PROJECT DOCUMENTATION

PROJECT TITLE: Maglev

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BASIC AIM:

Our project is to build a miniature working model of MAGLEV, or more specifically, we will make a car that can be instructed to move forward or backward on a short magnetic linear track by means of magnetic levitation.

BACKGROUND:

Magnetic levitation (maglev) is an innovative transportation technology. It is sometimes said to be the first fundamental innovation in the field of railroad technology since the invention of the railway. A high speed maglev train uses non-contact magnetic levitation, guidance and propulsion systems and has no wheels, axles and transmission. The replacement of mechanical components by wear-free electronics overcomes the technical restrictions of wheel-on-rail technology. Compared with traditional railways, maglev systems have features that could constitute an attractive transportation alternative:

1. High Speed
2. High Safety
3. Less Pollution
4. Low Energy Consumption

PROJECT MOTIVATION:

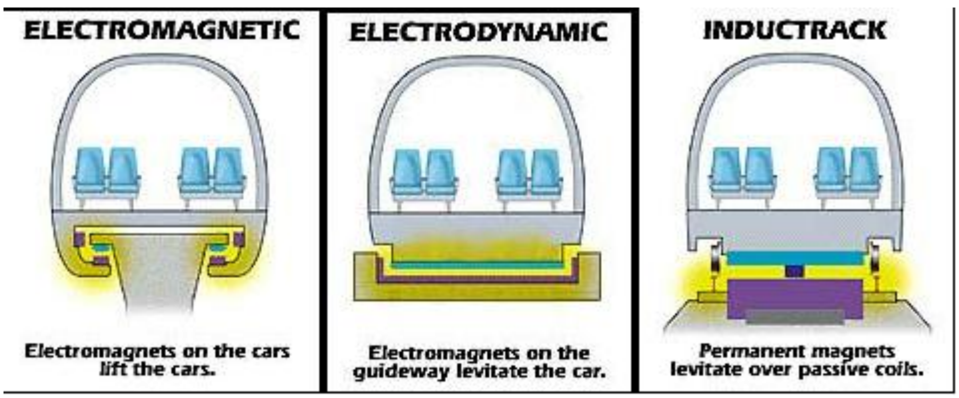
Magnetism has fascinated humans for centuries. So we were looking for a project based on the concept of magnetism. The idea for this project came after discussing with the coordinators and reading a Scientific American Article that described proposed maglev systems around the world and their potential for future travel.

THEORY OF OPERATION:

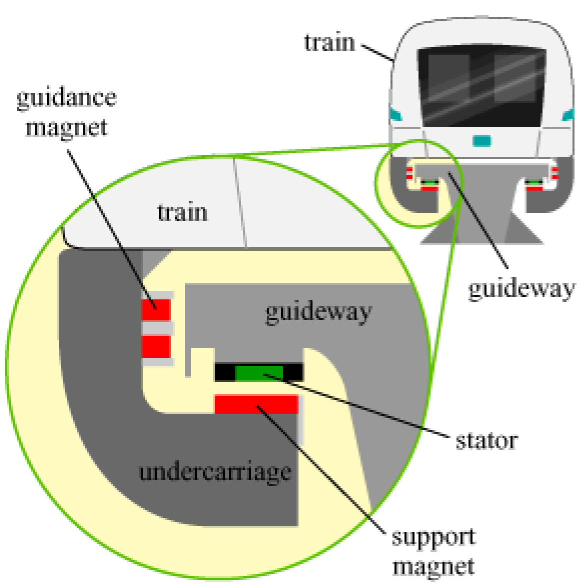
Maglev is defined as a "family of technologies in which a vehicle is suspended, guided, and propelled by means of magnetic forces". It consists of two parts:

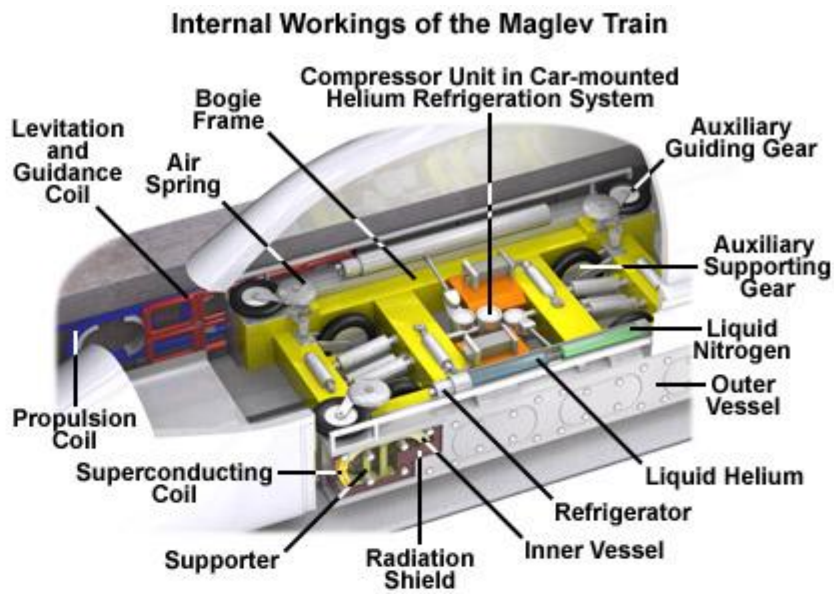
1. Propulsion System
2. Levitation System

