**A Guide for an HPS Chapter Presenting the**
**Boy Scouts of America Nuclear Science Merit Badge**

[NOTE: Teachers K-12 may request classroom assistance from the Health Physics Society (HPS) using the Teachers Request for Assistance form on the HPS Web site]

Identify a champion from within your chapter to head up the Boy Scouts of America (BSA) Nuclear Science merit badge. It would be nice if it is someone familiar with Scouting, but not necessary.

Determine if you want to cosponsor this with other organizations such as the American Nuclear Society (ANS) or the American Chemical Society (ACS).

Determine if you also want to offer this to others such as the Girl Scouts of the United States of America (GSUSA). As the GSUSA has no Nuclear Science merit badge, participating girls will complete the BSA requirements and have their performance documented on the same BSA form as the boys. The local GSUSA district may choose to award a special patch to its participants.

Determine what prerequisites you want. Scouts are as young as 11. You may therefore want to restrict participation to older boys who may have had more science in school and be more likely to understand the concepts you are teaching. One criterion may be that they have achieved the rank of First Class. They may still be young, but this would demonstrate an increased level of maturity.

Establish contact with the local BSA council or district. Some items to consider:

- Obtain copies of the Nuclear Science merit badge booklet. If you are going to be using several, they may need to be ordered in advance. They cost approximately $4 (instructors and students do not necessarily need their own copy but will need sections).

- Advertise through their roundtables, bulletin boards, Web site, etc. See Annex A and B for examples.

- Discuss the registration of merit badge counselors. The BSA prefers that all adults involved be registered. You may be able to make arrangements that only a designated person, who will be in charge and sign the merit badge cards, be registered. Instructors and students should not meet when no one else is present.

Solicit volunteers to teach the various requirements. There are some requirements that are optional, so what you present may vary based on the expertise you have available. The requirements are listed in Annex C. (If you have several instructors available and plan on having several Scouts, it has worked well to teach them in small groups that rotate. More on this is discussed below).

Decide which requirements you are going to teach. These can be divided up for instruction several different ways. If you plan to have several Scouts participate, it may be difficult to do some of the options. (What is discussed below has worked well, but is only a starting point for your own determination.)

Determine the time frame you are going to use to offer the material. The information below is based on presenting the merit badge over two consecutive Saturday mornings. One thing that has worked well is to give a homework assignment the first day asking the Scout to learn about a nuclear pioneer and careers and then make a presentation on the second day.

It is possible to conduct this merit badge in one or many days. A one-day event usually avoids the complication of people not having two consecutive Saturdays available (instructors and Scouts) and of having people not return for the second session. The cost of a one-day event may differ, mostly based on the cost of providing lunch. The other, more traditional option is to present the material over several evenings, usually during troop meetings. One or two instructors with a smaller group generally do this format.

Consider offering a tour (requirement 5) if your community has a nuclear facility. Almost every community has at least a hospital with a nuclear medicine department.

Find a location to present the merit badge. A science building at a local college works well.

Determine if you want to charge a modest fee, fund any costs as a chapter, or obtain industry sponsors. Costs may include such items as the merit badge booklets, copying, batteries for CD GM instruments, transportation to the tour site, snacks, and lunches. The main reason for the fee, besides defraying costs, is to help insure the Scouts will attend if they promise to. You will have to limit attendance based on the size of your facility and it is a good idea to try to ensure all who sign up will attend. It is not fair to deny others if some of the Scouts decide not to attend.

Meet as presenters to determine the movement of the Scouts through the various stations. Annex D provides an example letter that may be sent to potential teachers of what is expected, giving them some instruction and tips. Annex E may be used as an example of how to assign responsibilities.

Preregister the Scouts. Registration may consist of such things as recording the name, address, phone number, email, troop affiliation, rank, grade in school, and age of each Scout. Walk-in participants may be accepted as space allows. You may have individual Scout troops sign up their own Scouts, collect the fee (if any), and report the final names to the organizer at some specified time before the merit badge is taught.

