AUTOMOBILE ENGINEERING

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UNIT-1

Lecture – 01

Introduction to Automobile Engineering

Contents

- Introduction
- Definition
- Classification of vehicles
- Layout of automobile chassis
- Components of automobile
- Functions of major components of an automobile

Introduction

- Automobile engineering is the one of the stream of mechanical engineering.
- It deals with the various types of automobiles, their mechanism of transmission systems and its applications.
- Automobiles are the different types of vehicles used for transportation of passengers, goods, etc.
- Basically all the types of vehicles works on the principle of internal combustion processes or some times the engines are called as internal combustion engines.

Introduction contd..

- Different types of fuels are burnt inside the cylinder at higher temperature to get the transmission motion in the vehicles.
- Most of the automobiles are internal combustion engine vehicles only.
- Therefore, every mechanical and automobile engineer should have the knowledge of automobile engineering its mechanism and its various applications.

Definition

- The automobile is a self propelled vehicle that travels on land
- An automobile is a wheeled vehicle carrying its own motive power unit
- Motorized vehicle consisting of four wheels & powered by an internal engine.

- **Automobile Engineering** is a branch of engineering which deals with designing, manufacturing & operating of automobiles.
- The automobile carries people primarily for their personal transportation.

Classification of Automobiles

1. **Based on Purpose :**
   - **Passenger vehicles**: e.g: Buses, Cars, passenger trains.
   - **Goods vehicles**: e.g: Goods lorry, Goods carrier.
   - **Special Purpose**: Ambulance, Fire engines, Army Vehicles.

2. Based on Load Capacity:

- **Heavy transport vehicle** (HTV) or heavy motor vehicle (HMV), e.g. trucks, buses, etc.
- **Light transport vehicle** (LTV) e.g. pickup, station wagon, etc.
- **Light motor vehicle** (LMV), e.g. cars, jeeps, etc.

3. Based on fuel used:

- **Petrol engine vehicles** - motorcycle, scooter, cars, etc.
- **Diesel engine vehicles** - trucks, buses, etc.
- **Gas vehicles** (CNG) - LPG and CNG vehicles, where LPG is liquefied petroleum gas and CNG is compressed natural gas
- **Electric vehicles** - battery drive
- **Steam Engine vehicles** e.g: Steamboat, steam locomotive, steam wagon.

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 - gears are not required to be changed manually.
  - It is automatically changes as per speed of the automobile.
- Manual transmission vehicles (or) Conventional vehicles) e.g. car with 5 gears.
- Semi-automatic transmission vehicles: Vehicles that facilitate manual gear changing with a clutch pedal (a modified shift lever)

Semi-automatic transmission vehicles:

7. Based on Suspension system used:

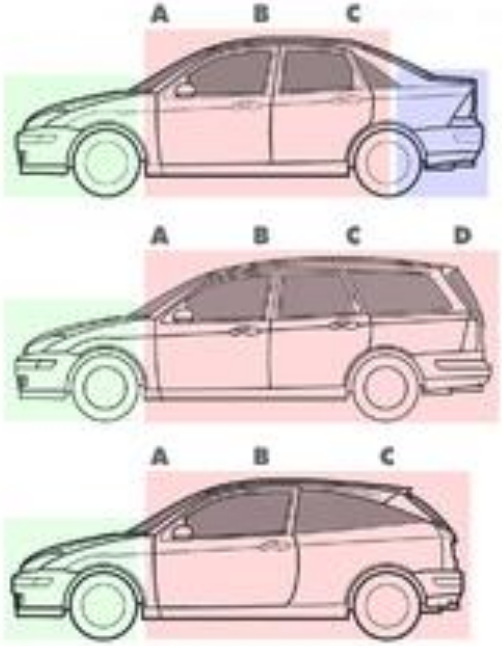
- Convectional – Leaf Spring
- Independent – Coil spring, Torsion bar, Pneumatic.

8. Based on Utility:

- Sports car
- Luxury car
- Special Vehicle (Bulldozer, earth scrappers etc)

9. Based on body:

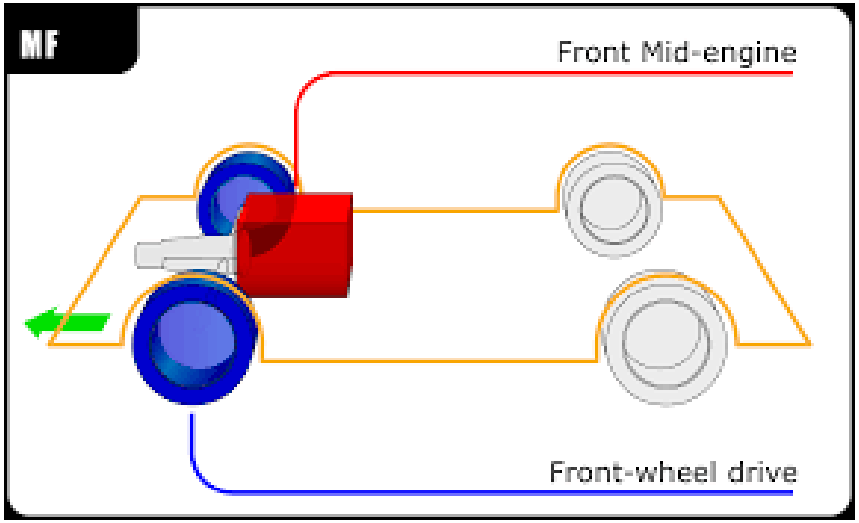
- Sedan with two doors
- Sedan with four doors
- Station wagon
- Convertible, e.g. jeep, etc.
- Van
- Special purpose vehicle, e.g. ambulance, milk van, etc.

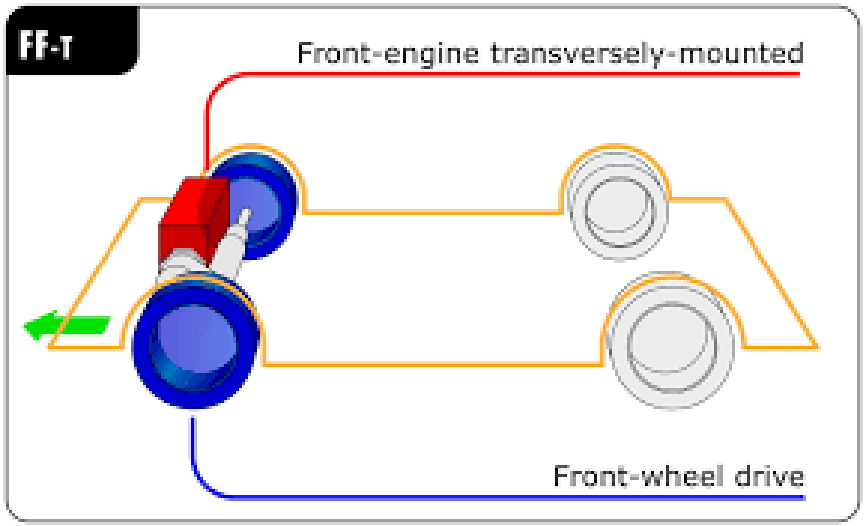


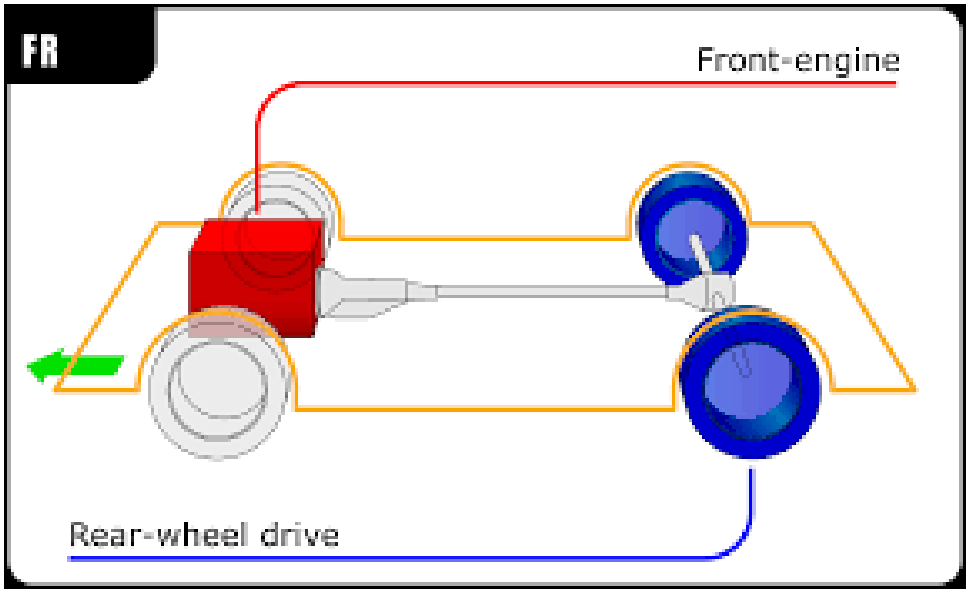
10. Based on Position of Engine

- **Engine in Front** : Most of the vehicles have engine in the front. Example : most of the cars, buses, trucks in India.
- **Engine in the Rear Side:** Very few vehicles have engine located in the rear. Example : Nano car.
  - Rear Engine front wheel drive: appeared in 1932; used only by a few prototypes
  - Rear Engine rear wheel drive: very common in transit buses and coaches due to the elimination of the drive shaft with low-floor bus.

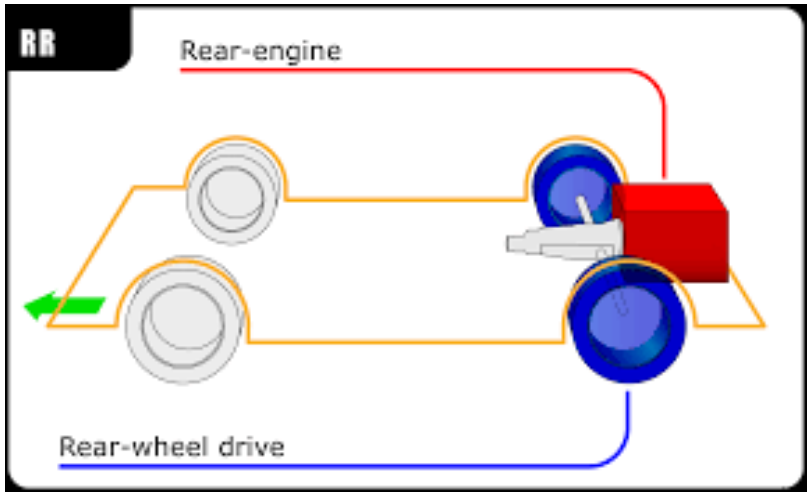
Engine positions-(Front)

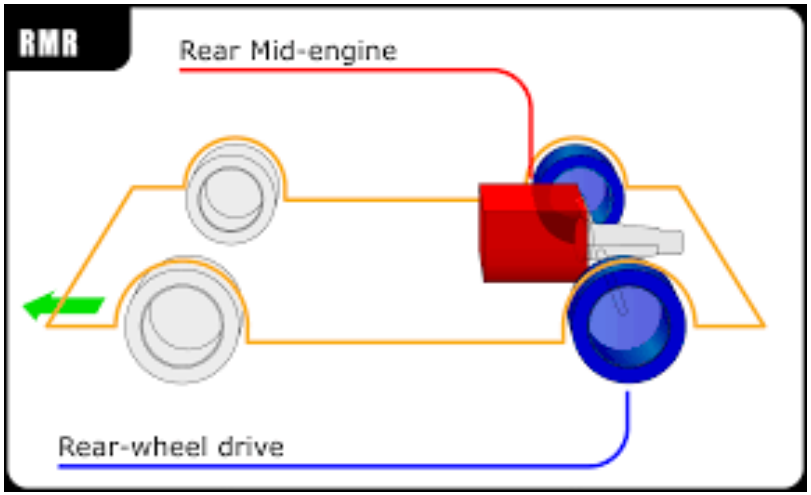


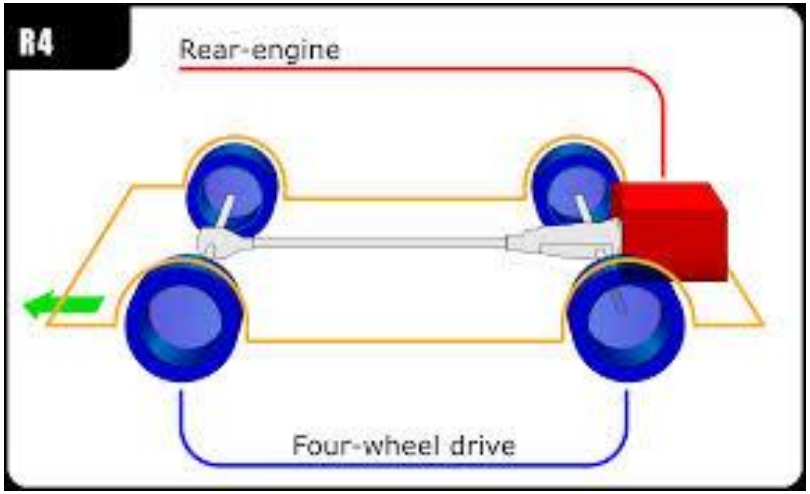




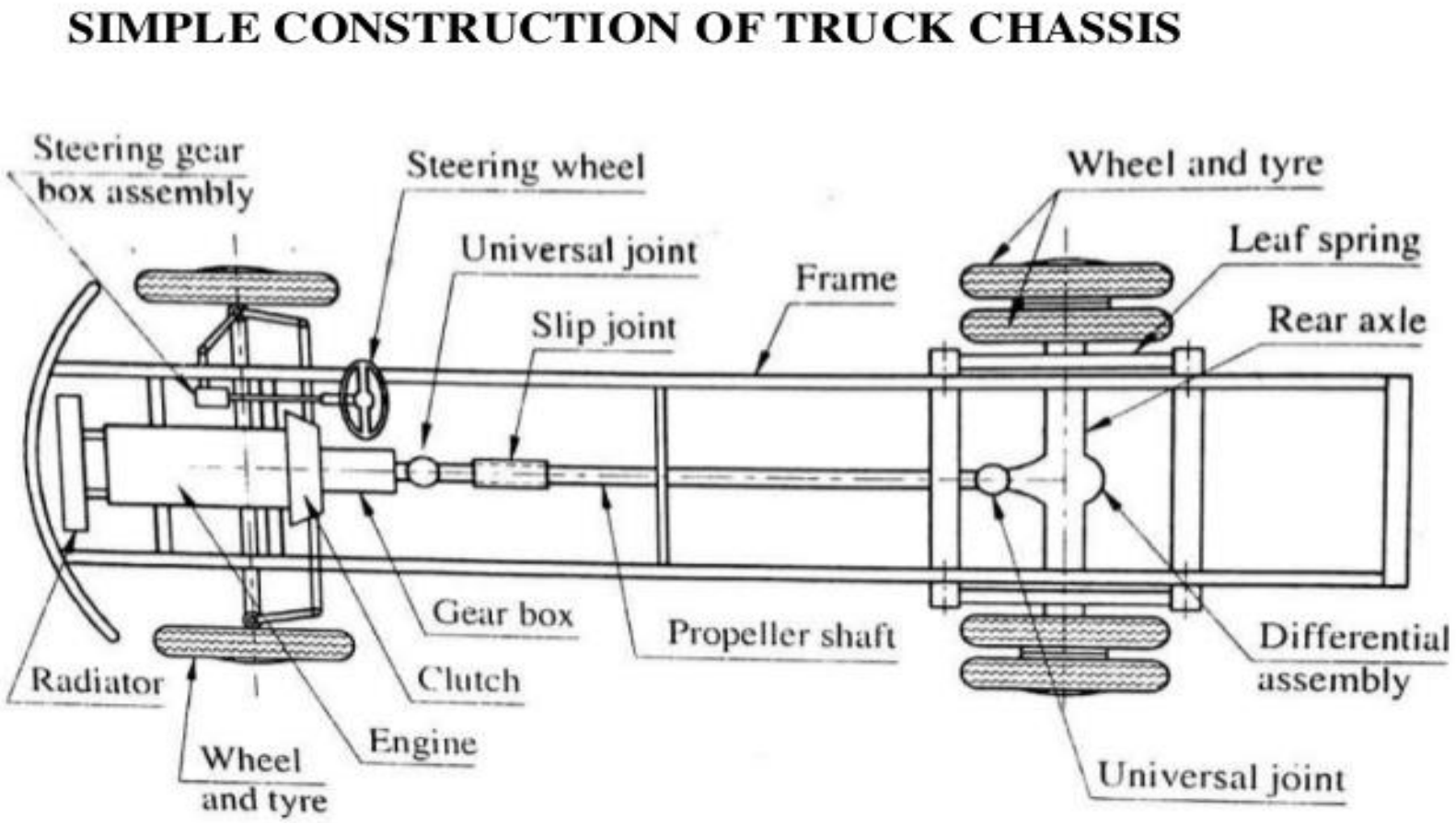
Engine positions-(Rear)







Layout of an Automobile



Main components of an Automobile

- **The basic structure** - body fitted on chassis (It supports the engine, wheels, body, braking system, steering, etc.)
- The engine or the power plant- source of power
- The transmission system
- The auxiliaries or accessories including light, air conditioner/heater, stereo, wiper, etc.
- The controls
- The super structure

1. **The Basic Structure**

- It is a unit on which the remaining units are built to make a complete automobile.
- It consists of:
  - Frame
  - The suspension system
  - Axles
  - Wheels

1.1 **Frame**

- A frame is the main structure of the chassis of a motor vehicle. All other components fasten to it.

The Functions of the Chassis frame are:

1. To carry all the stationary loads attached to it and loads of passenger and cargo carried in it
2. To withstand torsional vibration caused by the movement of the vehicle
3. To withstand the centrifugal force caused by cornering of the vehicle
4. To control the vibration caused by the running of the vehicle
5. To withstand bending stresses due to rise and fall of the front and rear axles.

1.1.1 **Classification of frames**

- **Conventional frame**: square or box shaped steel frame. The body is superimposed on it
- **Integral frame** or frameless construction: The body structure is designed in such a manner that it combines the function of body and frame

1.1.2 **Types of Frames**

- Ladder **frame** : It is now seen mainly on trucks

- Ladder frames offers good beam resistance- so it's generally preferred for towing or carrying heavy loads and for aggressive off-road driving.
- It's also easier to modify these vehicles' suspensions to make room for additional wheel travel or larger tires and wheels
- poor resistance to torsion

- **Unibody (or unitized body or frameless)**
  - in which the body of the vehicle, its floor plan and chassis form a single structure
  - is generally lighter and more rigid than a vehicle having a separate body and frame.
  - Ex- SUVs,

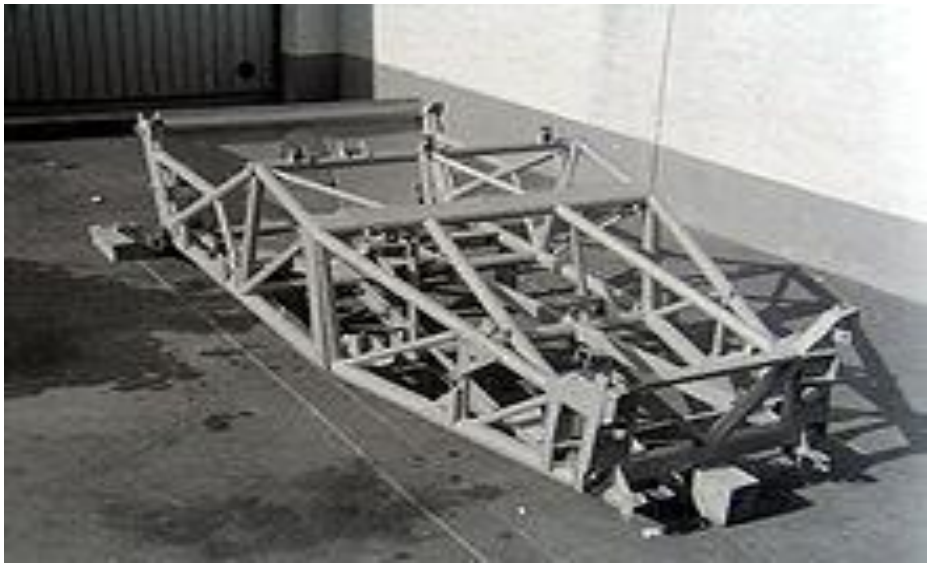
- This setup integrates the frame into the body construction so it’s a single piece.
- Because it doesn’t rely on heavy steel rails like those of a body-on-frame vehicle, unibody construction cuts significant weight out of the vehicle, allowing for better fuel economy.
- It also offers better handling and ride comfort and is safer, since the entire body can absorb the energy forces in a crash.

- **X-frame**
  - This is the design used for the full-size American models of **General Motors** in the late 1950s.
  - It was specifically chosen to decrease the overall height of the vehicles
  - It did not provide adequate side-impact and collision protection

- **Perimeter frame** (similar to ladder)
  - In addition to a lowered roof, it allows lower seating positions, and offers better safety in the event of a side impact
  - the design lacks stiffness

- **Platform frame**
  - modification of the perimeter frame
  - luggage compartment floor have been integrated
  - the most well-known of this is the **Volkswagen Beetle**

- **Space frame**
  - chassis, suspension, engine, and body panels are attached to a three-dimensional skeletal frame of tubes
  - to maximise rigidity and minimise weight, the design makes maximum use of triangles
  - **Jaguar C-Type** racing sports car



- **Subframe**
  - the rigid subframe can handle high chassis forces
  - are used to attach the suspension to the vehicle
  - The **Lamborghini Aventador**

Comparison of Conventional Frame and Frameless construction

Conventional frame construction	Frameless construction
It is used for commercial heavy vehicles.	It is used for light vehicle and mostly for cars.
In this type of frame construction, the frame and body are a seperate part. The chassis components and body are fitted on the frame.	In this type of frame construction, the frame and body are integrated part.and on it the different chassis components are fitted.
The heavy side members are used.	Light side members are used.
This construction is better for low volume produced a vehicle.	This construction is very much suitable for light and mass-produced vehicles.
There is flexibility to fitting a variety of bodies to the same chassis.	It is designed for a specific vehicle and there is no flexibility to change the body design for the corresponding chassis.

1.1.3 **Advantages of frameless construction**

- Light in weight & hence fuel efficient
- Manufacturing cost is less
- Safe for passengers during collision
- More stable automobile can be made because of the lower body construction.

1.1.4. **Disadvantages of frameless**

- Less strength and durability
- Cost of repair is high
- Economical **only if** adopted **in mass production**
- Cars without roof are difficult to design

1.2 **Suspension System**

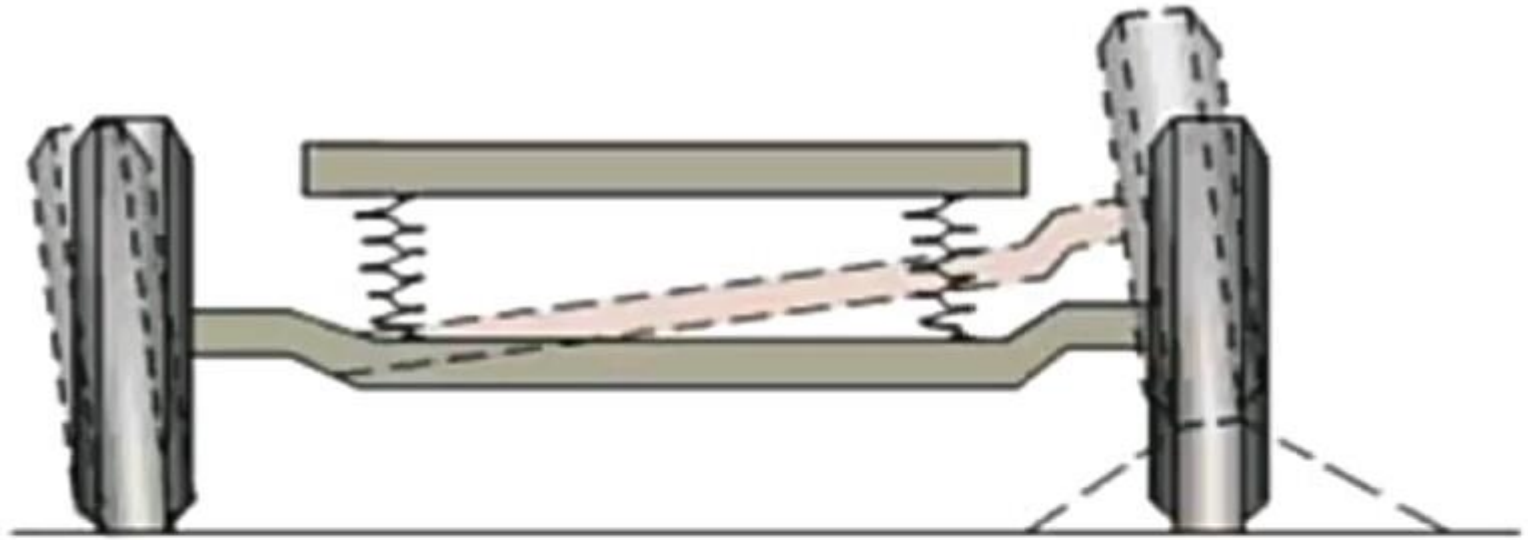
- Springs, shock absorbers and related parts between the wheels and the car body makeup the suspension system

Functions:

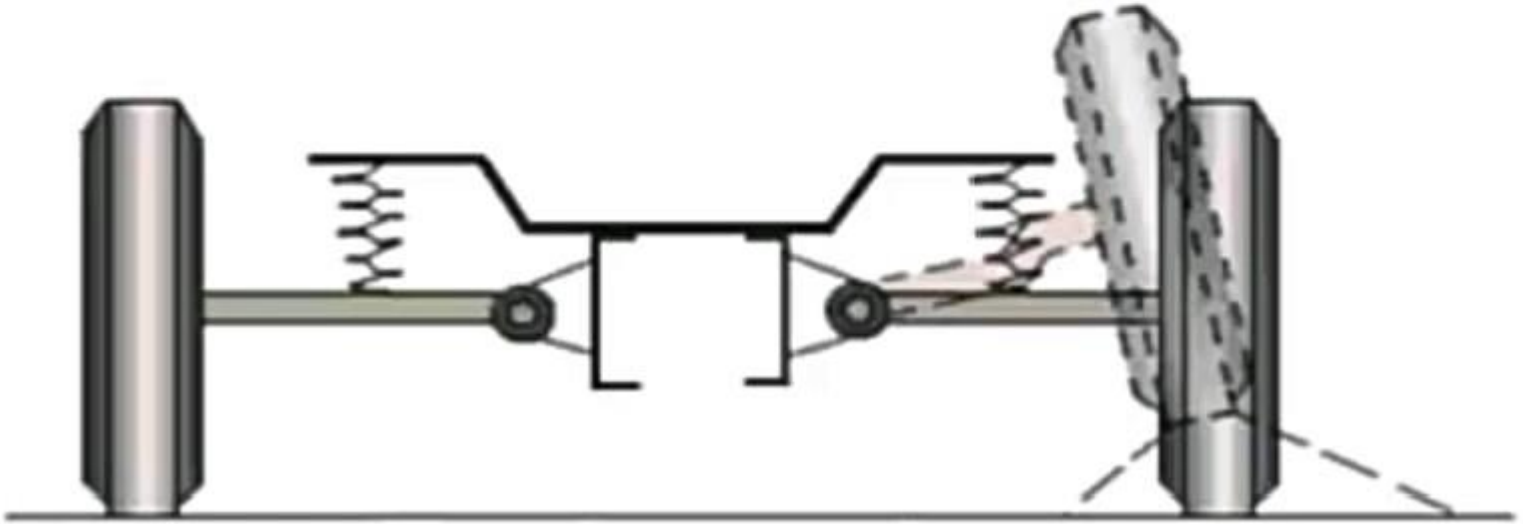
- Prevent road shocks from being transmitted
- To preserve the stability of vehicle
- Maintain proper steering geometry
- Provide good road holding while braking etc.