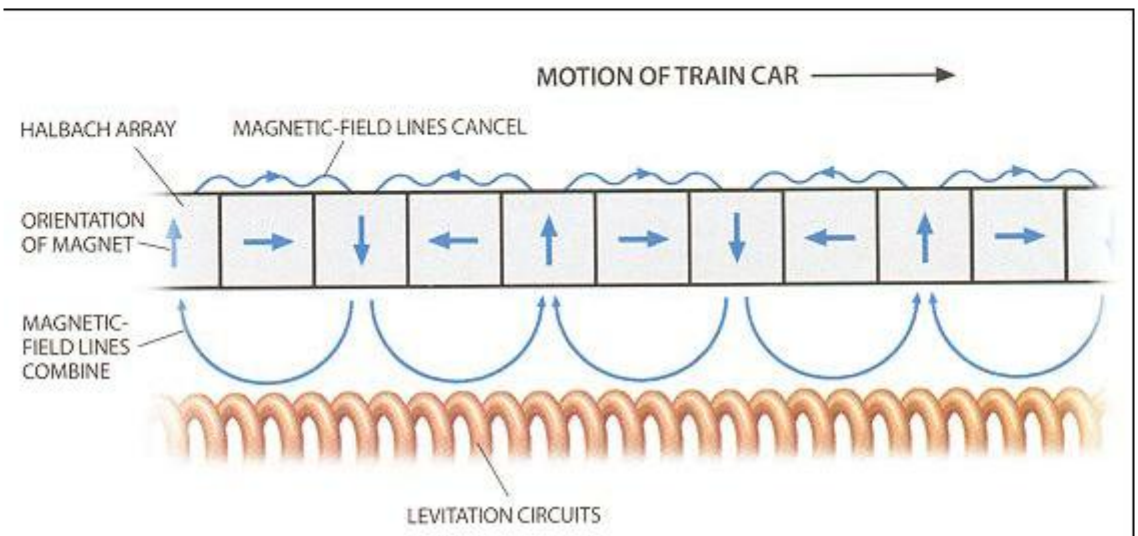
The propulsion system used is known as a linear motor. Unlike a conventional motor, a linear motor creates linear motion instead of circular motion. As mentioned above, the major principle behind its operation is magnetic repulsion.



TWO WAYS IN WHICH MAGLEVS WORK







The direction of these magnetic fields can be seen in figure. Since these magnetic fields are opposing each other, there is a repulsive force, which pushes the electromagnet away. The electromagnet experiences two repulsive forces, one from the electromagnet on one rail, and one from the other rail. The direction of these repulsive forces is away from their respective permanent magnets, and since the two permanent magnets are opposite of each other, in theory, the two repulsive forces would cancel each other out, and the net force would zero. However, there is an extremely low probability that the electromagnet is lined up exactly with the permanent magnets.

If the electromagnet is even the slightest bit off center - for example, if the electromagnet is further down than center, the force from the left permanent magnet will have a right and a down component, while the force from the right permanent magnet will have a left and down component. Though the left and right components cancel each other out by symmetry, there is still a net down component, giving the electromagnet, and therefore the train, a net acceleration downwards.

The electromagnet, initially when the train is started will in all probability not be perfectly lined up, so there will be a net force downwards. Also, if the train has some velocity, the train will have enough inertia to move to this point where it will feel the net force downwards, and will thus continue to move even faster downwards. Furthermore, the train will be in the magnetic field - which is the field due to the set of permanent magnets directly below the first set and the fields are pointing in the same direction, so there is an attractive force downwards (and by the same symmetry arguments used above, the train is also accelerated downwards by this set of forces as well).

When the train moves to the next set of magnets - the ones that it is attracted to – there will be an attractive force that resists motion. However, a sensor in the circuit senses the change in magnetic field, which sends a signal that causes the current to reverse. Thus the magnetic field of the electromagnet is in the opposite direction, the attractive force becomes a repulsive force, and the propulsion cycle continues.

