

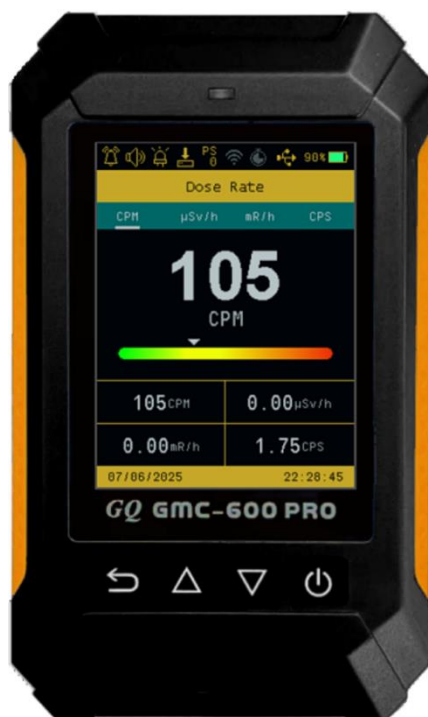


CNS Geiger Counter Program

MEASURING THE INVISIBLE



Canadian Nuclear Society Geiger Counter Program Educator Guide



*A companion to the CNS classroom Geiger Counter Program
Activities, worksheets, and a slide guide for confident classroom delivery using the
Geiger counter and teacher-supplied test materials.*

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Welcome

Thank you for bringing the CNS Geiger Counter Program into your classroom. This guide is written for you, the teacher, and is meant to be read from start to finish before your first session. It explains how to use the Geiger counter, why each activity works pedagogically, and how to handle the questions students tend to ask. Printable student worksheets for all five experiments are collected in the Appendix at the back, ready to photocopy once you are set to run the activities.

The program exists because radiation is one of the few areas of science where public intuition and physical reality often diverge sharply. Rather than telling students that low-level radiation is normal and safe, the counter lets them measure it themselves, using teacher-supplied everyday materials and the air of their own classroom, and draw that conclusion from real data. That approach is more durable than a lecture, and it's the thread running through everything in this guide.

Target audience: this guide scales from Grades 4–8 general science through Grades 9–12 physics, chemistry, and environmental science. Adjust the depth of discussion, such as how far you go into the unit conversions below, to your class.

Program hub and digital portal: cns-snc.ca/learn-nuclear/geiger-counter-program, the live version of the reference library, Geiger counter request form, and this guide.

Essential questions

- How much radiation do we receive day to day, and where does it come from?
- How can we detect and measure different kinds of radiation?
- How is measuring radiation useful in the real world?

Objectives

- Describe the types of radiation and where they come from.
- Use a Geiger-Muller counter to detect and quantify radiation.
- Explain, with evidence, why everyday radiation exposure is not the same as danger.

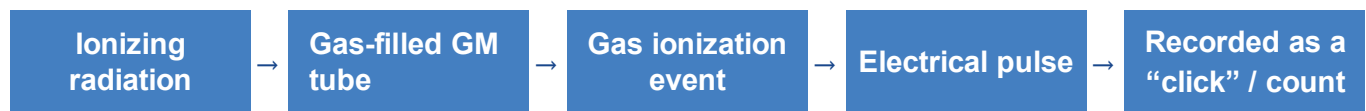
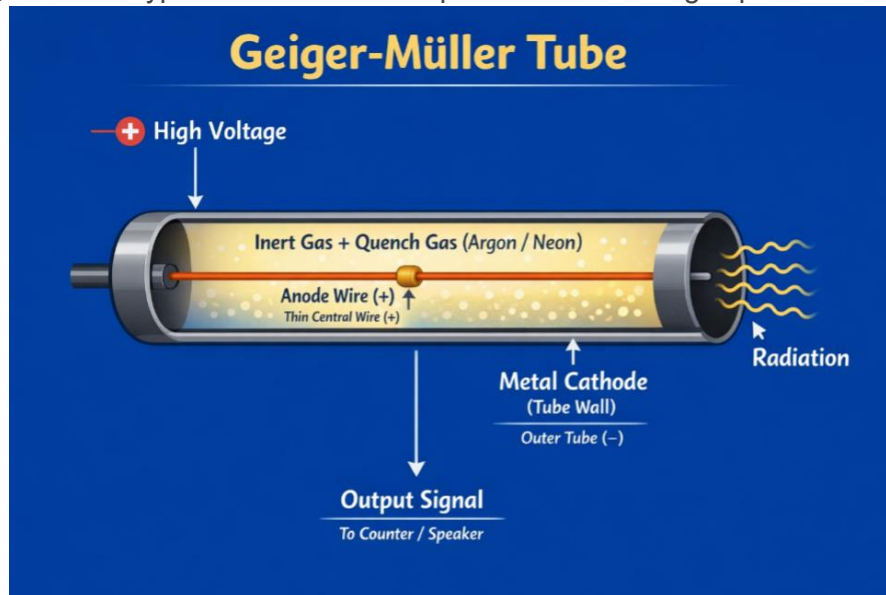
Consider opening your first session with Worksheet A in the Appendix, a short Think-Pair-Share that has students commit to their own answers on these questions before touching the detector. Naming misconceptions first, then testing them with real data, is what makes the hands-on activities land: students remember the moment their own prediction was wrong far more than a fact told to them upfront.