1.2.1 **Classification of Suspension System**

- **Rigid (non-independent) system:** Road springs are attached to a rigid beam axle
- **Independent system:** It does not have a rigid axle. In this each wheel is free to move vertically without any reaction on its mating wheel.



non-independent suspension



independent suspension

1.3 **Axles**

- These are the shafts on which road wheels are mounted.

Loads:

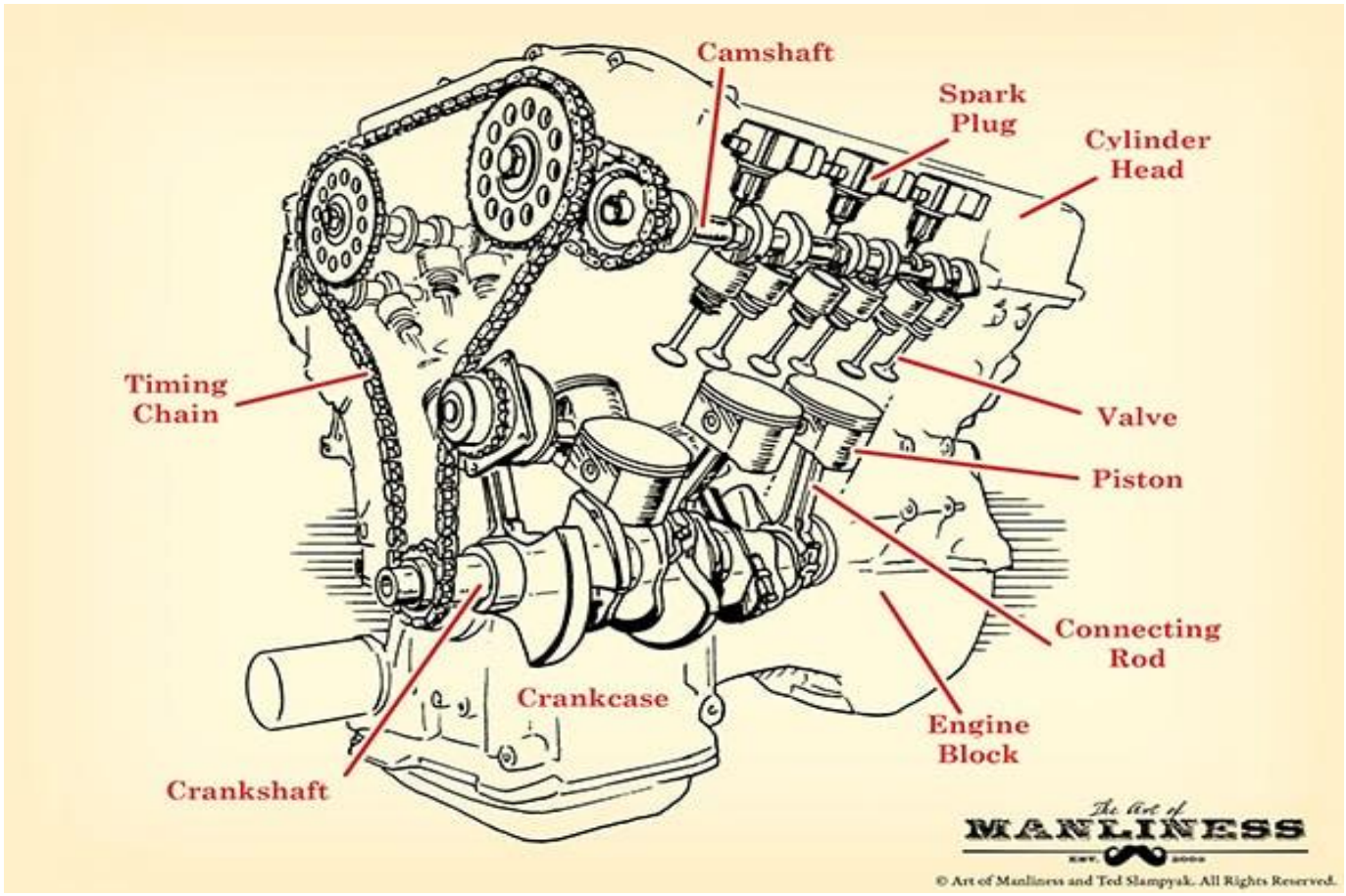
- Vertical load at spring center due to weight of vehicle
- Torque reactions due to drive or brakes

1.4 **Wheels**

- Used to take the load of vehicle
- Produce tractive force to move the vehicle
- Also used for retardation/stopping the vehicle

2. **The Engine or Power Plant**

- It provides power to drive the automobile



Engine or Power Plant contd..

- The engine is the power plant of the vehicle
- In general, internal combustion engine with petrol or diesel fuel is used to run a vehicle
- An engine may be either a two-stroke engine or a four-stroke engine
- An engine consists of a cylinder, piston, valves, valve operating mechanism, carburetor (or MPFI in modern cars), fan, fuel feed pump and oil pump, etc.
- Besides this, an engine requires ignition system for burning fuel in the engine cylinder.

That's all for this lecture. . .

~THANK YOU~

AUTOMOBILE ENGINEERING

UNIT-1

Lecture – 02

Contents

- Components and their function in an automobile continued
- Anatomy of an automobile
- Advantages and disadvantages of front & rear wheel drive
- Introduction to four-wheel drive
- Application of I.C. Engine

3. **The Transmission System**

- Used to carry power from the engine to the drive wheels
- Transmission system must do three jobs :
  - It must provide varying gear ratios. Number of gear ratio are equal to number of gears in a vehicle
  - It must provide a reverse gear for moving vehicle in reverse direction
  - It must provide a neutral or disconnecting arrangement so that the engine can be uncoupled from the wheels of the vehicle

Note: In a conventional transmission system, there is a clutch, a manually operated transmission (gear box), a propeller shaft and a differential or final drive.

Major parts:

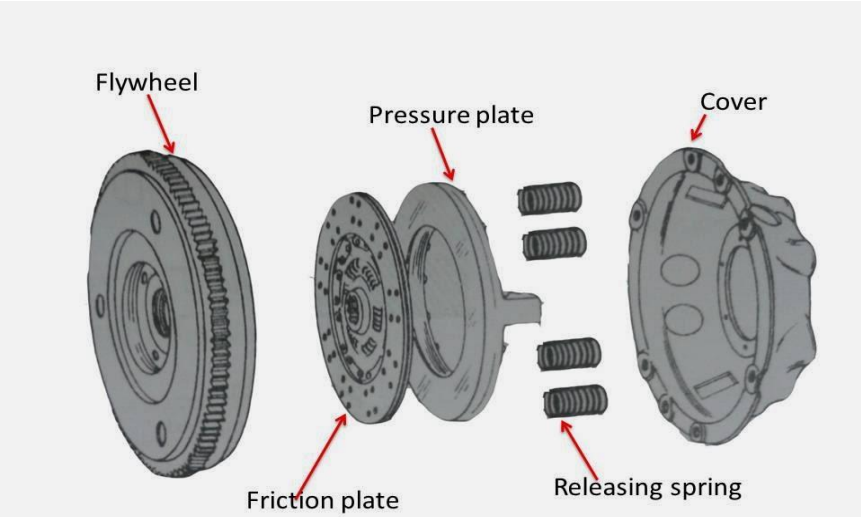
- Clutch
- Gear box (also called transmission)
- Propeller shaft (or drive shaft)
- Differential

Main functions of transmission system:

- Disconnect engine from road wheels when desired
- Connect engine to driving wheels without shock
- Reduce engine speed in a fixed ratio
- To protect engine from overload when starting

3.1 **Clutches**

- Manual transmission have a clutch
- It temporarily disconnect the engine from wheels



Main parts of clutch

3.2 **Gear Box**

- Provides necessary variation to the torque applied by the engine to the wheels

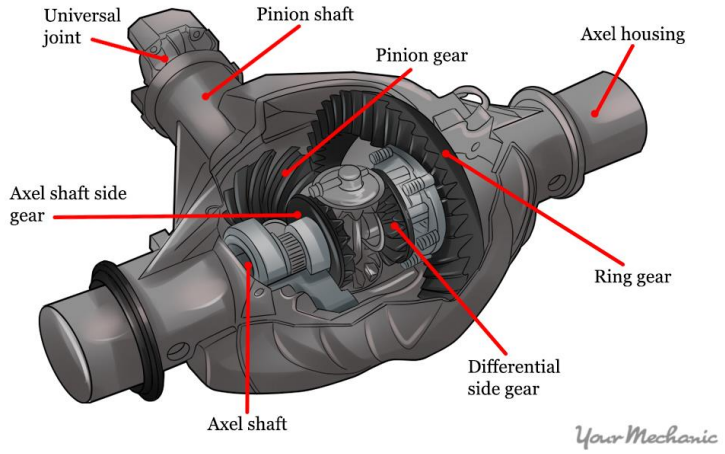
3.3 **Propeller Shaft**

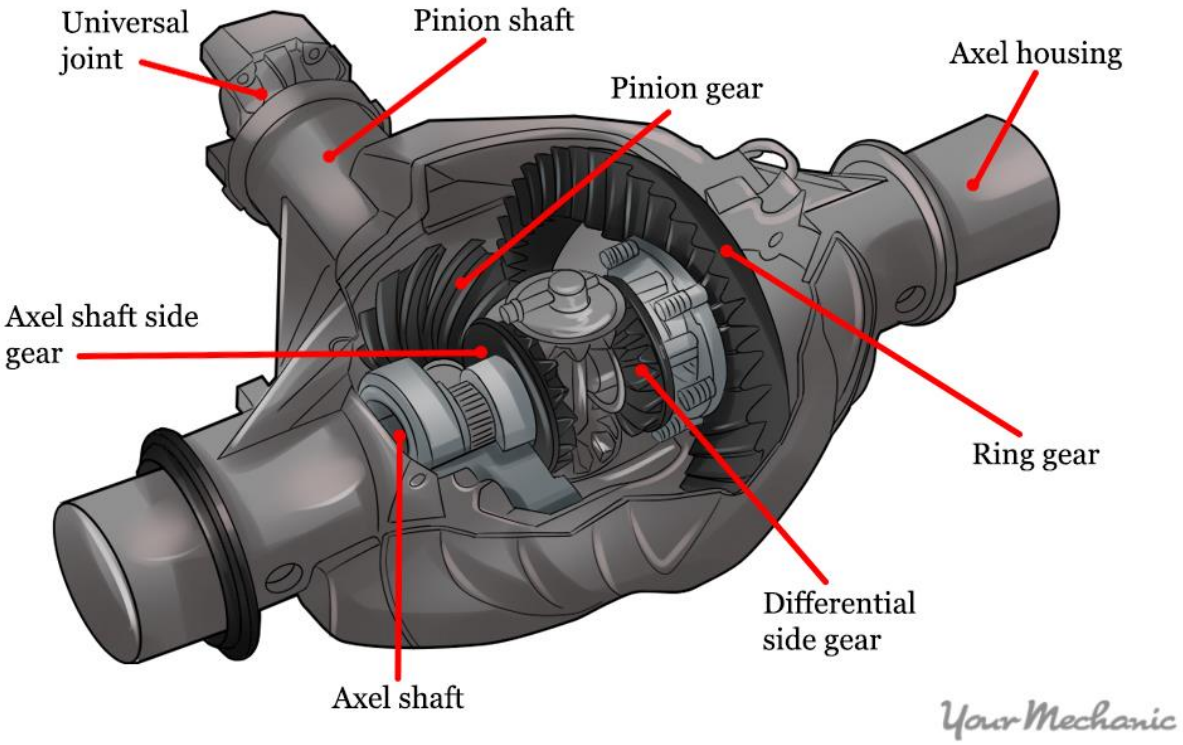
- It connects the gear box and the differential unit

- **Universal joints**
  - These provide for the relative movement between the engine and the driving wheel due to flexing of road springs
- **Bevel pinion**
  - Used to turn the drive round through 90^{o}
  - Also provides a permanent reduction in speed

3.4 **Differential**

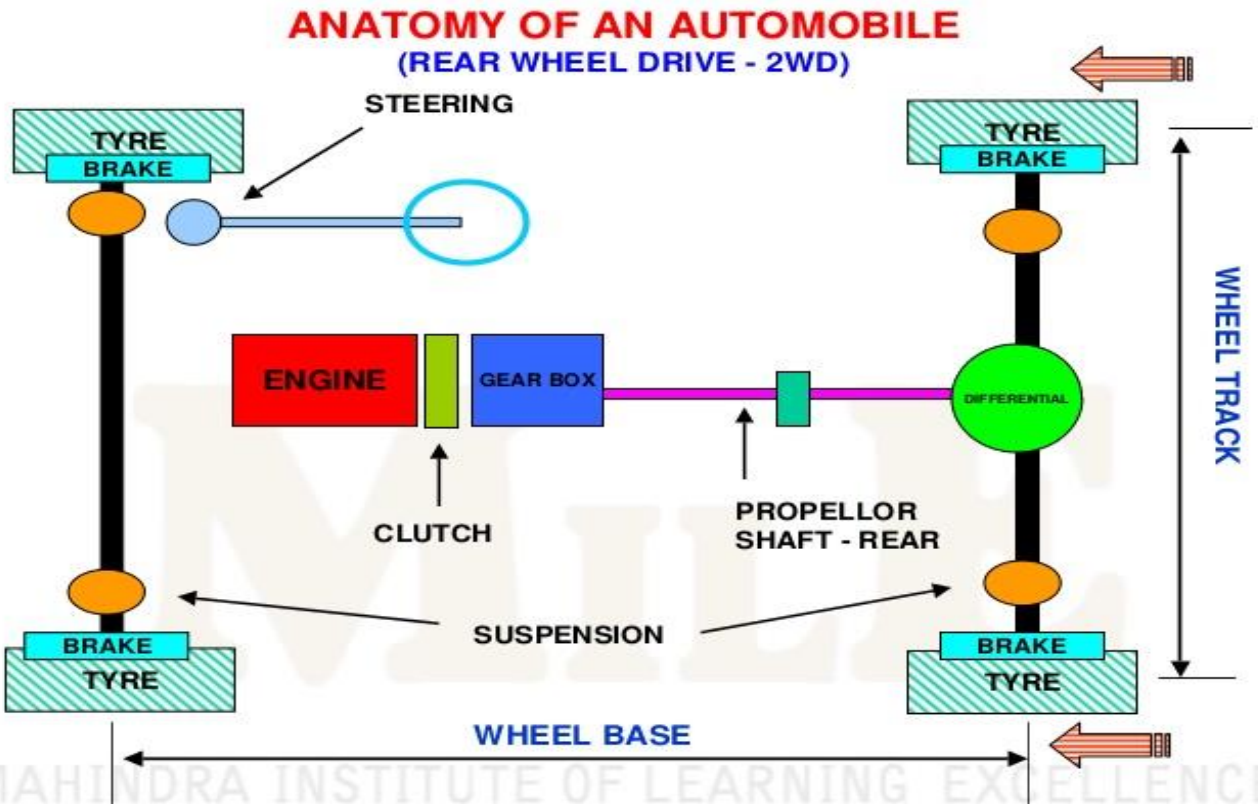
- It is to split power received from the propeller shaft to the rear axle shaft
- It allows the rear wheels to be driven at different speeds when the vehicle take turn




Universal joint
Pinion shaft
Pinion gear
Axel housing
Axel shaft side gear
Ring gear
Differential side gear
Axel shaft
YourMechanic

There are 3-types of Drive Trains

- Rear wheel drive vehicle
  - Engine has longitudinal mounting
- Front wheel drive vehicles
  - Engine mounts sideways (transverse)
- Four wheel drive vehicles
  - There is a transfer case (or box) which divides the torque equally between front and rear axles



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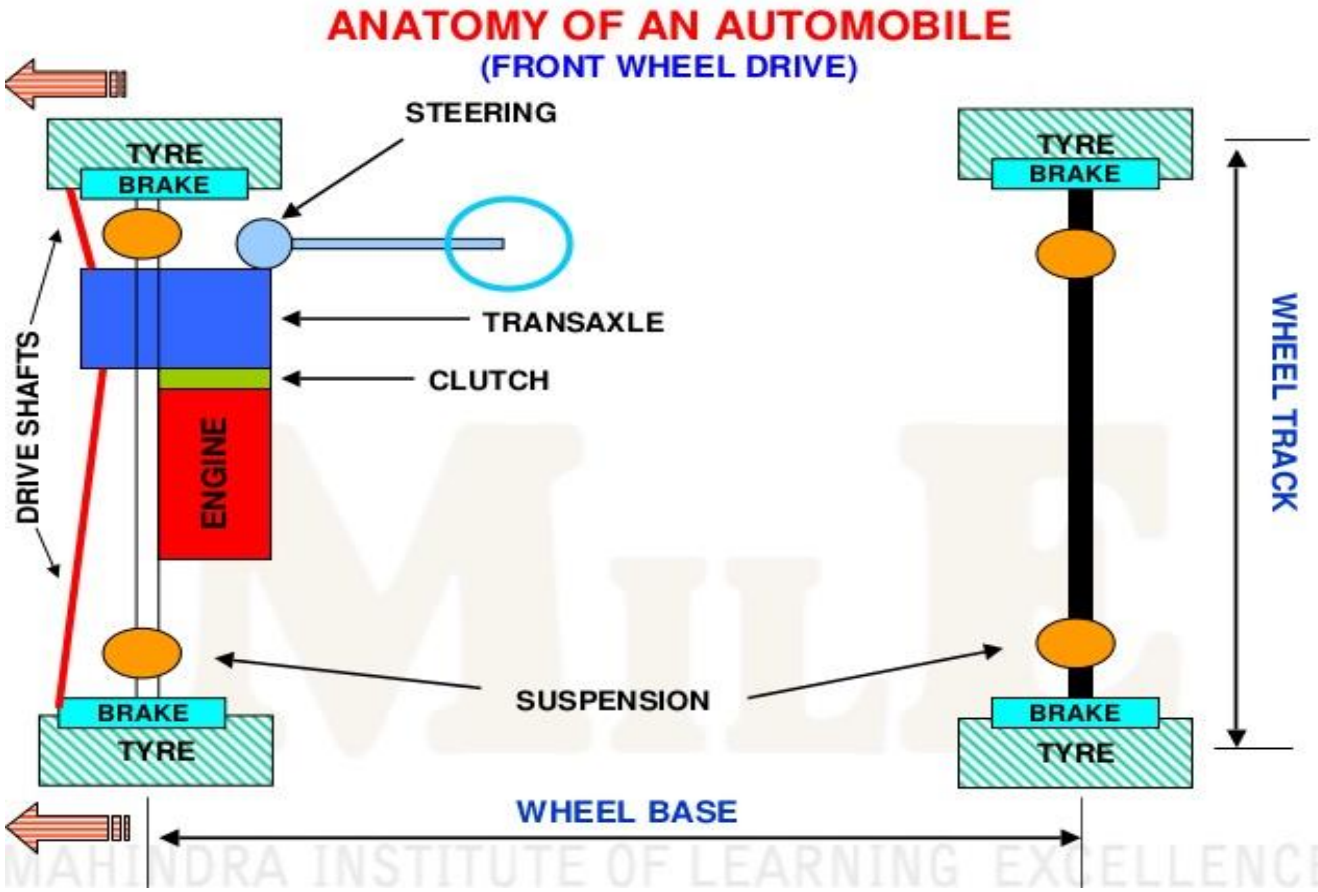

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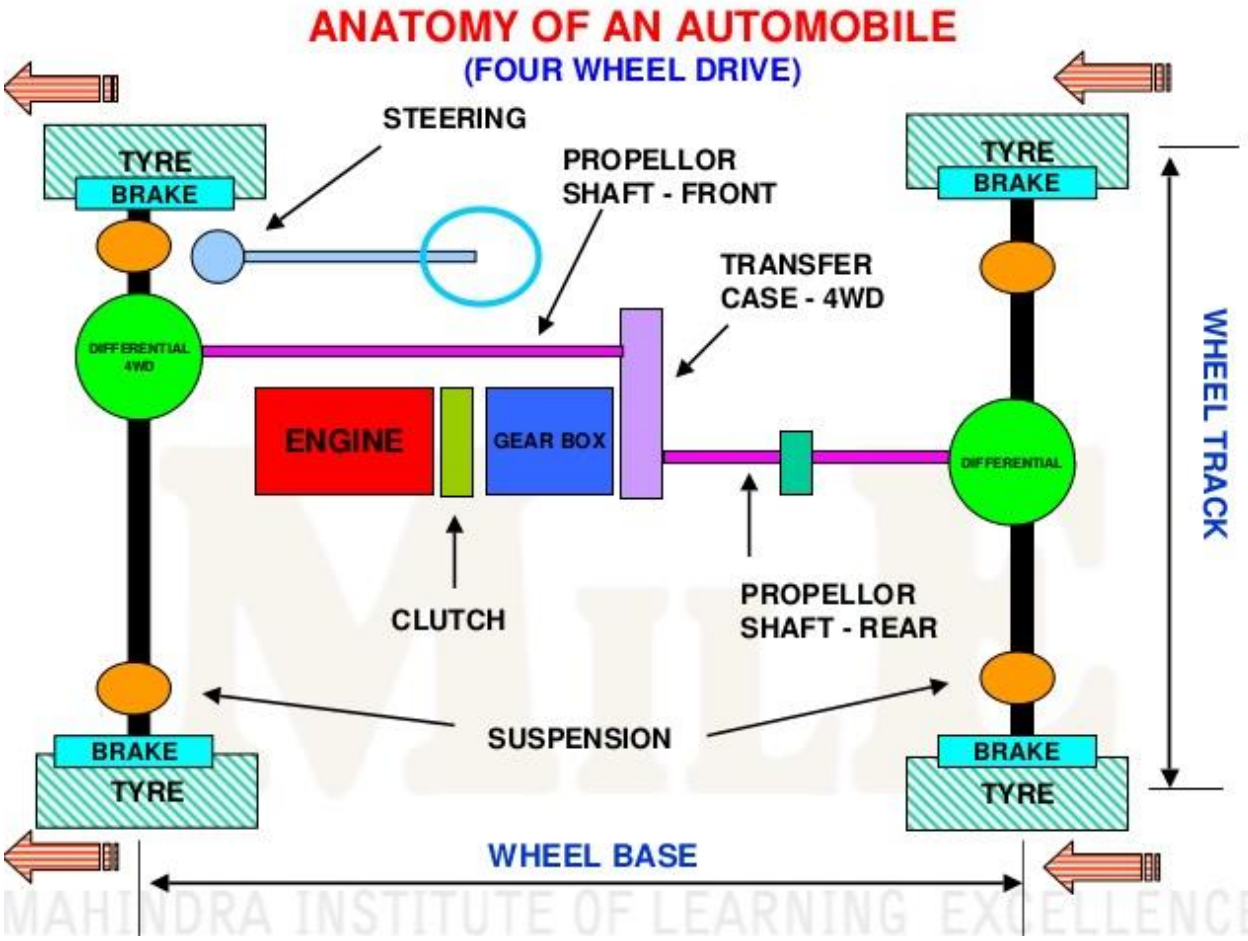

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Advantages of Rear wheel drive (RWD)

- Weight distribution is even
- During heavy acceleration, it improves traction
- No torque steer- this means an **unequal amount of stress** is put upon the drive shafts by the engine torque and that's what causes the car to pull to one side
- Better handling and braking
- Drive train components on a RWD vehicle are modular and do not involve packing as many parts in to a small space as in FWD

➢ Thus, requiring less disassembly

Disadvantages of RWD

- Under heavy acceleration, over-steer may occur
  - have a tendency to turn more sharply than intended
- On a snow, ice and sand RWD loses its traction
- Have less front leg room
  - Often no seat for a centre rear passenger
- Increased weight
- High initial purchase price
- Long propeller shaft

- ***Note: Corvette and Camaro*** *(sports cars) are RWD and are more exciting to drive*

Advantages Front Wheel Drive

- Vehicle may be less expensive for consumers
- Better fuel mileage
- Get better traction in snow and rain

Disadvantages of Front Wheel Drive

- **Handling suffers**
  - handling the vehicle around corners and curves isn't as strong especially **at faster speeds**

Note: On winding roads, you'll likely notice a difference between the two

- Lack of weight shifting limit the acceleration
  - Weight shifts back during acceleration giving more traction to rear wheel
    - Reason for all racing cars are RWD

Advantages of Four Wheel Drive

- Traction is nearly doubled
- It provides the versatility and power to take on any terrain or weather condition

Disadvantages of Four Wheel Drive

- Require more machinery & complex transmission components, so **cost is high**
- Rotational inertia & power transmission is high so reduction in performance in ideal dry condition
- **Hand brakes cannot be used** as drive train couples the front & rear axle together

All-Wheel Drive (AWD) vs. Four-Wheel Drive (4WD)

- There is no difference except that AWD has become an accepted description for a car that **drives all of the wheels, all of the time**
- When 4WD vehicles are driven on normal road surfaces, 4x4 must be deselected and the **vehicle driven in two wheel drive**
- 4WD is generally accepted as a car or more typically a **larger SUV**

➢ Example: All-Wheel Drive car- **Subaru Foreste, Honda CR-V**

All-Wheel Drive (AWD) vs. Four-Wheel Drive (4WD)---

Animation

https://www.youtube.com/watch?v=rHMDtEPeuQM

4. **The Auxiliaries**

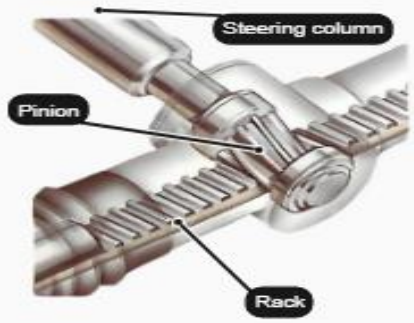
- It refers to electrical equipments
  - **Supply system:** A car has two sources of electricity
    - Battery & alternator in the charging system
  - **Starting motor:** Requires electricity to crank the engine
  - **Ignition system:** Requires electricity to deliver spark to the cylinder
  - **Ancillary devices:** Lights, horns, radio & air-conditioner

5. **The Controls**

- 5.1 **Steering system**
  - **Manual steering:** uses a **rack** and **pinion** to turn the rotational movement of the steering wheel into the back-and-forth movement
  - **Power Steering**: uses an **engine-mounted pump** to pressurize a two-way ram
  - There are three main power steering components-
    - power steering pump
    - power steering fluid reservoir
    - steering gear box

5.1.1 Manual Steering System

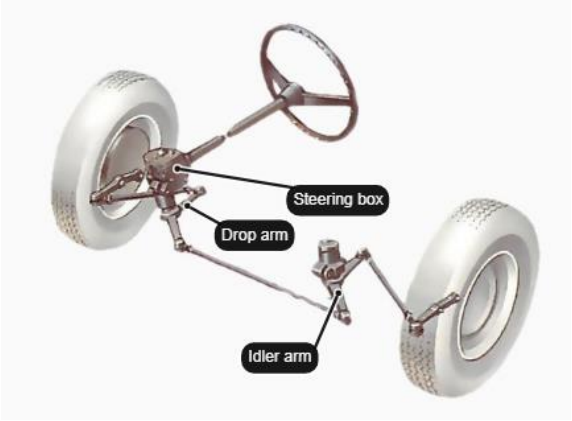
- There are two steering systems in common use - the **rack and pinion** and the **steering box**
  - **Rack and pinion**
    - A universal joint in the steering column allows it to connect with the rack without angling

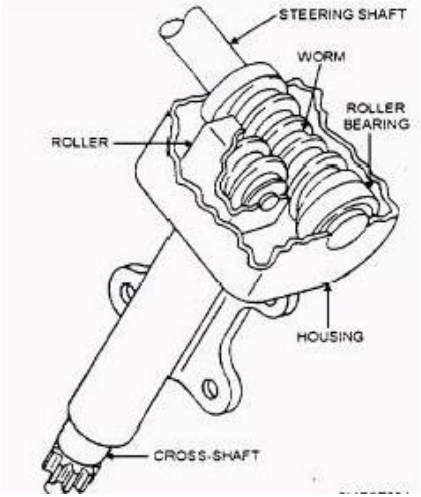


Rack-and-pinion gear
The pinion is closely meshed with the rack, so that there is no backlash in the gears. This gives very precise steering.

