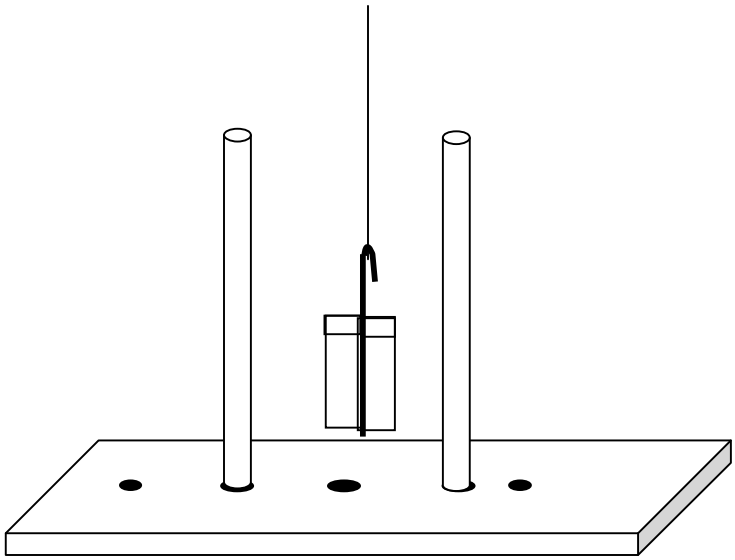
Electric Field and Magnetic Field Apparatus

In order to more easily conduct several of the essential laboratory investigations in the modeling approach to electricity and magnetism, leaders and participants in the 2007 FIU Advanced Modeling Workshop designed and constructed this multi-purpose lab apparatus. Further revisions and improvements have been made by the St. Louis Area Physics Teachers.

Electric Field Mapping

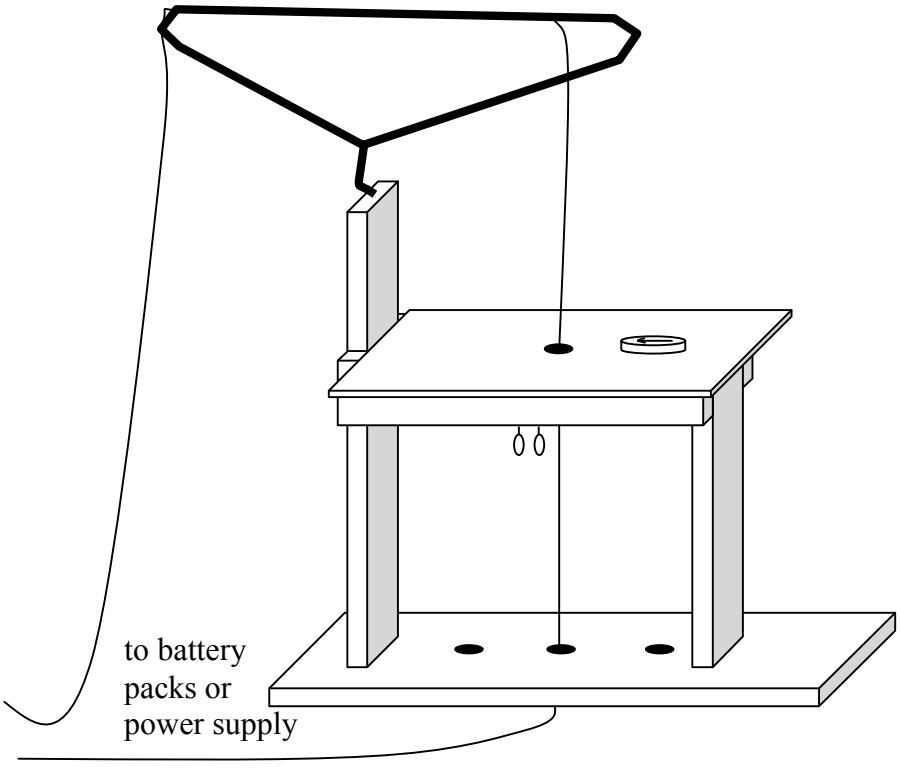
The base of the apparatus is used with a 4" dowel to support a PVC pipe. The pipe becomes negatively charged when rubbed with wool. An "electrostatic compass," consisting of two tapes separated from one another, attached to a straightened paper clip and suspended on a thread aligns with the electric field, and tracing the orientation of the compass on sheets of paper placed on the base produces a map of the field. Two pipes are used when mapping a dipole field. Wrapping one of the PVC pipes with aluminum foil makes it possible to charge it positively by induction.



