

BOBBING FOR MAGNETS

ELECTROMAGNETIC INTERACTION AND THE THIRD LAW

Thanks to Don Walters of the Naval Postgraduate School - Monterey, California

Name: _____ Per: _____ Date: _____

APPARATUS

2 alnico bar magnets	2 weak* springs	2 support rods/stands	2 crossbars
2 collar hooks	2 air core solenoids	lantern battery	2 connecting wires
hand generator	demonstration (or sensitive) galvanometer ($-500 \mu\text{m}$ - 0 - $+500 \mu\text{m}$, for example)		

INITIAL SETUP AND PRE-DEMO QUESTIONS

A permanent bar magnet is suspended from a delicate (low force constant) spring. The NORTH pole of the magnet is facing down.

- Suppose the top of the solenoid suddenly acted like a magnetic south pole? It would then ____ attract ____ repel the dangling north pole of the bar magnet.
- Suppose the top of the solenoid suddenly acted like a magnetic north pole? It would then ____ attract ____ repel the dangling north pole of the bar magnet.

SQUARE PEG, ROUND HOLE

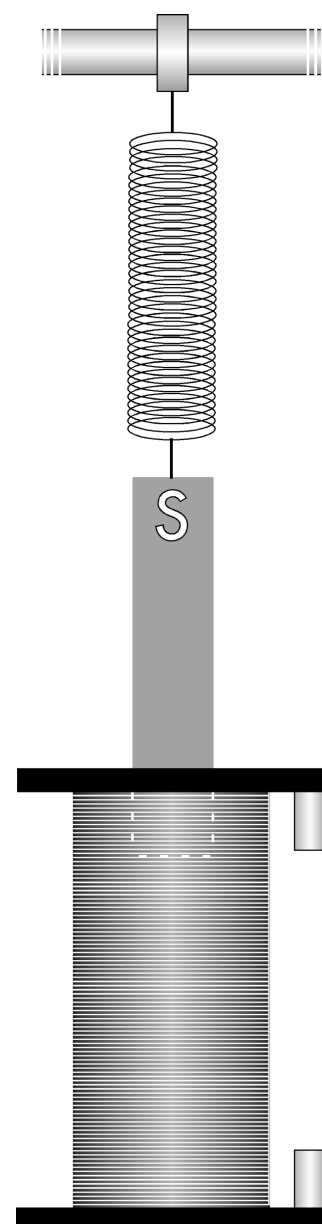
Arrange the air core solenoid so that the bottom of the suspended magnet is about two centimeters deep into the solenoid (at equilibrium). See diagram.

When the battery is connected to the solenoid, current will circle the immersed pole of the magnet as charge flows through the coiled wire.

- a. How does the magnet respond?

- b. What does this mean? That is, what was the behavior of the solenoid when current flowed through it?

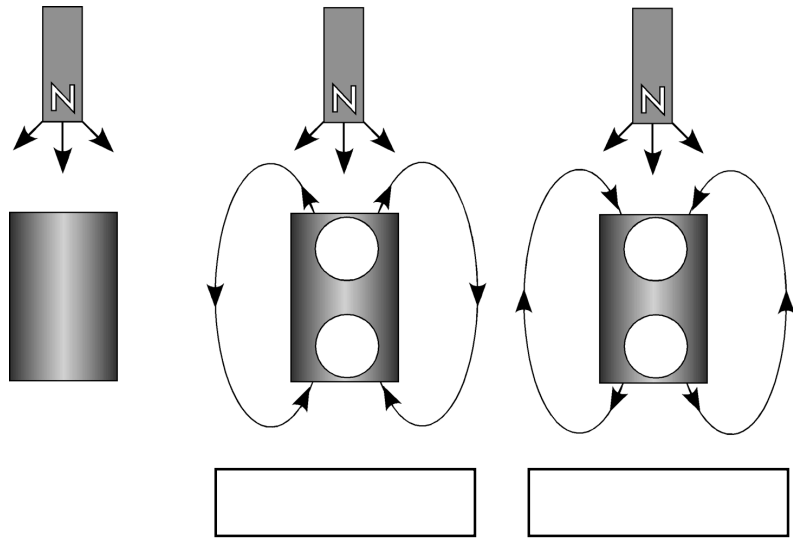
- c. Does the behavior change if the direction of current in the solenoid is reversed? Describe.



*such as those included in Pasco's Introductory Dynamics System—the force constants should be well-matched

The solenoid acts like a magnet when current passes through it.

