E-Field Detector

96-3580

INSTRUCTIONAL GUIDE

Contents

Equipment Components:

- E-Field Detector
- Power Supply
- Grounding lead
- BNC E-field detector nose

Recommended for activities:

- **Grounding Plate (96-3595)**
- **Charge Separation Rods (96-3590)**
- **Charge Proof Plane (96-3585)**

Introduction

The E-Field Detector is a sensitive instrument designed to facilitate a hands-on investigation of electrical charge. Not only does the E-Field Detector indicate if charge is present, it can also determine the sign and magnitude of the charge present. An LED display on the top of the instrument lights up red when positive charge is detected and blue if negative charge is present. More LEDs will light up as more charge is detected, allowing for qualitative investigations of charge. The back plate of the E-Field Detector houses ports so a voltmeter may be attached. Electrical potential is proportional to charge in a system where electrical energy is built up, so voltage is an easily measurable variable to use for quantitative experiments.

Charge is the fundamental building block in understanding electricity, a notoriously difficult concept to teach and learn in a classroom setting. The E-Field Detector readily shows that charge has magnitude and polarity—two qualities that are easily relatable to familiar kinematic physics concepts like work and power.

Background

Atoms are the fundamental building block of matter and are constructed of three subatomic particles: protons, neutrons, and electrons. Protons and neutrons are clumped at the center of the atom and make up the nucleus. Electrons orbit the nucleus in defined spaces called orbitals. Protons have positive charge, neutrons have no charge, and electrons have a negative charge. Atoms have the same number of positively charged protons as negatively charged electrons, so the overall charge is neutral. Atoms with an uneven number of electrons and protons are called ions. Ions are created when electrons are added or removed from atoms. Since electrons are negatively charged, removing electrons will create a positive ion (cation) and adding electrons will create a negative ion (anion).

Ionization takes energy. Even something as simple as rubbing two materials together can result in ionization, because the energy input is enough to strip electrons from one material and add them to another. The triboelectric series lists materials by their tendency to lose or gain electrons when rubbed (Figure 1). It is important to note that electrons are the only subatomic particles being exchanged. The strong nuclear forces between protons and neutrons prevent them from influencing the charge state.

Charge	**Material**
More positive	Human skin
	Glass
	Nylon
	Wool
	Silk
Less positive	Aluminum
Less negative	Amber
	Acrylic
	Polystyrene
	Plastic wrap
	Polyvinyl Chloride (PVC)
More negative	Ebonite

Figure 1. *The Triboelectric Series*

Insulators and conductors without a ground can hold this charge as static electricity. Static electricity is electricity that is not moving through a conductor like the electricity that runs through the powerlines; therefore, it has no current. It does have electrical potential which can be measured with a voltmeter and converted to a quantitative measurement of charge. The charge measured on each material after rubbing both together should be equal but have opposite signs. For example, if you rub an acrylic rod on wool the acrylic will gain electrons from the wool and become negatively charged and leave the wool positively charged. The charge on the wool will have the same magnitude as on the acrylic rod, but the two will be opposite in polarity.

Set-Up

1. Plug the AC adapter into a wall socket and turn on.
2. Connect the grounding lead (see below).
3. Set the sensitivity switch to HI.
4. Turn on the E-Field Detector with the toggle switch.
5. Press the reset button to zero the charge reading—there should be no LEDs lit.
6. Bring a charged rod close to the E-field Detector nose and check that the LEDs come on.

Grounding the Unit:

It is vital that the E-field detector is grounded, otherwise charge will build up in the sensitive electronic circuitry and be displayed on the LED array. This can be done with the enclosed grounding lead or with the optional Grounding plate.

Ground without the **Grounding Plate**:
1. Connect the grounding lead by inserting the 4mm plug into the green socket on the rear of the E-field detector.
2. Clip the crocodile clip on the other end of the grounding lead to a suitable ground (e.g. a faucet).

Ground with the **Grounding Plate**:
1. If you are using a Grounding Plate, first connect the grounding lead as above.
2. Use a 4mm connecting lead fitted with a crocodile clip to connect from the green socket to the Grounding Plate connecting screw.

