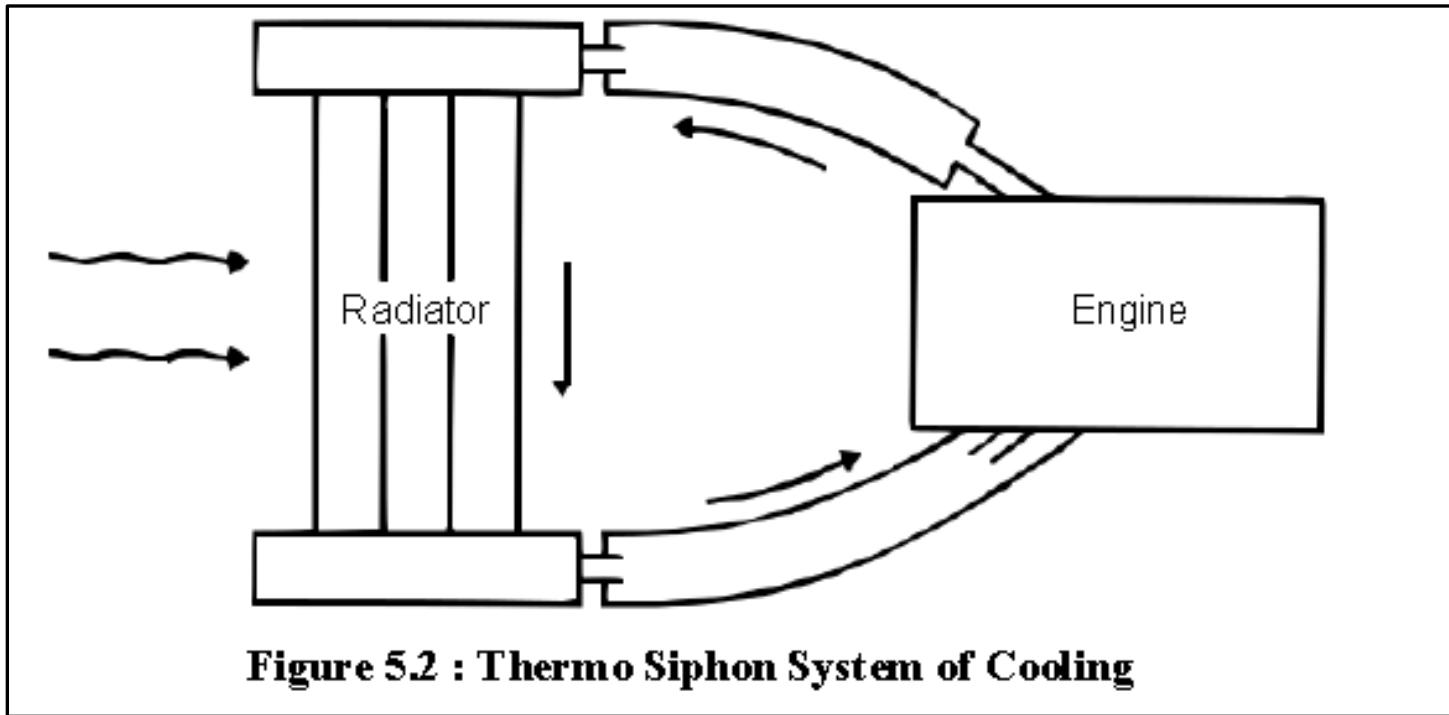
- (i) Direct or non-return system,
- (ii) Thermo-Siphon system,
- (iii) Pump/forced circulation system

## (i) Direct or non-return system,

- ✓ This is suitable for large installations and where **plenty of water** is available.
- ✓ The water from a storage **tank** is directly supplied to the **walls** of engine cylinder.
- ✓ The hot water is not cooled for reuse but simply discharges.

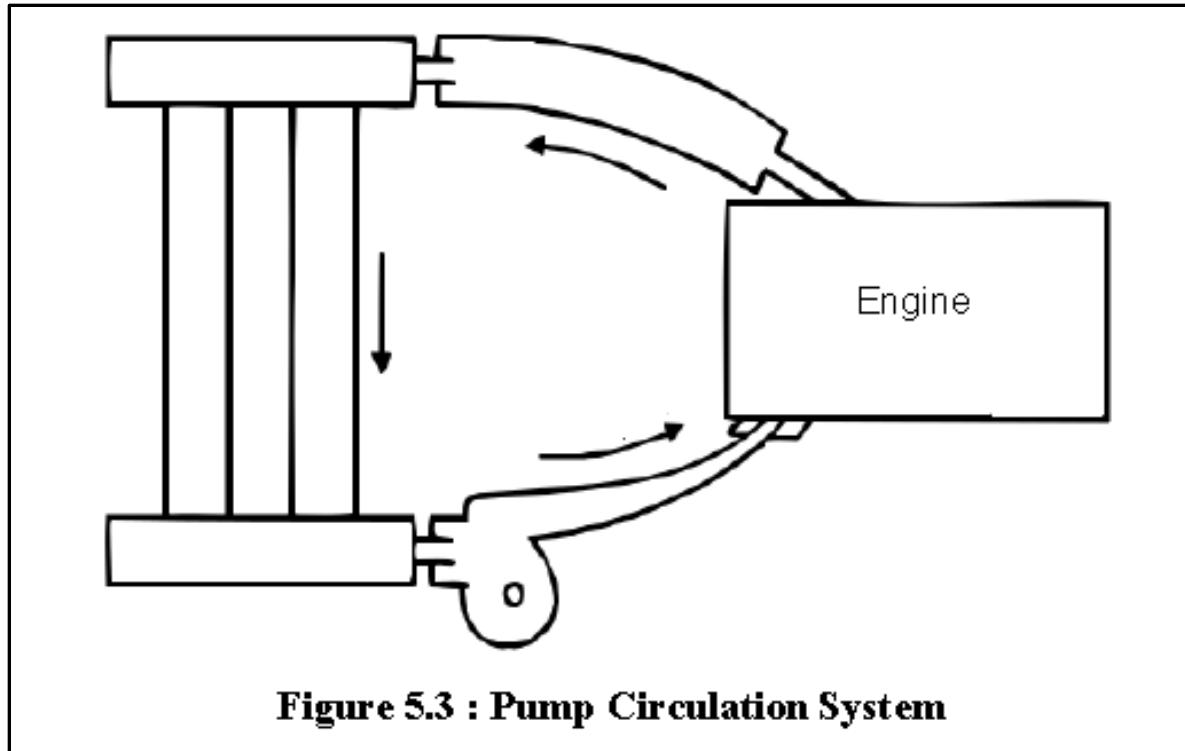


## (ii) Thermo-Siphon system,



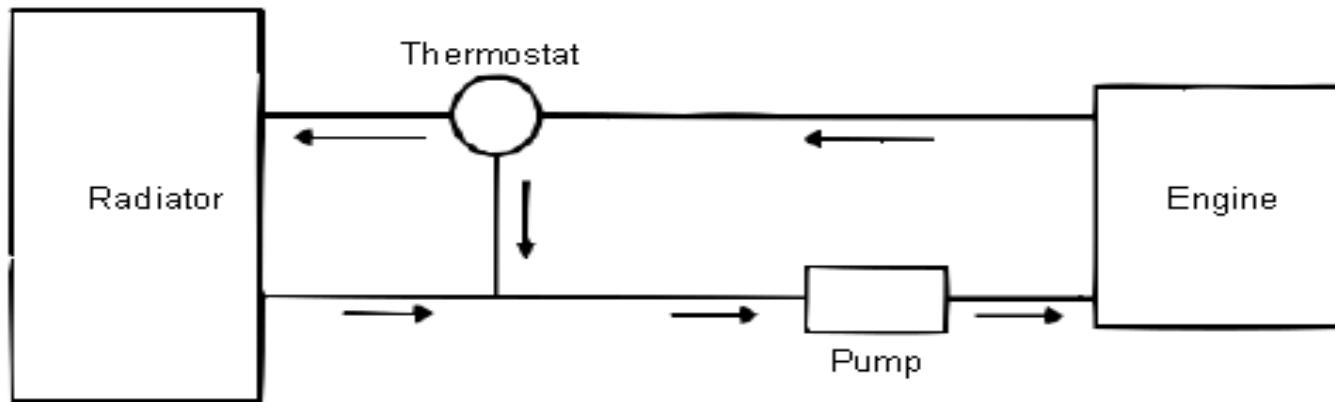
In this system the circulation of water is due to difference in temperature (i.e. difference in densities) of water.

### (iii) Pump/forced circulation system

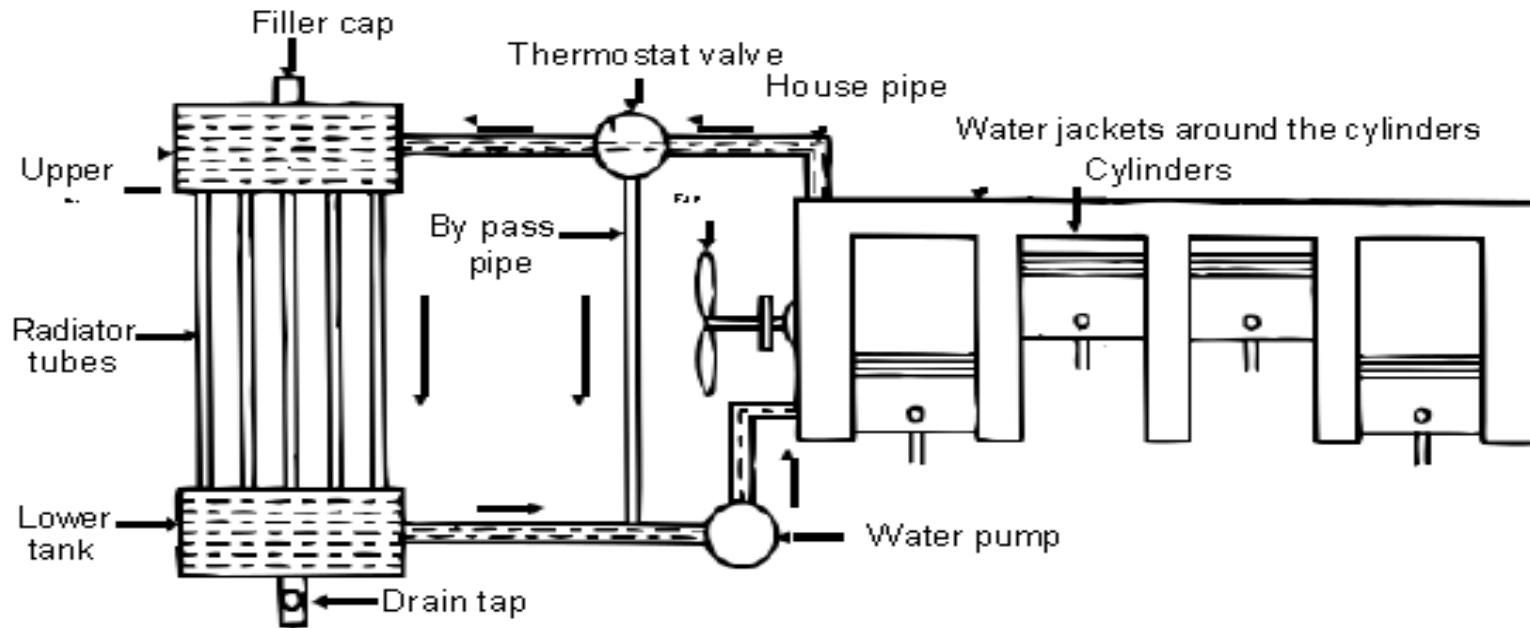


In this system circulation of water is obtained by a pump. This pump is driven by means of engine output shaft through V-belts.

# Components of Water Cooling System



**Figure 5.4 : Water Cooling System using Thermostat Valve**



**Figure 5.5 : Water Cooling System of a 4-cylinder Engine**

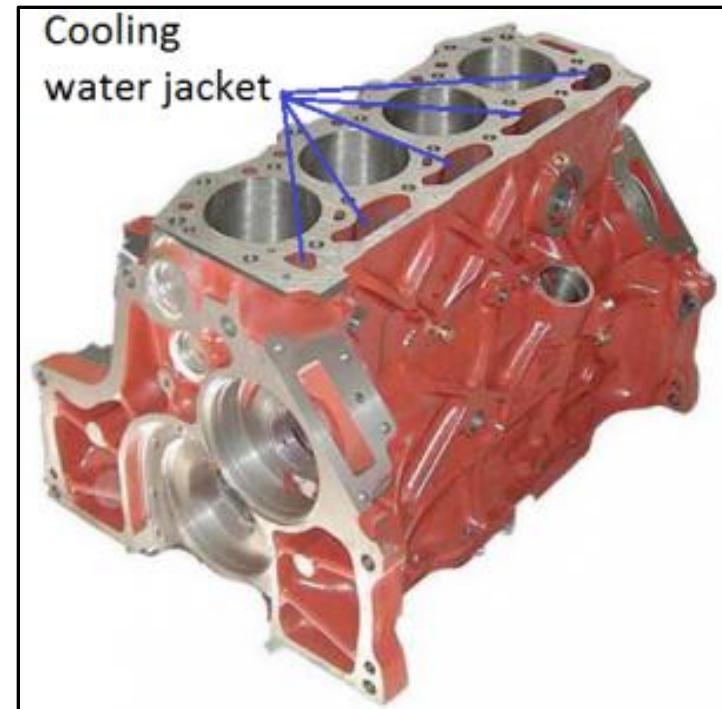
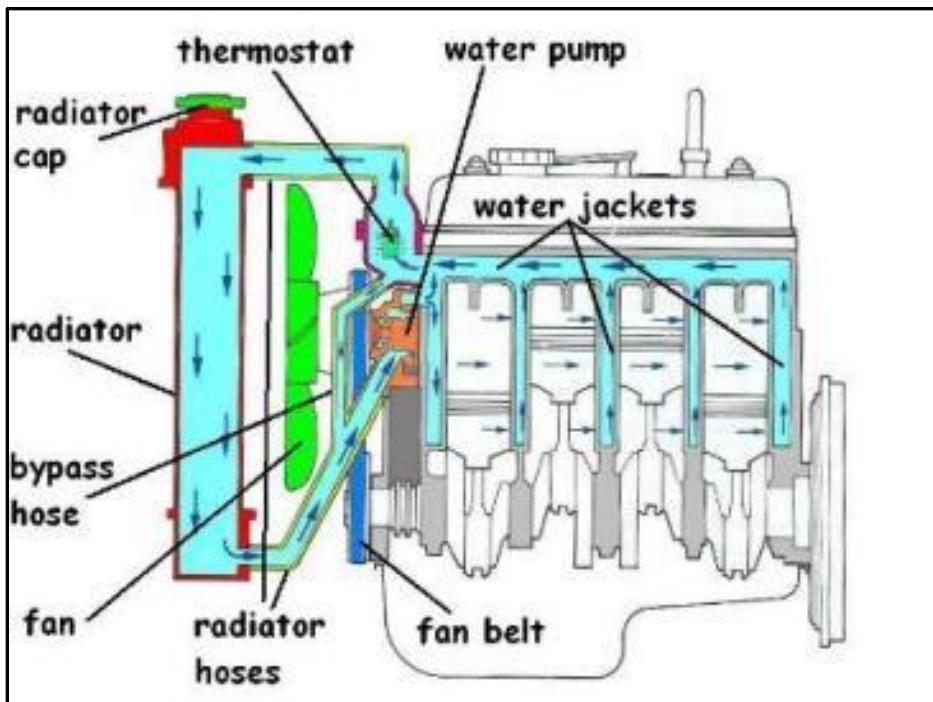
# Parts of Liquid Cooling System

The cooling system is made up of:

- Passages inside the engine block and heads
- Radiator to cool the coolant
- Water pump to circulate the coolant
- Cooling Fans
- Thermostat to control the temperature of the coolant
- Radiator cap to control the pressure in the system
- Connecting hoses between the engine and radiator

## □ Passages inside the engine block and heads

### Water Jacket (قميص التبريد)

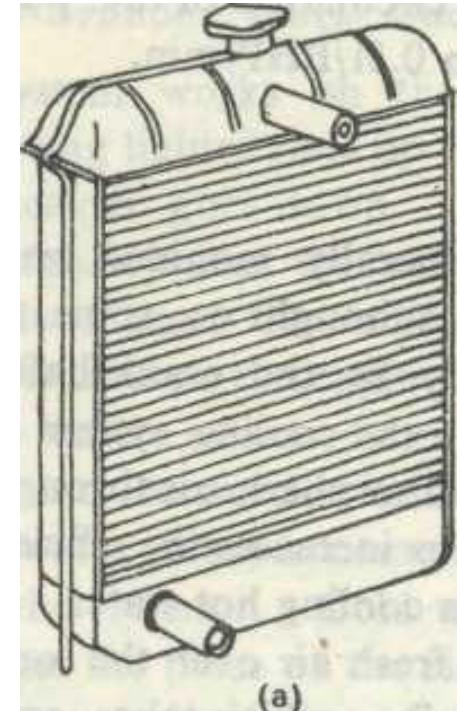


# Radiator

**The purpose of the radiator is to cool down the water received from the engine.**

**The radiator consists of three main parts:**

**(i) upper tank, (ii) lower tank and (iii) tubes.**

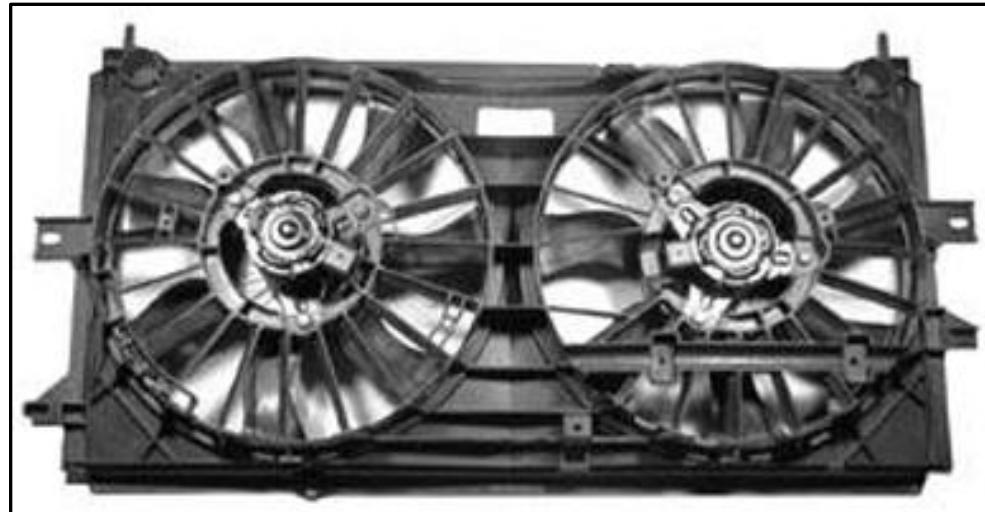


## Radiator Fans

It serves two purposes in the cooling system of a engine.

- (a) It draws atmospheric air through the radiator and thus increases the efficiency of the radiator in cooling hot water.
- (b) It throws fresh air over the outer surface of the engine, which takes away the heat conducted by the engine parts and thus increases the efficiency of the entire cooling system.

The fan is generally mounted on the water pump pulley, although on some engines it is attached directly to the crankshaft.

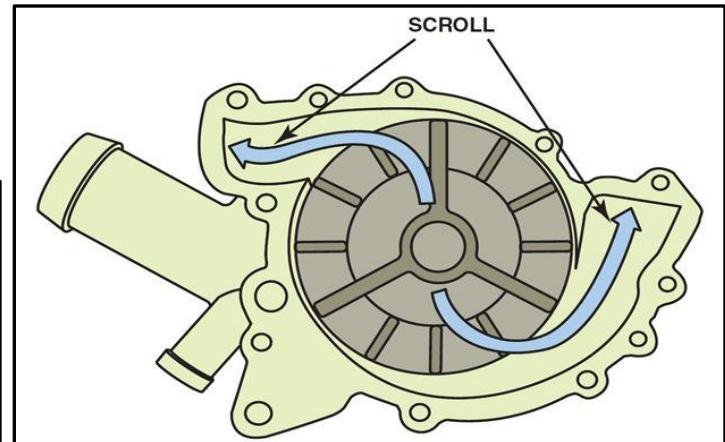


# Water Pump

This is a centrifugal type pump. It is centrally mounted at the front of the cylinder block and is usually driven by means of a belt.

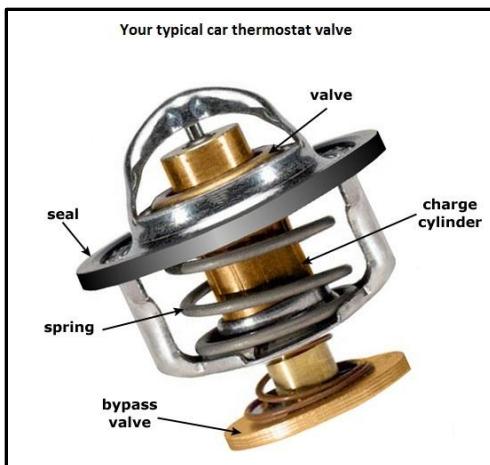
This type of pump consists of the following parts:

- body or casing,
- impeller (rotor),
- shaft,
- bearings, or bush,
- water pump seal and
- pulley.



# Thermostat Valve

- It is fitted in the water outlet of the engine.
- The valve opens and closes with the effect of temperature.
- During the warm-up period, the thermostat is closed.
- When the normal operating temperature is reached, the thermostat valve opens and allows hot water to flow towards the radiator



start opening at 70 to 75°C  
fully open at 82°C.

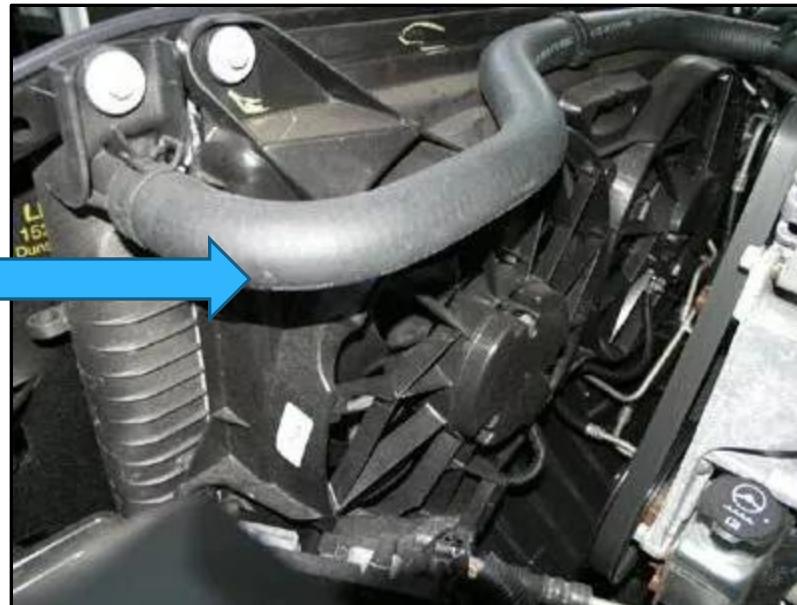
start opening at 80 to 90°C  
fully open at 92°C.



## Hoses

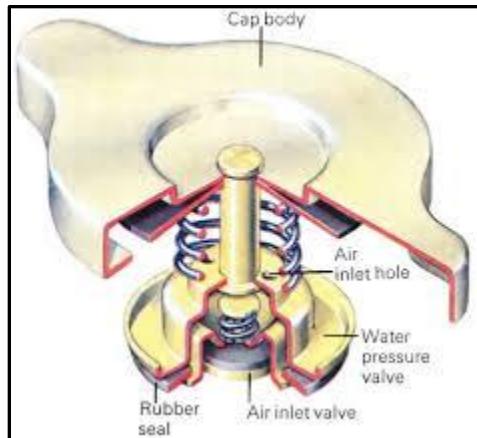
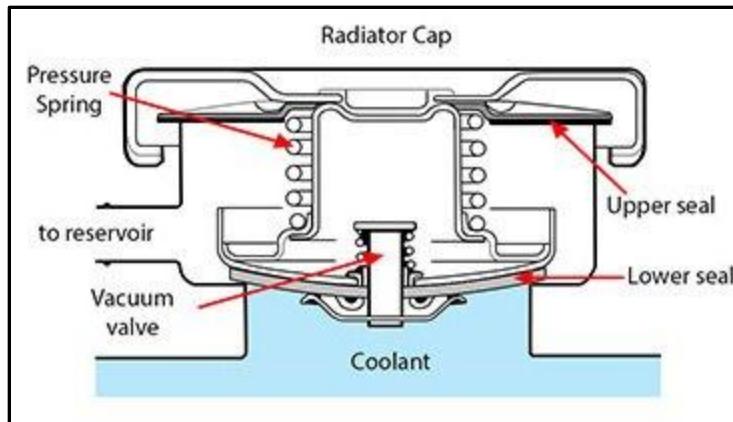
There are several rubber hoses to connect the components of the cooling system. The main hoses are called the upper and lower radiator hoses. These two hoses are approximately two inches in diameter and direct coolant between the engine and the radiator.

**Hoses**



## Pressure Cap in radiator

The radiator pressure cap is a simple device that will maintain pressure in the cooling system up to a certain point.

