Model Maglev Train

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For my honors physics II project, I built a model Maglev train similar to the Inductrack in California and the Trans-Rapid in Germany. It uses repulsive suspension from permanent magnets to levitate the train similar to the one made in California. To propel my train, I made a linear induction motor similar to Germany's Trans-Rapid. This project uses the properties of electromagnets and permanent magnets that we learned about in class.

I levitated the train solely with the use of permanent magnets. I placed the permanent magnets at the four corners of the train, all orientated with the north poles pointing in the same direction. I then lined the track on each side with permanent magnets orientated in the opposite polar direction of the magnets on the train. This means that like poles of the magnets on the train and track face and repel each other. I thought that the levitation would be the easiest part of the construction process of my model maglev train but found it to be one of the hardest parts. This is because permanent magnets have dipole magnetic fields making it almost impossible to balance the train without using guide rails. These guide rails create friction and slow the train down. I used wood for the guidance rails since the kinetic friction is small compared to other materials.

A linear induction motor uses a controlled magnetic field to move a permanent magnet or electromagnet. I used this type of motor because I had a few ideas on how to control the magnetic field without the use of a complex computer program. I created electromagnets, called solenoids, using zinc pated bolts wrapped four layers thick with 20 gauge copper wire. When plugged up to a battery, the bolts become magnetized with a certain north to south pole orientation. I used the right hand rule we learned in class to decide the orientation of the electromagnet when plugged up to a battery. I aligned five of these electromagnets with alternating polar direction along the bottom of the track and connected them in series to maintain a larger current through the solenoids than what would be achieved in a parallel series of the same voltage. The direction of current through this circuit remains constant throughout the operation of the train.

The second part of my linear induction motor is attached to the train. I made another solenoid as described above and placed it in the center of the train perpendicular to the solenoids aligned under the track. I developed a method for alternating the current in this solenoid, which is a key factor to continuing the movement of the train down the track that I will describe in detail later. First, I created a snake like copper wire configuration shown in the diagram below where two wires snake back and forth in opposite directions. These wires are connected to each end of the battery but are separated by tape to prevent them from touching each other. I also attached brushes to each of the wires coming from the solenoid on the train. When the train is placed on the track, these brushes touch the snake-like wire configuration on the track and complete the circuit. At each intersection, the current through the solenoid is momentarily zero. The momentum of the train carries it until the brushes touch the wires again and the current through the solenoid changes direction. This changes the north-south pole orientation of the magnet.

The interaction of the solenoids under the track and the solenoid on the train creates the linear induction motor. The first solenoid under the track has a magnetic field that is orientated in the north to south direction when plugged up to a battery. When the train is placed on the track the brushes touch the copper wires creating a magnetic field in the solenoid on the train having its north pole nearest the solenoids under the track. Since this north pole is above the center of the first solenoid under the track, it is repelled by the north pole of the first solenoid and attracted by the south poles of the first and second solenoids. When it is between these two south poles, the solenoid on the train shuts off and is carried until current runs through it again. This time, the polar orientation of the solenoid changes and the south pole is nearest the solenoids under the track. Again, this end of the solenoid is repelled by the south poles of the first and second solenoid and attracted to the north pole of the second solenoid. This alternation of the polar orientation of the solenoid on the train continues as the train is pushed and pulled down the track. The only downfall of this method is that the brushes create a lot of friction as they brush the copper wires. I initially tried to alternate the current through the solenoids using reed switches, but they were too fragile and did not last long. Important to making the train move with this friction is the amount of current that is run through the solenoids. I used a 6-volt battery for the solenoid on the train and about 50 volts with around 10 amps for the solenoids under the track. This provides enough power to move the train forwards.

Many of the full-scale maglev trains use technology much more advanced than I was able to afford, which allows for the train to be completely frictionless and to control the electromagnets along the track. These trains use computer programs and sensors to detect the location of the electromagnet on the train and activate the electromagnets in the correct direction in front and behind the train. They also use superconducting magnets to provide much more powerful levitation. The designing of a linear induction motor for propulsion and the permanent magnet array for levitation to build my model maglev train gave me further insight and experience with electricity and magnetism.

Sources:

Dave Althoff, Jr., "Electric Voodoo: It's Done with Magnets," *First Drop Magazine*, Issue 53/54, accessed November 29, 2011, http://capital2.capital.edu/admin-staff/dalthoff/lim.html.

