G. PULLAIAH COLLEGE OF ENGINEERING AND TECHNOLOGY
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Permanently Affiliated to JNTUA, Ananthapuramu
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Nandikotkur Road, Venkayapalli, Kurnool – 518452

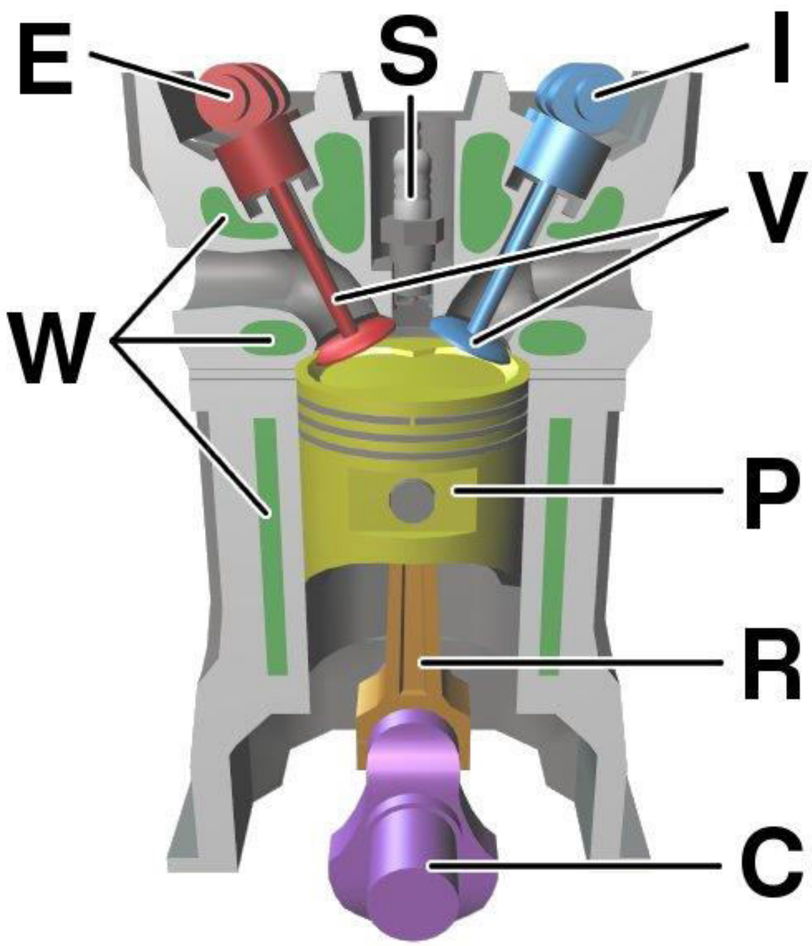
Department of Mechanical Engineering

Bridge Course
On
Automobile Engineering

UNIT -1

Engine: An **engine** or **motor** is a machine designed to convert one form of energy into mechanical energy. Heat engines burn a fuel to create heat, which is then used to create a force.

I**nternal combustion engine** (**ICE**): It is a heat engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine the expansion of the high-temperature and high-pressure gases produced by combustion applies direct force to some component of the engine. The force is applied typically to pistons, turbine blades, rotor or a nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy.



C : Crank shaft
E: Exhaust cam shaft
I : Inlet cam shaft
P : Piston

S: Spark plug
V : Valves
W : Cooling water jacket
R: Connecting Rod

4-stroke engines

1. Induction/Inlet stroke
2. Compression stroke
3. Power stroke
4. Exhaust stroke

The *top dead center* (TDC) of a piston is the position where it is nearest to the valves; *bottom dead center* (BDC) is the opposite position where it is furthest from them. A *stroke* is the movement of a piston from TDC to BDC or vice versa together with the associated process. While an engine is in operation the crankshaft rotates continuously at a nearly constant speed. In a 4-stroke ICE each piston experiences 2 strokes per crankshaft revolution in the following order. Starting the description at TDC, these are:[8][9]

