

RAJKUMAR GOEL INSTITUTE OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

FUNDAMENTAL OF MECHANICAL ENGINEERING

SUBJECT CODE- BME-101 /BME-201

UNIT-II

Introduction to IC Engines and Electric Vehicles

Syllabus

IC Engine: Basic definition of engine and Components, Construction and Working of Two stroke and four stroke SI & CI engine, merits and demerits, scavenging process; difference between two-stroke and four stroke IC engines and SI and CI Engines.

Electric vehicles and hybrid vehicles: Components of an EV, EV batteries, chargers, drives, transmission and power devices. Advantages and disadvantages of EVs. Hybrid electric vehicles, HEV drive train components, advantages of HV.

Topic: Engine and Heat Engine

An engine is a device which transforms one form of energy into another useful form of energy. Normally most of the engines convert thermal energy into mechanical work and therefore they are called “heat engines”.

Topic: Internal Combustion Engine (ICE) and External Combustion Engine (ECE)

Internal Combustion Engine (ICE)

In internal combustion engines, combustion of fuel takes place inside the engine cylinder.

Examples: Diesel Engines, Petrol Engines, Gas Engines.

External Combustion Engine (ECE)

In external combustion engines, combustion of fuel takes place outside the engine cylinder.

Examples: Steam engine, closed gas turbine etc.

Topic: Difference between Internal Combustion Engine (ICE) and External Combustion Engine (ECE)

S. No.	EC Engine	IC Engine
1	Combustion of fuel is outside the engine	Combustion of fuel is inside the engine
2	Bulky due to presence of auxiliary apparatus like boiler and condenser.	It is light and compact
3	High ratio of weight to power output	Low ratio of weight to power output
4	It can use cheaper fuels including solid fuels	High grade fuels are used with proper filtration
5	Higher requirement of water for dissipation of heat	Lesser requirement of water
6	Lower efficiency about 15-20%	Higher efficiency about 35-40%
7	Silent operation due to outside combustion	Very noisy operated engine

Topic: Classification of I.C. Engine

On the basis of strokes used

- Two Stroke cycle Engines
- Four Stroke Cycle Engines

On the basis of cycle used

- Otto Cycle Engines
- Diesel Cycle Engines
- Dual Cycle Engines

On the basis of types of fuel used

- Petrol Engines

- Diesel Engines
- Gas Engines

On the basis types of Ignition Method:

- Spark Ignition (SI)
- Compression Ignition (CI)

On the basis types of cooling system used:

- Air cooled engines
- Water cooled engines

On the basis types of different position of cylinder engines:

- Horizontal cylinder engines
- Vertical cylinder engines
- Inclined cylinder engines

Topic : Advantages and Disadvantages of I.C. Engine

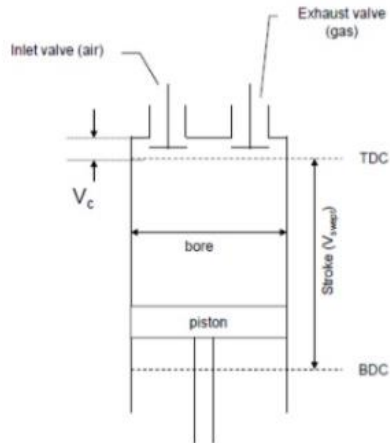
Advantages

- Mechanical Simplicity
- Low initial cost due to absence of boiler, turbine condenser etc
- High efficiency than external combustion engine
- Power to weight ratio is high
- Very suitable for small power requirement applications
- Starting time is very less
- Requires less maintenance

Disadvantages

- Variety of fuels that can be used is limited to very fine quality gaseous and liquid fuel.
- Fuel used is very costly like gasoline or diesel.
- Engine emissions are generally high compared to external combustion engine.
- Not suitable of large scale power generation.
- In case of reciprocating internal combustion noise is generated due to detonation

Topic : Nomenclature of IC Engine:



Bore

Inside diameter of the cylinder is termed as Bore.

Top Dead Center (TDC)

The extreme position reached by the piston at the top of the cylinder is called Top Dead Center.

Bottom Dead Center (BDC)

The extreme position reached by the piston at the bottom of the cylinder is called Bottom Dead center.

Stroke

Movement of piston from TDC to BDC or BDC to TDC is known as stroke.

Stroke Length:

The distance travelled by the piston in the cylinder from TDC to BDC or BDC to TDC is known as stroke length.

