The FUTURES Channel®

MOVIE GUIDE

MOVIE NUMBER **1004**

# Maglev Trains

## The Movie:

Gliding on a wave of electromagnetic force, a maglev (magnetic levitation) train could travel at 300 miles per hour or faster. Featured: James Powell, engineer, Brookhaven National Laboratories; Gordon Danby, physicist, Brookhaven National Laboratories. *(Movie length: 4:13)*

## Background:

The idea of flying through the air at hundreds of miles an hour is prosaic to most of today's travelers, used to the somewhat cramped and noisy environment of a modern jumbo jet. But it is very likely that, not long from now, hundreds of thousands of travelers each year will be flying through the air at hundreds of miles an hour in a quiet, roomy car that is moving only a few inches above the ground. Likely, that is, if the engineers, scientists and entrepreneurs behind the maglev train have their way.

Maglev trains are not a brand new idea: the concept occurred to U.S. physicist Robert Goddard and French inventor Emile Bachelet around 100 years ago, and the first patent for maglev trains was issued in 1934. But several factors have now come together to change the transportation scheme from a dream to a reality. These include scientific and engineering advances, new kinds of materials, and increasing demand for high-speed mass transportation.

Currently maglev trains are operating commercially in Germany and China, being tested in Japan, and being planned in various locations in the U.S.

## Curriculum Connections:

### 1 Networks, Measurement (distance, speed), Ratios

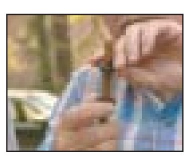
Get a map of the U.S. which shows all major cities.

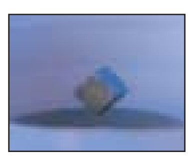
a) Create a network of maglev routes between at least 5 cities so that you can get from any one city to any other city, though not necessarily directly. Try to use the least possible amount of track to connect all of the cities.

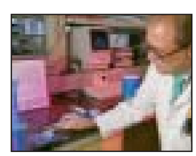
b) Assuming that the train will travel at 300 miles per hour, find the time of travel between all cities on the map (a total of 20 different travel times). Use the map legend to measure distances.

### 2 Measurement (temperature)

Some maglev trains use superconducting coils to produce a magnetic field; such coils have virtually no resistance and thus do not waste power. New materials are being researched which are superconducting at temperatures much higher than is currently required. One such material—a compound of Yerbium, Barium, Copper and Oxygen—becomes superconducting at around 100° Kelvin. What is this temperature in Centigrade and Fahrenheit?







## Measurement (speed, acceleration) 3

A maglev train begins a trip by accelerating from an initial speed of zero to its operating speed of, say, 150 meters per second.

Suppose that the rate of acceleration is 5 meters per second of speed increase each second. How long would it take to reach operating speed? You may wish to solve this problem by extending this table:

| # of seconds after beginning | Speed |
|---|---|
| 0 | 0 meters/second |
| 1 | 5 meters/second |
| 2 | 10 meters/second |
| 3 | 15 meters/second |
| 4 | etc. |

## Ratios, Measurement (transportation) 4

The amount of use of any form of mass transportation is measured in passenger-miles. For example, if there are 3 people in an automobile on a trip of 10 miles, that would be 30 passenger-miles. If there are 400 people in on a maglev train that travels 150 miles, that counts as 60,000 passenger-miles.

An automobile gets an average of around 20 passenger-miles for the energy in a gallon of gasoline (roughly 124,000 BTU's of energy). The Transrapid, a maglev train in Germany, is said to be three times as efficient. If that ratio applies, how much energy, measured BTU's, is required by the Transrapid to carry 300 passengers a distance of 50 miles?

## Algebra (solving equations) 5

It takes energy to get a maglev train up to speed; the amount of energy needed to reach a speed of *v* meters per second, starting from zero, is given by this formula

$$E = \frac{1}{2} mv^2$$

E = energy in joules
m = mass in kilograms
v = velocity in meters per second

a) How many joules of energy are required to bring a train with a mass of 20,000 kilograms to a velocity of 150 meters/second?

b) Suppose the same amount of energy were used on a train with a mass of 15,000 kilograms. What velocity would it reach?

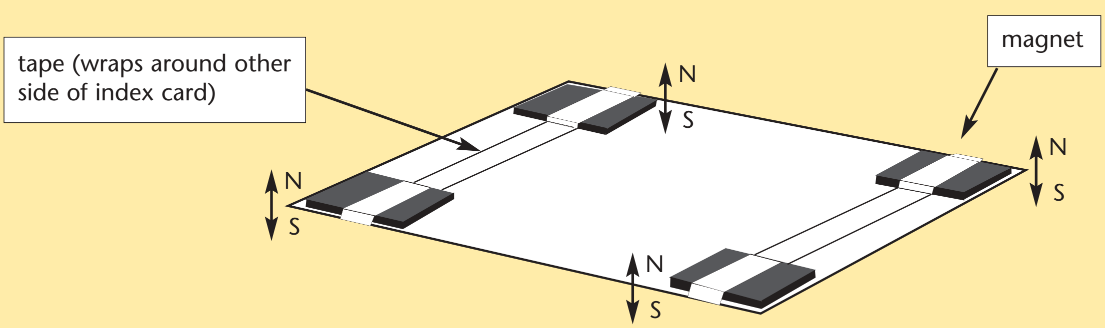
## Algebra (functions, linear equations) 6

In this experiment, students will build a magnetic testing device and use it to learn more about how magnets can levitate heavy objects.