1. **Intake**, **induction** or **suction**: The intake valves are open as a result of the cam lobe pressing down on the valve stem. The piston moves downward increasing the volume of the combustion chamber and allowing air to enter in the case of a CI engine or an air fuel mix in the case of SI engines that do not use direct injection. The air or air-fuel mixture is called the *charge* in any case.
2. **Compression**: In this stroke, both valves are closed and the piston moves upward reducing the combustion chamber volume which reaches its minimum when the piston is at TDC. The piston performs work on the charge as it is being compressed; as a result its pressure, temperature and density increase; an approximation to this behavior is provided by the ideal gas law. Just before the piston reaches TDC, ignition begins. In the case of a SI engine, the spark plug receives a high voltage pulse that generates the spark which gives it its name and ignites the charge. In the case of a CI engine the fuel injector quickly injects fuel into the combustion chamber as a spray; the fuel ignites due to the high temperature.
3. **Power** or **working stroke**: The pressure of the combustion gases pushes the piston downward, generating more work than it required to compress the charge. Complementary to the compression stroke, the combustion gases expand and as a result their temperature, pressure and density decreases. When the piston is near to BDC the exhaust valve opens. The combustion gases expand irreversibly due to the leftover pressure—in excess of back pressure, the gauge pressure on the exhaust port—; this is called the *blowdown*.
4. **Exhaust**: The exhaust valve remains open while the piston moves upward expelling the combustion gases. For naturally aspirated engines a small part of the combustion gases may remain in the cylinder during normal operation because the piston does not close the combustion chamber completely; these gases dissolve in the next charge. At the end of this stroke, the exhaust valve closes, the intake valve opens, and the sequence repeats in the next cycle. The intake valve may open before the exhaust valve closes to allow better scavenging.

2-stroke engines

The defining characteristic of this kind of engine is that each piston completes a cycle every crankshaft revolution. The 4 processes of intake, compression, power and exhaust take place in only 2 strokes so that it is not possible to dedicate a stroke exclusively for each of them. Starting at TDC the cycle consist of:

1. **Power**: While the piston is descending the combustion gases perform work on it—as in a 4-stroke engine—. The same thermodynamic considerations about the expansion apply.
2. **Scavenging**: Around 75° of crankshaft rotation before BDC the exhaust valve or port opens, and blow down occurs. Shortly thereafter the intake valve or transfer port opens. The incoming charge displaces the remaining combustion gases to the exhaust system and a part of the charge may enter the exhaust system as well. The piston reaches BDC and reverses direction. After the piston has traveled a short distance upwards into the cylinder the exhaust valve or port closes; shortly the intake valve or transfer port closes as well.
3. **Compression**: With both intake and exhaust closed the piston continues moving upwards compressing the charge and performing a work on it. As in the case of a 4-stroke engine, ignition starts just before the piston reaches TDC and the same consideration on the thermodynamics of the compression on the charge.

While a 4-stroke engine uses the piston as a positive displacement pump to accomplish scavenging taking 2 of the 4 strokes, a 2-stroke engine uses the last part of the power stroke and the first part of the compression stroke for combined intake and exhaust. The work required to displace the charge and exhaust gases comes from either the crankcase or a separate blower. For scavenging, expulsion of burned gas and entry of fresh mix, two main approaches are described: Loop scavenging, and Uniflow scavenging, SAE news published in the 2010s that 'Loop Scavenging' is better under any circumstance than Uniflow Scavenging

UNIT-II

Air pollution

Internal combustion engines such as reciprocating internal combustion engines produce air pollution emissions, due to incomplete combustion of carbonaceous fuel. The main derivatives of the process are carbon dioxide CO2, water and some soot — also called particulate matter (PM). The effects of inhaling particulate matter have been studied in humans and animals and include asthma, lung cancer, cardiovascular issues, and premature death. There are, however, some additional products of the combustion process that include nitrogen oxides and sulfur and some un combusted hydrocarbons, depending on the operating conditions and the fuel-air ratio.

Not all of the fuel is completely consumed by the combustion process; a small amount of fuel is present after combustion, and some of it reacts to form oxygenates, such as formaldehyde or acetaldehyde, or hydrocarbons not originally present in the input fuel mixture. Incomplete combustion usually results from insufficient oxygen to achieve the perfect stoichiometric ratio. The flame is "quenched" by the relatively cool cylinder walls, leaving behind unreacted fuel that is expelled with the exhaust. When running at lower speeds, quenching is commonly observed in diesel (compression ignition) engines that run on natural gas. Quenching reduces efficiency and increases knocking, sometimes causing the engine to stall. Incomplete combustion also leads to the production of carbon monoxide (CO). Further chemicals released are benzene and 1,3-butadiene that are also hazardous air pollutants.

Increasing the amount of air in the engine reduces emissions of incomplete combustion products, but also promotes reaction between oxygen and nitrogen in the air to produce nitrogen oxides (NO_x). NO_x is hazardous to both plant and animal health, and leads to the production of ozone (O_3). Ozone is not emitted directly; rather, it is a secondary air pollutant, produced in the atmosphere by the reaction of NO_x and volatile organic compounds in the presence of sunlight. Ground-level ozone is harmful to human health and the environment. Though the same chemical substance, ground-level ozone should not be confused with stratospheric ozone, or the ozone layer, which protects the earth from harmful ultraviolet rays.