Mail the registered participants anything they will need prior to the first session. This could include such items as a welcome letter (see Annex F), a map to the teaching site, and a list of the merit badge requirements that you have determined to deliver (See Annex C). Either include a blank BSA merit badge (blue) card or instruct them to get one

through their Scoutmaster. If you are going to have participants get their own merit badge booklet, they could be reminded of this in the letter.

Each Scout is responsible for filling out the administrative information on the blue card, getting it signed by his Scoutmaster (giving approval to work on the merit badge), and bringing it to the first meeting. The blue cards will then be kept by the coordinator during the week (if doing the merit badge in two consecutive Saturdays) and returned to the Scouts at the conclusion of the last day to take back to their troop leaders.

Determine any support and logistics needed for your situation.

Check in the Scouts at the first session. This may include the following: signing the roster, paying the activity fee (if applicable), and turning in their blue card. Each Scout could be given a routing signature form (Annex G) that each instructor will sign as that specific requirement is completed, a definitions handout worksheet (Annex H), a pioneering scientist and careers in nuclear science homework assignment sheet (Annex I), and the merit badge pamphlet (optional) in a color-coded folder. The color of the folder could be used to break the Scouts up by groups for rotation.

An example timetable of events for each day is presented in Annex J. A rotation matrix of groups is shown in Annex K. Divisions may be based on such things as age or grade in school (it works best to keep the younger Scouts together so the instruction can be given at their level).

Example First Day Overview: An introduction to nuclear science could be given to all the Scouts in a large group. The Scouts could then be broken out into groups, for example, five groups of six Scouts, each rotating through five different stations. In the smaller groups, the Scouts could receive additional instruction, answer questions in writing, conduct simple tests, or build items. Remember that these are young people giving up their time to learn; make it as interesting as possible by doing hands-on learning. The Scouts could reconvene as a large group for closing instruction and direction on the homework assignment.

Example Second Day Overview: The Scouts could again meet in a large group for an initial discussion and viewing of cloud chambers (or other items from requirement 5). This is also a good time for them to make their pioneering scientist report. Then break them up into groups (for example, into three groups of ten) to conduct discussions and “labs” in three different stations. It is good to close with the tour if you are electing to do that option.

Each teacher will sign the Scout’s signature form upon successful completion of his activity. These signature forms will be collected at the conclusion of the activities on each Saturday (i.e., they do not go home with the Scouts). During the tour or other closing activity, these forms will be reviewed to verify that all requirements have been met. If problems are identified, Scouts may be pulled out of the tour or closing activity for individual instruction to complete the merit badge. After the tour, the signed blue cards will be returned to the Scout for presentation to his Scoutmaster. Provide every

opportunity for the Scout to complete the merit badge at this time. If a Scout is unable to do this, he should be provided with contact information so that he can complete the requirements later (this is referred to as receiving a partial).

It should be set up so that there are no special safety considerations with this merit badge. Make sure that the individual teachers are not introducing any hazardous materials for use by the Scouts. Any radioactive material used should be natural, unlicensed quantities. General good conduct of Scouts is a requirement and, of course, is expected at the training center, on the bus, and during the tour. A leader should have a cell phone available to make emergency calls as necessary. If you are visiting a facility, make sure a briefing is presented before the tour and a qualified member of the facility staff is in attendance.

Annex A: Generic Announcements
Annex B: Merit Badge Announcement
Annex C: Merit Badge Requirements
Annex D: Teacher Letter
Annex E: Volunteer Sign-up
Annex F: Welcome Letter to Scouts
Annex G: Signature Sheet
Annex H: Definitions (requirement 2)
Annex I: Pioneering Scientist and Careers Homework Assignment (requirements 3 & 7)
Annex J: Schedule
Annex K: Rotation Matrix

## Annex A: Generic Announcements

## HPS Call for Help

The local chapter of the Health Physics Society is sponsoring the Boy Scouts of America Nuclear Science merit badge for boys and girls. We are in need of volunteers to help teach short segments of this merit badge to small groups. Lessons are fairly simple. If you are willing to help, please contact (Name, phone number, and email).

If you know a Scout age ?? and up (or a girl of corresponding age) who would like to participate, he (she) should contact (Name, phone number, and email). Enrollment will be limited to 30??? Scouts.