Attaching an external voltmeter or multimeter:

1. Connect the external **voltmeter** or multi-meter to the positive and negative sockets on the back of the Electrical Field Detector. Ensure polarity is observed.
2. This enables quantitative measurements to be made in conjunction with the visual LED indicators.

Activities

Activity 1: Friction Rod Kit (P6-1600)

1. Rub an ebonite rod with a silk or wool cloth.
2. Gradually bring the charged rod toward the nose of the Electrical Field Detector

Watch as more and more blue lights illuminate as the charged rod is brought closer. Repeat with bubble wrap and a glass rod and watch the red lights illuminate as the charged moves toward the detector.

Activity 2: Charge Separation Rods (96-3590)

1. Set up the charge rods so that they are touching, as shown in Figure 2.
2. Bring a charged ebonite rod towards one end of the rods. This will repel the electrons to the far end of the charge rods.
3. Separate the charge rods by moving them apart ensuring you only touch the support stand, so they do not discharge.
4. Using the E-field Detector, you can now demonstrate the charge that is left on each of the rods is opposite.

Figure 2. *Charge Separation Rods*

Activity 3: Stream of Water

1. Setup a thin stream of water. This can be obtained by turning a laboratory tap on very slowly or with a water canister connected to a thin tube.
2. Bring the E-field Detector near the water to show that it has neutral charge.
3. Charge a polycarbonate strip and bring it near the E-field Detector to show the charge (negative).
4. Bring the strip near the stream of water and it will repel the electrons away making the side of the stream near the rod positive so it will bend towards the rod.

Activity 4: Packing Tape

1. Take a roll of cellophane packing tape and hold it in front of the E-field Detector showing that it has a neutral charge.
2. Rip a piece of packing tape off the roll.
3. In turn, hold the roll and the piece of tape in front of the Electrical Field Detector to show that they now have opposite charges.
4. Stick the piece of tape back on the roll and the charge should return to almost neutral.

Activity 5: Charge Proof Plane (96-3585)

1. Reset the E-field detector
2. Charge the proof plane by rubbing it on a cloth.
3. Bring the proof plane in front of the nose of the E-field detector and the LEDs will light up depending upon what material used to rub the proof plane on.

Activity 6: Faraday's Pail

1. Place the Faraday's Pail on top of an insulated stand or grounding plate.
2. Remove the BNC connector from the nose of the E-Field Detector and replace with a suitable BNC lead such as a CRO probe.
3. Set the E-Field Detector to "Lo" sensitivity.
4. Connect the CRO lead to the outside of the pail and the grounding lead to the grounding plate.
5. Charge the proof plane by rubbing it on a piece of cloth or by induction.
6. Insert the proof plane inside the Faraday Pail and touch the side. The charge will flow to the outside of the pail, indicated by the LEDs on the E-Field Detector.
7. Repeat steps 1-6 to slowly increase the charge of the pail.

Troubleshooting

Issue	Explanation	Solution
LEDs are on maximum	This is normal as charge builds up in the circuit	Press reset button
LEDs gradually come on when detector is sitting idle	This is normal as charge builds up in the circuit	Ensure E-field detector is properly grounded using the grounding lead provided Press reset button
No LEDs light up when a charged object is brought near	The detector is not switched on	Ensure detector is switched on at the socket **and** on the unit itself
	The detector is set to Lo Sensitivity	Switch the detector to HI sensitivity.
	The detector is not grounded properly	Ensure the E-field detector is properly grounded using the grounding lead provided (and optional Grounding plate)

Related Products

Demonstration Electroscope (P6-1170) This aluminum needle-based electroscope's design makes it superior to traditional leaf-style electroscopes in part because the needle stays put when experiments are being performed.

Electrostatic High-Voltage Genecon (P6-2640) This hands-on alternative to traditional "Van de Graaff" generators allows electrical discharge experiments to be performed in the classroom with far greater ease and less cost. Gently turn the handle to generate more than 10,000V of high voltage static electricity!

Neulog Charge Sensor (NL-2460) This sensor measures electrostatic charges. It can be seen as a highly sensitive electroscope indicating whether a charge is positive or negative.

Deluxe Van de Graaff Generator (P6-3300) Generator provides power for all basic electrostatic experiments on a dramatic scale, with sparks of 8" to as high as 12" to 15". Yet with a maximum continuous current of just 10 microamps, it's quite safe for classroom use.