Carbon fuels contain sulfur and impurities that eventually produce sulfur monoxides (SO) and sulfur dioxide (SO_2) in the exhaust, which promotes acid rain.

In the United States, nitrogen oxides, PM, carbon monoxide, sulphur dioxide, and ozone, are regulated as criteria air pollutants under the Clean Air Act to levels where human health and welfare are protected. Other pollutants, such as benzene and 1,3-butadiene, are regulated as hazardous air pollutants whose emissions must be lowered as much as possible depending on technological and practical considerations.

NO_x, carbon monoxide and other pollutants are frequently controlled via exhaust gas recirculation which returns some of the exhaust back into the engine intake, and catalytic converters, which convert exhaust chemicals to harmless chemicals.

Battery:

A battery is a source of electrical energy, which is provided by one or more electrochemical cells of the battery after conversion of stored chemical energy. In today's life, batteries play an important part as many household and industrial appliances use batteries as their power source.

Types of Batteries

Batteries can be divided into two major categories, primary batteries and secondary batteries. A primary battery is a disposable kind of battery. Once used, it cannot be recharged. Secondary batteries are rechargeable batteries. Once empty, it can be recharged again. This charging and discharging can happen many times depending on the battery type. Alkaline batteries, Mercury batteries, Silver-Oxide batteries, and Zinc carbon batteries are examples of primary batteries whereas Lead-Acid batteries and Lithium batteries fall into the secondary battery's category.

Lead-Acid Batteries

Lead-acid batteries are the rechargeable kind of batteries invented in the 1980s. These large, heavyweight batteries find the major application in automobiles as these fulfill the high current requirements of the heavy motors. The composition of Lead-Acid battery changes in charged and discharged states.
A combination of Pb (negative) and PbO_2 (positive) as electrodes with H_2SO_4 as electrolyte in charged form and $PbSO_4$ and water in discharged form.

Applications

The major application of lead acid battery is in starting, lightning, and ignition systems(SLI) of automobiles. Its other form, wet cell battery is used as backup power supply for high end servers, personal computers, telephone exchanges, and in off grid homes with inverters. Portable emergency lights also use lead acid batteries.

UNIT-III

A **gear** or **cogwheel** is a rotating machine part having cut *teeth*, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape.[1] Two or more meshing gears, working in a sequence, are called a gear train or a *transmission*. A gear can mesh with a linear toothed part, called a rack, thereby producing translation instead of rotation.

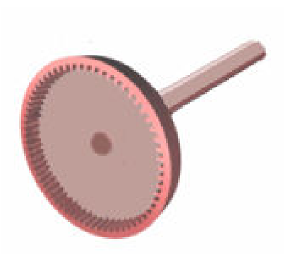
The gears in a transmission are analogous to the wheels in a crossed, belt pulley system. An advantage of gears is that the teeth of a gear prevent slippage.

When two gears mesh, if one gear is bigger than the other, a mechanical advantage is produced, with the rotational speeds, and the torques, of the two gears differing in proportion to their diameters.

In transmissions with multiple gear ratios—such as bicycles, motorcycles, and cars—the term "gear" as in "first gear" refers to a gear ratio rather than an actual physical gear. The term describes similar devices, even when the gear ratio is continuous rather than discrete, or when the device does not actually contain gears, as in a continuously variable transmission.

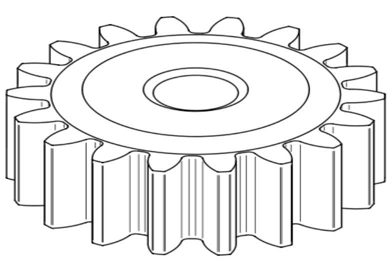
Types of Gears

An *external gear* is one with the teeth formed on the outer surface of a cylinder or cone. Conversely, an *internal gear* is one with the teeth formed on the inner surface of a cylinder or cone. For bevel gears, an internal gear is one with the pitch angle exceeding 90 degrees. Internal gears do not cause output shaft direction reversal.



Internal Gear

Spur gears or *straight-cut gears* are the simplest type of gear. They consist of a cylinder or disk with teeth projecting radially. Though the teeth are not straight-sided (but usually of special form to achieve a constant drive ratio, mainly involute but less commonly cycloidal), the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears mesh together correctly only if fitted to parallel shafts. No axial thrust is created by the tooth loads. Spur gears are excellent at moderate speeds but tend to be noisy at high speeds.

