

#### RadiationSafety Institute of Canada

Institut de radioprotection du Canada

#### Lunch, Learn, & Dance Wellness Webinars

February 18, 2021

## **Uses of Radiation**

Followed by STEPs Dance

**Good Science in Plain Language**<sup>®</sup>



# **Webinar Functionality**

- Audio and video
  - Will be from the presenters only
  - Use computer or telephone (call in)
  - Computer seems to give the best sound quality
- Use the "Chat" feature to enter comments
- Use the "Questions" feature to ask questions
- Posted on webinar page
  - Video, Q&A answers, copy of the slides
- Follow up email will be sent
  - Topics covered, time of attendance
- It may be possible to change your Zoom view if the controls are hiding the closed captioning.





- Matter and energy
- Broad categories of radiation
- Ionizing vs. non-ionizing
- Nuclear particle
- Particle accelerators
- Electromagnetic
- Waves in matter
- Mixed field
- Uses by type
- Uses with multiple types





#### **Matter & Energy**



#### FORMS OF ENERGY

- Matter
  - Has mass
  - Takes up space
- Energy
  - The ability to create change
  - Mechanical energy
    - Kinetic movement
    - Potential stored
- Radiation
  - Transfer of energy in a straight line
    - Beams of particles
    - Waves





# Broad Categories of Radiation

- Particles of matter
  - Nuclear
  - Particle beams
- EMF
  - Electromagnetic waves/beams of photons
  - Natural or created by devices
- Waves in matter
  - Need medium to travel
- Mixed field





# **Ionizing vs. Non-Ionizing**



- Any type can be categorized at ionizing or non-ionizing
- Ionizing
  - Enough energy to remove electrons from atoms
  - Can cause damage to large molecules, such as DNA molecules
  - Federally regulated
- Non-ionizing
  - Not enough energy to remove electrons from atoms
  - Damage mainly due to heating or photochemical effects
  - Provincially regulated



### **Nuclear Material Particles**

- Atom made up of
  - Protons (+)
  - Neutrons (0) and
  - Electrons (-)
- Nucleus
  - Protons and neutrons
  - At the center
  - Electrons orbit the nucleus
- Most elements stable
  - Unstable nuclei emit radiation to become stable
- Alpha, beta, neutron, gamma radiation are all ionizing.





#### Alpha (a) Radiation





Roughly 7 cm in air

Stopped by a sheet of paper

E

Absorbed in dead layer of skin



#### Beta (β) Radiation





Roughly 200 cm in air



Stopped by a glass and plastic



Can reach the living layer of skin





- Neutrons ejected from the nucleus of unstable atoms.
- Do not have charge
  - Hit electrons
  - Hit nuclei
- Only type that can make material radioactive
- Free neutrons decay into other radiation
- Very damaging





#### **Particle Accelerators**

- Humans can make beams of charged particles
- Not nuclear

- Can interact in the accelerator to produce nuclear
- Output can be the material particles or photons





Electromagnetic

# THE ELECTROMAGNETIC SPECTRUM





#### Gamma & X-Ray





#### **X-Ray Production**







#### **Mixed Field**



- Common
  - Alpha or beta emission is followed by gamma
  - Neutron irradiation can produce gamma
- Cosmic radiation
  - Particles that come from space
  - Also receive electromagnetic
  - Naturally occurring
  - Atmosphere protects Earth



#### **Waves in Matter**

- Energy can be transmitted
- Need a medium
- Technically radiation
- Examples
  - Sound
  - Ultrasound
  - Seismic waves
- Not ionizing





### **Alpha Radiation Uses**



- Smoke detectors
  - Americium
- Static eliminators
  - Polonium
  - Positive charge attracts electrons
- Spacecraft
  - Plutonium for propulsion
  - Thermoelectric heaters
- Energy source for remote areas
  - Strontium
  - Remote sensing stations
  - Buoys
  - Offshore oil platforms



#### **Beta Radiation Uses**

- Short distances
- Can trigger gamma emission
- Uses
  - Cancer treatments
  - Nuclear gauges
  - PET scanners
    - Material tagged with isotope
    - Short half-lives
    - C-11, N-13, O-15, or F-18
    - Ga-68, Zr-89, Rb-82





#### **Neutron Radiation Uses**



- Various techniques using neutrons
  - Composition of materials
  - Crystalline structures
  - Thin films
  - Engineering analysis of strain
  - Imaging and 3D imaging of materials
- Production of isotopes
  - Medical applications
- Nuclear Energy Production
- Nuclear Gauges



#### **Nuclear Power**



- Very efficient compared to electricity production by fossil fuels (coal, oil)
- Produces relatively small volume of waste
- But fission process produces radiation and radioactive byproducts



#### Nuclear Power in Canada – the CANDU Reactor

- CANDU means Canada Deuterium
  Uranium
- Uses natural uranium (99.3% U-238, 0.7% U-235)
- Uses heavy water D<sub>2</sub>O (versus H<sub>2</sub>O) to cool the fuel and moderate (slow down) the neutrons
- Currently 19 operating reactors in Canada – 18 in Ontario, 1 in New Brunswick
- 10 CANDU reactors globally



#### What is *Nuclear Fission ?*

Good Science in Plain Language\*







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#### **Particle Accelerator Uses**



- Particle accelerators use electric circuits and magnetic fields to speed charged particles to great speeds.
- They are used in
  - Research
  - Isotope production
  - Medical treatment

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#### **Electromagnetic Uses**