## Scout Meeting Announcement

## The Nuclear Science merit badge is being offered (insert date) at (insert facility).

- Sponsored by the Health Physics Society (and others as appropriate)
- Must be present both days
- Must be (First Class, ??? grade reading ability, ??? or older)
- Classroom instruction as well as fun hands-on lab classes
  - ❖ Learn history of nuclear science
  - ❖ Learn nuclear science principles including nuclear fission, chain reaction, and criticality
  - ❖ Learn about radiation safety
  - ❖ Learn about careers in nuclear science
  - ❖ Work with radiation detection instruments (optional)
  - ❖ Build/keep model reactor (optional)
  - ❖ Tour a nuclear energy site (optional)
- Experts in nuclear sciences fields provide the instruction
- Enrollment is limited to 30???
- Cost is $???
- Register by contacting (Name, phone number and email).

## Press Announcement

The local section of the Health Physics Society is sponsoring the Boy Scouts of America Nuclear Science merit badge to boy and girl Scouts ages ??? and up. Training will be conducted over two Saturday mornings at ??? on ???. Scouts will learn about nuclear science history, radiation safety, biological effects of radiation, detection of radiation, and criticality. Scouts will conduct several hands-on activities, including model building. Enrollment is limited to 30??? Scouts. If your Scout would like to attend this training, preregister by contacting (Name, phone number and email).

**Annex B: Merit Badge Announcement**

# Earn the *Nuclear Science* Merit Badge



The Health Physics Society is sponsoring the Boy Scouts of America Nuclear Science Merit Badge. The activity is open to boy Scouts and girls ages ??? and up.

**Where:** Training will be conducted at ???.

**When:** ??? starting at ??? a.m.

**What:** This is the study of Nuclear Science, its history, uses, and hazards. The completion of this merit badge will be conducted on two consecutive Saturdays???. Experts in the nuclear sciences fields will be teaching the material to the Scouts. We have set up several interactive activities. Each Scout will build and take home models of three-dimensional isotopes and a model nuclear reactor (optional). This experience should be interesting and rewarding for your Scouts. At the conclusion of this two-day study, each Scout will have completed the requirements to earn the Nuclear Science Merit Badge. Girl Scouts may be awarded an activity badge by the GSUSA.

**Who:** Scouts ages ??? and up. Although we will attempt to have most tasks conducted and completed "in class," some homework is required. This study requires a working knowledge of the atom (basic chemistry) and at least a ??? grade reading ability. Therefore, we are limiting participation to Scouts ages ??? and up. Maximum class size is 30??? Scouts.

**Cost:** $??? to cover miscellaneous supplies.

**How:** To register, please contact (Name, phone number and email).

**Annex C**


# NUCLEAR SCIENCE
# MERIT BADGE REQUIREMENTS

1. Do the following:
   a) Describe the biological effects and hazards of radiation to humankind, the environment, and wildlife. Explain the difference between deterministic and stochastic effects. In your explanation, discuss the nature and magnitude of radiation risks to humans from nuclear power, medical radiation, and background radiation. Explain the measures used by law to minimize these risks.
   b) Describe the radiation hazard symbol and explain where it should be used. Tell why and how people must use radiation or radioactive materials carefully.

2. Tell the meaning of the following: ALARA, alpha particle, atom, background radiation, beta particle, contamination, curie and Becquerel, gamma ray, half-life, ionization, isotope, neutron, nuclear energy, nuclear reactor, particle accelerator, quark, rad and gray, radiation, radioactivity, radon, rem and sievert, and xray.

3. Choose five individuals important to the field of atomic energy and nuclear science and explain each person's contribution (e.g., Henri Becquerel, Niels Bohr, Marie Curie, Albert Einstein, Enrico Fermi, Otto Hahn, Ernest Lawrence, Lise Meitner, Wilhelm Roentgen, and Sir Ernest Rutherford).

