MAGNETIC LEVITATION:

The word levitation is derived from a Latin word “LEVIS”, which means light. Magnetic levitation is the use of magnetic fields to levitate a metallic object. By manipulating magnetic fields and controlling their forces, an object can be levitated. Because of the growing need for quicker and more efficient methods for moving people and goods, researchers have turned to a new technique; one using electromagnetic rails and trains. This rail system is referred to as magnetic levitation, or maglev. Maglev is a generic term for any transportation system in which vehicles are suspended and guided by magnetic forces. Instead of engines, maglev vehicles use electromagnetism to levitate (raise) and propel the vehicle. Alternating current creates a magnetic field that pushes and pulls the vehicle which weighs almost about 1500 tonnes and keeps it above the support structure, called a guideway.

- **PRINCIPLE 1:-(LEVITATION)**
  When the *like* poles of two permanent magnets come near each other, they produce a mutually repulsing force that grows stronger as the distance between the poles diminishes. When the *unlike* poles of two permanent magnets are brought close to each other, they produce a mutually attractive force that grows stronger as the distance between them diminishes.

- **PRINCIPLE 2:-(PROPULSION)**
  A repulsive force and an attractive force induced between the magnets are used to propel the vehicle (superconducting magnet). The propulsion coils located on the sidewalls on both sides of the guideway are energized by a three-phase alternating current from a substation, creating a shifting magnetic field on the guideway. The on-board superconducting magnets are attracted and pushed by the shifting field, propelling the Maglev vehicle.
This is a horizontal force which causes the movement of train. An EDS system can provide both levitation and propulsion using an onboard linear motor. An EMS system can only levitate the train using magnets onboard, not propel it forward. As such, vehicles need some other technology for propulsion. A linear motor mounted in the track is one solution. Over long distances where the cost of propulsion coils could be prohibitive, a propeller or jet engine could be used. As it requires 3 parameters 1) large electric power supply 2) metal coil lining, a guide way or track. 3) larger magnet attached under the vehicle.

- **LINEAR MOTOR**:
  Its principle is similar to induction motor having linear stator and flat rotor. The 3-phase supply applied to the stator produces a constant speed magnetic wave, which further produces a Repulsive forces. Propulsion can be implemented by the use of two main methods, a linear synchronous motor (LSM), and a linear induction motor (LIM).

- **Linear Synchronous Motor**
  A linear synchronous motor (LSM) in which coils in the guideway are excited by a three phase winding to produce a traveling wave at the speed desired; Transrapid in Germany employs such a system.

The Low-Speed Urban Maglev Program is using the LSM method for propulsion and transverse guidance. This option was chosen due to the large air gap of 25 mm. An LSM is also cheaper for situations where more train cars are on the track. The use of an LSM creates a guidance force, and increases the passive levitation force. Three-phase windings of solid copper cables along laminated iron rails are placed along the track [12]. The three-phase windings being used are shown in figure 16. LSM propulsion controls the velocity of the train by varying frequencies. If improper control is used, the train will vibrate above the LSM due to “slip.” The LSM method may be used for the Magnetic Levitation Technology 1, Sr. Project.
Linear Induction Motor
An LIM can be used to levitate a system. LIM’s have conventionally been used by placing electromagnets inside the train portion of the system. The track is typically made of an aluminum ladder. When the train passes over a wrung of the ladder, an electromagnet turns on, inducing a repulsive force in the track. This can both levitate, and propel the train. The same concept can be used by placing the electromagnets in the track.

On the basis of levitation principle, Magnetic Levitation is broken into three main types of suspension or levitation, they are –

1. Electromagnetic Suspension.
2. Electrodynamic Suspension.
3. Inductrack

Electromagnetic Suspension:

The electromagnets on the underside of the train pull it up to the ferromagnetic stators on the track and levitate the train. The magnets on the side keep the train from moving from side to side. A computer changes the amount of current to keep the train 1 cm from the track.

Electrodynamic suspension:

Electrodynamic suspension (EDS), both the rail and the train exert a magnetic field, and the train is levitated by the repulsive force between these magnetic fields. The magnetic field in the train
is produced by either electromagnets (as in JR-Maglev) or by an array of permanent magnets (as in Inductrack). The repulsive force in the track is created by an induced magnetic field in wires or other conducting strips in the track. At slow speeds, the current induced in these coils and the resultant magnetic flux is not large enough to support the weight of the train. For this reason the train must have wheels or some other form of landing gear to support the train until it reaches a speed that can sustain levitation.