Cylinder volume (V)

It is the sum of swept volume of the cylinder and clearance volume of the cylinder.

$$V = V_s + V_c$$

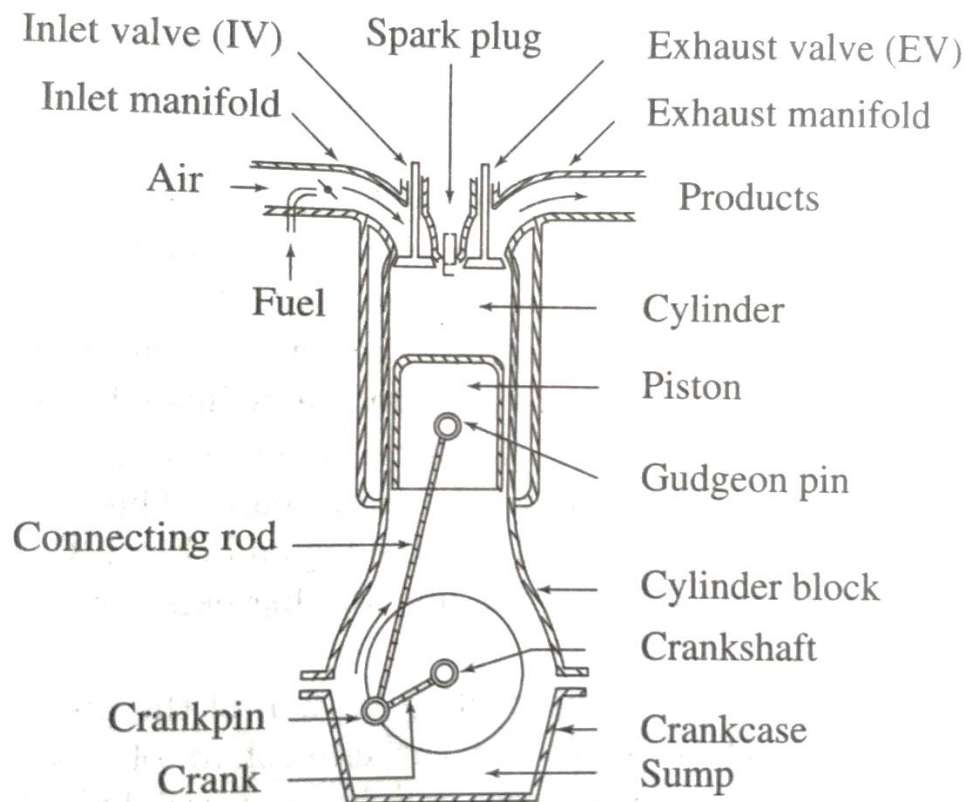
Swept volume (V_s)

It is the volume generated by the movement of piston inside the cylinder from TDC to BDC or BDC to TDC.

Clearance Volume (V_c)

It is the volume in the cylinder, when the piston is at Top Dead Center.

Topic: Components of I.C. Engines



Cylinder Block

It is the main block of the engine. It contains crank, camshaft, piston and other engine parts.

Cylinder Head

The cylinder head is bolted to the cylinder block by means of studs. The water jackets are provided for cooling water circulation.

Crankcase

It may be cast integral with the cylinder block. Sometimes, it is cast separately and then attached to the block.

Piston

It acts as a movable gas tight seal to keep the gases inside the cylinder. It transmits the force of explosion in the cylinder to the crankshaft through the connecting rod.

Piston Rings

Piston rings are inserted in the grooves provided in the piston. Two types of piston rings are used in the piston. Compression rings and oil rings.

Connecting Rod

It connects the piston and crank shaft. It transmits the force of explosion during power stroke to the crankshaft.

Flywheel:

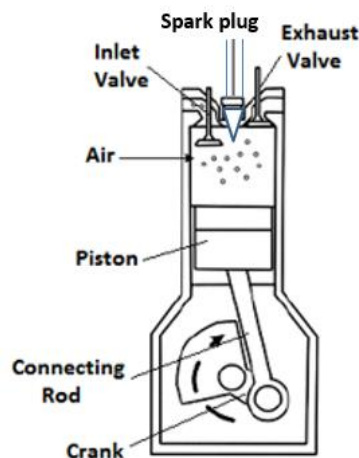
Store up energy necessary to carry the engine over the points at which it is not receiving power impulses from the explosion. It is connected to the electric starting motor by a set of teeth cut on its outer rim.

Valve: Two valves are used for each cylinder – an inlet and an exhaust valve. Inlet valve admitted the fuel/air to the cylinder and exhaust valve escaped the burned gases.

Camshaft: It actuates the valves and carries one cam for each valve to be operated. It is driven by the crankshaft and always rotates at half the speed of the crankshaft.