What you will receive

The CNS Geiger Counter Program provides a GQ GMC-600 series digital Geiger-Muller detector and this educator guide. No radioactive source kit is provided.

Teachers are asked to gather simple everyday materials for testing, such as granite, potassium-based salt substitute, ceramic items, or other safe household or classroom objects.

At its core is a highly sensitive, gas-filled pancake-style GM tube capable of detecting alpha, beta, and gamma radiation, the three types students will compare in the shielding experiment.



When ionizing radiation passes through the detector window, it knocks electrons loose from the gas inside, producing a tiny electrical pulse that the counter registers as one “count.” The display reads out three metrics:

- **CPS** (counts per second), best for real-time tracking during fast demonstrations or shielding tests
- **CPM** (counts per minute), the standard unit for baseline testing because it smooths out short-term random fluctuation
- **Dose rate** ($\mu\text{Sv/h}$), an empirical estimate of biological exposure rate, in microsieverts per hour

Understanding the units

μSv (microsievert)	One-millionth of a sievert, used for low-level hourly dose rates
mSv (millisievert)	One-thousandth of a sievert, the standard unit for annual background dose or regulatory limits (1 mSv = 1,000 μSv)

mrem (millirem)	A traditional North American unit still found in many textbooks ($1 \text{ mSv} = 100 \text{ mrem}$; $1 \text{ } \mu\text{Sv/h} = 0.1 \text{ mrem/h}$)
BED (Banana Equivalent Dose)	A friendly teaching unit. One banana delivers roughly 0.1 mrem from its natural potassium content.

With younger grades, BED is a good entry point before introducing mSv/ μ Sv; with senior grades, use the mSv/mrem conversion to connect classroom readings to older textbook material.

Safety, in plain terms

Every activity in this guide uses naturally occurring, low-level radiation from everyday materials selected by the teacher, such as granite, potassium-based salt substitute, or ceramic items. No radioactive source kit is provided. Teachers should use only safe, intact materials and follow their school's normal safety procedures. The point of the program is comparison and discussion, not finding the highest possible reading.

This is also a natural moment to introduce **ALARA** (As Low As Reasonably Achievable), the guiding principle radiation workers use. It is built on three simple, memorable levers students can apply to any of today's activities:

Time	Less time near a source means less dose, which is why Experiment 1 only needs a few minutes per reading
Distance	Dose falls off sharply with distance, which is the basis of Experiment 4
Shielding	The right material blocks radiation, which is the basis of Experiment 3

Curriculum connections

Concept	Where it fits
Radioactivity & half-life	Physics / Chemistry — atomic structure, decay
Inverse-square law	Physics — measured directly in the distance experiment
Data & statistics	Any science course — count-rate fluctuation, uncertainty

Environmental science

Geology's effect on background radiation; radon

Five classroom experiments

Each activity takes 15–30 minutes and uses the supplied Geiger counter plus everyday materials selected by the teacher. Matching printable worksheets for each experiment are in the Appendix.

1. Measure background radiation

Materials: none beyond the kit

- 1 Turn on the counter and record CPM readings every minute for 10 minutes.
- 2 Graph CPM over time as a class.

Students learn: Radiation is always present at low levels; readings vary naturally and statistically.

2. Compare everyday materials

Materials: granite sample, potassium-chloride salt substitute, a ceramic mug

- 1 Hold the counter near each object in turn and record CPM.

Students learn: Geology and even common foods and household items carry small amounts of Natural radioactivity.

More everyday items you can test

Teachers may choose locally available, safe, intact items such as granite, potassium-based salt substitute, ceramic items, or other everyday materials. Potassium-based salt substitute is typically available at grocery stores for a few dollars and can be a simple, low-cost item to include. Some items, such as bananas, potatoes, or clay-based cat litter, may produce readings that are close to background because their radiation levels are very low. Avoid damaged antiques, unknown powders, loose materials, or items that cannot be handled safely in a classroom.