5.1.2 Steering Box System

- At the base of the steering column there is a worm gear inside a box
- The steering-box system has many moving parts, so is less precise than the rack system





Animation of Manual Steering System

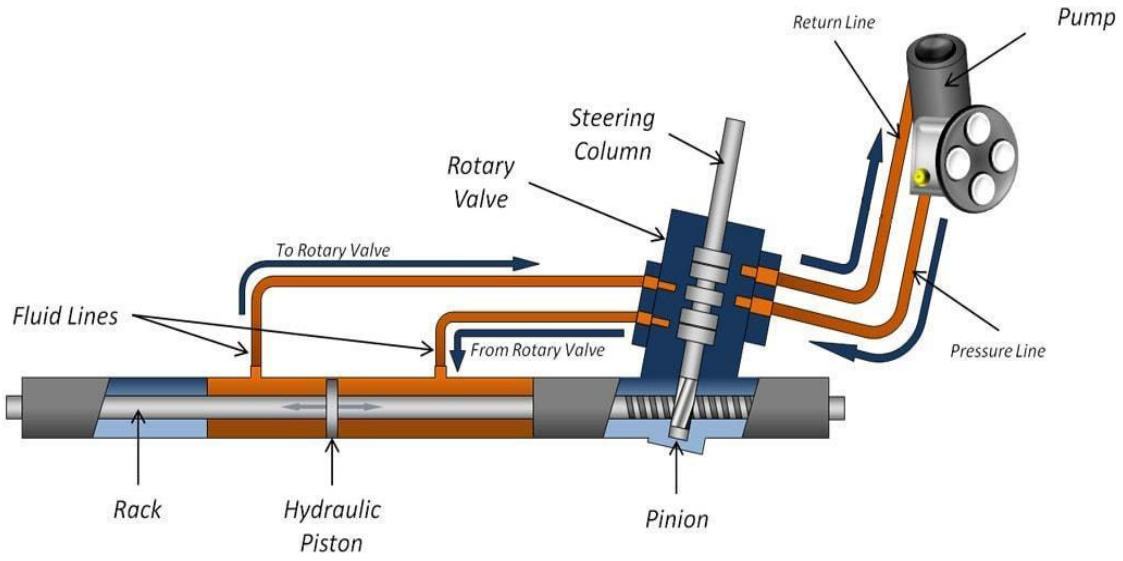
5.2 Power Steering System

- The engine drives a pump that supplies oil under high pressure to the rack or the steering box
- Valves in the steering rack or box open whenever the driver turns the wheel, allowing oil into the cylinder
- The oil works a piston that helps to push the steering in the appropriate direction
- As soon as the driver stops turning the wheel, the valve shuts and the pushing action of the piston stops

- **The power only assists the steering** - the steering wheel is still linked to the road wheels in the usual way.
- So if the power fails, the driver can still steer but the steering becomes much heavier.

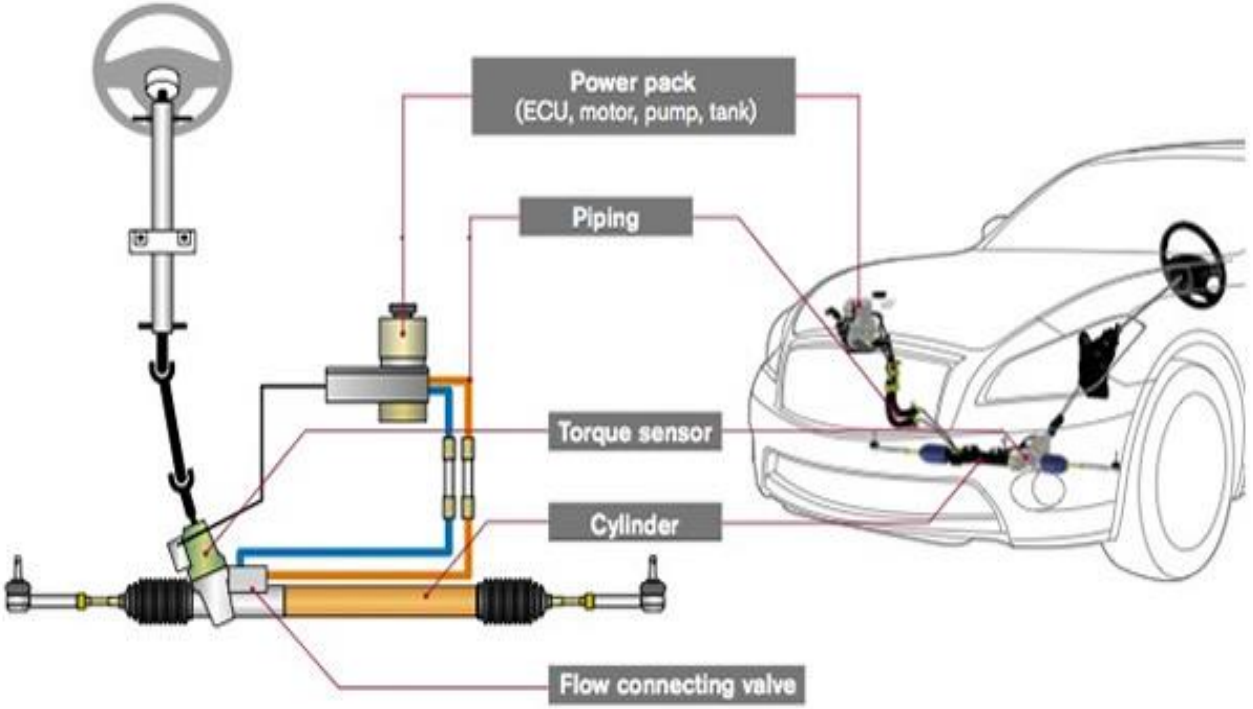
5.2.1 Types of Power Steering

- **Hydraulic power steering**
  - Use hydraulic fluid

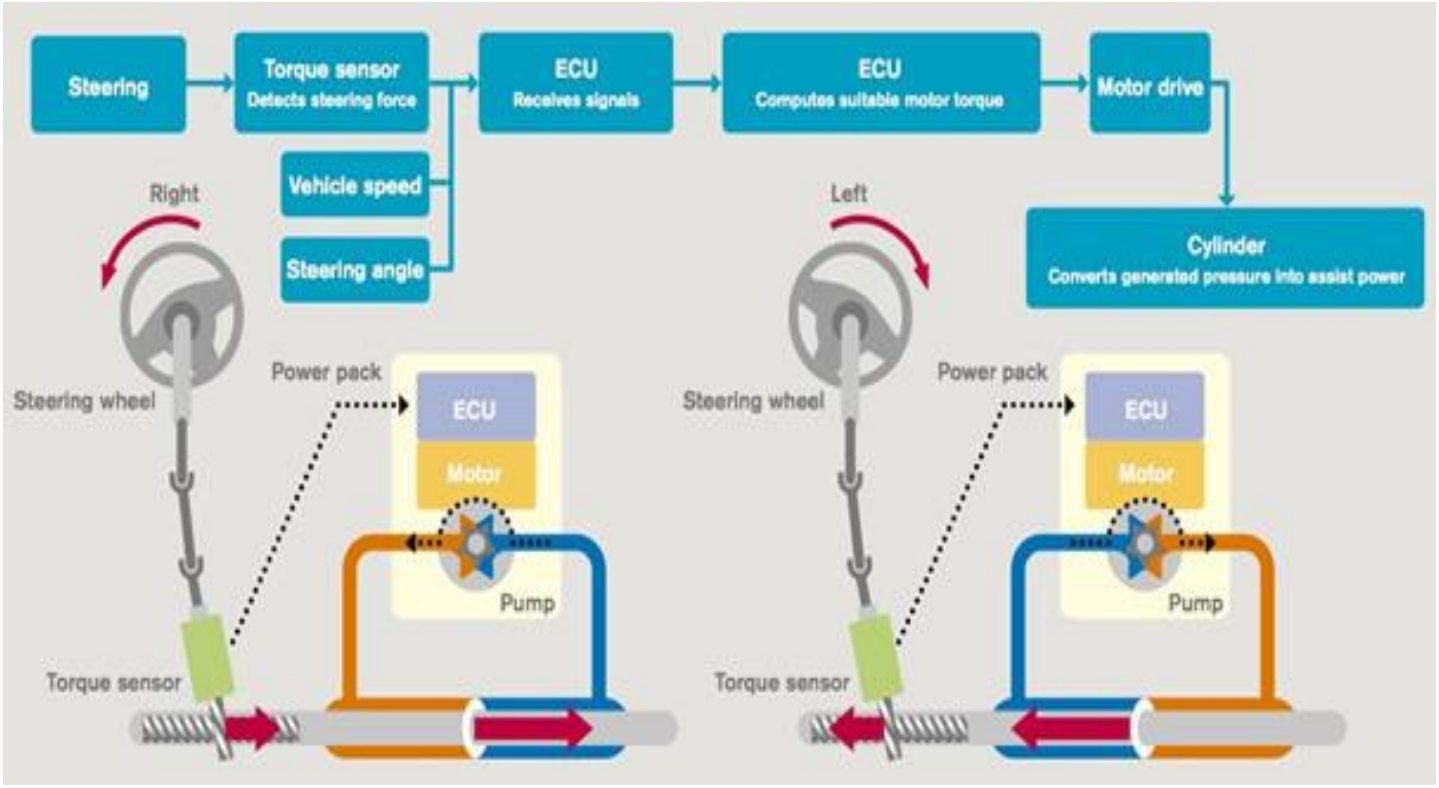


- **Electric power hydraulic steering (EPHS)**
  - Drive belts and pulleys that drive a power steering pump, are replaced by a brushless motor
  - It is driven by an electric motor and thus also reduces the amount of power taken from engine

5.2.2 Electric power hydraulic steering (EPHS)



Electric power hydraulic steering (EPHS)-Overview



5.2.3 Fully electric power steering(EPS)

- In these systems, the steering movement is assisted by an electric motor
- The electric motor is either attached to the steering rack or to the steering column
- The very important component is the electronic control unit **(ECU)** that controls the steering dynamics

➢ EPS are often preferred for the **fuel economy and lower emission**

5.2.4 Next-Generation Electric Power Steering

- Ford, Audi, Mercedes-Benz, Honda and GM are introducing steering systems with variable ratios on some platforms
- Some automakers are also calling this adaptive steering

➢ **The ratio continually changes with vehicle speed, optimizing the steering response in all conditions**

5.3 **Braking System**

- Brakes are used to slow down or stop the vehicle
- Hydraulic brakes are generally used in automobiles, where brakes are applied by pressure on a fluid
- Mechanical brakes are also used in some vehicles. These brakes are operated by means of leavers, linkages, pedals, cams, etc.
- Hand brake or parking brake is known usually mechanical brake. These are used for parking the vehicles on sloppy surfaces and also in case of emergency.
- **Types of brakes:**
  - Drum Brakes
  - Disc Brakes
  - Combination of two

6. **The Super Structure**

- A **vehicle** body **superstructure** includes a first side rail member, a second side rail member, a roof member, and a gusset.
- The roof side surface extends along a breadthways direction of the **vehicle** body and is connected to the roof member
- Main purpose is to provide accommodation for the driver & passenger with suitable protection against wind & weather
- The degree of comfort provided depends upon the type of car & its cost

APPLICATION OF I. C. ENGINE :

- Road vehicles * Aircraft * Locomotive * Construction Equipment Pumping set * several Industries
- **Small Two Stroke Petrol Engine :** Used when operation is simple and requirement of low cost of prime mover (scooters, pumping sets etc.)
- **Small Four Stroke Petrol Engine :** Used in automobiles, generators, pumping set.
- **Two Stroke Diesel Engine :** High power, generally used in ship propulsion.
- **Four Stroke Diesel Engine :** Mostly used engine, have diameter 50 to 600 mm, speed ranges from 100 to 4400 rpm, power developed is 1 to 1000 kW. Used in pumping sets, construction machinery, drilling rigs, tractors, diesel electric locomotive, mobile & stationary electric generation plants

That's all for this lecture. . .

~THANK YOU~

AUTOMOBILE ENGINEERING

UNIT-1

Lecture – 03

POWER & TORQUE CHARACTERISTICS

Lecture-03

Contents

- Engine performance
- Various types of power analysis w.r.t. engine
- Dynamometer
- Engine power and torque curves

Engine Performance

- How its input varies over the entire range of its operation
- To see how effectively the conversion from fuel energy to engine power is carried out
- The efficiency & specific fuel consumption curves are also studied
  - The main variables considered are: **speed, load, mean effective pressure & air-fuel ratio**

Power

- Power is the rate at which work is done
  - It considers the length of working hours or days
- There are factors that is affecting the power such as mass, momentum, inertia, torque, work and energy
- There are also ways to measure those factors

Engine Power

- Most common unit power: **Horse Power (hp)**
  - Measure of the rate at which a horse can work
- **1 hp = 746 Watts = 0.746kW**
- **1 kW = 1.34 hp**
- Horse power can be calculated as:

  hp = (torque * rpm)/ 5252
  - This formula is used when measuring engine performance with a chassis or engine dynamometer

Various types of Powers Available w.r.t. Engine

- Indicated horse-power (ihp)
- Brake horse-power (bhp)
- Frictional horse-power (fhp)
- Taxable horse-power (Thp)
- Drawbar horse-power (Dhp)

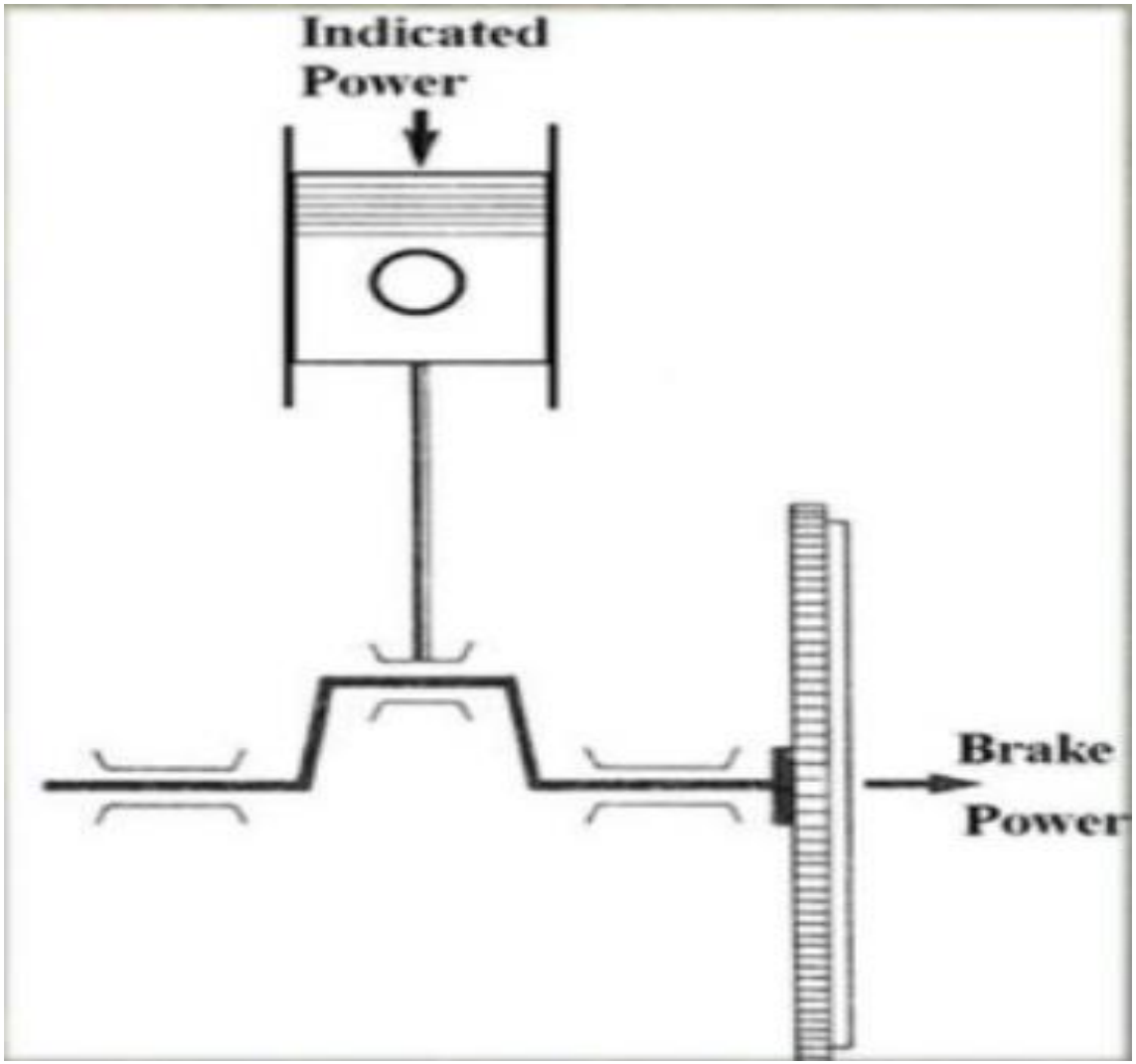
1. **Indicated Horsepower**

- Power developed inside the combustion chambers during combustion
- Power generated in the cylinder & received by piston
- It is determined by measuring the pressure in the engine cylinder
- It is essentially a measure of the total potential horse power the engine is capable of developing

$$ihp = \frac{P_m L A n K}{1000}\ kW$$

- P_m = indicated mean effective pressure, kPa
- L = length of stroke, m
- A = area of cylinder cross section, m^2
- n = no. of working strokes per second, rps
- K = no. of engine cylinders

Some of the power developed is lost in overcoming the internal friction in the engine


Indicated
Power
Brake
Power

2. **Brake Horse-Power** (or belt horse power)

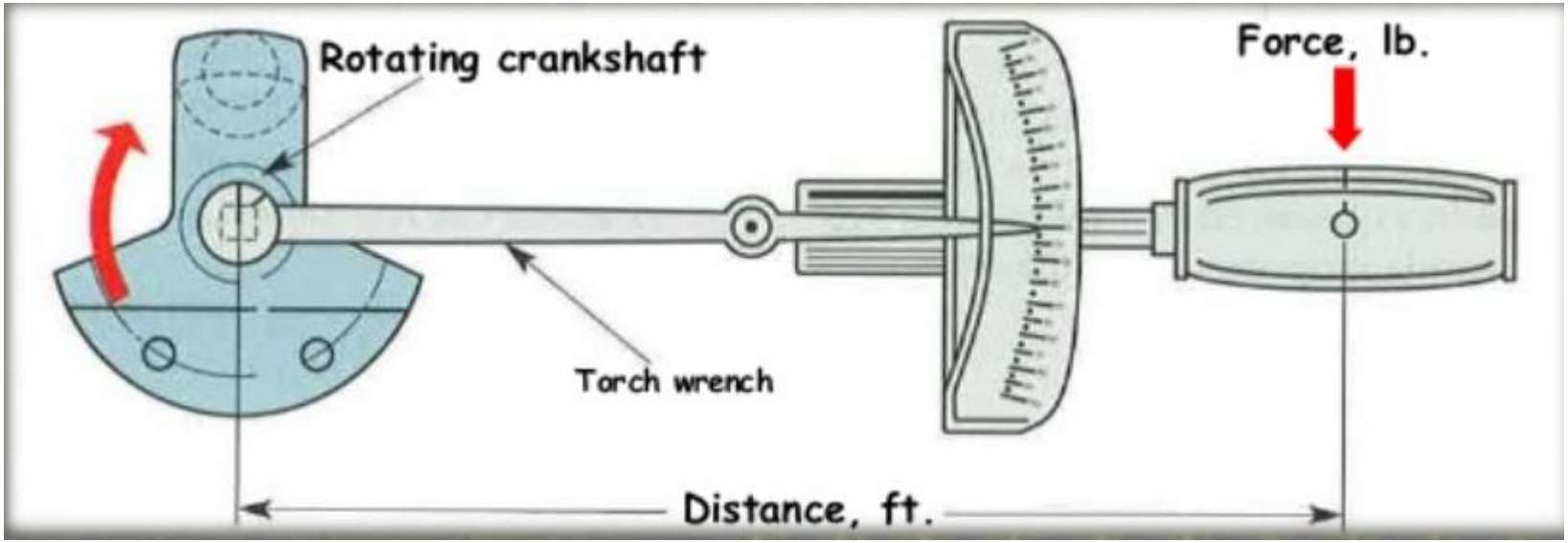
- Actual usable horsepower available at the engine crank-shaft to do work
- It does not remains constant with changes in engine speed
- The available power of an engine, assessed by measuring the **“force needed to brake it”**
- The amount of power tells how fast work can be done
- Brake horsepower is measured using a Dynamometer

- When **N** is in **rpm** & **T** is in **kgf-m**

$$bhp = \frac{2\Pi NT}{4500}$$

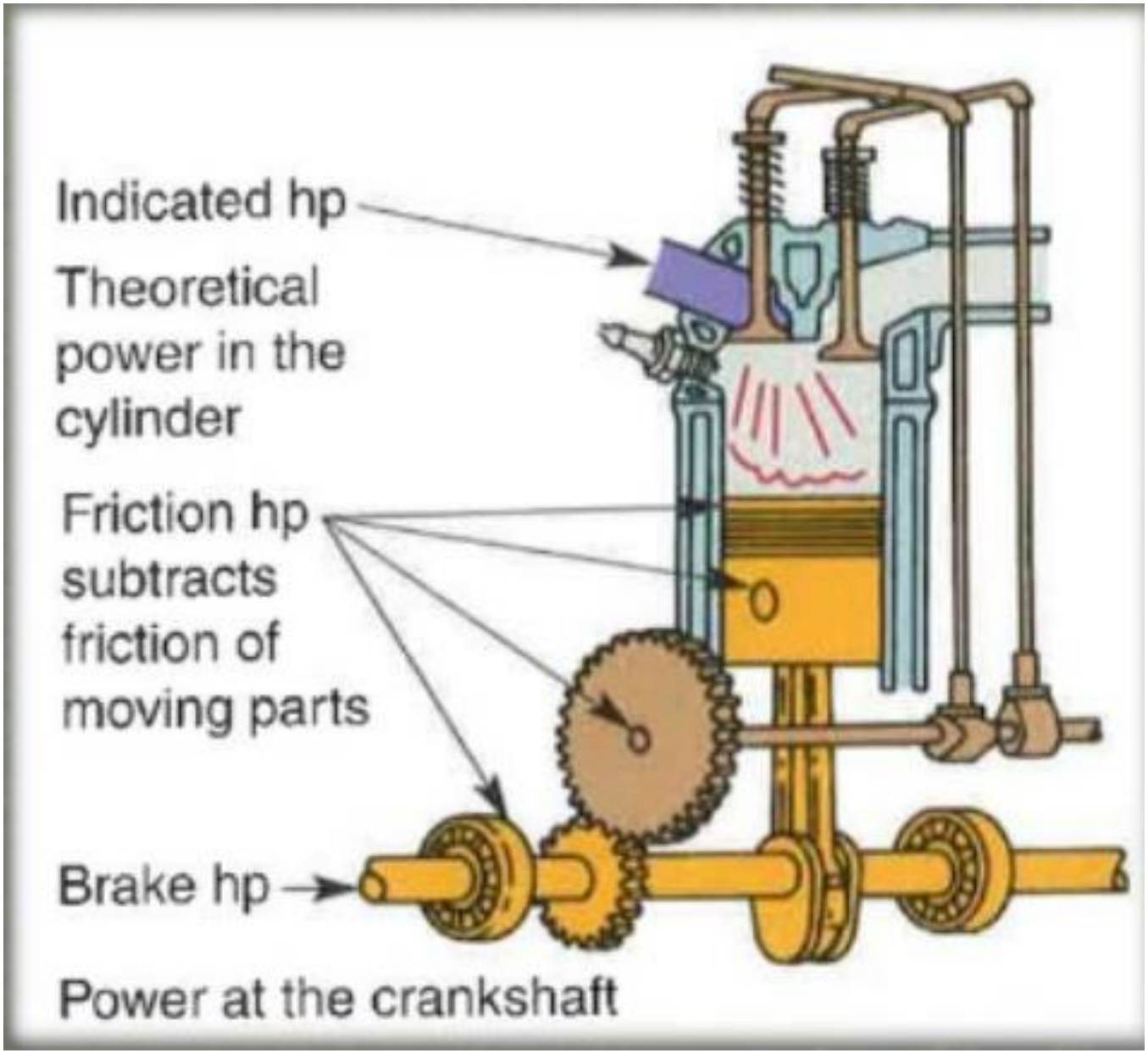
- When **N** is in **rps** & **T** is in **Nm**

$$bhp = \frac{2\Pi NT}{1000}\ kW$$



3. **Frictional Horsepower**

- Power required to overcome the friction of the internal moving parts
- Major cause of friction loss is **piston-ring** friction (account almost 75% of all friction losses)
- Fhp = ihp - bhp