4. Choose an element from the periodic table. Construct three-dimensional models for the atoms of three isotopes of this element, showing neutrons, protons, and electrons. Use the three models to explain the difference between atomic number and mass number. Then do the following:
   a) Make a drawing showing how nuclear fission happens. Label all details. Draw another picture showing how a chain reaction could be started and how it could be stopped.
   b) Explain what is meant by a "critical mass."

5. Do any THREE of the following: (Once you have selected which requirement you will offer, you should delete the others prior to communicating the requirements to the Scouts)
   a) Build an electroscope. Show how it works. Place a radiation source inside and explain any differences seen.
   b) Build a model of a reactor. Show the fuel rods, control rods, shielding, moderator, and any cooling material. Explain how a reactor could be used to change nuclear energy into electrical energy or make things radioactive.
   c) Using a radiation survey meter and a radioactive source, show how the measurements per minute change as the source gets closer to or farther from the radiation detector. Place three different kinds of materials between the source and the detector, then explain any differences in the measurements per minute. Explain how time, distance, and shielding can reduce the radiation dose.
   d) Obtain a sample each of irradiated and nonirradiated foods. Prepare the two foods and compare their taste and texture. Store the leftovers in separate containers and under the same conditions. For a period of 14 days, observe their rate of decomposition or spoilage, and describe the dereference you see on days 5, 10, and 14.

e) Describe how radon is detected in homes. Discuss the steps taken for the long-term and short-term test methods, describe how to interpret the results, and explain when each type of test should be used. Explain the health concern related to radon gas and tell what steps can be taken to reduce radon in buildings.
f) Visit a place where x ray is used. Draw a floor plan of the room in which it is used. Show where the unit, the unit operator, and the patient would be when x ray is used. Explain the precautions taken when x ray is used and the importance of those precautions.
g) Make a cloud chamber. Show how it can be used to see the tracks caused by radiation. Explain what is happening.
h) Visit a place where radioisotopes are being used. Using a drawing, explain how and why they are used.
i) Obtain samples of irradiated seeds. Plant them. Plant a group of nonirradiated seeds of the same kind. Grow both groups. List any differences you observe during a 30-day period. Discuss with your councilor what irradiation does to seeds.
j) Visit an accelerator (research lab) or university where people study the properties of the nucleus. After your visit, discuss what you have learned with your councilor.

6. Do ONE of the following: (Once you have selected which requirement you will offer, you should delete the other two prior to communicating the requirements to the Scouts)
   a) Give an example of each of the following in relation to how energy from an atom can be used: nuclear medicine, environmental applications, industrial applications, space exploration, and radiation therapy. For each example, explain the application and its significance to nuclear science.
   b) Find out how many nuclear power plants exist in the United States. Locate the one nearest your home. Find out what percentage of electricity in the United States is generated by nuclear power plants, by coal, and by gas.
   c) Identify three particle accelerators in the United States. For each accelerator, describe three experiments that have been done or are in progress.

7. Find out about three career opportunities in nuclear science that interest you. Pick one and find out the education, training, and experience required for this profession and discuss this with your counselor. Tell why this profession interests you.

## Annex D: Teacher Letter


## Nuclear Science Merit Badge Teachers:

Thank you for volunteering to teach part of the Nuclear Science merit badge. We will meet in ??? on ??? at ??? a.m. for an organizational meeting. There we can meet each other and share ideas on teaching.

The Scouts and supporting organizations expect you to be prepared. I am confident that this will not be a problem. Please arrive on time and be ready to go.

Be sure to have read the associated material from the merit badge book (and any other supporting information as appropriate) and understand what it is you are going to teach. We have limited the ages to ??? and up so the Scouts should have a basic understanding of the atom, parts of the atom, and probably ionization. The information you present will need to be on a ??? grade level. The more hands-on demonstration and video clips you can present, the better the information will probably sink in.

We will have at least one rover during each morning session who could help out if a “situation” presents itself.

The merit badge book has definite guidelines for what the Scouts are supposed to write, tell, show, etc. Be sure that they write, tell, or show as indicated to you. We have made the groups small on purpose to help you do this. The groups are larger on the second day to especially accommodate the longer time required to build model reactors (optional) as well as the history section, thus allowing Scouts to learn a more complete history from each other.