Topic: Construction and Working of Four Stroke Petrol Engine

Construction: A piston reciprocates inside the cylinder. The piston is connected to the crank shaft by means of a connecting rod and crank. The inlet and exhaust valves are mounted on the cylinder head. A spark plug is provided on the cylinder head. The fuel used is petrol.



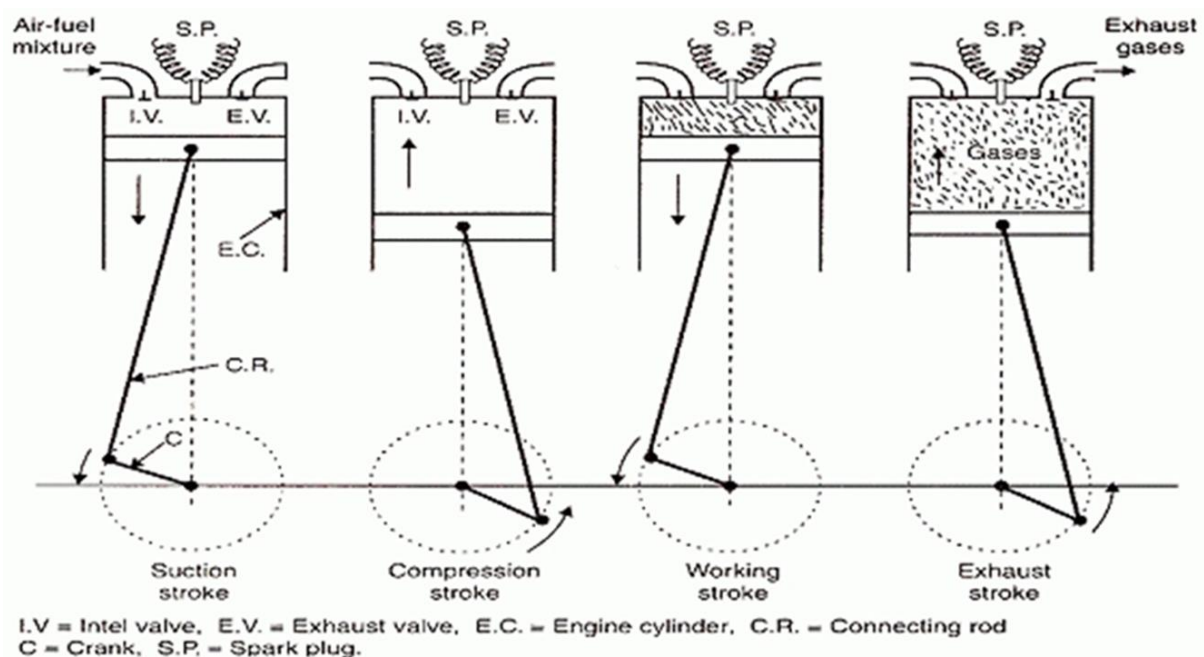
Working:

Suction Stroke: Piston moves down from TDC to BDC, **Inlet valve is opened and the exhaust valve is closed.** Pressure inside the cylinder is reduced below the atmospheric pressure. The mixture of air fuel is sucked into the cylinder through the inlet valve.

Compression Stroke: Piston moves up from BDC to TDC. **Both inlet and exhaust valves are closed.** Temperature and pressure increased due to compression of air fuel mixture in the cylinder.

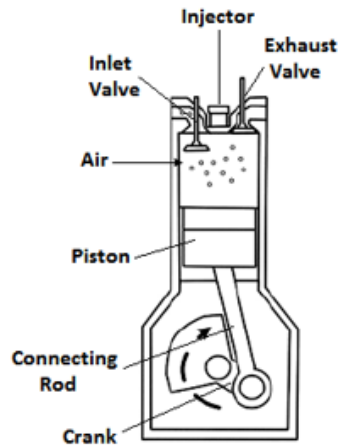
Power or Expansion Stroke: The burning gases expand rapidly. They exert an impulse (thrust or force) on the piston. The piston is pushed from TDC to BDC. This reciprocating motion of the piston is converted into rotary motion of the crankshaft through connecting rod. **Both inlet and exhaust valves are closed.**

Exhaust Stroke: Piston moves upward from BDC to TDC. Exhaust valve is opened and the inlet valve is closed. The inlet valve opens slightly before TDC and the cylinder is ready to receive fresh charge to start a new cycle. The burnt gases are forced out to the atmosphere through the exhaust valve (Some of the burnt gases stay in the clearance volume of the cylinder)



Topic: Construction and Working of Four Stroke Diesel Engine

Construction: A piston reciprocates inside the cylinder. The piston is connected to the crank shaft by means of a connecting rod and crank. The inlet and exhaust valves are mounted on the cylinder head. A fuel injector is used. The fuel used is diesel.