	Wavelength (m)	Frequency (Hz)	Energy (J)	
Radio	> 0.1 m	< 3 x 10 <sup>9</sup>	< 2 x 10 <sup>-24</sup>	
Microwave	1 x 10 <sup>-3</sup> - 1 x 10 <sup>-1</sup>	3 x 10 <sup>9</sup> - 3 x 10 <sup>11</sup>	2 x 10 <sup>-24</sup> - 2 x 10 <sup>-22</sup>	A CARACTER CONTRACTOR
Infrared	7 x 10 <sup>-7</sup> - 1 x 10 <sup>-3</sup>	3 x 10 <sup>11</sup> - 4 x 10 <sup>14</sup>	2 x 10 <sup>-22</sup> - 3 x 10 <sup>-19</sup>	
Optical	4 x 10 <sup>-7</sup> - 7 x 10 <sup>-7</sup>	4 x 10 <sup>14</sup> - 7.5 x 10 <sup>14</sup>	3 x 10 <sup>-19</sup> - 5 x 10 <sup>-19</sup>	
UV	1 x 10 <sup>-8</sup> - 4 x 10 <sup>-7</sup>	7.5 x 10 <sup>14</sup> - 3 x 10 <sup>16</sup>	5 x 10 <sup>-19</sup> - 2 x 10 <sup>-17</sup>	
X-ray	1 x 10 <sup>-11</sup> - 1 x 10 <sup>-8</sup>	3 x 10 <sup>16</sup> - 3 x 10 <sup>19</sup>	2 x 10 <sup>-17</sup> - 2 x 10 <sup>-14</sup>	
Gamma-ray	< 1 x 10 <sup>-11</sup>	> 3 x 10 <sup>19</sup>	> 2 x 10 <sup>-14</sup>	the second se

Data courtesy of NASA



#### **Radio Uses**

- Can pass through the atmosphere and most building materials
- Bounces off ionosphere
- Can be easily reflected
- Non-destructive
- Used for
  - Communications
  - Heating
  - Remote controls
  - MRI Scans



Image courtesy Jan Ainali, CC BY 3.0



#### **Microwave Uses**



Image courtesy brewbooks, CC BY-SA 2.0

- Subset of radiofrequency
- Line of sight
- Small antennae
- Uses
  - Heating
  - Communications
    - Satellite
  - Radar





- Predates laser
- Microwave Amplification by
  Stimulated Emission of Radiation
- Creates coherent beam of microwave radiation
- Used in
  - Satellite and air to air communications
  - Radio telescopes
  - Radar









- Just below red light in terms of energy and frequency
- Heats material
- Uses
  - Electric heaters
  - Cooking
  - Remote controls
  - Thermal imaging cameras

Image courtesy Black Hills Thermal Imaging, CC BY-SA 3.0





- Detected by the human eye
- Wavelength: 400 to 750 nm.
- Colour order
  - Red
  - Orange
  - Yellow
  - Green
  - Blue
  - Indigo
  - Violet
- Can transmit through glass
- Easily reflected off smooth surfaces









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- Light Amplification by Stimulated Emission of Radiation
- Light reflects back and forth
  - Leave chamber
  - Monochromatic
  - Coherent
  - One direction
- Uses many
  - Electronics
  - Research
  - Dermatology
  - Tattoo & hair removal
  - Surgery
  - Holography
  - Weapons
  - Communications



### Ultraviolet (UV) Uses

- Just above violet light in terms of energy and frequency
- Higher energies are ionizing
- Exposure can cause
  - Cataracts
  - Cancer
- Used in
  - Tanning beds
  - Nail polish curing
  - Fluorescent pigments and dyes
  - Kill bacteria/viruses
- Insects, other animals





#### Gamma (ɣ) Uses



Image Courtesy of Mosaic

- Medical
  - Cancer treatment
  - Imaging
  - Sentinel node dissection
- Sterilization of objects
  - Food
  - Art
- Industry
  - Imaging
  - Nuclear gauges
  - Crosslinking of polymers
- Materials analysis
  - Spectrometry





- XRF materials analysis
- Analytical x-ray materials analysis
- Cabinet x-ray for food quality control
- Cabinet x-ray for baggage scanning
- Cabinet x-ray for electronics part inspection





#### **Uses of X-rays in Health Care**













# Computed Tomography (CT) scanning machines



Takes many x-rays from different angles

A computer can put all the images together to create one 3-D image



#### Mixed Radiation Used in Healthcare







#### **Nuclear gauges**

- Beta, neutron, or gamma radiation
- Used to determine
  - Thickness
  - Density
  - Fill level
- Can be
  - Fixed
  - Portable
- Used in
  - Construction
  - Mining, oil extraction
  - Manufacturing

#### Fixed - Level Gauge





#### **Contact Information**



#### **Canadian Nuclear Safety Commission**

website: http://www.cnsc-ccsn.gc.ca/ phone: 1-800-668-5284 email: info@cnsc-ccsn.gc.ca



#### **Radiation Protection Bureau**

website: http://www.hc-sc.gc.ca/ahc-asc/branch-dirgen/hecsdgsesc/sep-psm/rpb-br-eng.php phone: 1-866-225-0709 email: ccrpb-pcrpcc@hc-sc.gc.ca



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# Radiation Safety Institute of Canada

- The Radiation Safety Institute of Canada is an independent, notfor-profit organization specializing in radiation safety.
- For further information on all types of radiation contact us at:

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