Each Scout will be carrying a sheet with signature blocks for the given requirements. Each teacher is expected to sign each Scout’s paper in the appropriate section after the Scout has successfully completed the requirement. Requirement 2 is an extensive list of definitions. (For this we are using a worksheet where Scouts match definitions to terms.)

There will be dry-erase boards and overhead projectors in each room. I will provide dry-erase markers. The main classroom will have a PowerPoint projection capability ???.

This should be fun and rewarding for all of us.

I will expect feedback from each teacher at the conclusion of the process so we can make any needed improvements next year.

Thanks for your help.

???

## Annex E: Volunteer Sign-up

| Activity Title | Responsibility | # | Days | Volunteer |
|---|---|---|---|---|
| Organizer | General organization, planning, recruiting | 1 | Duration | |
| Advertising | Post notice in HPS newsletters about need of volunteers. Notify Scout office and Scoutmasters and post notices in HPS newsletters about program. Submit information to newspaper. | 1 | Duration | |
| Tour Coordinator | Find tour destination, tour guide, and transportation; determine what personal information is required for access, determine maximum group size (could split into two or more groups for parallel tours). | 1 | Duration | |
| Supplies | Order all necessary supplies, as requested by teacher, for various workstations. Order BSA Nuclear Science merit badge pamphlet (as needed). | 1 | Duration | |
| Facilities | Arrange for facility with classrooms. | 1 | Duration | |
| BSA/GSUSA legalities | Ensure coordination with BSA and GSUSA rules/requirements/buy-in. Present plan to organizations—seek input. | 1 | Duration | |
| Check-in | Registration | 2 | Day 1<br>Day 2 | |
| Floater/Substitute | Check in with each work station, see if any items are needed, lend hand in teaching/reviewing definitions (one-on-one but not alone as necessary, take pictures, substitute in case of teacher illness, maintain schedule. | 2 | 1 day per volunteer | |
| Introduction | Conduct introductory 40-minute classroom training session. | 1 | Day 1 | |
| Station A | Conduct requirement 1b training with *ALARA and contamination* definitions. | 1 | Day 1 | |
| Station B | Conduct requirement 5c training:<br>Detection, shielding, distance, time. | 1 | Day 1 | |
| Station C | Conduct requirement 1a training:<br>Biological effects. | 1 | Day 1 | |
| Station D | Conduct requirement 4 training with definitions of *atom, neutron,* and *isotope*. Isotope models. | 1 | Day 1 | |
| Station E | Put it in perspective, average annual dose with definitions *background radiation, radon, Ci, Bq, Sv, gray, rem, and rad.* | 1 | Day 1 | |
| None | Definitions grader | | Day 2 | |
| Station F | Conduct requirement 4a and 4b training with *nuclear energy and particle accelerator* definitions.<br>Fission, chain reaction, criticality | 1 | Day 2 | |
| | Conduct requirement 7 training:<br>Applications and Careers. | 1 | Day 2 | |
| Station G | Conduct requirement 5b training with *nuclear reactor* definition; build model reactor. | 2 | Day 2 | |
| Station H | Lead classroom discussion on history of pioneers satisfying requirement 3; review day 1 definitions for requirement 2. | 1 | Day 2 | |
| Tour | Tour | 2-5 | Day 2 | |

## Annex F: Welcome letter


Date

Dear <Scout>,

Please share this letter with your parent(s).

I am excited to let you know that you have been registered for the Nuclear Science merit badge to be held ??? at ??? in the mornings at ???. We have lined up enthusiastic experts in the nuclear sciences fields to guide you through the requirements of this merit badge. These teachers work daily with many of the things you will be learning! Many of the teachers were Scouts themselves and are currently active in leadership roles in the Scouting organization.

Enclosed you will find additional information and details on how you will earn this merit badge. If for some reason you cannot attend the training, please let me know as soon as possible so that other interested Scouts can take your place.

**Location:** All training will be conducted at the ??? building. I have enclosed a map showing the location. Once you enter the building, you will see signs and other Scouts who will be able to direct you to the correct room.