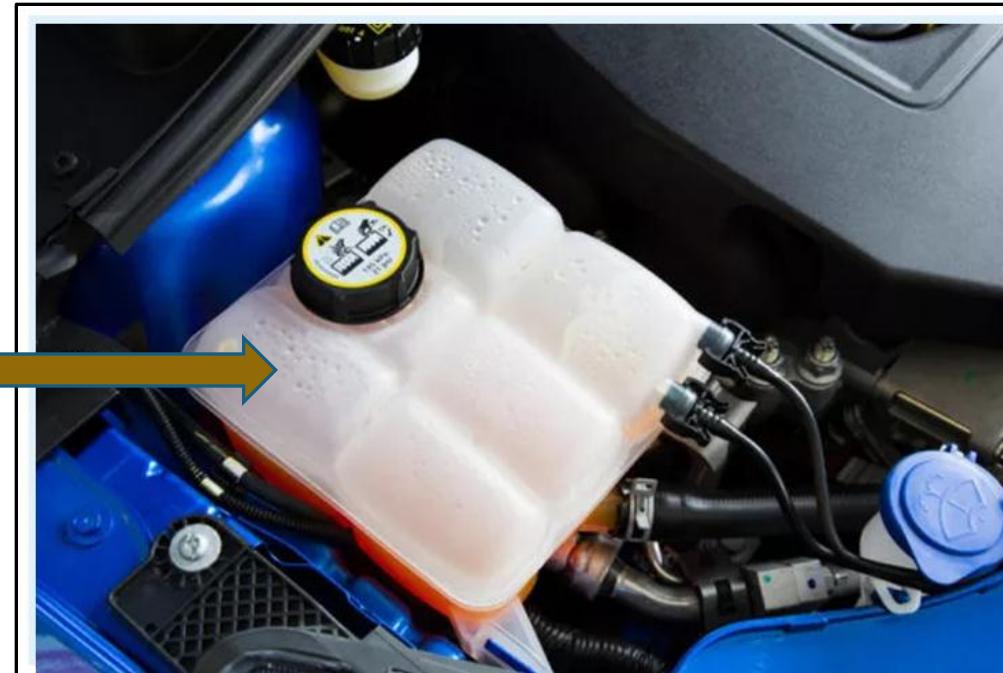


Radiator Cap

## Reserve Tank

When the engine is at normal operating temperature, the coolant in the translucent reserve tank should be up to the Full-Hot line. After the engine has been sitting for several hours and is cool to the touch, the coolant should be at the Full-Cold line.

Reserve Tank



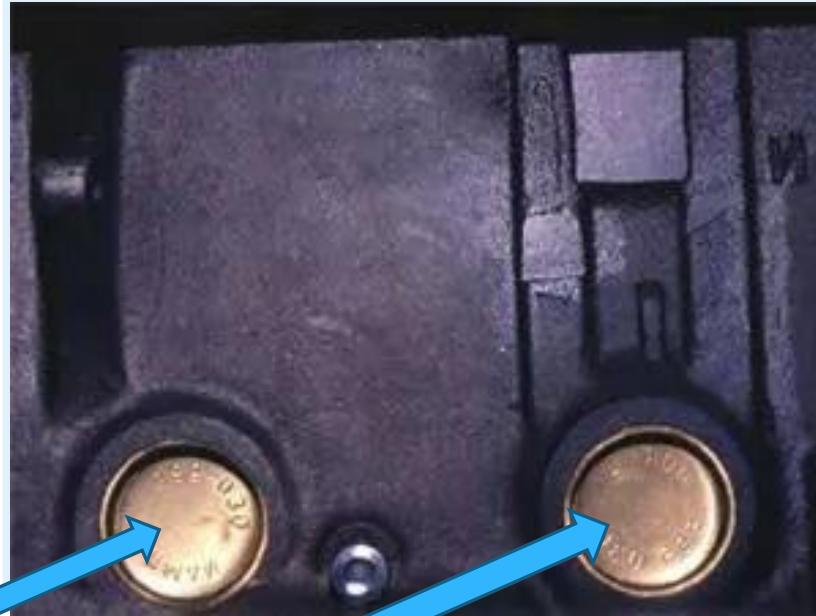
## Antifreeze

to prevent the water in the cooling system from freezing, some chemical solutions which are known as anti-freeze solutions are mixed with water.



## Freeze Plugs

When an engine block is manufactured, a special sand is molded to the shape of the coolant passages in the engine block.



Freeze Plugs

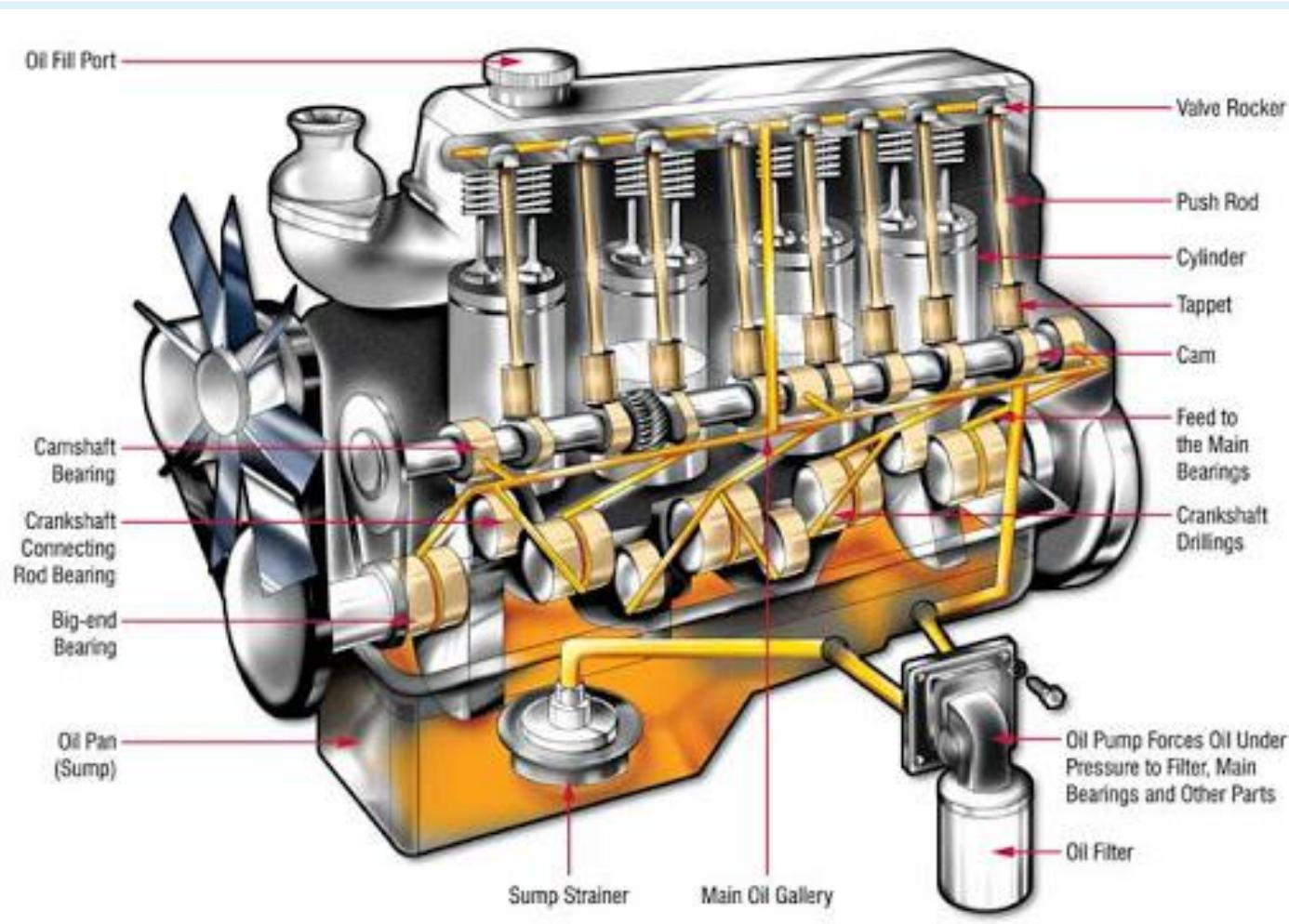
# Cooling System Maintenance and Repair

- A visual inspection of all cooling system components, including belts and hoses
- A radiator pressure cap test to check for the recommended system pressure level
- A thermostat check for proper opening and closing
- A pressure test to identify any external leaks to the cooling system parts; including the radiator, water pump, engine coolant passages, radiator and heater hoses, and heater core
- An internal leak test to check for combustion gas leakage into the cooling system
- An engine fan test for proper operation
- A system power flush and refill with car manufacturer's recommended concentration of coolant



# Question?

# Lubrication System

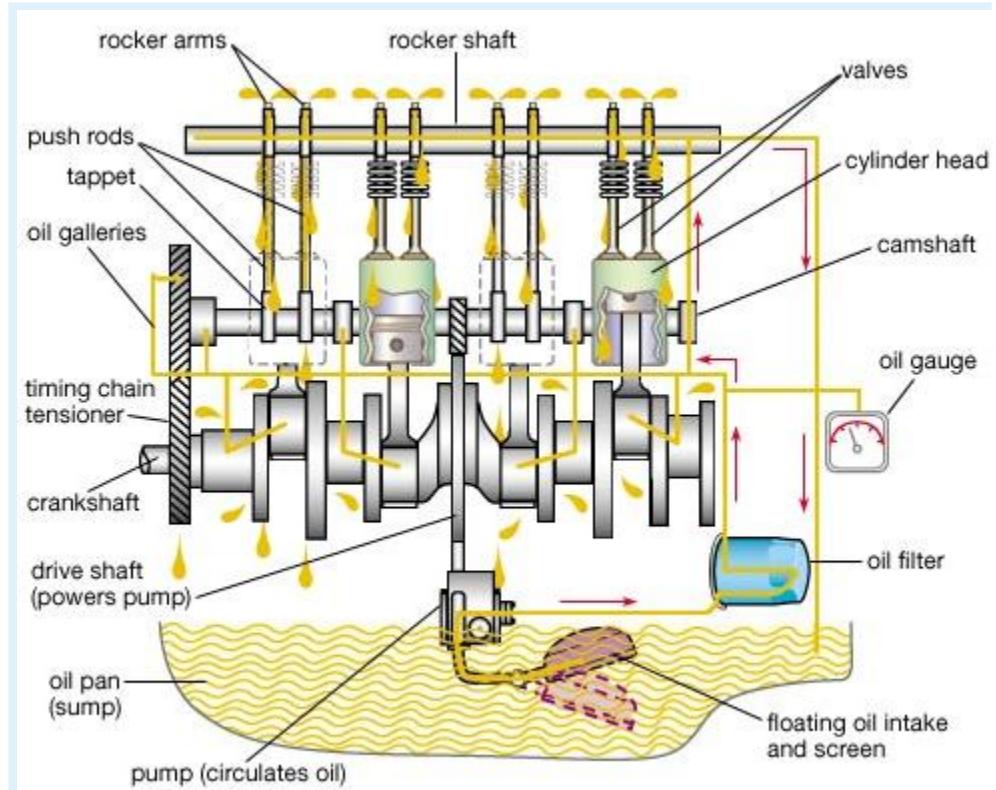


## Purpose of Lubrication:

- Reducing friction effect... *Reduce friction and wear between two rubbing surfaces.*
- Cooling effect... *Lubrication creates cooling effect on the engine parts.*
- Sealing effect... *It prevents leakage of gases from the engine cylinder.*
- Cleaning effect... *keeps the engine clean by removing dirt or carbon from inside of the engine*

# The parts which require lubrication are:

1. Cylinder walls and piston
2. Piston pin and small end
3. Crankshaft and connecting rod bearings
4. Camshaft bearings
5. • Timing gears
6. valve operating mechanism
7. Valves



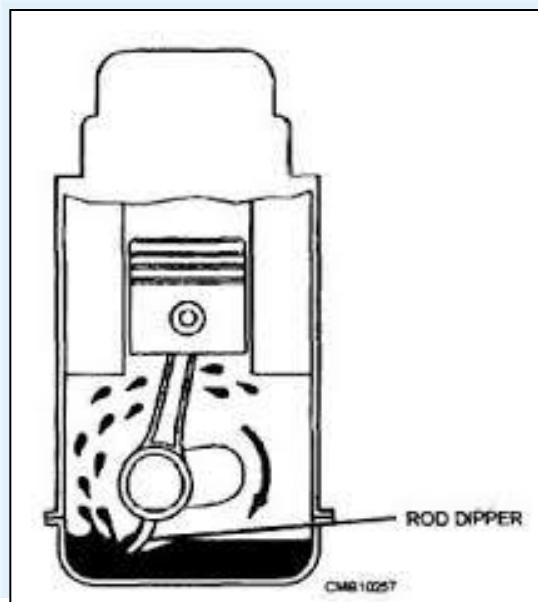
# Engine Lubricating Systems

There are three common systems of lubrication used on stationary engines, tractor engines and automobiles:

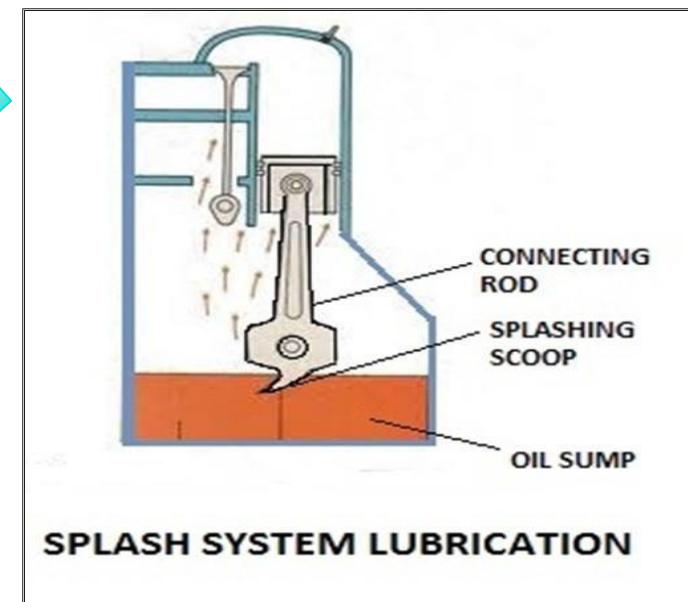
- **Splash system**
- **Forced feed system**
- **Combination of splash and forced feed system.**

# Splash System

The splashing action of oil maintains a fog or mist of oil that drenches the inner parts of the engine such as bearings, cylinder walls, pistons, piston pins, timing gears etc.

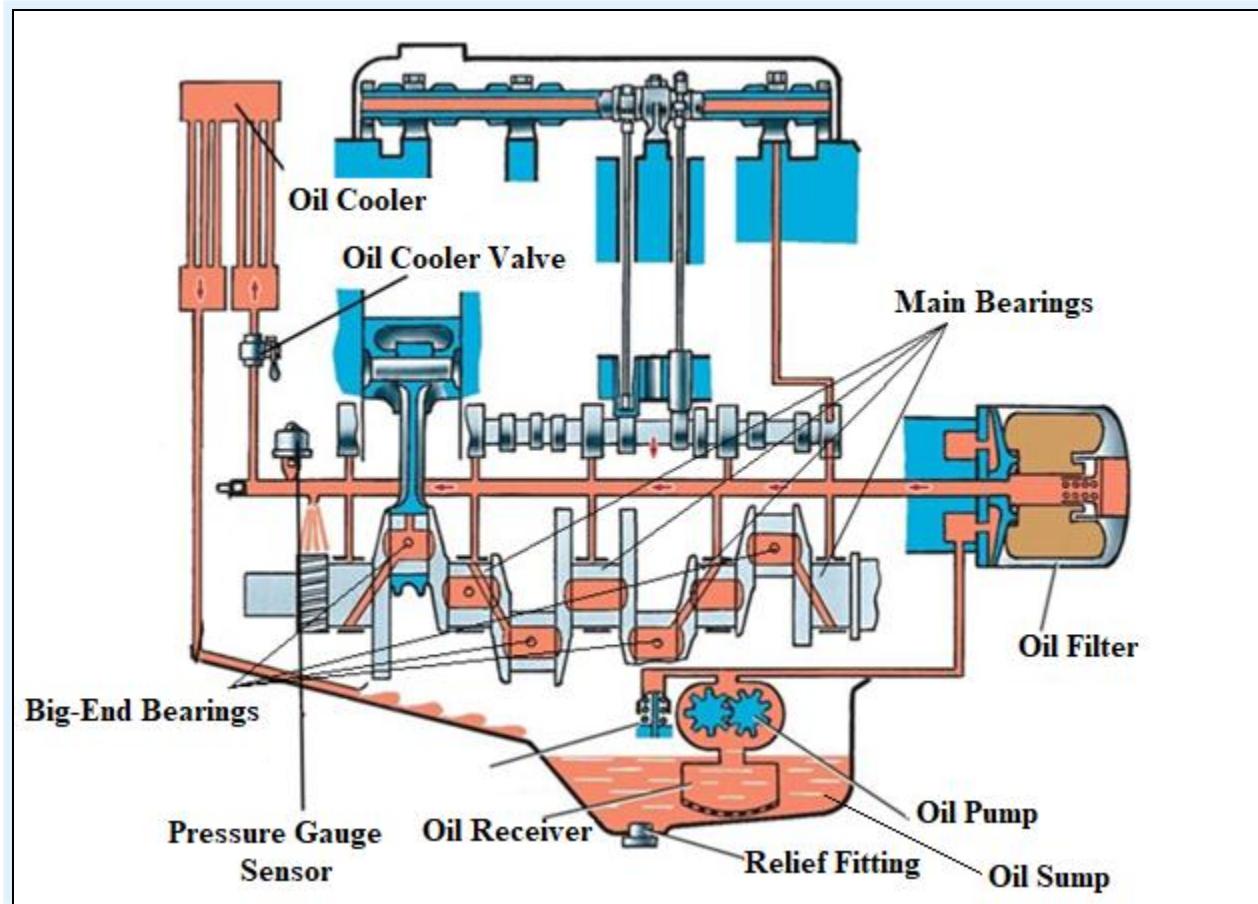


**Splash lubrication system**



# Forced Feed System

In this system, the oil is pumped directly to the crankshaft, connecting rod, piston pin, timing gears and camshaft of the engine through suitable paths of oil.

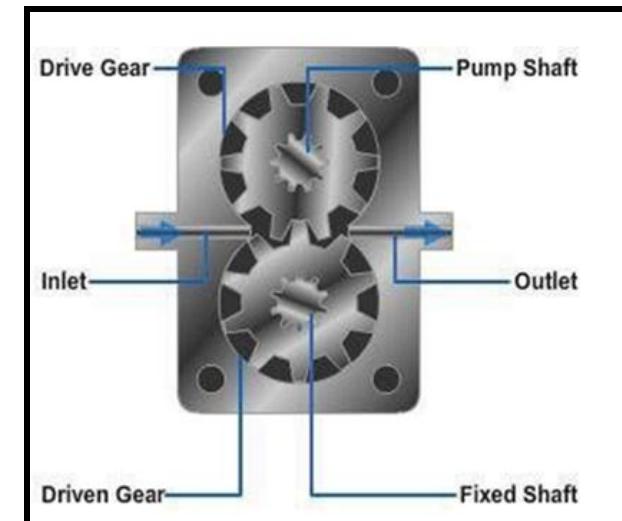
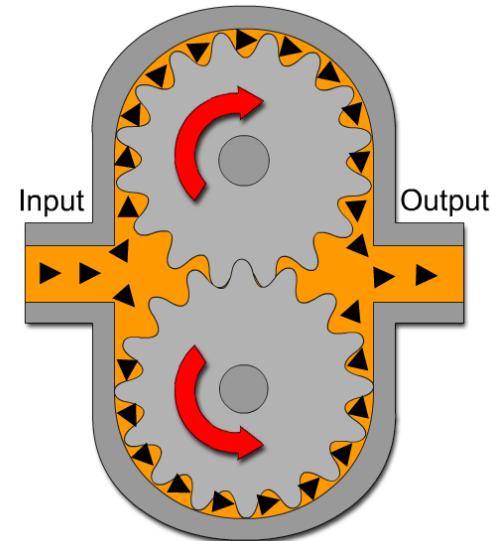


# Lubrication System Components

- Oil pump
- Oil pickup and strainers
- Pressure relief valve
- Oil filter
- Oil cooler
- Oil pan (crankcase)
- Oil level gauge
- Oil galleries
- Oil pressure indicator and gauge

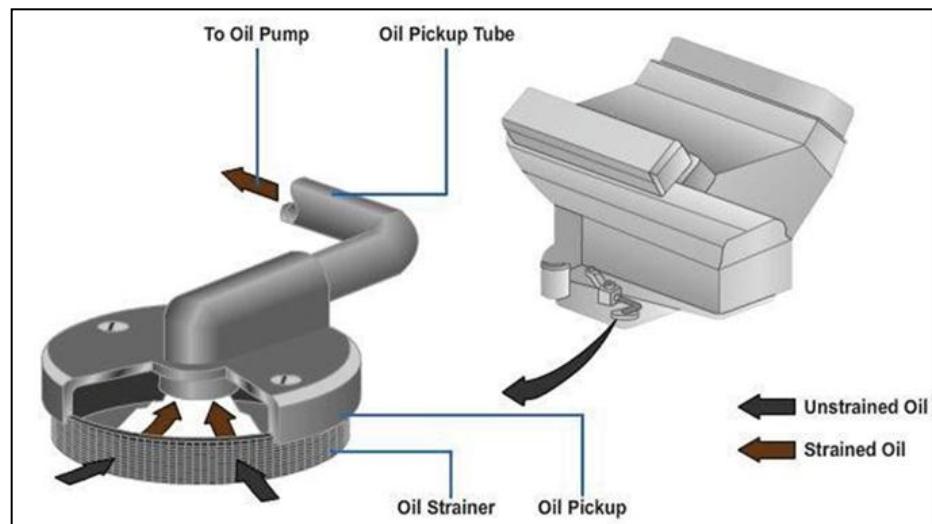
## ➤ Oil pump

- Oil pump is usually a gear type pump used to force oil into the oil pipe.
- The pump is driven by the camshaft of t engine.



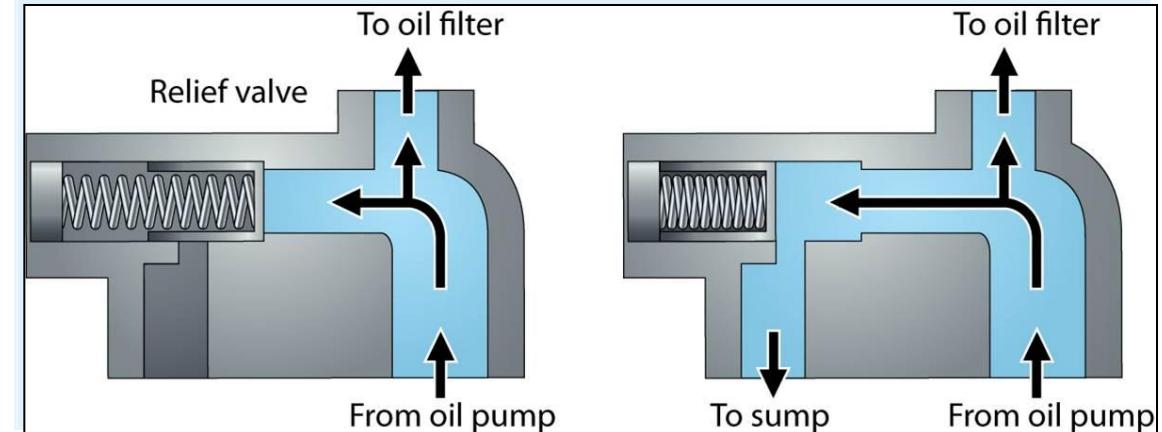
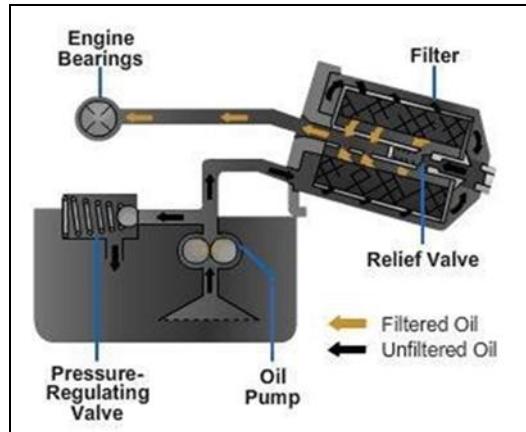
## ➤ Oil pickup and strainers

The strainer has a mesh screen suitable for straining large particles from the oil and placed about 1/2 inch to 1 inch from the bottom of the oil pan. This device prevents any sludge or dirt that has accumulated from entering and circulating through the system.

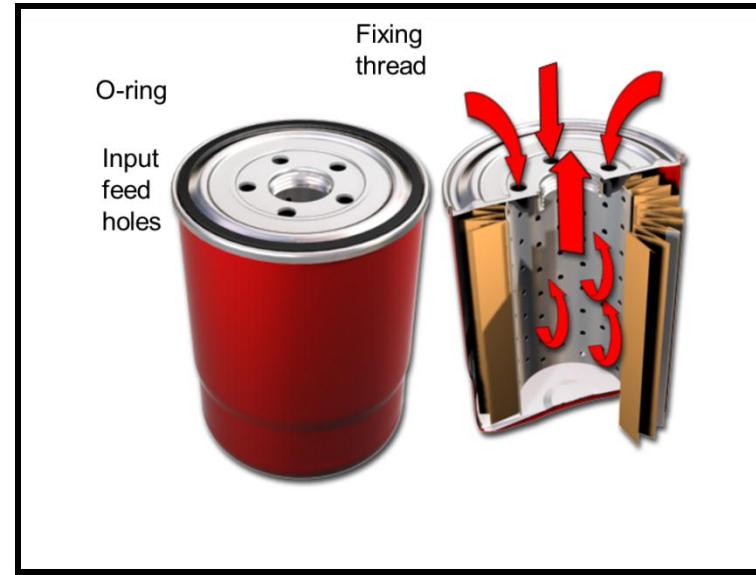


## ➤ Pressure relief valve

Relief valve is provided to control the quantity of oil circulation and to maintain correct pressure in the lubricating system.



