THE DEMONSTRATION CORNER

The Levitron

by

Alan Hirsch

Port Credit SS, Mississauga, ON 905-278-3382

What physics toy have you seen that can attract the attention of every passerby in a mall during the December shopping rush? And what toy can you expect your physics students to exclaim "hey, cool" when they see it? The answer to each of these questions is the same: The *Levitron*: The Amazing Antigravity Top.

Design and Operation

The *Levitron* consists of a magnetic top, a clear plastic lifter plate, and a wooden base in which are embedded some permanent magnets. Accessories include some wooden wedges to help keep the base level, and several washers to vary the mass of the magnetic top.

To operate the *Levitron*, the physics genius places the plastic lifter plate squarely on the wooden base, and twirls the magnetic top above the circle painted on the lifter plate (Figure 1). Once the top is spinning, the user gently raises the lifter plate about 2 cm until the top levitates and the lifter plate can be slipped away from under the top. The top will levitate in mid-air for two to three minutes, until the rotation rate is too low to maintain stability.

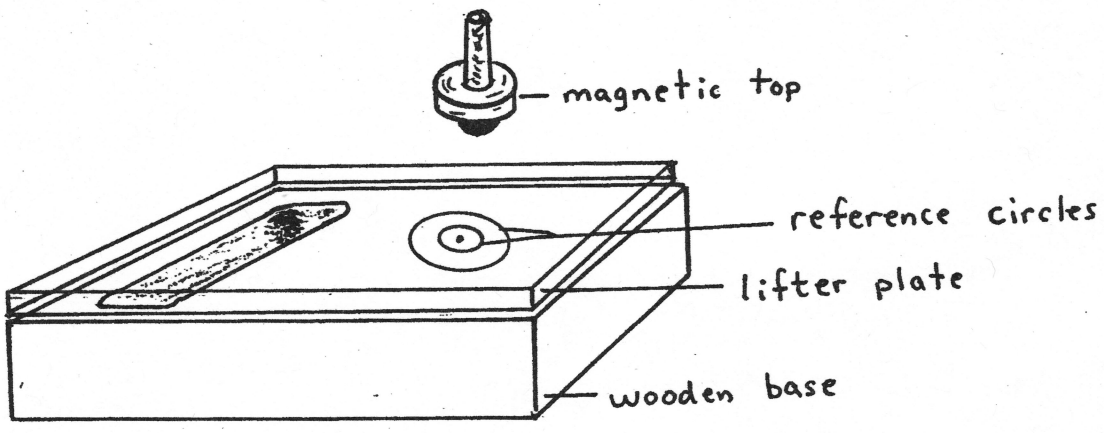


Figure 1 The arrangement of the *Levitron* components.

Co-ordination and Practice

Don't expect the *Levitron* to operate as easily as the above description indicates. There are many problems that must be avoided or overcome before you put on a levitation show for your students.

- Spinning the magnetic top in the presence of the repelling magnetic field takes a lot of coordination and practice.
- Adjusting the mass of the magnetic top involves trial-and-error by varying the number and sizes of the washers. With too little mass, the spinning top will fly away; with too much mass, the top will not levitate. Success at one location and on one day does not ensure success at a different location or on a different day. Fine tuning may be necessary at different locations or on different days. (One day when the top would not levitate at a certain location, I discovered that there was a steel support beam beneath the wooden tabletop where the base was positioned. Moving the base allowed success!)
- If the wooden base is not level, the spinning top will move to one side easily. Using trial-and-error to position the wooden wedges will help overcome this problem.
- A flying top can easily strike the floor, becoming chipped and reducing the chances of a well-balanced rotation. To prevent this problem, arrange a barrier on the desktop to prevent the top from falling to the floor.
- A major problem is buying a *Levitron* that never has worked properly. I recommend that you have the store salesperson prove that the device works before you pay for it. I had to exchange the first *Levitron* I bought because the top didn't levitate!

