CANARA ENGINEERING COLLEGE,

Benjanapadavu, Bantwal

Department of Mechanical Engineering

Introduction to Mechanical Engineering

1BMEES144/244

Semester: I[st]

Module No.: 2

Module Title: ENGINES

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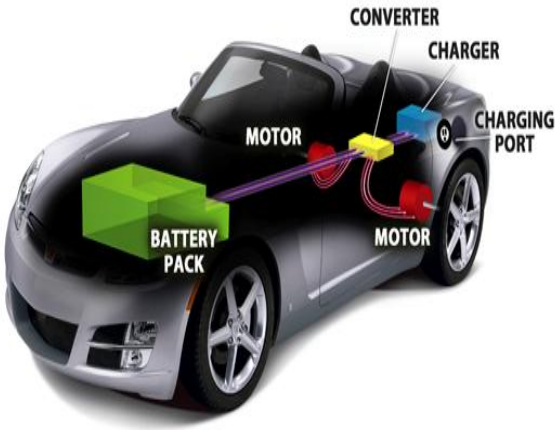


MODULE 1

INTRODUCTION TO I C ENGINE

Lecture 10:

Syllabus of the module

Engines: Introduction, petrol engine, diesel engines, Working of four Stroke engines, applications. Insight into Future Mobility: Electric and Hybrid Vehicles, Components of Electric and Hybrid Vehicles. Advantages and disadvantages of EVs and Hybrid vehicles.

Power Transmission systems: Classification of gears, simple & compound gear trains, concepts of automatic and CVT transmission.

Fundamentals of IC engines:

Engine: It is a device which converts heat energy liberated by combustion of fuel into mechanical energy.

Types of engines:

1)External combustion engine:

Here the combustion takes place outside the engine cylinder and the combustion products are supplied to the engine cylinder to convert heat energy into mechanical energy.

2) Internal combustion engine:

In this type of engine, the combustion takes place inside the engine cylinder itself.

Classification of I.C engines:

1) Based on fuel used

a) Petrol engine
b) Diesel engine
c) Gas engine
d) Bi-fuel engine

2) Based on thermodynamic cycle

a) Otto cycle engine
b) Diesel cycle engine
c) Dual combustion cycle engine

3) Based on strokes

a) 4 stroke engine
b) 2 stroke engine

4) Based on method of ignition

a) Spark ignition or S.I engine

b) Compression ignition or C.I engine

5) Based on number of cylinders as

a) Single cylinder engine

b) Multi cylinder engine

6) Based on position of cylinder as

a) Horizontal engine

b) Vertical engine

c) Vee – engine

d) Opposed cylinder engine

e) Radial engine

7) Based on the method of cooling as

a) Air-cooled engine

b) Water-cooled engine

Parts of the I.C engine:

1. Cylinder: The heart of the engine is the cylinder in which the fuel is burnt and the power is developed. The inside diameter is called bore. To prevent the wearing of cylinder block, a sleeve will be fitted tightly in the cylinder. The piston reciprocates inside the cylinder.

2. Piston: The piston is a close fitting hollow cylindrical plunger moving to-and-fro in the cylinder. The power developed by the combustion of the fuel is transmitted by the piston to the crankshaft through the connecting rod.

3. Piston rings: The piston rings are the metallic rings inserted into the circumferential grooves provided at the top end of the piston. These rings maintain a gas-tight joint between the piston and the cylinder while the piston is reciprocating in the cylinder. They also help in conducting the heat from the piston to the cylinder.

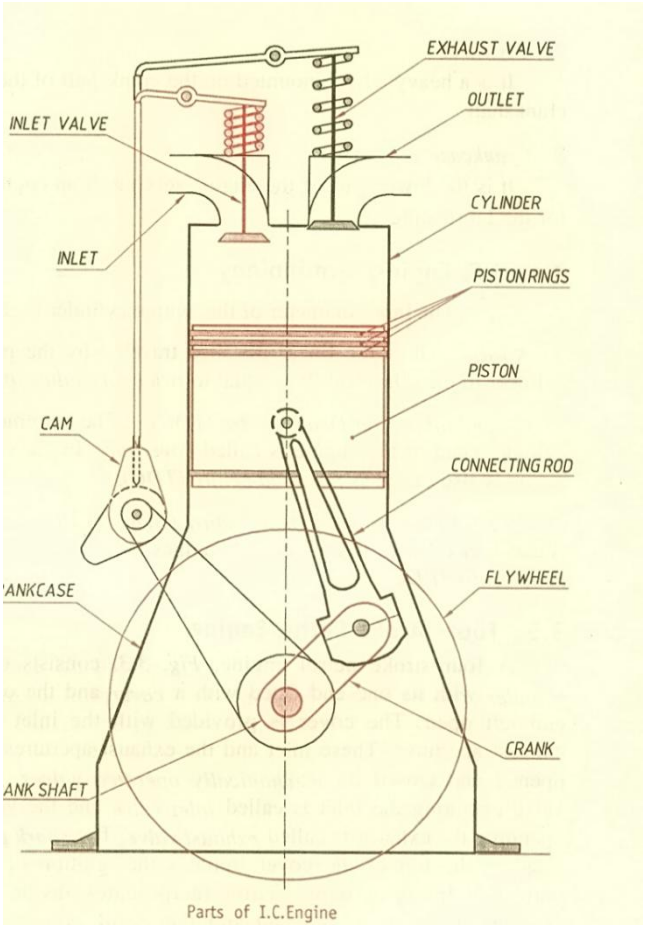
4. Connecting rod: It is a link that connects the piston and the crankshaft by means of pin joints. It converts the rectilinear motion of the piston into rotary motion of the crankshaft.

5. Crank and crankshaft: The crank is lever that is connected to the end of the connecting rod by a pin joint with its other end rigidly connected to a shaft called crankshaft. It rotates about the axis of the crankshaft and causes the connecting rod to oscillate.

6. Crank case: It is the lower part of the engine serving as an enclosure for the crankshaft and sump for the lubricating oil.

7. Valves: The valves are the devices which controls the flow of the intake and the exhaust gas to and from the cylinder. They are also called poppet valves. These valves are operated by means of cams driven by crankshaft through a timing gear and chain.

8. Fly wheel: It is a heavy wheel mounted on the crankshaft of the engine to maintain uniform rotation of the crankshaft.



I.C engine terminology:

1. Stroke: It is the distance travelled by the piston from the cover end to the crank end or from crank end to the cover end. It is denoted by L.

2. Bore: It is the diameter of the cylinder or outer diameter of the piston. It is denoted by D.

3. Top Dead Centre (TDC) or cover end: It is the extreme position of the piston, when the piston is near cylinder head.

4. Bottom Dead Centre (BDC) or crank end: It is the extreme position of the piston, when the piston is near the crankshaft end.

5. Swept Volume (Vs): It is the volume covered by the piston when the piston moves from TDC to BDC. It is denoted by Vs and is given by,

$$Vs = (\prod D2/4)*L$$

6. Clearance Volume (Vc): It is the volume occupied by the charge at the end of compression stroke when the piston is at TDC.

7. Compression Ratio (C.R): It is the ratio of total volume of the cylinder to the clearance volume.

i.e., CR or r= Total volume/clearance volume = VT/Vc = (Vs+ Vc)/Vc

8. Piston speed: The total linear distance travelled by the piston per unit time is called piston speed. It is expressed in m/min and is given by,

Piston speed=2LN m/min

L= length of stroke in m

N= speed of the engine in rpm.

Brainstorming Questions:

1. **What is the difference between EC and IC engine?**
2. **List the examples of IC and EC engines?**
3. **What is the classification of IC engines based on fuels and position of the cylinders?**
4. **Why is cooling required?**

Lecture 11:

FOUR STROKE PETROL ENGINE:

Features:

It consists of a cylinder with its one end fitted a cover and the other end open.