**Time:** Please be at there at 8:00 a.m. on Saturday ??. The first morning will finish up at about ?? p.m. On the following Saturday, ???, we will meet at the same time and place. We will finish at ??? p.m. Participation during both days, along with assigned homework, is necessary to complete the merit badge requirements.

**Uniform:** Come in your Scout (Class A) uniform on both days.

**What to bring:**

First day:

- Merit badge (blue) card, filled out and signed
- Pencil or pen
- $??? to cover the cost of supplies

Second day:

- Pencil or pen
- Information packet (supplied on first day)
- Sack lunch???
- Student or other form of ID, required for tour ???
- Wear close-toed shoes???

**Tour:** ???

(Optional, **Parents:** We will be carpooling to ??? so we need some parents to volunteer to drive. If you are willing, please contact the coordinator listed below. If you want to drive just your child, that is also fine, but let us know so we can plan the carpooling.)

I think you will find the training a lot of fun. I look forward to seeing you on ???. Please feel free to contact me if you have any questions.

Sincerely,

???, Event Coordinator
(Home phone, work phone, email)

## Annex G: Signature Sheet

Scout name _____

### Nuclear Science Merit Badge
### Signature Sheet

| | Station | Requirement | Task | Initials |
|---|---|---|---|---|
| Day 1 | A | 1b | Learn radiation safety/symbols<br><br>Definitions to learn:<br>**ALARA, contamination** | |
| | B | 5c | Radiation sources: effects of distance and shielding | |
| | C | 1a | Biological effects | |
| | D | 4 | Build isotope models<br><br>Definitions to learn:<br>**atom, neutron, isotope** | |
| | E | na | So what does it all mean to me?<br>What is my dose?<br>Definitions to learn:<br>**Ci, Gray, Bq, Rad, Rem, Sv, Radon** | |
| Day 2 | F | 4a, 4b | Show nuclear fission/chain reaction<br>Definitions to learn:<br>**nuclear energy, particle accelerator** | |
| | | 6a,<br>7 | Applications and<br>Career discussion | |
| | G | 5b | Build model nuclear reactor; discuss nuclear power plants<br>Definition to learn:<br>**nuclear reactor** | |
| | H | 3 | Pioneers in nuclear science (history)<br><br>Definitions:<br>Review and answer any questions | |
| | none | 2 | Definitions | |

## Annex H: Nuclear Science Merit Badge Definitions Worksheet, Requirement 2

Match the term with the correct definition. Place letter associated with the term in front of the correct definition. Use your merit badge book as much as needed.

| | | | |
|---|---|---|---|
| A | ALARA | | A measure of radiation equivalent to the amount of radioactivity emitted by 1 g of radium. |
| B | alpha particle | | Time required for half of a large group of radioactive elements to undergo decay. |
| C | atom | | Like a *gray*, this is a measure of the radiation dose absorbed by a material (not man). 1 gray = 100 of these. |
| D | background radiation | | Like rem, another measure for the radiation effect on man; 100 rem = 1 of these. |
| E | beta particle | | Subatomic components that make protons and neutrons. |
| F | contamination | | As Low As Reasonably Achievable; refers to worker radiation dose when working with radioactive materials. |
| G | curie | | Short for roentgen equivalent man, this is a measure of the radiation intensity and its effect on man; therefore, the type and penetrating power is a function of the measure. |
| H | becquerel | | Energy released from the nucleus of an atom when it undergoes fission, fusion, or radioactive decay. |
| I | gamma ray | | A particle emitted from a nucleus of an atom composed of 2 protons and 2 neutrons (He nucleus) with a +2 charge. |
| J | half-life | | An electron emitted from a nucleus of an atom. |
| K | ionization | | Like *rad*, this is another measure for the radiation dose absorbed by a material (not man); 100 rads = 1 of these. |
| L | quark | | The smallest piece of an element consisting of protons, neutrons, and an electron shell. An element is specific to the number of protons in the nucleus. |
| M | isotope | | A naturally occurring radioisotope found in all parts of the country at various concentrations. |
| N | neutron | | As it relates to radioactive particles, this is the process of energetic particles or photons released or emitted during radioactive decay. |
| O | nuclear energy | | The radioactive particle or photon (alpha, beta, gamma, or x ray) emitted from a radioactive element. |
| P | nuclear reactor | | Ionizing radiation present all around you from sources such as cosmic rays, radon and decay products, building materials, foods, and each other (including ourselves). |
| Q | particle accelerator | | Process that causes an atom to lose or gain an electron(s). |
| R | rad | | A variation of an element driven by a variation in the number of neutrons in the nucleus. |
| S | gray | | A measure of radiation (like a curie), 1 disintegration per second. |
| T | radiation | | High-energy radiation emitted from the electron cloud around a nucleus. It is created/harnessed to take x-ray pictures. |
| U | radioactivity | | A high-energy photon emitted from a nucleus of an atom. |
| V | radon | | Radioactive materials in a place where you do not want them to be. |
| W | rem | | A device that can speed subatomic particles at extremely high speeds into targets of atoms. It is usually used to study subatomic particles. |
| X | sievert | | A device in which a nuclear chain reaction takes place. |
| Y | x ray | | A neutral-charged particle that usually resides in the nucleus of an atom. It weighs nearly the same as a proton (atomic weight of 1). |

