

Synchrotron Applications Presentation

Created by: Blair Proctor, College of Education, University of Saskatchewan. A Lesson Plan for Grade 12 Physics

Pan-Canadian Objectives

| Science Grade | Knowledge | Science, technology, society and the environment | Skills | ATTITUDES |
|---------------|-----------------------------|--|-------------------------------|--|
| 10-12 | 325-4, 325-13, 327-6, 328-1 | 115-3, 115-7, 116-all, 117-1, 117-2, 117-5, | 213-6, 213-7, 214-12, 215-all | 436, 439, 440, 441, 442, 443, 445 |
| 7-9 | 308-8, 308-11, 308-12 | 109-7, 111-all, 112-all, 113-2 | 209-5, 211-all | 422, 423, 424, 425, 426, 427, 428, 430, 431, |

Factors of Scientific Literacy:

A3 holistic
 A4 replicable
 A7 unique
 B1 change
 B2 interaction
 B10 cause-effect
 B12 conservation
 B16 system
 B21 accuracy

B22 fundamental entities
 B27 amplification
 C4 working cooperatively
 C5 measuring
 D1 science and technology
 D5 public understanding gap
 E1 using magnifying instruments
 F1 longing to know and understand

Common Essential Learnings:

COM - To enable students to understand and use the vocabulary, structure and the process of synchrotron light.

TL - To develop a contemporary view of relating science to technology.

TL - To develop an understanding that technology both shapes society and is shaped by society.

Materials:

- ✿ Model of a synchrotron light pathway (optional)
- ✿ Red laser pointer
- ✿ Mirrors
- ✿ Picture of the pathway on overhead (transparency)
- ✿ Lazy Susan →→→→→→→→→
- ✿ Popcorn kernels

- ✿ Flypaper (or very sticky tape)
- ✿ Bunsen burner
- ✿ Steel plate



Establishing Students' Prior Knowledge: The following concepts/vocabulary should have already been taught in order to complete this lesson:

- | | |
|------------------|----------------------|
| ✿ Energy | ✿ Magnetic field |
| ✿ Microwave | ✿ Dipole |
| ✿ Speed of light | ✿ Electron volt (eV) |
| ✿ Volt | ✿ Force |
| ✿ Electromagnet | |

Motivational Set

Select a student to put the lazy Susan in motion either at the front of the class or on a student's desk, preferably someplace visible to everyone. Have other students speed up the lazy Susan by applying a force in the direction of motion. What do you notice about the lazy Susan? The speed increases. If this process were to continue, the lazy Susan would reach impeccable speeds in ideal condition.

This demo uses centripetal motion to speed up the process; the synchrotron uses electromagnets to speed up the electrons in the same manner. At this point, students will be curious for more.

Teaching Method

Lecture, demonstrations, student presentations

Body of the Lesson

The Teacher will:

1. Discussion of the synchrotron.
 - a. Uses extremely bright, high energy light
 - b. Uses electromagnets and radio frequency waves
 - c. Used in crystallography (structures of macromolecules) to create new drugs; advanced material research; environmental research; imaging; forensics; etc.
 - d. Employs many. The CLS is mainly used for research.
 - e. The importance of the stability and foundation of the CLS
2. Display the diagram of the synchrotron on the overhead projector. Used this overhead as a guide for discussions.
 - 4 main parts to a synchrotron**
 - i. Electron gun and linear accelerator
 - ii. Booster ring
 - iii. Storage ring
 - iv. Beamlines & Endstation
 - a. Electron gun and LINAC
 - ✿ Uses high amounts of electricity to “boil” electrons off of a tungsten-oxide disk and onto a positive charged screen.
 - ✿ To help illustrate an E-gun, take a handful of popcorn kernels and place them on a steel plate over the flame of a Bunsen burner. While

kernels are heating up, hold flypaper 3 inches above the kernels. Once the kernels have absorbed enough energy they will pop up and stick to the paper just like the electrons of an E-gun.

- ✿ The LINAC takes electrons and speeds them up with microwave frequency energy fields.
 - ✿ Everything occurs in a vacuum chamber. Ask students if they know what a vacuum chamber is and for what reasons would scientists prefer to use them.
- b. Booster Ring
- ✿ Electrons get a speed boost using the magnetic fields created by large electromagnets.
 - ✿ Speed nearly reaches the speed of light; discuss the properties of an electron at such high speeds.
- c. Storage Ring
- ✿ Electrons that have absorbed enough energy to produce light are ejected into the storage ring where they can remain for up to 12 hours.
 - ✿ Dipole magnets change the direction of the electrons releasing energy in the form of photons or light.
 - ✿ Discuss insertion devices used to make a narrow beam of intense light.
- d. Beamlines & Endstations
- ✿ Synchrotron light covers the full range of the light spectrum.
 - ✿ The Beamlines can be fine tuned so that only certain light wavelengths can pass through. Certain light is useful for certain experiments.
 - ✿ Types of beamlines

Activity

1. Place students into groups for oral presentations.
2. Presentations will be on the applications of the Beamlines and will be less than 10 min in length per group.
3. Presentations will include:
 - a. title of beamline (i.e. Bio, materials, ...)
 - b. type of light used and the reasons for it
 - c. how is this information analyzed
 - d. where is the information used in industry
4. Presentations will be on the beamlines that are currently available at the CLS:
 - a. Bio beamline
 - b. Materials beamline
 - c. Polymers and plastics beamline
 - d. Pharmaceutical beamline – Protein Crystallography
 - e. Environmental beamline
5. Students will be given 3 days to prepare for presentations with one day spent researching during class time.

6. Students may use the information from the web. Suggest to students to read over the package provided by the CLS found here:
<http://www.lightsource.ca/education/s-package.pdf>

Debrief

As a class:

- ✿ Discuss the societal benefits of having the synchrotron.
- ✿ Discuss the set up of a synchrotron.
- ✿ Discuss types of beamlines.

Evaluation

Students will be evaluated on their presentations using the attached marking sheet.

References

<http://www.lightsource.ca/>

<http://www.lightsource.ca/education/whatis.php>

<http://www.sasked.gov.sk.ca/docs/physics/u730phy.html>

Presentation marking sheet


Name of

Presenters: _____

Your name: _____

Date: _____


Physical elements of presentation:

 Eye contact

 Appropriate Posture/gestures

1 2 3


Oral Component:


 Pronunciation


 Modulation (tone)


1 2 3

Content

 Title of beamline (i.e. Bio, materials, ...)

 Type of light used (and its wavelength) and the reasons for it

 Method of analysis

 Relate to industry

1 2 3 4 5 6 7 8 9