EVERYDAY HOUSEHOLD RADIATION SOURCES

SAFE & COMMON ITEMS TO TEST WITH A DIGITAL GEIGER-MÜLLER COUNTER



THE KITCHEN & PANTRY



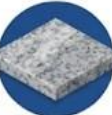
SALT SUBSTITUTE (KCI)

- Concentrated Potassium Chloride (KCI) contains a stable, naturally occurring isotope: Potassium-40 (^{40}K).
- An easy-to-source check source for testing.



BANANAS & POTATOES

- These potassium-rich foods emit weak, natural background radiation.



GRANITE COUNTERTOPS

- Natural igneous stone can trap micro-deposits of uranium and thorium.

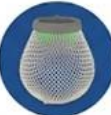


HARDWARE & SAFETY ITEMS



SMOKE DETECTOR

- Ionization models use a microscopic, safely sealed speck of Americium-241 (^{241}Am).
- Source is shielded inside the casing.



VINTAGE LANTERN MANTLES

- Older mantles were treated with Thorium dioxide for a brighter glow.



POTASH FERTILIZER

- High-concentration potassium compound used for plant nutrients.



ANTIQUE COLLECTIBLES



URANIUM GLASS (VASELINE GLASS)

- Vintage glassware using uranium oxide glaze, which glows brightly green under UV blacklight.



VINTAGE ORANGE CERAMICS

- Bright orange mid-century pottery glazes used natural uranium oxide.



RADIUM DIALS & COMPASSES

- Historical artifacts with hands painted with self-luminous Radium-226.

TEACHER TIP: Use the GMC-600's rear mesh window directly against these objects for the best readings.

SAFETY NOTE: These household items emit only trace, natural, or safely contained radiation.

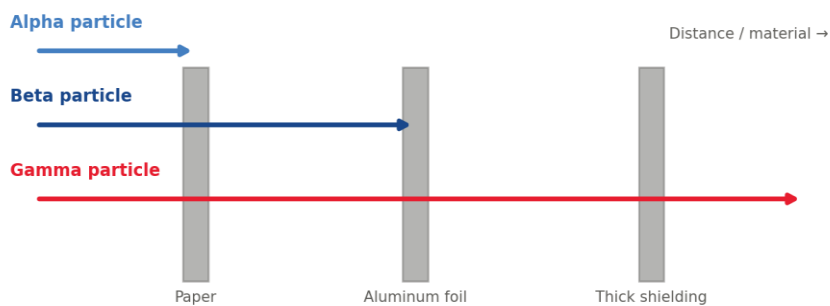
Suggested teacher-supplied test materials include granite samples or countertops, potassium-based salt substitute, ceramic items, bananas, potatoes, or other safe everyday objects. Teachers should avoid materials that are damaged, loose, unidentified, or not appropriate for student handling.

3. Shielding

Materials: paper, aluminum foil, plastic, one granite or salt-substitute sample

- 1 Place each material between the counter and the sample.
- 2 Predict which material blocks the most radiation, then test.

Students learn Different materials block radiation differently; alpha, beta, and gamma behave differently.

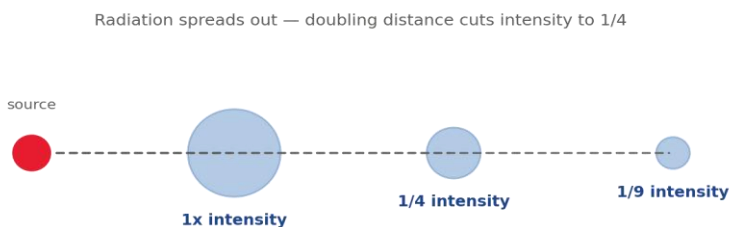


4. Distance and intensity

Materials: one natural sample used above

- 1 Measure CPM at several distances from the sample.

Students learn Radiation intensity falls off with distance (inverse-square law); low count rates carry more uncertainty.



5. Live graphing

Materials: laptop with USB connection

- 1 Connect the counter to a laptop and observe the live graph.
- 2 Repeat the shielding or distance test and watch the graph respond in real time.