Student directions for the lab investigation are posted at:
http://science.jburroughs.org/mschober/em1-charge/09_E1E-FieldMapping.pdf

The apparatus configured for investigating the magnetic field of a current carrying wire.

The platform rests on two cross braces, and the legs are kept from sliding by dowels fastened into the legs that fit in holes in the base. The clothes hanger, platform, and bracing are easily removed for more compact storage. The wire is supported by a plastic clothes hanger. The wire hanging off the back of the apparatus can affect results, so take care to keep it away from the measuring platform.



Magnetic Field Mapping Due to a Current-Carrying Wire
An upper frame is added to the base mapping the magnetic field around a long straight wire. The elevated platform forms the working surface for investigating the magnetic field around the wire with a magnetic compass.

The magnetism unit of the modeling materials contains template sheets for observing the direction of the magnetic field resulting from the earth and the current-carrying wire. Subsequent investigation separates out the unique effect of the current-carrying wire.

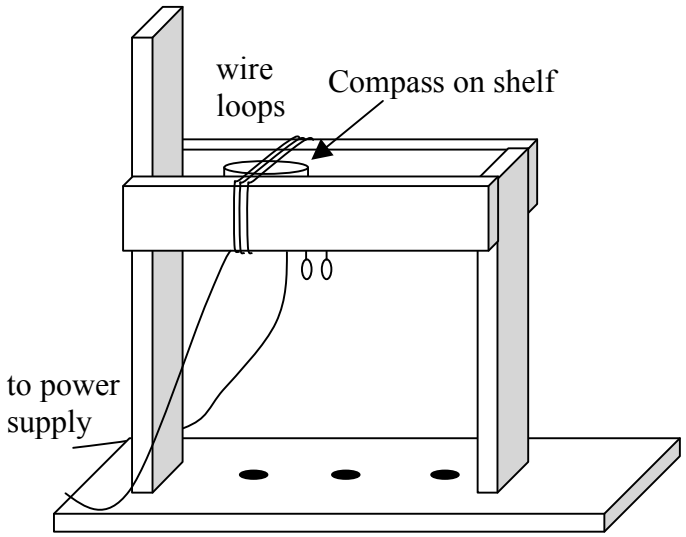
A power supply capable of delivering high currents is needed for this investigation. A battery pack with a momentary contact switch may be used, or a fused, variable power supply can be used.

Quantitative Investigation of the Magnetic Field Due to a Current-Carrying Wire
The same setup is used to quantitatively relate current, distance from the wire, and magnetic field strength. The teacher's notes in the magnetism unit of the modeling materials provide a detailed description of the lab discussion, development, and procedure.

