

JOIN



Telegram
@PuneEngineers

For more Subjects

<https://www.studymedia.in/fe/notes>



SCAN ME



CLICK HERE
@PuneEngineers



Unit III – Vehicles and their Specifications

• Classification of automobiles

Q1. How are automobiles classified? [5m]

Answer: The automobiles are classified as follows -

1. Based on Purpose :

- **Passenger vehicles:** These vehicles carry passengers. e.g: Buses, Cars, passenger trains.
- **Goods vehicles:** These vehicles carry goods from one place to another place. e.g: Goods lorry, Goods carrier.
- **Special Purpose:** These vehicles include Ambulance, Fire engines, Army Vehicles.

2. Based on Load Capacity:

- **Light duty vehicle:** Small motor vehicles. eg: Car, jeep, Scooter, motorcycle
- **Heavy duty vehicle:** large and bulky motor vehicles. e.g: Bus, Truck, Tractor

3. Based on fuel used:

- **Petrol engine vehicles :** Automobiles powered by a petrol engine. e.g: scooters, cars, motorcycles.
- **Diesel engine vehicles :** Automobiles powered by diesel engine. e.g: Trucks, Buses, Tractors.
- **Gas vehicles :** Vehicles that use gas turbine as a power source. e.g: Turbine powered cars.
- **Electric vehicles :** Automobiles that use electricity as a power source. e.g: Electric cars, electric buses.
- **Hybrid Vehicles :** Powered by combination of IC Engine & Battery with Electric Motor
- **Steam Engine vehicles :** Automobiles powered by steam engine. e.g: Steamboat, steam locomotive, steam wagon.

4. Based on Drive of the vehicles:

- **Left-Hand drive :** Steering wheel fitted on the left-hand side.
- **Right-Hand drive :** Steering wheel fitted on the right-hand side.
- **Fluid drive :** Instead of Gear box , vehicles employing torque converter, fluid flywheel or hydramatic transmission.

5. Based on number of wheels and axles:

- **Two wheeler :** motorcycles, scooters
- **Three-wheelers :** Tempo, auto-rickshaws
- **Four wheeler :** car, Jeep, Bus, truck
- **Six-wheelers :** Buses and trucks have six tires out of which four are carried on the rear wheels for additional reaction.
- **Six axle wheeler :** Dodge(10 tire) vehicle

6. Based on type of transmission:

- **Automatic transmission vehicles:** Automobiles that are capable of changing gear ratios automatically as they move and uses epicyclic gearbox with torque converters.
- **Manual transmission vehicles:** Automobiles whose gear ratios have to be changed manually.
- **Semi-automatic transmission vehicles:** Vehicles that facilitate manual gear changing with a automatic clutch control

7. Based on Suspension system used:

- **Convectional** – Leaf Spring
- **Independent** – Coil spring with Torsion bar or air suspension

Main Components of an Automobile :

1. **The Basic Structure (Framework)** : Chassis, Suspension System, Axles, Wheels
2. **Engine or Source of Power and Exhaust System** : Air & Fuel supply system, IC Engine (petrol /diesel/other), Exhaust system
3. **The Power Train or Transmission system or Gear Box** : Clutch, Gear Box, Universal couplings, Propeller Shaft, Differential, Rear Axle, Transmission shafts
4. **Body or Super structure**: Cabin, seating arrangement, Storage space
5. **The auxiliary systems**: Electrical systems (battery, alternator), Lubrication system, Cooling System (radiator), Front axle, Steering systems, Suspension systems, Braking systems
6. **Safety system** : Primary or **Active** safety system (design/ use of technology in manufacturing to prevent accidents- Anti lock braking (ABS), Traction control, cruise control, mirrors, Rear view camera, etc); **Passive** safety systems (to protect the passengers to minimize risk/severity of injury – Seat belts, Airbags, bucket seats, etc)

• Vehicle Specifications –

2W, 3W, LMV, Trucks, Buses, Multi-axle vehicles

1.(b). Solution:

Heavy Motor Vehicle Specification

ENGINE	
Model	Tata 697
Type	Water-cooled direct injection diesel engine
Max. Engine Output	130 HP at 2400 rpm
Max. Torque	410NM at 1400-1700 rpm
Capacity	5675 cc
Emission norms	Euro II
BRAKES	
Service brake	Fully duplicated, full air S-CAM brake system.
CLUTCH	
Type	Single plate dry friction
DIMENSION	
L X W X H (mm)	6970 X 2434 X 2460