Indicated hp
Theoretical power in the cylinder
Friction hp subtracts friction of moving parts
Brake hp
Power at the crankshaft

4. Taxable Horsepower (or SAE Horsepower)

- It was an early system by which taxation rates for automobiles were reckoned in some European countries
- It helps in categorizing engines on a uniform basis of their displacements
- Although the formula does not give an accurate indication of the actual horsepower developed

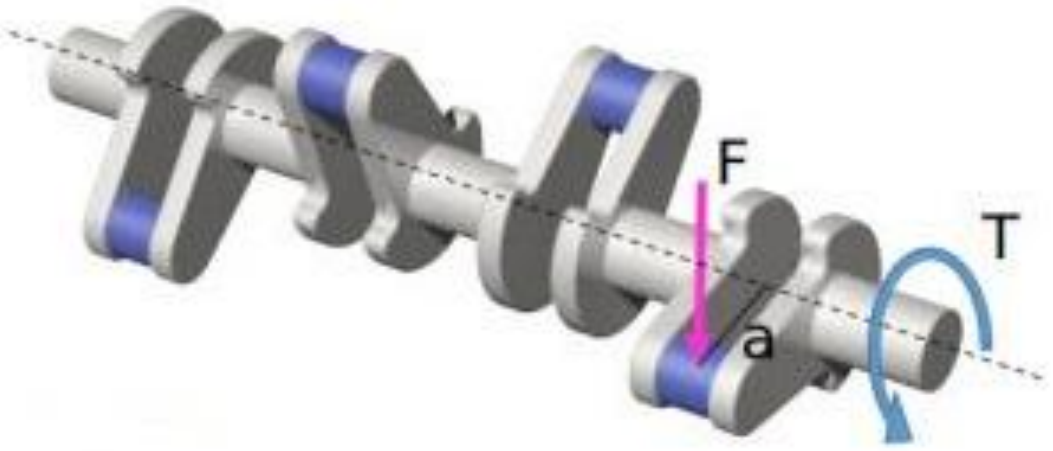
$$thp = \frac{(bore\ of\ cylinder\ in\ inch)^2 * No.of\ Cylinders}{2.5}$$

5. **Drawbar Horsepower**

- A large proportion of horsepower goes waste in overcoming various resistances such as road, gradients & wind resistance
- Rest of the power is utilized to propel the vehicle called **Drawbar-horsepower**
- dhp = bhp - resistances

Engine Torque

- Engine torque results from combustion pressures pushing down on the pistons
- The torque at the crankshaft is produced by the force applied on the conrod journal through the connecting rod



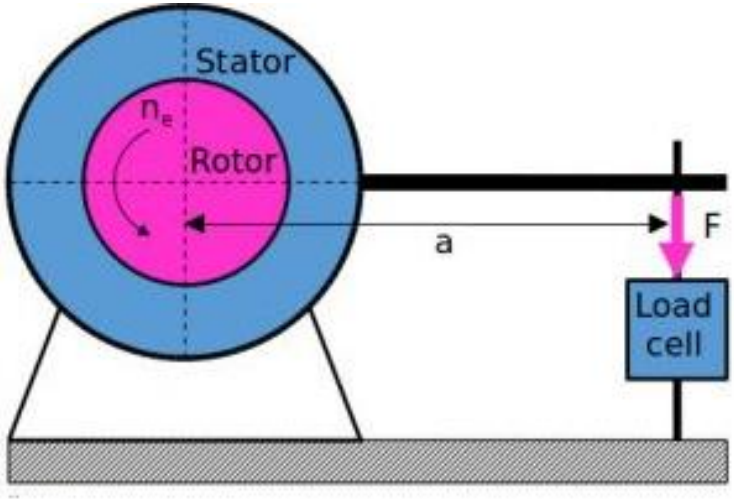
- The magnitude of the force F depends on the combustion pressure within the cylinder.
- The higher the pressure in the cylinder, the higher the force on the crankshaft, the higher the output torque
- The dynamometer measures the engine's torque by recording the force it exerts against the resistance of brake

- The length of the lever arm has impact on the overall **engine balance**
- Increasing it too much can lead to engine imbalance, which results in higher forces in the crankshaft journals

Engine dynamometer

- Engine speed is measured using a sensor on the crankshaft (flywheel)
  - Technically, this is possible but not applied in the automotive industry
  - Because of the operating conditions of the crankshaft (temperatures, vibrations)

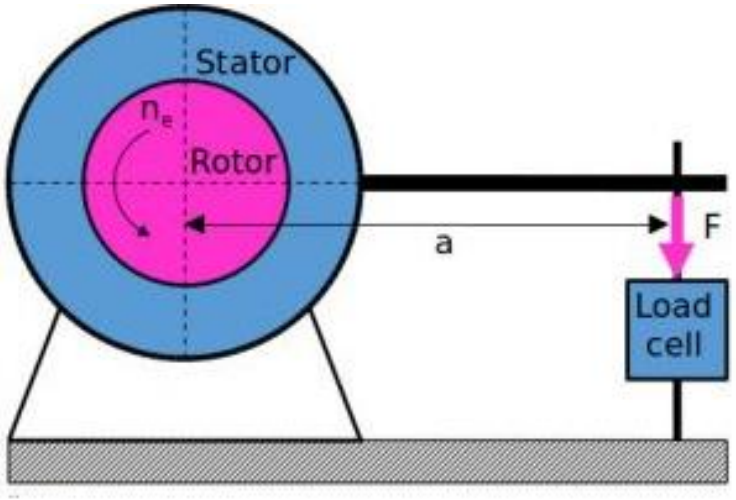
- Therefore, engine torque is measured on the full range of speed and load, using a **dynamometer** (test bench), and mapped (stored) into the engine control unit.



- The dynamometer is basically a **brake** (mechanical, hydraulic or **electrical**) which absorbs the power produced by the engine

- Electric dynamometer is actually an electric machine that can be operated as a generator or motor
- By varying the generator's load torque, the engine can be put in any operating point (speed and torque)
- Also, with the engine at **fuel cut** (no fuel injection), the generator can be run as an electric motor to spin the engine
- This way engine friction and pumping torque losses can be measured

- The rotor is connected to the crankshaft
- The link between rotor and stator is electromagnetic
- The stator is fixed through a lever arm to a **load cell**
- To balance the rotor, the stator will push against the load cell
- The torque *T* is calculated by multiplying the force *F* measured in the load cell with the length of the lever arm (a)



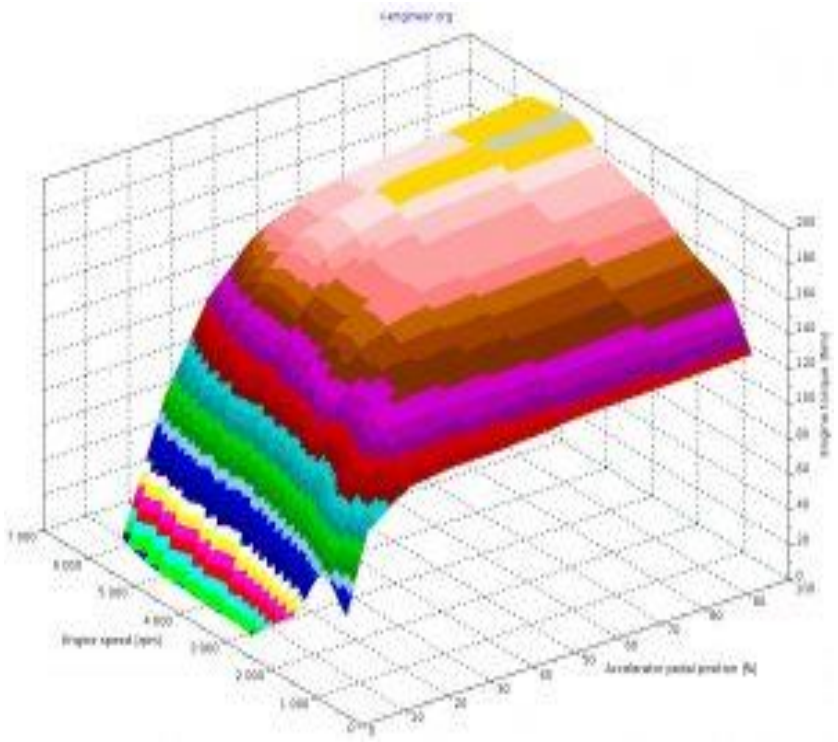
- What comes out from a dynamometer engine test are **torque maps** (surfaces) which give the value of the engine torque at a specific engine speed and load (stationary operating points)
- The load of the engine is equivalent to **the position of the accelerator pedal**

Other mechanism of Dynamometer

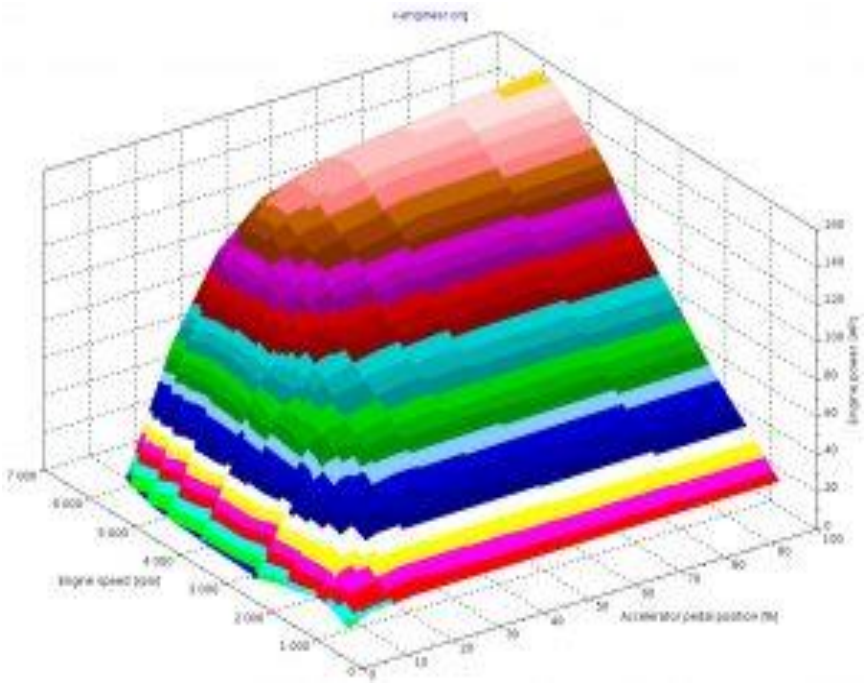
- The electronic control module (ECM) of an ICE has the **torque map** stored in the memory
- It calculates (interpolates) the engine torque function of the current engine speed and load
- In the ECM, the load is expressed as **intake manifold pressure** for gasoline (**spark ignition, SI**) engines and **injection time or fuel mass** for diesel (**compression ignition, CI**) engines

Plotting the torque and power data, function of engine speed and load, gives the following surfaces:

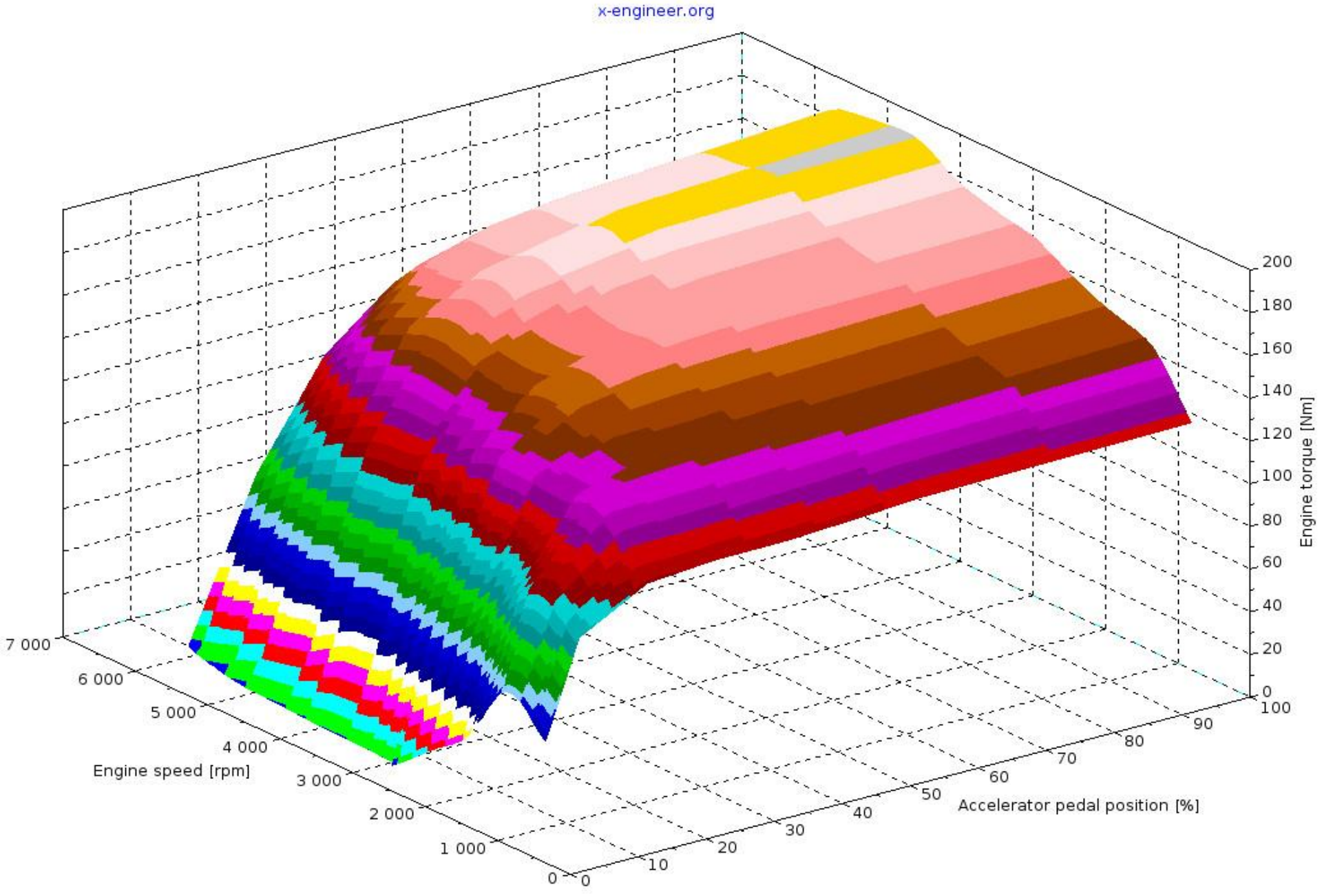
- For SI Engine



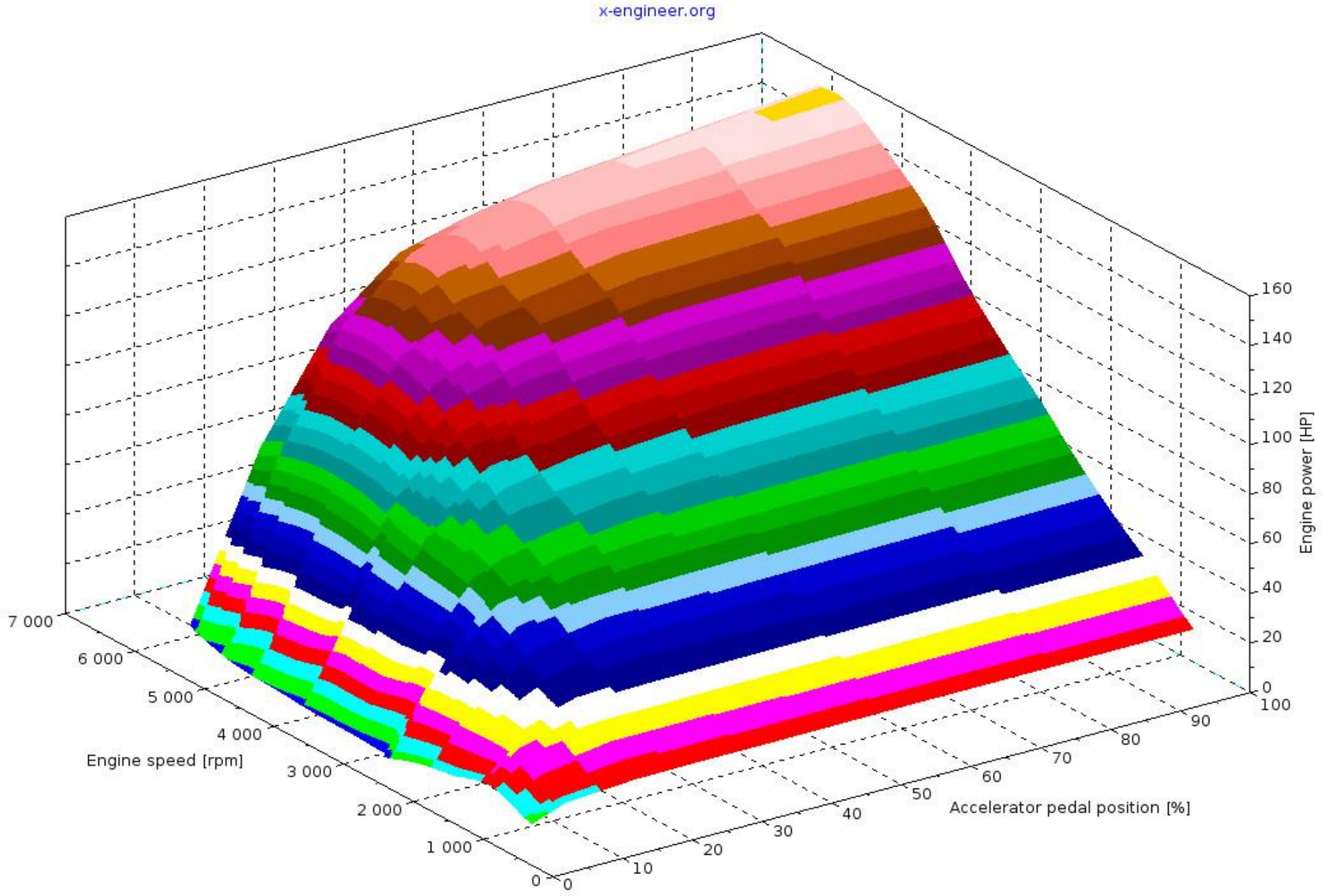
For CI Engine



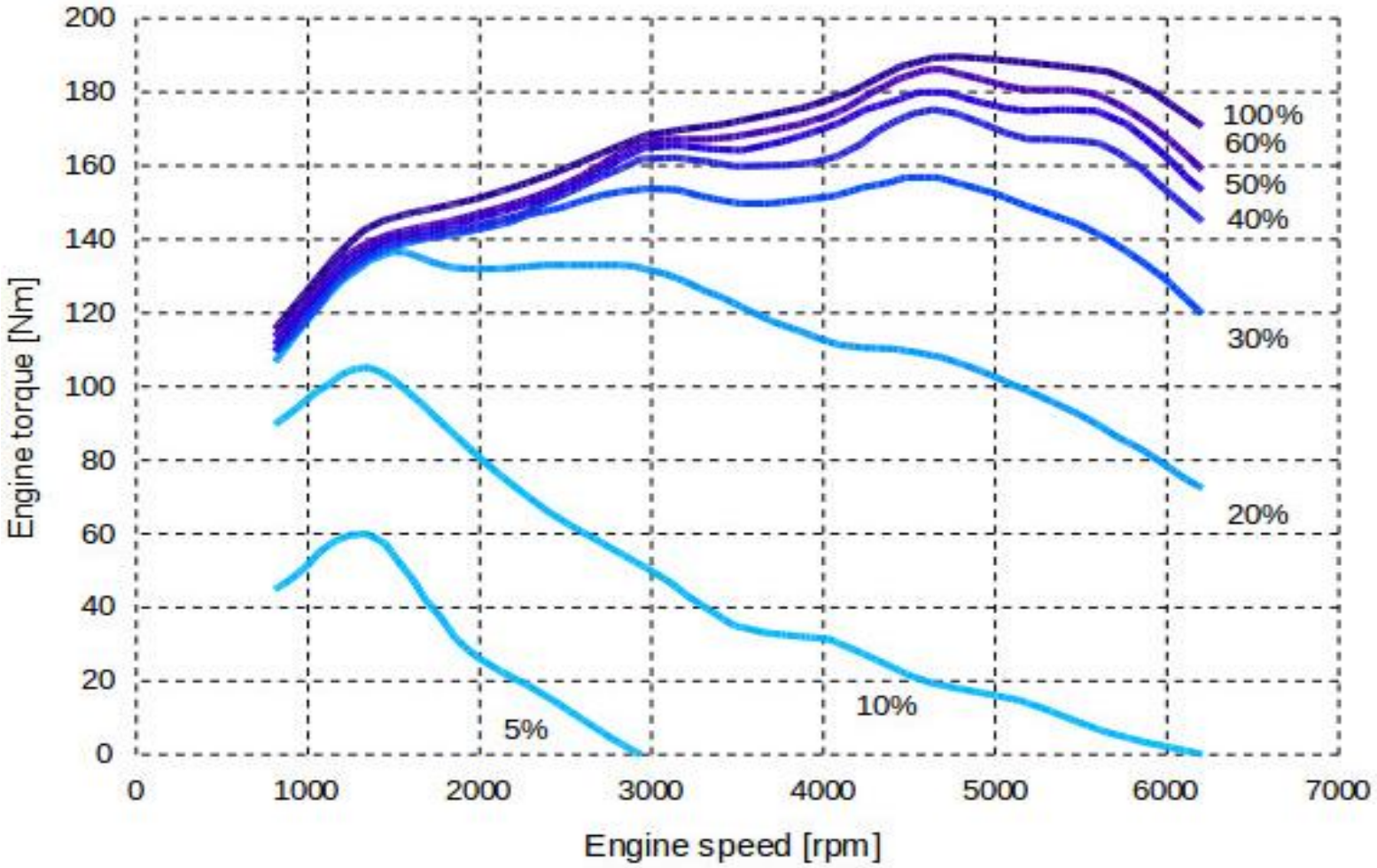
For SI Engine



For CI Engine



For a better interpretation of the torque and power maps, a 2-D torque line can be plotted for a fixed value of the accelerator pedal position.