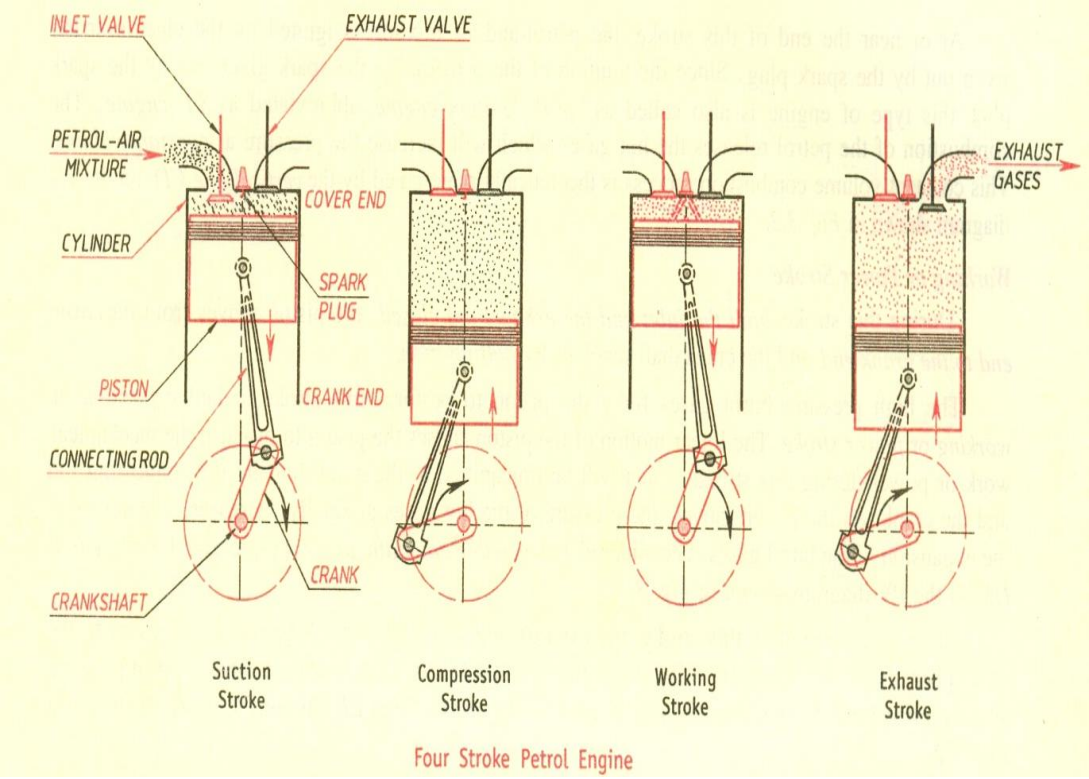
The cover is provided with inlet and exhaust apertures which are mechanically operated by valves called inlet and exhaust valve, respectively.

The spark plug fitted at the top of the cover initiates the ignition of the petrol, hence the name spark ignition engine.

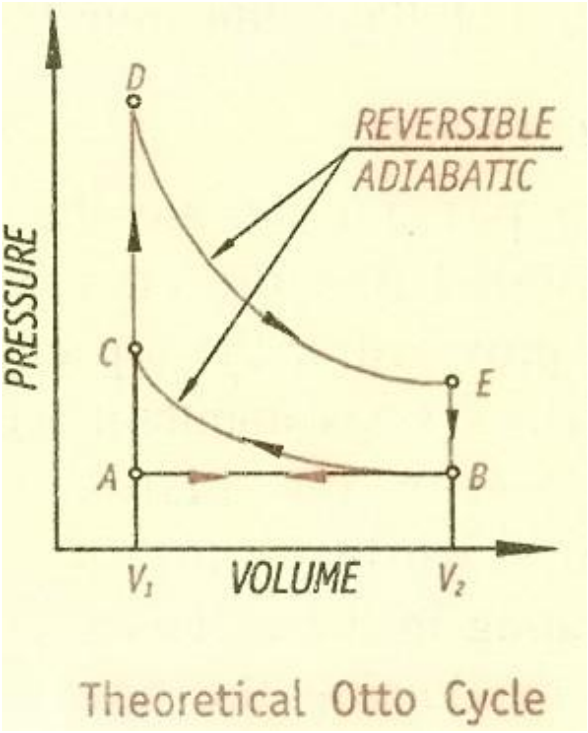
A freely moving piston reciprocates inside the cylinder. The connecting rod and the crank convert the reciprocating motion of the piston into the rotary motion.

The petrol engines work on the principle of theoretical OTTO cycle, also known as constant volume heat addition cycle.

The piston performs 4 strokes to complete one working cycle, hence the name 4S engine.



Four Stroke Petrol Engine



Theoretical Otto Cycle

The four different strokes are,

i) Suction stroke
ii) Compression stroke
iii) Working or power stroke
iv) Exhaust stroke.

SUCTION STROKE:

- Inlet is open and the exhaust is closed.
- The piston moves from the cover end to the crank end. Crankshaft revolves by half rotation.
- The volume in the cylinder increases, the pressure decreases.
- This sets up a pressure differential between the atmosphere and the inside of the cylinder.
- Due to this pressure differential the petrol & air mixture will be drawn into the cylinder through the carburetor.

COMPRESSION STROKE:

- Both the inlet and exhaust are closed.
- Piston moves from crank end to cover end.
- Crankshaft revolves next half revolution.
- The petrol and air mixture contained in the cylinder is compressed.
- The compression ratio of petrol engine varies from 7:1 to 11:1.
- At the end of the stroke the high temperature and pressure petrol-air mixture is ignited by electric spark produced by spark plug.

WORKING OR POWER OR EXPANSION STROKE:

- Both inlet and exhaust are closed.
- Piston moves from cover end to crank end.
- Crank revolves by half revolution.
- The high pressure of the burnt gases forces the piston downwards performing power stroke.
- The linear motion of the piston is converted to rotary motion of the crankshaft by connecting rod.
- At the end of the stroke exhaust valve opens.

EXHAUST STROKE:

- Exhaust is open and inlet is closed.
- Piston moves from crank end to cover end.
- Crank revolves by half rotation.
- The burnt gases are expelled from cylinder at atmospheric pressure.

Brainstorming Questions:

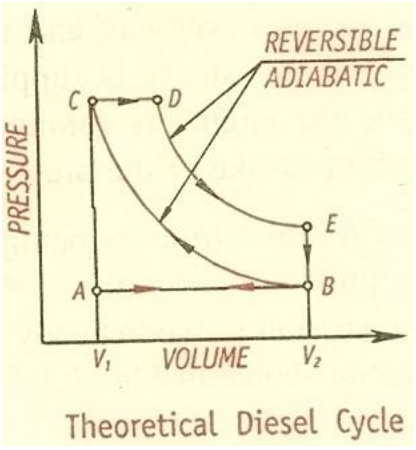
1. **List the components of IC engines?**
2. **What is bore and Stroke?**
3. **Why is Auto cycle called Constant Pressure Heat addition Cyle?**
4. **How many revolutions of the crank will takes for one working cycle of 4 stroke petrol engine?**

Lecture 12:

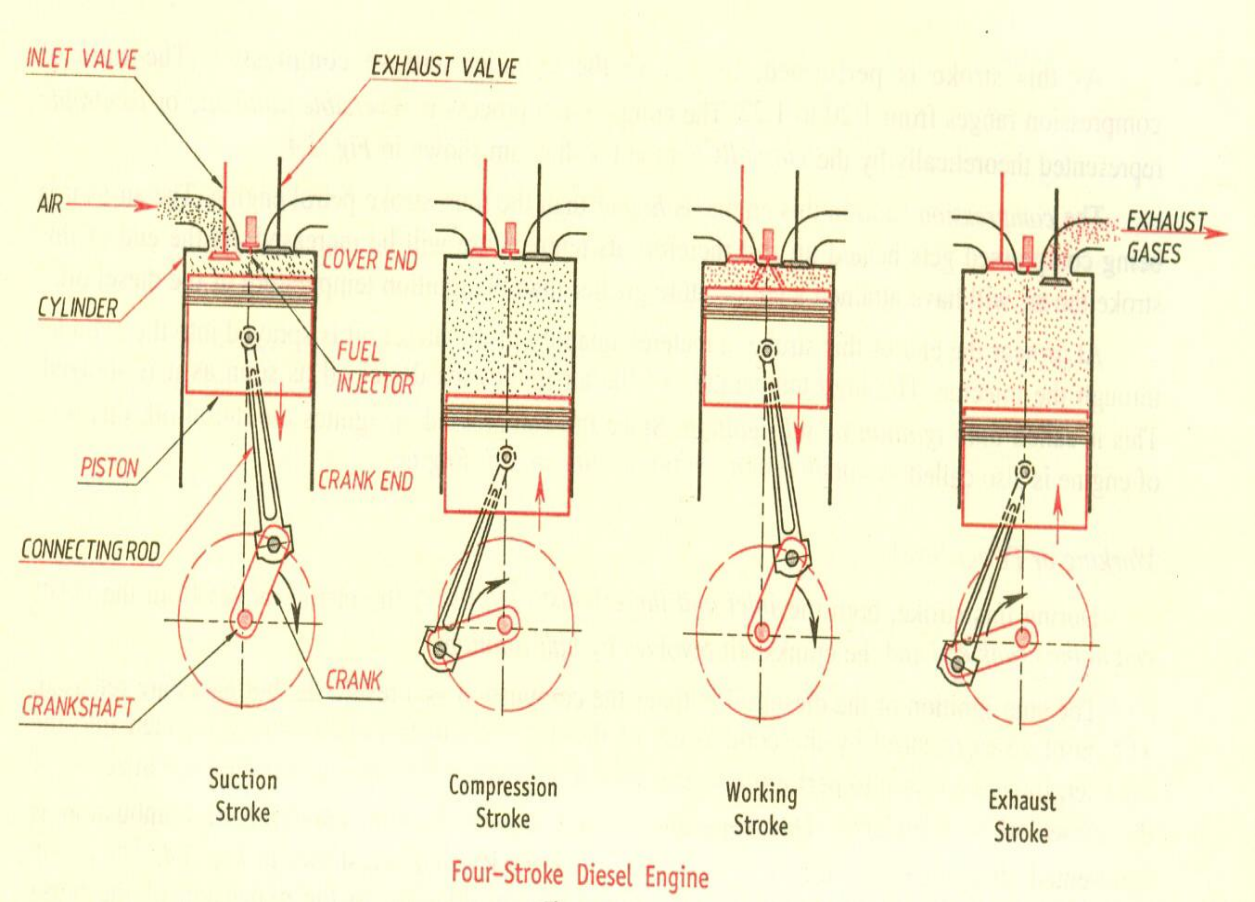
FOUR STROKE DIESEL ENGINE:

Features:

- It consists of a cylinder with its one end fitted a cover and the other end open. The cover is provided with inlet and exhaust apertures which are mechanically operated by valves called inlet and exhaust valve, respectively.
- The fuel injector mounted in its place injects Diesel fuel supplied by the fuel pump.
- A freely moving piston reciprocates inside the cylinder. The connecting rod and the crank convert the reciprocating motion of the piston into the rotary motion.
- The diesel engines work on the principle of theoretical DIESEL cycle, also known as constant pressure heat addition cycle.
- The compressed air ignites the diesel oil in the engine, hence the name compression ignition engine.
- The piston performs 4 strokes to complete one working cycle, hence the name 4S engine.



Theoretical Diesel Cycle



The four different strokes are,

i) Suction stroke
ii) Compression stroke
iii) Working or power stroke
iv) Exhaust stroke.

SUCTION STROKE:

- Inlet is open and the exhaust is closed.
- The piston moves from the cover end to the crank end. Crankshaft revolves by half rotation.
- The volume in the cylinder increases, the pressure decreases.
- This sets up a pressure differential between the atmosphere and the inside of the cylinder.
- Due to this pressure differential, only the atmospheric air will be drawn into the cylinder.

COMPRESSION STROKE:

- Both the inlet and exhaust are closed.
- Piston moves from crank end to cover end.
- Crankshaft revolves next half revolution.
- The air in the cylinder is compressed.

- The compression ratio of diesel engine varies from 16:1 to 22:1.
- The process of compression is reversible adiabatic or isentropic. At the end of the stroke a metered quantity of diesel oil is sprayed into the cylinder through the injector.
- The high temperature of the air ignites the diesel as soon as it is sprayed and is called self-ignition or auto ignition.

WORKING OR POWER OR EXPANSION STROKE:

- Both inlet and exhaust are closed.
- Piston moves from cover end to crank end.
- Crank revolves by half revolution.
- The auto ignition of diesel takes place almost at constant pressure till the injection is completed.
- The high pressure of the burnt gases forces the piston downwards initially and later by expansion of burnt gases performing power stroke.

EXHAUST STROKE:

- Exhaust is open and inlet is closed. Piston moves from crank end to cover end.
- Crank revolves by half rotation.
- The burnt gases are expelled from cylinder at atmospheric pressure.
- In 4 stroke engines, the 4 stroke constitute one cycle, hence the name 4 stroke cycle engine.
- Crankshaft makes two revolutions to complete one cycle.
- The power is developed in every alternate revolution of the crankshaft.
- 4S diesel engines produce higher power than 4S petrol engines.

Lecture 22:

COMPARISON OF PETROL AND DIESEL ENGINE:

PRINCIPLE	PETROL	DIESEL
1. Cycle of operation	**Otto cycle**	**Diesel cycle**
2. Fuel used	Petrol	diesel
3. Admission of fuel	Air & petrol during suction	Diesel oil by injector at the end of compression stroke.
4. Charge drawn during suction	Air and petrol mixture	Only air
5. Compression ratio	7:1 to 12:1	16:1 to 22:1
6. Ignition of fuel	Spark ignition	Compression or auto ignition

7. Governing	Quantitative	Qualitative
8. Engine speed	High about 7000rpm	Low from 500 to 3000rpm
9. Power output capacity	Less	More
10. Thermal efficiency	Less	High
11. Noise & vibration	Almost nil	High
12. Weight of the engine	Less	high
13. Initial cost	Less	More
14. Operating cost	High	Less
15. Maintenance cost	Less	Slightly higher
16. Starting of the engine	Easily started	Difficult to start in cold weather
17. Exhaust gas pollution	More	Less
18. Uses	Scooter, motorcycle, car, etc.,	Trucks, tractors, buses, etc.,

Application of I C engine:

Application of IC engines in power generation:

In Diesel engine power plant

(a) Peak load plants: Diesel plants can be used in combination with thermal or hydro plants as peak load units. They can be easily started or stopped at short notice to meet the peak demand.

(b) Mobile plants: Diesel plants mounted on trailer can be used for temporary or emergency purposes such as supplying power to large civil engineering works.

(c) Standby unit: If the main unit fails or can't cope up with demand, a diesel plant can supply necessary power. For example, if the water available in the hydro plant is not adequately available due to less rainfall, the diesel station can operate in parallel to generate short fall of power.

(d) Emergency plant: During power interruption in a vital unit like key industrial plant or hospital, a diesel electric plant can be used to generate the needed power.

(e) Nursery station: In the absence of the main grid, a diesel plant can be installed to supply power in a small town. In course of time when electricity from main grid becomes available in the town, the diesel unit can be shifted to some other area which needs power in small scale. Such diesel station is called nursery station.

(f) Starting station: Diesel units can be used to run auxiliaries (like FD & ID fans) for starting large steam power plant.

(g) Central station: Diesel electric plant can be used as central station where power required is small.