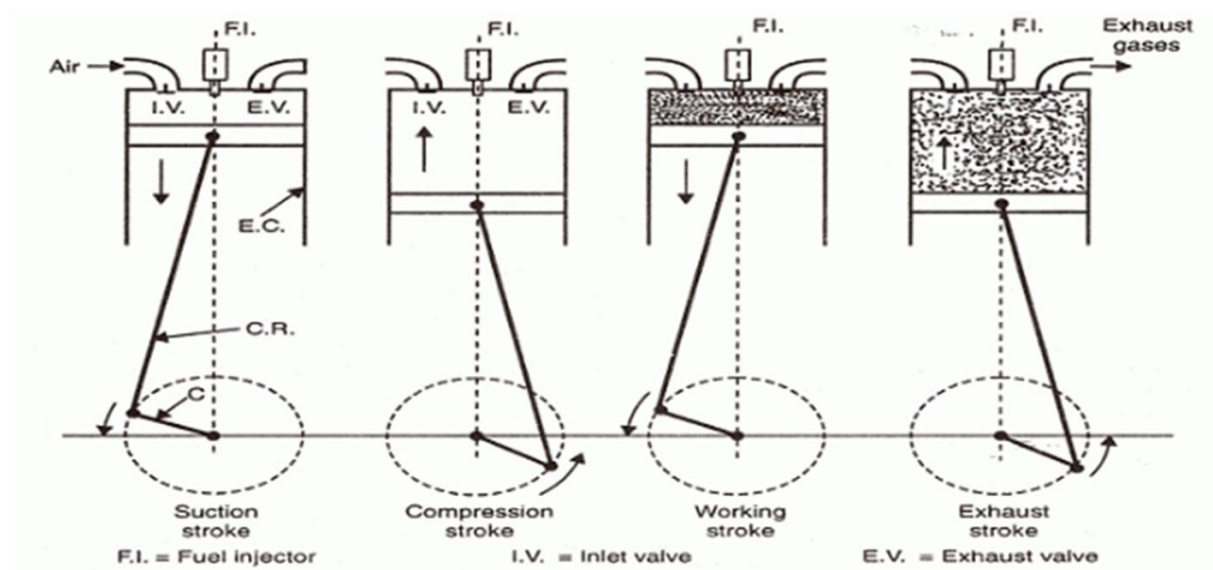
Working:

Suction Stroke: Piston moves from TDC to BDC. Inlet valve is opened and the exhaust valve is closed. The pressure inside the cylinder is reduced below the atmospheric pressure. Fresh air from the atmosphere is sucked into the engine cylinder through air cleaner and inlet valve.

Compression stroke: Piston moves from BDC to TDC, Both inlet and exhaust valves are closed. The only air is drawn during suction stroke is compressed to a high pressure and temperature.

Power or expansion stroke: Fuel (diesel) is injected inside the cylinder with the help of fuel injector. The burning gases expand rapidly and push the piston from TDC to BDC. This movement of piston is converted into rotary motion of the crank shaft through connecting rod. Both inlet and exhaust valves are closed.

Exhaust Stroke: Piston moves from BDC to TDC and exhaust valve is opened the inlet valve is closed. The burnt gases are forced out to the atmosphere through the exhaust valve. The inlet valve opens slightly before TDC and the cylinder is ready to receive fresh air to start a new cycle.