- There is a linear relationship between the engine torque (T) and its brake mean effective pressure (bmep)

$$bmep = \frac{2\Pi N}{LAn} * T = CT$$

$$where\ C = \frac{2\Pi N}{LAn} = constant\ for\ particular\ engine$$

$$where\ C = \frac{2\Pi N}{LAn} = constant\ for\ particular\ engine$$

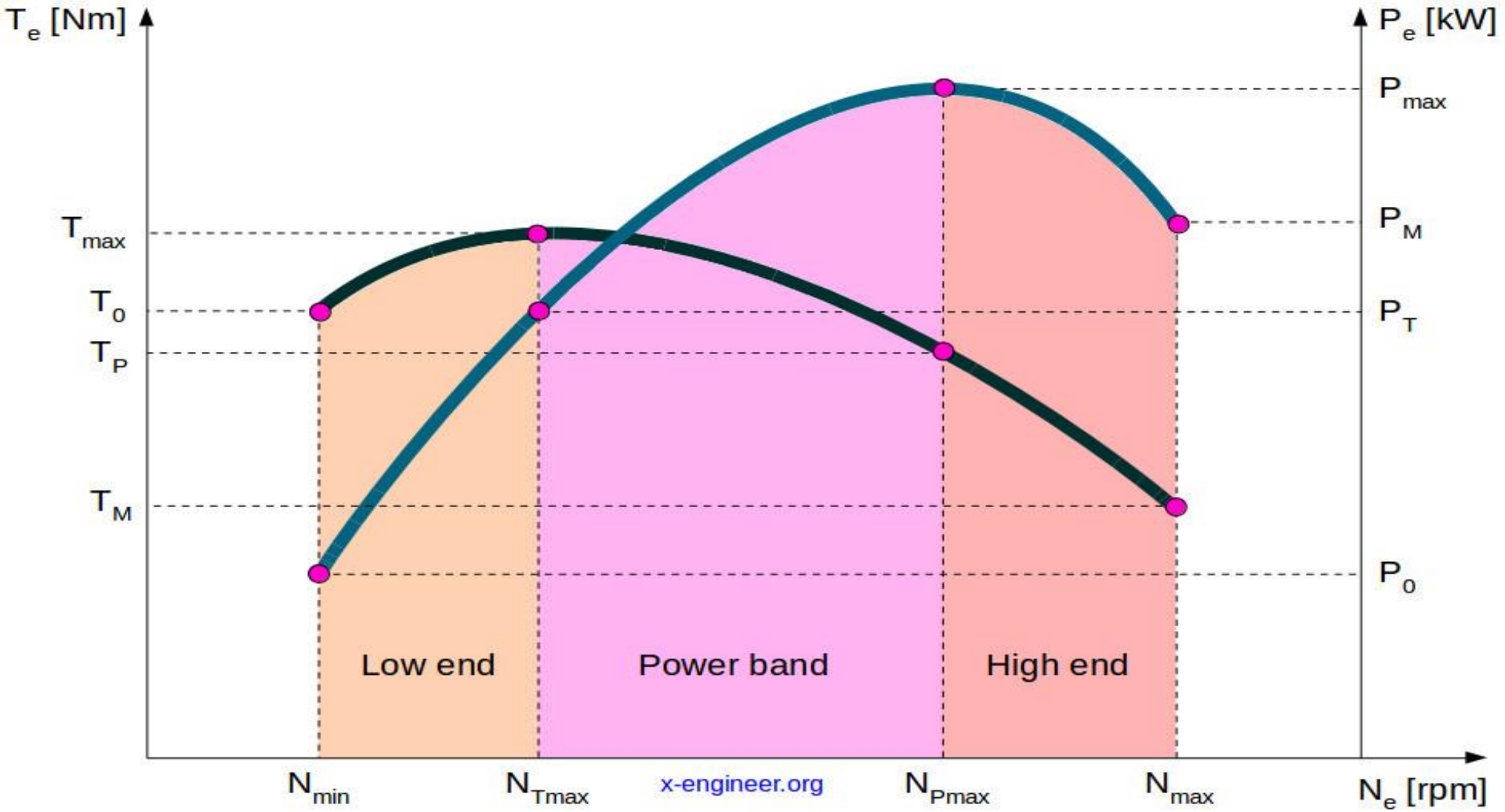
$$bhp = \frac{2\Pi NT}{60} = \frac{bmep * LAn}{60}$$

- Thus, the bmep is directly proportional to the engine torque and is independent of the engine speed

Engine Power & Torque Curves

- Torque and power of an IC engine depend on both engine speed and load
- Usually, engine manufacturers are publishing the torque and curve characteristics (curves) at **full load** (100% accelerator pedal position)

- Full load torque and power curves highlight the **maximum torque and power distribution** through the **whole range of engine speed**



- The shape of the above torque and power curves are **not from** a real engine, the scope being to explain the main parameters
- The horsepower does not start at **zero** because an **engine will not run** at zero speed
- Horsepower increases as the engine speed and load increases
- Engine reaches its max horsepower of P_{max} at N_{Pmax} rpm
  - An engine can run faster than this but, horsepower begins to decrease afterwards

- Engine speed N_e *[rpm]* is characterized by four main points:

  N_{min} – is the minimum stable engine speed at full load
  N_{Tmax} – is the engine speed at maximum engine torque
  N_{Pmax} – is the engine speed at maximum engine power; also called **rated engine speed**
  N_{max} – is the maximum stable engine speed

- At minimum speed, the engine should run smoothly, without oscillations or stalling

- The **full load engine torque** curve T_e is characterized by four points:
  - T_0 – engine torque at minimum engine speed
    T_{max} – maximum engine torque (peak torque or **rated torque**)
    T_P – engine torque at maximum engine power
    T_M – engine torque at maximum engine speed
- Depending on the type of intake air (atmospheric or turbocharged) the peak torque can be either a point or a line
- For turbocharged or supercharged engines, maximum torque can be kept constant between two engine speed values

- The **full load engine power** curve P_e is characterized by four points:
  - P_0 – engine power at minimum engine speed
    P_{max} – maximum engine power (peak power or **rated power**)
    P_T – engine power at maximum engine torque
    P_M – engine power at maximum engine speed

Low End Torque Zone

- The higher the torque in this area, the better the launch/acceleration capabilities of the vehicle
- When the engine is operating in this area, at full load, if the road resistance increase, the engine speed will decrease, which will result in a drop of engine torque and an **engine stall**
- For this reason, this area is also called **unstable torque zone**

Power Band Zone

- During vehicle acceleration, for best performance, the gearshift (up) should be performed at maximum engine power
- Depending on the gear ratios of the gearbox, after the gearshift, the selected gear will drop the engine speed at maximum torque, which will give optimum acceleration
- Shifting the gears at maximum engine power will keep the engine speed within the power band

- When the engine speed is kept between N_{Tmax} and N_{max}, if the vehicle road resistance increases, the engine speed will drop and the output **torque will increase**, thus compensating for the road load increase
- For this reason, this area is called the **stable torque region**.

High End Torque Zone

- Higher torque results in higher output power, which translates in higher maximum vehicle speed and better acceleration at high speed

That's all for this lecture...

~THANK YOU~

AUTOMOBILE ENGINEERING

UNIT-1

Lecture – 04

Specific Fuel Consumption

- Specific fuel consumption is the amount of fuel consumed by a vehicle for each unit of power output
- The specific fuel consumption of an engine is the rate of fuel burnt to produce a unit of thrust
- Depending upon the amount of power used (*viz.* indicated or brake), the consumption is termed as
  - Indicated Specific Fuel Consumption- can be defined as a generic function of relative spark timing, mixture air/**fuel** ratio and exhaust gas recirculation rate.

Brake-specific fuel consumption

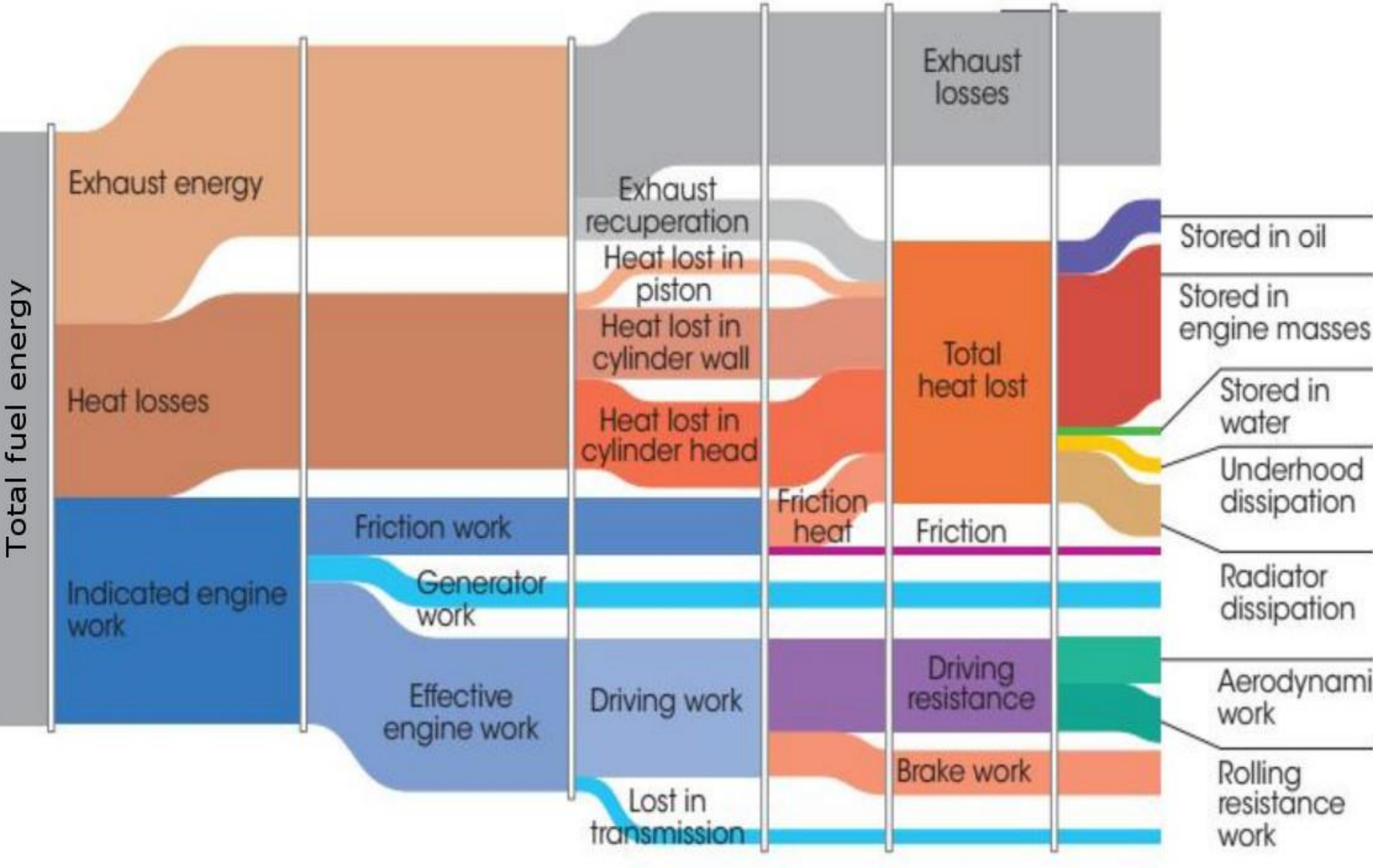
- It is a measure of the fuel efficiency of any prime mover that burns fuel and produces rotational, or shaft power
- It is typically used for comparing the efficiency of internal combustion engines with a shaft output
  - It is the rate of **fuel consumption** divided by the power produced.
  - To calculate the actual efficiency of an engine, the energy density of the fuel being used

- The lower the brake specific fuel consumption, the more efficient is the engine
- For **spark ignition** engine the BSFC is around **250 g/kWh** and for **compression ignition engine** around **200 g/kWh**

Engine efficiency function of BSFC

- Fossil fuel like gasoline and diesel are characterized by a very high energy density
- Due to the combustion process and principle of working of the internal combustion engine, only a fraction of the total fuel energy ends up as mechanical energy at the crankshaft

Overview of the energy losses in an ICE powered vehicle



Overview of the energy losses in an ICE powered vehicle

- After combustion, around 30% of the energy is lost through heat, in the engine components
- Another 30% of the energy is lost in the exhaust gases
- This gives around 40% as indicated energy from which we extract the friction and pumping loses
- The **overall efficiency** of the engine ends up to be around between 25% – 40%

- The efficiency of an internal combustion engine can be calculated function of the brake specific fuel consumption and the lower heating value (LHV) of the fuel

$$\eta_f = \frac{1}{BSFC \cdot Q_{HV}}$$

  - η_f – fuel conversion efficiency (engine efficiency)
  - *BSFC [g/kWh]* – brake specific fuel consumption
  - Q_{HV} *[kWh/g]* – fuel lower heating value

Summary of BSFC

- If the load is increased whilst the engine speed remains constant, the fuel efficiency decreases due to:
  - The spark being retarded as the engine becomes knock limited
- If the engine speed is increased whilst the load remains constant, the fuel efficiency is dominated by the:
  - Increasing engine friction

Summary Contd…

- If the load is decreased whilst the engine speed remains constant, the fuel efficiency is dominated by the:
  - Increasing pumping work
- If the engine speed is decreased whilst the load remains constant, the fuel efficiency is dominated by the:
  - Increasing heat losses

Volumetric Efficiency

- The ratio of the volume of the air or gaseous mixture inducted in a given time into the cylinder at atmospheric condition surrounding the engine, to the total piston displacement of all the induction strokes during same time
- For a supercharged engine, the volumetric efficiency is based on the temperature & pressure conditions in the intake manifold

- With the increase in engine speed, charge velocity is increased, which decreases the charge inducted **as a higher pressure drop is then required**
- However, the **ramming effect** caused by the inertia of the charge, increases the charge inducted
- **As the two effects vary differently with speed, the volume of the charge inducted in a given time increases, attains a maximum & then decreases**
  - And so is the volumetric efficiency derived

- For un-supercharged engines, the maximum volumetric efficiency is about 80% at specific speed
- Volumetric efficiency depends upon the engine speed and load as well as layout of the inlet and the exhaust systems, sizes of the ports & valve timing

Resistance Forces on A Vehicle

A vehicle faces various types of resistances while attempting to move from a stall condition or while accelerating

- To sustain motion, this resistance must be overcome by the powerplant of the engine
- Power produced < Resistance to motion
  - Vehicle will gradually slow down
- Vehicle slows down- if we go uphill or if wind blows from front or a poorly inflated tyre
- These are the resistances that force the vehicle to slow down under their effect.

Broadly, the resistances can be categorized into:

The major components of the resisting forces to motion are comprised of :

- Inertia (F_I) or Acceleration resistance
- Aerodynamic or Air resistance (F_a)
- Gradeability requirements (F_g)
- Rolling resistance (F_{rr})

$$F = F_a + F_I + F_{rr} + F_g$$

Note: Inertia (F_I)- This comes into the picture only when a vehicle accelerates or decelerates, while the other three always offer a resistance when the vehicle is moving at a constant speed

Air Resistance/Aerodynamic drag

- When a body travels with in a dense medium, the molecules of the medium collides with the moving object and thereby absorb some of the energy
- If the medium is denser, then the resistance is more
- Also, when the object moves at a faster speed, the resistance increases proportionately

- Mathematically

$$F_A = C_d \times A \times V^2$$

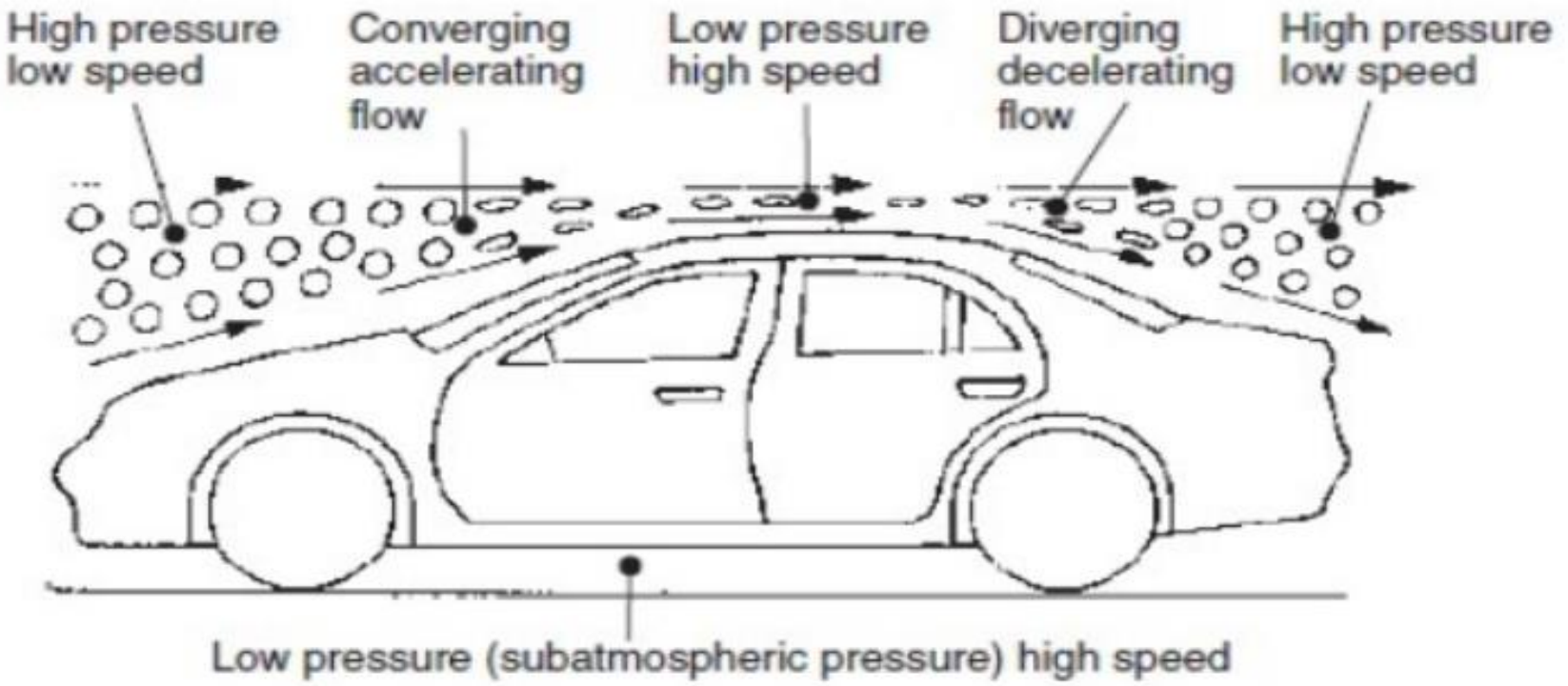
where

C_d = Co−efficient of drag

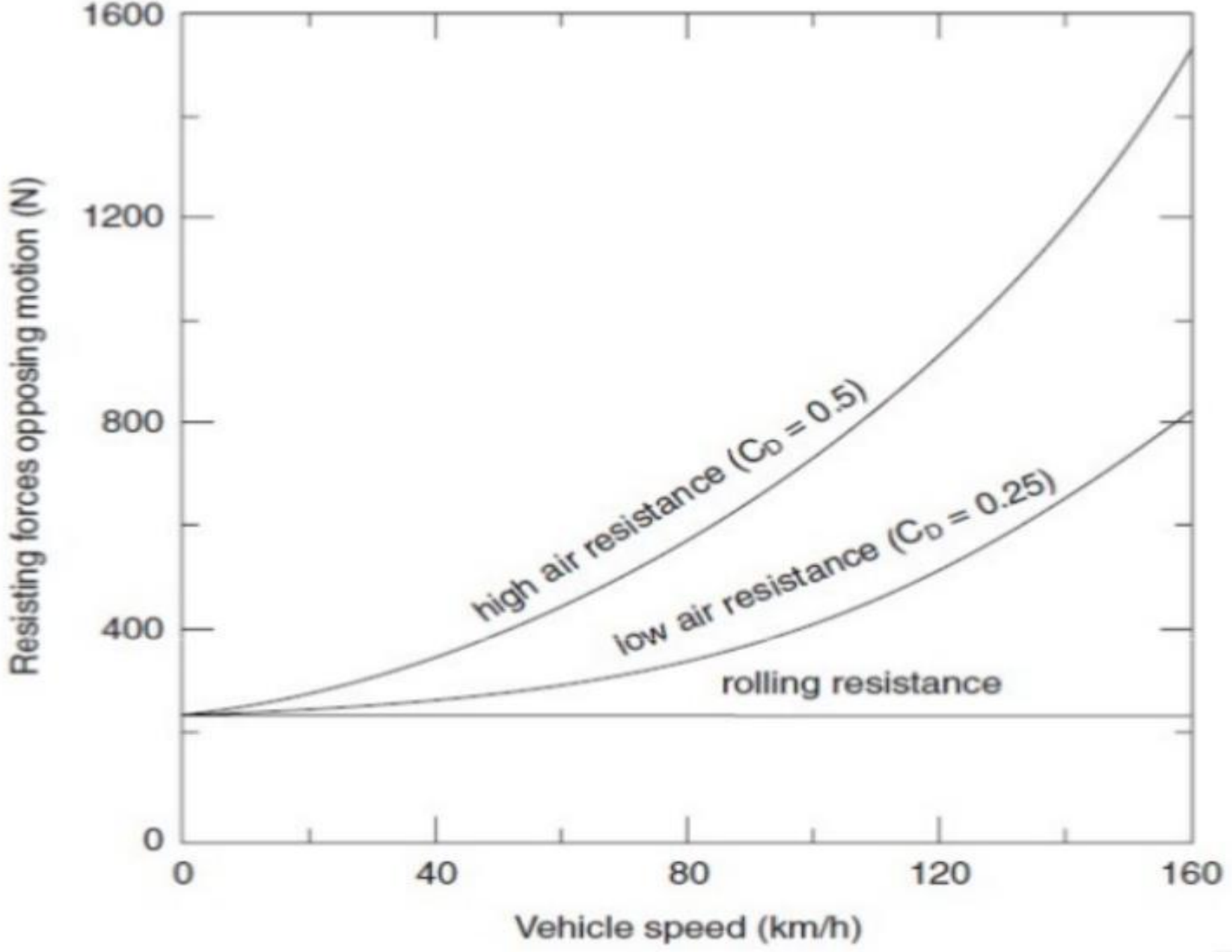
= 0.6

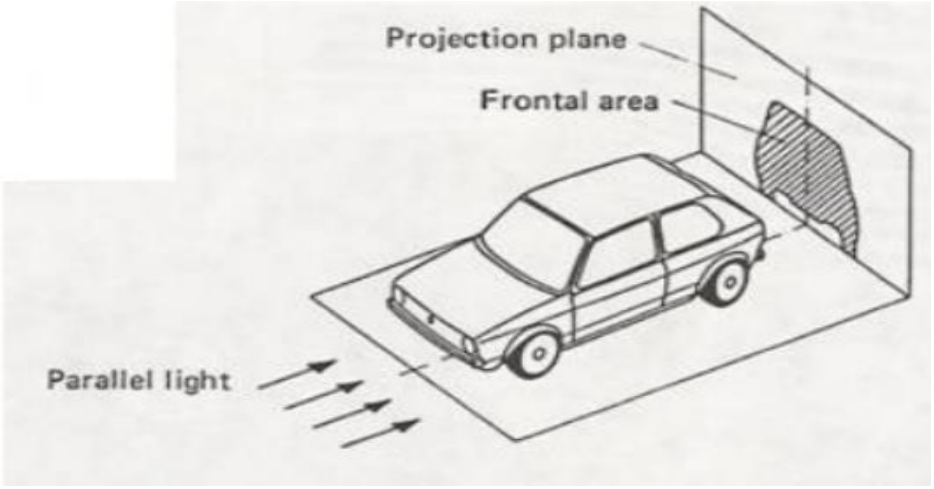
A = Frontal Area Of Vehicle

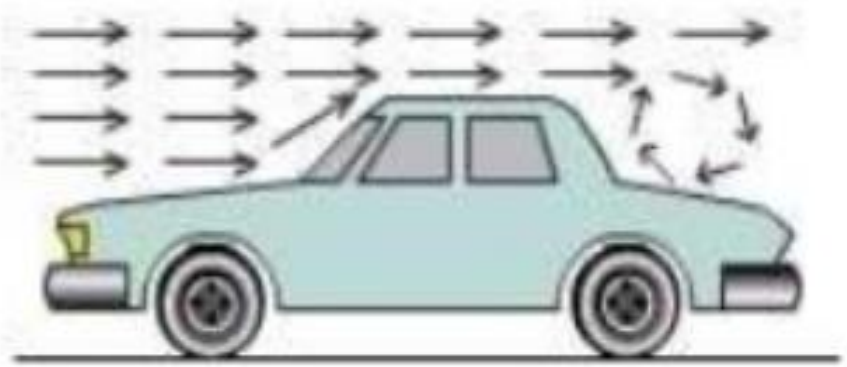
V = Velocity of the vehicle

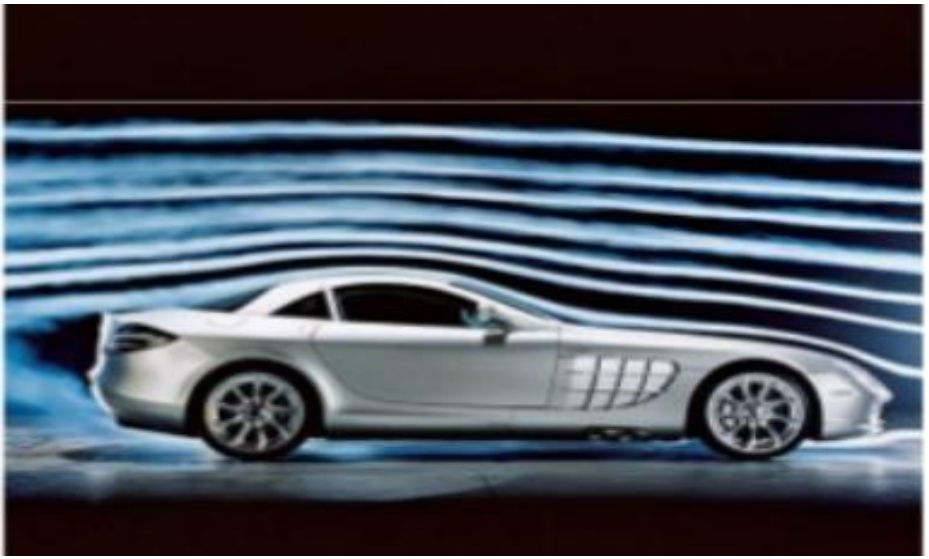


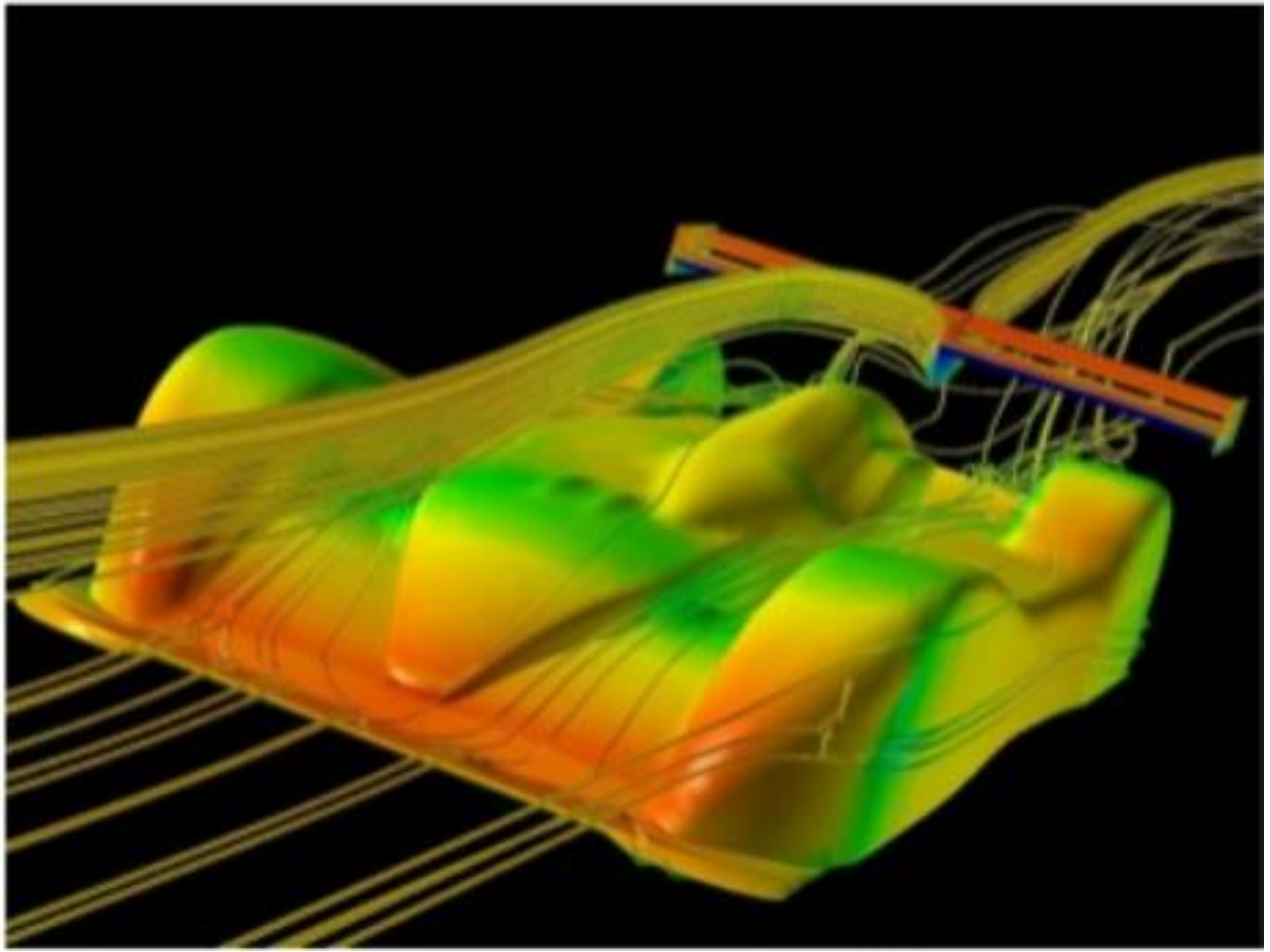
Relative air speed and pressure conditions over the upper profile of a moving car