Application of IC engines in agriculture:

There is no doubt that engines are vital to the agricultural industry today. Many aspects would be less efficient and reliable year to year if engines were not available. Engines allow faster production, more food to be grown and harvested, and superior procedures concerning countless tasks.

Farm Equipment

- Farm equipment and machinery are at the heart of the agricultural industry. **Tractors, planters, and combines are all powered with engines to plant and harvest crops**. Balers are used to cut and harvest hay for animals. Tractors with bush hogs are used to mow grass and cut down brush and weeds on parts of the farm and in ditches next to fields.

Trucks for Transportation

- Along with the farm machinery that is needed to grow and harvest crops, trucks are required to transport these products. During harvest, semi-trailers are filled from the combines with product ready to go to market. These semi-trucks then transport the product to the intended destination.
- Trucks and tractor trailers are also used to transport fertilizer, herbicides and pesticides, and even water to fields to help prepare them for planting and keeping the crop healthy while it is growing. This job would be immensely harder if not for engine-powered machinery.

Application of IC engines in marine:

- Marine engines on ships are responsible for propulsion of the vessel from one port to another. Whether it's of a small ship plying in the coastal areas or of a massive one voyaging international waters. A marine engine of either 4-stroke or 2-stroke is fitted onboard ship for the propulsion purpose.

The two basic types of marine diesel engines are –

- 4 stroke engines.
- 2 stroke engines.

A 4-stroke engine can be installed on the ship to produce electrical power and to propel the ship (usually in small size vessel). This engine takes 4 cycles to complete the transfer of power from the combustion chamber to the crankshaft.

Application of IC engines in aircraft propulsion:

An aircraft engine, often referred to as an aero engine, is the power component of an aircraft propulsion system. Most aircraft engines are either piston engines or gas turbines, although a few have been rocket powered and in recent years many small UAVs have used electric motors.

The operation of aerospace propulsion engines rests on the foundation of Newton's laws of motion. The second of these laws explains that the change in momentum of the fluid passing through an engine is equal to the force acting on the fluid. The third law states that the force

acting on the fluid exerts a reaction, an equal and opposite force, on the boundaries separating the fluid and the engine. Indeed, such engines are often referred to as reaction motors.
In general, aerospace propulsion engines may be thought of as idealized flow machines in which fluid within the machine has work and/or heat added to it prior to its exit from the machine as a jet, thereby producing thrust according to the reaction principle described above. The fluid may enter the machine from the surroundings or may be carried entirely within the machine prior to being processed. The former engines are usually called airbreathing engines and the latter, rockets. Of primary interest is the magnitude of the thrust produced and the efficiency with which the heat and power is used in generating thrust.

Application of IC engines in automobile:
IC engines are used in Road vehicles like scooters, motorcycles, cars, buses trucks etc.

Brainstorming Questions:

1. **List the advantages of 4 stroke petrol engine?**
2. **List the advantages of 4 stroke Disel engine?**
3. **List the application of IC engine?**
4. **What are the major differences of petrol and Diesel engine?**

Lecture 13:

INSIGHT TO FUTURE MOBILITY TECHNOLOGY

ELECTRIC AND HYBRID VEHICLES:

Why Electric Vehicles (EV)?
There are many reasons why people are moving to Electric Vehicles (EV) to get them to the places they need to be. These include:

- EVs are fun to drive because they are fast and smooth.
- Many studies show that the emissions from burning fossil fuels such as gasoline produce harmful greenhouse gases. EV's produce no smelly fumes or harmful greenhouse gases.
- EVs are innovative and cool.
- EVs only cost approximately $360 a year to operate compared to $3600 for a gasoline vehicle.
- EVs are a smart and convenient choice.

There are 3 types of electric vehicle: Battery Electric Vehicle (BEV), Plugin Hybrid Electric Vehicle (PHEV) and Hybrid Electric Vehicle (HEV).

Battery Electric Vehicle (BEV)

A battery electric vehicle (BEV) runs entirely using an electric motor and battery, without the support of a traditional internal combustion engine, and must be plugged into an external source

of electricity to recharge its battery. Like all electric vehicles, BEVs can also recharge their batteries through a process known as regenerative braking, which uses the vehicle's electric motor to assist in slowing the vehicle, and to recover some of the energy normally converted to heat by the brakes.

Pros

- No emissions
- No gasoline or oil changes
- Ability to conveniently charge at home
- Fast and smooth acceleration
- Low cost of operation - about $30 a month.

Cons

- Shorter range than gasoline vehicles, although most people drive well within the range of today's BEV and could rent a hybrid for the rare long trips.
- Slightly more expensive than their gasoline equivalent although the gasoline savings pay off the difference in typically 2-3 years.

Plug-in Hybrid Electric Vehicle (PHEV)

Plug-in hybrids (PHEVs) use an electric motor and battery that can be plugged into the power grid to charge the battery, but also has the support of an internal combustion engine that may be used to recharge the vehicle's battery and/or to replace the electric motor when the battery is low. Because Plug-in Hybrids use electricity from the power grid, they often realize more savings in fuel costs than tradition hybrid electric vehicles (HEV).

Pros

- Longer range than BEV
- Less fuel consumption than fuel only vehicle
- Fewer emissions
- Very simple mechanics, less to go wrong.

Cons

- Produces tailpipe emissions
- Needs fuel and oil changes
- More expensive to operate than Battery Electric Vehicle (BEV) but less than traditional hybrid vehicle (HEV).

Hybrid Electric Vehicles (HEVs)

Hybrid Electric Vehicles (HEVs) have two complementary drive systems: a gasoline engine with a fuel tank; and an electric motor with a battery. Both the engine and the electric motor can turn the transmission at the same time, and the transmission then turns the wheels. HEVs cannot be recharged from the electricity grid – all their energy comes from gasoline and from regenerative braking.

Pros

- Longer range than BEV
- Less gas consumption than gas only vehicle

- Fewer emissions than gas only vehicle

Cons

- Still produces emissions
- Complex mechanics – Gasoline + Electric
- Expensive to operate (8-10 times more expensive than BEV) but less than traditional gasoline vehicle.
- No ability to conveniently charge at home.

Brainstorming Questions:

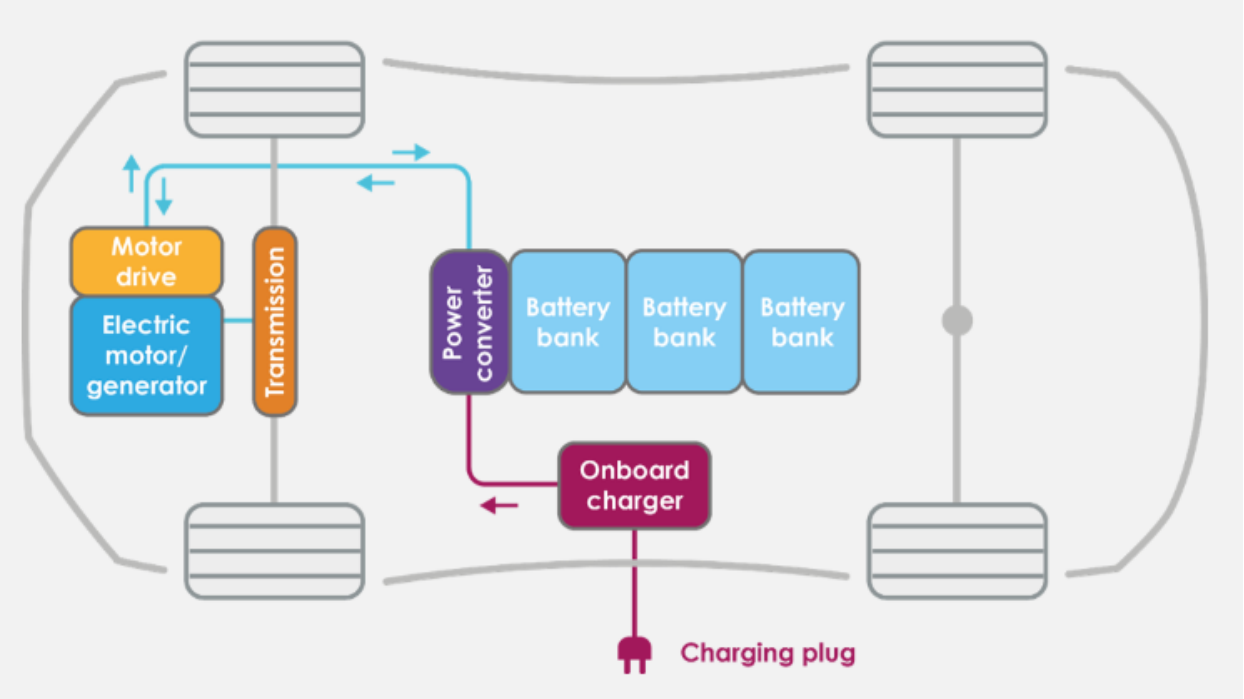
1. **What is the need of future mobility vehicles?**
2. **Differentiate Battery electric vehicle and plugin electric vehicle?**
3. **What are the pros and cons of BEV?**
4. **What is hybrid electric vehicle?**