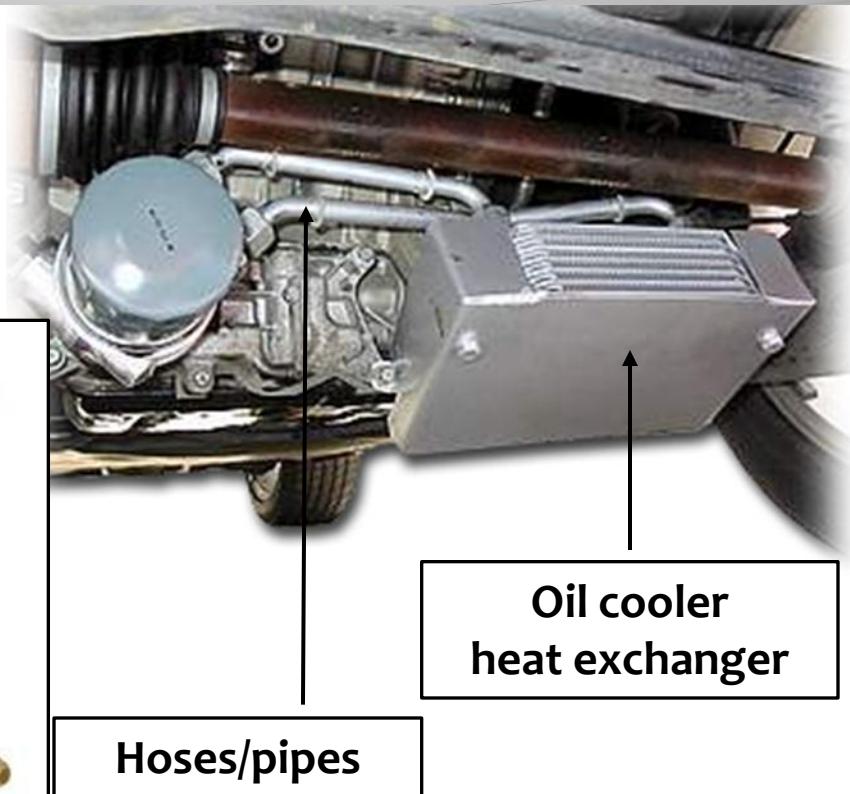
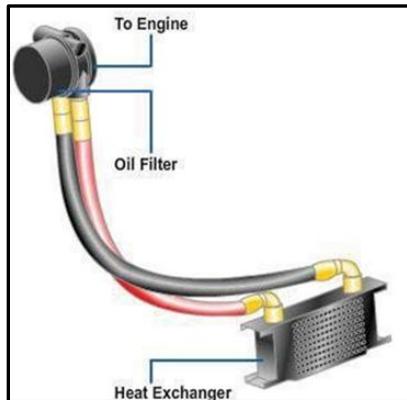
## ➤ Oil filter



**Oil filter removes the dirty elements of the oil in an effective way. It is a type of strainer using cloth, paper, felt, wire screen or similar elements.**

## ➤ Oil cooler

To help lower and control the operating temperature of the engine oil. It consists of a radiator-like device, called a heat exchanger, connected to the lubrication system by the use of an oil cooler adapter.



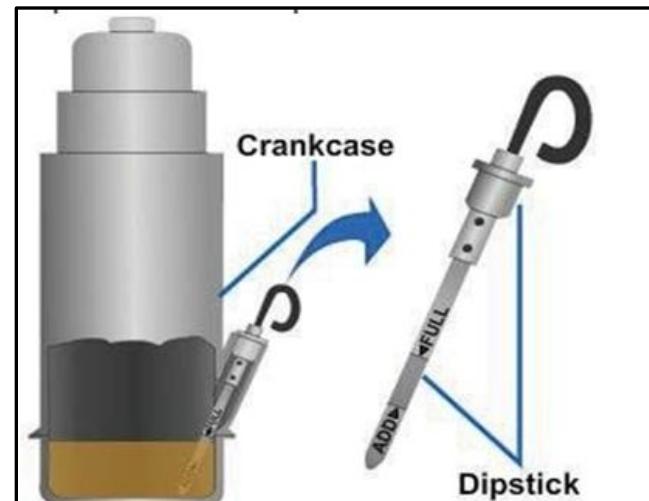
## ➤ Oil pan (crankcase)

- The oil pan is normally made of thin sheet metal of aluminum, and bolts to the bottom of the engine block.
- It holds a supply of oil for the lubrication system. The oil pan is fitted with a screw-in drain plug for oil changes.



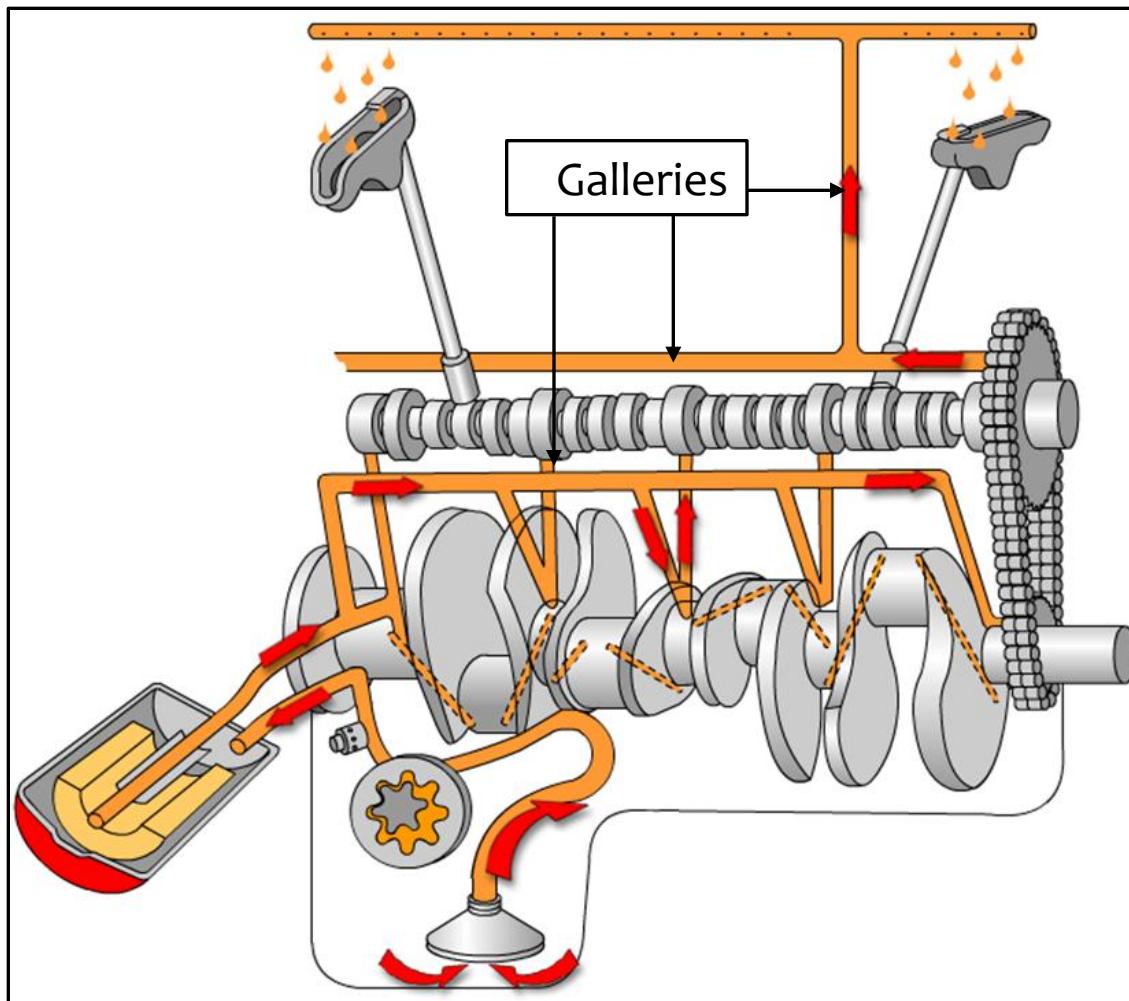
## ➤ Oil level gauge

It is marked to show the level of oil within the oil pan.

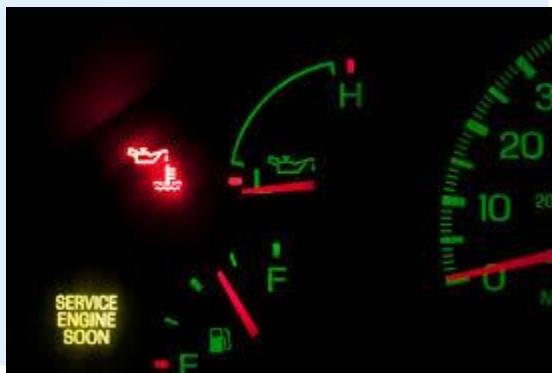


## ➤ Oil galleries

Passages through the cylinder block and head called galleries carry oil to all parts of the engine.



## ➤ Oil pressure indicator and gauge



Oil pressure gauge is used to indicate the oil pressure in the oil lines. It serves to warn the operator of any irregularity in the system.

# Common troubles in lubrication system

## 1. Excessive oil consumption

More oil goes to combustion chamber and gets burnt  
leakage occurs in some parts

Loss of oil in form of vapour through ventilating system.

## 2. Low oil pressure and

Damaged oil pump

Weak relief valve spring

Obstruction in the oil lines

## 3. Excessive oil pressure

Stuck relief valve

Strong valve spring

Clogged oil line and

Very heavy oil

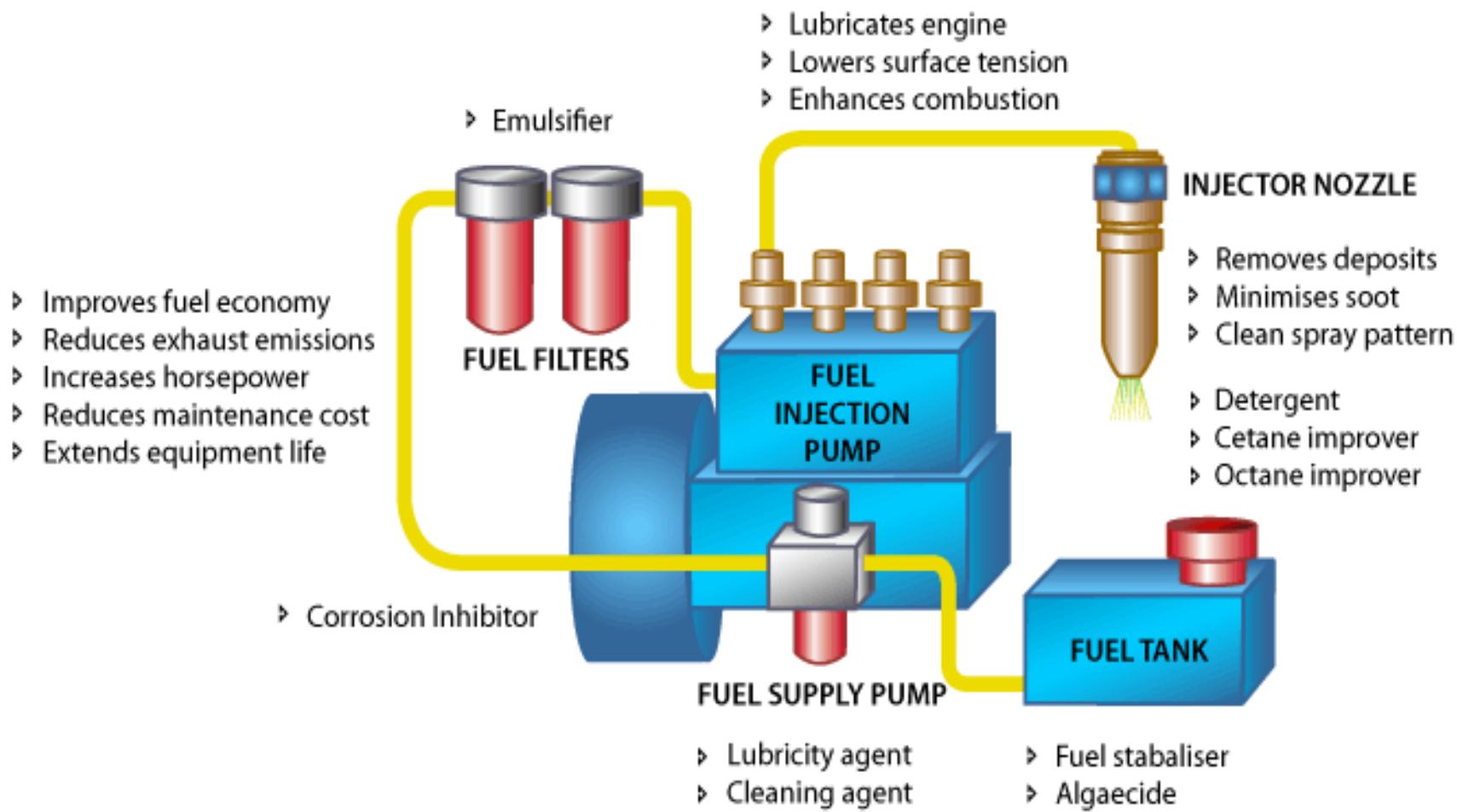
## Care and Maintenance of Lubrication System

- A good design of oil circulation system should be chosen.
- Correct grade of lubricant ensures long and trouble free service.
- Oil should be maintained at desired level in the oil chamber.
- Oil should be changed regularly after specified interval of time.
- Old filters should be replaced by new filters.
- Before putting the new oil, the crankcase should be cleaned well.
- Precautions should be taken to keep the oil free from dust and water.



**Question?**

# Fuel Systems



## ➤ The function of the fuel system:-

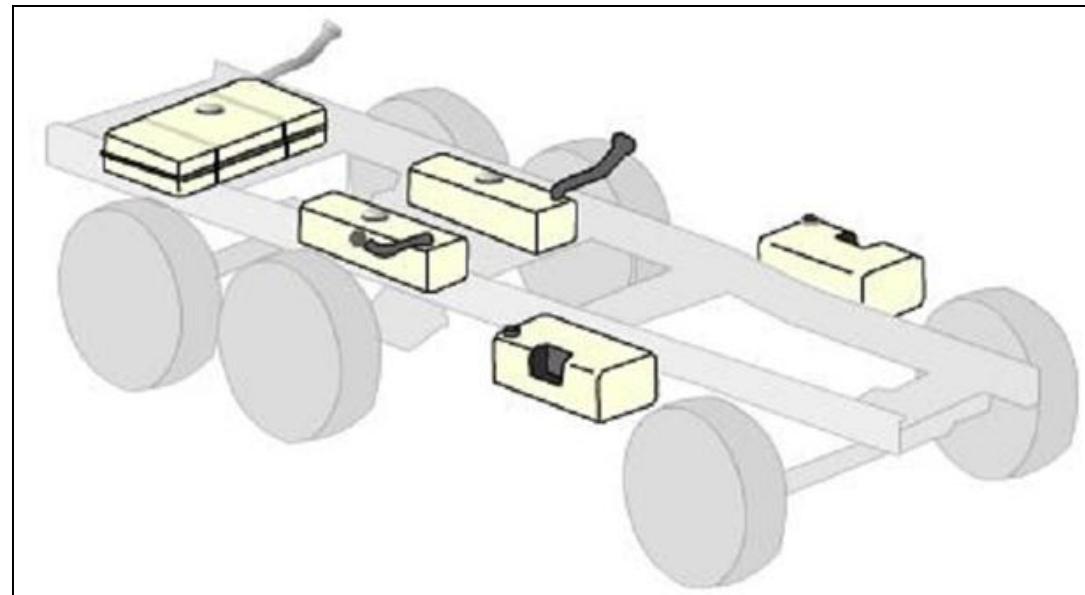
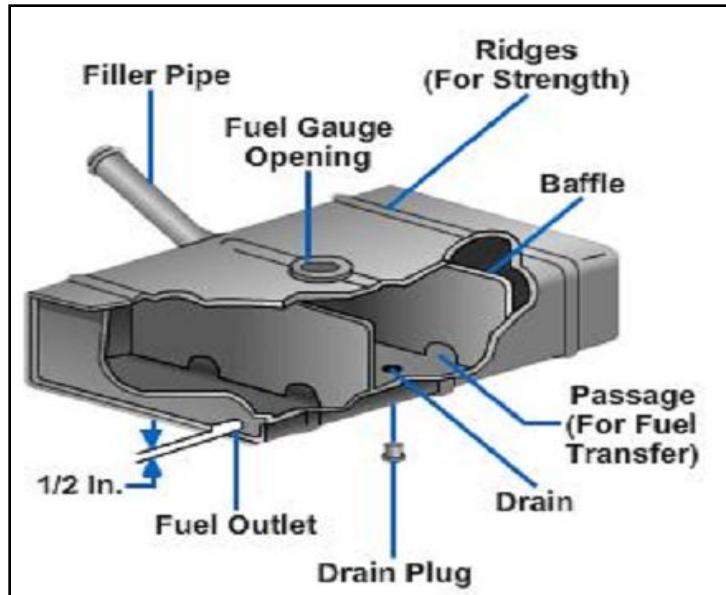
- Is to supply a combustible mixture of air and fuel to the engine in the case of *petrol engines.*
- But.. In *diesel engines* it is supplies only the fuel because in a diesel engine is that the diesel fuel is mixed with compressed air in the cylinder.

# Gasoline Fuel Systems Components

The basic parts of a fuel supply system include the following:

- **Fuel tank (storage gasoline)**
- **Fuel pump (draws fuel from the tank and forces it)**
- **Fuel filters (remove contaminants in the fuel)**
- **Carburetor or gasoline injectors**
- **Fuel lines (carry fuel between tank, pump, and other parts)**

# Fuel Tank

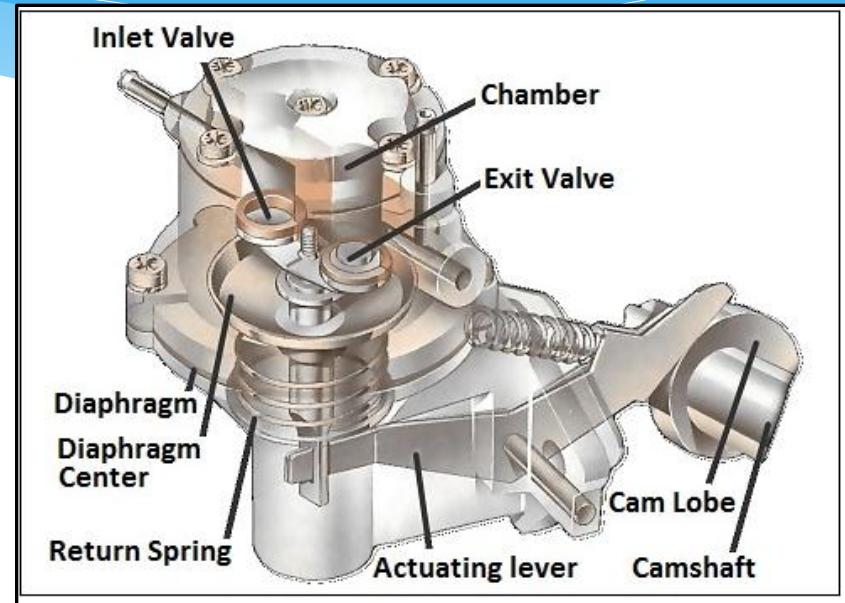
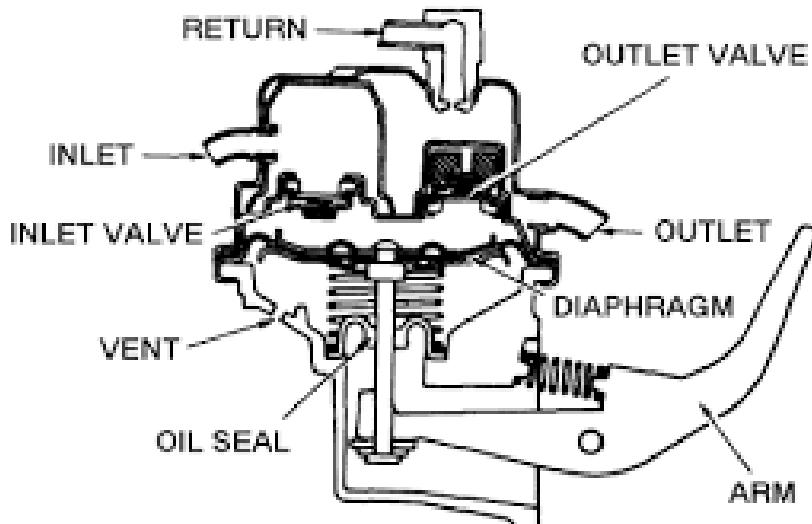


**Fuel tanks are usually made of thin sheet metal**

**Main parts (filler neck, fuel tank cap, and baffles)**

# Fuel Pump

## Mechanical Type



The device that draws the fuel from the tank to the engine's carburetor or injection system.



# Fuel Pump

## Electrical Type

- All late model vehicles use an electric fuel pump.
- The fuel pump can be located either inside the tank or in the fuel system after the tank.

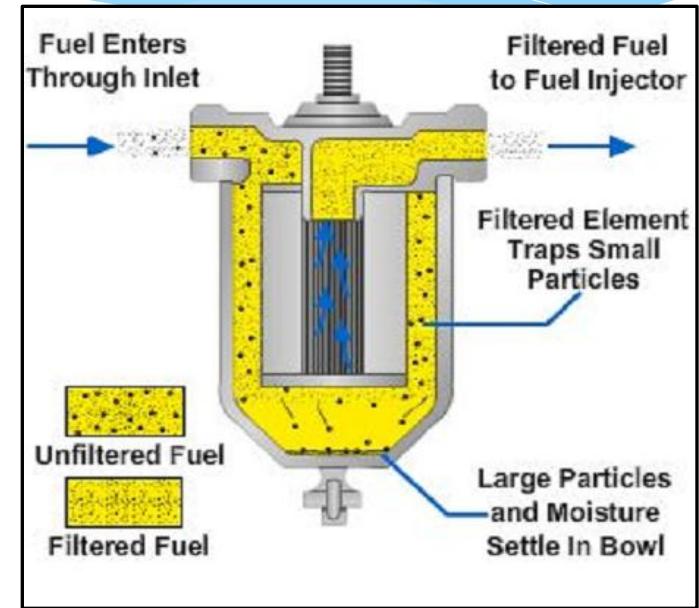


# Fuel Filters

**Fuel filters prevent water, dirt, and rust particles from entering the system.**

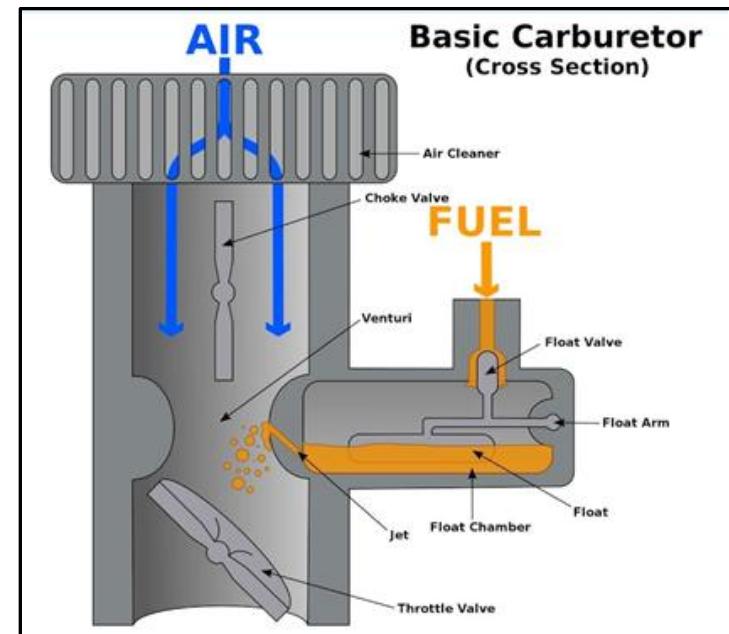
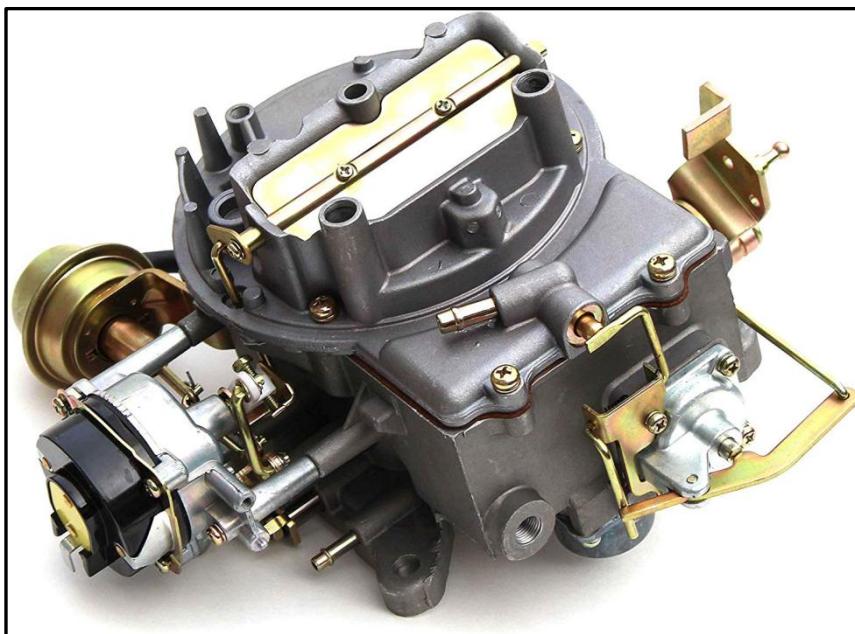
**Contaminated fuel can cause:-**

- incomplete combustion,**
- smoky exhaust,**
- engine knocking, and**
- difficulties starting the engine.**



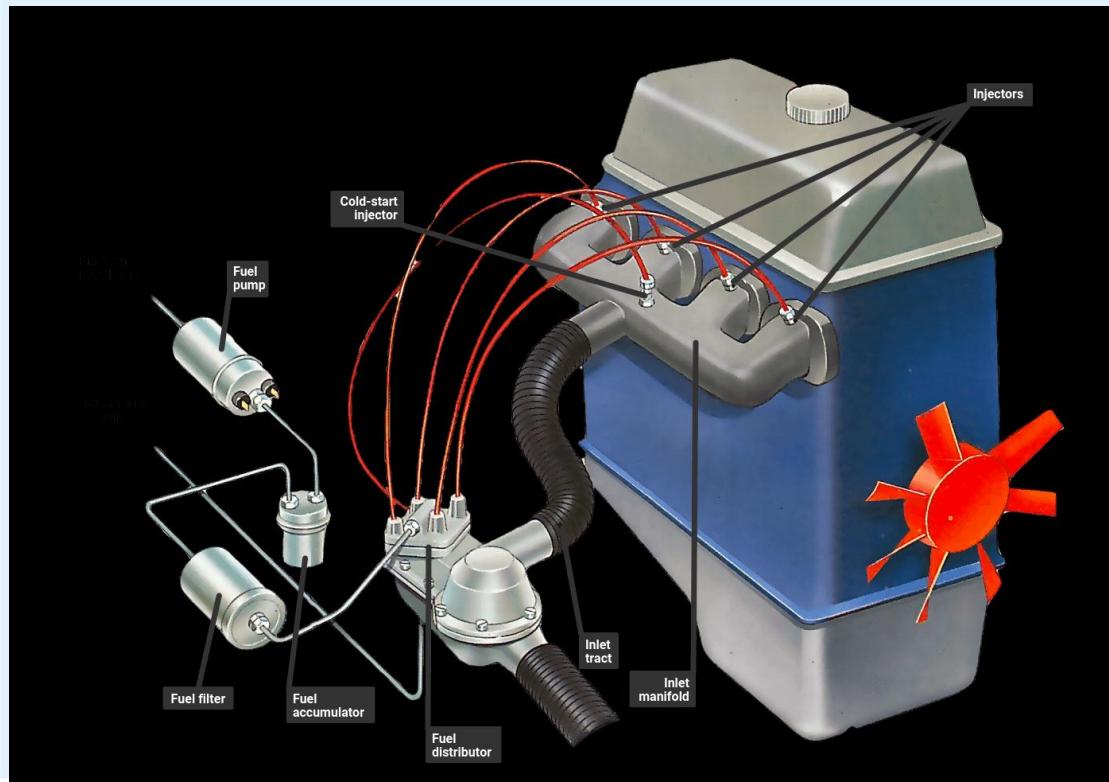
# Carburetor

The process of formation of a combustible fuel-air mixture by mixing the proper amount of fuel with air before admission to engine cylinder is called carburetion and the device which does this job is called a carburetor.



