Principles of health physics
2016

Course Description

This course covers the following topics: sources of nuclear radiation; ionization and energy deposition in matter; basic tools for radiation detection and measurements; principles of dosimetry; determination of exposure and limits for internal and external emitters; basic shielding calculations. The course is designed to provide students with a comprehensive background in the basic physical and biological factors governing radiation effects and with practical means for assessing and controlling the radiation doses expected from various radiation fields.

Chapter 1: Review of physical principles
Units, dimensions and energy and energy transferring.
Basic physical principles.

Chapter 2: Radioactivity
Radioactivity and transformation mechanisms.
Transformation kinetics, serial transformation and naturally occurring radioactivity.

Chapter 3: Interaction of radiation with matter
Interaction of beta particles and heavy charged particles.
Interactions of photons – interaction of photons in absorbing media.
– attenuation coefficients and energy absorption.
Interactions of neutrons.

Chapter 4: Methods for radiation detection
Gas-filled detectors, ionization process, charge migration, ionization counters and proportional counters.
Semiconductor detectors.
Neutron detection techniques

Chapter 5: Radiation dosimetry
Units, dose, exposure, dose-exposure relationship.
Specific gamma ray emission, beta radiation.
Internal deposited radioisotopes, MIRD method and neutron dose.

Chapter 6: Biological Effect of radiation
Physical and chemical characteristics of the biological effect of ionizing

Chapter 7: Physics of radiation therapy and radiation protection in radiotherapy

Chapter 8: Radiation protection criteria and exposure limits introduction, philosophy of radiation protection.

- **Chapter 9**: Introduction to Medical Imaging
  - 1.1 The Modalities
- Radiography, Fluoroscopy, Mammography, Computed Tomography (CT), Nuclear Medicine Imaging, Nuclear medicine planar images, Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI), Ultrasound Imaging, Doppler Ultrasound Imaging
  - 1.2 Image Quality

Chapter 10: Health effects of nanoparticles

• Fundamental physical constants

- ● Avogadro's number: $NA = 6.022 \times 10^{23}$ *atoms/g-atom.*
- ● Avogadro's number: $NA = 6.022 \times 10^{23}$ *molecules/g-mole.*
- ● Speed of light in vacuum: $c = (3 \times 10^{8}$ *m/s).*
- ● Electron charge: $e = 1.602 \times 10^{-19}$ *C.*
- ● Electron rest mass: $me- = 0.5110$ *MeV/*c^2*.*
- ● Positron rest mass: $m_e+ = 0.5110$ *MeV/*c^2*.*
- ● Proton rest mass: $m_p = 938.3$ *MeV/*c^2*.*
- ● Neutron rest mass: $m_n = 939.6$ *MeV/*c^2*.*
- ● Atomic mass unit: u = 931.5 MeV/c^2*.*
- ● Planck's constant: $h = 6.626 \times 10^{-34}$ *J·s.*
- ● Permittivity of vacuum: $E_0 = 8.854 \times 10^{-12}$ C/(V·m).
- ● Permeability of vacuum: $u_0 = 4\pi \times 10^{-7}$ (V·s)/(A·m).
- ● Newtonian gravitation constant: $G = 6.672 \times 10^{-11}$ *m3·kg*$^{-1}$*·s*$^{-2.}$
- ● Proton mass/electron mass: $m_p/m_e = 1836.0.$
- ● Specific charge of electron: $e/m_e = 1.758 \times 10^{11}$ *C/kg.*

Health Physicist Specialist in Radiation Safety

- Protect People and the Environment
  - From unnecessary exposure
  - From contamination
- Minimize Exposures to occupational Workers and the Public ALARA-
- Comply with state regulations,

➢ Protective clothing, lab coats, gloves, masks, eye protection, sealing tapes etc,

➢ The Work place, designate Clean area, Hood, Absorbent paper, locks, no food items

The ALARA PRINCIPLE

As Low As Reasonably Achievable

• ALARA Philosophy

➢Use every reasonable effort to minimize dose

•Basis of Health Physics Guidelines

➢Has been incorporated into regulation

•Use of ALARA Provisions

➢Facilitates proactive measures for radiation safety and protection

- Understand Evaluate and Control Risks
  - Evaluate relative risk to benefit
- Provide Training
  - Safe use, methods, monitoring
- Dedicated to Radiation Safety
  - Maintain Education
  - Develop and apply safety programs

Medical Health Physicists

Check Radiation Equipment
- Prevent unnecessary dose to patients
- Minimize dose to workers

Control Radioactive Materials
- Train users to minimize dose to patients and workers
- Proper waste disposal

Work with Oncologists
- Safely administer large doses to cancer patients

Industrial Health Physicists

- Train Workers
- Proper handling
- Safety rules
- Prevent unnecessary dose
- Proper Disposal of Radioactive Waste

Utility Health Physicists

- Responsible for Radiation Safety of Nuclear Power Plants
  - Workers
  - Environment
  - Public
- Develop Safety Procedures for Workers

Health Physicists in Education and Research

- Training of Nuclear Technicians
- Provide Education for Professional Health Physicists Research
  - Effects of radiation
  - Develop better equipment to measure radiation

What is the heath physics?