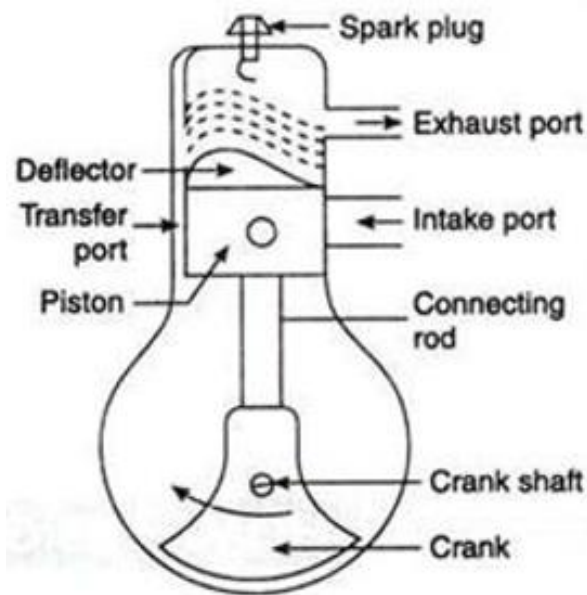


Topic: Spark Ignition (SI) and Compression Ignition (CI) engines

Spark Ignition Engines (SI)	Compression Ignition Engines(CI)
It draws air fuel mixture into the cylinder during suction stroke.	It draws only air into the cylinder during suction stroke.
Petrol engines operate with low pressure and temperature.	Diesel engines operate with high pressure and temperature.
Pressure ranges from 6 to 12 bar.	Pressure ranges from 35 to 40 bar.
Compression ratio is 6 – 10.	Compression ratio is 16 -20.
Temperature ranges from 250° to 300°C.	Temperature ranges from 600° to 700°C.
It is fitted with carburetor and spark plug.	It is fitted with fuel pump and injectors.
The burning of fuel takes place at constant volume.	The burning of fuel takes place at constant pressure.
Ignition of air fuel mixture takes place by an electric spark produced by spark plug.	Ignition of air fuel takes place by a injection of fuel into the hot compressed air.
Petrol engines are widely used in automobiles and aero planes etc.	Diesel engines are widely used in heavy vehicles, such as buses, lorries, trucks etc.
Starting is easy.	Starting is difficult.
Less initial cost and maintenance cost.	More initial and maintenance costs.
Weight per unit power is less.	Weight per unit power is more.
Produces less noise.	Produces more noise.
Thermal efficiency is less.	Thermal efficiency is high.
The fuel used is petrol.	The fuel used is diesel.
Operating speed is more.	Operating speed is less.
Fuel used is costlier than diesel.	Fuel used is cheaper than petrol.
It is more volatile and fire hazard.	It is less volatile and fire hazard.

Topic: Construction and Working of Two Stroke Petrol Engine

Construction: A piston reciprocates inside the cylinder. It is connected to the crankshaft by means of connecting rod and crank. There are no valves in two stroke engines, instead of valves ports are cut on the cylinder walls. There are three ports, namely inlet, exhaust and transfer ports. The closing and opening of the ports are obtained by the movement of piston.



Working:

Compression and Ignition: The piston moves from (BDC) to (TDC). Both transfer and exhaust ports are covered by the piston. Air fuel mixture is compressed by moving piston. The pressure and temperature increases at the end of compression.

Piston almost reaches the top dead center. The air fuel mixture inside the cylinder is ignited by means of an electric spark produced by a spark plug. At the same time, the inlet port is uncovered by the plane. Fresh air fuel mixture enters the crankcase through the inlet port.

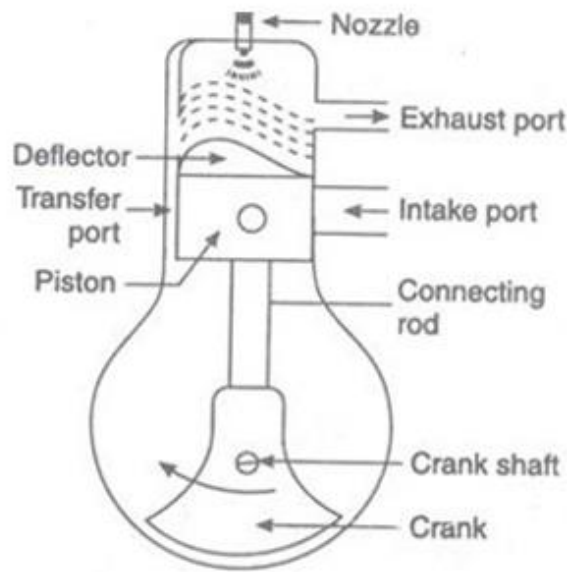
Expansion and Exhaust:

The burning gases expand in the cylinder. The burning gases force the piston to move down. Thus useful work is obtained. When the piston moves down, the air fuel mixture in the crankcase is partially compressed. This compression is known as crank case compression.

At the end of expansion, exhaust port is uncovered. Burnt gases escape to the atmosphere. Transfer port is also opened.

Topic: Construction and Working of Two Stroke Diesel Engine

Construction: In two stroke diesel engines fuel injector is used in place of spark plug. There are no valves in two stroke engines, instead of valves ports are cut on the cylinder walls. A plate is provided in the crank case to admit air into the crank case. Transfer and exhaust ports are provided in the cylinder. These ports are covered and uncovered by the moving piston.