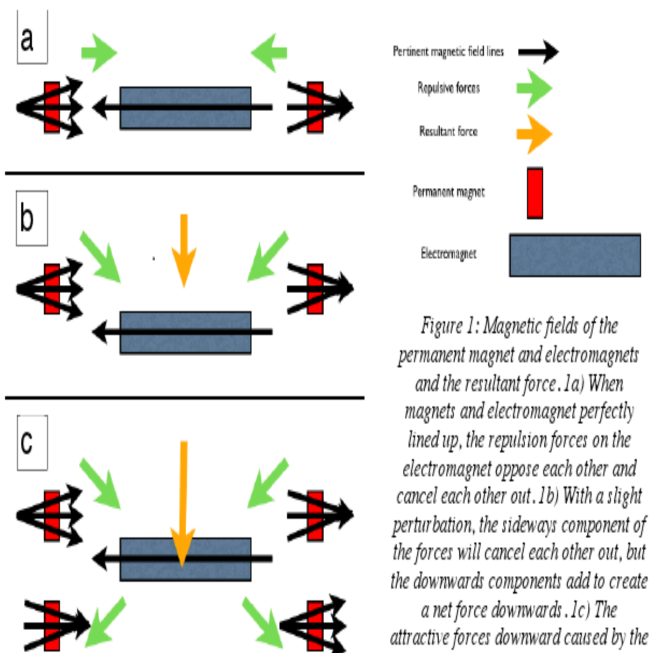


Figure 1: Magnetic fields of the permanent magnet and electromagnets and the resultant force. 1a) When magnets and electromagnet perfectly lined up, the repulsion forces on the electromagnet oppose each other and cancel each other out. 1b) With a slight perturbation, the sideways component of the forces will cancel each other out, but the downwards components add to create a net force downwards. 1c) The attractive forces downward caused by the next magnets in the series also result in a net downwards force, making the downwards pull even stronger.

To create levitation, a magnetic repulsion force is used to counteract the force of gravity. The right magnetic material must be used to achieve levitation. Magnetic materials are classified into three categories: paramagnetic, diamagnetic, and ferromagnetic. Among the three diamagnetic is the best option to go with since it repels the permanent magnet placed near it .

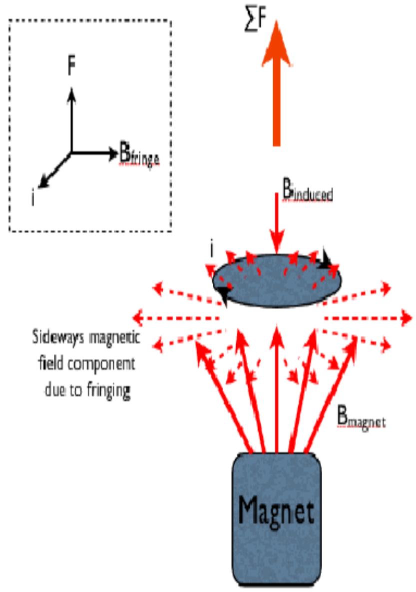


Figure 3: Model of a diamagnetic material repelling a magnet. The diamagnetic material is the disk in the center. A changing magnetic field induces a current in the material that opposes the magnetic field. In this example, current flows clockwise. Due to the fringing magnetic field from the permanent magnet, there is a field component on the same plane as the current flow. By the right hand rule, a force is felt perpendicular to the plane of current and field. In this example, this force is up. In all cases, the force will be pointing away from the magnet. (This can be shown using deduction analogous to this). Thus a diamagnetic material will always repel a permanent magnet or any type of net magnetic dipole.

HARDWARE CONFIQURATION :

Our project was actually of all hardware. Following are the works done:

Here is the pdf file of calculation regarding the force and solenoid.

SOLENOID:

According to our calculation we made four solenoids each of around 4500 turns.

TRACK:

Here is the pic of track we made.

1. We made 2 hollow boxes each of 100x15x7 cm length.
2. As in above figure we glued the magnets of length 40x25x4 mm on the horizontal surface called levitation path on both the boxes.

3. Similarly, we glued the magnets of length 25x7x3 mm on the vertical side of track which is called guide way path on both the boxes .
4. We joined the two boxes having both guidewey path facing each such that the distance between the two boxes was just little greater than the length of the solenoids. To reduce the disturbance, we used a stick and glued it to the solenoids.