Tell what the following term, or acronym, means:

ALARA _____ .

**Extra Credit**

Define fallout: _____

_____

Name a radioactive isotope in your body: _____

List the parts of the Nuclear Science merit badge:

| | |
|---|---|
| u: |  |
| d: | |
| $e^-$: | |
| uud: | |
| ddu: | |
| $\bar{\nu}$: | |
| E: | |
| m: | |
| c: | |
| Who developed the formula $E = mc^2$? | |

## Annex I: Nuclear Science Merit Badge Homework Assignment, Requirement 3

### Pioneering Scientists

1) You have been assigned the name of one historical figure in the history of nuclear energy. You need to make a presentation about this person (3 minutes) to your teammates. In this presentation you need to share the following:

- Who was this person (birth nation, country/facility where study was conducted, any special training/education this person had, etc.)?
- What did he/she discover relative to the field of nuclear science?
- What year was this discovery (or discoveries) made?
- How did this discovery build on previous discoveries? (For example, what was postulated or discovered before that made this discovery possible?)
- Provide a picture of this person and his/her experimental equipment if possible. (You can share pictures directly from a book.)
- Share any other interesting facts about this person, his/her research, challenges, etc.

Your resources may include the merit badge pamphlet, encyclopedias, biographies from the library, Internet searches, or any other reference material you can find.

2) Pick any four of the other names listed below or as given in your merit badge book and write what they discovered about nuclear science. Check your answer when your teammate discusses this person at the next meeting. (Note: you can use the worksheet below to take notes from presentations by your teammates.)

Who was ***Henri Becquerel***? _____

_____

What did he discover? _____

_____

Who was ***Niels Bohr***? _____

_____

What did he discover? _____

_____

Who was ***Marie Curie***? _____

_____

What did she discover? _____

_____

Who was ***Albert Einstein***? _____

_____

What did he discover? _____

_____

Who was ***Enrico Fermi***? _____

_____

What did he discover? _____

_____

Who was ***Otto Hahn***? _____

_____

What did he discover? _____

_____

Who was ***Ernest Lawrence***? _____

_____

What did he discover? _____

_____

Who was ***Lise Meitner***? _____

_____

What did she discover? _____

_____

Who was ***William Röntgen (alternate spelling Roentgen)***? _____

_____

What did he discover? _____

_____

Who was ***Sir Ernest Rutherford***? _____

_____

What did he discover? _____

_____

Who was _____? _____

_____

What did he/she discover? _____

_____

Who was _____? _____

_____

What did he/she discover? _____

_____

**Annex I continued: Nuclear Science Merit Badge Homework Assignment**

**Careers in Nuclear Science, Requirement 7**

Find out about three career opportunities in nuclear science that interest you. Pick one and find out the education, training, and experience required for this profession and discuss this with your counselor. Tell why this profession interests you.