# Gasoline Injection System

A modern gasoline injection system uses pressure from an electric fuel pump to spray fuel into the engine intake manifold. Like a carburetor



# Fuel Lines

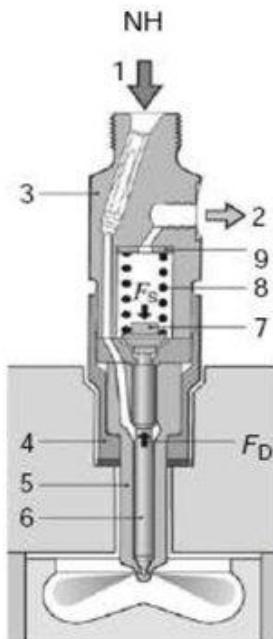
- Fuel lines and hoses carry fuel from the tank to the filter and carburetor or fuel injection assembly.
- They can be made from either metal tubing or flexible nylon or synthetic rubber hoses.



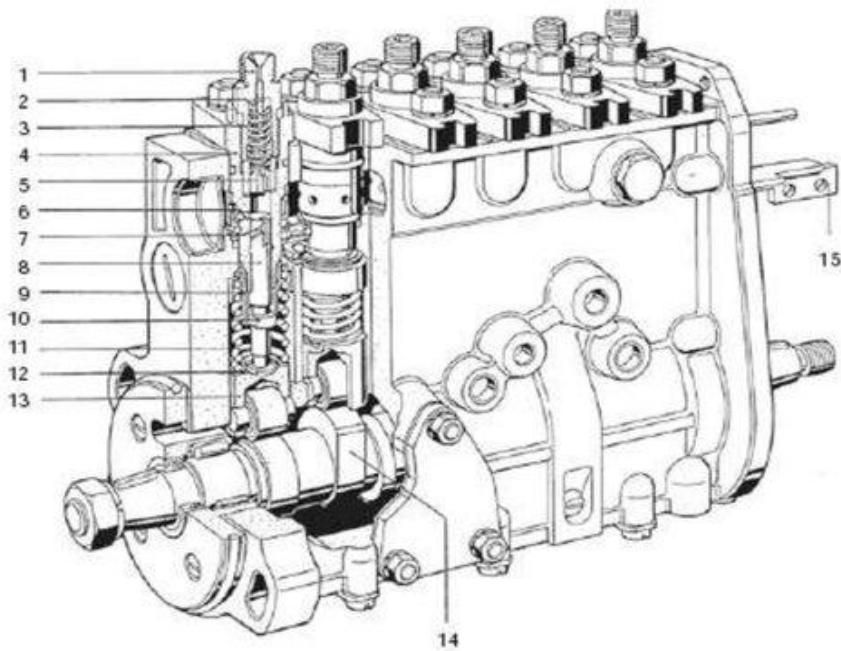
# Internal Combustion Engine

## Fuel Systems

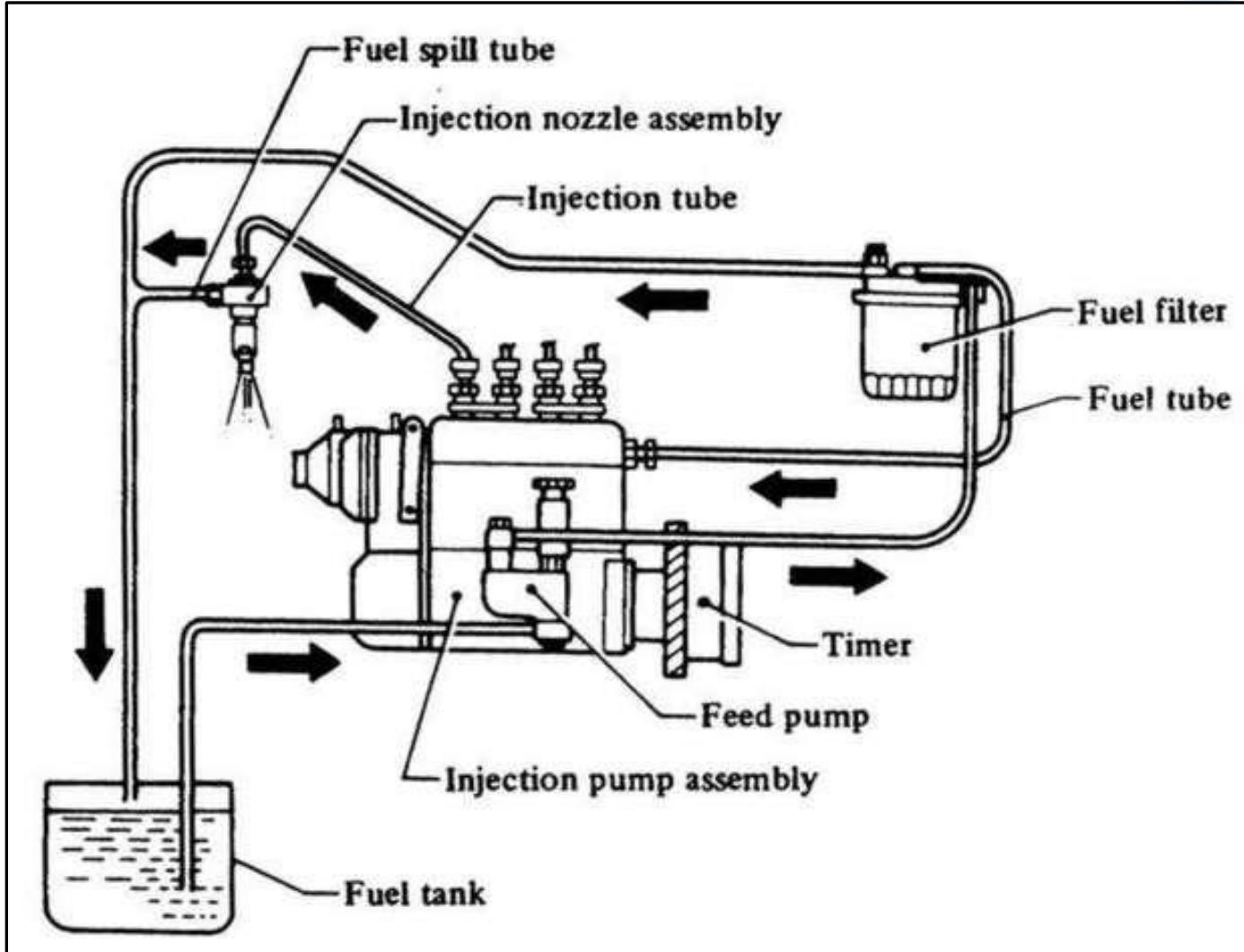
### The diesel injection system



Aleksey Terentyev

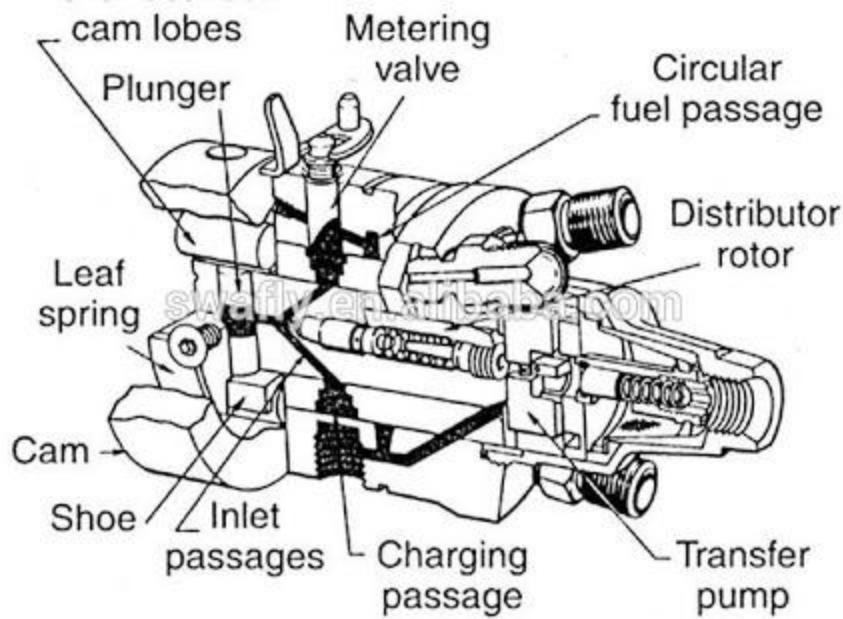


# Diesel Fuel Systems Components



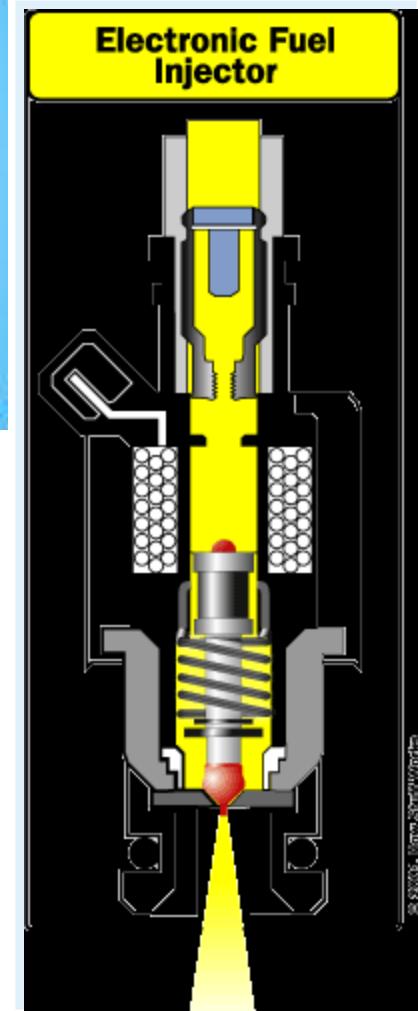
# Diesel fuel pump parts

An Injection Pump is the device that pumps diesel (as the fuel) into the cylinders of a diesel engine.



# The Injector

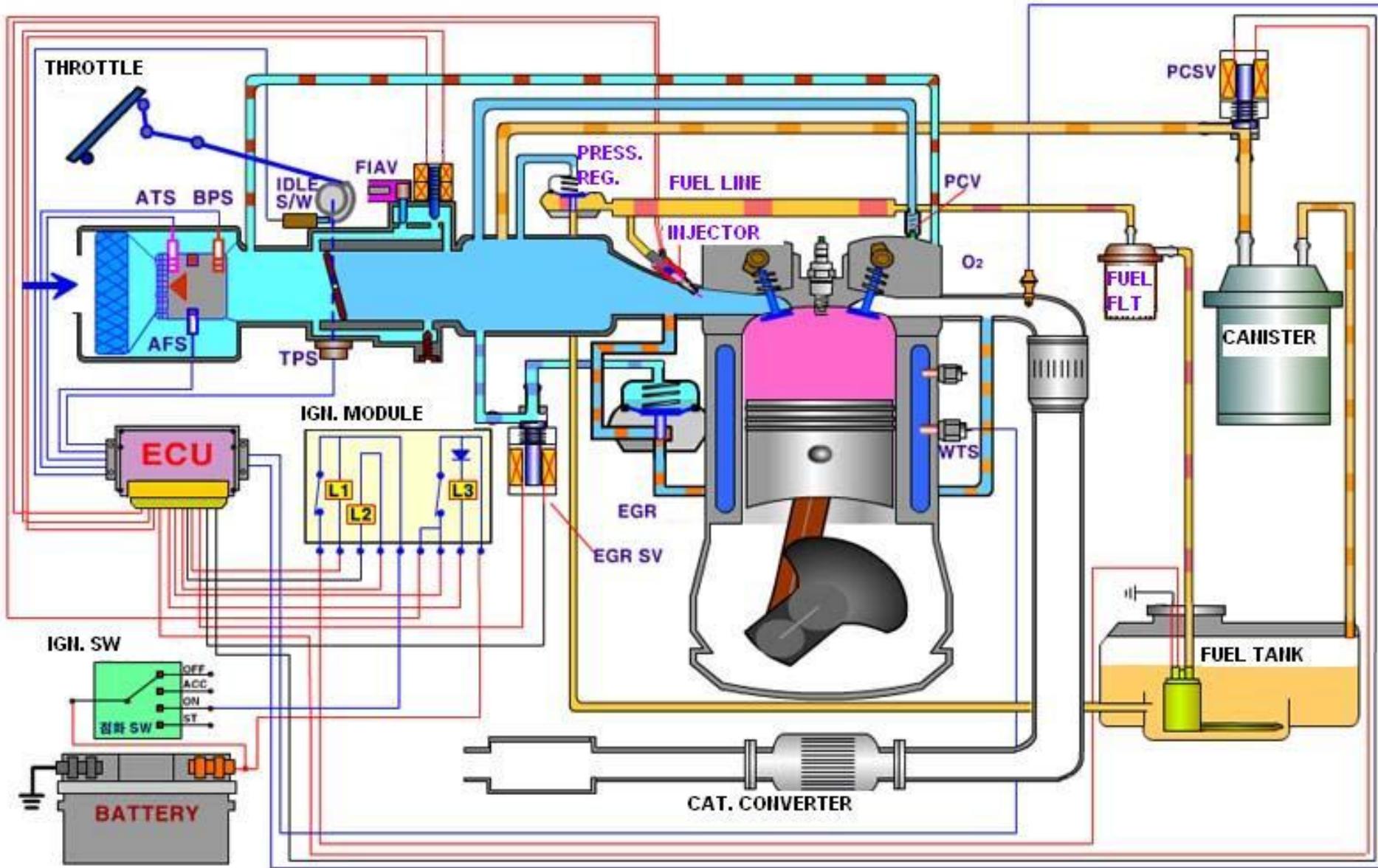
A fuel injector is nothing but an electronically controlled valve. It is supplied with pressurized fuel by the fuel pump in your car, and it is capable of opening and closing many times per second.





Question?

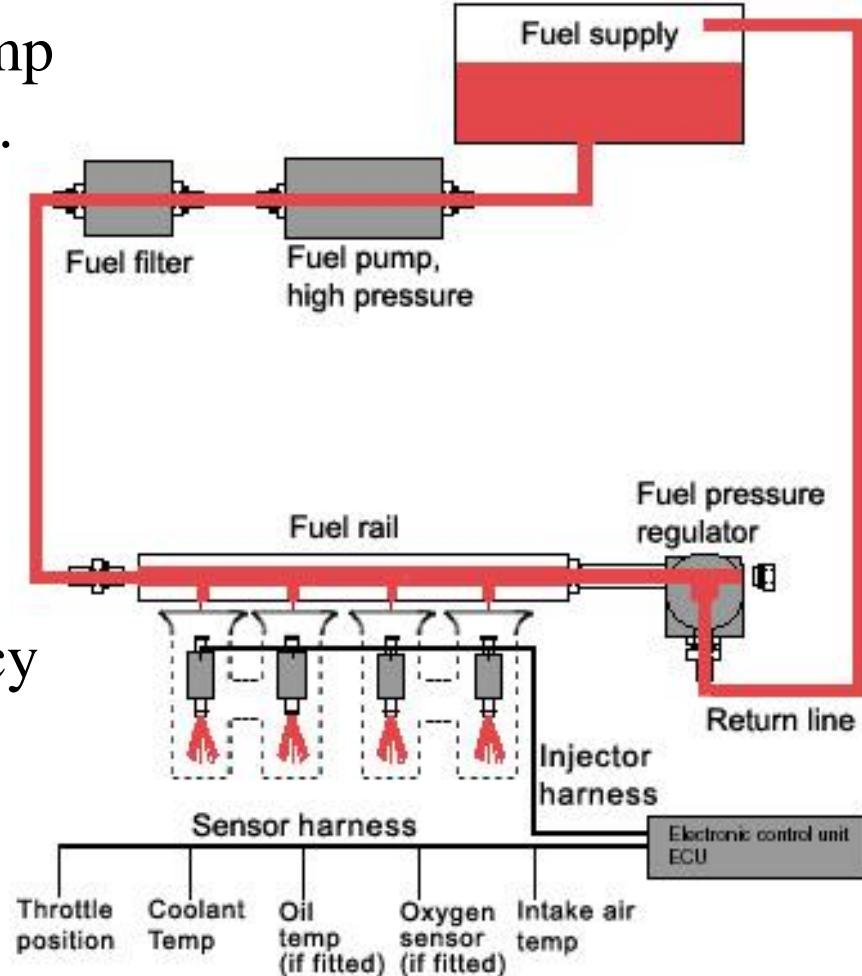
# Electronic Fuel Injection (EFI)



# Fuel Injection System

## Purpose

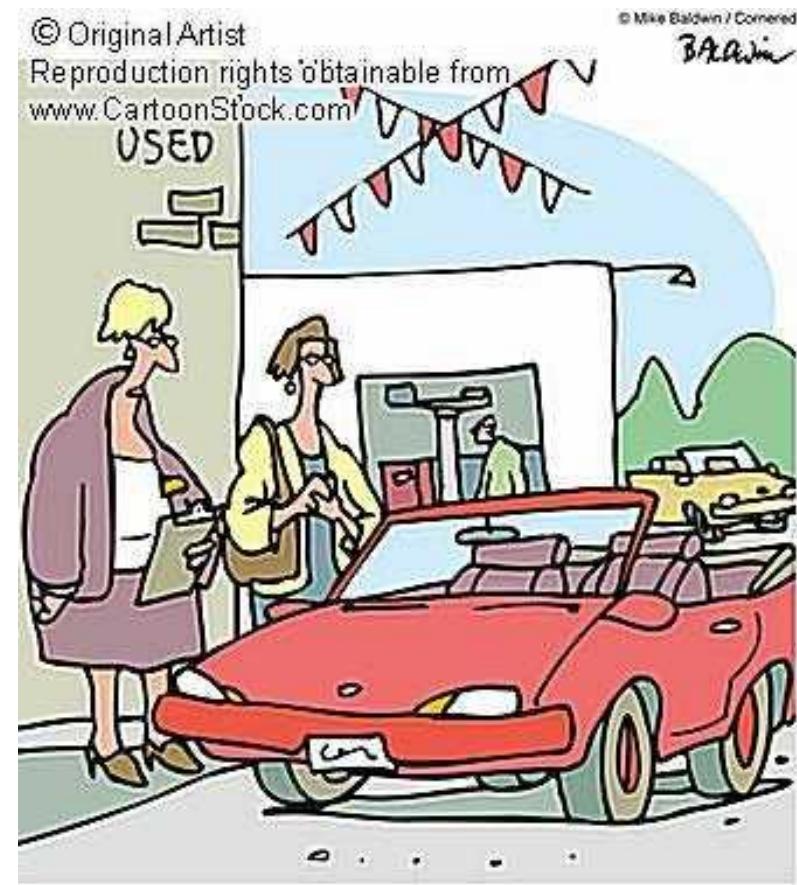
- Uses pressure from an electrical pump to spray fuel into the intake manifold.
- Provides the engine with proper air-fuel ratio (14.7 : 1)
- Delivers a more **precise** fuel “charge” to the engine.
- Ensures maximum engine efficiency and fuel economy.



# Fuel Injection System

## Advantages

- Improved Atomization
- Better fuel distribution
- Smoother idle
- Improved fuel economy
- Lower emissions
- Better cold weather drivability
- Increased engine power
- Simpler

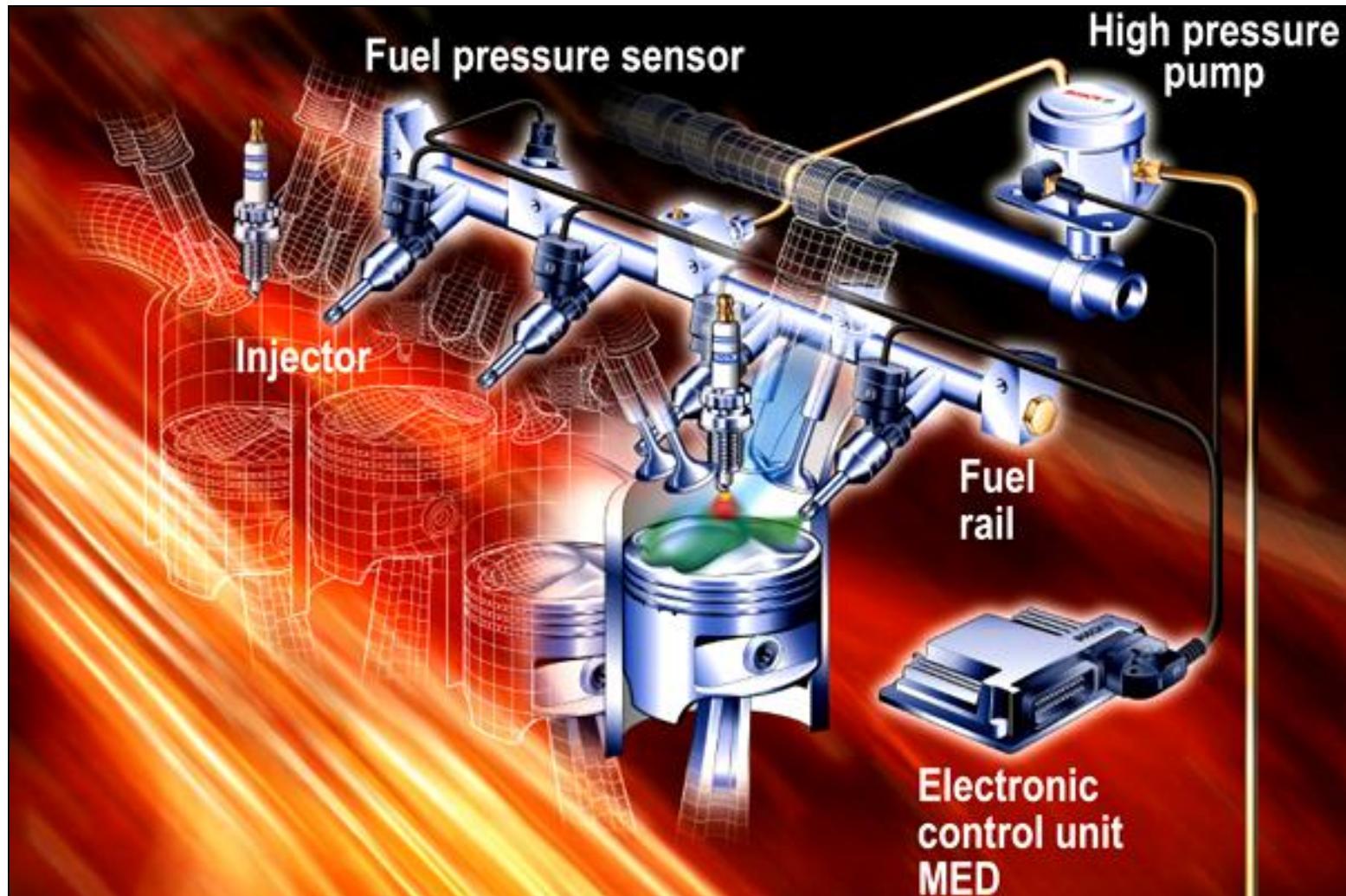


# Some advantages are as follows:

- Improved atomization. Fuel is forced into the intake manifold under pressure that helps break fuel droplets into a fine mist.
- \* Better fuel distribution. Equal flow of fuel vapors into each cylinder.
- Smoother idle. Lean fuel mixture can be used without rough idle because of better fuel distribution and low-speed atomization.
- Lower emissions. Lean efficient air-fuel mixture reduces exhaust pollution.

