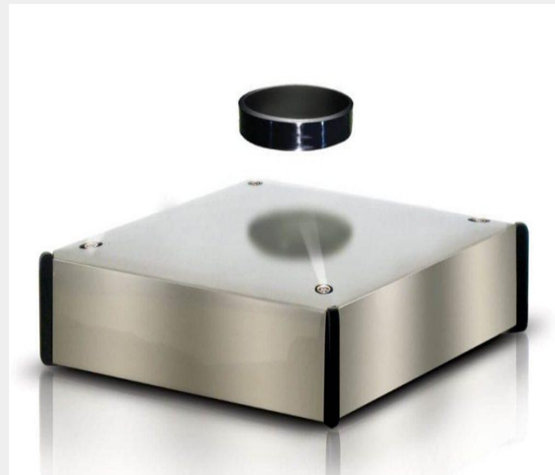
Magnetic Levitation

By Victor Young and Forest Young

Overview



What is Magnetic Levitation?

Magnetic levitation is a method by which an object is suspended only by magnetic fields.

Two things are involved in magnetic levitation: **lifting forces** and **stability**.

The lifting force counteracts gravity, and stability ensures that the object doesn't spontaneously flip.

Overview

Magnetic levitation (**maglev**) or **magnetic suspension** is a method by which an object is suspended with no support other than magnetic fields.

Magnetic force is used to counteract the effects of the gravitational force and any other forces.

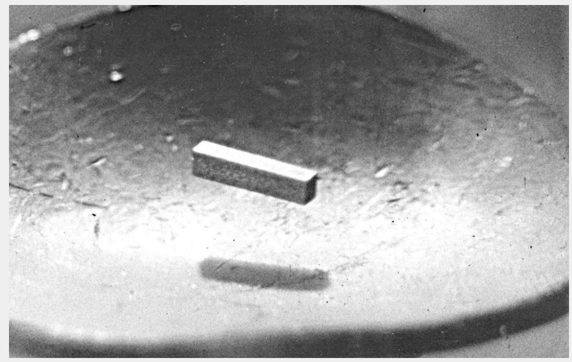
The two primary issues involved in magnetic levitation are *lifting forces*: providing an upward force sufficient to counteract gravity, and *stability*: ensuring that the system does not spontaneously slide or flip into a configuration where the lift is neutralized.

Magnetic levitation is used for maglev trains, contactless melting, magnetic bearings and for product display purposes. Moreover, recently magnetic levitation has been approached in the field of microrobotics.

History

- **1893**: Samuel Earnshaw proved Earnshaw's Theorem
    - Electrostatic levitation can't be stable
- **1913**: Emile Bachelet awarded patent
    - Electromagnetic suspension system
- **1933**: Walther Meissner and Robert Ochsenfeld discover Meissner effect
    - Superdiamagnetism
- **1934**: Hermann Kemper awarded Reich Patent
    - Monorail vehicle with no wheels attached

A small metal block is being levitated.



Overview

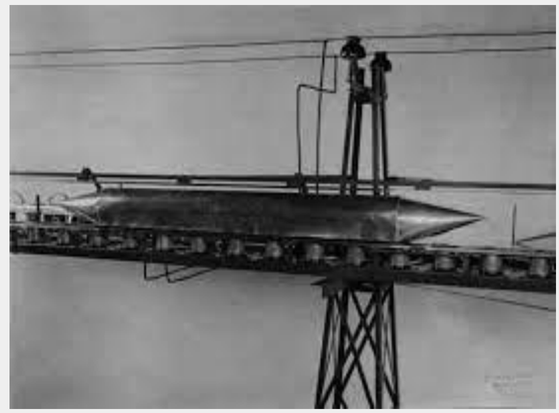
- 1839 Earnshaw's theorem showed electrostatic levitation cannot be stable; later theorem was extended to magnetostatic levitation by others
- 1913 Emile Bachelet awarded a patent in March 1912 for his "levitating transmitting apparatus" (patent no. 1,020,942) for electromagnetic suspension system
- 1933 Superdiamagnetism Walther Meissner and Robert Ochsenfeld (the Meissner effect)
- 1934 Hermann Kemper "monorail vehicle with no wheels attached." Reich Patent number 643316
- 1939 Braunbeck's extension showed that magnetic levitation is possible with diamagnetic materials
- 1939 Bedford, Peer, and Tonks aluminum plate placed on two concentric cylindrical coils shows 6-axis stable levitation.[25]
- 1961 James R. Powell and BNL colleague Gordon Danby