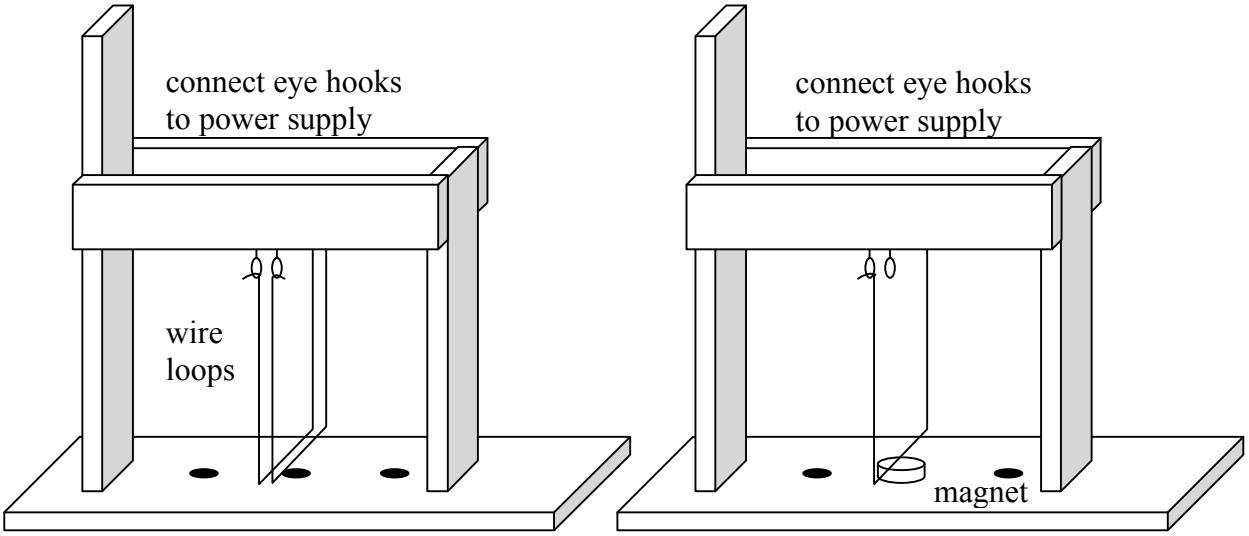
Also needed for this investigation are compasses with good angle resolution and ammeters. Suggested parts and ordering information are included in the materials list.

Tangent Galvonometer:
Magnetic field strength vs. Current;
Magnetic field strength vs. Number of turns of wire.

See Rex Rice's writeup in the "Magnetism Circus" file.



Investigating the forces between parallel wires. Remove the upper platform and add two "U" shaped wire loops that hook into the eye screws and swing freely. The ends of the magnet wire should be stripped of insulation so that connecting the eye hooks to the power supply allows students to qualitatively investigate the forces between wires carrying parallel and anti-parallel currents.



Investigating the forces between a current carrying wire and a permanent magnet. When one wire is removed, a neodymium or horseshoe magnet can be used to determine the relative directions between the direction of the force, B-field, and current. The magnets removed from an old hard drive also work well.

Parts List for building 12 Electric Field/Magnetic Field Mapping Apparatus

quan	description	supplier	cost
1	49” x 97” sheet of ¾” medium density fiberboard (MDF)	hardware	24.17
1	36” x 3/8” diameter dowel	hardware	.84
2	48” x ½” diameter dowels	hardware	2.88
3	10’ x ¾” o.d. non-metallic electrical tubing (ENT) (aka PVC)	hardware	4.17
12	Plastic coat hangers	Dollar store	1.50
12	12’ lengths of 16-2 stranded wire, split (72’)	hardware	22.00
24	Solid 14 gauge wire bent into 3 ¾” x 12” U-shapes with hooked ends. (60’ total)	hardware	6.00
12	Magnetic compasses, water filled, with degree markings http://www.brasscompass.com/		7.50 ea
1	2’ x 4’ x 1/8” melamine or masonite, cut into 9” x 12” pieces	hardware	4.00
48	Self adhesive feet	hardware	10.00
48	½” eye hooks	hardware	3.00
12	Rolls of clear tape	grocery	
	Paper clips	Grocery	
	thread	Grocery	
	Paper		
1	Yard of wool or wool blanket - cut to 8” x 8” squares	Fabric store	6.
1	Aluminum foil roll or foil tape	Grocery	2.25
12	Battery packs or power supplies		
12	Ammeters or digital multimeters	Harbor Freight	3.00 ea