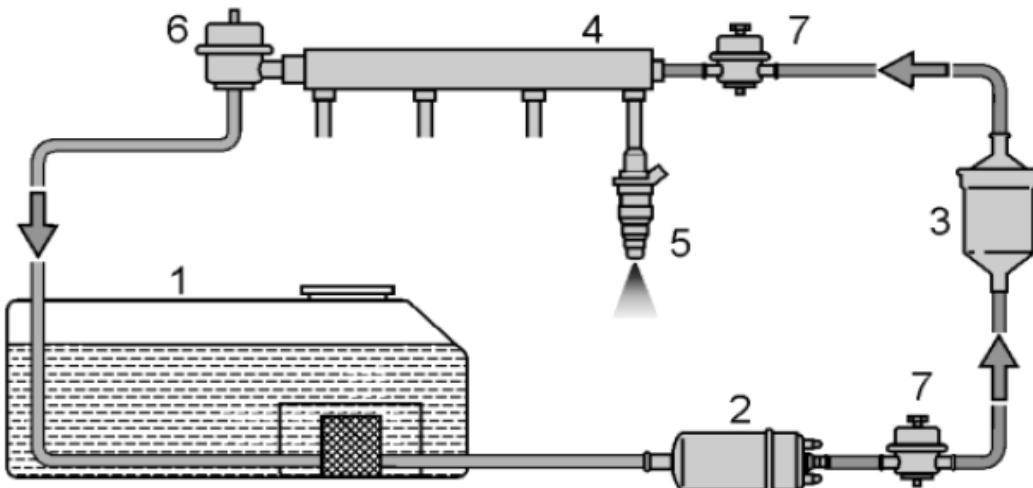
- \* Better cold weather drivability. **Injection** provides better control of mixture enrichment than a carburetor.
- Increased engine power. Precise metering of fuel to each cylinder and increased air flow can result in more horsepower output.
- \* Fewer parts. Simpler, late model, electronic fuel injection system have fewer parts than modern computer-controlled carburetors.

# EFI - System Components



# EFI - System Components

- \* Fuel tank
- \* Electric fuel pump
- \* Fuel filter
- \* Electronic control unit
- \* Common rail
- \* Electronic Injectors
- \* fuel line



1. Fuel Tank
2. Fuel Pump
3. Fuel Filter
4. Fuel Rail
5. Injector
6. Fuel Pressure Regulator
7. Fuel Pulsation Damper

# EFI - System Components

- \* **Electronic Parts**

- \* **Computer (PCM):**

- \* logic device.

- \* **Sensors :**

- \* input data to the computer.

- \* **Actuators :**

- \* output devices the computer operates.

- \* **Mechanical Parts**

- \* Fuel tank.

- \* Fuel pump.

- \* Fuel filter and lines.

- \* Injectors.

- \* Fuel rail.

- \* Pressure regulator.

# Fuel delivery system

## Fuel Tank

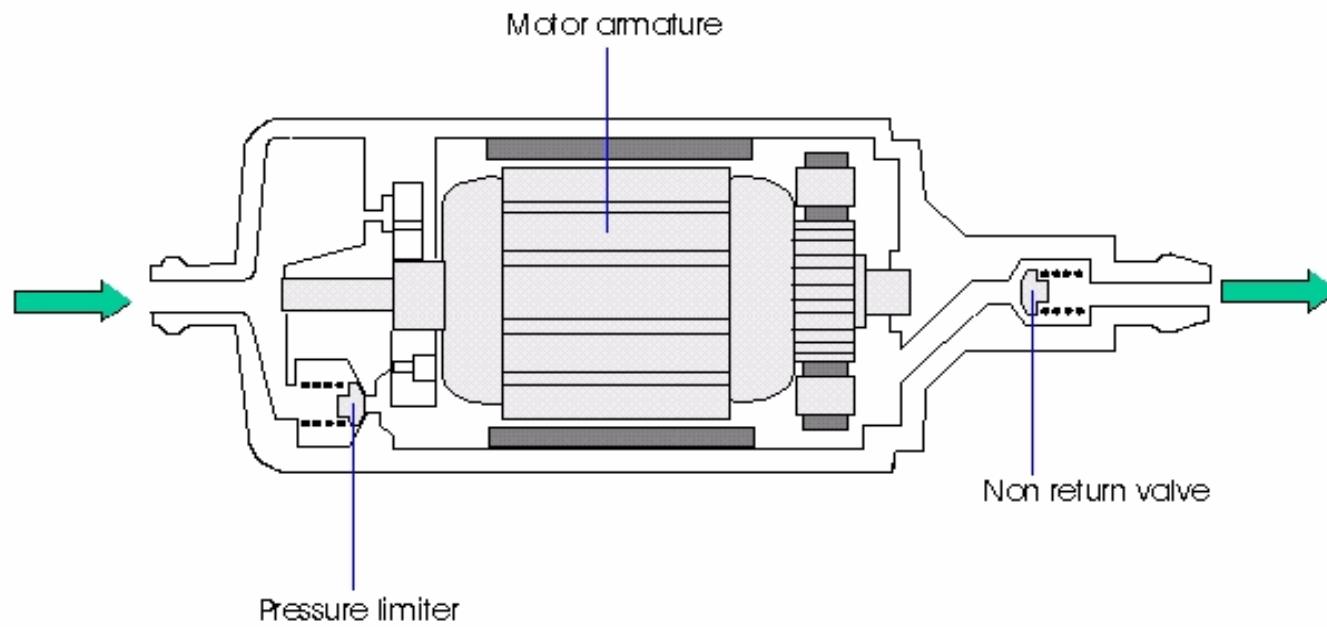
Fuel tank is a safe container for flammable liquids and typically part of an engine system in which the fuel is stored and propelled (fuel pump) or released (pressurized gas) into an engine.



# Fuel Delivery system

## Electrical Fuel Pump

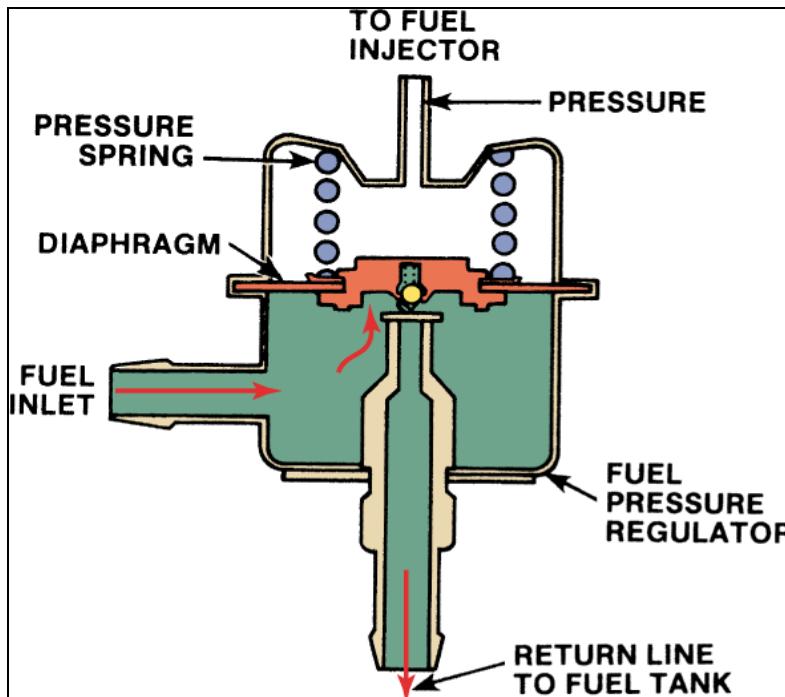
- The electric fuel pump maintains a continuous flow of fuel from the tank. It can be installed either within the tank itself (in-tank) or mounted externally in the fuel line (in-line).



# Fuel Delivery system

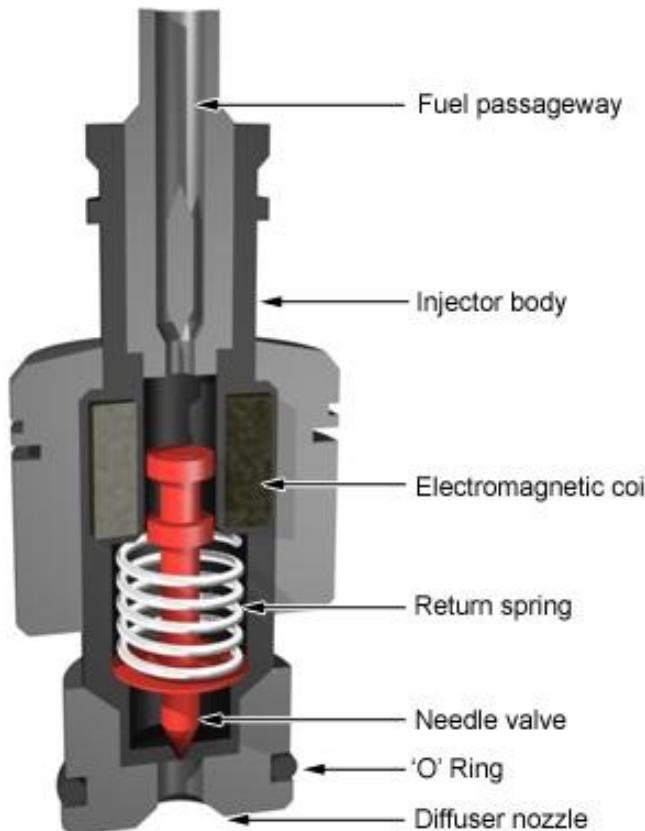
## Pressure Regulator

Controls the amount of pressure that enters the injector and any extra fuel is returned to the fuel tank.

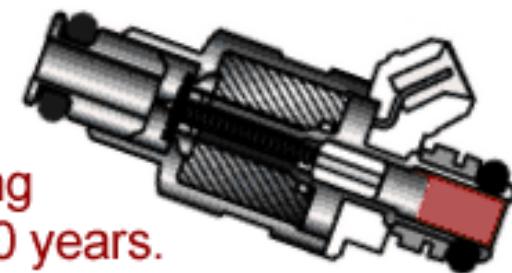


# Fuel Delivery system

## Fuel Injector



### ***High Performance and Racing Fuel Injectors***



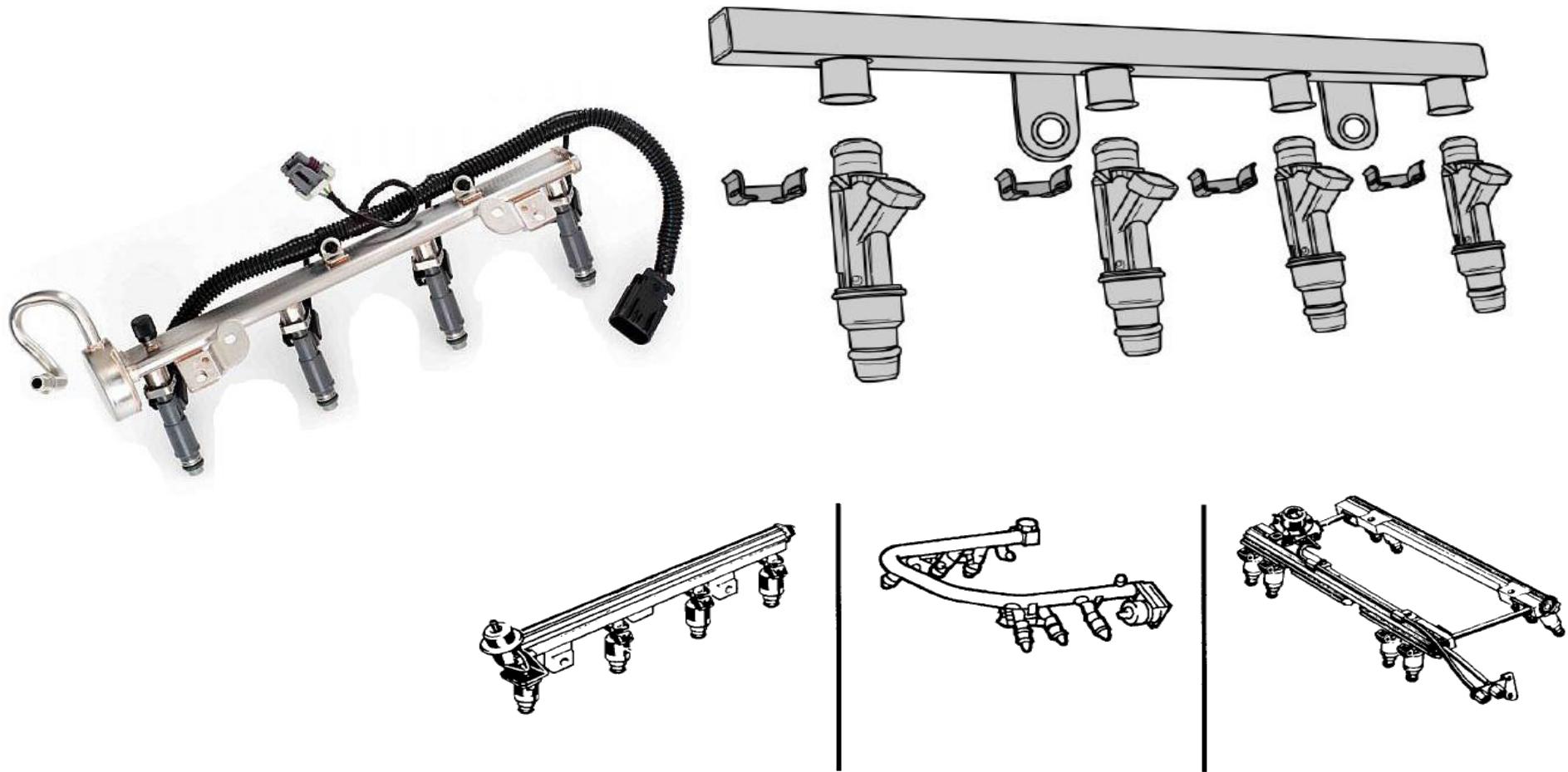
**Serving the  
Professional Racing  
Industry for over 30 years.**

- is simply a coil or solenoid operated valve.
- Spring pressure holds the injector closed.
- When engaged, the injector sprays fuel into the engine.

# Fuel Delivery system

## Fuel rail

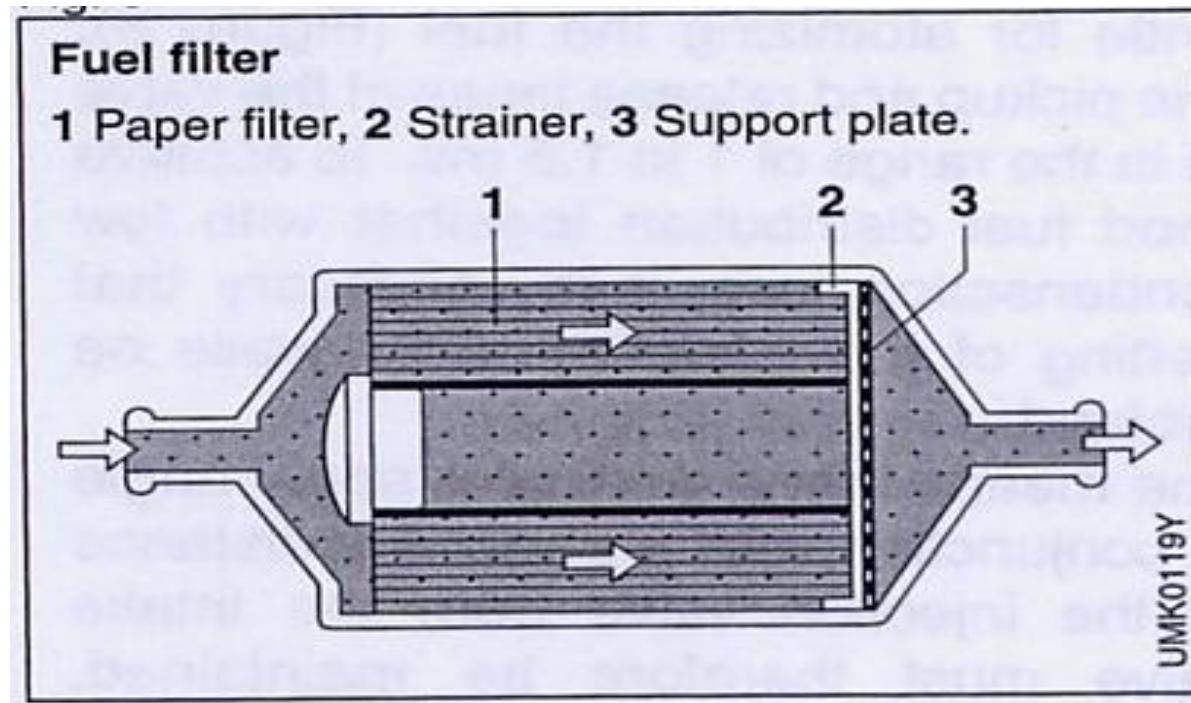
The fuel rail supplies all injection valves with an equal quantity of fuel and ensures the same fuel pressure at all injection valves.



# Fuel Delivery system

## Fuel Filter

The fuel filter filters off impurities in the fuel which could impair the function of the injection system.



# Air Induction System

- Air filter



- Throttle valve



- Sensors



- Connecting ducts



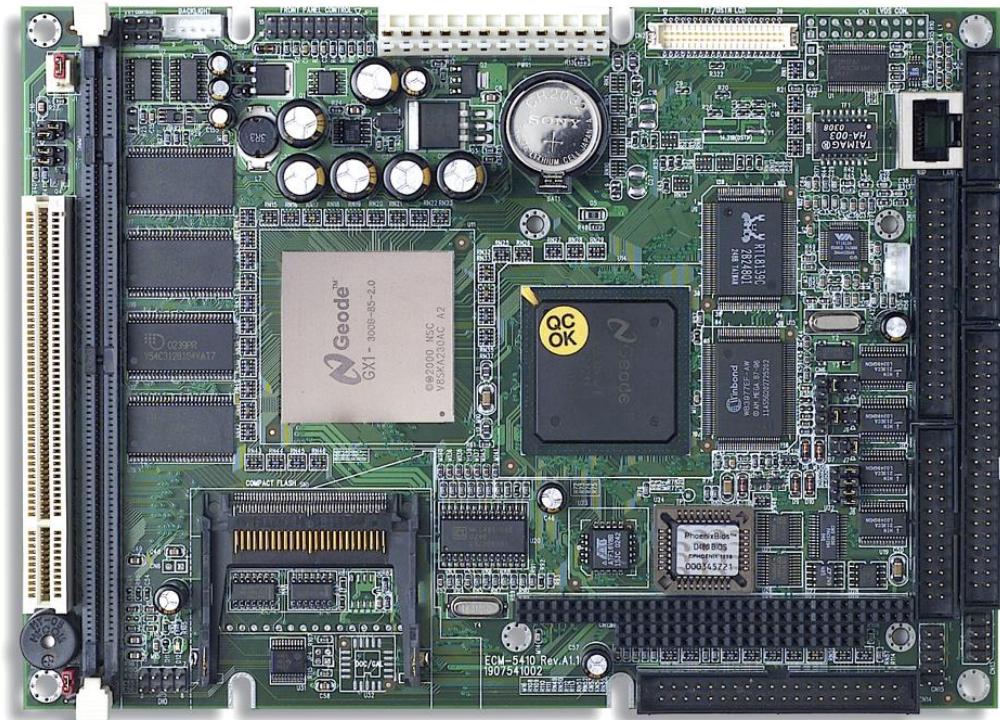
# Sensor System



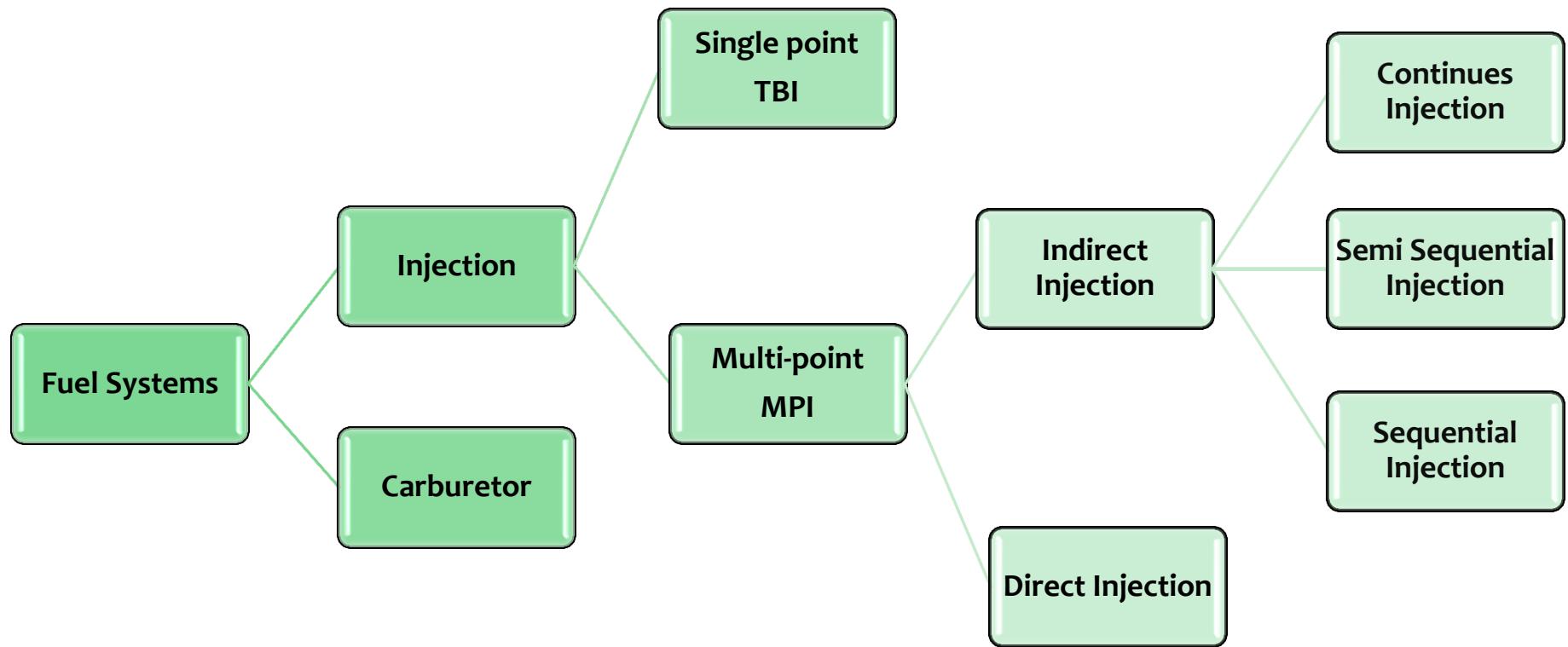
- Monitors engine operating condition and reports this information to ECM (computer).
- Sensors are electrical devices that change resistance or voltage with change in condition such as temperature, pressure and position.

# Computer Control System

- Uses electrical data from the sensors to control the operation of the fuel injectors.
- Engine Control Module (ECM)- “Brain” of the electronic fuel injection.



# Injection Systems Types



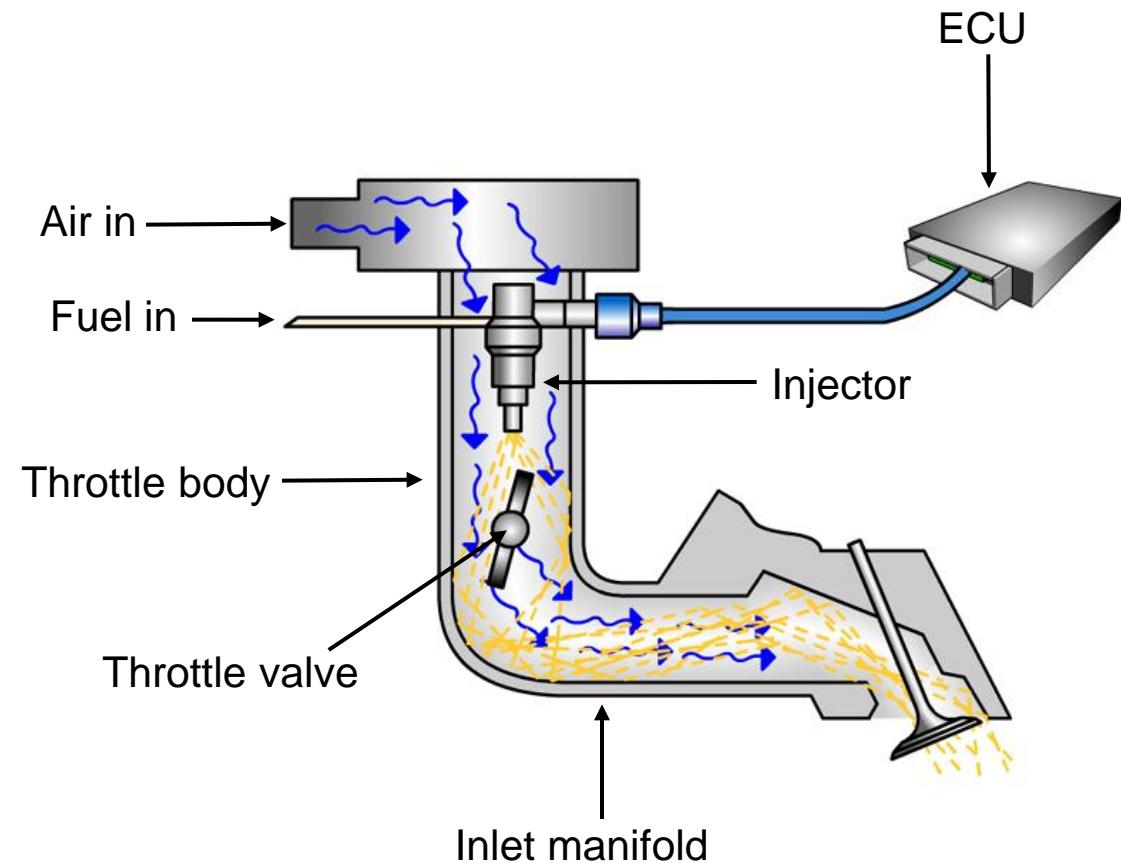
# Single Point Fuel Injection (Throttle Body Injection - TBI)

Fuel injection systems classified by point of injection.