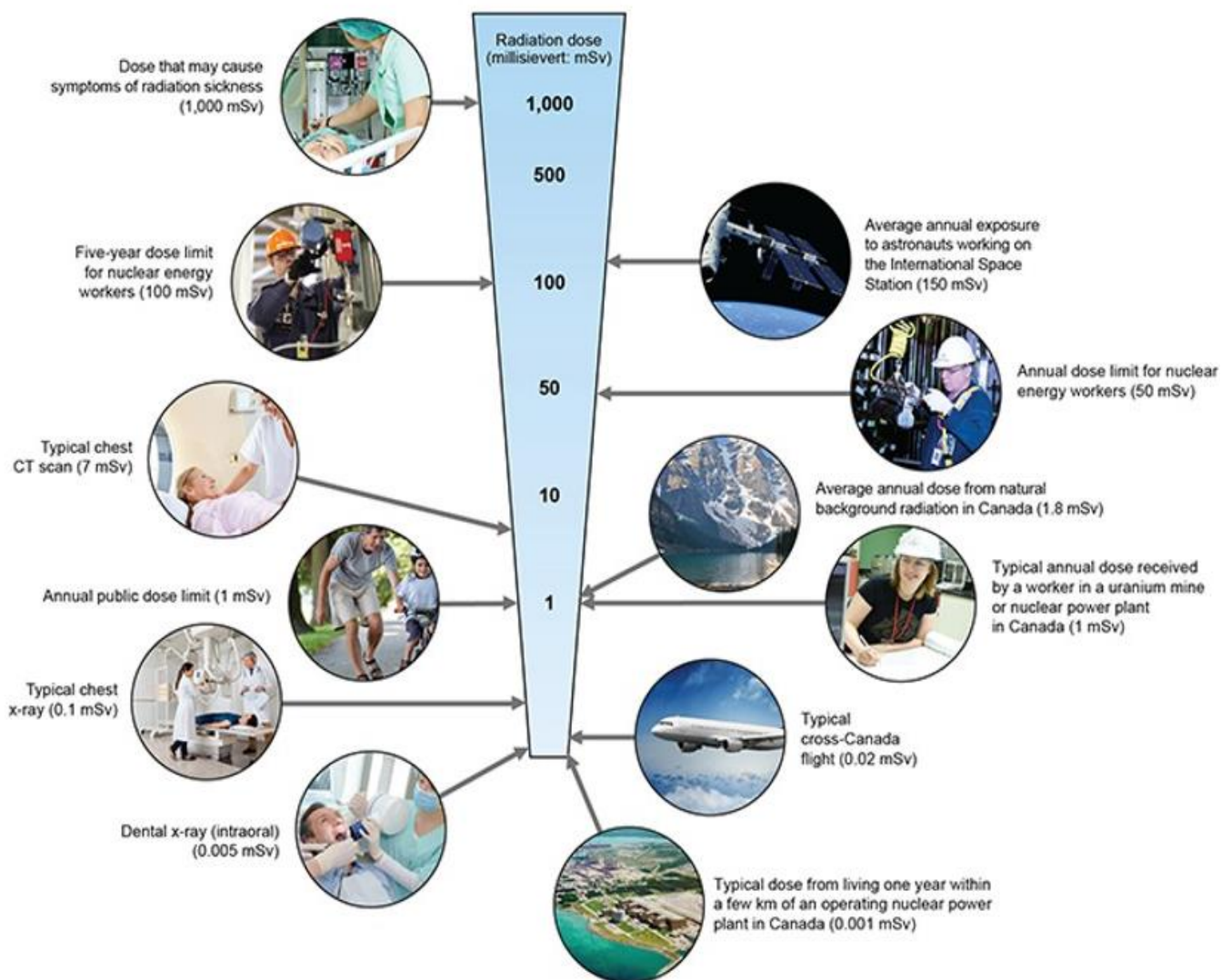
Students learn: How scientific instruments capture and visualize data as it's collected.

Putting the numbers in context

Students often ask: Is this a lot? The visual below, published by the Canadian Nuclear Safety Commission, places a range of everyday and occupational doses on a single scale. It is a good one to project alongside students' own classroom readings.

Source	Typical annual or one-time dose
Cross-Canada flight	0.02 mSv (one trip)
Dental x-ray	0.005 mSv (one x-ray)
Chest x-ray	0.1 mSv (one x-ray)
Living near a nuclear plant	0.001 mSv per year
Canadian average, natural background	1.8 mSv per year
Chest CT scan	7 mSv (one scan)
Public annual dose limit (Canada)	1 mSv per year (added, non-medical)
Nuclear energy worker annual limit	50 mSv per year

Radiation dose examples



Source: Canadian Nuclear Safety Commission, "Radiation doses," cnsccsn.gc.ca/eng/resources/radiation/radiation-doses/

Try it live: the Energy Education Canadian Radiation Dose Calculator (energyeducation.ca) lets students build their own comparison interactively. It is a good five-minute warm-up before this activity.