Q2. Explain specification points of any Vehicle.(2W/3W/LMV-Car/ HMV- Truck) [5m]

Parameters	Vehicle comparison		
	2-Wheeler	3-Wheeler	Mahindra Marazzo
	Yamaha FZ	TVS Autorickshaw	
Body Type	Tubular	Steel pipes with angle bars	Ladder frame
Fuel	Petrol	Petrol	Diesel
Engine/Transmission			
Engine	4-stroke, Air cooled, single cylinder	4-stroke, Air cooled, single cylinder	4-stroke, Water cooled, Four cylinder Model -D15-1.5 lit
clutch	Wet multidisc type	Wet multidisc type	
Cubic Capacity	153	198.88	1497 Turbo Diesel
Bore & Stroke	58.0 X 57.9 mm		
Ignition		Spark Ignition	
Fuel supply system			CRDi
Compression Ratio			
Emission			BS IV
BHP @ rpm	14 PS at 7500 rpm	7.6KW at 5000rpm	90.2K (121 BHP) at 3500 rpm
Torque @ rpm	13.6 Nm at 6000 rpm	17 Nm at 3500rpm	300 Nm at 1750-2500 rpm
Gear Box type	5 speed constant mesh	4 forward + 1 reverse gear	6 speed manual
Gear Box Speeds			
Gradeability		19%	
Drive Train			Front wheel Drive
Dimensions			
Wheelbase	1334 mm	2000 mm	2760 mm
Ground Clearance	160 mm		160 mm
Width	770 mm	1300 mm	1866 mm
Length	1973 mm	2635 mm	4585 mm
Height	1090 mm	1700 mm	1774 mm
Kerb Weight	135 kg	348 kg	1650 kg
Mileage			17.3 KmPL
Fuel Tank	12 liters		45 liters
Fuel Supply system	Carburettor		
Brakes -Front	Hydraulic Single Disc		Disc, ABS+ Electronic Brake Distribution (EBD)

Brakes -Rear	Drum		Disc, ABS+EBD
Suspension - Front			Double -Wishbone
Suspension - Rear			Rear Twist Beam
Front Tyre	100/80-17		215/65-R16 Tubeless Radial
Rear Tyre	140/60-R17		215/65-R16 Tubeless Radial
Minimum Turning Radius			5.25 m
Steering			Electric Power assisted Steering (EPAS), Tilttable
Electricals			
Battery	12 V, 5.0 Ah		
Head Light	12V, 35 W/ 35 W- Halogen bulb		
Start	Self start (electrical) / Kick Start		
Safety -Air Bag			Twin Airbags
Seating Capacity			8 seater
Boot space			190 lit
Price			9.99 lakh - 13.90 lakh

Multi-Axle Vehicles

A vehicle which has more than two axle called multi-axle. Multi Axle which is a shaft connected to wheels with suspension to transmit engine power through gears in the transmission to move a large vehicle. It carries a whole weight of the vehicle. In bus it makes more spaces for the passengers.



Specifications	Volvo 9400 14.5 M
Length	14500 mm
Height	3600 mm
Width	2600 mm
Wheelbase	8350 mm

<i>Gross Vehicle Weight</i>	22,200 kg
<i>Suspension</i>	Electronically Controlled Air Suspension (ECS)
<i>Brakes</i>	All disc brakes with EBS
<i>No. of Doors</i>	01 - Front
<i>Diesel Engine</i>	Volvo D11C 410
<i>Transmission</i>	I-Shift, Automatic Gear Shifting System 12-Speed splitter/range gearbox
<i>Max. Power</i>	410 hp @1600-1900 rpm
<i>Max. Torque</i>	1980 Nm @1600-1900 rpm
<i>No. of Cylinders</i>	6
<i>Displacement</i>	10.8 ltr
<i>Turning radius</i>	11.54 mt

Multi-axles vehicle have Improved Handling and Smoother ride, but having more axles will cost more than the standard two axles. Having more axles means more parts to maintain.

Multi-axles vehicle have Improved Handling and Smoother ride, but having more axles will cost more than the standard two axles. Having more axles means more parts to maintain.