**Injector located inside  
throttle body, sits on top of  
inlet manifold.**

**Injector sprays fuel  
from above throttle  
valve.**

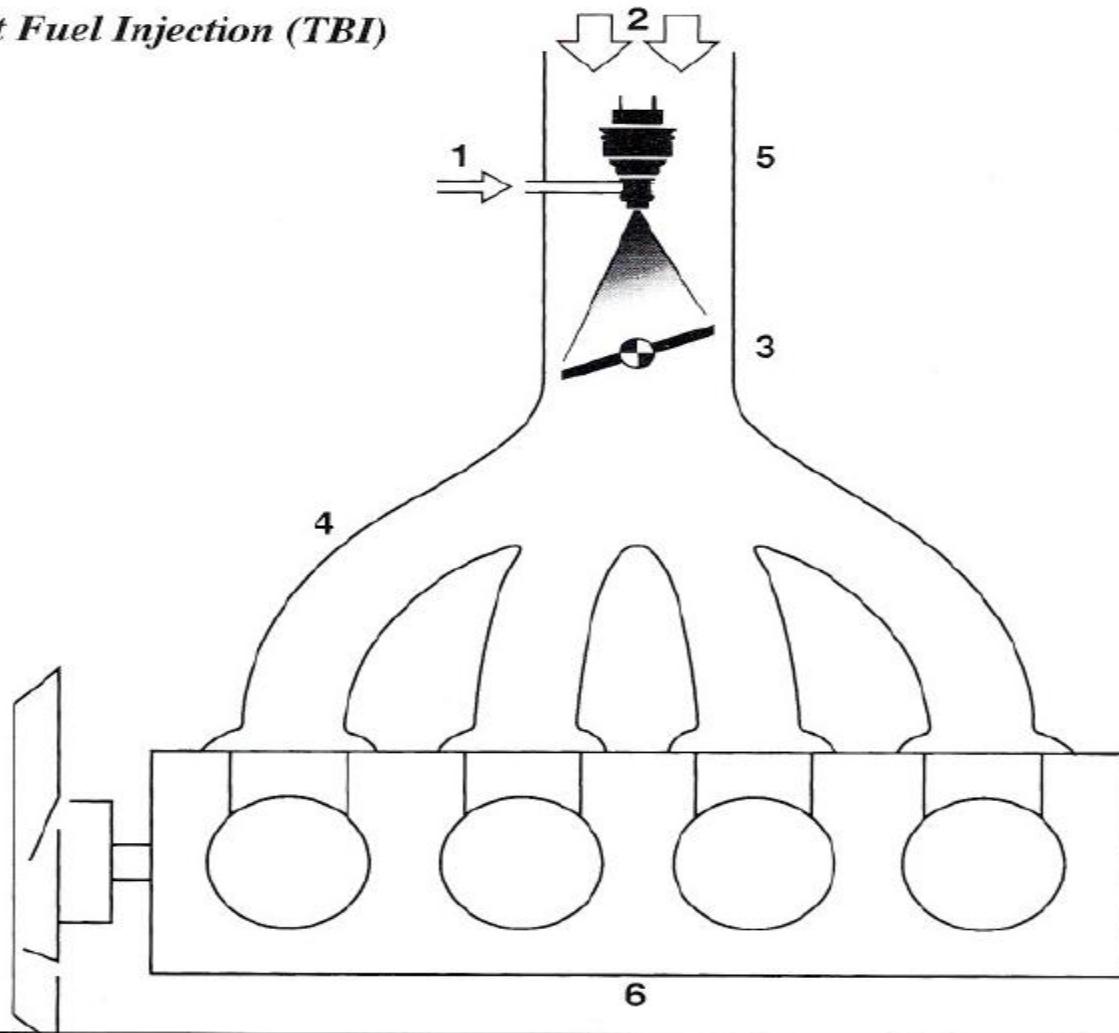
**ECU controls injector  
opening.**



# Single Point Fuel Injection (Throttle Body Injection - TBI)

## *Single Point Fuel Injection (TBI)*

1. Fuel
2. Air
3. Throttle Valve
4. Intake Manifold
5. Injector
6. Engine



**Introducing fuel at a single point—whether from a carburetor or a throttle body injector—"wets" a large area of manifold surface, and gives unevaporated droplets many chances to drop out, forming puddles of fuel. (Robert Bosch Corporation)**

# Throttle Body Injection

- Uses one or two injectors.
- Injectors (*pulse*) spray fuel into the top of throttle body air horn.
- Atomized fuel mixes with air and drawn into the engine.
- Fuel pressure regulator is spring loaded and is part of the housing.
- Fuel is being injected whenever the engine is running, also called **CIS**: Continuous Injection System.

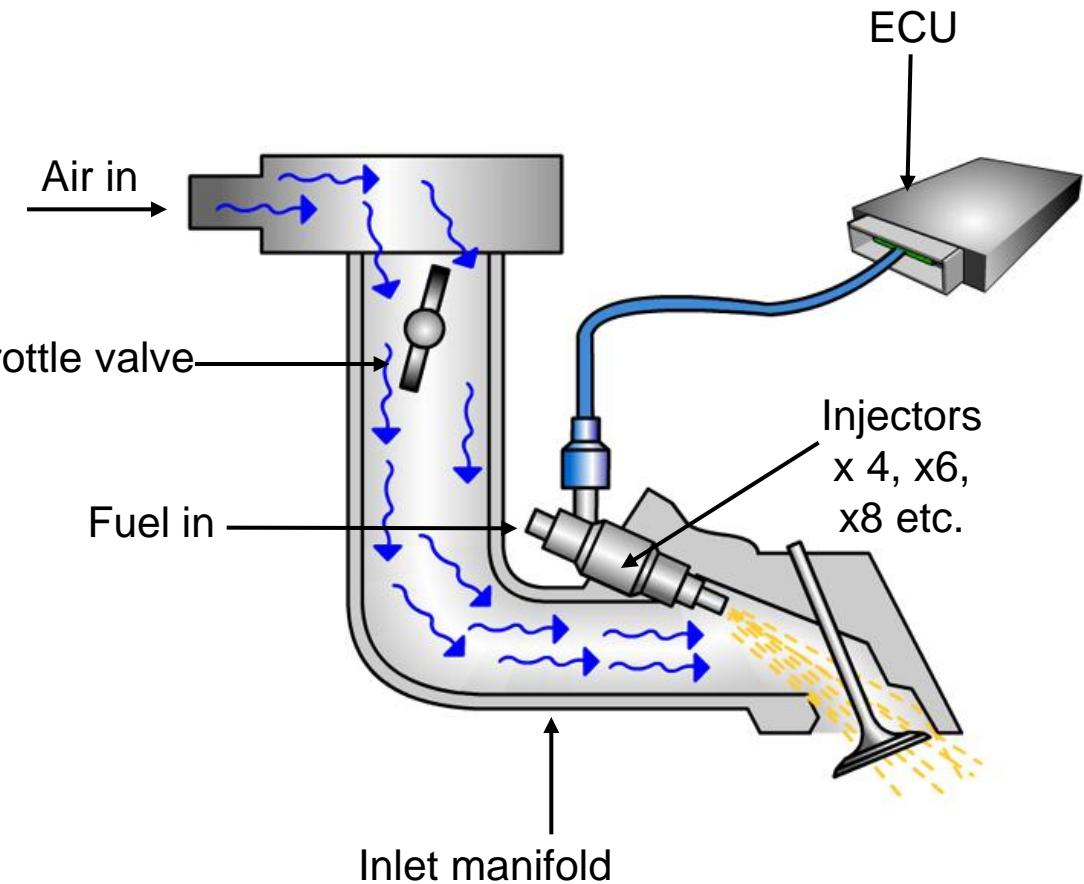


# Multipoint EFI Systems

**Injector located in each branch of inlet manifold, below throttle valve.**

**Injectors spray fuel directly into each port.**

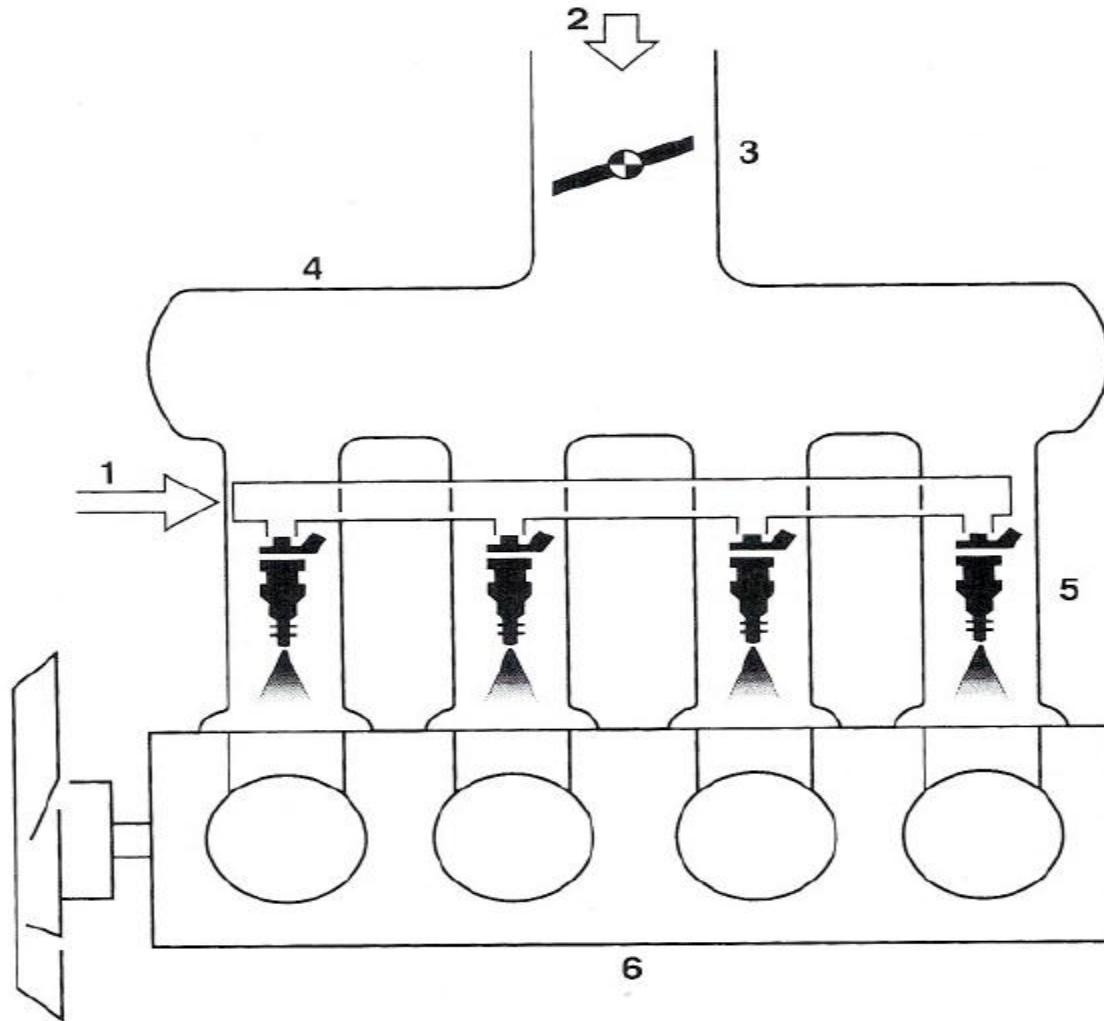
**ECU controls opening of injectors.**



# Multipoint Electronic Fuel Injection System (MFI)

## *Multi-Point Fuel Injection (MFI)*

- 1. Fuel
- 2. Air
- 3. Throttle Valve
- 4. Intake Manifold
- 5. Injectors
- 6. Engine

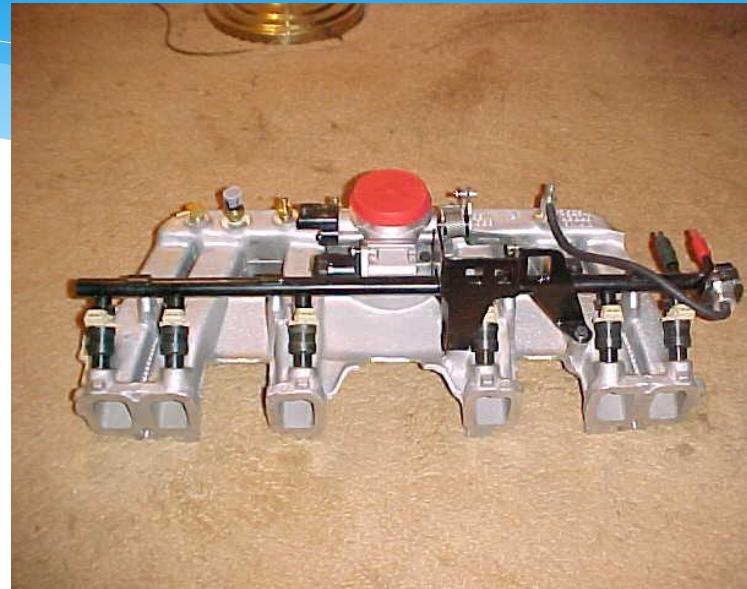


Multi-point injection ensures equal mixture strength at each cylinder. (Robert Bosch Corporation)

# EFI

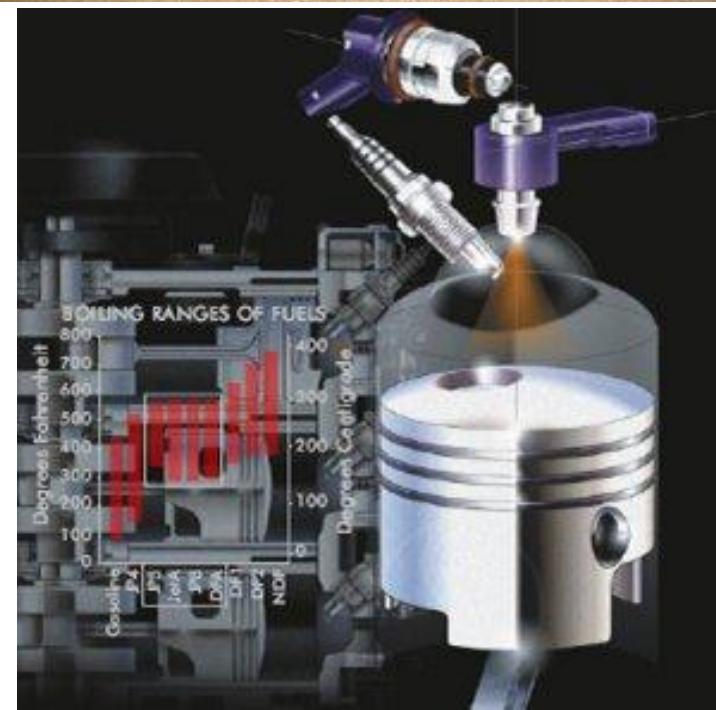
## EFI Multi port Injection System

- Injector is pressed into the runner(*Port*) in the intake manifold.
- Injector sprays towards an engine intake valve.
- Each cylinder has it's own injector



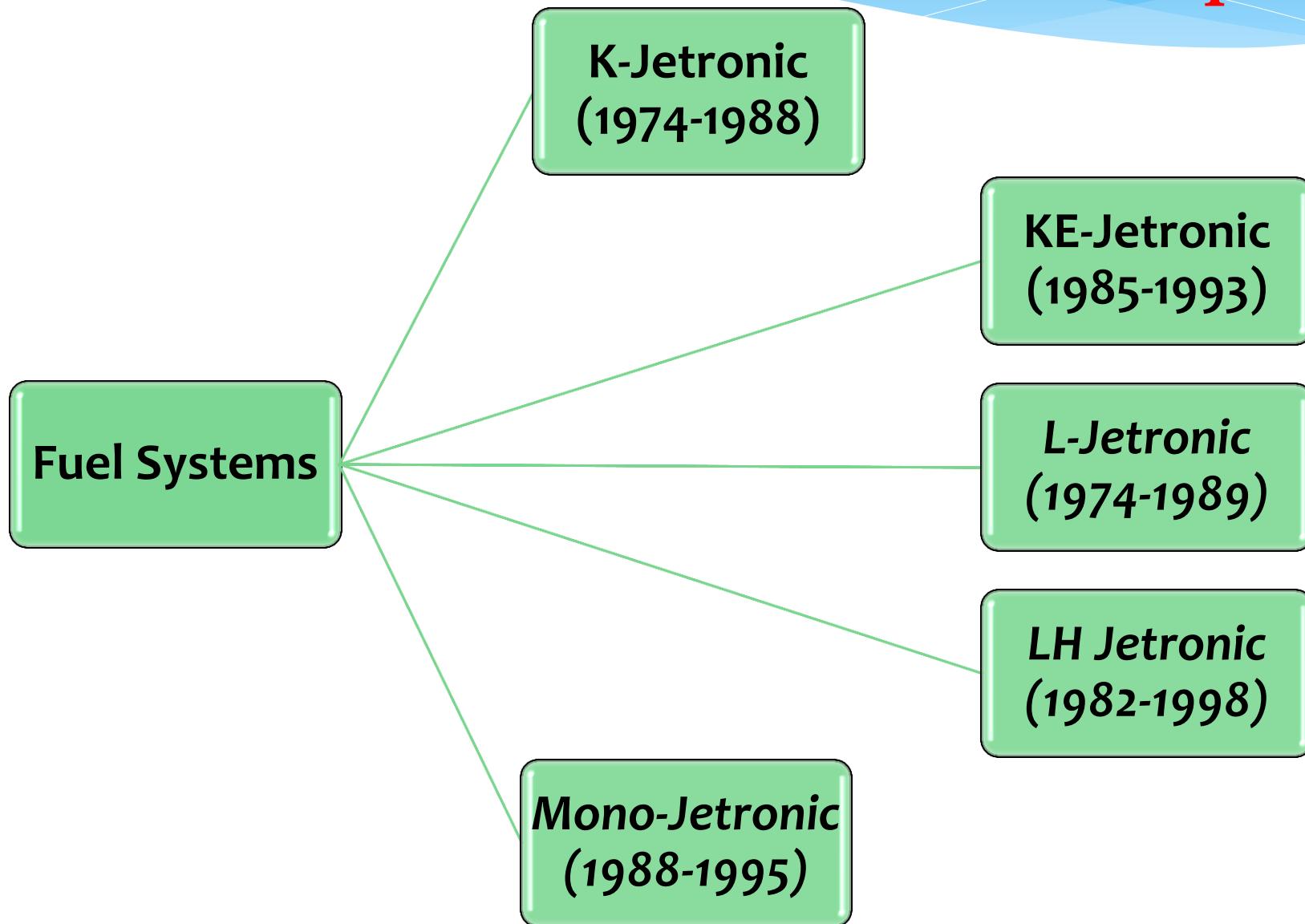
## EFI Direct fuel Injection System

- Injectors are pressed into the combustion chamber and spray fuel directly into the combustion chamber.



# Injection Systems :-

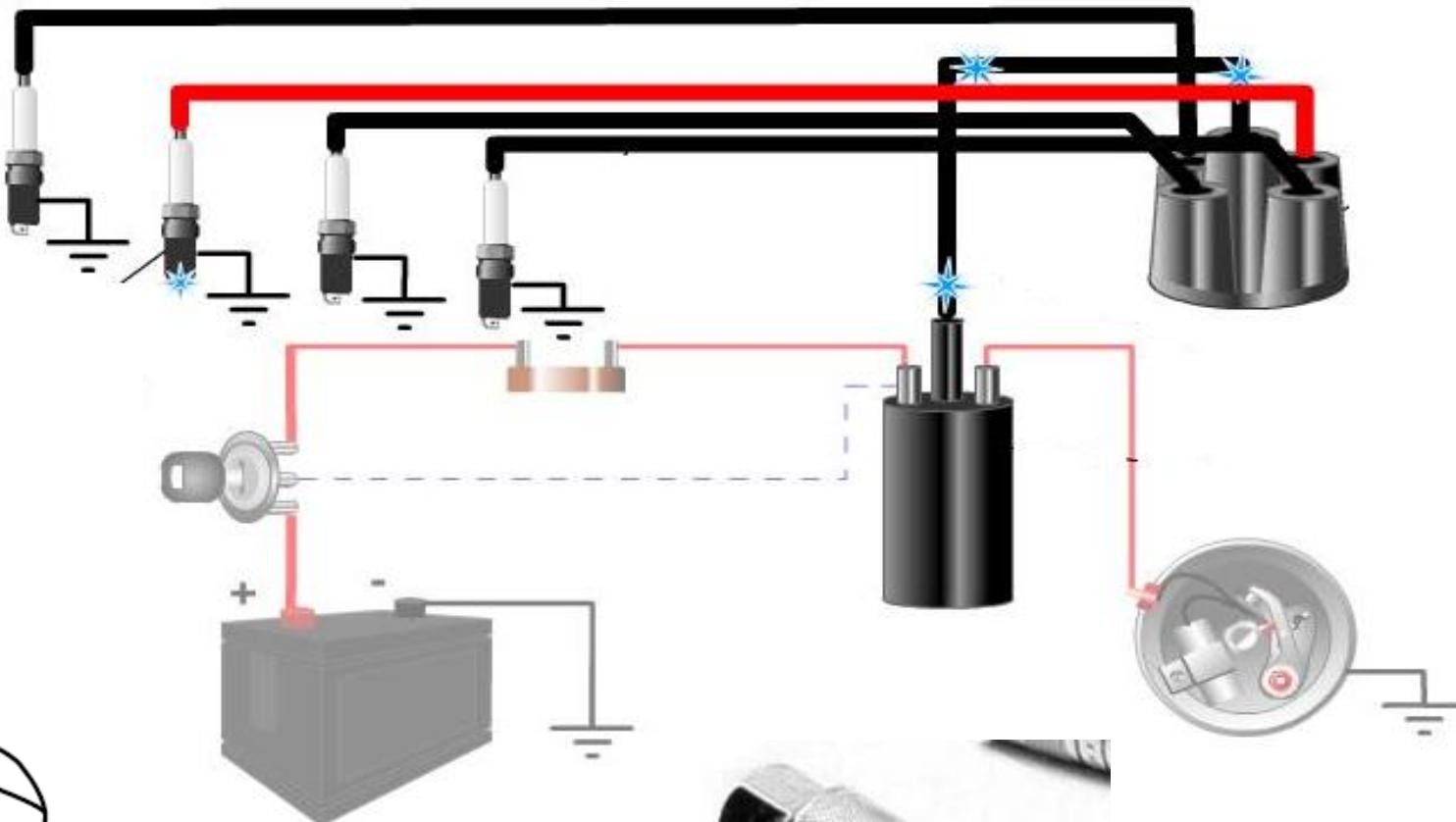
## *Historical Developments*



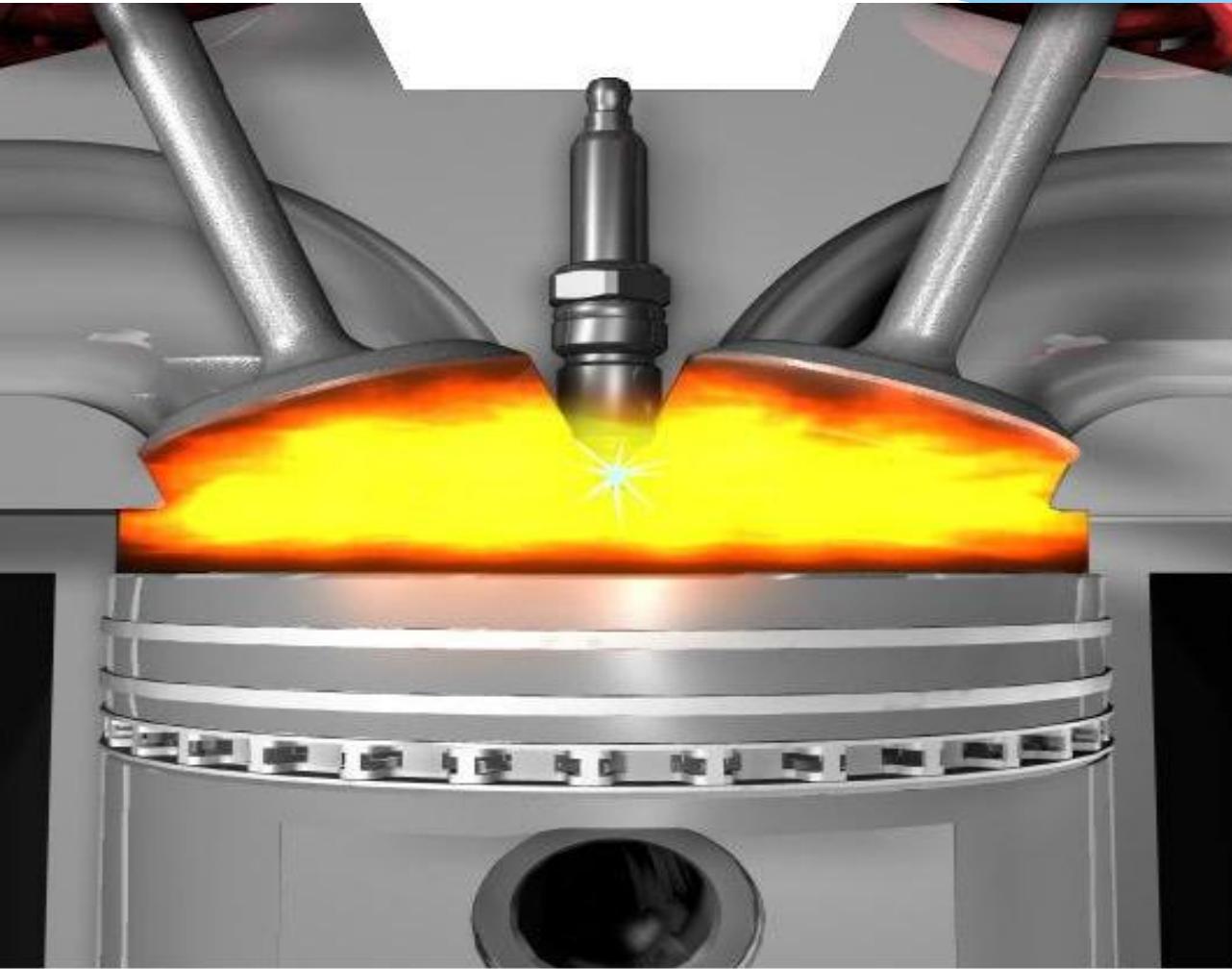


Question?