1600
1200
800
400
0
Resisting forces opposing motion (N)
high air resistance (C_D = 0.5)
low air resistance (C_D = 0.25)
rolling resistance
0
40
80
120
160
Vehicle speed (km/h)

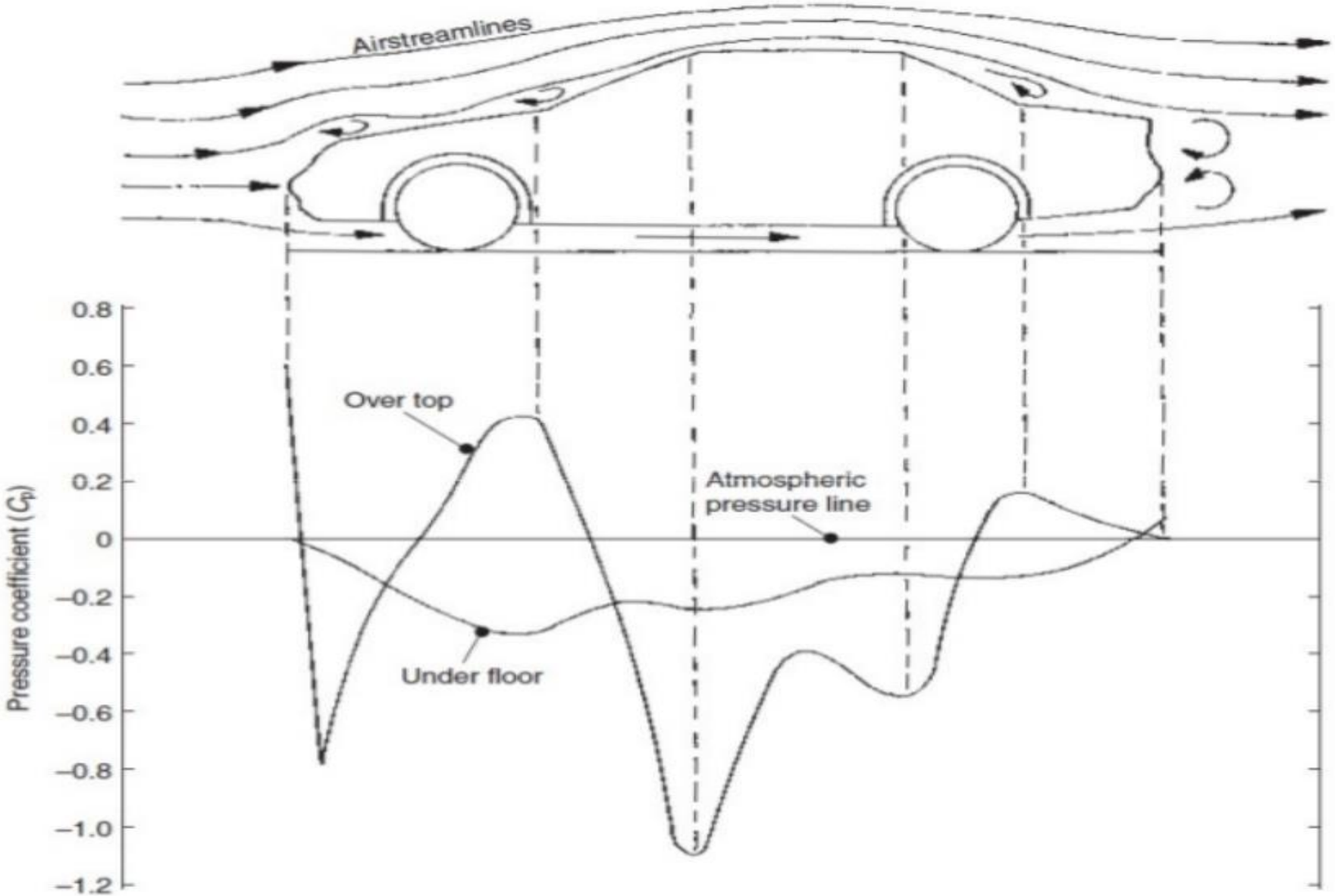

Projection plane
Frontal area
Parallel light

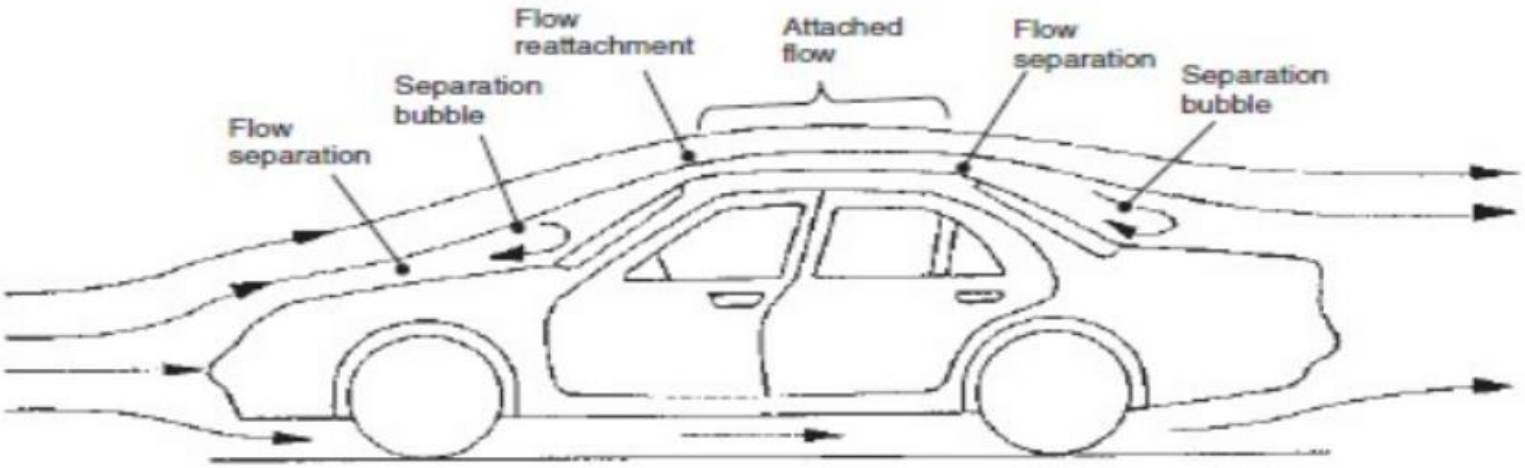




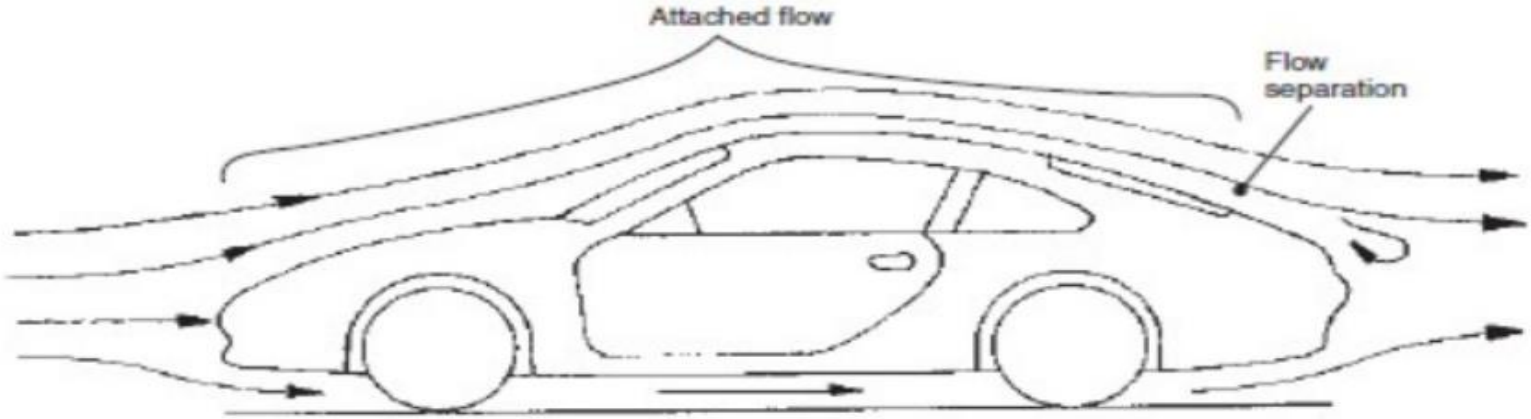


Pressure distribution above and below the body structure



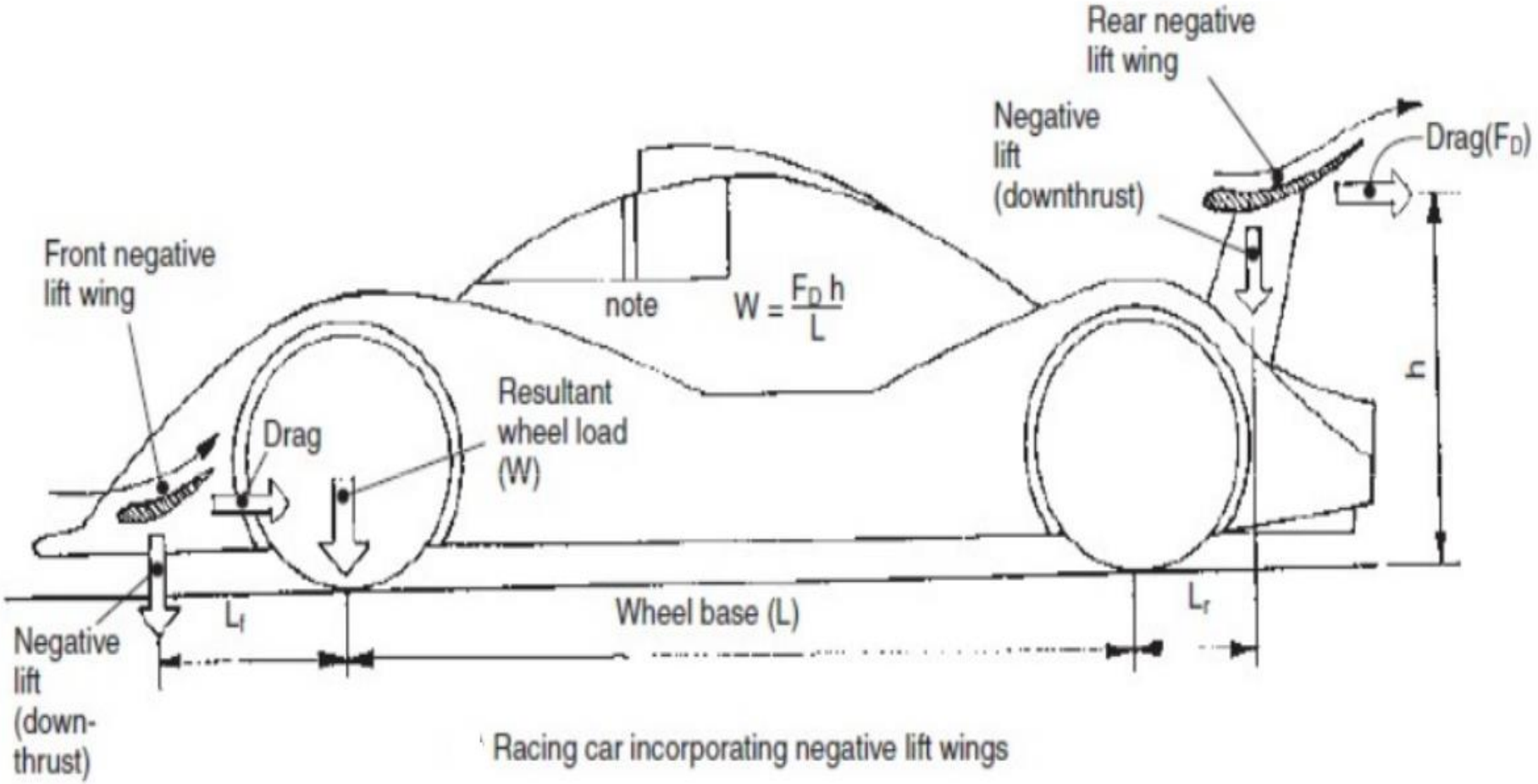


(a) Notch front and rear windscreens



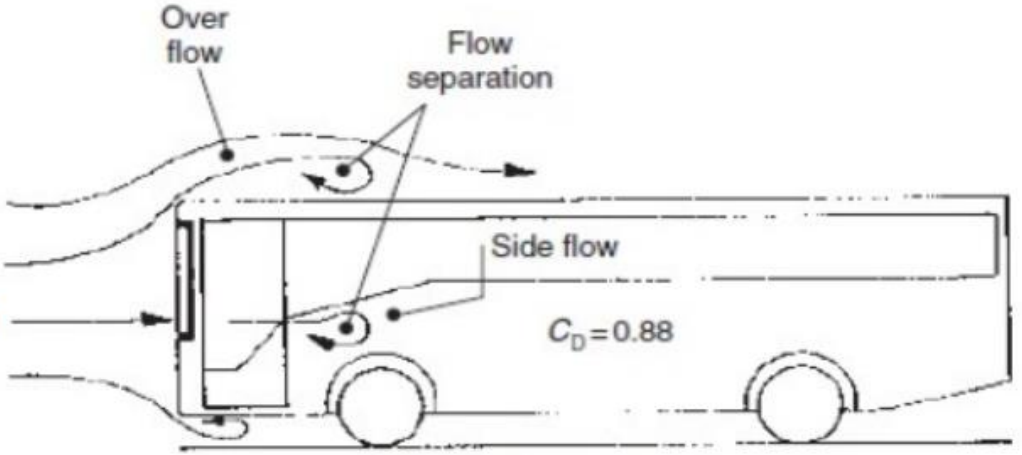
(b) Very streamlined shape

Flow seperation and reattachement

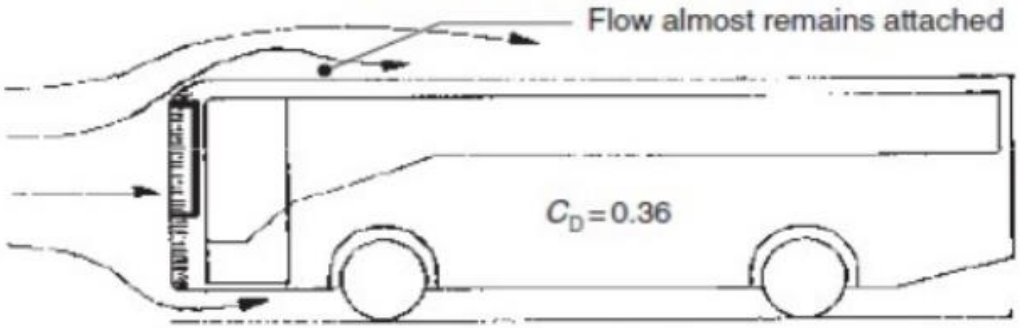


Racing car incorporating negative lift wings

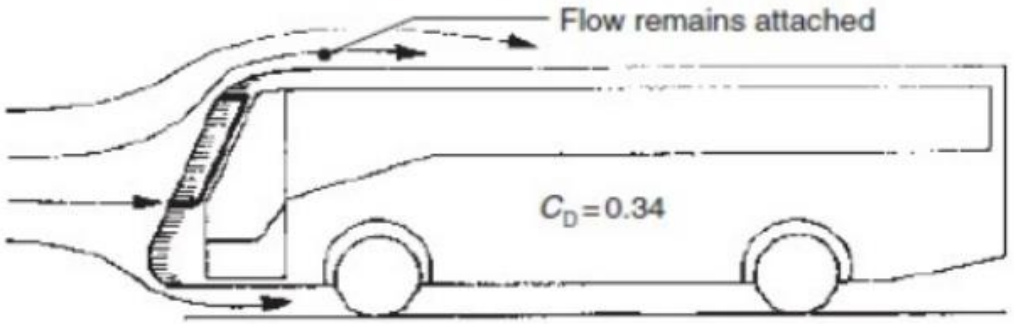
C_D for various shapes of truck leading edges



(a) Coach with sharp leading edges



(b) Coach with rounded leading edges



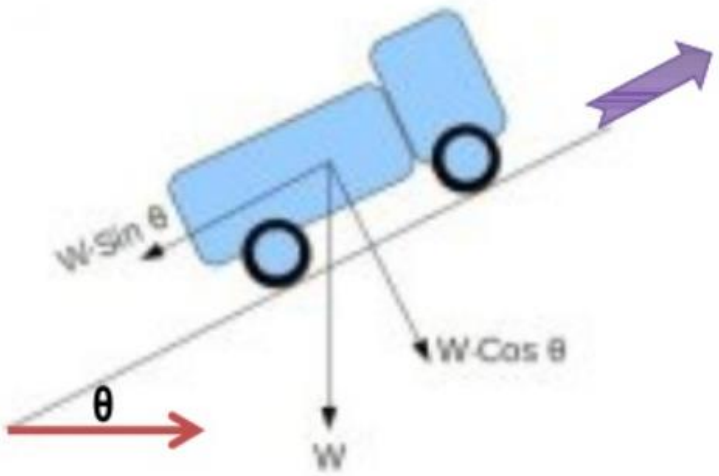
(c) Coach with rounded edges and backsloping front

Gradient Resistance

- When the vehicle travels uphill, a component of its weight works in a direction opposite to its motion
- If some energy is not supplied to overcome this backward force, then the vehicle would slow down, stall and roll backwards
- If a vehicle is trading uphill at a slope θ, then the weight of the vehicle, W has two components
  - Perpendicular to the road surface
  - Along the road surface

- The component along the road surface is the one that tries to restrict the motion
- The gradient resistance is given by

$$F = W \sin\theta$$



Rolling Resistance

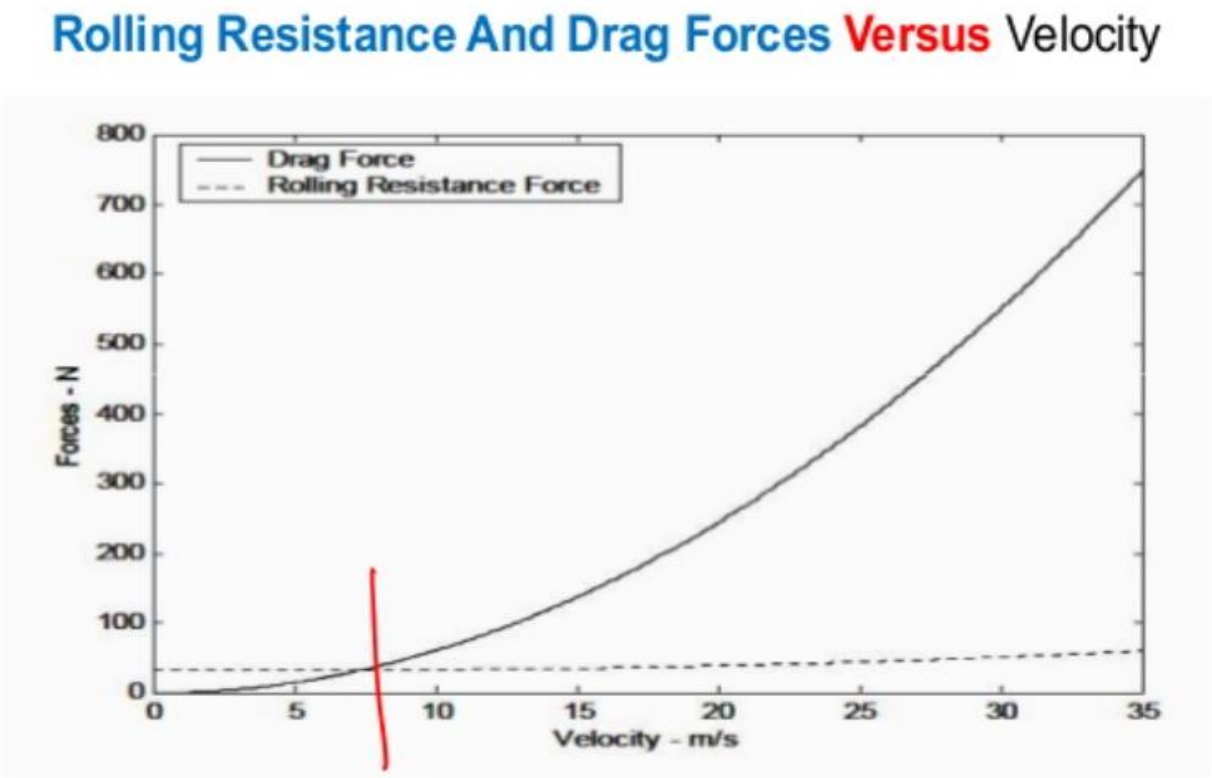
- When a vehicle rolls, it rolls with its tires in contact with the road surface
- Relative motion of two hard surfaces produces a friction
- Neither the road nor the tire are perfectly rigid, hence both flex under the load slightly
- As there is gradual deformation at the contact between the road and the tire, the slip of the tire w.r.t. the road produces another type of loss of energy which results in a resistance

Rolling resistance is composed of the following components:

- Tyre rolling resistance ($F_{R,T}$)
- Road rolling resistance ($F_{R,Tr}$)
- Resistance due to tyre slip angle ($F_{R,\alpha}$)
- Resistance due to bearing friction and residual braking ($F_{R,fr}$)
- Hence the rolling resistance offered may be written as:

$$F_{RR} = (F_{R,T}) + (F_{R,Tr}) + (F_{R,\alpha}) + (F_{R,fr})$$

- The tyre rolling resistance $F_{R,T}$ is a result of the resistance due to flexure of the tyre, air resistance on the tyre and friction of the tyre with the road



Inertial or Transient Forces

- Transient forces are primarily comprised of acceleration related forces where a change in velocity is required.

These include:

- The rotational inertia requirements ($F_{I\alpha}$) and the translational mass (F_{ma}).

- If rotational mass is added it adds not only rotational inertia but also translational inertia.

That's all for this lecture...

~THANK YOU~

AUTOMOBILE ENGINEERING

UNIT - 1

Lecture 05

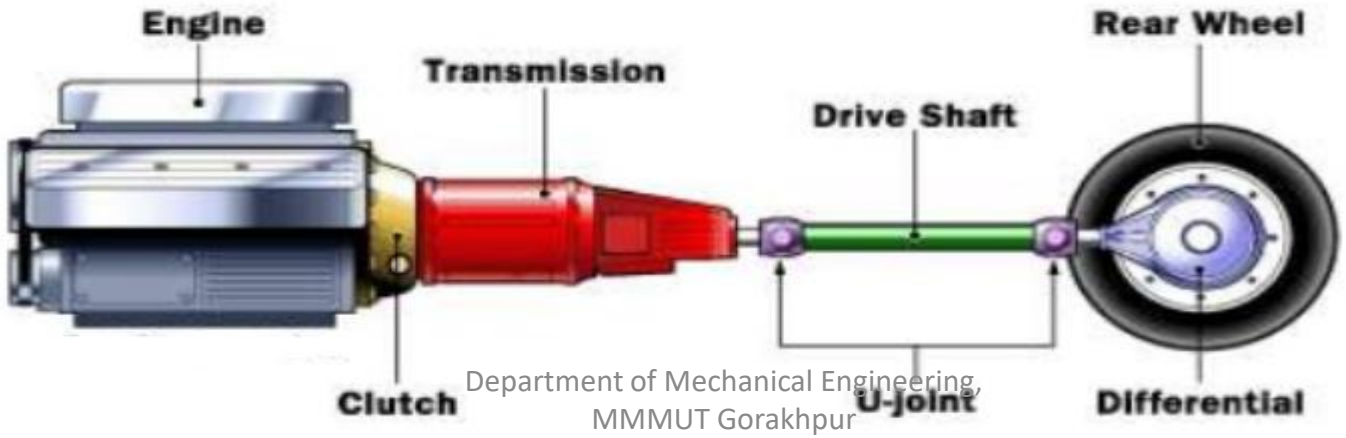
Contents

- Introduction to gear box
- Purpose of gear box
- Types of transmission system

Gear Box

- The **gearbox** is the second stage in the transmission system, after the clutch
- It is usually bolted to the rear of the engine , with the clutch between them
- Modern **cars** with manual transmissions have four or five forward speeds and one reverse, as well as a neutral position.

- The gear lever , operated by the driver, is connected to a series of selector rods in the top or side of the gearbox. The selector rods lie parallel with shafts carrying the gears.
- Number of gears needed depends on:
  - Engine torque
  - Load to be moved
  - Speed of the vehicle



Purpose of Gear Box

- It produces a **mechanical advantage**
  - Most modern **gearboxes** are used to increase torque while reducing the speed of a prime mover output shaft (e.g. a motor crankshaft).
  - This means that the output shaft of a **gearbox** rotates at a slower rate than the input shaft, and this reduction in speed produces a mechanical advantage, increasing torque.
  - The transmission provide the torque needed to move the vehicle under a variety of road & load conditions

- The low gears covering a shorter distance and are useful when speed is low
- It can be shifted into reverse, so the vehicle can move backwards
- It can be shifted into neutral for starting the engine & running it without turning the drive wheels
- To provide a means to take power away from the gearbox to power auxiliary components

Types of Transmissions

- **Manual Transmission**

- The simplest and oldest type of transmission still in use is the **trusty manual**.
- This gearbox uses a friction clutch modulated by the driver's foot to connect the engine's rotational energy to the transmission's input shaft
  - From there, a fixed set of gears are engaged using a synchro and gear-selector fork connected to the shifter operated by the driver's left hand (or right, in certain countries).