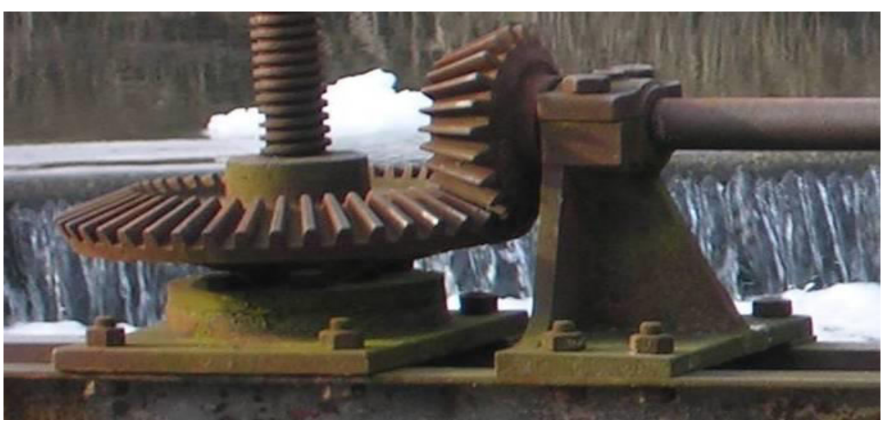


Spur Gear

Helical or "dry fixed" gears offer a refinement over spur gears. The leading edges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling makes the tooth shape a segment of a helix. Helical gears can be meshed in parallel or crossed orientations. The former refers to when the shafts are parallel to each other; this is the most common orientation. In the latter, the shafts are non-parallel, and in this configuration the gears are sometimes known as "skew gears".

Helical Gear

A bevel gear is shaped like a right circular cone with most of its tip cut off. When two bevel gears mesh, their imaginary vertices must occupy the same point. Their shaft axes also intersect at this point, forming an arbitrary non-straight angle between the shafts. The angle between the shafts can be anything except zero or 180 degrees. Bevel gears with equal numbers of teeth and shaft axes at 90 degrees are called *miter gears*

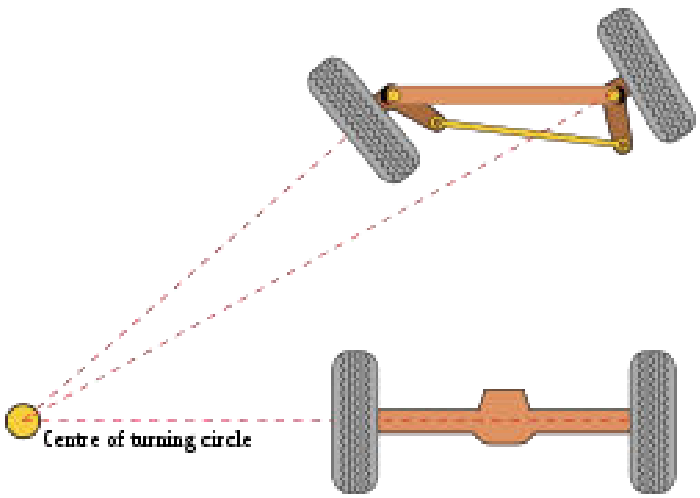


Bevel Gear

UNIT-IV

Steering

It is the collection of components, linkages, etc. which allows any vehicle (car, motorcycle, bicycle) to follow the desired course. he most conventional steering arrangement is to turn the front wheels using a hand–operated steering wheel which is positioned in front of the driver, via the steering column, which may contain universal joints (which may also be part of the collapsible steering column design), to allow it to deviate somewhat from a straight line. Other arrangements are sometimes found on different types of vehicles, for example, a tiller or rear–wheel steering. Tracked vehicles such as bulldozers and tanks usually employ **differential steering** — that is, the tracks are made to move at different speeds or even in opposite directions, using clutches and brakes, to bring about a change of course or direction.



The basic aim of steering is to ensure that the wheels are pointing in the desired directions. This is typically achieved by a series of linkages, rods, pivots and gears. One of the fundamental concepts is that of *caster angle* – each wheel is steered with a pivot point ahead of the wheel; this makes the steering tend to be self-centering towards the direction of travel.