- electrodynamic levitation using superconducting magnets and "Null flux" figure 8 coils[7]
- 1970s Spin stabilized magnetic levitation Roy M. Harrigan
- 1974 Magnetic river Eric Laithwaite and others
- 1979 transrapid train carried passengers
- 1981 First single-tether magnetic levitation system exhibited publicly (Tom Shannon, Compass of Love, collection Musee d'Art Moderne de la Ville de Paris)
- 1984 Low speed maglev shuttle in Birmingham Eric Laithwaite and others
- 1997 Diamagnetically levitated live frog Andre Geim[13]
- 1999 Inductrack permanent magnet electrodynamic levitation (General Atomics)
- 2000 The first man-loading HTS maglev test vehicle "Century" in the world was successfully developed in China.[26]
- Present: Japan Fastest Maglev L0 series

History

- **1970s**: Roy M. Harrigan discovered spin stabilized magnetic levitation
- **1984**: Eric Laithwaite invented first maglev train
    - “Father of the Maglev Train”
- **1997**: Andre Geim levitated live frog
- **Present & Future**: Magnetic levitation research continues!

Emile Bachelet’s “The Showman and the Flying Train”



Overview

- 1839 Earnshaw's theorem showed electrostatic levitation cannot be stable; later theorem was extended to magnetostatic levitation by others
- 1913 Emile Bachelet awarded a patent in March 1912 for his "levitating transmitting apparatus" (patent no. 1,020,942) for electromagnetic suspension system
- 1933 Superdiamagnetism Walther Meissner and Robert Ochsenfeld (the Meissner effect)
- 1934 Hermann Kemper "monorail vehicle with no wheels attached." Reich Patent number 643316
- 1939 Braunbeck's extension showed that magnetic levitation is possible with diamagnetic materials
- 1939 Bedford, Peer, and Tonks aluminum plate placed on two concentric cylindrical coils shows 6-axis stable levitation.[25]
- 1961 James R. Powell and BNL colleague Gordon Danby

- electrodynamic levitation using superconducting magnets and "Null flux" figure 8 coils[7]
- 1970s Spin stabilized magnetic levitation Roy M. Harrigan
- 1974 Magnetic river Eric Laithwaite and others
- 1979 transrapid train carried passengers
- 1981 First single-tether magnetic levitation system exhibited publicly (Tom Shannon, Compass of Love, collection Musee d'Art Moderne de la Ville de Paris)
- 1984 Low speed maglev shuttle in Birmingham Eric Laithwaite and others
- 1997 Diamagnetically levitated live frog Andre Geim[13]
- 1999 Inductrack permanent magnet electrodynamic levitation (General Atomics)
- 2000 The first man-loading HTS maglev test vehicle "Century" in the world was successfully developed in China.[26]
- Present: Japan Fastest Maglev L0 series

Plans and Implementation

Right now and in the future, magnetic levitation can be used for:

- Transportation
  - Maglev Trains
  - Levicars
  - Vactrain
- Floating Cities
- Elevators
- Wind Turbines
- Weightlessness Studies
- Display Purposes