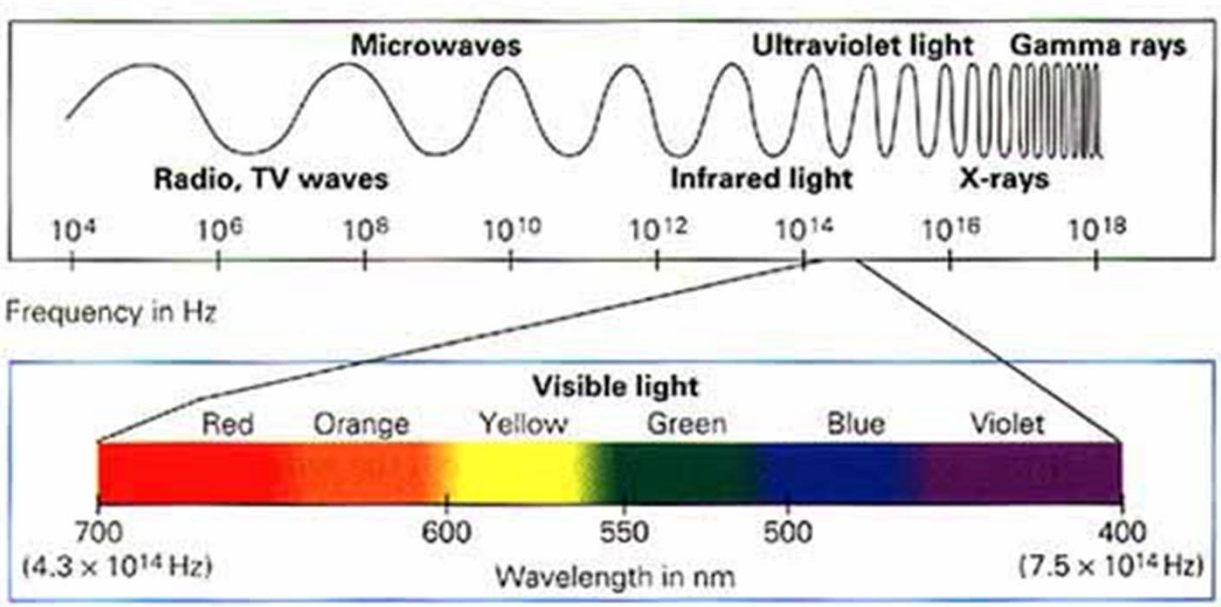
- Health physics, radiological health, or radiological engineering are synonymous terms for that area of public health and environmental health engineering that deals with the safe use of ionizing and nonionizing radiation in order to prevent harmful effects of the radiation to individuals, to population groups, and to the biosphere.
- The health physicist is responsible for safety aspects in the design of processes, equipment, and facilities utilizing radiation sources and for the safe disposal of radioactive waste so that radiation exposure to personnel will be minimized and will at all times be within acceptable limits; he or she must keep personnel and the environment under constant surveillance in order to ascertain that these designs are indeed effective. If control measures are found to be ineffective or if they break down, the health physicist must be able to evaluate he degree of hazard and make
- recommendations regarding remedial action

Classification of radiation

- radiation is classified into two main categories, nonionizing
- and ionizing, depending on its ability to ionize matter. The ionization potential of atoms (i.e. the minimum energy required to ionize an atom) ranges from a few electron volts to 24.5 eV.
- Non-ionizing radiation (cannot ionize matter).
- Ionizing radiation (can ionize matter either directly or indirectly):
- Directly ionizing radiation (charged particles): electrons, protons, ά particles and heavy ions.
- Indirectly ionizing radiation (neutral particles): photons (X rays and gamma rays), neutrons
- Directly ionizing radiation deposits energy in the medium through direct Coulomb interactions between the directly ionizing charged particle and orbital electrons of atoms in the medium.

- Indirectly ionizing radiation deposits energy in the medium through a two step process:
- In the first step a charged particle is released in the medium (photons release electrons or positrons, neutrons release protons or heavier ions);
- In the second step the released charged particles deposit energy to the
- medium through direct Coulomb interactions with orbital electrons of the
- atoms in the medium.

Both directly and indirectly ionizing radiations are used in the treatment of disease, mainly but not exclusively for malignant disease. The branch of medicine that uses radiation in the treatment of disease is called radiotherapy, therapeutic radiology or radiation oncology. Diagnostic radiology and nuclear medicine are branches of medicine that use ionizing radiation in the diagnosis of disease.


Microwaves
Ultraviolet light
Gamma rays
Radio, TV waves
Infrared light
X-rays
10^4
10^6
10^8
10^10
10^12
10^14
10^16
10^18
Frequency in Hz
Visible light
Red
Orange
Yellow
Green
Blue
Violet
700
(4.3 × 10^14 Hz)
600
550
500
400
(7.5 × 10^14 Hz)
Wavelength in nm

General Handling Precautions

Lab coats, gloves, masks, eye protection, sealing tapes

•Protective Clothing:

•The Work Place

Designate Clean area, Hood, Absorbent paper, locks, no food items

•Manipulations of Radioactive Materials

plan ahead, pip petting, use minimum amounts, sealing tubes, reduce volatilization, proper monitoring, shielding, dosimeter, public perception

How to know if there is a radiation source or radiation area- Symbols?

How to know if there is a radiation source or radiation area- Symbols?

"CAUTION RADIATION AREA"

“CAUTION RADIOACTIVE MATERIALS"

Radiation Badges

- Generally exchanged quarterly or even monthly
- Workers using gamma or high energy beta emitters need a whole body badge
- Workers using > 10 mCi of gamma or beta emitters need a ring badge
- Only wear while working
- Do not wear for personal medical procedures
- Exchange in a timely manner
- Store away from radiation area when not in use