Q3. Explain the meaning of : a) Engine, b) Kerb weight, c) Drive Train, d) Torque, e) Horse Power, f) Gradeability, g) Compression ratio

Answer :

Engine : Its an Internal Combustion Engine of any type such as Petrol/CNG/LPG/Diesel and 2 stroke/ 4 stroke with single or multi-cylinder

Kerb Weight : It is weight of vehicle without fuel and without any accessories. Vehicle weight consists of weight of Engine , Drive train, Chassis and systems like suspension, brake, steering, cooling, etc.

Drive Train : Power transmission elements includes Clutch, Gearbox, Propeller shaft with universal Couplings, Differential Gear unit, Transmission shafts which mounts wheels.

Each element has its unique function. Gear box changes torque & speed, Propeller shaft transmits power to differential where direction of power is changed by 90 deg. Differential allows two wheels to rotate at different speeds (essential while turning) while power is supplied to the wheels.

Torque : Torque is the amount of rotational force produced at a give radius at the output shaft. However, for a given power produced by engine the if torque increase , the speed is reduced. This is done by changing the speed ratio at the gearbox.

Horse Power : Power measured in FPS units. 1HP = 0.746 KW .

Brake Horse Power (BHP) is the measurement of an engine's power without any power losses, while HP is equal to BHP less the power losses.

BHP is measured in a controlled environment without anything attached to the engine, HP is measured by hooking up the engine to a dynamometer (load).

Engine power or horsepower is the maximum power that an engine can put out. It can be expressed in kilowatts or horsepower. The power output depends on the size and design of the engine, but also on the speed at which it is running and the load or torque. Maximum power is achieved at relatively high speeds and at high load.

Gradeability : A car's gradeability is its ability to climb slopes. Gradeability is measured either in degrees or percentage. A 45 degree gradient is equivalent to 100%.

Gradeability is dependent on engine power, drivetrain type, gear ratio, weight, weight distribution, car's center of gravity and traction. It ranges from 10% to 45%.

Compression Ratio : The compression ratio is the ratio of the total volume of the cylinder and the combustion chamber (when the piston is at the bottom), and the volume of the combustion chamber (when the piston is at the top).

The compression ratio is the total swept volume of the cylinder with the piston at bottom dead center (BDC), divided by the total compressed volume with the piston at top dead center (TDC). Higher the compression-ratio, better is the thermal efficiency of the engine. Thus, the engine can extract more mechanical energy from the given mass of the air-fuel mixture. Diesel engines are designed to operate at higher compression ratios, usually between 15 to 20, while petrol engines have lower compression ratios usually between 8 to 10.

- **Engine Components**

Q4. Draw a sketch of Four Stroke I.C. Engine. List & explain components of IC Engine with sketches. [4m]

Answer: An Internal Combustion Engine has following components -

Engines Components & Materials

1. Cylinder block & Crank case:

To hold engine components, water jackets, Cooling jackets, oil passages, passages for push rods, fitment for crank shaft, lubrication pump, etc. (Material : Grey CI, Al alloy)

2. Cylinder head:

SP, injectors, valve openings, comb chamber, mounting for valve operating mechanism (Material : CI , Al alloy)

3. Oil pan:

Oil sump (Material : Pressed steel sheet, Al alloy)

4. Manifolds:

Inlet & exhaust tubing for AF intake & exhaust (Material : CI)

5. Gaskets:

For leak proof sealing bet. two components (Material : Embossed steel, cork, special rubber)

6. Cylinder liners (Replaceable):

Pistons reciprocate in cylinders for comb space (Material : Steel alloyed with Si, Mn, Nickel, Chromium; Centrifugally cast, hardened by nitriding, chromium plating) Dry & Wet liners

7. Piston:

For transmission of force, light weight, high thermal k, low thermal coefficient of expansion (Material : Al alloy)

8. Piston rings:

For high pressure leak proof sealing between piston & cylinder, 2 to 4 + 1 to 2 oil scrapper rings (Material : Alloy CI with Si, Mn with chromium plating)