Futuristic model of a maglev train

Overview

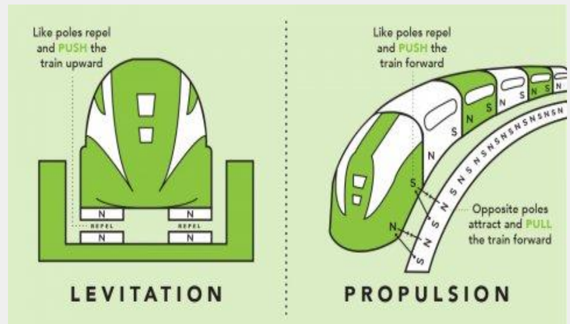
Magnetic levitation (maglev) can create frictionless, efficient, far-out-sounding technologies. Here are some of the craziest uses that engineers and designers have dreamed up.
Transportation: Each private pod, suspended from an elevated guideway, could carry three passengers and would use maglev technology to reach speeds of up to 150 mph
Floating cities: Wei Zhao, Whole country in the sky
Wind turbines: Old 1% New 20%
Weightlessness: In the presence of a strong magnet, water's electrons rearrange to oppose the magnet. When researchers expose living organisms to superconducting magnets, this molecular effect causes the organisms to levitate.

Maglev Trains

Maglev trains aren't widely used today, but they'll definitely be a major form of transportation in the future. Here are some characteristics of maglevs.

- Maximum speed is 505 km/h
- Uses electromagnetism to move
- Very quiet
- Efficient and environmentally friendly
- Levitated on cooled superconducting magnets
- Less turbulence

Maglevs use electromagnetism to stay levitated and move forward. Because *like poles repel*, the train can be levitated and propelled.



Overview

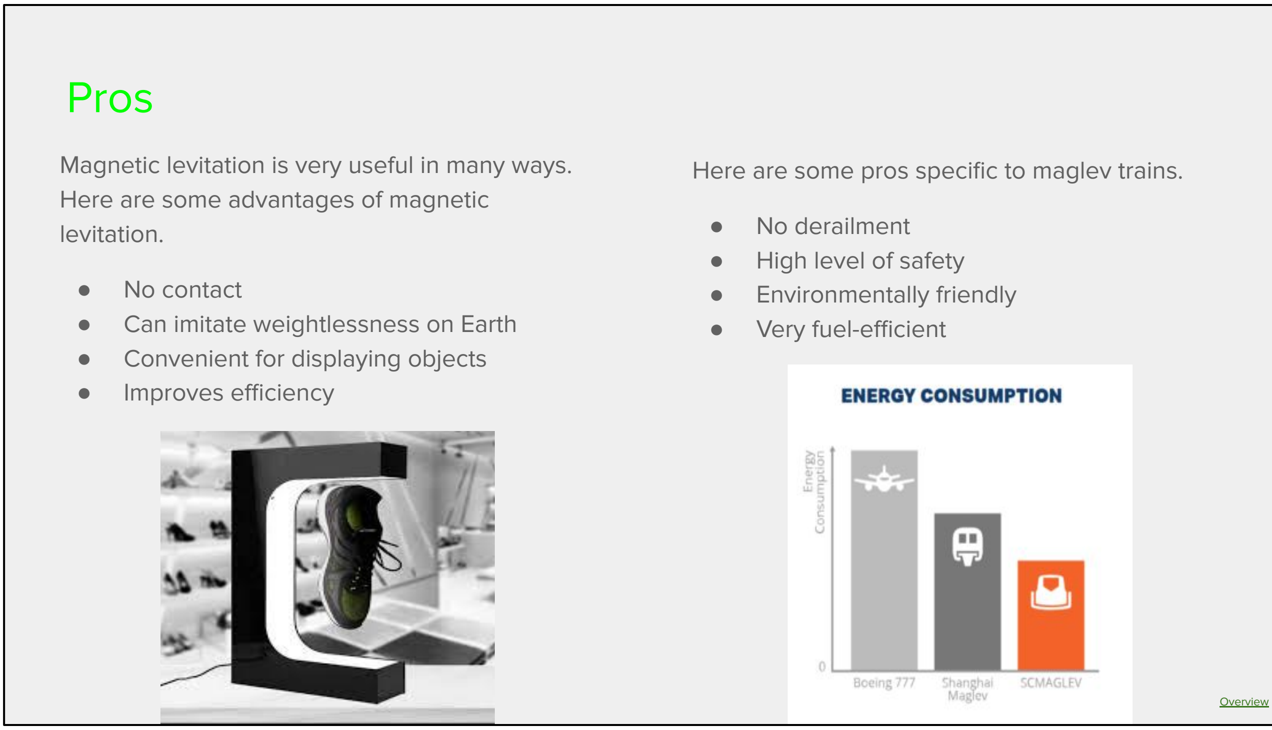
Maglev (derived from *magnetic levitation*), is a system of train transportation that uses two sets of electromagnets: one set to repel and push the train up off the track, and another set to move the elevated train ahead, taking advantage of the lack of friction.