Lecture 14:

Layout or Components of an Electric vehicle:

1. Electric Motor

Converts electrical energy to mechanical energy, that is delivered to the wheels via single ratio transmission



2. DC-AC Converter

The DC supplied by battery pack is converted to AC and supplied to the electric motor. This power transfer is managed by a sophisticated "motor control mechanism" that controls the frequency and magnitude of the voltage supplied to the electric motor to manage the speed.

3. **Battery pack**

The battery pack is made up of multiple lithium-ion cells and stores the energy needed to run the vehicle. Battery packs provide DC output.

4. **On-Board Charger-**

Converts AC received through charge port to DC and controls the amount of current flowing into the battery pack.

Apart from the core parts, there are multiple hardware and software components in an EV powertrain. Electronic Control Units (ECU'S) are basically software programs integrated with the powertrain components to help data exchange and processing

5. **Battery Management system (BMS) –**

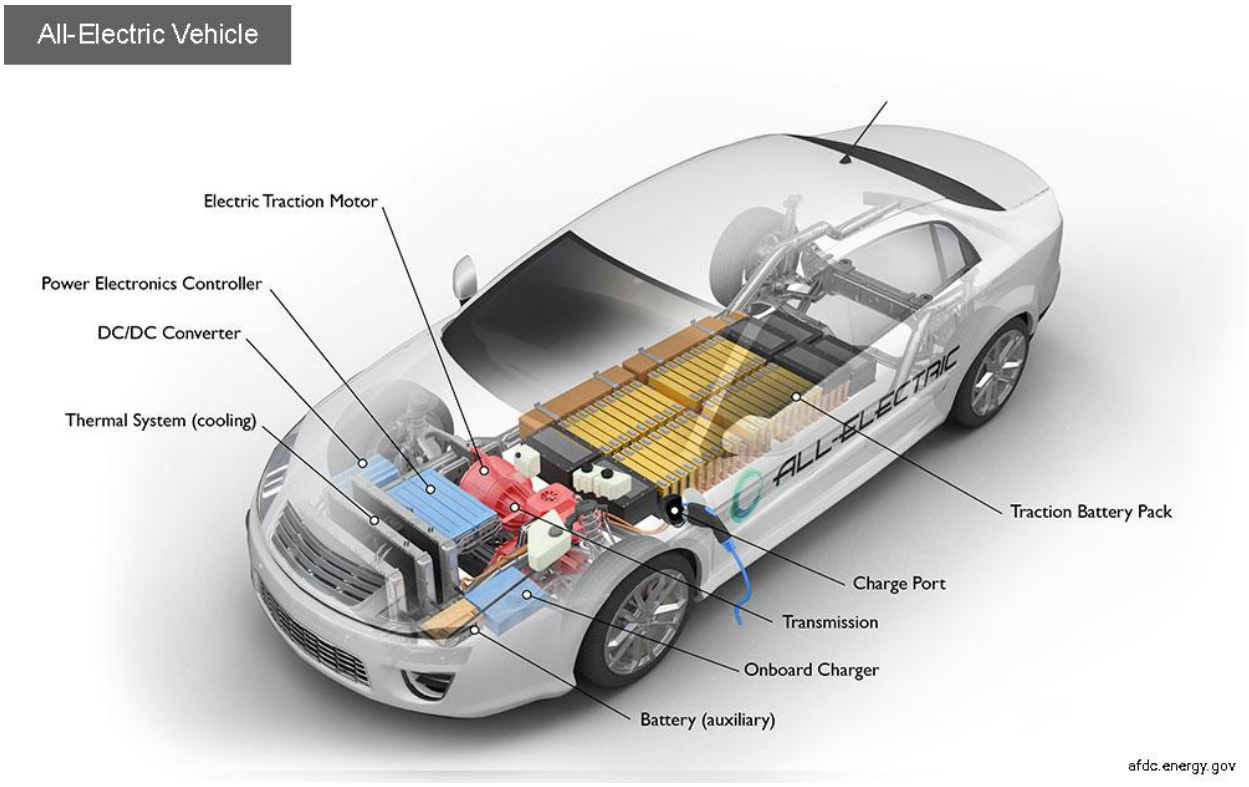
A BMS continuously monitors the state of the battery and is responsible for taking necessary measures in case of a malfunction. BMS performs cell balancing to deliver maximum efficiency from the battery pack.

6. **DC-DC Converter –**

A battery pack delivers a fixed voltage, but the requirement of other accessories like wipers, lights, infotainment systems, mirror control in EV would vary. This converter helps to distribute power to different systems by converting the power from battery pack to the expected level.

7. **Thermal Management system –**

Responsible for maintaining optimum operating temperature range for powertrain components.



Brainstorming Questions:

1. **List the components of BEV?**
2. **Which type of battery is used in BEV?**
3. **What is BMS?**
4. **List the merits and demerits of BEV?**

Lecture 15:

Advantages and disadvantages of an Electric vehicle:

ADVANTAGES

- They are easier on the environment without any harmful emissions.
- Electricity is cheaper than gasoline. Long term savings in fuel cost
- Convenience of charging the car at home
- Maintenance is less frequent and less expensive.
- They are very quiet. Hence ride comfort is better.
- Buyers can claim tax benefits.
- Easy driving with the absence of clutch and gear box

DISADVANTAGES

- Non availability of many recharges' stations
- Initial investment of the vehicle is high.
- Short driving range and speed
- Longer recharge times.
- Not suitable for cities facing shortage of power.
- Battery replacement and disposal issues.

Key components of a Hybrid Electric Vehicle

Hybrid vehicles (HVs) :

A hybrid car uses more than one means of energy, combining a petrol or diesel engine with an electric motor, and the two systems work with each other to move the vehicle.

- This allows the car to burn less gasoline, achieving better fuel efficiency than a traditional engine that solely uses fuel.
- Hybrids, except for plug-in hybrids, charge the battery through its internal system, so they do not need recharging.

These greener vehicles allow drivers to experience their more improved fuel economy than conventional cars."

As mentioned before, an HEV combines a conventional engine and electric powertrain. Hence, you can find engine-related and electric powertrain components in an HEV. Below are the key components of a Hybrid Electric Vehicle.

- **Internal combustion engine:** The primary power source of an HEV is a conventional engine. Hence, it is the main component responsible for propelling the vehicle. An HEV cannot run alone on an electric powertrain without an engine.