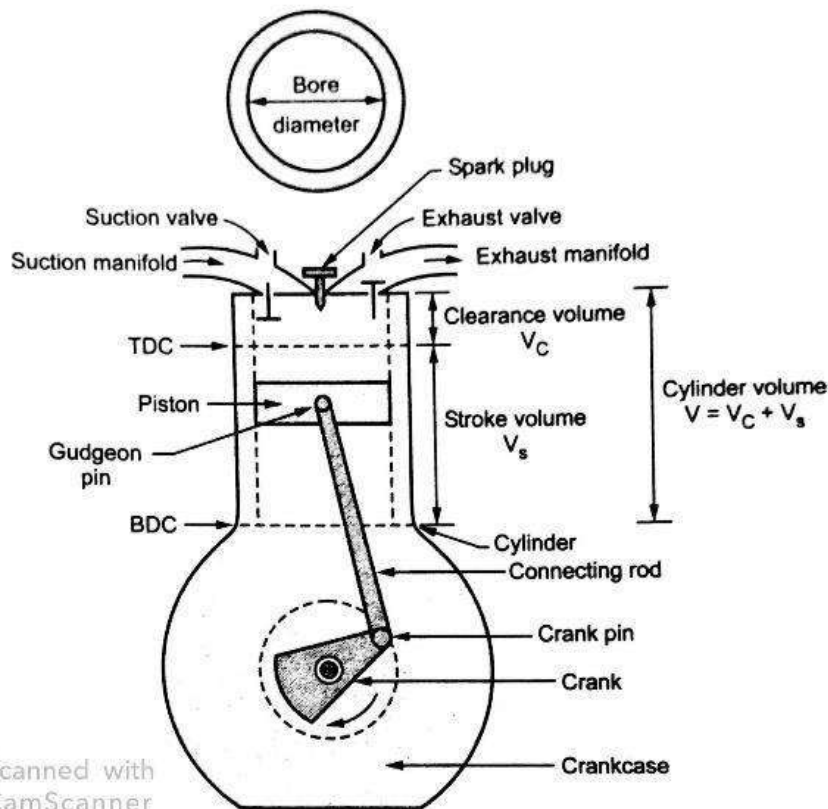
9. Connecting rod:

Axial and bending stresses

For transmitting force on piston to crankshaft I-section (Material : drop forged from steel)

10. Piston/Gudgeon Pin:

For connecting piston with connecting rod (Material : Case hardened steel)



11. Crankshaft:

For converting reciprocating motion of piston to rotary motion of crankshaft by connecting rod, vibration damper and fly wheel fitted,

Main journal, crank pins, crank webs, counterweights (Material : Forged from spheroidal graphite iron)

12. Main & Big end bearings:

For facilitating holding & friction free rotation of crankshaft (Material : Babbitt material- alloy steel)

13. Engine Valves:

Inlet –for air/AF intake (Material : Silicon-chrome steel (C+Ni +Mn+Si))

Exhaust- for exiting burnt gases (Material : (C+Ni+Mn+Si+Mb))

14. Camshaft:

For operating valves (rotates at half speed of C/S) (Material : Forged alloy steel)

15. Silencer/Muffler:

For reducing exhaust/comb sound (Material : Sheet Metal)

• **Study of Engine Specifications**

Fuel type, Engine type, Bore x stroke, Displacement /CC ,Max Power (BHP@RPM), Max Torque (Nm @ RPM), No. of Cylinders, Valves per Cylinder, Fuel supply system, Compression ratio

Q5. Explain engine specifications with suitable example.

Answer : Engine specifications should contain details of following parameters -

- Engine speed: engine speed is measured in revolutions per minute (RPM). diesel engines -1500–4000 RPM , gasoline engines (~2200–6000 RPM)
- Thrust: Thrust is the force arising from the interaction between Piston and cylinder
- Torque: Torque is the force being exerted to the output shaft of an engine. Maximum torque is obtained at lower speed than input speed (rpm). This change in torque and speed is done through Gear box by changing the gear ratio.
- Power: Power is the amount of work being done.
- Efficiency: Ratio of output to input
- Sound levels: In the case of sound levels, engine operation is of greatest impact with respect to mobile sources such as automobiles and trucks

• **Comparison of specifications of Vehicles**

Engine(Fuel type, Displacement/cc, Max Power, Max torque), Fuel Efficiency & performance (Mileage, Top Speed, Acceleration), Transmission system (Type of transmission, No. of Gears), Braking system, Suspension system, steering (Power steering, Steering Adjustments), Dimensions (Ground Clearance, boot Space, Seating Capacity)

Q6. Why it is necessary to compare specifications of vehicles? [6m]

Answer : Vehicle comparison helps in arriving at a specific vehicle to buy. We considered the following parameters to take buying decision :

- Good low end torque. BHP numbers cannot be the only criteria as you won't be driving only in the highways
- Light and linear clutch
- Good suspension
- Seamless engine performance.