Working:

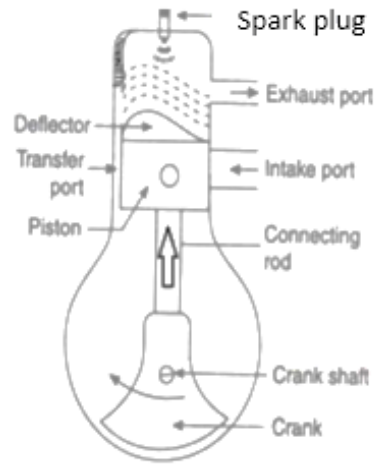
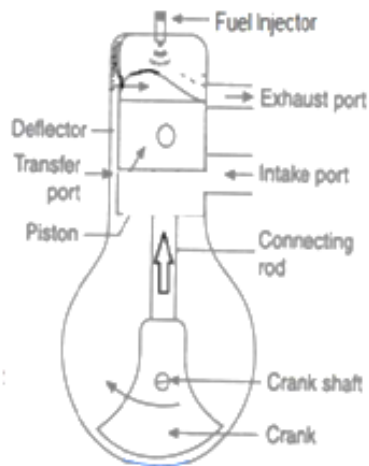
Compression and ignition: The piston moves upwards from (BDC) to (TDC). Both transfer and exhaust ports are covered. Air which is transferred already into the engine cylinder is compressed by moving piston. The pressure and temperature of the air increases.

Piston almost reaches the top dead center. The fuel is injected into the hot compressed air inside the cylinder. The fuel mixed with hot air and burns. The admission of fresh air into the crankcase continues till the piston reaches the top center.

Expansion and Exhaust: The burning gases expand in the cylinder. Burning gases force the piston to move down. Thus useful work is obtained. At the same time, the air in the crankcase is compressed by the movement of the piston. All the ports and the plate valve are in closed position.

At the end of expansion, the exhaust port is uncovered. The burnt gases escape to the atmosphere through the exhaust port.

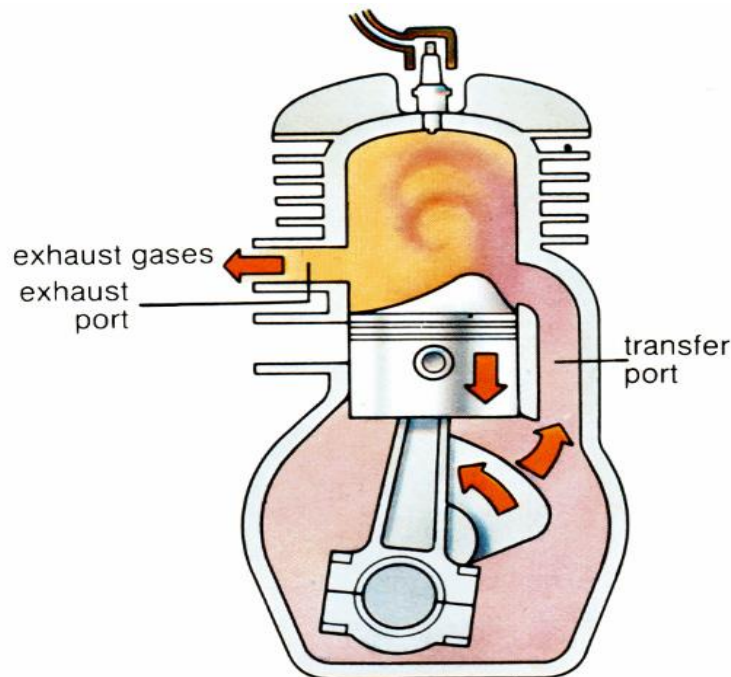
Topic: Difference between Two Stroke and Four Stroke Engine



Two Stroke Cycle Engine	Four Stroke Cycle Engine
One power stroke in one revolution of the crankshaft.	One power stroke in two revolutions of the crank shaft.
Power developed for the same engine speed is theoretically twice that of a four stroke engine.	Power developed for the same engine speed is theoretically half that of a two stroke engine.
Simple design and lighter in construction for the same power.	Complicated design and heavier in construction for the same power.
Uniform torque is obtained. Hence a lighter fly wheel can be used.	Non uniform torque is obtained. Hence a heavier flywheel can be used.
Design of ports is simpler. Hence initial cost is less.	Design valve mechanism is difficult. Hence initial cost is more.
Mechanical efficiency is high.	Mechanical efficiency is less.
Starting is easy.	Starting is noteasy.
These engines are generally air cooled.	These engines are generally water cooled.
Consumption of lubricating oil is more.	Consumption of lubricating oil is less.
Fuel consumption is more.	Fuel consumption is less.
More wear and tear of moving parts.	Less wear and tear of moving parts.
Thermal efficiency is less.	Thermal efficiency is more.
They produces more noise.	They produces less noise.

Topic: Scavenging

It is the process of forcing out the burnt exhaust gases from the cylinder by admitting the fresh charge into the cylinder. This action takes place in the two stroke engine.



