

Introduction to Radiation

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Key concepts, types, sources, interactions, and safety considerations

1. What Is Radiation?

Definition	Explanation
Radiation	The emission and propagation of energy in the form of particles or electromagnetic waves through space or a material medium.
Ionizing vs. Non-ionizing	Ionizing radiation carries enough energy to remove tightly bound electrons from atoms, creating ions.
	Non-ionizing radiation lacks this energy; it can excite atoms but not ionize them.

2. Types of Radiation

Category	Subtype	Typical Energy Range	Primary Examples
Electromagnetic	Gamma (γ)	> 100 keV (up to several MeV)	Nuclear decay, astrophysical sources
	X-ray	0.1 keV – 100 keV	Medical imaging, industrial inspection
	Ultraviolet (UV)	3 eV – 100 eV	Sunlight, UV lamps
	Visible light	1.65 eV – 3.1 eV	Sun, LEDs
	Infrared (IR)	0.001 eV – 1.65 eV	Thermal cameras, heaters
Particle	Alpha (α)	4–9 MeV (He ²⁺)	Decay of heavy nuclei (U-238, Pu-239)
	Beta (β)	0.01–3 MeV (e ⁻ or e ⁺)	Decay of C-14, Sr-90
	Neutron	0.025 eV – several MeV	Nuclear reactors, spallation sources
	Proton, heavy ions	> MeV per nucleon	Particle accelerators, cosmic rays

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Category	Subtype	Typical Energy Range	Primary Examples
Acoustic / Mechanical	Sound waves	10^{-12} eV – 10^{-2} eV	Ultrasound imaging, sonar

Only the first three rows (α , X-ray, β , γ , neutrons) are typically classified as ionizing radiation.

3. Sources of Radiation

Source	Natural	Man-made
Cosmic rays	High-energy particles from space	None
Terrestrial radionuclides	Uranium, thorium, radon in rocks/soil	None
Radon gas	Decay product of uranium in the ground	None
Medical	Diagnostic X-rays, CT scans, radiotherapy	Radiopharmaceuticals
Industrial	Radiography, gauge devices, smoke detectors	Industrial irradiators
Nuclear power	Fission product emissions (controlled)	Reactor operations, spent fuel
Research	Particle accelerators, neutron sources	Synchrotrons, cyclotrons

4. Interaction Mechanisms

4.1 Electromagnetic Radiation (Photons)

Interaction	Dominant Energy Range	Effect on Matter
Photoelectric effect	< 100 keV	Photon absorbed, electron ejected
Compton scattering	~ 100 keV – 10 MeV	Photon loses part of its energy, changes direction
Pair production	> 1.022 MeV	Photon creates e^-/e^+ pair near nucleus
Rayleigh scattering	< 10	