# Ignition Systems



# Ignition System Purpose



## Ignition system purpose:

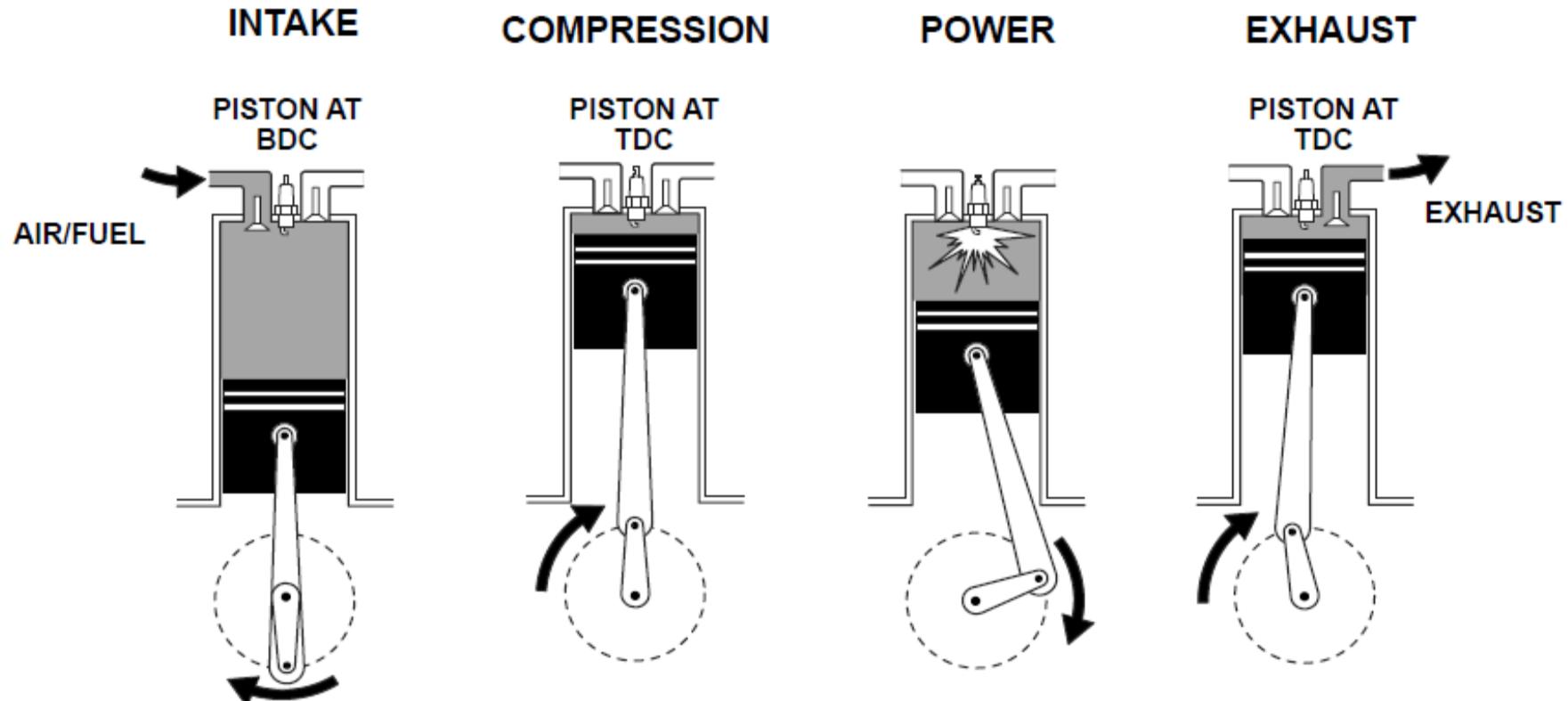
- Produce high voltage
- Create electric arc to jump spark plug gap
- Spark ignites air/fuel mixture when piston is close to top of compression stroke to burn it properly

## الغرض من نظام الإشعال

توليد فرق جهد مرتفع يصل إلى ٤٠ ألف فولت، ليسمح للشرارة بالتنغلب على مقاومة الهواء بين طرفي شمعة الاشتعال.

هذه الشرارة تحرق خليط الهواء والوقود

# The four-stroke principle



## Intake stroke

- Intake valve: open,
- Exhaust valve: closed,
- Piston travel: downward,
- Combustion: none.

## Compression stroke

- Intake valve: closed,
- Exhaust: closed,
- Piston travel: upward,
- Combustion: initial ignition phase.

## Power stroke

- Intake valve: closed,
- Exhaust valve: closed,
- Piston travel : upward,
- Combustion: combustion

## Exhaust stroke

- Intake valve: closed
- Exhaust valve; open,
- Piston travel: upward,
- Combustion: none

# Ignition Systems Types

الإشعال التقليدي (الأبلاتين و الكوندنسير)

الإشعال باستخدام الترانزستور

الإشعال باستخدام أشباه الموصلات

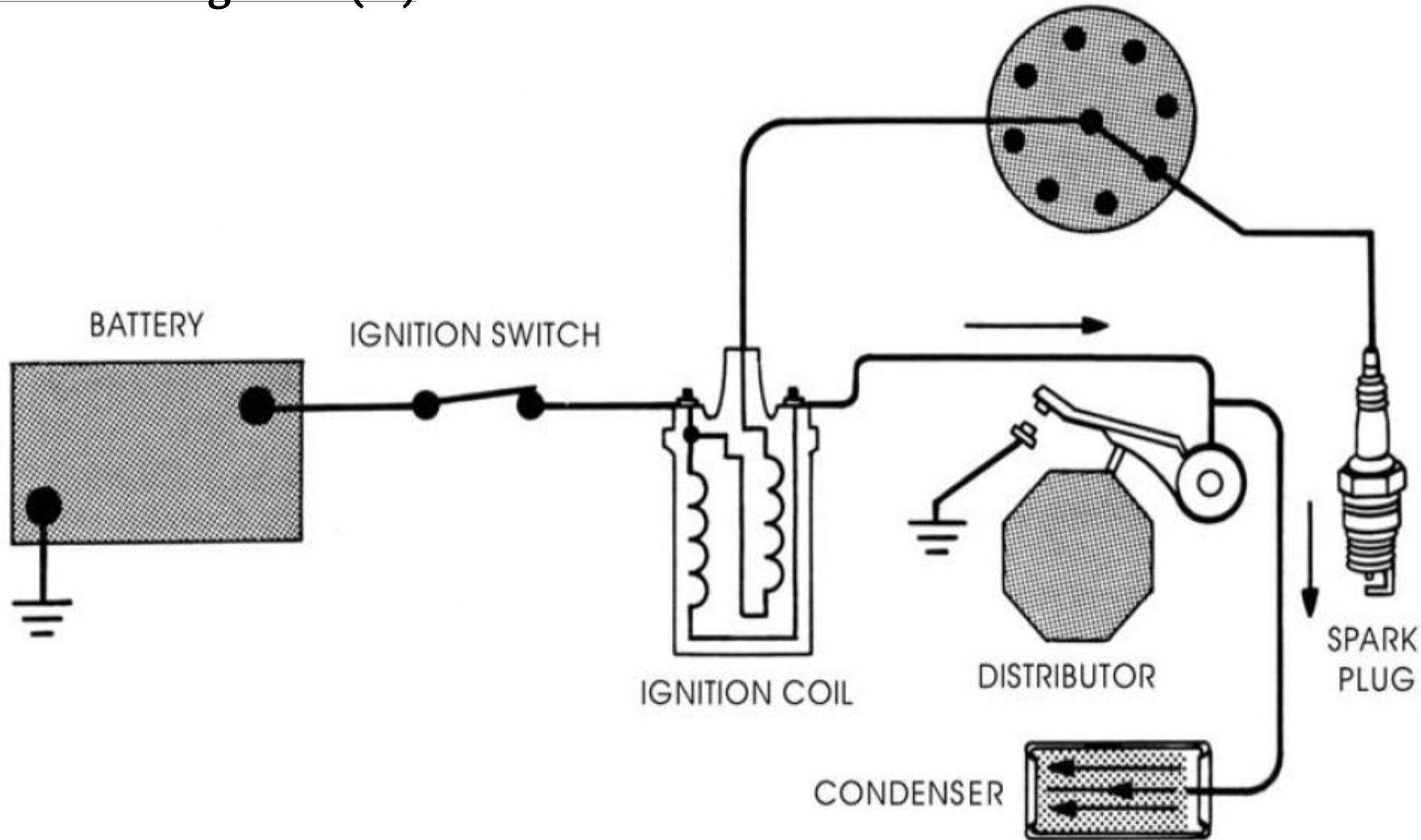
الإشعال المباشر - بدون اسبراتير

# Basic Ignition System Components

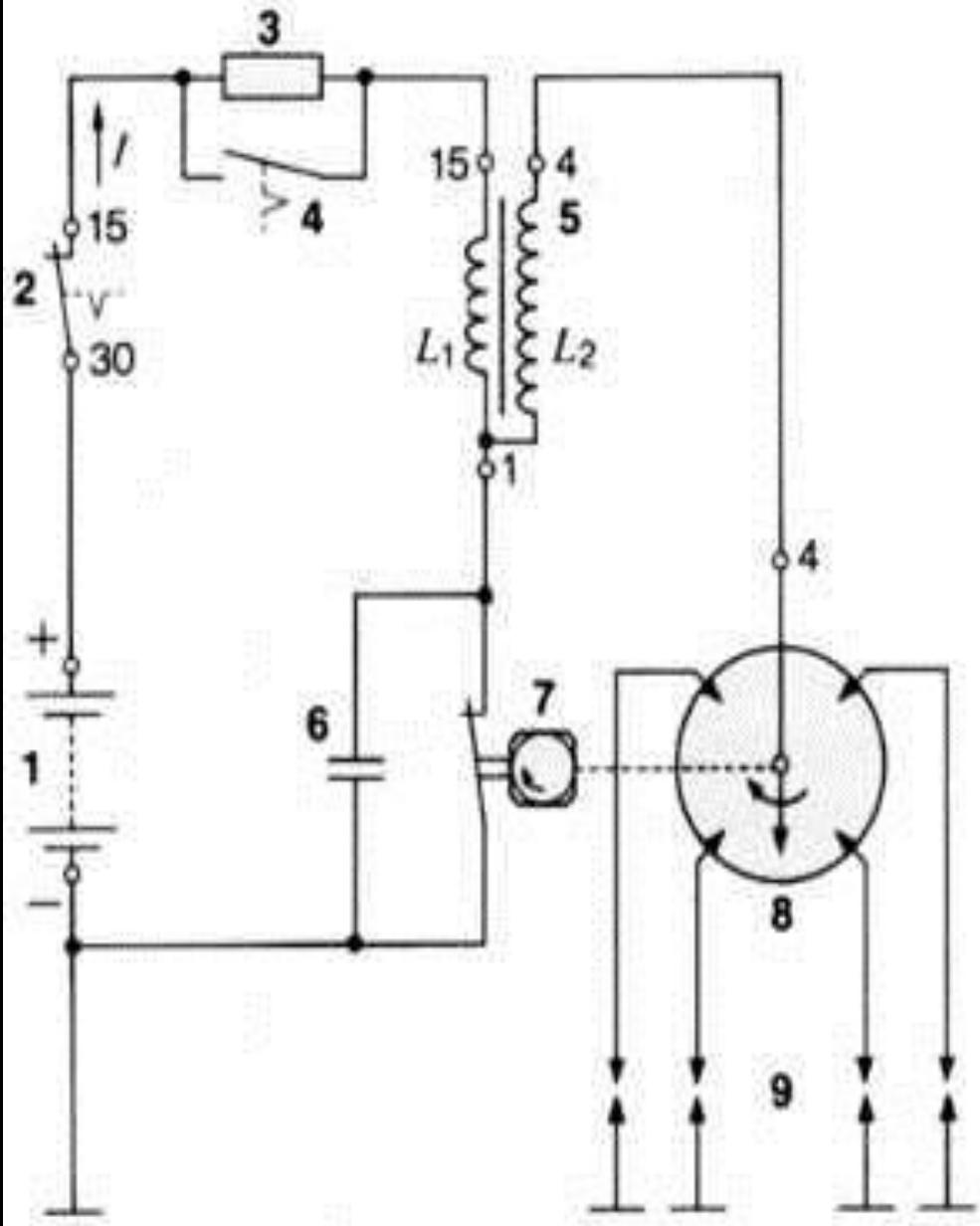
- \* **Battery**
- \* **Ignition Switch**
- \* **Ignition Coil**
- \* **Distributor**
- \* **Spark Plug**
- \* **Ignition System Wires**

# Conventional Ignition System

## Conventional ignition (CI)



# Conventional ignition CI Circuit



- 1 Battery
- 2 Starting switch
- 3 Additional resistor
- 4 Increment switch V at starting
- 5 Ignition coil
- 6 Ignition capacitor
- 7 Contact breaker
- 8 Ignition distributor
- 9 Plugs

# Conventional ignition Components

Breaker Point Ignition - Primary Side



Battery:

- Generates energy to start engine
- Supplies low voltage to primary side of ignition system

البطارية

- تعطى الطاقة اللازمة لبدء المحرك
- تعطى الكهرباء للملف الابتدائي في المويبدة

# Conventional ignition Components

Breaker Point Ignition - Primary Side



## Ignition switch:

- Provides power to the ignition system
- Turns engine on and off
- Supplies current to primary side of ignition system
- Powers starter motor when engine is starting

## مفتاح الكومنتاكت

- يعطى الطاقة الكهربائية لملف الإشعال (الموبينة)
- يعتبر المفتاح الكهربائي لفتح وغلق المحرك
- يوصل الكهرباء إلى الملف الابتدائي داخل الموبينة
- يعتبر مفتاح إدارة المارش عند بدء المحرك

# Conventional ignition Components

## Breaker Point Ignition - Primary Side



### Ballast resistor:

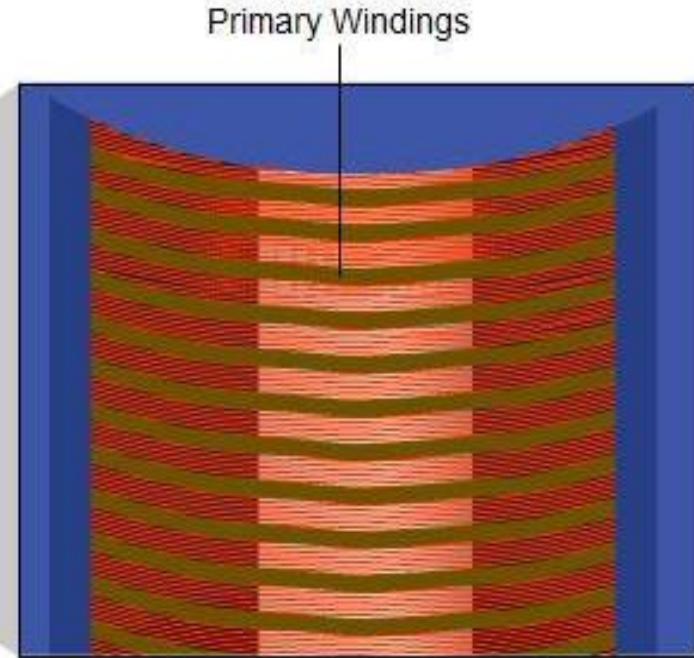
- Protects ignition system components
- Decreases current flow
- Provides steady supply of low voltage
- Bypassed when engine is starting
- Located between ignition switch and coil

### مقاومة الحماية (الموازنة)

- تحمي ملف الإشعال و تطيل من عمره الافتراضي عن طريق تقليل التيار المار به
- لا تعمل إثناء إداره المحرك
- يتم وضعها قبل ملف الإشعال و بعد مفتاح الكونتакت

# Conventional ignition Components

Breaker Point Ignition - Primary Side



Primary windings:

- Hundreds of turns of heavy gauge wire
- Wrapped around soft iron core inside ignition coil
- Carry battery voltage when circuit is closed, allowing magnetic field to build up around windings
- When magnetic field collapses, high voltage is induced into secondary windings

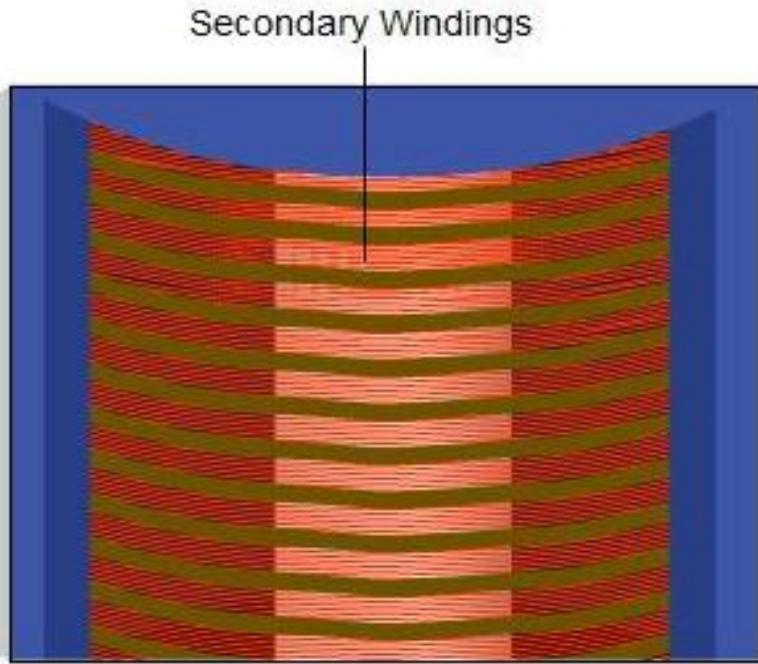
ال ملف الابتدائي داخل الموبينة  
من ١٠٠ الى ٤٠٠ لفة من سلك قطره كبير نسبيا

# Conventional ignition Components

## Breaker Point Ignition - Secondary Side

الملف الثانوى  
داخل  
الموبينة  
من ١٠٠٠  
إلى ٤٠٠٠  
من سلك  
قطره صغير  
نسبيا

و بداخله عمود  
من الحديد  
المطاوع



### Ignition coil secondary windings:

- Several thousand turns of wire wrapped around soft iron core along with primary windings
- When current flows through primary windings, magnetic field is generated
- When magnetic field in primary windings collapses, it induces current into secondary windings
- Current is transformed into high voltage and carried to distributor cap

# Conventional ignition Components



# Conventional ignition Components

## Breaker Point Ignition - Primary Side



### Breaker points/contact points:

- Switching device attached to distributor advance plate
- Movable spring-loaded arm
- If points are closed, current flows
- If points are open, current flow is interrupted

### نقاط التلامس (الابلاتين)

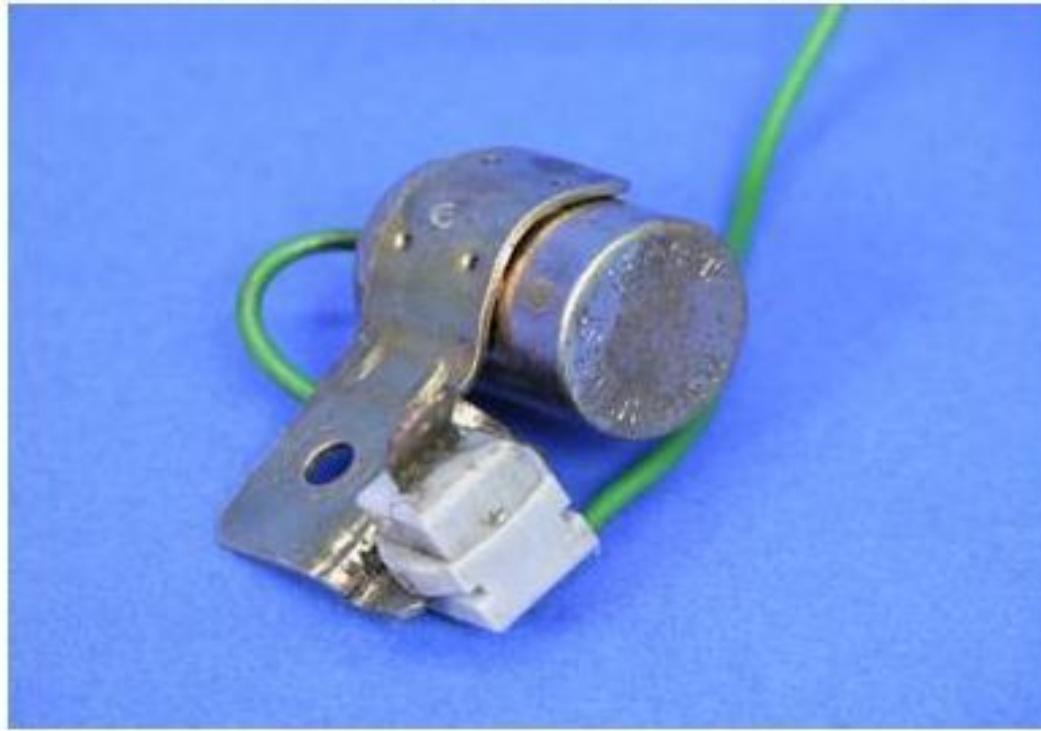
- يقطع التيار الداخل إلى الملف الابتدائي ، مكانه داخل الموزع
- عبارة عن مفتاح كهربائي به سوسته
- عندما يغلق يمر التيار للملف الابتدائي و عندما يفتح يقطع التيار

# Conventional ignition Components



# Conventional ignition Components

Breaker Point Ignition - Primary Side



## Condenser:

- Connected to breaker points
- When points open, voltage spike is absorbed
- Spike is caused by magnetic field collapsing in primary windings
- Protects points from burning

المكثف (الكندنسير)

- متصل على التوازي مع الابلاتين

- يحمي الابلاتين من التلف بواسطة الشرارة

التي تنتج من فرق الجهد المستحث داخل الملف الابتدائي

# Conventional ignition Components



# Conventional ignition Components

## Breaker Point Ignition - Secondary Side



### Distributor cap:

- Made of non-conductive material with metal terminals molded in
- Center terminal carries voltage to rotor
- Outer terminals carry voltage to spark plugs

### غطاء الموزع

- يصنع من مادة غير موصلة للكهرباء .
- الطرف الأوسط يأتي من الموبينة و يحمل الجهد العالي.
- الإطراف الخارجية تحمل الجهد العالي إلى البوจيهات حسب الميعاد.