- Seating comfort
- Fuel efficiency
- Reasonable maintenance cost etc.

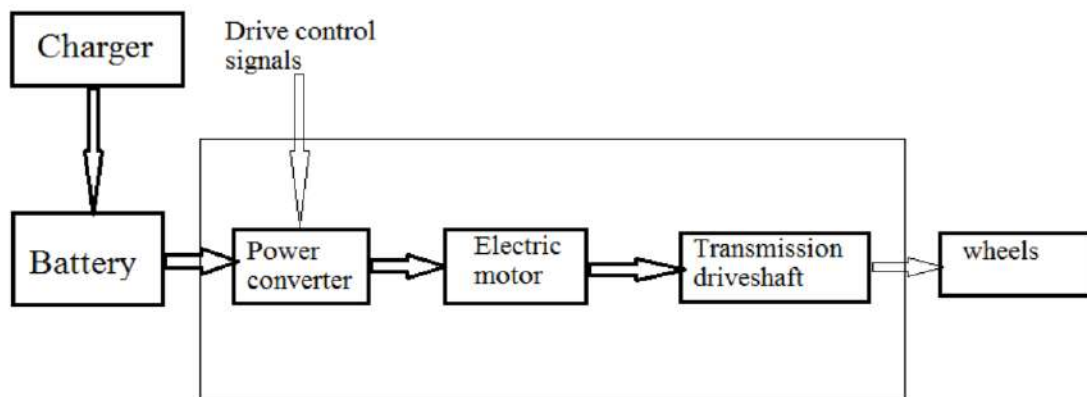
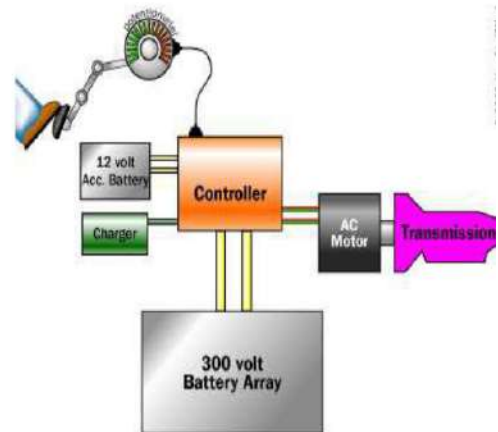
• Introduction of Electric & Hybrid Vehicles

➤ Pure EV, Hybrid EV (HEV), Plug-in Hybrid EV (PHEV)

Q7. Explain with block diagram, elements of “Electrical Vehicle” or “battery electric vehicles”. [6m]

Answer :

An Electric vehicle is an automobile that is propelled by one or more electric motors, using electrical energy stored in energy storage device. The primary components are motor, controller, power source, and transmission.



- The driver presses the accelerator which in turn sends the signals to the controller.
- Depending on the signals received, a microprocessor based controller allows voltage supply to the motor.
- The speed of the motor varied by varying the voltage across the motor smoothly and sleeplessly through the accelerator.
- Motor is connected to the gear box. From gear box mechanical energy is transferred to the wheels through differential gear box.
- The motor can be used as a generator to charge the battery.

<i>Avon E Scoot Specifications</i>	
<i>Starting mechanism</i>	Self-start only
<i>Price</i>	Rs.41,554
<i>Fuel economy</i>	65 km per charge
<i>Maximum speed</i>	24 Kmph
<i>Electric motor power</i>	250 W
<i>Gear box</i>	Automatic
<i>Ground clearance</i>	140 mm
<i>Battery capacity</i>	48 V, 20 Ah
<i>Type of motor</i>	Hub Mounted BLDC 250W
<i>Type of charger</i>	220 AC/48 V DC
<i>Front wheel</i>	16 inch
<i>Rear wheel</i>	16 inch
<i>Battery recharge time</i>	6 to 8 hours

ELECTRIC VEHICLE- Advantages

- Reduce dependence on oil and gasoline
- High operational reliability
- Pollutants and noise free
- Recyclable batteries
- No fire hazards
- Low maintenance and low operation cost

