## Intro Health Physics Study Group – Working Syllabus

[Textbooks](https://usepa.sharepoint.com/:f:/r/sites/HealthPhysics/Shared%20Documents/Intro%20HP%20Training/Textbooks?csf=1&web=1&e=P3WsZU)

* Moe 1992 – Operational Health Physics Training
* Gollnick 2011 (6th Ed) – Basic Radiation Protection Technology
* Cember & Johnson 2009 (4th Ed) or Johnson 2017 (5th Ed) – Introduction to Health Physics

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| **MODULE 0** | **Physics and Mathematics Review**  While not part of our “official” studies, some may find it useful to review physics and math concepts. Here are some reference materials:   * Gollnick, chapter 1 (SD recommends: mathematics review pg. 4-9; physics review pg. 9-19) * Cember, chapter 2 | | |
| **MODULE 1** | **Radiation Fundamentals**  Learning Objective:Have a basic understanding of the fundamental science behind radiation protection through familiarization with topics such as atomic structure, radioactivity and radioactive decay, types of radiation, radiation quantities and units, and sources of radioactivity  “Prologue” materials:   * CDC Radiation basics videos   + Segment 1: Sources of radiation (<https://www.youtube.com/watch?v=AXu1bMaX3l0>)   + Segment 2: Radioactive decay (<https://www.youtube.com/watch?v=Im-M7WWlBXM>) * NRC Intro HP Slides – [Ch1 History of Health Physics](https://usepa.sharepoint.com/:b:/r/sites/HealthPhysics/Shared%20Documents/Intro%20HP%20Training/NRC%20Intro%20HP%20Slides/ML11210B517_Ch1%20History%20of%20Health%20Physics.pdf?csf=1&web=1&e=8KNZhg) | | |
| **Part** | **Topics/Outline** | **Recommended Study Materials** | **Supplemental Materials** |
| 1A. Radioactive Material & Radioactivity  (3-4 weeks) | * Basic atomic structure * Protons, neutron, electrons * Unstable atoms and radioactivity   + Neutron to proton ratio related to nuclear stability   + Isotopes, nuclides * Nuclear decay processes:   + Alpha decay   + Beta decay   + Positron decay   + Photon emission   + Fission decay * Types of ionizing radiation   + Particulate: Alpha, beta, positrons, neutrons   + EM: gamma rays and x-rays | **WEEK 1-2**   * Moe Section 1 – Basic Information: subsections A-C * Moe Section 2 – Radioactivity and Its Properties: subsections A-F * Moe questions\*: 1.2, 1.10, 1.11, 2.2, 2.4, 2.6, 2.8, 2.11, 2.17, 2.20, 2.24   **WEEK 3-4**   * High-level: Gollnick “Nuclear Decay Processes” (pg. 41-52 in pdf version) * In the weeds: Moe Section 3 – Properties of Alpha, Beta, Gamma, X-rays: subsections A, B, E, and F (Note: skip over math-heavy parts if it doesn’t interest you!) * Moe questions: 3.4, 3.5, 3.8, 3.9, 3.15, 3.16, 3.20, 3.35, 3.36   [Problem Set 1](https://usepa.sharepoint.com/:w:/r/sites/HealthPhysics/Shared%20Documents/Intro%20HP%20Training/Problem%20Sets/1A%20Problem%20Set%20-%20Intro%20HP%202025.docx?d=w5b14d5d3a47c4e379bd14779e1445f09&csf=1&web=1&e=hGYJg0)  \*NOTE: at the end of each chapter, Moe has both *Questions* and *Problems* | **Other textbook sections**   * Gollnick, chapter 2 * Cember (4ed)/Johnson (5ed), chapter 3   **Other training materials**   * [ORAU slides – introduction to radioactivity](https://usepa.sharepoint.com/:b:/r/sites/HealthPhysics/Shared%20Documents/Intro%20HP%20Training/ORAU%20Course/ORAU%20Intro%20to%20Radioactivity%20and%20Radiation.pdf?csf=1&web=1&e=BIsFfr) * [NRC Intro HP slides – Ch3 Fundamentals](https://usepa.sharepoint.com/:b:/r/sites/HealthPhysics/Shared%20Documents/Intro%20HP%20Training/NRC%20Intro%20HP%20Slides/ML11210B519_Ch3%20HP%20Fundamentals.pdf?csf=1&web=1&e=2fLTbX) * [Western Oregon University – webpage on radioactivity and nuclear chemistry](https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch103-allied-health-chemistry/ch103-chapter-3-radioactivity/)   **Advanced (for the adventurous)**   * Tom Johnson videos (note: these are intended for CHP exam prep and get pretty deep into technical topics)   + [Atomic Structure A](https://usepa.sharepoint.com/:v:/r/sites/HealthPhysics/Shared%20Documents/CHP%20Workgroup/01%20Atomic%20Structure/42%20m%20Atomic%20Structure%20A.wmv?csf=1&web=1&e=4syptf&nav=eyJyZWZlcnJhbEluZm8iOnsicmVmZXJyYWxBcHAiOiJTdHJlYW1XZWJBcHAiLCJyZWZlcnJhbFZpZXciOiJTaGFyZURpYWxvZy1MaW5rIiwicmVmZXJyYWxBcHBQbGF0Zm9ybSI6IldlYiIsInJlZmVycmFsTW9kZSI6InZpZXcifX0%3D)   + [Atomic Structure B](https://usepa.sharepoint.com/:v:/r/sites/HealthPhysics/Shared%20Documents/CHP%20Workgroup/01%20Atomic%20Structure/34%20m%20Atomic%20Structure%20B.wmv?csf=1&web=1&e=FSC4TP&nav=eyJyZWZlcnJhbEluZm8iOnsicmVmZXJyYWxBcHAiOiJTdHJlYW1XZWJBcHAiLCJyZWZlcnJhbFZpZXciOiJTaGFyZURpYWxvZy1MaW5rIiwicmVmZXJyYWxBcHBQbGF0Zm9ybSI6IldlYiIsInJlZmVycmFsTW9kZSI6InZpZXcifX0%3D) |