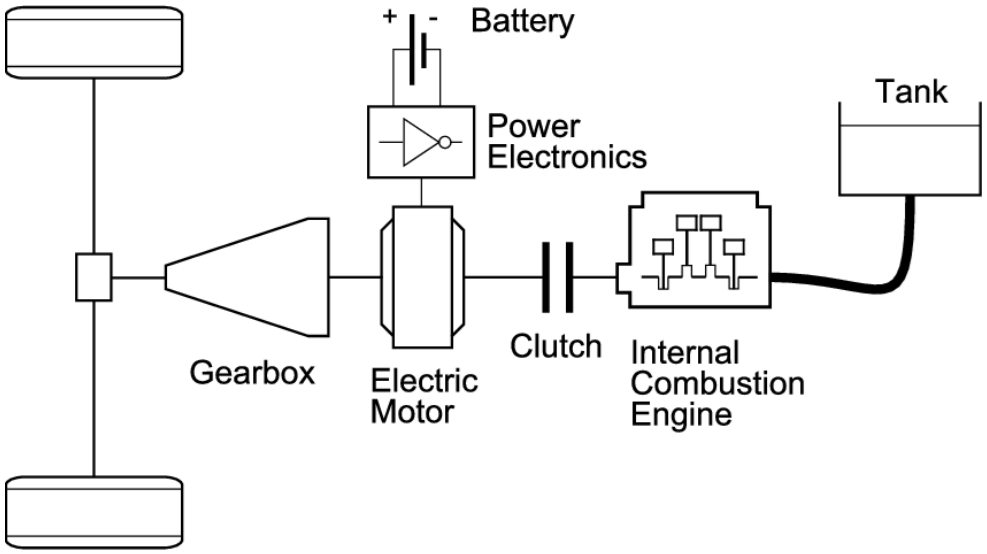
- **Electric motor:** The secondary power source of an HEV is the electric motor. It assists the engine during initial acceleration to improve performance and fuel economy. It runs on electrical energy stored in the battery pack. It can also charge the battery when the vehicle is braking or coasting via the regenerative braking system.

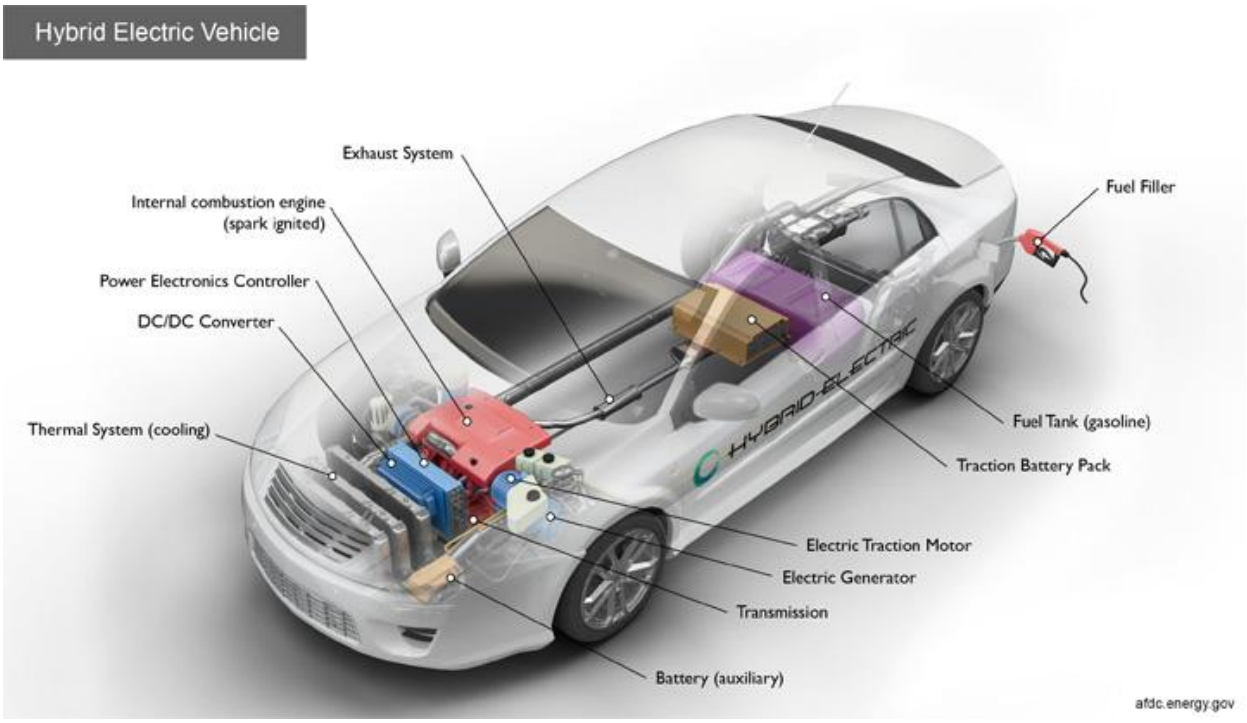
- **Battery pack:** A battery pack powers the electric motor. Basically, it acts as a fuel tank for the battery, wherein it stores the electrical energy via regenerative braking and the generator driven by the IC engine. The battery pack can also power auxiliary electrical components such as lights.

- **Generator:** It is an essential component found in the series hybrid vehicle. We will touch upon what series hybrid is in the upcoming sections. A generator draws power from the IC engine to power the electric motor and charge the battery pack. In simple words, a generator converts mechanical energy into electrical energy.

- **Transmission:** Typically, hybrid vehicles use conventional transmissions similar to petrol or diesel cars. It transmits the power produced by the IC engine to the drive shaft. The basic working principle of transmission remains the same, even in an HEV. It is one of the crucial components required to propel the vehicle.

- **Fuel tank:** Similar to a conventional car, hybrid electric vehicles also have a fuel tank to store the conventional fuel. With the electric powertrain involved in a hybrid car, the fuel consumption will be comparatively less than a vehicle purely relying on an IC engine.





Types of Hybrid Electric Vehicles

There are three types of HEVs based on power delivery and distribution. Below are more details on the same.

1. Series hybrid

In a series hybrid system, the IC engine powers the electric generator, which drives the electric motor and charges the battery. In this setup, the engine does not directly power the wheels. Series hybrid is also called a range extender since the engine powers the electric motor and the battery pack.

2. Parallel hybrid

In this system, both the engine and electric motor work parallel to propel the vehicle. The engine and the electric motor deliver optimum power for the efficient functioning of the car. The battery pack gets charged via regenerative braking. If you wonder what regenerative braking is, here's a brief explanation. Regenerative braking is a process of utilising the kinetic energy produced while slowing the vehicle down to charge the battery pack.

3. Series-parallel hybrid

A series-parallel is a flexible system wherein the IC engine, and electric motor can work in conjunction or independently. The power delivery or the power distribution helps the vehicle achieve maximum efficiency in terms of power output or fuel-efficiency.

Advantages and disadvantages of Hybrid vehicle:

ADVANTAGES

1) Environmental friendliness: Hybrid cars house a gasoline engine and an electric motor, resulting in less dependence on fossil fuels, and producing low CO2 emissions.
2) Financial benefits: Many tax credits and incentives are available to make hybrid cars more affordable.
3) Regenerative braking system: The energy from the motion of applying the brake is captured and used to recharge the battery. Such a system allows you to eliminate the amount of time for regularly recharging the battery.
4) Higher resale value: With the growing popularity, hybrids' resale value is higher than the average.

DISADVANTAGES

1) Higher costs: A hybrid car is comparatively expensive than a regular gasoline car, and its technology requires higher costs for maintenance.
2) Less power: The power of a combination of a gasoline engine and an electric motor in hybrid cars is less than that of a gasoline powered engine in many cases.
3) Poorer handling: Hybrid vehicles have more machinery than regular cars do. Manufacturers' attempts to avoid extra weight in vehicles result in smaller motor and battery in addition to reduced support in the suspension and body.
4) High voltage batteries: In case of an accident, the presence of the high voltage increases the risk of the passengers being electrocuted and makes the rescuers' task more difficult.