With maglev technology, the train travels along a guideway of electromagnets which control the train's stability and speed. Maglev vehicles have set several speed records, and maglev trains can accelerate and decelerate much faster than conventional trains; the only practical limitation is the safety and comfort of the passengers.

A Maglev train car is just a box with magnets on the four corners. The magnets employed are superconducting, which means that when they are cooled to less than 450 degrees Fahrenheit below zero, they can generate magnetic fields up to 10 times stronger than ordinary electromagnets, enough to suspend and propel a train.

A rider experiences less turbulence than on traditional steel wheel trains because the only source of friction is air.

Any two trains traveling the same route cannot catch up and crash into one another because they're all being powered to move at the same speed.



This floating magnet design creates a smooth trip. Even though the train can travel up to 375 miles per hour, a rider experiences less turbulence than on traditional steel wheel trains because the only source of friction is air.

Another big benefit is safety. Maglev trains are “driven” by the powered guideway.

MagLevs use 30% less energy than normal trains. In theory, a MagLev and its track would require very little maintenance; since the train never touches the track there is virtually no wear and tear.

Maglev trains are extremely environmentally friendly as they have zero carbon emissions, since they run on electricity.

Maglev trains also reduce noise pollution compared to regular trains.

The foremost advantage of maglev trains is the fact that it doesn’t have moving parts as conventional trains do, and therefore, the wear and tear of parts is minimal, and that reduces the maintenance cost by a significant extent.

More importantly, there is no physical contact between the

train and track, so there is no rolling resistance. While electromagnetic drag and air friction do exist, that doesn't hinder their ability to clock a speed in excess of 200 mph.
Absence of wheels also comes as a boon, as you don't have to deal with deafening noise that is likely to come with them.
Maglevs also boast of being environment friendly, as they don't resort to internal combustion engines.
These trains are weather proof, which means rain, snow, or severe cold don't really hamper their performance.
Experts are of the opinion that these trains are a lot safe than their conventional counterparts as they are equipped with state-of-the-art safety systems, which can keep things in control even when the train is cruising at a high speed.

Cons

Here are some cons for magnetic levitation.

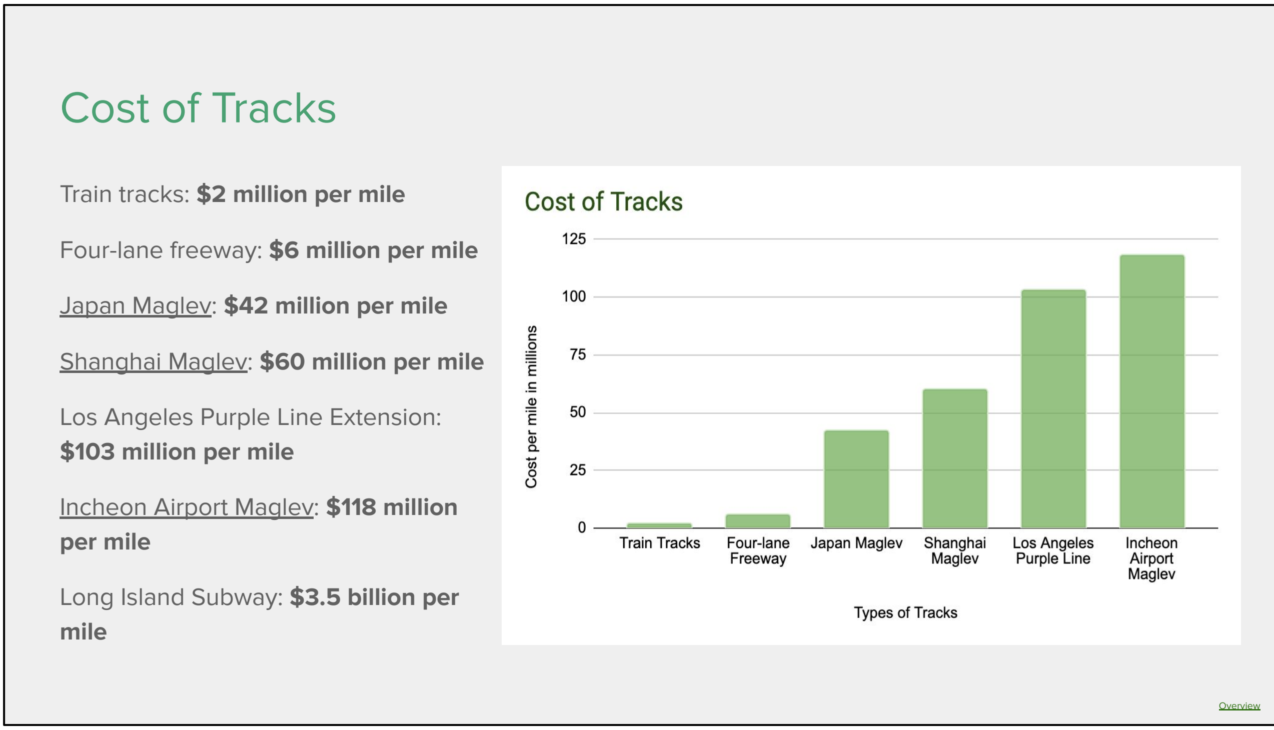
- Requires superconductors
- Superconductors have to be cooled to about 30 Kelvin
- Very Expensive

