BOBBING FOR MAGNETS
ELECTROMAGNETIC INTERACTION AND THE THIRD LAW X
Thanks to Don Walters of the Naval Postgraduate School - Monterey California

Name:____ Per:________ Date:______________

APPARATUS

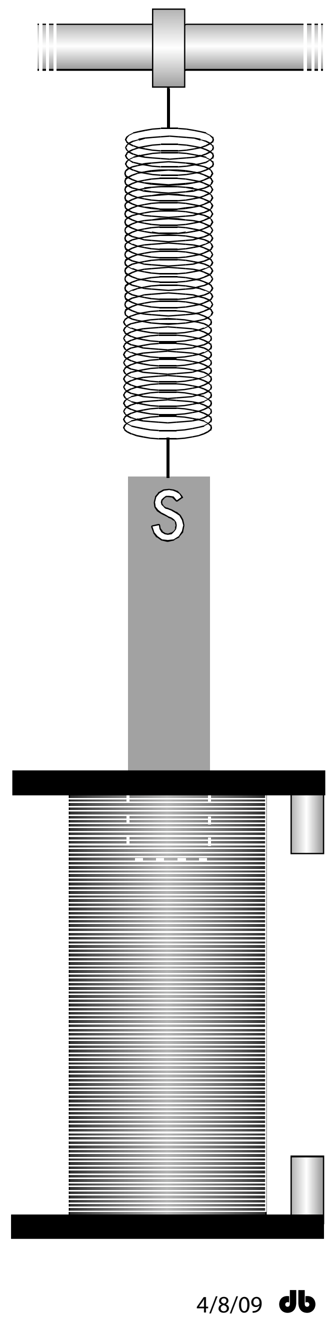
2 alnico bar magnets	2 weak* springs	2 support rods/stands	2 crossbars
2 collar hooks	2 air core solenoids	lantern battery	2 connecting wires
hand generator	demonstration (or sensitive) galvanometer (–500 μm-0-+500 μm, for example)		

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.

1. 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.

2. 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.

3. 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?

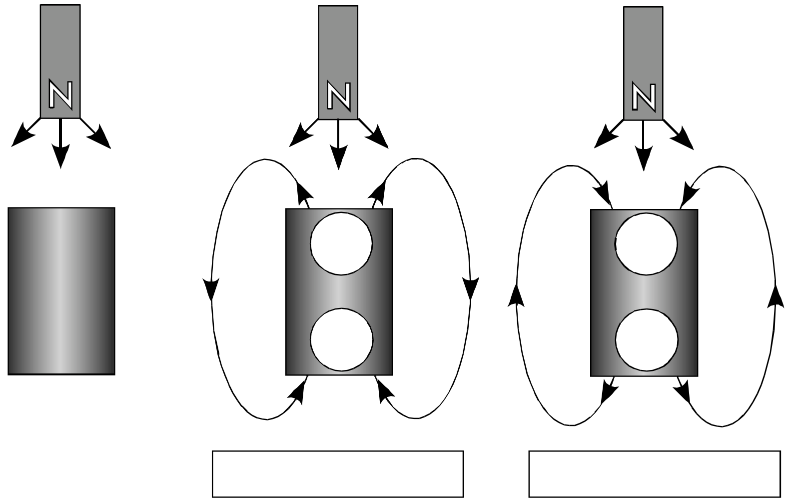
c. Does the behavior change if the direction of current in the solenoid is reversed? Describe.

*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 5 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...

A CURRENT EVENT

9. a. Allow the magnet to oscillate into an 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.

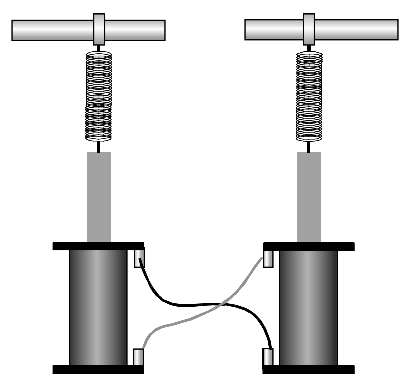
b. While the magnet bobs, connect the terminals of the solenoid to each other. What effect—if any—does this have on the bobbing?

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.

DOUBLING UP... OR DOWN?

10. 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

a. Observation. *Describe* what happens without trying to *explain* it.

b. Explanation. How does it work?
i. The moving bar magnet...

induces current in its solenoid.

ii. The induced current flows ...

in the other (second) solenoid, inducing a magnetic field around the second solenoid.

iii. The magnet in the second solenoid...

Moves in response to the induced magnetic field around the second solenoid.

iv. The motion of the bar magnets is best described as ___in phase _x_out of phase. That is, as the first bar magnet is moving down, the second bar magnet is being pushed ___up___.

11. Since the current spirals in ___in the same direction___ 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.
_x_opposes the magnetic field of the bar magnet.

LENZ'S LAW
12. 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.*

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.

Reverse the connections to the second solenoid
--or--
Reverse the orientation of one of the magnets

b. Does the suggested arrangement produce the desired results?

Yes! The magnets oscillate in phase; when one goes up, the other goes up.