Propulsion coils on the guideway are used to exert a force on the magnets in the train and make the train move forward. The propulsion coils that exert a force on the train are effectively a linear motor: An alternating current flowing through the coils generates a continuously varying magnetic field that moves forward along the track. The frequency of the alternating current is synchronized to match the speed of the train. The offset between the field exerted by magnets on the train and the applied field creates a force moving the train forward. The Electrodynamics Suspension system is more stable is that it is able to carry a much heavier weight load without having its levitation greatly affected. Propulsion coils on the guideway have coils running along the top and bottom of the SCMs. Induced current within these coils creates alternating magnetic fields that attract or repel the SCMs, sending the train in the forward or reverse direction.

Because the trains are moving by magnetic waves that push and pull it forward, it’s virtually impossible for trains to collide since they are in essence “riding the same magnetic waves”.

No engine or other power source is required to keep the train moving except the initial speed that is required to begin levitation. Therefore wheels are required to keep the train moving until about 100 km/hr (65 mph) where it can then begin to levitate.
Stabilized Permanent Magnet suspension:-

SPM maglev systems differ from EDS maglev in that they use opposing sets of rare earth magnets (typically neodymium alloys in a Halbach array) in the track and vehicle to create permanent, passive levitation; i.e., no power is required to maintain permanent levitation. With no current required for levitation, the system has much less electromagnetic drag, thus requiring much less power to move a given cargo at a given speed. SPM maglev systems require a mechanism to create lateral stability (i.e., controlling the side-to-side movement of the vehicle). One way to provide this stability is to use a set of coils along the bottom of the magnet array on the vehicle being levitated, which centers the vehicle over the rails by means of small amounts of current. Because the voice coils are not needed to provide lift and there is almost no drag, this system uses less power than other maglev systems: when the vehicle is centered over the rails, it uses no power. As the vehicle navigates a curve, the controller moves the vehicle to a ‘balance point’ inside the curve so that the (magnetic) centripetal pull of the magnetic rails in the ground offset the vehicle’s (kinetic) centrifugal momentum. This balance point varies based on the vehicle’s weight, which the controller automatically accounts for, resulting in zero steady state power consumption.

Principle of lateral guidance:-

The levitation coils facing each other are connected under the guideway, constituting a loop. When a running Maglev vehicle, that is a superconducting magnet, displaces laterally, an electric current is induced in the loop, resulting in a repulsive force acting on the levitation coils of the side near the car and an attractive force acting on the levitation coils of the side farther apart from
the car. Thus, a running car is always located at the center of the guideway

**Pros and Cons of different technologies:-**

Each implement of the maglev principle for train-type travel involves advantages and disadvantages. Time will tell us which principle, and whose implementation, wins out commercially.

<table>
<thead>
<tr>
<th>technology</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMS (Electromagnetic suspension)</td>
<td>Magnetic field inside and outside the vehicle are less than EDS; proven, commercially available technology that can attain very high speeds (500km/h); on wheels or secondary propulsion system is needed</td>
<td>The separation between the vehicle and the guideway must be constantly monitored and corrected by computer systems to avoid collision due to the unstable nature of electromagnetic attraction; due to the system’s inherent instability and the required constant corrections by outside systems, vibration issues may occur.</td>
</tr>
<tr>
<td>EDS (Electrodynamic suspension)</td>
<td>Onboard magnets and large margin between rail and train enable highest recorded train speeds (581km/h) and heavy load capacity; has recently demonstrated (dec2005) successul superconductors in its onboard magnets, cooled with inexpensive liquid nitrogen.</td>
<td>Strong magnetic fields onboard the train would make the train inaccessible to passengers with pacemakers or magnetic storage media like HDD and CC; necessitating the use of magnetic shielding; limitations on guideway inductivity limit the maximum speed of the vehicle; vehicle must be wheeled for travel at low speeds.</td>
</tr>
<tr>
<td>INDUCTIVE SYSTEM(Permanent magnet EDS)</td>
<td>Failsafe suspension- no power required to activate magnets; magnetic field is localized below the car; can generate enough force at low speeds( around 5km/h) to levitate maglev train; in case of power failure on their own safely halbach arrays of permanent magnets may prove more cost effective than electromagnets</td>
<td>Requires either wheels or track segments that move for when the vehicle is stopped. New technology (as of2008) and as yet has no commercial version or full scale system prototype.</td>
</tr>
</tbody>
</table>