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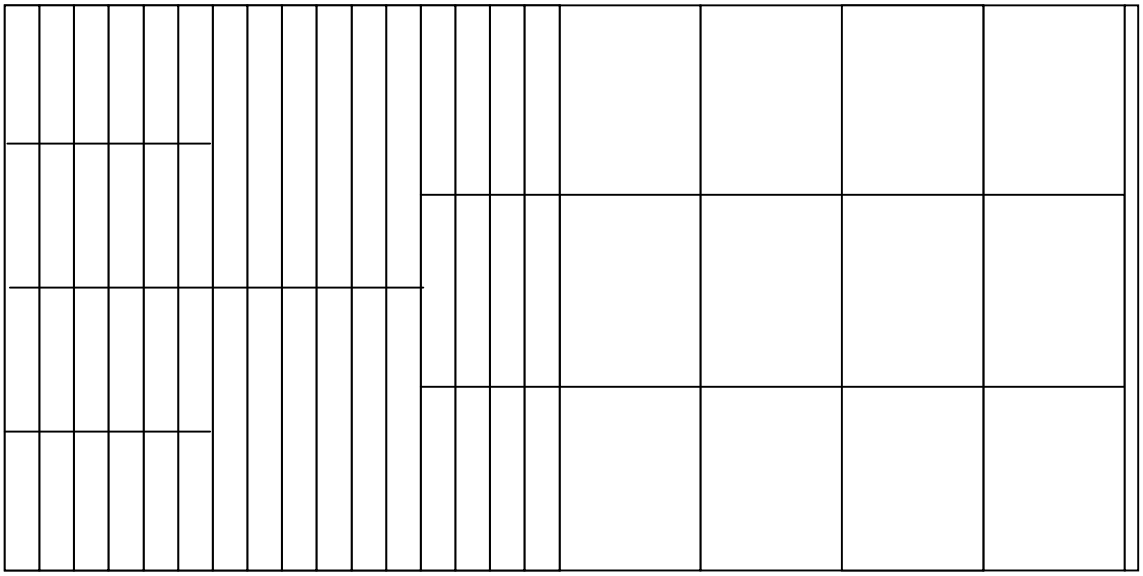
- Automatic zero adjust
- Overange indicator
- 2.5x second sample time
- Low battery indicator
- Fuse and diode protected circuit

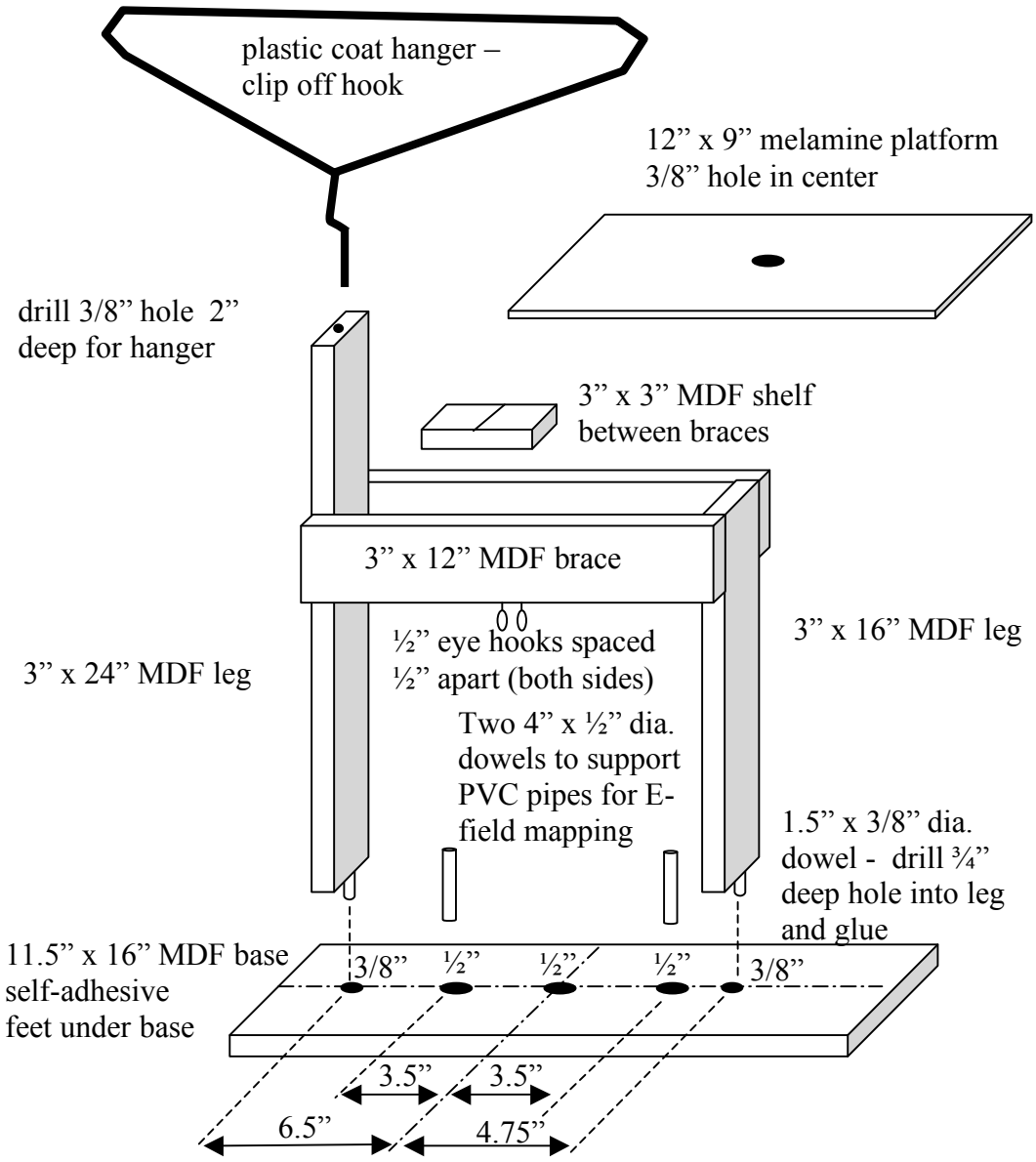
DC-A: 0-200μ A-2000μ A-20mA-200mA ; Resistance: 0-200-2000-20K-200K-2000K ohm; DC-V: 0-200mV-2000mV-20V-200V-1000V ; AC-V: 0-200-750V