Here are some cons specific to maglev trains.

- Very expensive to build maglev tracks
- Not compatible with railroad tracks so whole new tracks will have to be built

Overview

Maglev guide paths are more costly than conventional steel railway tracks because the magnetic coils and material used in this setup are very costly.
The MagLev's track is much more expensive than railroad tracks.
maglev requires a dedicated infrastructure including substations and power supplies and cannot be integrated directly into an existing transportation system.
While the fast conventional trains that have been introduced of late, work fine on tracks which were meant for slow trains, maglev trains require an all new set up right from the scratch. As the present railway infrastructure is of no use for maglevs, it will either have to be replaced with the Maglev System or an entirely new set up will have to be created—both of which will cost a decent amount in terms of initial investment.



The estimated cost of the Long Island Rail Road project, known as “East Side Access,” has ballooned to **$12 billion**, or nearly **$3.5 billion for each new mile** of track.
The Shanghai Maglev, which happens to be the fastest train in the world, cost a whopping **$1.2 billion** dollars to build. At only 20 miles long, that is an incredible amount of capital cost. At that cost, it is about **$60 million dollars per mile of track**.

Summary

We don’t have any uncomfortable feelings towards this ever-growing technology. We think it is super cool and exciting to ride in a completely silent train!

- Useful, helpful, and important
- Present applications (E.X. maglev train)
- Future applications (E.X. floating cities)
- Cool!

Overview

Though not many countries can afford this type of technology, we think that magnetic levitation is very useful, helpful, and important.
Magnetic levitation is the ability to suspend things in air, so there are many applications regarding this technology, such as the maglev train. There are also many uses that require this technology that’s to be made in the future, such as floating cities.

References

https://northeastmaglev.com/2018/09/25/transportation-innovation-history-of-maglev-in-the-world/ By Northeast Maglev - September 25, 2018

https://www.popsci.com/diy/article/2004-02/ignorance-maglev-bliss/ By Theodore Gray - February 2, 2004

https://science4inquiry.com/LessonPlans/PhysicalScience/Magnetism/LevitationEngineersForcesFinal.pdf By Heather Miller - January 21, 2016

http://ffden-2.phys.uaf.edu/212_spring2011.web.dir/Chan_Jeon/proscons-of-maglev-train.html By Chan Jeon

https://www.sciencedirect.com/topics/engineering/magnetic-levitation By Donald M. Rote - 2004

https://wheelzine.com/advantages-disadvantages-of-maglev-trains By Wheelzine & Buzzle.com, Inc.

Overview

Cap + T = Kapptie