- **Note:** Aside from its inherent simplicity, performance, and fuel economy, **perhaps the most compelling case for the venerable stick shift is the driving experience itself**
  - For true driving enthusiasts, nothing can beat the feeling of a **perfectly timed shift** on a good old manual.
  - This type of transmission is also known as a **"stick shift" or a "standard" transmission.**
  - They also offer the **best fuel economy** and manual transmission vehicles are typically a **bit cheaper.**

- **Automatic Transmission**

- Manual transmissions are mechanically simpler, but they are more complex to use
- Many drivers either **don't know how to drive a manual transmission or do not like the extra work involved**
- For such drivers, the best type of transmission is an automatic transmission
- This type of transmission can automatically change gear ratios as the vehicle moves, meaning the driver does not have to shift gears manually

- It uses a highly-complex **torque converter** to transmit the engine's rotational energy, while gear shifts are controlled by the vehicle's computer and accomplished with a **planetary gear set** and a series of clutches and brakes
- Though most automatics **can't match a manual transmission for performance or fuel economy,** modern examples are much closer than previous generations

Available automatic transmission cars in India

- MARUTI SUZUKI CELERIO
- TATA NEXON
- TOYOTA YARIS
- HONDA AMAZE
- MARUTI SUZUKI VITARA BREZZA
- MARUTI SUZUKI DESIRE
- HUNDAI VERNA

- **Continuously variable transmission (CVT)**

- The CVT offers a similar driving experience to an automatic, **but operates using a completely different mechanism**
- In fact, the CVT **doesn’t have gears at all** — instead, it uses a system of belts and pulleys to produce an infinite range of ratios
- The car’s computer decides how to adjust the pulleys to create the optimal ratio for the particular driving situation

- This creates the CVT's primary advantage: fuel economy
  - a CVT can keep the engine in its optimum power range, thereby increasing efficiency and gas mileage
- Since they're not as complicated as automatics, CVTs are **less prone to failure** (though not as much so as manuals)
- Their **biggest drawback** may be a subjective one — the **driving experience**
  - Since there are no gearshifts, just smooth and seamless acceleration, CVTs may leave a true driving enthusiast feeling like he or she is operating an appliance instead of driving a car

- **Note:-** The CVT's belt-driven design offers approximately 88% efficiency, which is lower than that of a manual transmission, **but this can be offset** by lower production cost and by enabling the engine to run at its most efficient speed for a range of output speeds.

Available CVT automatic transmission cars in India

- Maruti Suzuki Baleno
- Nissan Micra XL CVT
- Honda Amaze VX CVT
- Honda City SV CVT
- Toyota Corolla Altis CVT

Pros of CVT vs Automatic Transmission

- A key benefit of the CVT is its ability to change its **gear ratio continuously** as the engine speed changes
  - This means the engine is always operating at its peak efficiency
- A CVT draws top engine power from a small engine, which gives drivers **quicker acceleration** than standard automatic transmissions
- Because of their greater ability to control the engine speed range, CVTs produce fewer emissions

- CVTs are also lighter weight than traditional automatic transmissions
  - You get better fuel economy, especially in city driving
- As for the driving experience, some drivers comment that the CVT car ride is extremely smooth compared to normal automatic transmissions
  - They like that they notice RPM or engine speed changes only when the car is cruising or accelerating.

Cons of CVTs vs. Automatics

- CVT-equipped vehicles can make it seem like the engine is droning loudly under hard acceleration
- Servicing a CVT is different from servicing an automatic transmission
  - CVTs need special oil, transmission fluid, and parts
- CVT-equipped vehicles find transmission repair is more expensive than compared to automatic transmission repair or replacement

- Other common problems CVT-equipped vehicle include the occasional sudden loss of acceleration and overheating
- Drivers complain of jerking, slipping, and shuddering
- CVT belts can suffer excessive stretching and wear
- Some owners have experienced transmission failure

Basic Principle

- The most basic type of gear is a spur gear, and it has straight-cut teeth, where the teeth are cut parallel to the axis of the gear.

- Wider gears and those that are cut for smoother meshing are cut with the teeth at an angle. These are called helical gears.

Helical Gear vs **Spur Gear**

- Because of the angle of cut, helical gear teeth have a much more gradual engagement with each other
  - They operate more smoothly and quietly than spur gears
- **Helical can transmit more torque**
  - At any time, more number of teeth are in mesh
- Helical gears also exerts undesirable axial thrust
  - To prevent this, double helical gears are used

Types of Gearboxes

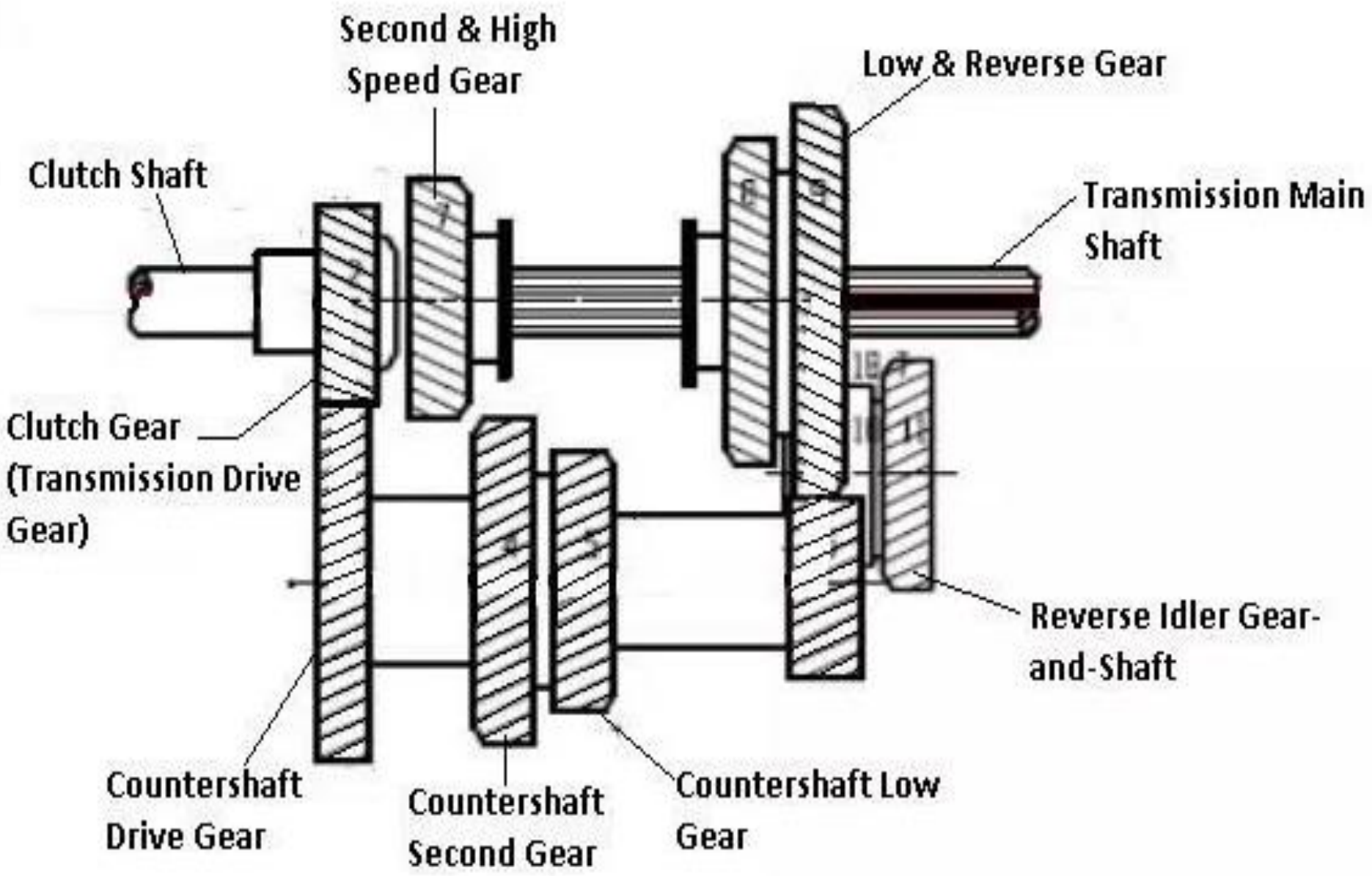
- Sliding Mesh Gear box
- Constant Mesh Gear Box
- Synchromesh Gear Box
- Transaxle Gear Box
- Sequential gear box
- Automatic Gear Box

In Unit -1

- We will study 3 types of gearboxes used in vehicles:
  - Sliding mesh type
  - Constant mesh type
  - Synchromesh type
- In vehicles mostly constant mesh and synchromesh is used
- Sliding mesh is used in **low speed vehicles**
  - where there is less chance of damage to gear teeth
- For High speed vehicles use **synchromesh type gearbox**
- For passenger cars or commercial vehicles (like 3-wheelers) mostly use **constant mesh gearbox**

Sliding Mesh Type Gear Box

- It is the simplest type of gearbox
- The arrangement of gears is in a neutral position
  - (The gear housing and bearing are not shown)
- The clutch gear is fixed to the clutch shaft
  - It remains always connected to the drive gear of the counter-shaft



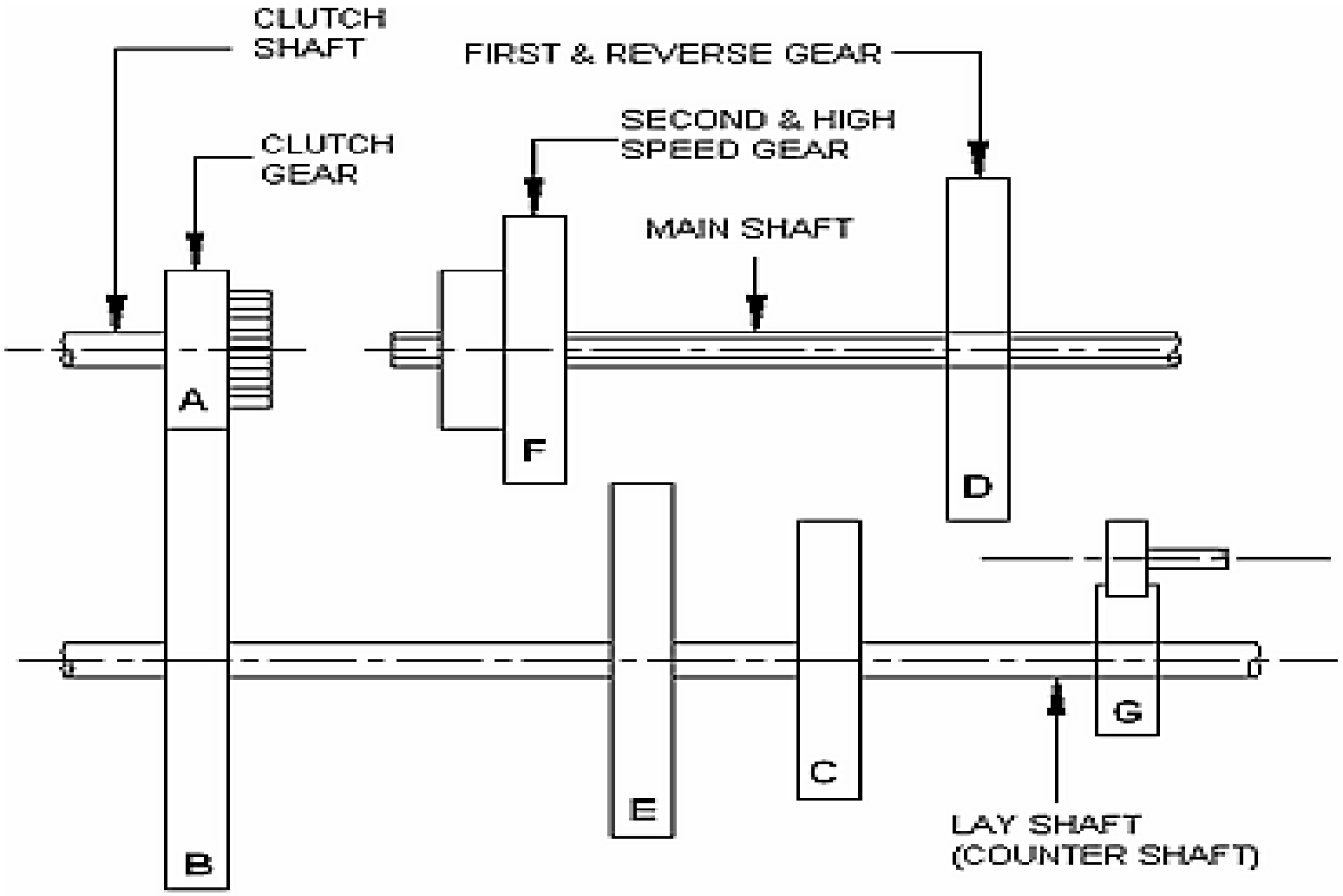
Sliding Mesh Gear Box

- Three other gears like first speed, second speed and reverse speed gear are also rigidly fixed to the countershaft or also known as lay-shaft
- Two gears mounted on the splined main shaft which can slide by the shifter yoke when the shaft lever is operated

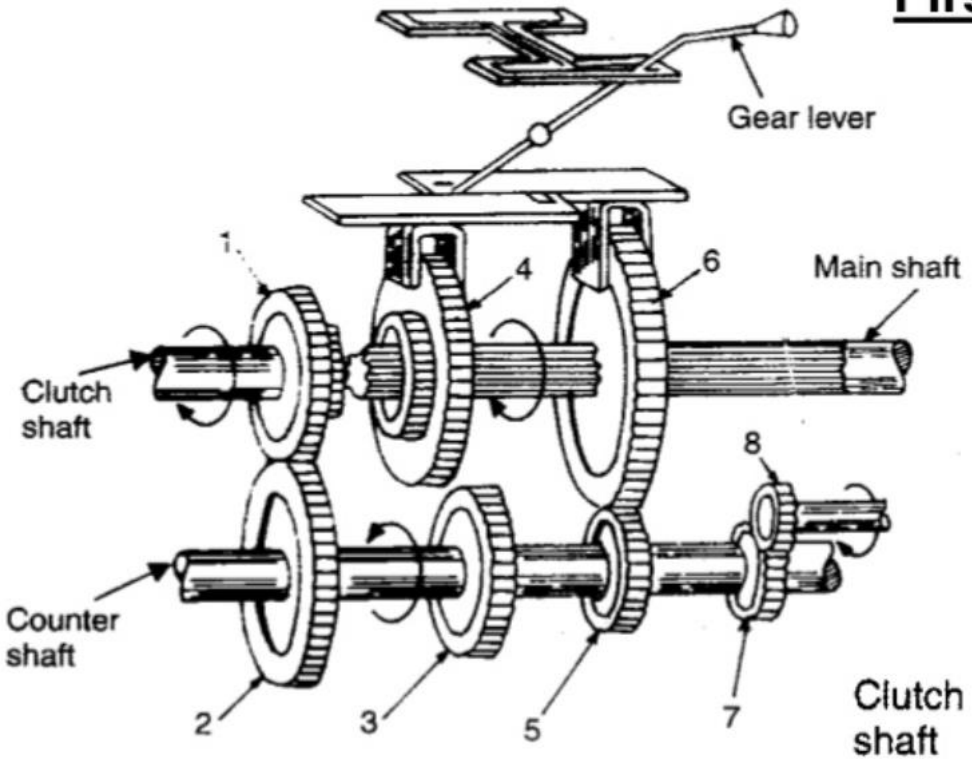
When Gear is neutral

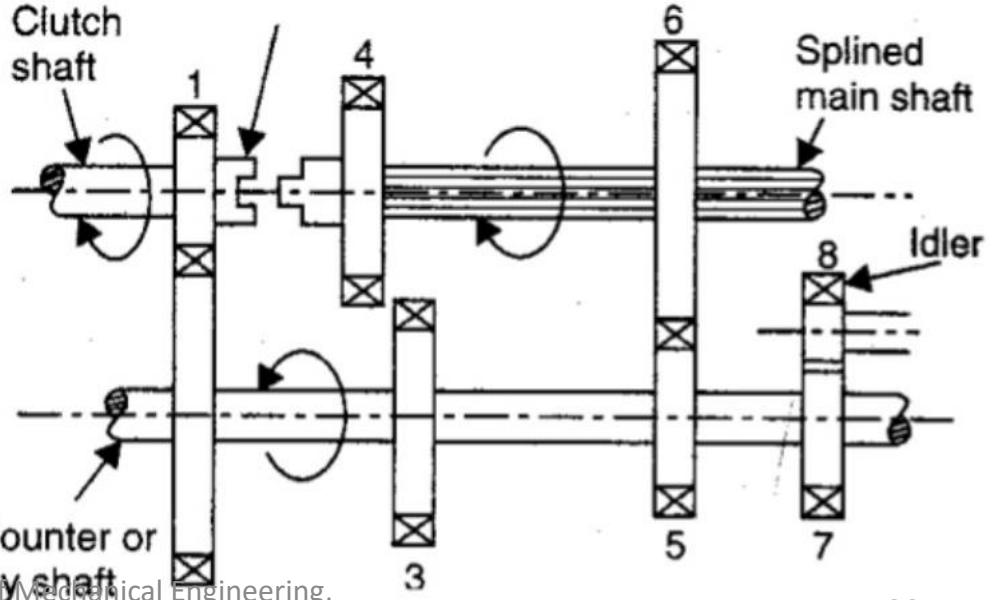
- In this position of the gear, the engine power is not transmitted to the gear axle
  - The clutch gear is transmitting the power to gear on the countershaft and the countershaft further not transmitting line power to main shaft
- Remember that in a neutral position, just the **clutch shaft gear is engaged** to the countershaft gear
  - **Other gears are free**, and therefore the transmission main shaft is not rotating

Sliding Mesh Gear Box Working

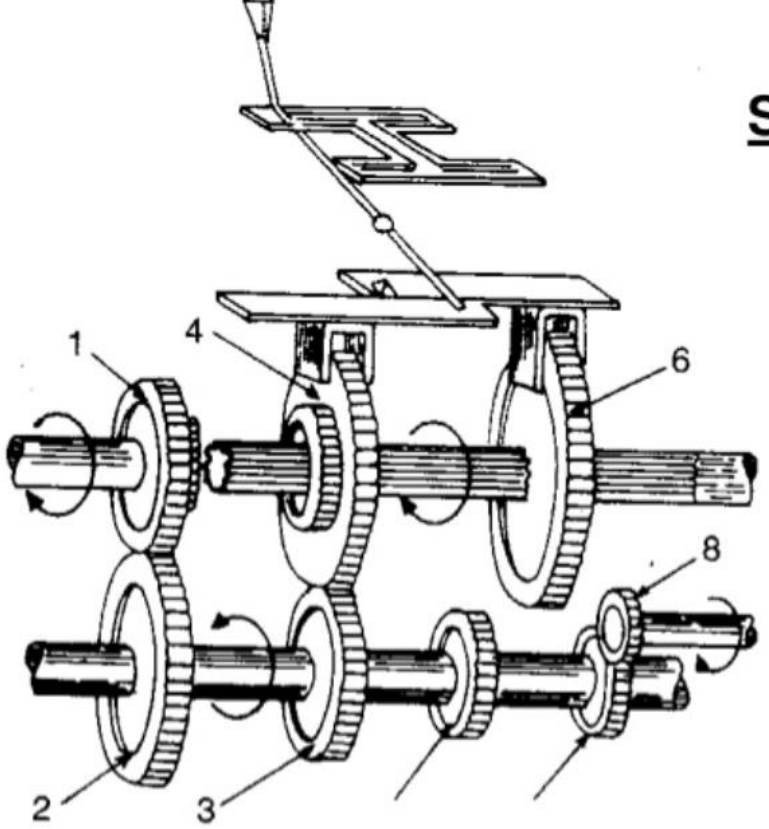


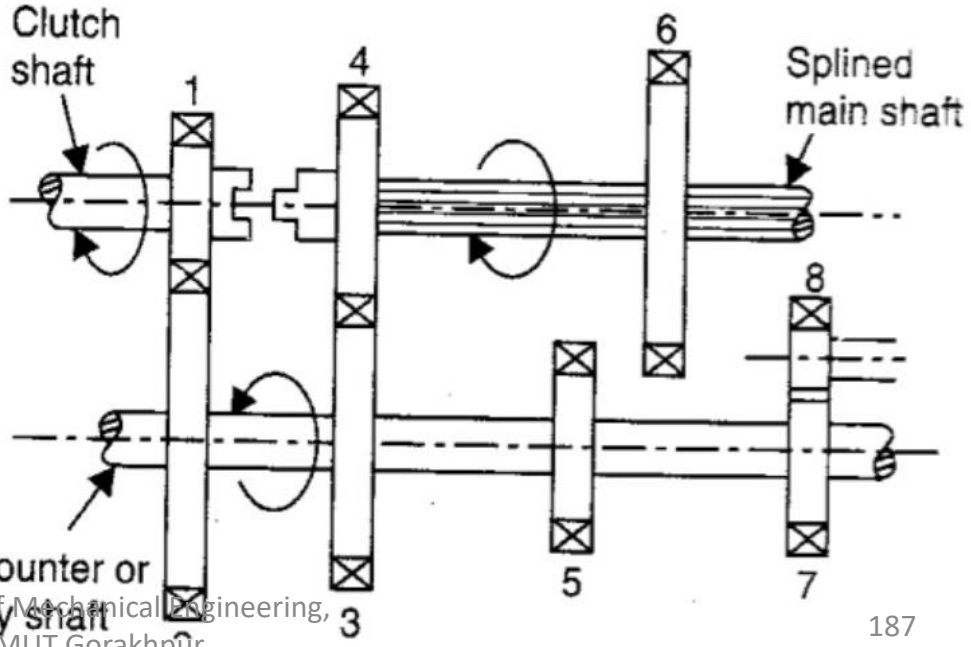
First gear position



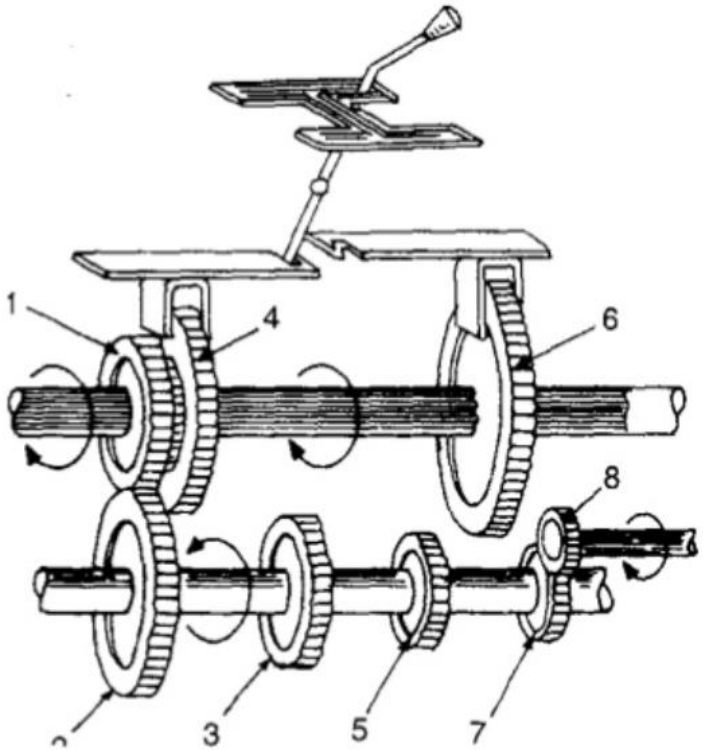


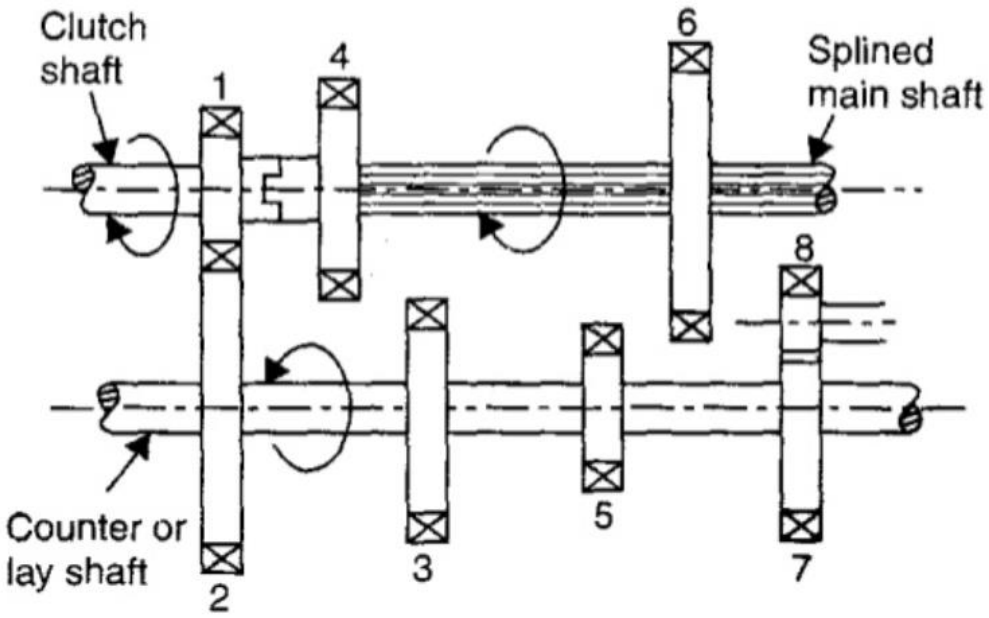
Second gear position



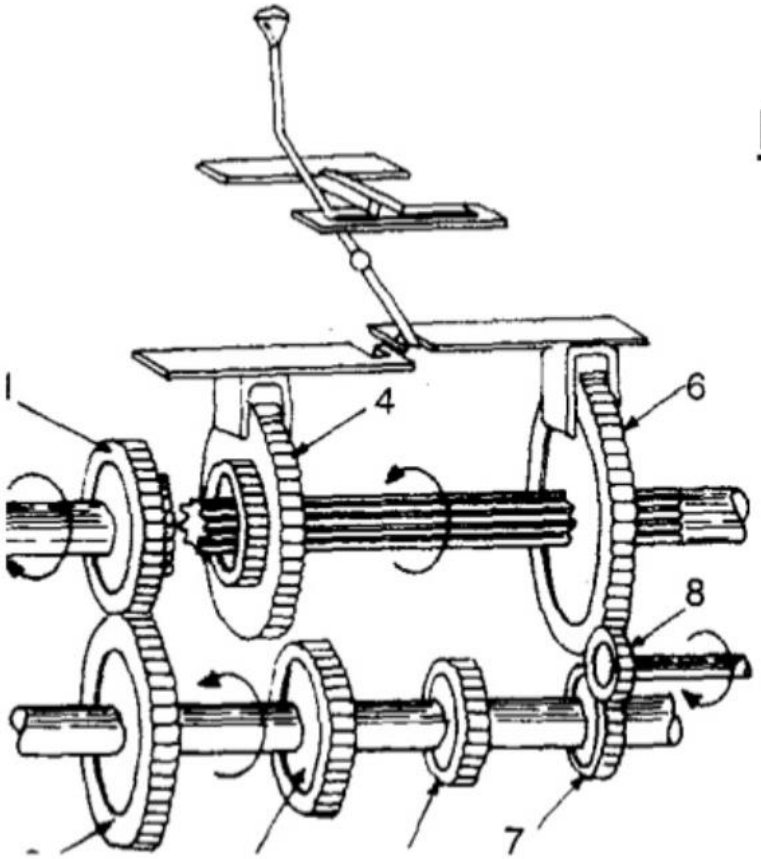


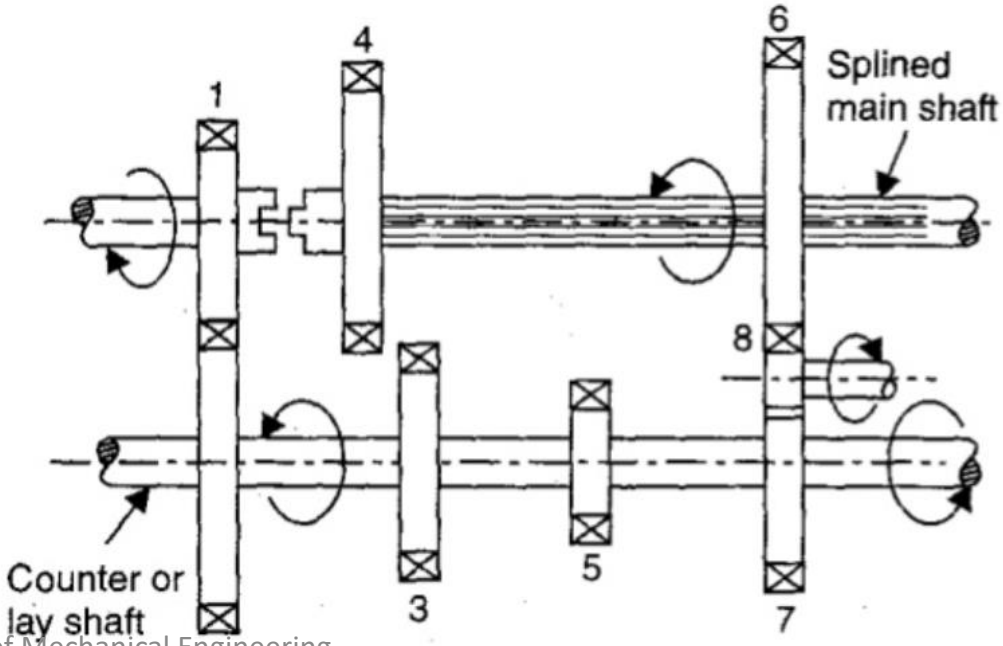
Third gear position





Reverse gear position





Application

- It is the oldest type of gearbox used in early 19s models of cars
  - **Alfa 12HP** used sliding mesh gearbox with 4 - speed manual transmission
  - **Fiat 6HP** used 3-speed manual transmission
  - **Mercedes 35HP** used 4-speed manual transmission
  - **Renault Voiturette** used manual 3-speed transmission

Animation of Sliding Mesh Gear Box

https://www.youtube.com/watch?v=n1EvThvz-8k

- **Advantages**
  - Simple in design
  - Low cost components, hence cheap
- **Disadvantages**
  - Changing of gears is not easy
  - Mechanical efficiency is very low
  - It has spur gears which are noisy

That's all for this lecture...