Advantages of EVs and Hybrid vehicles over Internal combustion engines:

1. If electricity is generated from renewable energy sources, the electric car is advantageous since it produces less emissions.
2. If the electricity is generated from fossil fuels, the electric car remains competitive only if the electricity is generated onboard.
3. If the electricity is generated with an efficiency of 50–60% by a gas turbine engine connected to a high-capacity battery and electric motor, the electric car is superior in many respects.
4. EVs are fast and smooth.
5. EV's produce no smelly fumes or harmful greenhouse gases.
6. EV's no gas or oil change is required.
7. EV's can be charged conveniently at homes/ charging points.
8. Running cost of EVs are less since electricity is used as compared to Internal combustion engine where petrol or diesel is used.

Disadvantages of EVs and Hybrid vehicles over Internal combustion engines:

1. Shorter range than internal combustion engine vehicles.
2. Slightly more expensive than their internal combustion engine vehicle equivalent although the petrol/diesel fuel savings pay off the difference in typically 2-3 years.

3. Complex mechanisms for Hybrid vehicle which have both IC engine and Electric power.

Brainstorming Questions:

1. **List the components of Hybrid BEV?**
2. **How does Hybrid BEV works?**
3. **Differential BEV and Hybrid BEV?**
4. **List the merits and demerits of Hybrid BEV?**

Lecture 16:

Power Transmission systems

Power transmission systems in mechanical engineering transfer rotational power from a source (like a motor) to a component where it does useful work, often by changing speed, torque, or direction. Common systems include gears, belts and pulleys, chains and sprockets, and couplings, which allow for the adjustment of motion to meet application requirements.

Key components and their function

Gears:

Meshed wheels used for transmitting power between shafts, capable of changing speed and torque. Gearboxes in vehicles are a prime example.

Belts and Pulleys:

A belt wrapped around two or more pulleys. The distance between the shafts determines whether belts are most suitable. They are used for long-distance power transmission.

Chains and Sprockets:

Used for intermediate distances, chains with sprockets offer a positive engagement, unlike belts which can rely on friction.

Couplings:

Connect two shafts to transmit torque, used for joining shafts that are in line.

Shafts:

Transmit power from the source to the driven machine. Transmission shafts are often stepped (having different cross-sections) to accommodate elements like gears and pulleys.

Power Screws:

Convert rotational motion into linear motion, used in applications like screw jacks and lead screws.

Clutches and Brakes:

Allow for the control of power transmission by engaging or disengaging the drive.

Primary functions of power transmission

- **Modify speed and torque:**
  Transmissions can increase or decrease speed and the associated torque. This is often done by trading speed for torque, as power is lost due to friction.
- **Change the direction of motion:**

Systems like gears can be configured to change the direction of rotation.

- **Transmit power over a distance:**
  Using belts or chains, power can be transferred between shafts that are a significant distance apart.
- **Convert motion:**
  Systems can change rotational motion into linear motion (back-and-forth) or vice versa.

Classification of gears

- **Parallel Axis Gears:**
  The shafts of the gears are parallel to each other.
  - **Spur Gears:** The most common type, with straight teeth parallel to the gear's axis, used for parallel shafts.
  - **Helical Gears:** Feature teeth cut at an angle to the axis, providing smoother and quieter operation than spur gears.
- **Intersecting Axis Gears:**
  The shafts of the gears cross each other at an angle.
  - **Bevel Gears:** Designed to transmit motion between intersecting shafts, often at a 90-degree angle.
- **Nonparallel/Nonintersecting Axis Gears:**
  The shafts are neither parallel nor intersecting.
  - **Worm Gears:** Consist of a screw-like "worm" and a "worm wheel," used to connect shafts at perpendicular, non-intersecting angles.

Other Classifications and Types

- **Herringbone Gears:** Similar to double helical gears, they have teeth sloping in opposite directions, which helps to balance axial thrust.
- **Rack and Pinion:** A gear that converts rotational motion to linear motion, or vice versa, by meshing with a toothed linear "rack".
- **Hypoid Gears:** A type of bevel gear that can be offset, allowing shafts to be neither parallel nor intersecting.
- **Screw Gears:** Also known as crossed helical gears, they have teeth that do not run parallel to the axis but are angled to intersect with other shafts, creating a sliding motion.
- **Internal Gears:** A type of gear where the teeth are on the inner surface of a ring, used in some parallel shaft applications.

Brainstorming Questions:

1. **What is a power transmission system?**
2. **List the types of gear?**
3. **List the primary functions of power transmission system?**

Lecture 17:

Simple gear trains

Simple gear trains are found in various everyday devices, including the transmission in a simple machine, the chain drive of a bicycle, and basic mechanical linkages in tools like a lathe. These systems use a single gear on each shaft to transmit motion and torque, with a basic example being the two gears directly meshing to turn a shaft

Examples of simple gear trains

- **Bicycle chain drive:**

  The chain connects two sprockets (gears) of different sizes, allowing the rider to change speed by selecting different gears. The chain itself acts as the medium for transferring motion, a characteristic of a gear train.

- **Lathe:**

  A simple gear train can be used to transmit power from the motor to the cutting tool in a lathe, often with intermediate gears to adjust the speed for different materials and operations.

- **Clock and watch mechanisms:**

  While some watches use compound gear trains, simple gear trains can be found in certain clockwork mechanisms to achieve specific speed ratios for spinning different hands or other components.

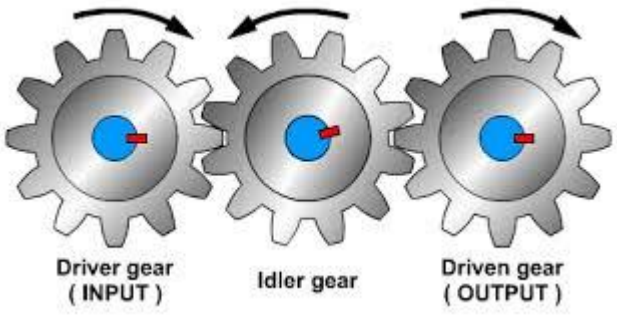
- **Simple mechanical devices:**
  Many simpler machines, from hand-cranked devices to electric mixers, use simple gear trains to change speed or torque for a specific task.

Working of Simple gear trains

A simple gear train is a system that consists of two or more gears that mesh with each **other** in a single line. Each gear is mounted on **its** own shaft**.** The purpose of this arrangement is usually to transmit motion and power from one shaft to another and to change the speed or direction of **rotation**.

Main Components

1. **Driver Gear** – The gear connected to the power source (like a motor).
2. **Driven Gear** – The gear that receives motion from the driver.
3. **Idler Gear (if present)** – The gear(s) placed between the driver and driven gears to transmit motion and possibly change the direction of rotation (but not the speed ratio).



Working Principle

When the **driver gear rotates**, its teeth push against the teeth of the **driven gear**, causing it to rotate.

- If **two gears** are in mesh, they rotate in **opposite directions**.
- If an **idler gear** is placed between them, the **driven gear rotates in the same direction** as the driver.
- The **speed ratio** (gear ratio) depends on the number of teeth on each gear.