Vocabulary

Term	Plain-language meaning
Ionizing radiation	Energetic particles or waves with enough energy to knock electrons loose from atoms
CPM	Counts per minute, or how often the detector registers a radiation event
Dose (mSv)	A measure of radiation energy absorbed by the body, used to compare exposures
Background radiation	The natural radiation always present from the ground, air, food, and space
Half-life	The time it takes for half of a radioactive sample to decay
Shielding	A material that blocks or reduces radiation passing through it

Frequently asked questions

Is any of this dangerous?

No. All sources used are naturally occurring and low-level; the same materials are already part of everyday life.

Can I request more than one Geiger counter, or a replacement?

Geiger counters are limited and prioritized by request date and school need. Use the request form on the program page.

Where can I go deeper than this guide?

See the reference library on the program webpage for fact sheets, videos, and the isotope chart app.

Further resources

- CNSC — Radiation Doses & Natural Background Radiation fact sheets (cnsccsn.gc.ca)
- Energy Education — Canadian Radiation Dose Calculator (energyeducation.ca)
- IAEA Chart of the Nuclides app (iOS / Android, works on Chromebook)
- CNS Ionising Radiation Workshop video channel (YouTube: search CNS IRW)

Going further: real-world applications

For classes with extra time, or as a short research project, have students pick one application below, connect it back to something they measured in class, and present it in their own words.

Smoke detectors

Many household smoke detectors use a small amount of americium to detect smoke particles, an everyday example of a radioactive source doing useful work safely.

Nuclear medicine

Isotopes are used to image organs, treat cancer, and sterilize medical equipment. Connect to the Medicine & Isotopes topic on the CNS website.

Food and material dating

Radioactive decay at a known half-life is used to date artifacts, rocks, and archaeological finds.

Industrial gauges and inspection

Radiation is used to check welds, measure material thickness, and inspect sealed containers without opening them.

Questions, feedback, or requesting a Geiger counter?

Canadian Nuclear Society, Education Committee · cns-snc.ca/learn-nuclear/geiger-counter-program

Appendix: Student Worksheets

Photocopy the pages below for classroom use. Worksheet A pairs with the Essential Questions on page 2. Worksheets 1–5 pair with the experiments earlier in this guide.

Student worksheet A — Before we start — what do you already think?

Name: _____ Date: _____

Question	What I think	What my partner thinks	What we'll share
What is radiation?			
What are the risks?			
What are the benefits?			
How can we detect it?			

Reflection questions

After today's activities, which of your first answers changed the most? Why?

Student worksheet 1 — Background radiation over time

Name: _____ Date: _____

Minute	1	2	3	4	5	6	7	8	9	10
CPM										

Reflection questions

Did your CPM readings stay exactly the same each minute? Why or why not?

What do you think would happen if you measured for 60 minutes instead of 10?

Student worksheet 2 — Comparing everyday materials

Name: _____ Date: _____

Object	CPM reading	Notes
Teacher-selected item 1		
Teacher-selected item 2		
Teacher-selected item 3		
Classroom air (background)		

Reflection questions

Which object gave the highest reading? Were you surprised by any result?

Where might the radioactive atoms in these objects have come from?

Student worksheet 3 — Shielding materials

Name: _____ Date: _____

Material	Prediction (blocks a lot / some / none)	CPM reading
Paper		
Aluminum foil		
Plastic		
No shielding (control)		

Reflection questions

Which material blocked the most radiation? Did your prediction match your result?

Alpha particles are stopped by paper; gamma rays need thick, dense shielding. What does that tell you about the type of radiation your sample was giving off?

Student worksheet 4 — Distance and intensity

Name: _____ Date: _____

Distance (cm)	5	10	20	40	80
CPM					

Reflection questions

As distance doubled, roughly how much did your CPM drop? Does this match the inverse-square pattern shown in this guide?

Why might a real measurement not match the inverse-square law exactly?

Student worksheet 5 — Explore your own annual dose

Name: _____ Date: _____

Activity or source I entered	Dose (from the calculator)
My estimated total	

Reflection questions

Go to the Canadian Radiation Dose Calculator (energyeducation.ca) and build an estimate of your own year using activities that actually apply to you — flights taken, x-rays, where you live. Record each one and the running total above.

Before you calculated, what did you guess your total would be? How close was your guess?