(**Demo** continued on page 3)

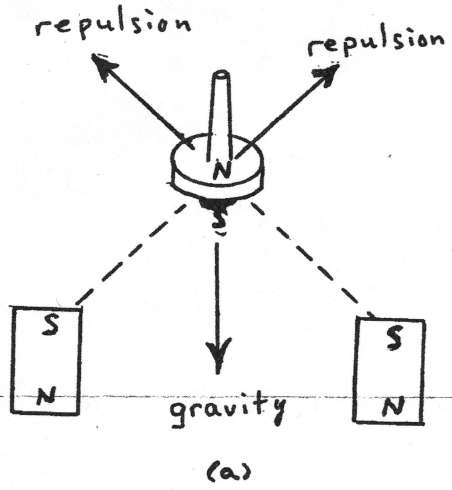
Column Editor: Ernie McFarland, Physics Dept., University of Guelph, Guelph, Ontario, N1G 2W1
Email: elm@physics.uoguelph.ca

Submissions describing demonstrations will be gladly received by the column editor.

(...Demo continued from page 4)

ENHANCING YOUR DEMONSTRATION

While you are demonstrating this amazing toy to your class, pose the questions listed below as well as others you may think of:



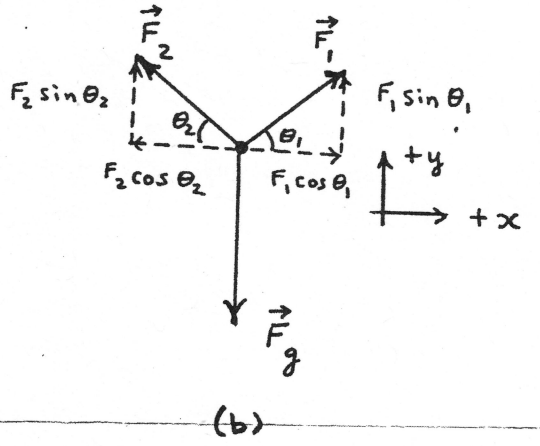


Figure 2 Forces acting on the top during levitation.

(a) Sketch of the situation (showing two of the four base magnets).

(b) A free-body diagram of the top.

- What is the shape of the magnet in the top? What are the possible arrangements of its poles? (The magnet is disc-shaped, with N on the top and S on the bottom, or *vice-versa*.)
- How can we discover the number and arrangement of the magnets in the wooden base? (This question confuses me because when I test the box with a magnetic compass or magnetic filings, I find that there are four separate permanent magnets in the base, whereas some references suggest there is one large disc magnet in the base.)
- When the magnetic top is spinning, what would happen if we were to try to pass our fingers (or a pen, or a ruler, or an aluminum bar, or a copper bar, or an iron bar, etc., etc.) between the magnet and the wooden base? (Try it and see!)
- Would the *Levitron* operate whether the base contained a single ring magnet or four smaller disc magnets arranged in a square?
- Can you draw a two-dimensional, free-body diagram of the levitating magnet to explain the forces acting on the spinning magnet during levitation? (Refer to Figure 2.)

AVAILABILITY

The *Levitron* is sold at The Nature Company, which has numerous stores in the USA and the following two outlets in Canada:

- The Eaton Centre on Yonge Street in Toronto, First Level: Phone 416-971-5858
- Sherway Gardens at the intersection of Highway 427 and the QEW in Etobicoke: Phone 416-621-2700

The price of the *Levitron* is $ 57.95, although The Nature Company offers a 15% discount on all items to teachers.

REFERENCES

Besides the instructions that accompany the *Levitron*, there are various resources in magazines and on the Internet that you may find interesting and useful. For example, if you use the Internet search engine called *Metacrawler* and enter the key search words "Levitron magnetic levitation," you will discover about one dozen articles, some of which are pertinent to the toy. It is interesting to find that some other purchasers of the toy discovered that the top would levitate only if the base was turned over! One serious article describes the physics of the top's motion, including the precession, and even describes how to set up a synchronous drive using Helmholtz-like drive coils to cause the top to remain perpetually levitated. The address for this site is:

http://www.physics.ucla.edu:80/marty/levitron/node8.html

A highly-recommended magazine article that mentions the *Levitron* as well as several other interesting demonstrations is called "Playthings of Science" by Fred Guterl, in the December, 1996, edition of *Discover*.

There have been at least three articles in *The Physics Teacher* that relate to magnetic levitation. These are:

Edge, Ron. "Levitation Using Only Permanent Magnets," *Phys. Teach.* Vol. 33, 252 (1995).

Kagan, D. "Building a magnetic levitation toy," *Phys. Teach.* Vol. 31, 432 (1993).

Rossing, T. and Hull, J. "Magnetic levitation," *Phys. Teach.* Vol. 29, 552 (1991).