Cutting diagram to get 12 setups out of one 49” x 97” sheet of Medium Density Fiberboard:



- Along the 4’ dimension, rip, with panel saw or circular saw, sixteen 3” wide strips.
- Rip the remainder of the board into four strips 11.5” wide.
- Cut the 11.5” strips into 16” lengths for the bases.
- Cut six of the 3” strips into 24” lengths.
- Cut four of the 3” strips into 16” lengths.
- Cut six of the 3” strips into 12” lengths.

Assembly steps: *(refer to diagram on the following page)*
Drill ½” and 3/8” holes in the base according to the assembly diagram.
Add self adhesive feet under the base.
Cut the 3/8” dowel into 1.5” long pieces.
Drill a 3/8” hole to a depth of ¾” into the ends of the 24” x 3” and 16” x 3” legs.
Glue the 1.5” dowels into the holes in the end of the legs.
Glue and clamp the 12” side braces between the legs.
Insert two eye screws ½” apart, centered on the bottom edge of each side brace.
Drill a 3/8” hole to a depth of 2” into the opposite end of the 24” x 3” leg for the clothes hanger.
Cut the 2’ x 4’ sheet of melamine or masonite into 9” x 12” pieces.
Drill a 3/8” hole in the center of the 9” x 12” melamine pieces.
Cut the ½” dowel into 4” long pieces.
Cut the PVC into 10” long pieces.
Cut and bend the magnet wire into “U” shaped loops. Beginning with a 30” piece, strip two inches of insulation from each end. Form a hook in one end, make a 90˚ bend 12” away, a second 90˚ bend 3 ¾” away and the final hook 12” away.


plastic coat hanger –
clip off hook
12” x 9” melamine platform
3/8” hole in center
drill 3/8” hole 2”
deep for hanger
3” x 3” MDF shelf
between braces
3” x 12” MDF brace
3” x 16” MDF leg
½” eye hooks spaced
½” apart (both sides)
3” x 24” MDF leg
Two 4” x ½” dia.
dowels to support
PVC pipes for E-
field mapping
1.5” x 3/8” dia.
dowel - drill ¾”
deep hole into leg
and glue
11.5” x 16” MDF base
self-adhesive
feet under base
3/8”
½”
½”
½”
3/8”
3.5”
3.5”
6.5”
4.75”