The steering linkages connecting the steering box and the wheels usually conform to a variation of Ackermann steering geometry, to account for the fact that in a turn, the inner wheel is actually travelling a path of smaller radius than the outer wheel, so that the degree of toe suitable for driving in a straight path is not suitable for turns. The angle the wheels make with the vertical plane also influences steering dynamics (see *camber angle*) as do the tires

UNIT-V

Suspension System

It is the system of tires, tire air, springs, shock absorbers and linkages that c ems must support both road holding/handling and ride quality,[2] which are at odds with each other. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the road or ground forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different.

A **leaf spring** is a simple form of spring commonly used for the suspension in wheeled vehicles. Originally called a *laminated* or *carriage spring*, and sometimes referred to as a **semi-elliptical spring** or **cart spring**, it is one of the oldest forms of springing, dating back to medieval times.

A leaf spring takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. In the most common configuration, the center of the arc provides location for the axle, while loops formed at either end provide for attaching to the vehicle chassis. For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions. While the interleaf friction provides a damping action, it is not well controlled and results in stiction in the motion of the suspension. For this reason some manufacturers have used mono-leaf springs.

A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness. Some springs terminated in a concave end, called a *spoon end* (seldom used now), to carry a swiveling member.

The leaf spring has seen a modern development in cars. The new Volvo XC90 (from 2016 year model and forward) has a transverse leaf spring in high tech composite materials, a solution that is similar to the latest Chevrolet Corvette. This means a straight leaf spring, that is tightly secured to the chassis, and the ends of the spring bolted to the wheel suspension, to allow the spring to work independently on each wheel. This means the suspension is smaller, flatter and lighter than a traditional setup.

BRAKE

A **brake** is a mechanical device that inhibits motion by absorbing energy from a moving system.[1] It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction

Most brakes commonly use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat, though other methods of energy conversion may be employed. For example, regenerative braking converts much of the energy to electrical energy, which may be stored for later use. Other methods convert kinetic energy into potential energy in such stored forms as pressurized air or pressurized oil. Eddy current brakes use magnetic fields to convert kinetic energy into electric current in the brake disc, fin, or rail, which is converted into heat. Still other braking methods even transform kinetic energy into different forms, for example by transferring the energy to a rotating flywheel.

Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

Since kinetic energy increases quadratically with velocity ,an object moving at 10 m/s has 100 times as much energy as one of the same mass moving at 1 m/s, and consequently the theoretical braking distance, when braking at the traction limit, is 100 times as long. In practice, fast vehicles usually have significant air drag, and energy lost to air drag rises quickly with speed.

Friction brakes on automobiles store braking heat in the drum brake or disc brake while braking then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake.

When the brake pedal of a modern vehicle with hydraulic brakes is pushed against the master cylinder, ultimately a piston pushes the brake pad against the brake disc which slows the wheel down. On the brake drum it is similar as the cylinder pushes the brake shoes against the drum which also slows the wheel down.

Frictional brakes are most common and can be divided broadly into "shoe" or "pad" brakes, using an explicit wear surface, and hydrodynamic brakes, such as parachutes, which use friction in a working fluid and do not explicitly wear. Typically the term "friction brake" is used to mean pad/shoe brakes and excludes hydrodynamic brakes, even though hydrodynamic brakes use friction. Friction (pad/shoe) brakes are often rotating devices with a stationary pad and a rotating wear surface. Common configurations include shoes that contract to rub on the outside of a rotating drum, such as a band brake; a rotating drum with shoes that expand to rub the inside of a drum, commonly called a "drum brake", although other drum configurations are possible; and pads that pinch a rotating disc, commonly called a "disc brake". Other brake configurations are used, but less often.

A drum brake is a vehicle brake in which the friction is caused by a set of brake shoes that press against the inner surface of a rotating drum. The drum is connected to the rotating road wheel hub.

Drum brakes generally can be found on older car and truck models. However, because of their low production cost, drum brake setups are also installed on the rear of some low-cost newer vehicles. Compared to modern disc brakes, drum brakes wear out faster due to their tendency to overheat.

The disc brake is a device for slowing or stopping the rotation of a road wheel. A brake disc , usually made of cast iron or ceramic, is connected to the wheel or the axle. To stop the wheel, friction material in the form of brake pads (mounted in a device called a brake caliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop.

Ceramic brakes, also called "carbon ceramic", are high-end type of frictional brakes with brake pads and rotors made from porcelain compound blends, that feature better stopping capability and greater resistance to overheat. Due to their high production cost, ceramic brakes aren't widely used as factory equipment, and their availability on the automotive aftermarket is low compared to traditional metallic brakes. However, being performance-oriented equipment, ceramic brakes are popular among racers.