



Nuclear Science

Scouts BSA · STEM

Name

Started

Completed

Nuclear science explains what's inside atoms and how that energy can be used for medicine, power, and research. You'll build atomic models, learn about radiation safety, and do hands-on experiments. It's a fascinating peek into how the universe works at its smallest level.

Requirements

Every official requirement, in plain language. Check the official wording when you sign off (scouting.org/merit-badges/nuclear-science/). Tips and examples are ideas, not extra requirements.

1 Radiation

Tips for this section: Make a list of natural and everyday sources of radiation, and explain ALARA in your own words.

Example for this section: Explain alpha, beta, and gamma radiation with a stop test: paper stops alpha, aluminum stops beta, thick lead or concrete slows gamma. Then explain ALARA as time, distance, and shielding, like an X-ray tech stepping behind a wall.

- ☐ **1a** Explain what radiation is and how ionizing and nonionizing radiation differ

- ☐ **1b** Explain the ALARA principle and how you'd keep your dose ALARA while doing this badge's requirements

- ☐ **1c** Describe the radiation warning (hazard) symbol and where it belongs

- ☐ **1d** Explain how we're exposed every day to ionizing radiation from space and from the earth. List four naturally occurring radioactive materials (NORM) found in your home or a grocery store and why they're radioactive

- ☐ **1e** Explain how radiation exposure differs from contamination and the hazards radiation poses to people, the environment, and wildlife. Estimate your yearly radiation dose and compare it with a typical nuclear power plant worker's

2 Basic nuclear science

Tips for this section: Build atom models from candy, beads, or clay, using different colors for protons, neutrons, and electrons.

Example for this section: Pick carbon and build models of carbon-12, carbon-13, and carbon-14 from beads or clay, one color each for protons, neutrons, and electrons, and label each with its mass and atomic numbers. Add a drawing of the quarks inside a proton and a neutron, and explain why carbon-14 lets scientists date old wood and bone.

- ☐ **2a** Explain these terms: atom, nucleus, electron, proton, neutron, quark, isotope, radioisotope, radioactivity, stability, ionization, alpha particle, beta particle, gamma ray, and X-ray

- ☐ **2b** Pick an element and build 3-D models of three of its isotopes showing protons, neutrons, and electrons, and write each one's isotope notation, including atomic and mass numbers. Using another model or a diagram, show the quarks that form protons and neutrons

3 Modern particle physics

Tips for this section: Look up a well-known particle accelerator and share what scientists are trying to learn with it.

Example for this section: Learn how an accelerator speeds particles up with electric fields and steers them with magnets. Then pick three, like the Large Hadron Collider at CERN, Fermilab, and Jefferson Lab, and describe an experiment at each and a practical use, like making medical isotopes.

- ☐ **3a** Explain how a particle accelerator works

3b Accelerator activity: Choose 1 of 2

- ☐ **3b1** Visit an accelerator, research lab, or university and talk with a scientist about how they study the nucleus or nucleons

- ☐ **3b2** List three particle accelerators and describe several of their experiments, including the basic science and practical uses

4 Classic experiments: Choose 2 of 3

Tips for this section: Pick two experiments with your counselor, and only use any materials or equipment under their guidance.

Example for this section: With your counselor, build a cloud chamber in a clear container with isopropyl alcohol and dry ice, with an adult handling the dry ice and any radioactive source, and watch for trails.

- ☐ **4a** Build an electroscope and show how it works. With an adult handling the radioactive material, put a radiation source near the ball and explain what happens

- ☐ **4b** Make a cloud chamber and show how it reveals radiation tracks, explaining what's going on. Adults must handle the radioactive materials and dry ice

- ☐ **4c** Do a half-life experiment with nonradioactive items such as candy or coins, and discuss decay chains

5 Radiation safety: Choose 1 of 3

Tips for this section: Work with your counselor to choose an activity, and ask a science teacher or university lab if they can help.

- ☐ **5a** With an adult handling the source, use a survey meter to show how counts per minute change as a radioactive source moves closer to or farther from the detector. Put three different materials between them and explain the differences. Explain how time, distance, and shielding lower a person's dose

- ☐ **5b** Describe how radon is detected in homes: the steps for long-term and short-term tests, how to read the results, and when to use each. Explain radon's health risks and how to reduce it in buildings

- ☐ **5c** Visit a place that uses X-rays and draw a floor plan of the room showing where the unit, operator, and patient are during use. Explain the safety precautions for the operator and why they matter

6 Nuclear energy: Choose 1 of 2

Tips for this section: Draw a simple diagram showing how a power plant turns heat from fission into electricity.

Example for this section: Draw the path from atom to outlet: a neutron splits a uranium atom, the heat boils water, steam spins a turbine, the turbine turns a generator. Label where the control rods and cooling water fit in.

- ☐ **6a** Draw how nuclear fission works. Watch an adult-built mousetrap reactor and use it to show how a chain reaction gets going, how a reactor stops or controls one, and what critical mass means. Afterward, talk with your counselor about how nuclear power plants produce electricity

- ☐ **6b** Visit a nuclear plant or reactor in person or online (with a parent's or guardian's OK) to learn how it works and makes power. Graph what share of US and your state's electricity comes from nuclear and other sources. Afterward, talk with your counselor about how nuclear power plants produce electricity

- ☐ **7** Give an example of each and explain how nuclear science is used and why it matters: nuclear medicine, environmental uses, industrial uses, space exploration, and radiation therapy

Tip: Look for examples in medicine, food safety, or space exploration.

Example: Give one example for each of the five areas: nuclear medicine finding heart disease with a scan, an environmental use like tracing how groundwater moves, an industrial use like irradiating food to kill germs, radioisotope power for space probes too far from the sun for solar panels, and radiation therapy aimed at a tumor.

- ☐ **8** Research one career related to nuclear science: training and education, costs, job outlook, pay, duties, and advancement. With a parent's or guardian's OK you may search online or at a library, interview a pro, or visit a workplace. Discuss your findings with your counselor and what makes the career appealing

Tip: Ask a scientist, engineer, or medical technologist about their work, or research what training they needed.