



***Materials Needed for Assembly:***

- Glue (super OR hot)
- Razorblade
- Electrical Tape (Duct would also work)
- Screwdriver
- Wire strippers (Could be done without, but we used them to make it easier)
- Sandpaper
- 1/16” metal plates (be creative, we used spare door hinges)

QUANTITY:	DESCRIPTION OF MATERIAL:	COSTS:	RECOMMENDED PLACE OF PURCHASE:
6	1"x1/4" N45 Gold Platted NIB Magnets	\$3.00 Each Plus Shipping	Forcefield Magnets 877-944-6247
2	1/4" x 1/4" x 1/2" Bar NIB Magnets	\$1.00 Each Plus Shipping	Forcefield Magnets 877-944-6247
1	Rods of 1/8" graphite	\$26.00 for 12 rods	Ted Pella (tedpella.com/carbon_html)
1	Battery Holder (Prod. 270-0398)	\$0.99	Radioshack (Both Online & In Stores)
1	3V LED light (Prod. 276-026)	\$.99 for 2	Radioshack (Both Online & In Stores)
1	AAA Batteries (Prod. 230-0876)	1.99 for 2	Radioshack (Both Online & In Stores)
1	Photo-sensor (Prod. 276-1657)	\$2.49 for 5	Radioshack (Both Online & In Stores)
1	9V Battery Snap Connectors (Prod. 270-324)	\$1.99 for 5	Radioshack (Both Online & In Stores)
1	9V Battery (Prod. 230-0875)	\$2.89	Radioshack (Both Online & In Stores)
1	Breadboard Circuit Panel (Prod. 276-175)	\$7.99	Radioshack (Both Online & In Stores)
1	Capacitor (Prod. 272-996)	\$0.99	Radioshack (Both Online & In Stores)
1	Electrical Wire (Prod. 278-567)	\$4.49	Radioshack (Both Online & In Stores)
1	Resistors (Prod. 271-1125)	\$.99 for 5	Radioshack (In Stores only)
1	Fish Bowl (We used Round Critter Keepers)	\$4.99 In Store/ \$8.99 Online	Petsmart (Both Online & In Stores)
3	8-32 Screws	\$.09 each	Local Hardware Store
1	Flat Iron Plate (see AutoCAD drawing)	Depends Should Be Around \$40	Local Machine Shop
1	1"x1" Aluminum Foil	FREE Everyday Household Foil	Home
1	Cardboard box	FREE	Home/Grocery Store
1	A-D converter (DI-194RS)	\$24.95	Dataq Company www.dataq.com
1	Seismometer software	FREE	Download From AmaSeis

### ***Instructions On How to Build Your Seismograph:***

1. Take your six cylindrical magnets and set them up in pairs, so their sides are together. You should have 3 sets of two. Note: these magnets are very fragile and if they snap together they can brake. Keep these sets about a foot from each other.
2. Now, take a pair in each hand and set them together end to end. Again use caution these magnets will brake and/or pinch your fingers. You should decide which set will be your center set and try to get the other two sets to attract end to end on each side of the center pair. By the end of this step you should have all six magnets in two columns with three magnets in each column.
3. If you have not already done so place screws in plate and with the screwdriver make the plate level. Note: it does not have to be perfectly level right now the graphite will serve as a leveling device later.
4. You will now take the iron plate and decide which screw you wish to be you main adjustment. Set the magnet columns up so the valley between the columns is lined up with the main adjustment screw, going through the center of the plate. Note: try to be as close to the center of the plate as possible.
5. With the two columns on the plate, cut a piece of cardboard about 3/8" wide and about 3 1/2" long from one of the lid flaps of the box. A razor or a stout pair of scissors will work. Now, starting at one end of the columns pry the magnets apart and slide the cardboard between the two rows of magnets. This can be difficult and an extra pair of hands does help. If you are having trouble getting the magnets apart use the screwdriver to wedge between the columns. This spacing will make the graphite float higher. Note: make sure the cardboard does not stick up between the magnet valley too high; this could cause the graphite to rub against it. Trim the excess cardboard from the ends of the columns.
6. Take your 2 rectangular magnets and attract them to each end of the columns. These serve as both a stopper and make it possible to extend the period a small amount.
7. Take rod of 1/8" graphite and cut it into a piece 2" long. A razorblade works good here but be careful. A screwdriver also worked but it did not make the fine cut. If cut is sloppy just rub ends gently against sandpaper to smooth out.
8. For this step try to be in a shop or area you don't mind getting it a little dirty. Take the 2" piece of graphite and wedge it between two 1/16" metal plates. Begin sanding, as you go make sure to hold the plates firmly together so the graphite does not slip. Sand down until graphite surface is flush with the metal plates. This should leave you with a half cylinder rod of graphite. This takes some weight away and allows for rotational stability (like a boat) so the sail can be attached more easily.
9. Cut a piece of aluminum foil 1" long and 1/4" wide, a razor works well. Now take that sliver of aluminum foil and fold 1/8" in from one end. Then take the long tail left and fold it back 1/16." Then take what is left of the tail and fold it in half so that it touches the base just made. Stand up the sail, so a sort of up side down T is formed.