The first diagram to the right shows the dangling north pole of the permanent magnet hanging above a solenoid. The other two show the magnetic field of the solenoid when current passes through it.



4. Add labels to those two diagrams to indicate which shows attraction and which shows repulsion. In the circles, indicate the poles of each electromagnet.

Disconnect the battery and connect the hand generator (Genecon).

5. a. Can the results obtained with the battery be reproduced using the hand generator? Describe.

RESONANCE

b. What is a resonant oscillation and what technique is used to establish it in this demonstration?

NEWTON'S THIRD LAW

6. These demonstrations show that a(n) _____ can exert a force

on a(n) _____. But if that's true, then a(n)

_____ must be able to exert a force on a(n)

_____.

ELECTRO-MAGNETIC—MAGNETO-ELECTRIC

Disconnect the Genecon and connect the galvanometer.

7. a. What technique is used to produce current in the solenoid?

b. This ___ confirms ___ contradicts the statement in part 6 above. Defend your answer.

8. a. When the magnet is moved into or out of the solenoid, _____ is induced, as shown by the galvanometer.

b. But _____ in the solenoid induces a _____,

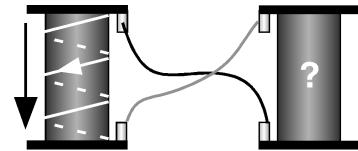
which should affect the bar magnet that's being moved to induce the _____ in the first place.

What's the nature of this induced magnetic field? Does it align with the bar magnet or oppose the bar magnet? Let's look for clues...

DOUBLING UP... OR DOWN?

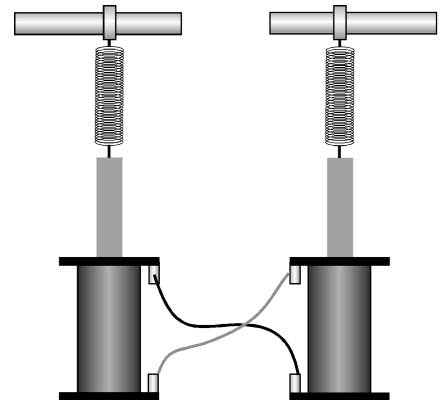
9. What's going on in the demonstration shown? Two magnets are suspended into two coils, north pole down. The coils are connected with wires.

a. If current were to spiral downward in one coil, which way would it go in the other coil?
 ___ spiral downward
 ___ spiral upward



b. This means the second coil is ___ a duplicate ___ an opposite of the first coil.

c. Observation. Describe what happens without trying to explain it.



d. Explanation. How does it work?

i. The moving bar magnet...

ii. The induced current flows ...

iii. Which induces a...

iv. The magnet in the second solenoid...

v. The motion of the bar magnets is best described as ___ in phase ___ out of phase. That is, as the first bar magnet is moving down, the second bar magnet is being pushed _____.

10. Since the current spirals in _____ in the solenoids, this demonstration shows that the current induced by the moving magnet induces a magnetic field that _____ aligns with the magnetic field of bar magnet.
 _____ opposes the magnetic field of the bar magnet.

LENZ'S LAW

11. The observations made in this demonstration should be consistent with Lenz's Law, which tells us that the magnetic field that results from an induced current opposes the change in the magnetic field that induced the current in the first place.

A CURRENT EVENT

12. a. Allow the magnet to oscillate into and out of a disconnected solenoid. That is, the terminals of the solenoid are not connected to anything. With the terminals free of any connections, the coiled wire of the solenoid represents an

_____ circuit, so _____ current flows through the coil and there is _____ magnetic field induced in the coil.

b. While the magnet bobs, connect the terminals of the solenoid to each other. What effect—if any—does this have on the bobbing?

c. Select a statement that corresponds to your observations.

_____ The current induced in the coil induces a magnetic field that tends to sustain the motion of the bar magnet.

_____ The current induced in the coil induces a magnetic field that has no effect on the motion of the bar magnet.

_____ The current induced in the coil induces a magnetic field that tends to diminish the motion of the bar magnet.

d. This observation _____ confirms _____ contradicts Lenz's Law.

MAGNETIC MOD

13. a. How can the demonstration apparatus be arranged so that the bobbing of the two bar magnets has the opposite nature from what was previously observed. That is, if they previously bobbed out of phase, how can they be made to bob in phase? Add to the diagram below to show the modification.

b. Does the suggested arrangement produce the desired results?

c. What is another way that the result could have been "reversed."