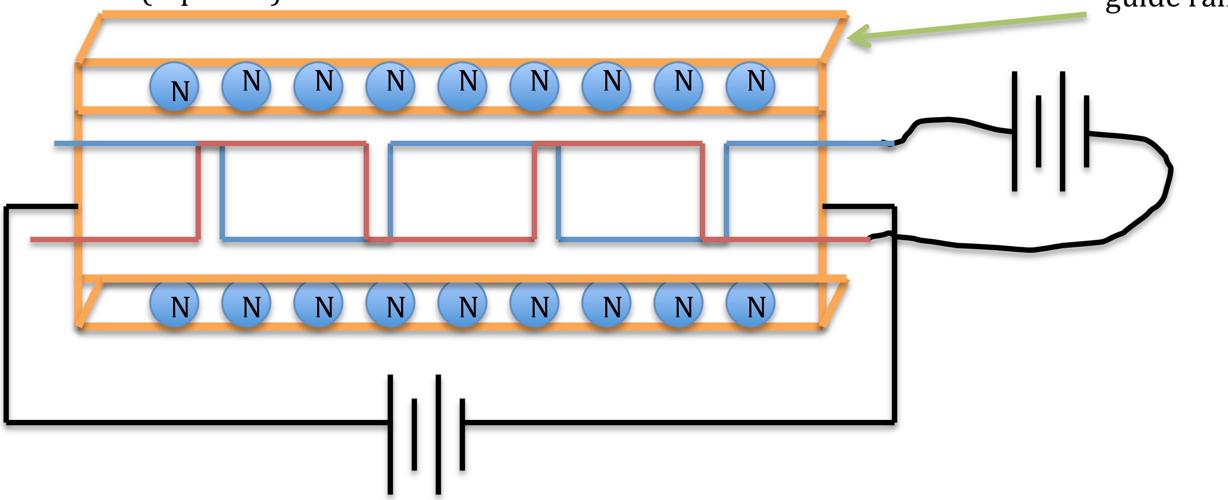
"How Do I Make and Electromagnet," Jefferson Lab, accessed November 29, 2011, http://education.jlab.org/qa/electromagnet.html.

Richard Freeman, *The Science of Maglev* (American Almanac, 1993), accessed November 29, 2011, http://american_almanac.tripod.com/maglev.htm.

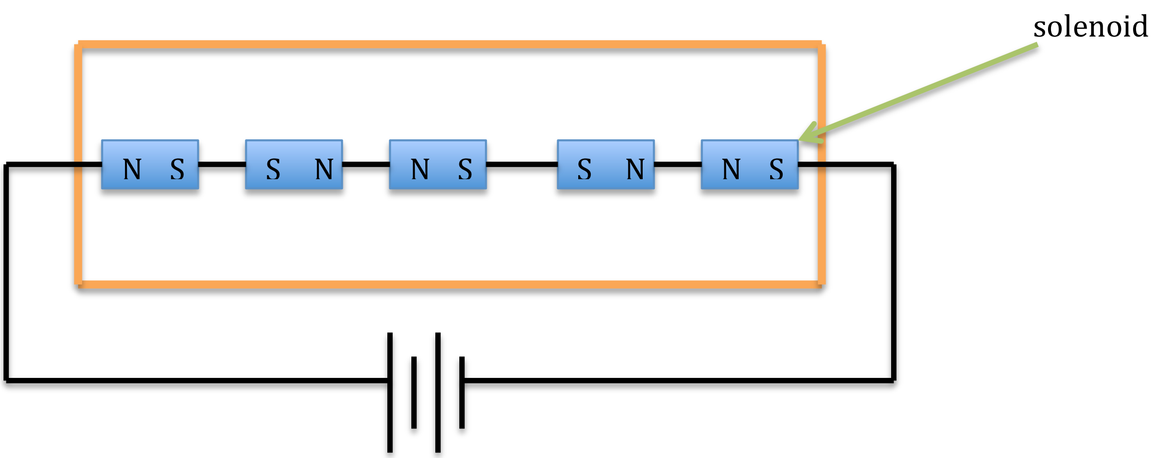
"Toward More Efficient Transport: The Inductrack Maglev System," accessed October 3, 2011, http://gcep.stanford.edu/pdfs/ChEHeXOTnf3dHH5qjYRXMA/09_Post_10_11_trans.pdf.

Paul Friend, "Magnetic Levitation Train Technology 1" (Final Report, Bradley University Department of Electrical and Computer Engineering, 2004), accessed November 29, 2011, http://cegt201.bradley.edu/projects/proj2004/maglevt1/MaglevTrain1FinalReport.pdf.

Track (top view):



Track (bottom view):



Train cart (side view):