10. With the graphite find the relative center and a put a drop of super glue down, on the flat area you made before. Have paper towel or napkin ready in case of excess glue dripping. Now place aluminum sail on graphite and let dry.
11. This is where the process might get a little tricky. Take the breadboard, photo-sensor, electrical wire, battery holders, resistors and capacitor. On the breadboard each row and column is labeled with a number or letter. We will use this system to explain where each wire will go. Make sure you have the board long from left to right with the words Experimental 350 to the right.

Capacitor- (H,15) to (E,12)

Signal wire (electrical wire)- Positive (C,12) Negative (F,10)

9V Power- Positive (C,15) Negative (H, 10)

Photo-Sensor- (J,15) to (J,10)

Resistor One- (E,15) to (G,15)

Resistor Two- (G,10) to (D,12)

AAA Power- Positive in (F,3) Negative in (F,1)

Power to LED (electrical wire)- Positive out (J,3) Negative out (J,1)

12. Now take the LED and wrap a piece of tape around the base of the light to the end of the light. This will help concentrate the light on the area you want. Bend the wires so you have the LED raised a little. Bend the light 90 degrees one way and about ¼” down bend the wires again 90 degrees the other way. This should look like a lazy S. Mount this unit on a square of cardboard 1”x1” with glue.  
Note: Make sure to leave yourself enough wire on the ends to attach the battery.
13. Mount the LED and it’s pad with hot glue on one side of the magnet columns near the center. The LED light should be pointing across the valley of the magnets somewhere near the center of the middle magnet.
14. Now, take the assembled breadboard and mount it with hot glue on the other side of the column, with the photo-sensor facing the LED.
15. This step is for visual pleasure only, take the 9V batter and AAA battery holder, glue or tape them on the underside of the plate near breadboard. All the wires coming off the breadboard including the hookup wires, and battery connector wires can be taped together in a bundle.
16. Now place the graphite with sail in the valley of the magnets. You’re looking to achieve balance so if the graphite seems to be sticking to one end adjust your main adjustment screw until it levitates in the center of the middle magnet. If the graphite is rubbing on the sides adjust your other screws in order to get the graphite floating on it’s own with no rubbing.
17. For this step sometimes having the lights dimmed or being in a darker room helps. Insert the batteries into there respective holders the LED should come on. Try to make it so the light shows on half of the sensor while the other half is on the sail. Adjusting the main adjustment screw slightly can also help to achieve this, otherwise, adjust your photo-sensor so that the light is shining only on half of its face.
18. Now cut a ½” by ½” slot in the side of the fish tank you want the wires to come out of.

19. Place the clear aquarium or fish tank over the unit. This makes it so you can show your students the seismograph with out running the risk of them playing with it. Now place the box over the whole unit, it needs to be completely dark for the unit to work correctly. You may spray paint the cardboard box black, if you feel necessary to achieve complete darkness.
20. With all the software installed and the wire connectors coming out of the serial port, connect the hook up wires with the serial port wires. Note: in order to get the best readings place the seismograph in a place it is relatively quite and it will not be bumped or disturbed in any way.