~THANK YOU~

AUTOMOBILE ENGINEERING

UNIT - 1

Lecture 06

Types of Gearboxes

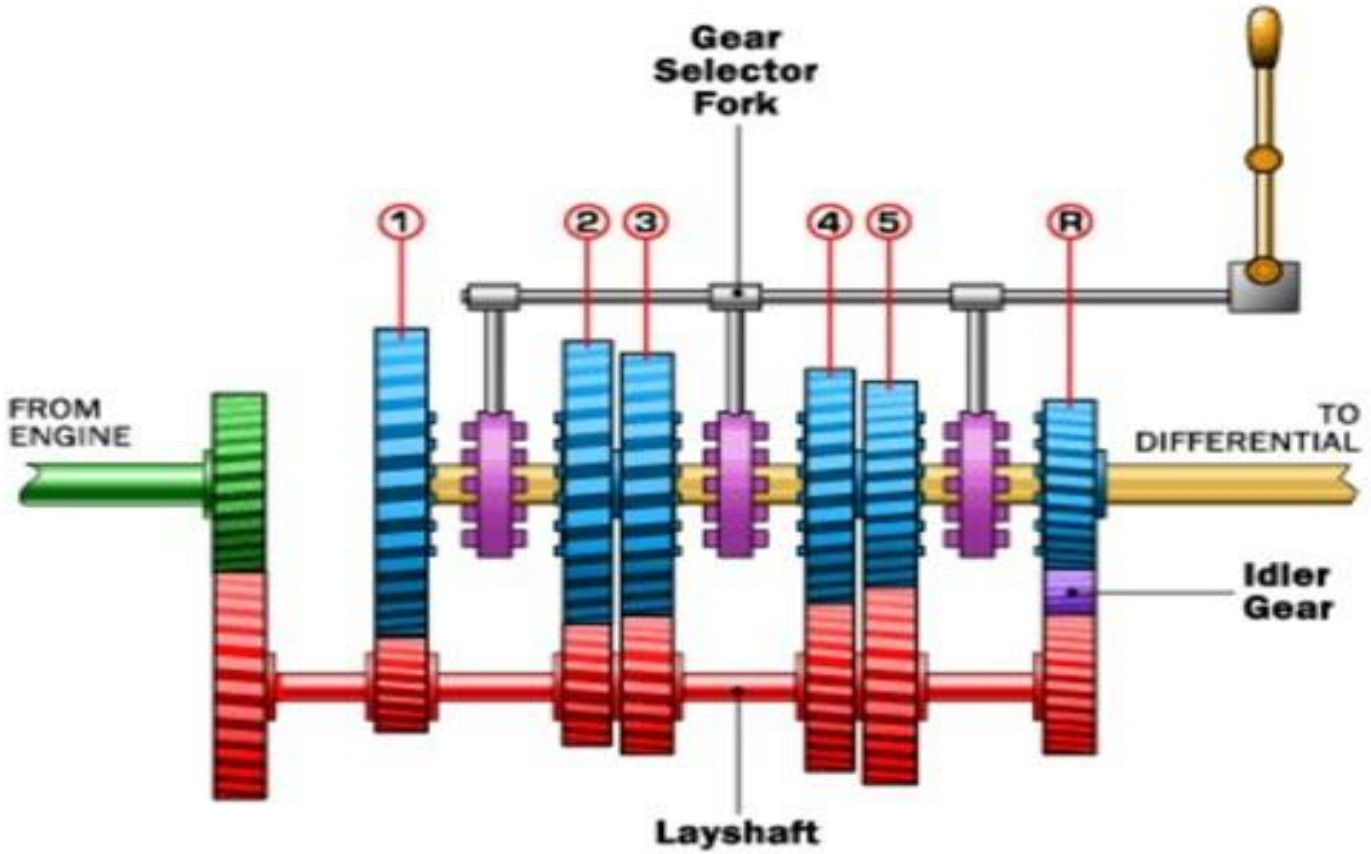
- Sliding Mesh Gear box
- Constant Mesh Gear Box
- Synchromesh Gear Box
- Transaxle Gear Box
- Sequential gear box
- Automatic Gear Box

Constant Mesh Gear Box

- **Constant Mesh Gearbox** was invented to overcome the limitations of the sliding mesh gearbox.
- In this gearbox, all the gears are always in mesh.
- The gear remains fixed and not slide like the sliding mesh gearbox.
- A constant mesh gearbox usually comes with 4-speed 1-reverse manual transmission configuration.
- Constant gear mesh gearbox employed helical gears for power transmission.
- The gears are rigidly fixed in the lay shaft.

- The gears in output shaft rotates freely without engaging with shaft, thus not transmitting power.
- To engage the gears with output shaft **dog clutch** is used.
- The dog clutch is shifted by the selector fork moved by gear lever.
- To provide reverse gearing a idler gear is used.
- **Sliding dog clutches** are provided on the main shaft
  - Dog clutch slides on the main shaft to rotates with it
- When the gear lever is pushed, the gear selector fork pushes the dog clutch.
- The dog clutch engages the gear and the output shaft, thus power from lay shaft now transmitted to output shaft.

Constant Mesh Gear Box



Main Parts of Constant Mesh Gearbox:

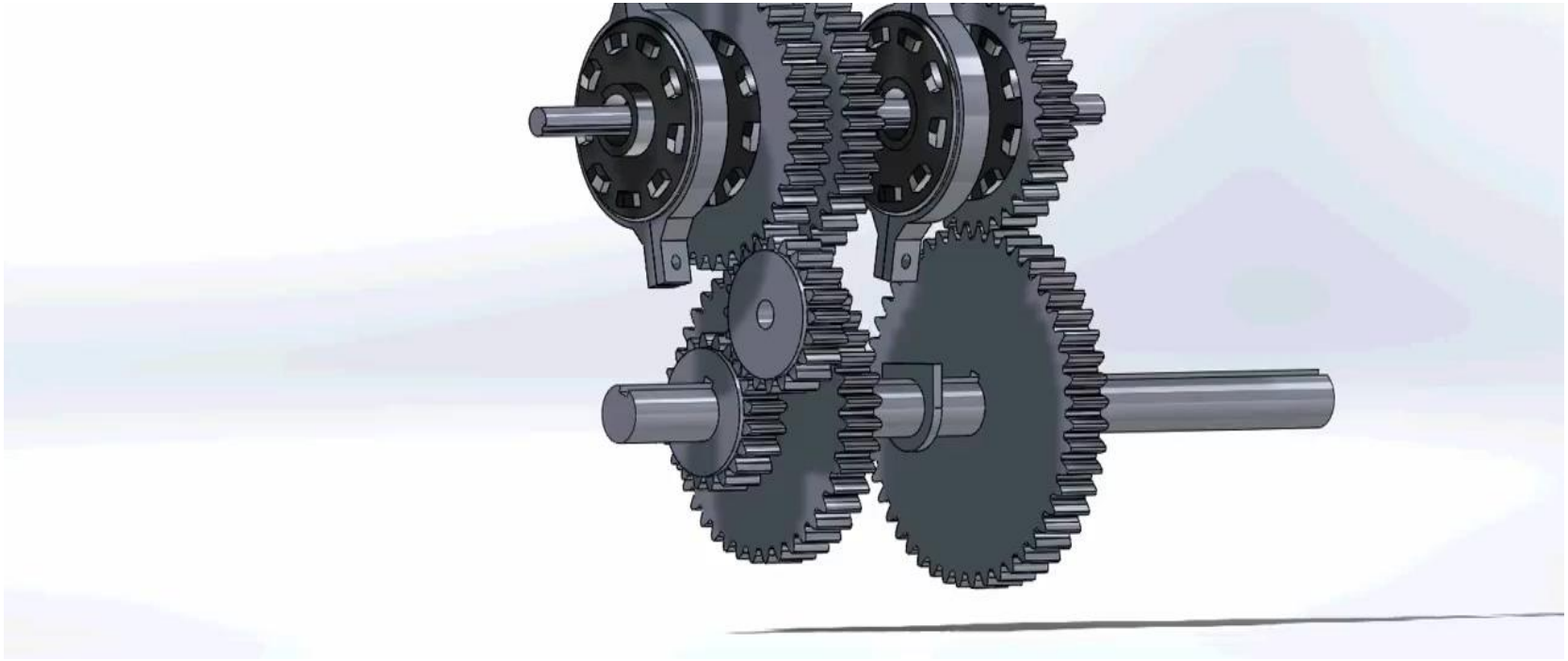
1. **Shafts –** There are 3 shafts present in this gear box which are :

- **Main Shaft-** It is also known as output shaft.
  - It is the splined shaft over which the dog clutches along with gears are mounted.
  - **Gears on this shaft are free to rotate.**
- **Lay Shaft or Counter Shaft-**
  - It is an intermediate shaft between the Main Shaft and Clutch Shaft.
  - The gears of counter shaft are in constant mesh with gears of main shaft.
  - Also the gears of counter-shaft are **not free to rotate** as they are directly connected to the Counter Shaft.
- **Clutch Shaft-**
  - The clutch shaft carries the engine output to the gearbox but act as input for the gearbox.
  - It is also known as input shaft.

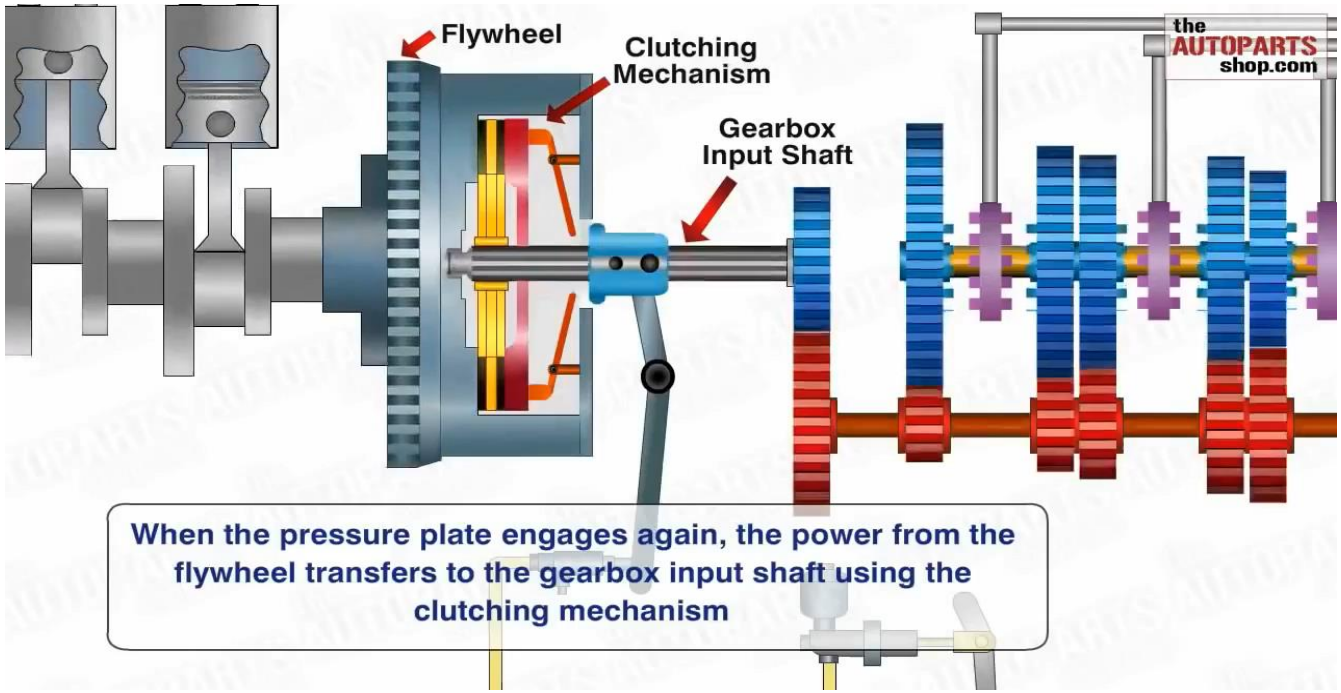
2. Dog Clutch

- The dog clutch couples the lay shaft and main shaft **by interference and not by friction.**
- It is a device for coupling two shafts in order to transmit motion
  - One part having teeth which engage with slots in another
- Dog clutches are used where **slip is undesirable**
- There are usually two dog clutches in a Constant Mesh Gear Box.

Dog Clutch Animation



Dog Clutch Animation



Links for Constant Mesh Animation

- https://www.youtube.com/watch?v=K2IfBlea9cc
- https://www.youtube.com/watch?v=_Y7rcikXGyE
- https://www.youtube.com/watch?v=wCu9W9xNwtI

3. Gears:

- Gears of constant mesh gearbox come in pairs.
- All gears of lay shaft or counter shaft are always paired with gears of main shaft or output shaft.
- This paired gears of counter shaft and main shaft provide different gear ratio which can be transmitted to main shaft by engaging dog clutch with appropriate gear ratio required.
- Two type of gears are used in constant mesh gearbox:-
  - **Helical Gears:** These gears have angular cut teeth over cylindrical cross-section metal body.
  - **Bevel Gears:** These gears have angular cut teeth over conical cross-section metal body.

Advantages

- **Utilization of helical gears**
  - The double helical gears and the helical gears are extremely beneficial owing to their quieter operating capabilities
- **Any harm is suffered entirely by the dog clutch teeth**
  - The teeth belonging to the gear wheels remain intact

Disadvantages

- It is less efficient than the others due to higher mesh teeth
  - Skill is required for it
- The double clutch mesh is required
  - This is required to have the spinning movements of the shaft

Construction of Constant Mesh Gearbox:

- The output of the engine is carried by clutch shaft.
- The gear in clutch shaft is in constant mesh with the gear of lay shaft.
- There are 5 gears in lay shaft, one of which is connected to gear of clutch shaft and the other 4 are connected with gears of main shaft.
- All four gears are of different sizes to obtain different gear ratios.
- An idler gear is present between the gear of lay shaft and gear of main shaft to form reverse gear.

Working of Constant Mesh Gearbox:

- When the **dog clutch** is engaged with different gears of main shaft, different gear ratios are obtained as gears of main shaft are always paired with gears of counter shaft to form different gear ratios.
- If the dog clutch is not in contact with any gear of main shaft the gears of main shaft rotates freely and does not rotates the main shaft as they are connected with main shaft using bearings.
- The main shaft rotates only when one of the dog clutch is engaged with any of the gear of the main shaft.
- Reverse gear is obtained in this gearbox using the same technique that was in sliding gearbox i.e using the idle gear between main shaft gear and counter shaft gear.

Different gear ratios in Constant Mesh Gearbox:

- **First Gear:**
  - First gear is obtained in constant mesh gearbox when dog clutch gets engage by interference with the largest gear of main shaft which is in constant mesh with smallest gear of main shaft.
  - This gear provides maximum torque and minimum speed to the main shaft.
- **Second Gear:**
  - Second Gear is obtained when dog clutch gets engage with second largest gear of main shaft which is in a constant mesh with second smallest gear of lay shaft.
  - This gear provides higher speed and lower torque than first gear.

- **Third Gear:**
  - Third gear is obtained when dog clutch engages with second smallest gear of main shaft which is in constant mesh with second largest gear of lay shaft.
  - This gear more speed and less torque than second gear.
- **Fourth Gear:**
  - This gear provides the highest or maximum speed in a vehicle using constant mesh gearbox.
  - This gear is obtained when dog clutch engages with smallest gear of main shaft which is in constant mesh with largest gear of lay shaft.
- **Reverse Gear:**
  - In this gear the vehicle goes in reverse direction.
  - Like sliding mesh gearbox, an idler gear is also used in constant mesh gearbox between the main shaft gear and lay shaft gear to form reverse gear.
  - Reverse gear is obtained when dog clutch engages with gear in main shaft which is paired with idler gear.

Advantages of Constant Mesh Gearbox:

- Constant Mesh Gearbox are quieter because helical or herringbone gears can be used in this gearbox instead of spur gears.
- Since the gears are engaged by dog clutches, if any damage occurs while engaging the gears, the dog unit members get damaged and not the gear wheels.
- **Application:**
  - Constant mesh gearbox was mainly used in farm trucks, motor bikes and heavy machinery.
  - It is also used in cars like Ford Model
  - Constant Mesh Box was used in motor bikes before the introduction of synchromesh gearbox in 1928 by General Motors.

What problems of Sliding Mesh Gearbox were solved by Constant Mesh Gearbox ?

- The shifting of gears was very noisy process as spur gears were used but in constant mesh gearbox the gear shifting process becomes very less noisy as helical gears and bevel gears are used.
- In sliding mesh gearbox, gears to be messed were in continuous rotation, so the meshing of gears can cause breakage of gear teeth or wear and tear of gears.
  - This problems was solved by constant mesh gearbox by introducing dog clutches.
- Shifting was not an easy task for drivers and requires special skill to change gears using double-de-clutching technique.
  - But changing gears become easy for drivers after introduction of constant mesh gearbox.

Synchromesh Gear Box

- The Synchromesh gear box is similar to the constant mesh type in that all the genes on the main shaft are in constant mesh with corresponding gear on the layshaft.
- The gears or the layshaft are fixed to it while those on the main-shaft are free to rotate on the same.
- It's working is also similar to the constant mesh type, but in the former there is one definite improvement over the later.
  - This is the provision of **synchromesh device** which avoids the necessity of double declutching.
- The parts which ultimately are to be engaged, are first bought into frictional contact which equalizes their speed, after which there may be engaged smoothly.

- Recapping the process,(of last point in previous slide) downshifting from fourth to third:

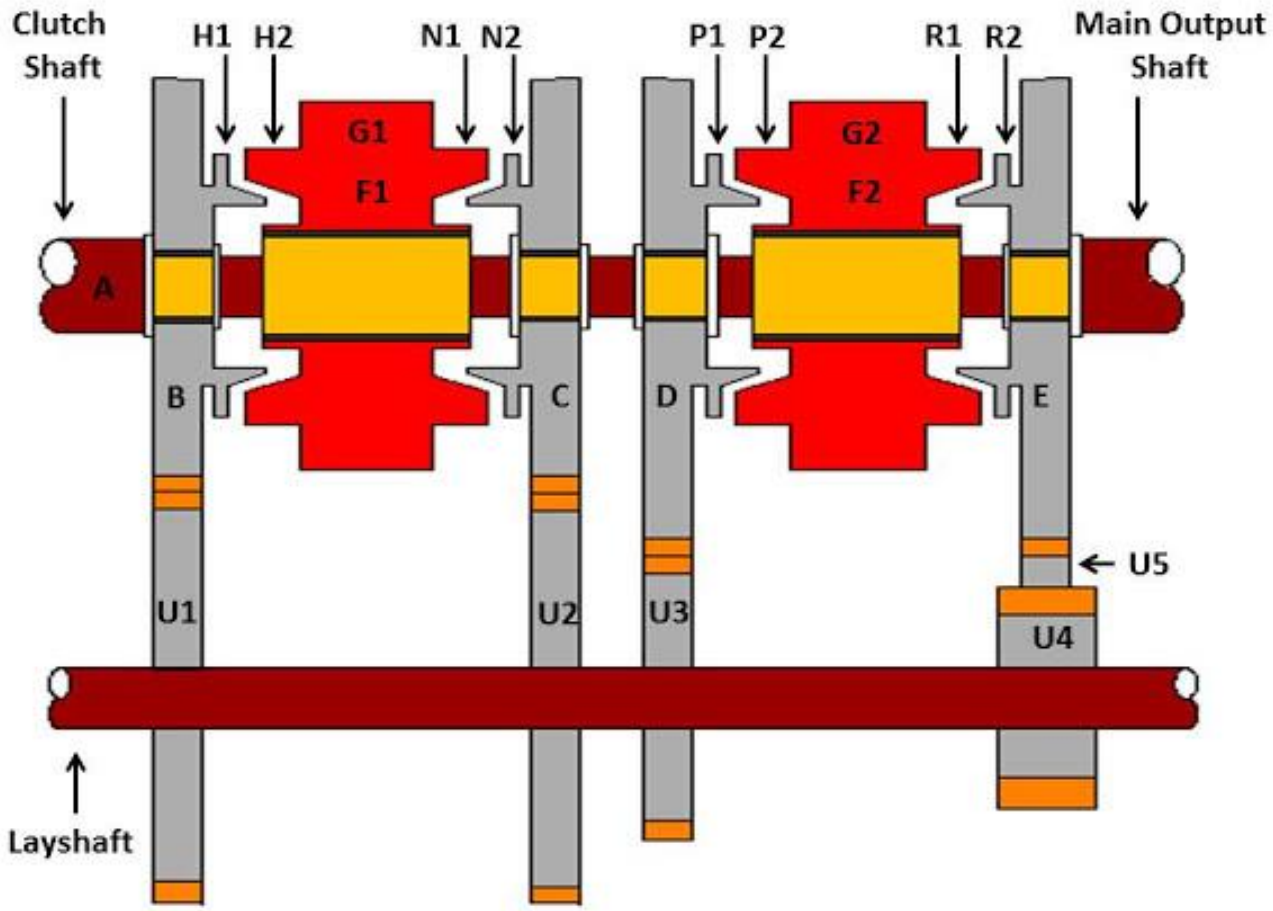
1. Press in the clutch pedal.
2. Place the shifter in neutral.
3. Release the clutch.
4. Tap the throttle.
5. Press in the clutch pedal once more.
6. Place the shifter into third gear.
7. Release the clutch pedal.

Synchromesh Gear Box contd..

- It is the **latest version** of Constant mesh type
- It is a manually operated transmission in which, change of gears takes place between gears that are already revolving at the same speed
- In this type of gearbox, gears can rotate freely or locked on layout shafts
- **Synchromesh is really an improvement on dog clutch**

- The synchronizer is the main part of this gearbox that stabilizes the speed
  - kind of clutch which lets components turning at different speeds
- This synchronizer consists two parts:
  - Synchro cone
  - Baulk ring

- **Cone** is the **part of a gear** and **ring** is the part of the **synchronizer**
- The baulk ring prevents the gears engaging before they are rotating at correct speeds
- While engaging, the ring will gradually slide into the cone and the friction will slow or speeds up the gear wheel
- Finally, it stabilizes the speed of synchronizer gear and thus revolves at the same speed
- The gears on the lay-shaft are fixed to it while those on the main shaft are free to rotate on the same



Synchromesh Gearbox

Synchromesh Gearbox Animation

https://www.youtube.com/watch?v=slH9-02NbYg

Advantages

- Smooth and Noise free shifting of gears which is most suitable for cars
- No loss of torque transmission from the engine to the driving wheels during gear shifts
- Double clutching is not required
- Less vibration
- Quick shifting of gears without the risk of damaging the gears

Disadvantages

- It is extortionate due to its high manufacturing cost and the number of moving parts
- When teeth make contact with the gear, the teeth will fail to engage as they are spinning at different speeds which causes a loud grinding sound as they clatter together
- Improper handling of gear may easily prone to damage
- Cannot handle higher loads
- **Historically, heavy-duty freight truck transmissions do not have synchronizers.**

That's all for this lecture. . .

~THANK YOU~