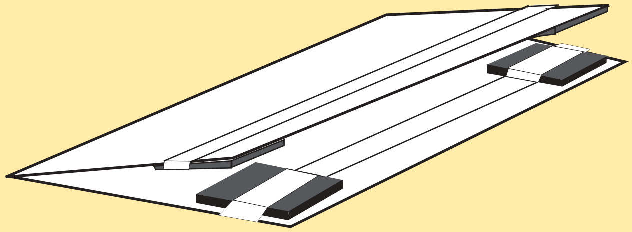
Students should work in teams of 4 members each. Each team will need these materials:

A few 4 x 6 index cards
Four small, flat magnets or magnetic strips
Masking tape
30 pennies

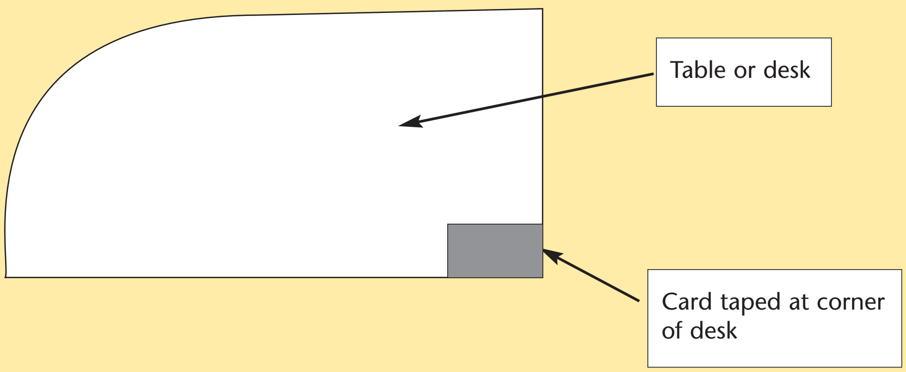
Step 1: Tape one of the flat magnets at each corner of a 4 x 6 index card. The magnets must be taped so that all have the same pole—north or south—pointing up.



2. Fold the card exactly in half across its width, so that the magnets oppose each other. Crease the fold sharply.



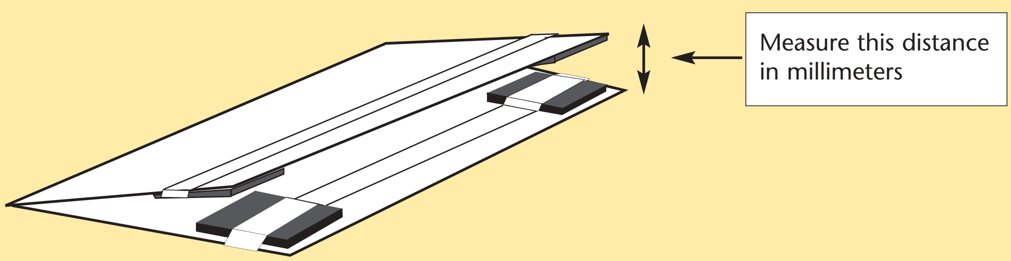
3. To complete the testing device, tape the bottom of the card to a corner of a table or desk (this will make it easier to measure the separation between the top and bottom of the card):



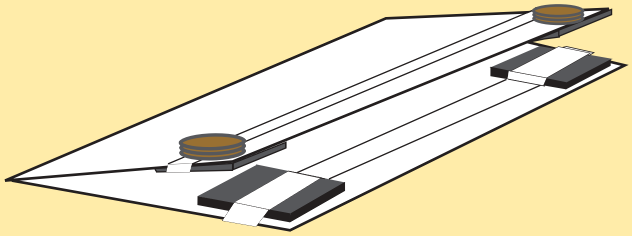

4. Next you are going to be stacking weights on the top of the card and measuring the changing distance between the top and bottom half of the card. Before carrying out the experiment, write down what you think will happen as you add more weight, and explain why.

5. The weights you will use will be stacks of 3 pennies. First, make 10 such stacks by taping 3 pennies together for each stack. (Note: Masking tape is recommended for both these weights and taping the magnets to the cards, because the tape has a slightly rough surface which will prevent the pennies from sliding off the top of the card.)

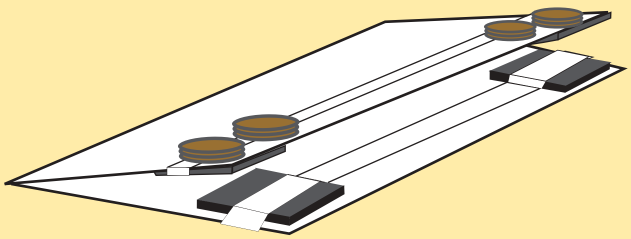
6. Measure the distance from the top to the bottom of the card:



7. Put two stacks of pennies on the top of the card, and measure the distance again.



8. Add more stacks of pennies, two at a time, each time measuring the indicated distance.



9. Make a table which presents the information you gathered, with "number of pennies" in one column and "distance" in the other column. Then graph the data in an *xy* coordinate system, with "number of pennies" as the independent variable and "distance" as the dependent variable.

10. Answer these questions:

a) Does the relationship between "number of pennies" and "distance" seem to be a function?

b) Is it a linear function? Explain your answer.

c) How many pennies would be required to close the distance to 1 millimeter? Explain your answer.

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