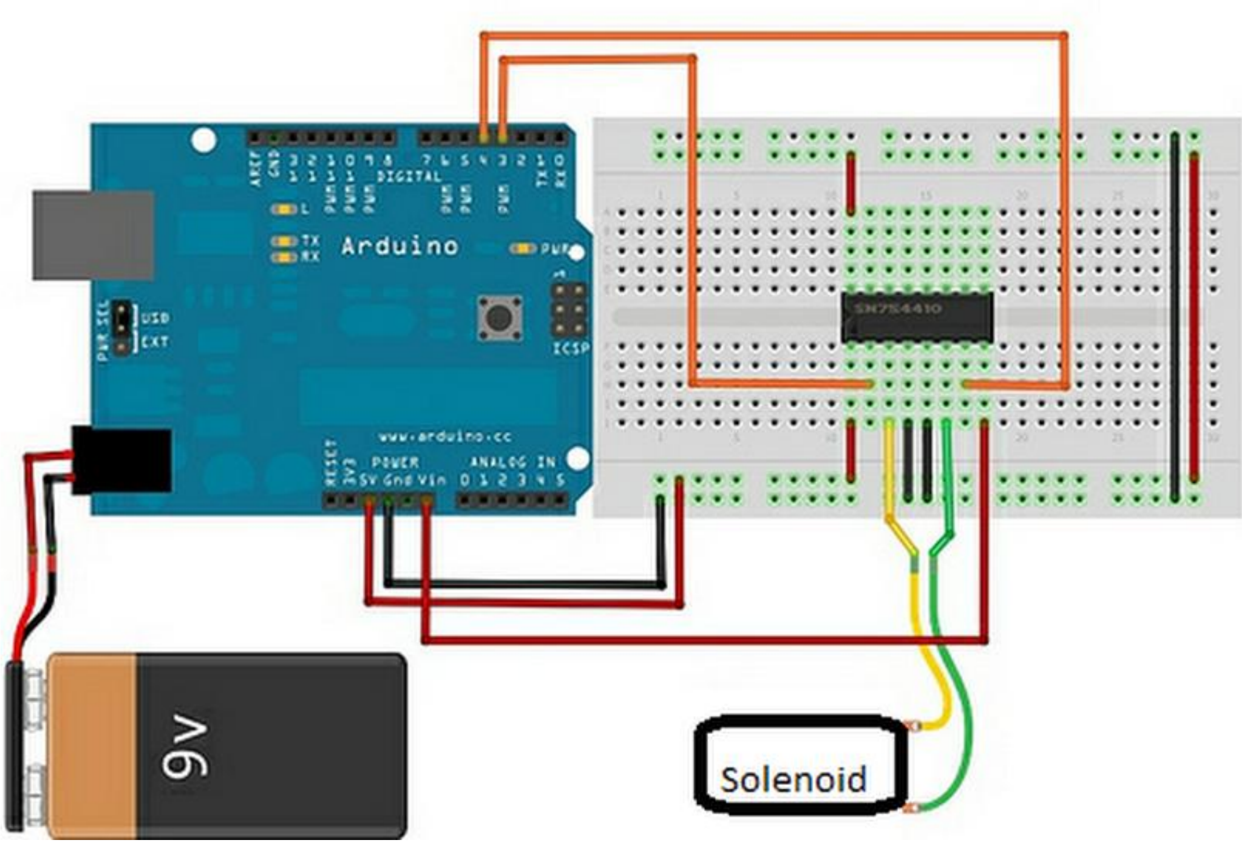
CAR

1. We used a light weight fibre sheet for car so that more levitation could be obtained.
2. We glued the three solenoids with epoxy on the car at appropriate distances according to our logic.
3. We then placed a piece of breadboard on the car with sensors connected on it.
4. We drilled holes in order to pass connecting wires through them to provide current to solenoids and also take reading from sensors to arduino and process them accordingly.

THE LEVITATION OF THE CAR

CIRCUIT EXPLANATION

For connection of one L293 and arduino, we connected pin1(enable), pin2 and pin7(input) to arduino's digital pins, pin3 and pin6(output) to solenoids' terminals, pin4 and pin5 to ground and provided external power to pin8(VS) for solenoid. Here is the schematic diagram-



ARDUINO AND CODING

Our coding logic is based on phenomenon of electromagnetic propulsion. After getting reading from hall effect sensor placed at appropriate distances, we turn of current in that solenoid whose centre coincides with that of guide way's magnet. If centre of solenoid is between two magnets, we pass current in them in such a way that the polarity of solenoid becomes opposite to that of approaching magnet such that they attract each other. This is for one side of solenoid. Since magnets with opposite polarities are placed on guide way, we don't need to worry about other face of solenoid, it automatically gets adjusted.

FURTHER IMPROVEMENTS

Though we could only levitate the train and not propel it forward because of many sort of problems we faced, we intend to study the problems more and try to do the other part of the project as well.

ACKNOWLEDGEMENTS

I would like to thank, our mentors for giving us ideas and suggestions, and for giving us feedback and keeping us on track with our project. I would also like to thank them for their help with the circuit design. I would like to thank physics workshop for their help with cutting the material for the final track and gluing magnets on track.

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