The charge (air fuel mixture or air) enters the engine cylinder from the crank case at a pressure higher than the exhaust gases. This fresh charge forces the burnt gases to the atmosphere through the exhaust port. During the period both the transfer and exhaust ports are kept open for a short period.

Hence there is a possibility of the fresh charge escaping out with the burnt gases. This is overcome by designing the piston to have a deflected shape. This shape of piston deflects the fresh charge upward in the engine cylinder. It also helps out in forcing out the burnt gases to atmosphere.

Topic: Electric vehicles

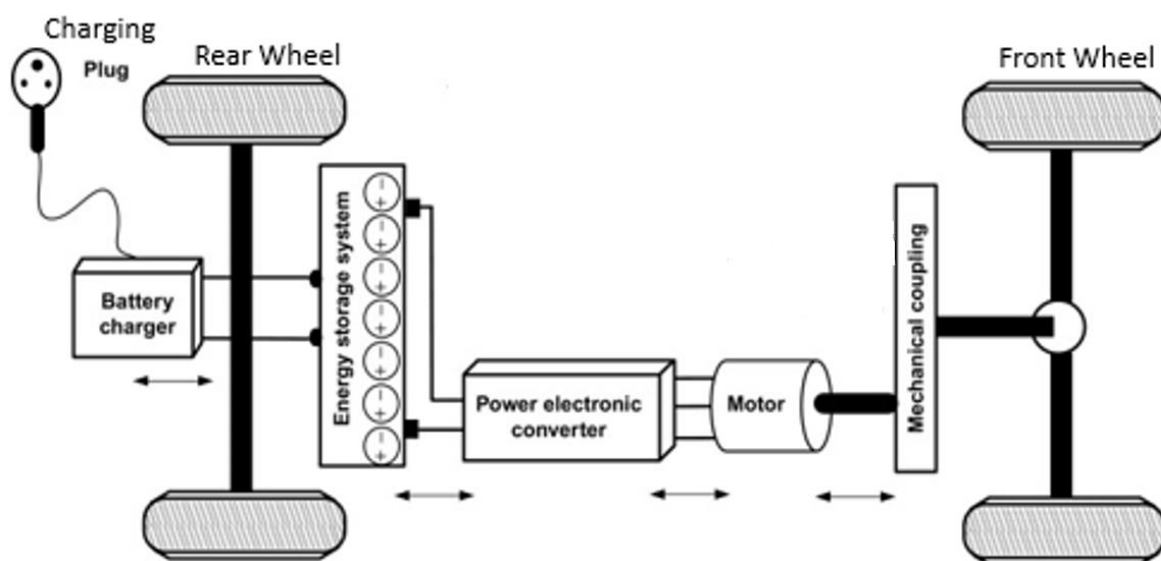
An electric vehicle (EV) is a vehicle that uses one or more electric motor for propulsion.

An electric vehicle may be powered through a battery, solar panels, fuel cells or an electric generator to convert fuel to electricity.

EVs first came into existence in the mid-19th century, when electricity was among the preferred methods for motor vehicle propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time.

Modern internal combustion engines have been the dominant propulsion method for motor vehicles for almost 100 years, but electric power has remained commonplace in other vehicle types, such as trains and smaller vehicles of all types.

Commonly, the term EV is used to refer to an electric car. In the 21st century, EVs have seen a comeback due to technological developments, and an increased focus on renewable energy.



Advantages and Disadvantages of Electric Vehicles

Advantages:

- Better for the environment.
- Electricity is less expensive than fuels.
- Less maintenance at a lower cost.
- Electric vehicles tend to be quiet.

Disadvantages:

- Some EVs have short ranges for driving.
- Charging can take a lot of time.
- Initial investment is high.

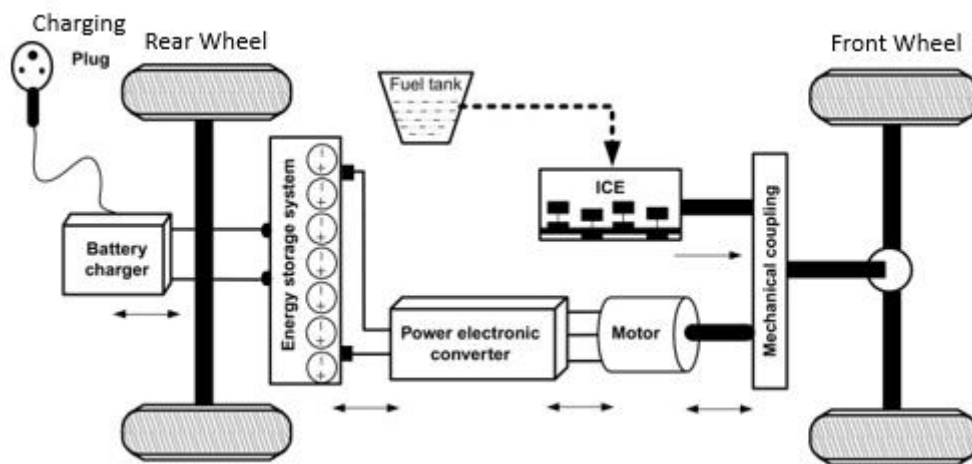
- Charging stations are not available everywhere.

