10810 Handheld Geiger Counter

Introduction:
The Science First® Handheld Digital Geiger Counter has been designed for use in school laboratories for studying and understanding the field of radioactivity. It is a compact, portable low-level radiation detector that is sensitive to alpha (α), Beta (β), gamma (γ), and X-ray radiation. Its all digital circuitry provides a clear digital display as well as an audio response. The LCD screen displays count, cpm, or mR/hr, along with elapsed time and charge state. A user is able to conduct various experiments with a high degree of accuracy. The counter may be operated by solar power or solar-charged capacitor.

Specifications:

Detector:	Halogen-quenched Neon (Ne), stainless steel Geiger-Müller tube
Modes:	continuous, cpm, mR/hr
Display:	LCD with count, mode, elapsed time, charge status
End window:	Mica, 1.5-2.0 mg/cm^2 areal density
Sensitivity:	18 cps/mR/hr Cobalt-60
	Gamma > 0.01 MeV
	Beta > 0.2 MeV
	Alpha > 4 MeV
Range:	0 - 8 mR/hr
Operating Voltage:	500 V
Dead time:	90 μs
Power sources:	Direct solar, solar-charged capacitor

WARNING: SENSOR FACE IS DELICATE, DO NOT TOUCH!

Before you begin your experiments, read the operational instructions carefully.

Theory:
Ordinary human senses cannot detect invisible particles that are produced by radioactive materials. The Geiger- Müller handheld counter has been developed for the purpose of detecting radiation. Inside the instrument a potential difference of several hundred volts is maintained between coaxial electrodes in a gas filled (i.e., Neon) tube. When a particle (i.e., α, β, γ, or X-ray) enters the tube, it ionizes the gas, allowing a short pulse of electricity to trigger the detector circuitry. This pulse can be heard as a beep in a speaker and as a change in the number on the scale of the digital readout.

Natural radioactivity was first studied in the late 19th century by the French scientist Henri Becquerel. In the 20th century, Ernest Rutherford carried out the gold foil experiment. As a result of the experiment, scientists now had a clear picture of the structure of the atom relative to the time period and the location of its fundamental particles. The atom was found to consist of mostly empty space with a densely packed core, the nucleus, consisting of all the positive charge (i.e., protons). Rutherford formed this conclusion based on the experimental evidence that showed that some alpha particles (positively charged) deflected directly back to the source when they hit the positive center. Rutherford named the three types of observed radiation - alpha, beta, and gamma - after the first three letters of the Greek alphabet. Further research by Bohr and others would ultimately result in the modern depiction of the atom's structure under the quantum mechanical model.

Alpha particles are really helium nuclei. Each alpha particle carries a double positive charge. An alpha particle is emitted from an atom at a velocity about 1/20th the speed of light. Alpha particles do not have a high penetrating power. In fact, a an ordinary sheet of paper is sufficient to stop alpha particles. Beta particles are electrons emitted from decaying radioisotopes. Beta particles are negatively charged. A sheet of aluminum a few millimeters thick is sufficient to stop beta particles. Gamma rays have no charge; however, gamma rays have high energy and a short wavelength. Thus, gamma rays are the most penetrating of the three particles. Gamma rays are able to penetrate a block of iron one foot thick. Thick sheets of lead or concrete provide protection from penetrating gamma rays.

If you turn on your Geiger counter with no radioactive source in the area, you will hear random beeps. These beeps are the result of cosmic rays and natural radiation emanating from objects that surround you. This is known as background radiation.

The unit of radiation exposure is called the roentgen (R). It was introduced at the Radiological Congress held in Stockholm in 1928. It has been the most widely used unit of X-ray dose since its introduction. The roentgen is an integrated measure of exposure, and it is independent of the time over which the exposure occurs. The strength of a radiation field is usually given as an exposure rate, such as roentgens per minute. Measurements of exposure to human tissue are taken via a specialized health physics counter and are expressed as the dose equivalent or rem.

Operation:

POWERING THE COUNTER:
The counter will run in direct sunlight or thereafter off a charged capacitor. Turn the unit on/off by flipping the switch on the bottom of the unit to the desired mode. During use, the counter will preferentially power itself with the highest voltage source. In direct sunlight, this is usually the solar panel. Power usage by the counter is very low. When charged, the capacitor will power the unit for approximately 25 minutes. The largest current draw is from the audio transducer.

COUNT MODES:
The counter functions in three main modes, which are cycled by the mode button on the unit. The unit's current mode is indicated by an arrow on the left hand side of the LCD.