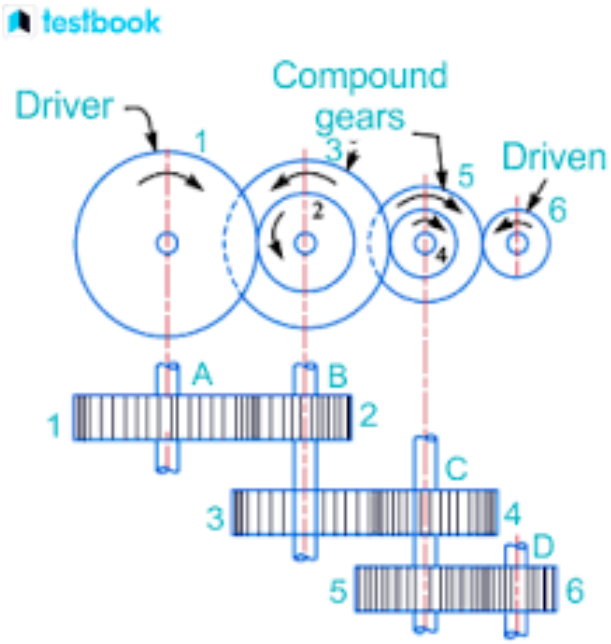
$$\text{Speed Ratio} = \frac{\text{Speed of Driven Gear}}{\text{Speed of Driver Gear}} = \frac{\text{Number of Teeth on Driver}}{\text{Number of Teeth on Driven}}$$

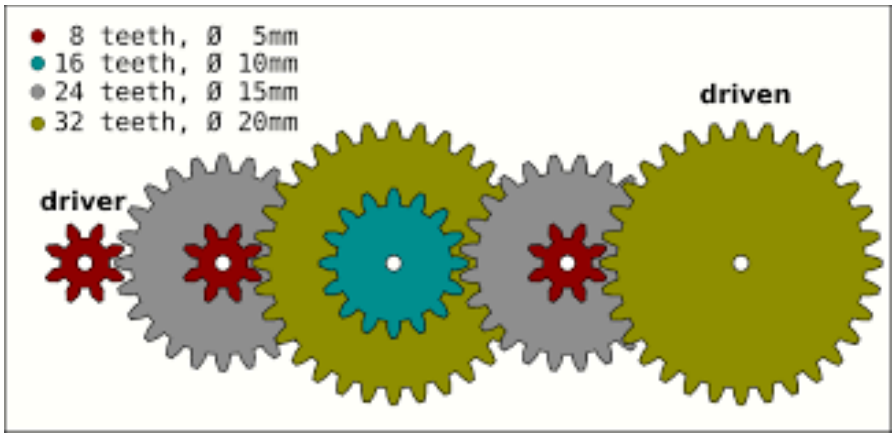
Compound gear trains

A compound gear train is a gear system where at least one shaft has two or more gears fixed to it, which allows for larger speed reductions or increases in a smaller space compared to a simple gear train. While a simple gear train uses one gear per shaft, a compound train uses one or more shafts to connect multiple gear pairs, achieving a greater overall gear ratio by multiplying the ratios of each pair.

Key features

- **Multiple gears on a shaft:**
  The defining characteristic is having more than one gear on a single shaft, which are fixed together and rotate at the same speed.
- **Larger speed ratios:**
  Compound trains are used when a significant speed reduction is needed, as they multiply the speed ratios of each gear pair to achieve a higher overall ratio.
- **Bridging distance:**
  They can be used to bridge large distances between an input and output shaft.
- **Non-influential intermediate gears:**
  Similar to a simple gear train, the gears on the intermediate shafts that connect the driven and driver gears do not affect the overall velocity ratio (though they do affect the direction of rotation).





Brainstorming Questions:

1. **What is simple gear trains?**
2. **What is compound gear trains?**
3. **List the application of simple gear train?**

Lecture 18:

Automatic Transmission

An **Automatic Transmission** is a type of vehicle transmission system that **changes gear ratios automatically** as the vehicle moves, so the driver doesn't need to manually shift gears.

Working Principle:

- It uses a **torque converter**, **planetary gear sets**, and **hydraulic or electronic controls**.
- The torque converter connects the engine to the transmission and allows the engine to spin somewhat independently of the wheels.
- Based on vehicle speed and throttle input, the transmission **automatically selects the right gear ratio** to deliver smooth acceleration and power.

Key Features:

- No clutch pedal; the driver only operates accelerator and brake.
- Smooth gear shifts and easier driving, especially in traffic.
- Slightly less fuel efficient compared to manual transmission (in older designs).

CVT (Continuously Variable Transmission)

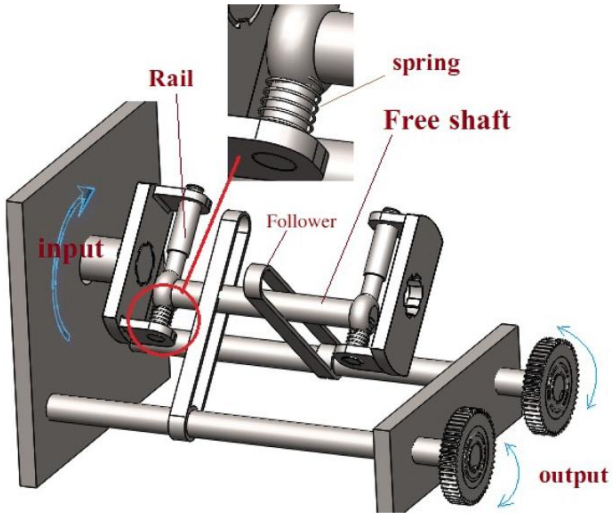
A **CVT**, or **Continuously Variable Transmission**, is a special type of automatic transmission that **does not have fixed gear ratios**. Instead, it provides **infinite gear ratios** within a range, allowing the engine to operate at the most efficient speed for any driving condition.

Working Principle:

- CVT uses a **belt and pulley system** or **toroidal rollers** instead of conventional gears.
- The pulleys change their diameters continuously, so the transmission can **seamlessly vary the gear ratio**.
- This ensures **smooth acceleration** without noticeable gear shifts.

Key Features:

- Provides better **fuel efficiency** and **smooth power delivery**.
- Ideal for scooters, hybrid cars, and small cars.
- Some drivers feel a "rubber-band effect" (no distinct gear change feel).



Key differences between automatic and CVT transmission

Feature	Automatic Transmission	CVT
Gears	• Limited, fixed set of gears	• Infinite range of gear ratios
Mechanism	• Planetary gearsets, clutches, and bands	• Two variable-diameter pulleys and a belt/chain
Shifting	• Distinct, stepped gear changes	• Seamless and continuous, "shiftless" operation
Efficiency	• Less efficient than a CVT in • some situations due to fixed gear ratios	• It can be more fuel-efficient by keeping the engine in its optimal range
Performance	• More traditional "gear" feeling	• Smooth, fluid acceleration

Brainstorming Questions:

1. **What is an automatic transmission system?**
2. **What is CVT?**

QUESTION BANK

1. Draw a neat sketch internal combustion engine and label the components. **(VTU July 2022)**
2. Explain the concept of an electric vehicle with components **(VTU July 2022)**
3. List out components of electrical and hybrid vehicles **(VTU Feb 2022)**
4. Briefly explain the application of the IC engine in Power generation (**VTU Feb 2022)**
5. List the merits and demerits of electrical and hybrid vehicles (**VTU Feb 2022)**
6. Explain the working of a 4-stroke petrol engine with a neat sketch. Indicate the 4 stokes and changes in pressure volume on a P-V diagram **(VTU Feb 2021)**
7. Distinguish between SI and CI engine **(VTU July 2021)**
8. With a neat sketch and PV diagram, explain the working of a 4-stroke diesel engine **(VTU Feb 2020)**

9. Distinguish between a petrol and a diesel engine.
10. List and explain the application of the CI engine.
11. Draw a layout of EVs and explain the components.
12. Explain the components of hybrid vehicles with a neat sketch.
13. Explain the terminology of the IC engine.
14. List the differences between conventional IC engines and Electric and hybrid vehicles.
15. Explain the classification of the IC engine.
16. List the types of hybrid vehicles.
17. List the classification of gears
18. Explain simple and compound gear trains with a neat sketch
19. Explain an automatic and CVT transmission.
20. List the differences between automatic and CVT transmissions

WEB RESORCES

1. https://www.youtube.com/watch?v=Y32gDgLq6hE
2. https://www.youtube.com/watch?v=vIJ50aUiBgM
3. https://www.youtube.com/watch?v=mRcFO7X8yP4
4. https://mechanicalboost.com/internal-combustion-engine/
5. https://energyeducation.ca/encyclopedia/Internal_combustion_engine

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2. An Introduction to Mechanical Engineering, Jonathan Wickert and Kemper Lewis, Third Edition, 2012