Topic: Hybrid Electric Vehicles

A hybrid electric vehicle (HEV) is a type of hybrid vehicle that combines a conventional internal combustion engine (ICE) system with an electric propulsion system (hybrid vehicle drive train).

The presence of the electric power train is intended to achieve either better fuel economy than a conventional vehicle or better performance.

There is a variety of HEV types and the degree to which each function as an electric vehicle (EV) also varies. The most common form of HEV is the hybrid electric car, although hybrid electric trucks (pickups and tractors) and buses also exist.



Modern HEVs make use of efficiency-improving technologies such as regenerative brakes which convert the vehicle's kinetic energy to electric energy, which is stored in a battery or super-capacitor.

Some varieties of HEV use an internal combustion engine to turn an electrical generator, which either recharges the vehicle's batteries or directly powers its electric drive motors this combination is known as a motor-generator.

Types of Hybrid Vehicles

Parallel Hybrid

Toyota Camry, Honda Accord, Toyota Prius, Hyundai Sonata, etc.

Series Hybrid

BMW i3, Kia Optima, Ford Fusion, Chevrolet Volt, etc.

Plug-in Hybrid

BMW 330e, Hyundai Ioniq Plug-in Hybrid, Volvo XC40

Mild-Hybrid

Maruti Suzuki Ertiga, Ciaz, Baleno, etc.

Advantages of Hybrid Cars

Cleaner Emission: Compared to the ICE engine, hybrid cars produce less emissions and it is environmental friendly.

Less Fuel Dependency: With an electric motor to support the primary petrol engine, there is additional power available. Hence, there is less dependency on fossil fuel.

Smaller and Efficient Engine: Petrol engines used in hybrid cars are smaller in size and comparatively fuel efficient.

Regenerative Braking: Every time the brake is applied in a hybrid vehicle, the electric generator generates electricity and recharges the battery. This eliminates the need to stop the vehicle to charge the battery pack.

Disadvantages of Hybrid Cars

Lower Performance: Since the main motive is to increase the fuel efficiency or range of the hybrid car, the power or acceleration can lag behind a conventional internal combustion engine car.

Expensive to Buy: Although car companies are trying to bridge the gap in pricing between a conventional vehicle and hybrid, hybrids continue to demand higher costs.

High Maintenance Cost: With several mechanical parts in the cars and with two sets of engines powering the hybrids, the maintenance continues to be on the higher side. Also, not all mechanics are trained to repair a hybrid car.

Topic: Electric Vehicles Vs Hybrid Electric Vehicles

Electric Vehicles Vs Hybrid Electric Vehicles

	Electric Vehicles	Hybrid Electric Vehicles
Power/Fuel Source	Electricity Through Battery Pack (DC)	Electricity and Fossil Fuel (Petrol and Diesel)
Engine	Electric Motor(s)	Internal Combustion Engine (ICE) and Electric Motor(s)
Fuel Efficiency	Depends on Battery Range	Combination of ICE and Battery Range
Emission Levels	Lower Compared to ICE and Hybrid vehicles	Higher Compared to Electric vehicles
Price Range	High	Similar to Conventional ICE vehicles
Charging	Required	Not required

Questions

S. No.	Questions
	IC Engine
1.	Write down the name of basic components of an I.C. engines. Also write down advantages and disadvantages of I.C. engines.
2.	Explain the following terms as applied to I.C. engines : Bore, stroke, T.D.C., B.D.C., clearance volume, swept volume, compression ratio.
3.	Explain the working of a four-stroke SI engine with neat sketch.
4.	Explain the working of a four-stroke CI engine with neat sketch.
5.	Explain the working of a two-stroke SI engine with neat sketch.
6.	Write down the differences between SI and CI engine.
7.	Write down the differences between two stroke and four strokes engine.
8.	What is the scavenging process?
9.	What is electric vehicle? What are the main components of electric vehicle?
10.	What is hybrid vehicle? Give the classification of hybrid vehicles.
11.	Compare the relative advantages and disadvantages among IC engine, Electric and Hybrid vehicles.