- **cont** (continuous mode): In this mode, a running tally of ionization events is updated in the COUNT/EXP field of the LCD. The duration of the current count is displayed in the ELAPSED TIME field.
- **cpm** (counts per minute): The counter will log events for a specified duration. The default setting is 15 seconds. Extrapolate this count into a one-minute interval, as needed when performing the investigations below.
- **mR/hr**: In this mode, the counter displays the common dose rate of milliRoentgen per hour.

NOTE: Changing count mode resets the current count of the processor.

MUTE:
When the counter detects a pulse, an audible chirp will be heard. The speaker can be muted by pressing the bell symbol with the line through it. The bell symbol will continuously appear on the LCD, when the unit is not muted. Muting the counter will greatly extend capacitor charge and battery life.

SENSOR ORIENTATION:
When measuring alpha or beta sources, direct the window at the source. The Geiger-Müller tube in the counter is mounted below the LCD screen with its window facing outward. Care should be taken to protect the mica end window. It is extremely fragile. Gamma radiation is generally of too high an energy to interact directly with the gases inside the tube. It is usually beta particles emitted from Compton scattering within the steel wall of the tube that cause ionization and a pulse within the tube.

Investigations:

CAUTION - Although the radioactive sources supplied to you by your instructor/teacher should be of low level and considered safe for limited use by students, they should not be used more than necessary. Please be sure to wash your hands thoroughly after each experiment.

EXPERIMENT 1 - MEASURING BACKGROUND RADIATION
Change the mode to cpm. Record the COUNT/EXP for 15s. Extrapolate the value at 60s by multiplying the COUNT/EXP by four. Alternatively, set the mode to cont and record the COUNT/EXP every minute for a total of 20 minutes. Determine the average number of background radiation counts by dividing the total number of counts by the total number of readings. This number gives the average background radiation level in your area.

EXPERIMENT 2 - MEASURING A RADIOACTIVE SOURCE
Obtain a radioactive source from your instructor. Place the source about 30 cm from the Geiger-Müller opening. The distance from the source to the counter has a dramatic effect on the count rate. Adjust this distance to approximately 10 cm and set the device to the cont mode. Record the COUNT/EXP every minute for a total of 20 minutes.

EXPERIMENT 3 - COUNT RATE AS A FUNCTION OF DISTANCE
Place a meter stick on a table and place the Geiger- Müller tube opening at the zero end of the stick. Place a radioactive source 100 cm from the tube opening. Set the device to the count mode and record the COUNT/EXP every minute for a total of ten minutes. Move the source to the 90 cm mark on the meter stick and record the COUNT/EXP every minute for a total of ten minutes. Repeat for 80 cm - 10 cm. After recording the readings for each respective distance, sum the readings and divide by 10 to get the average reading for each distance (cm). Make a graph of average count versus distance. What type of curve is obtained?

EXPERIMENT 4 - ABSORBANCE (requires additional materials)
The maximum range of radioactive particles as they travel through an absorbing material depends on several factors, including the density and the atomic number of the absorbing material. In this experiment, you will determine the thickness of an absorbing material that will completely block beta particles from entering the Geiger tube. You will need a source that emits essentially only beta particles (e.g., ^{14}C, ^{99}Tc, ^{204}Tl, ^{210}Bi, or ^{234}Pa). You will need aluminum foil. Tear or cut the foil into ~100 sheets of uniform size. The thickness of an individual aluminum sheet is close to 0.001".

a) Place the beta source approximately 10 cm from the Geiger tube.
b) Turn the unit on and set the mode to cpm.
c) Obtain a background reading for the default 15s interval. Extrapolate the value at 60s by multiplying the COUNT/EXP by four.
d) Place a single sheet of aluminum foil between the tube and the source. While set in the cpm mode, obtain a reading (i.e., COUNT/EXP). Extrapolate the value at 60s by multiplying the COUNT/EXP by four.
e) Add a second sheet of aluminum foil between the tube and the source and make another measurement as outlined in step d.
f) Continue making readings for sheets 3 and beyond until no audible beep is heard to signify a radiation reading. Record the number of sheets of aluminum foil and total thickness in inches, the COUNT/EXP each time a reading is made and the extrapolated values for 60s at each new thickness. For example, with three sheets of aluminum foil the thickness is ~0.003".
g) Subtract the background from each measurement. Make a plot of Count v. aluminum thickness (inches).
h) Compare the values obtained with aluminum foil to other materials (e.g., plastic wrap, cardboard). Follow the procedure outlined above.

Warranty and Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered. 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.