# Conventional ignition Components

## Breaker Point Ignition - Secondary Side



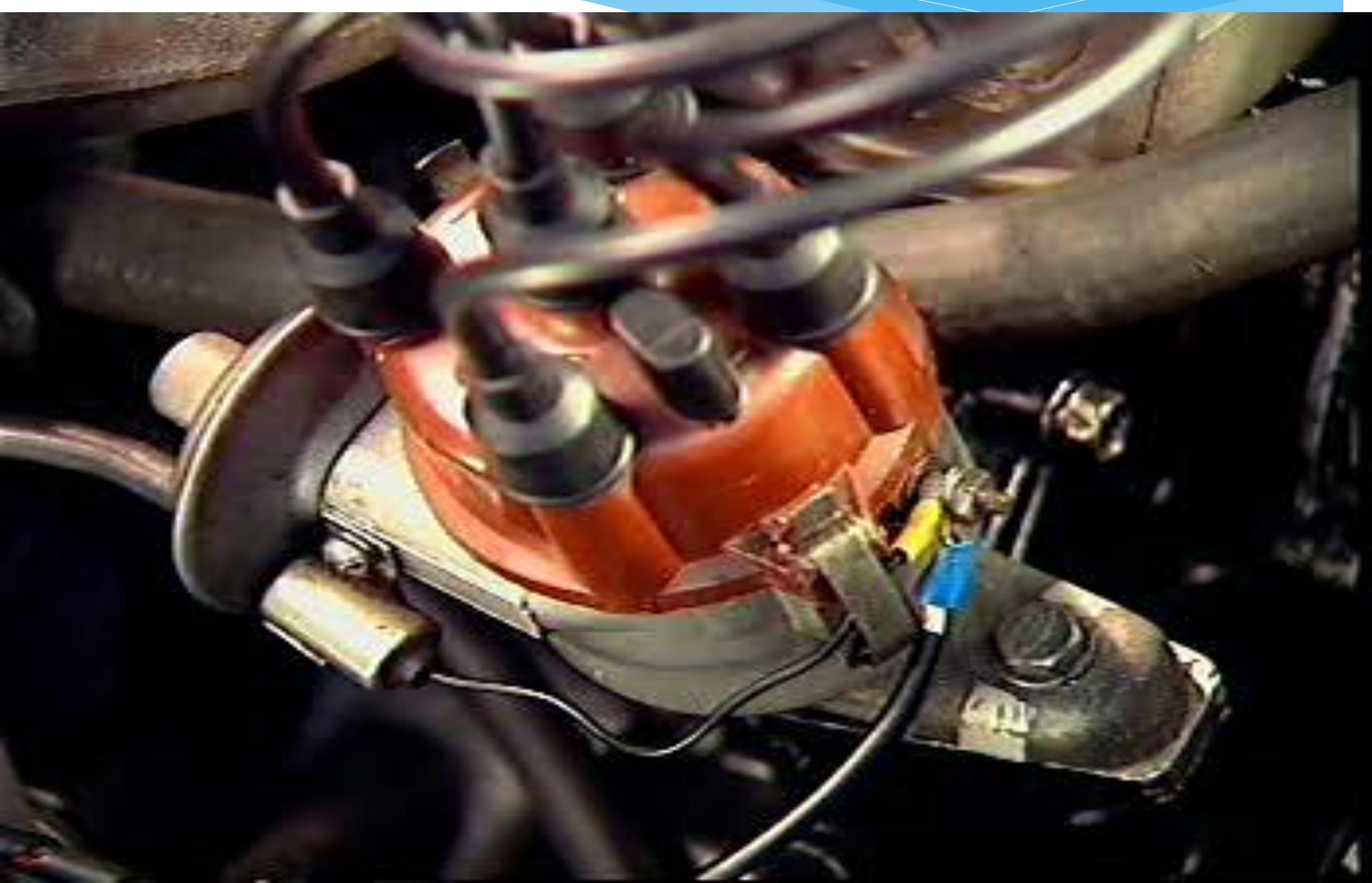
Distributor rotor:

- Switching device that is mounted on top of distributor shaft
- Spins to distribute high voltage from distributor cap to spark plugs
- High voltage jumps across gap between firing end and outer terminals to feed spark plugs

- يدور مع عمود الاسبراتير و يوزع الجهد العالي الخارج من الملف الثانوي على البوgieات ، الجهد يصل إلى البوgieات و يسبب الشرارة بين طرفي البوجية.

العضو الدوار ( الشاكوش )

# Conventional ignition Components



# Conventional ignition Components

## Breaker Point Ignition - Secondary Side



### Spark plug wires:

- Carry high voltage from distributor cap outer terminals to spark plugs
- Newer wires are built of several layers: synthetic core, rubber insulation, fiberglass braid and silicone jacket
- Insulated boots provide tight connection and seal

# Conventional ignition Components

Breaker Point Ignition - Secondary Side



## Spark plugs:

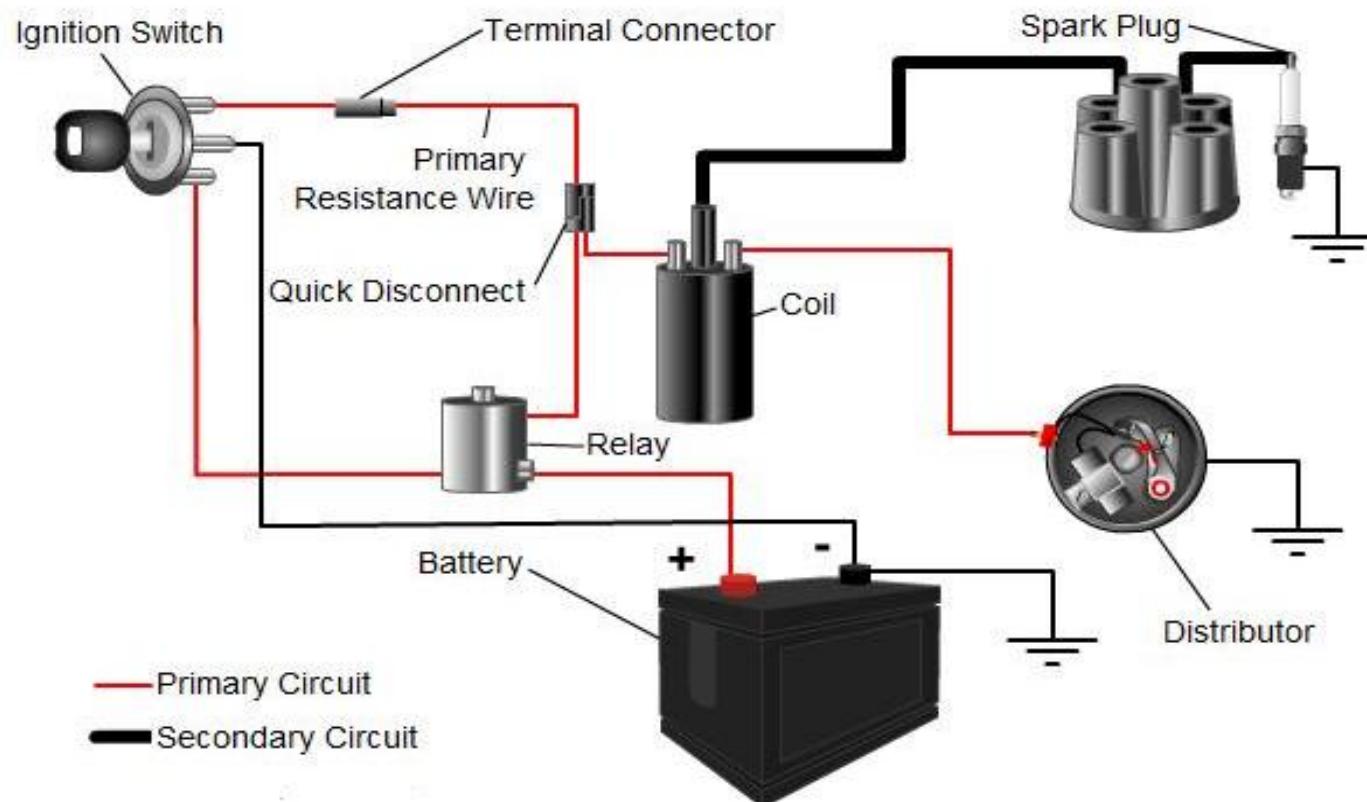
- Receive high voltage from ignition coil
- Produce spark to ignite air/fuel mixture in combustion chamber
- Made of center electrode, ceramic insulator, metal shell and side electrode
- Most spark plugs have an internal resistor to reduce radio interference
- Spark occurs when high voltage jumps across gap between electrodes

# **Development of Ignition Systems**

# Breaker Point Ignition

Breaker point ignition:

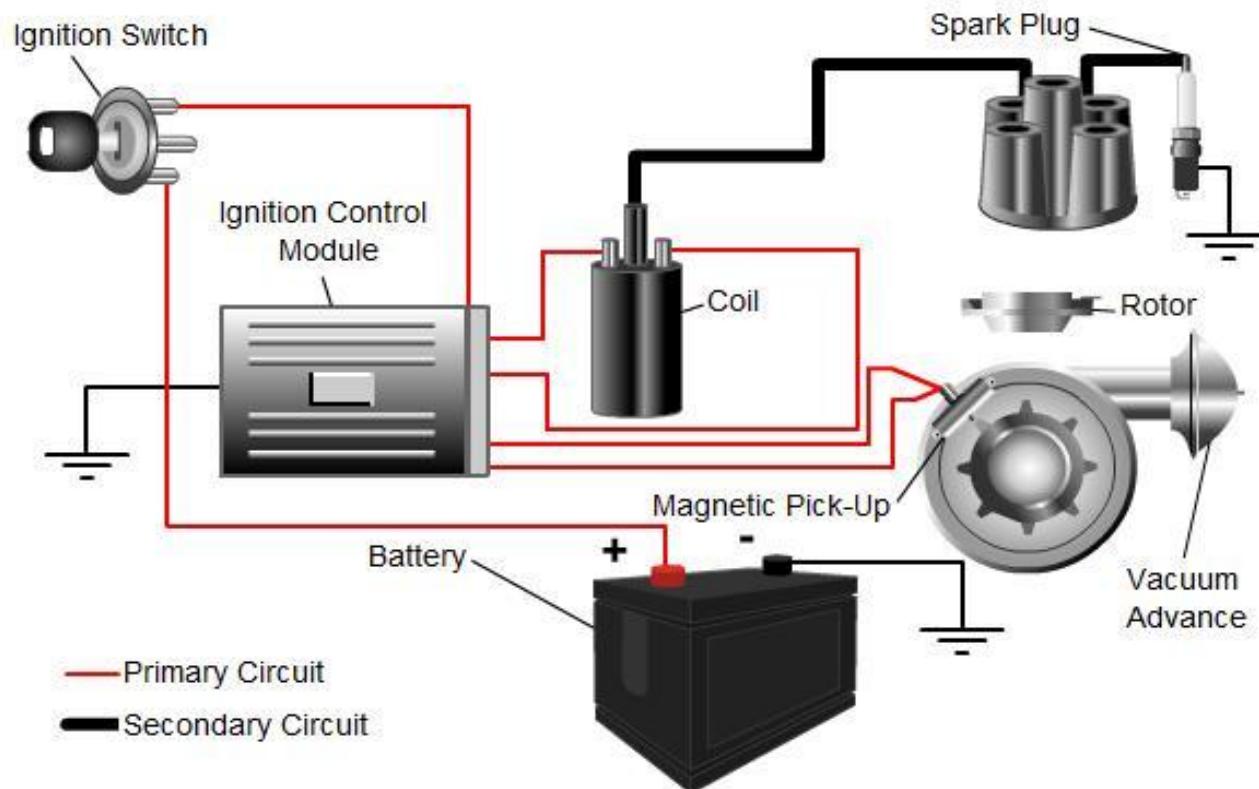
used a rotating magnet to induce current in a coil in order to produce spark. The first reliable breaker point ignition system powered by a battery was developed by Charles Kettering in the early 1900s and it was adopted by many manufacturers.



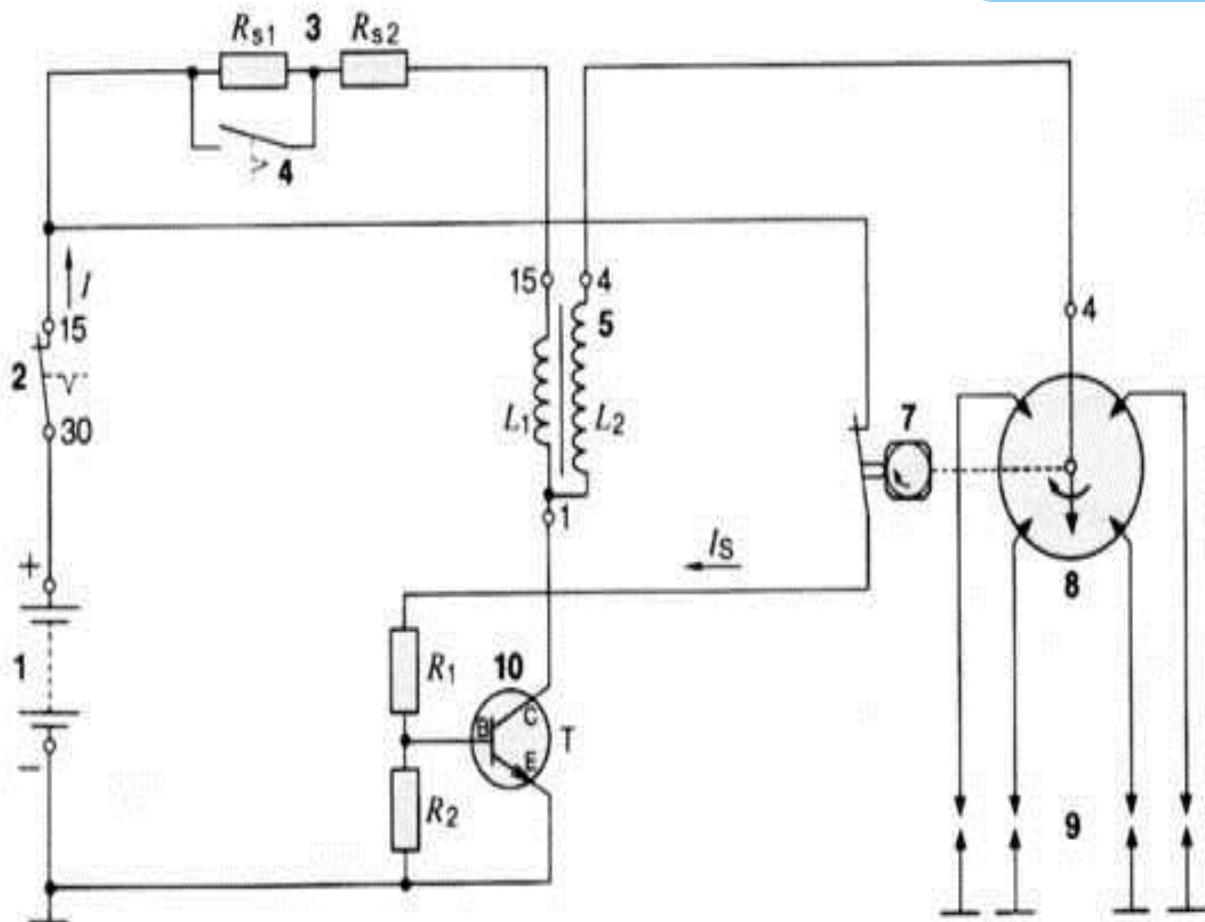
# Electronic Ignition

Electronic ignition:

One of the main disadvantages of breaker point ignition systems was that they suffered mechanical wear from the constant arcing across points. Around the early 1970s, electronic ignition systems became the best option for vehicle manufacturers. The new system used an electronic switch as a substitute for breaker points. This increased reliability, reduced maintenance and allowed vehicle performance to meet emission standards.



# Transistorized ignition Breaker TI-B



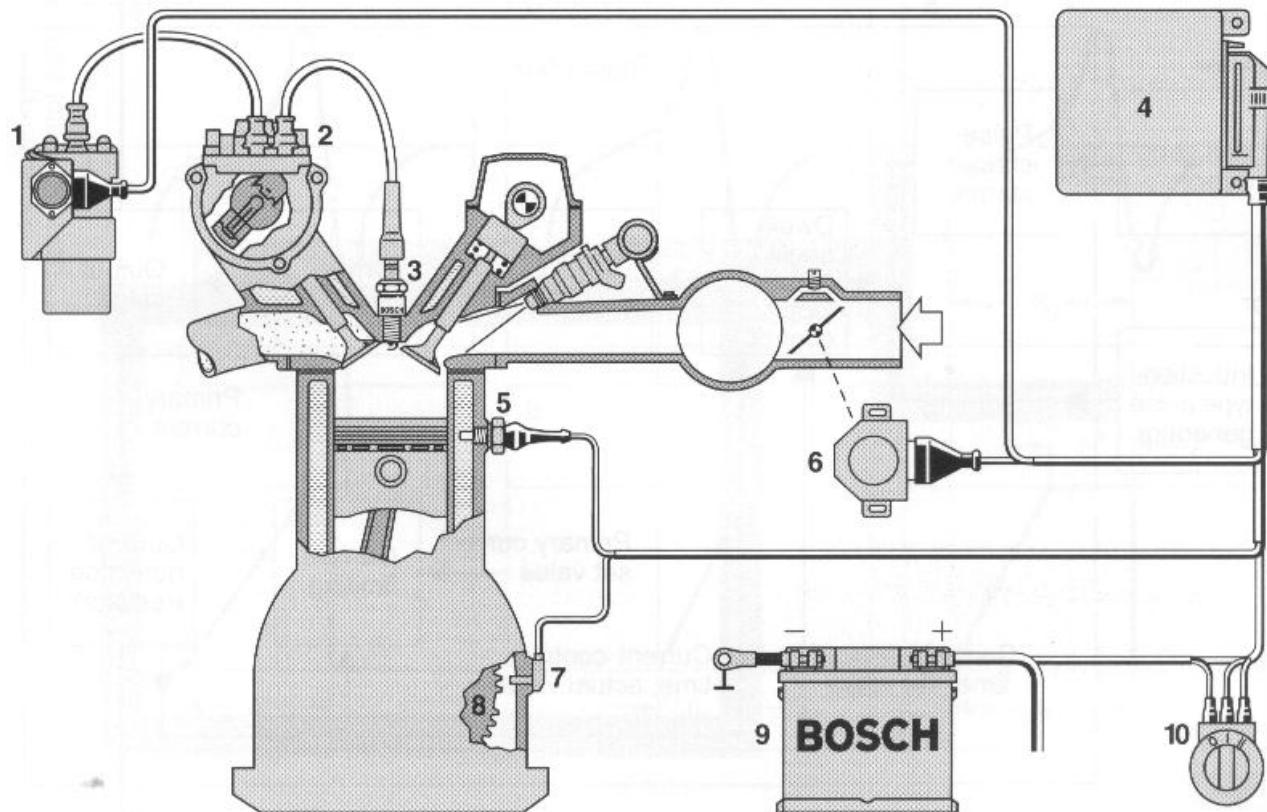
The breaker-triggered transistorized ignition system is a further development of the conventional, non-electronic coil-ignition system. The transistor T is used as the circuit breaker in place of the contact breaker and assumes its switching function in the primary circuit of the Ignition system. However, since the transistor has a relay characteristic, it must be caused to switch in the same way as the relay.

10 Electronic components with resistances of the voltage divider  $R_1$ ,  $R_2$  and transistor T.

# Semiconductor ignition SI

Fig. 1: Semiconductor ignition system (SI)

1 Ignition coil with attached ignition output stage, 2 High-tension distributor, 3 Spark plug, 4 ECU,  
5 Engine-temperature sensor, 6 Throttle-valve switch, 7 Rotational-speed sensor and reference-mark  
sensor, 8 Ring gear, 9 Battery, 10 Ignition and starting switch.



On the "semiconductor ignition system", there is no mechanical spark-advance system in the distributor. Instead, a pulse-generator signal, in the form of an engine-speed signal, is used to trigger the ignition.

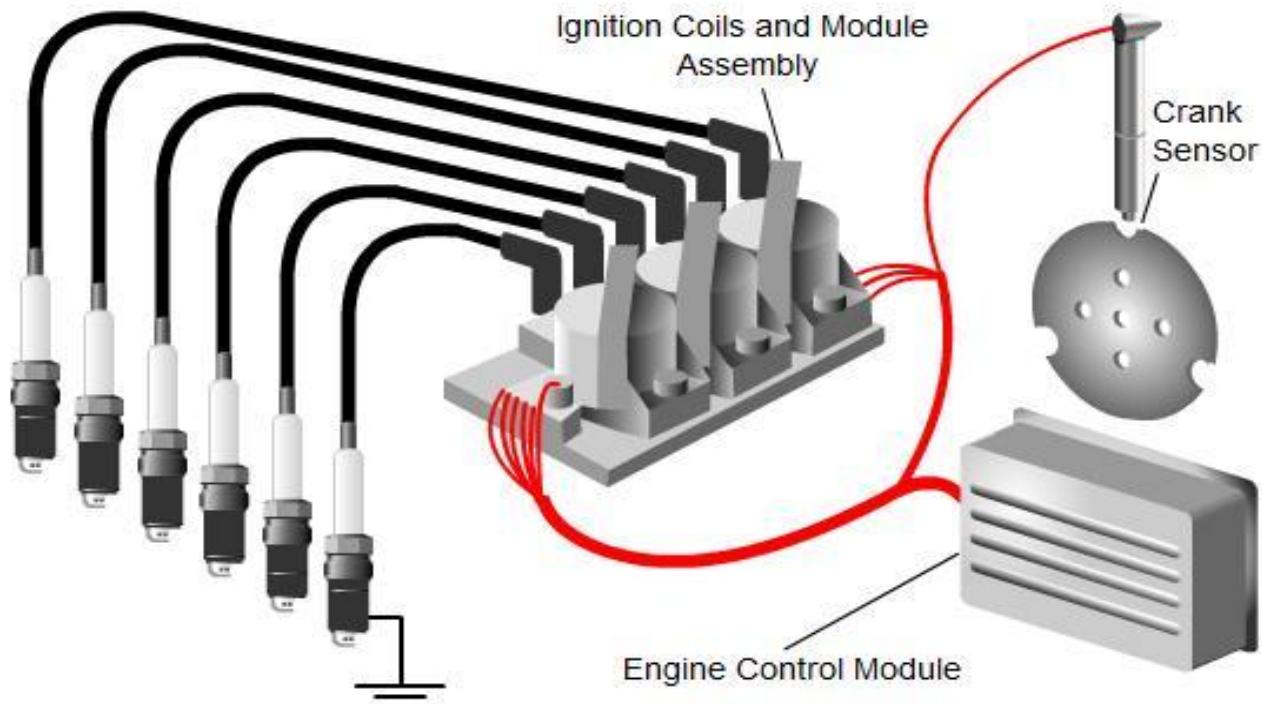
An additional pressure sensor supplies the load signals.

The microcomputer computes the required ignition-point adjustment and modifies the output signal issued to the trigger box accordingly.

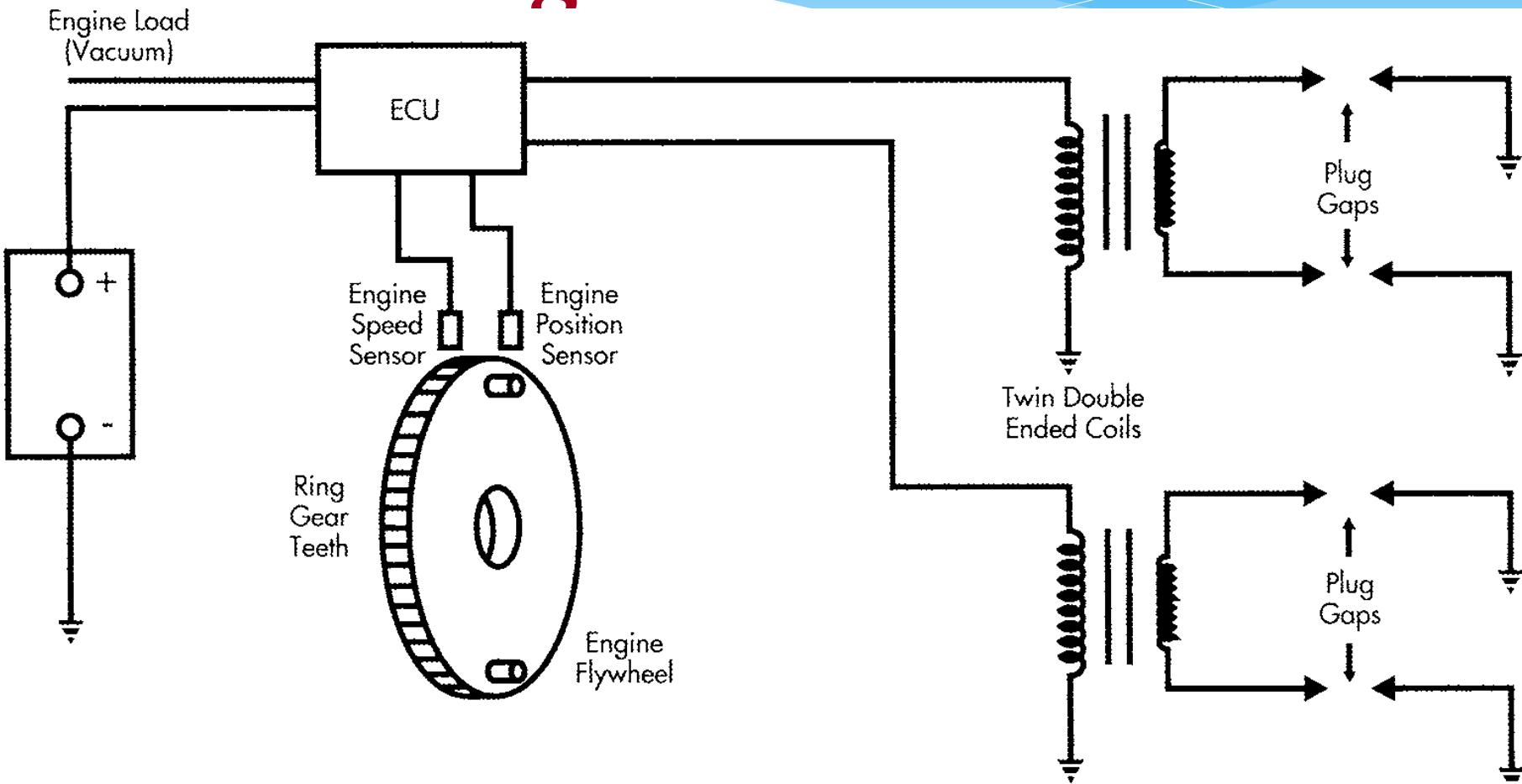
# Electronic distributor-less ignition

Electronic distributor-less ignition:

Electronic distributor-less ignition systems were developed to provide a new and more reliable way to ignite the air/fuel mixture. This system has proved to be effective in controlling emissions and significantly reducing maintenance required by previous ignition systems.



# Distributor less semi-conductor ignition DLI



The two spark plugs are electrically connected in series with this ignition coil so that one spark plug is connected to each of its high voltage outputs. These two spark plugs must be arranged so that one spark plug fires in the working stroke of the cylinder and the other in the exhaust stroke of the cylinder.



# Question?