615-4095 (10-250) Tangent Galvanometer

Introduction:
What is a galvanometer? A galvanometer is a type of ammeter and has existed since the early nineteenth century. In 1820, Hans Oersted described the movement of a compass needle in the presence of an electrical field. Electricity and magnetism are closely related phenomena. As a current passes through a coil of wire, it will generate a magnetic field. In the case of the galvanometer, this magnetic field causes the needle of a compass to deflect. From this deflection, it is possible to calculate the strength of the current. The deflection is caused by the interaction of the two magnetic fields affecting the compass. One is generated by the earth, and the other by the coil. They run perpendicular to each other. Although the earth's magnetic field is far stronger than the coil's, the compass is closer to the coil and thus more affected by it, in accordance with the inverse square law. The inverse square law states that the magnetic intensity is inversely proportional to the square of the distance. In other words, at one distance from the source, the strength will be a certain value. At twice this distance, the field will be spread over four times the area, making the intensity one fourth as much. At three times this distance, the field will encompass nine times the area, making the field one ninth as intense. It is easy to see that the field drops to negligible strength after a certain distance.

Operation: For your set you will need one D-cell battery, which is placed in the holder. There is a U shaped wire that must be secured in place to allow current to flow. You will notice two knobs: one of them switches between the three coils: one of 100 turns, 200 turns, and 400 turns. These three coils all occupy the acrylic cylinder. The second knob is used to tune the device. The coils of wire surround a horizontal acrylic plate. A compass is included in the set.

To use, place the compass in the center of the copper coil, on the acrylic plate. Acrylic is entirely non-magnetic and won't affect the experiment. For convenience, it is best to align the compass so that the red half of the needle rests on the North or 0° mark. Also, be sure to orient the galvanometer so that the plane of the coil is perpendicular to the earth's magnetic field. This will simplify calculations. Turn your galvanometer to 100 turns. You will notice that the needle will deflect. You can control the amount of deflection by using the small tuning knob. The knob increases current as it is turned clockwise. If the knob I set at maximum, you may not see any difference in needle position. The needle will likely remain perfectly perpendicular to the coils. Observe how far the needle deflects. You will need this value to calculate the strength of the current.

When the current is passed through the coil, it creates a magnetic field at the corners given by the following equation: **B=** $\frac{\mu_0 n I}{2r}$,

where:

- I= the current in amperes.
- n= the number of turns in the coil.
- r= the radius of the coil.
- μ= the permeability of the sample to electromagnetism. For our purposes, this value is irrelevant.

Note: our coil actually contains three coils sharing the same housing. A selector knob allows you to choose a coil with 100 turns, 200 turns, or 400 turns. For best results, calculate the strength of the current using all the coils. This will give you a basis for comparison.

When you have determined the value for B, you can use it to determine the strength of the electrical current. To do this, you will need the equation: $I = \left(\frac{2rB}{\mu_0 n}\right)\tan\theta$ where:

- r= the radius of the coil.
- B= the value for the magnetic field.
- tan θ= the angle of deflection observed by the needle.
- μ= Electromagnetic permeability.

As an additional experiment, you can use the tangent galvanometer to calculate the strength of the Earth's magnetic field in your location. On the housing for the dial you will find jacks that can accommodate banana plugs. You can use a low voltage power supply to apply a known current to the coil. Use the dial to deflect the needle 45 degrees. Since you know the strength of the current, the angle of deflection, and the radius of the coil, you can use the above equation to solve for B. In this case, B represents the earth's magnetic field.

Benchmarks for Science Literacy				*National Science Education Standard*
Grades 9 – 12 **The Physical Setting**	**4G/H 5ab***	Magnetic forces are very closely related to electric forces and are thought of as different aspects of a single electromagnetic force. Moving electrically charged objects produces magnetic forces and moving magnets produces electric forces.	Grades 9-12 **Physical Science Content Standard B.6-**Interactions of Energy and Matter	"Electricity and Magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces."
Grades 9 – 12 **The Physical Setting**	**4B.1**	"The change in motion of an object is proportional to the applied force and inversely proportional to the mass."	Grades 9-12 **Physical Science Content Standard B.1** – Motions and Forces	"Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force. Whenever one object exerts a force on another, a force equal in magnitude and opposite in direction is exerted on the first object." (p. 180)

Warranty and Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

May we suggest:

615-4585 Electromagnet Kit: Gilley coil. Here's everything you need to build a powerful electromagnet. Experiment with induced currents, reversed polarity, magnetic lines of force and more! Includes: 2 coils with stand-alone binding posts; round and square iron cores; 2 half-round cores; double U core; 4 clip leads; iron filings; instructions. Operation needs 6 v power supply such as 10-171.

615-0250 Magnetic Field Viewer: Explore the mysteries of magnets in three dimensions! Iron filings mixed with oil inside an acrylic plastic cube will react in fascinating ways to a magnetic field or electric current.

615-0300 Small Lifting Magnet: Weighs 2 pounds - lifts 200, due to precision machining. This is the way magnets lift cars in junk yards. Uses only one 1-1/2 volt "D" cell battery (not included). 1-3/4" diameter cold rolled steel core and yoke are ground to within a fraction of 1/1000 inch. Coil has 175 turns of #28 magnet wire, 4 strands parallel. Includes: alligator clip leads, battery holder fastened directly to magnet for portability, instructions with experiments. Works best with included yoke, may not work on other surfaces.

615-3190 Wimshurst Machine: This easy-to-use device consists of two high resistance plastic discs 25 cm in diameter with equally spaced metal sections. The discs are supported with two upright posts and rotate in opposite directions with a hand crank, producing substantial opposite charges which are deposited in the capacitors and on the metal electrodes. You can collect induced charge with the brushes and adjust the electrodes and Leyden jar capacitors for higher potential, thus generating sparks by lowering the system's capacitance. It is mounted on an attractive wooden base.

652-1010 Anemometer: This colorful working model is sensitive to breezes as slight as 2 mph. Since it rotates at speeds 1/6 that of the wind velocity, wind speeds can be determined quantitatively by counting the rotations. Consists of: Four (4) plastic molded cups, three black and one red for contrast, mounted on a low-friction axle and attached to a sturdy base. Instructions include sample questions, problem and wind speed chart.

615-3130 400 kV Van de Graaff generator or 615-3100 200 kV Van de Graaff generator: Create your own lightning with these time-tested devices that have delighted students for decades! Named after the inventor Van de Graaff, an American physicist, this machine produces low-amperage static electricity that can be "shocking" but perfectly safe. Two different pulleys inside a plastic column create and carry static charge up to the aluminum collector globe. You can draw out this static charge in a burst of lightning - or you can set each hair on your head on end! Our instruction booklet tells you how to raise hair; produce lightning and electric wind; experiment with St. Elmo's fire or electrostatic attraction and repulsion. *Color may vary.*