ELECTRIC VEHICLE- Disadvantages

- *Limited range of 80- 100 miles per charge*
- High initial cost
- Batteries need frequent recharging and there is High recharge time.
- Silence may be fatal
- Low speed

Hybrid Electric Vehicle

Q8. Explain working of Hybrid Electrical Vehicle. [7m]

Answer :

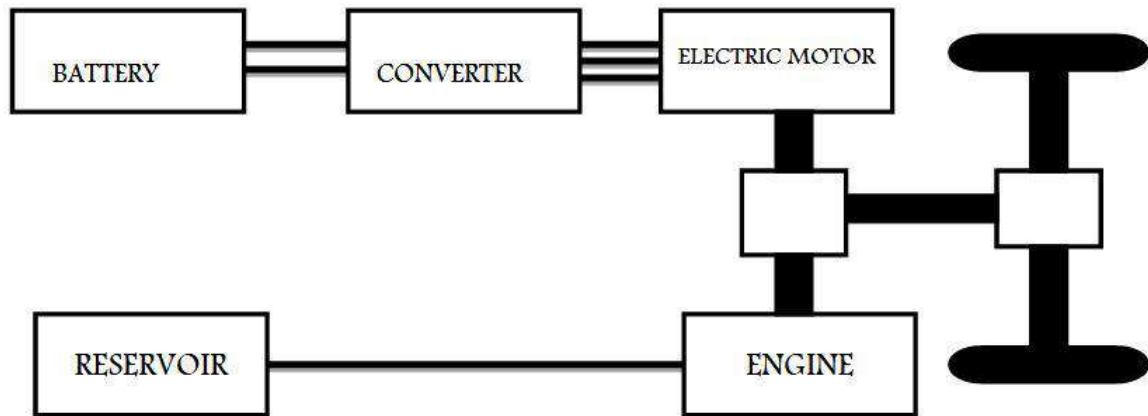
Hybrid Vehicle

In a hybrid vehicle, two or more power sources are used for propulsion.

The most commonly used hybrid vehicles are hybrid electric vehicles (HEVs). In a hybrid electric vehicle, both internal combustion engine and electrical propulsion system are used to move the vehicle.

By using this combination of two power sources, a better solution is made to the efficiency and mileage.

For a hybrid Vehicle Important Parts are-



1. Conventional car engine – It can be a gasoline engine or also petrol or diesel respectively. But whatever engine is used, will be more advanced than the usual ones, as they have to work together with the electrical system. They will be smaller with greater efficiency and lesser emissions.

2. Fuel Tank – For storing the fuel needed to run the car engine.

3. Batteries – Batteries are needed to store and release energy as required by the car. The energy from the battery is taken by the motor.

4. Electric Motor and generator – Though motors can act as generators, both of them are needed for this car. A motor will be needed to take energy from the batteries and accelerate the car. Generators, on the other hand, are needed to produce the electrical power.

5. Transmission System – The entire transmissions that were performed in a conventional car will be done here as well, but in the hybrid manner.

- The term hybrid vehicles in general usage refer to vehicles with two or three different type of sources delivering power to the wheels for propulsion.
- The most common hybrid vehicles have an IC engine and one or more electric machines for vehicle propulsion.
- The IC engine can be used to generate electric energy 'on board' to power the machines.



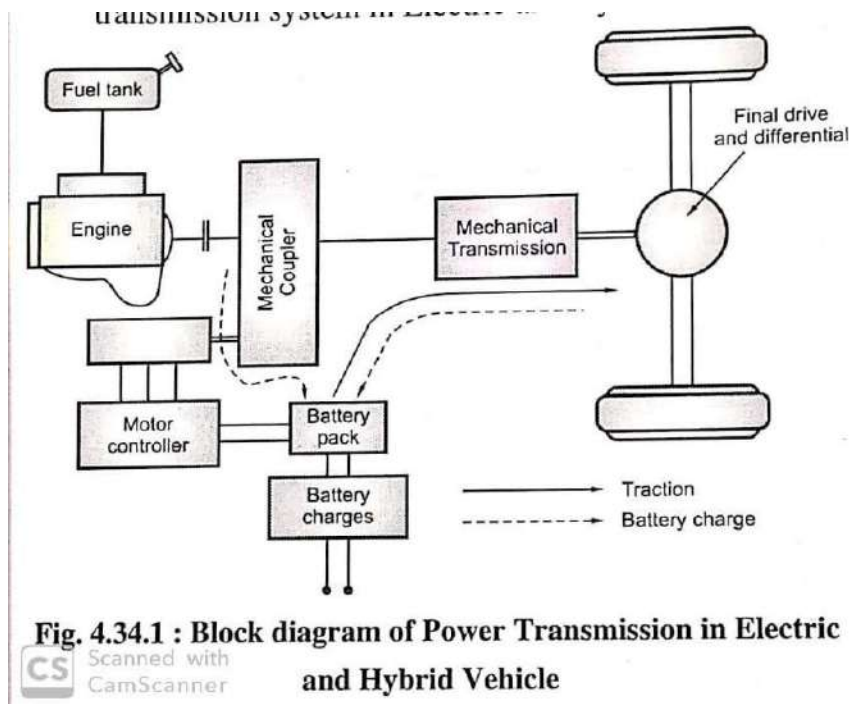
During Braking , the kinetic energy is converted to electric energy using regenerative braking by electric motor (acting as a generator) and supplied to battery.



