Bouncing Magnets

Overview: Want to see a really neat way to get magnetic fields to interact with each other? While levitating objects is hard, bouncing them in invisible magnetic fields is easy. In this experiment, students will take two, three, or even four magnets and have them perform their antics.

What to Learn: We're putting together the ideas of the inverse square law and magnetic fields by having you play with the invisible magnetic lines of force.

Materials

- 3 identical magnets
- Optional: thick piece of aluminum metal

Lab Time

1. Stack two magnets on top of each other so they are all oriented in the correct direction.
2. Slide one off the top and find a magic spot where it hovers in mid-air. This takes patience, so work slowly.
3. Give the top of the floating magnet a *gentle* tap.
4. You should see the magnet vibrate in the air.
5. Using the clock or stopwatch, time how long it vibrates: _____(unit of time?)
6. Now restack the two magnets and add a third. Slide the top one off and move it to the side, away from where you're working, but be sure not to flip it.
7. Slide the second magnet off and again find a magic spot where it hovers in mid-air.
8. Slowly move the magnet that's off to the side toward you. You want to add it very slowly to the other side of the non-moving magnet.
9. Give one of the floating magnets a *gentle* tap. You should not only see the magnet vibrate in the air, but the second magnet moving as well.
10. Do you notice how sometimes one floating magnet moves more, and then slows down as the other floating magnet starts to increase its movement? What do you think is going on? Write it here:

    _____

    _____

    _____

11. You can adjust your two bouncing magnets to have nearly the same "bounce" (frequency) by changing their distance apart. Notice that when one magnet starts bouncing, the magnetic field changes, which pushes and pulls on the other magnet. The two magnets interact with each other through their magnetic fields, pushing and pulling each other into resonance. How far apart are your magnets when it works best?

    _____ (units?)

12. What happens if you try floating three or four magnets?

13. If you have a sheet of metal, like an aluminum cookie sheet, hover it above your bouncing magnets. What happens? Write it here:

    _____

    _____

Reading

While this activity may seem a bit trivial (and a little fun), the idea of a magnetic field is one of the greatest leaps ever made in science.

Scientist Faraday imagined the idea that a magnet had not only a magnetic field, but that it could push and pull on other magnets ***and*** moving electric charges. This crazy idea was so wild that it took many scientists a lifetime to come to terms with it… as it replaced an older idea from Newton that had stood for centuries. And, as usually happens when someone has a new bright idea, others are quick to add to it.

Shortly after Faraday's idea about magnetic fields and electrical charges, Maxwell combined complicated mathematics (stuff you'll only see at a university) into his four famous equations (Maxwell's Equations) that describe all electric and magnetic fields.

We're going to cover eddy currents in a later lesson, but the basic idea in case your students are chomping at the bit to know about it now is that when a magnet moves near an object that conducts electricity (usually metal), it creates electric currents called *eddy currents* which start to flow in the conductor. These eddy currents create magnetic fields (electricity causes magnetism as we'll see in the next set of experiments in *Electromagnetism*) in the opposite direction of the moving magnet, slowing an object down so it appears to float. In our experiment today, the eddy currents created in the metal by the moving (floating) magnets create an opposing magnetic field that work to "brake" the moving magnet and stop it from bouncing.

Exercises

1. Why does the magnet float?
2. After you tap the floating magnet, does it vibrate for a short or long time? Why?
3. Why do we stack the magnets first before trying to levitate them?
4. How many magnets can you get to interact while floating?
5. When you float two magnets above the main magnet, how do the floating magnets interact with each other? Why do they do that?

Answers to Exercises: Bouncing Magnets

1. Why does the magnet float? (Like poles repel each other, right? But there's one more step in understanding this experiment – it's not just the poles we are dealing with, it's the magnetic fields. Remember that a magnet has field lines that connect the two poles, and it's the magnetic fields that are doing the repelling.)
2. After you tap the floating magnet, does it vibrate for a short or long time? Why? (Loooong because there's little friction in the experiment.)
3. Why do we stack the magnets first before trying to levitate them? (Initially your magnets stack up because they are north on the top surface and south be the entire bottom surface. The poles are all facing the same way so the like poles will repel and levitate the magnet.)
4. How many magnets can you get to interact while floating? (My personal record is six.)
5. When you float two magnets above the main magnet, how do the floating magnets interact with each other? Why do they do that? (When one magnet starts bouncing, the magnetic field changes, which pushes and pulls on the other magnet. The two magnets interact with each other through their magnetic fields, pushing and pulling each other into resonance. There's an energy transfer going on between the magnets.)