Career: _____

_____

Education: _____

_____

Training/experience: _____

_____

_____

Where could you work at this career? _____

_____

Why does this interest you? _____

_____

_____

_____

_____

_____

_____

## Annex J: Schedule

Day 1 (6 groups of 5)

| Activity | Description | Teachers | Duration, min | Start Time | End Time | Location | Discuss Definitions |
|---|---|---|---|---|---|---|---|
| Check-in | Safety equipment on display in classroom | | 0:30 | 8:00 | 8:30 | | |
| Opening remarks | Describe process for day | | 0:15 | 8:30 | 8:45 | | |
| Lecture | Introduction to Nuclear Science | | 0:45 | 8:45 | 9:30 | | radioactivity, radiation, alpha particle, beta particle, x ray, gamma ray, half-life, quark, ionization |
| Lab/Lecture (4) | Build models of isotopes | | 0:30 | 9:30 | 12:00 | | atom, neutron, isotope |
| Lab (5c) | Distance/shielding | | 0:30 | 9:30 | 12:00 | | |
| Lab/Lecture (1a) | Biological effects | | 0:30 | 9:30 | 12:00 | | |
| Lab (1b) | Rad symbol/Safety | | 0:30 | 9:30 | 12:00 | | ALARA, contamination |
| Lab/Discussion (2 partial) | Your radiation exposure, and units of measure | | 0:30 | 9:30 | 12:00 | | background radiation, Ci, Bq, rem, Sv, gray, rad, radon |
| Lecture | Assign homework | | 0:15 | 12:00 | 12:15 | | |
| Closing | | | 0:15 | 12:15 | 12:30 | | |

## Annex J continued: Schedule

Day 2 (3 groups of 10)

| Activity | Description | Teachers | Duration, h:min | Start Time | End Time | Location | Definitions |
|---|---|---|---|---|---|---|---|
| Check-in | Cloud chambers on display | | 0:30 | 8:00 | 8:30 | | |
| Introductory remarks | Announcements, peel off in groups | | 0:10 | 8:30 | 8:40 | | |
| Lecture | Discuss cloud chamber (3 would be great) | | 0:20 | 8:40 | 9:00 | | |
| Lab/Lecture (4a, 4b) | Nuclear fission/chain reaction/critical mass | | 0:30 | 9:00 | 12:00 | | nuclear energy, particle accelerator |
| Discussion (6a, 7) | Applications and Career discussion | | 0:30 | 9:00 | 12:00 | | |
| Lab (5b) | Build model nuclear reactor | | 1:00 | 9:00 | 12:00 | | nuclear reactor |
| Lecture (2 and 3) | Pioneers (40m)/Definitions help (20m) | | 1:00 | 9:00 | 12:00 | | Check definitions from day 1. |
| Wrap up/Bathroom break | | | 0:15 | 12:00 | 12:30 | | |
| Tour with sack lunch on the bus | Tour | | 1:00 | 13:00 | 14:15 | | |

**Annex K: Rotation Matrix**

## Day 1

Divide into 5 teams of 6 Scouts
Rotation

| | **Station A** | **Station B** | **Station C** | **Station D** | **Station E** |
|---|---|---|---|---|---|
| **9:30-10:00** | Team 1 | Team 2 | Team 3 | Team 4 | Team 5 |
| **10:00-10:30** | Team 5 | Team 1 | Team 2 | Team 3 | Team 4 |
| **10:30-11:00** | Team 4 | Team 5 | Team 1 | Team 2 | Team 3 |
| **11:00-11:30** | Team 3 | Team 4 | Team 5 | Team 1 | Team 2 |
| **11:30-12:00** | Team 2 | Team 3 | Team 4 | Team 5 | Team 1 |

## Day 2

Divide into 3 teams of 10 Scouts
Rotation

| | **Station F** | **Station G** | **Station H** |
|---|---|---|---|
| **9:00-10:00** | Team 1 | Team 2 | Team 3 |
| **10:00-11:00** | Team 3 | Team 1 | Team 2 |
| **11:00-12:00** | Team 2 | Team 3 | Team 1 |