Fig. 3.11.1 : Layout of Series Hybrid Vehicle



Fig. 3.11.2 : Layout of Parallel Hybrid Electric Vehicle



Hybrid Vehicles can be classified according to the way in which power is supplied to drive train: Parallel Hybrids, Series Hybrids and Power-split Hybrids

In Parallel Hybrids, IC Engines and Electric Motor are connected to the mechanical transmission to drive wheels. IC Engine can also acts as a generator for supplemental recharging. It is more efficient in urban stop & go conditions.

In Series Hybrids, a smaller IC engine works at its optimum setting for charging the battery and the battery is connected to drive train for driving wheels. It is more efficient in extensive city driving.

Power-split Hybrids have advantages of a combination of series and Parallel systems since the series hybrid are more efficient whereas parallel hybrids are more efficient at high speeds. The cost of power -split hybrids is more than the parallel hybrids.

There are **plug-in Hybrids** to connect to the electrical grid which ensures recharging independent of IC engine & have much larger electric range.

Advantages of Hybrid Electric Vehicle:

- Advantages of IC Engine and Electric motor drive can be availed
- It operates nearly twice as efficiently as traditional IC Engine vehicles
- It has equivalent power, range, cost and safety of a conventional vehicle , while reducing fuel costs & harmful emissions
- Battery is continuously recharged by a motor / generator driven by the IC Engine or by regenerative braking. Batteries need not be charged by an external source.

disadvantages of Hybrid Electric Vehicle:

- The initial cost will be very high – higher than other cars.
- Since a lot of batteries will be needed, the car will be very heavy.

- As there are electrical components, there is risk of shock during an accident.
- The vehicle can be repaired only by professionals.

- **Hybrid Vehicles also classified by nature of the Power Source**

- Electric – Internal Combustion Engine Hybrid
- Fuel Cell Hybrid
- Human Power & Environmental Power Hybrid
- Pneumatic Hybrid
- Hydraulic Hybrid
- Solar Operated Vehicles

- **Cost Analysis of the Vehicles**

Parameters – Engine Torque, Engine Speed, No. of Cylinders, Types of Brake used, Cooling system used

Cost, Safety and Comfort Parameters for Comparison of Vehicles –In addition to technical parameters following parameters are also considered while comparing LMV (Cars)

--On Road Price, Aesthetics, Maintenance cost, Warranty, Driver & Passenger safety Devices, Interior, Infotainment systems

Cost analysis of Vehicles- Fixed & variable; case study

a. Explain the Cost Analysis of vehicle. [5m]

Answer : The cost of vehicle is an important factor for its sale in market. Cost depends on capacity , performance of engine, features provided in vehicle, safety systems, Life of parts ; operation cost & maintenance cost.

Table below shows effect of the parameter on the cost of vehicle.

Parameters	Vehicle Cost High	Vehicle cost Low
Cubic Capacity	Cylinder volume higher	Cylinder volume lower
Torque	Increase in Torque	Decrease in torque
Power	More Engine power	Lesser power of Engine
Speed	Increase in speed of vehicle	Lower speed of vehicle

No. of cylinders	Increase in no. of cylinders	Decrease in no. of cylinders
Type of brakes	Disk brake / ABS Hydraulic brakes Pneumatic brakes	Drum shoe brakes
Cooling system	Water cooled with pump	Air cooling