| 1B. Properties of Radiation  (1-2 weeks) | * Decay chains * Half-lives * Penetrating power of radiation | [still in progress]   * Moe Section 2 – Radioactivity and Its Properties: subsections A-F (revisit) * Gollnick * Decay chains – Cember/Johnson? |  |
| 1C. Chart of the Nuclides  (1 week) | * Chart of Nuclides * Review of radioactivity basics | * [IAEA Live Chart of Nuclides](https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html) * ACTIVITY: nuclide scavenger hunt | ORAU slides – intro to radioactivity (p. 18-26) |
| 1D. Radiation Quantities and Units | * Traditional vs SI * Physical quantities- directly measurable:   + Activity units/Specific activity   + Exposure: R/Exposure rate   + Absorbed dose: Rad * Protection quantities   + Equivalent dose - Rem   + Effective dose - Rem | * Moe Section 4 – Radiation Quantities: subsections A.2, A.4, A.5, B, and C | Cember Ch. 6 |
| 1E. Sources of natural and man-made radioactivity | * Naturally occuring   + Cosmic radiation   + Terrestrial radiation   + Food   + Internal   + Radon * Man-made   + Fall-out from weapons testing   + Nuclear facilities   + Consumer products   + Medical sources   + Occupational exposure | * NCRP 160 – Executive Summary (p. 1-13) * Moe Section 6 – Background Radiation: subsections Intro, A-E, G, H, and I | Cember Ch 4 (4 ed pg. 109-135) |
| **MODULE 2** | **\*\*\*WORK IN PROGRESS\*\*\* Radiation Interaction with Matter**  Learning Objective: Identify the various types of physical events that occur when charged particles and electromagnetic radiation interact with the atoms of a medium during their passage through it. | | |
| **Part** | **Outline** | **Recommended Study Materials** | **Supplemental Materials** |
| 2A. Directly Ionizing - Charged Particle Interactions | * Excitation * Ionization * Bremsstrahlung * Stopping power * Charged particle range | * ORAU slides - Charged Particle Interactions | Cember chapter 5 |
| 2B. Indirectly Ionizing - Photon Interactions | * Photoelectric * Compton * Pair Production |  |  |
| 2C. Indirectly Ionizing - Neutron Interactions | * Slow neutron interactions * Fast neutron interactions * Neutron activation |  |  |
| **MODULE 3** | **\*\*\*WORK IN PROGRESS\*\*\* Radiation Health Effects**  Learning Objective: Demonstrate an understanding of the science and technique of determining radiation dose due to both radiation sources that are outside the human body and intake of radioactive materials into the human body. | | |
| **Part** | **Outline** | **Recommended Study Materials** | **Supplemental Materials** |
| 3A. Radiation effects on the human body | * Radiation effect classification   + Time of effect onset   + Deterministic vs stochastic * Types of effects   + Deterministic     - Whole body and local exposures     - Acute radiation syndrome     - Threshold values for various effects   + Stochastic   + Hereditary effects * Exposure modes and effects   + High-dose vs low-dose exposure   + Acute vs chronic exposure |  | Bev Ch. 5? |
| 3B. Mechanism of Effects | * Radiation damage and repair of DNA * direct and indirect biological effects of radiation * Genetic mutations   + Cancer induction * Radiosensitivity of organs and tissues |  |  |
| 3C. External and internal dosimetry | * External dosimetry   + External dosimetry terms   + Dosimeters overview * Internal dosimetry   + Routes of intake   + Internal dosimetry terms   + Bioassays overview * Regulatory dose limits   + Occupational & public dose limits   + Derived limits     - ALI, DAC and DAC-hr |  |  |
| 3D. Radiation Health Risks | * Risks of health effects of radiation * Risks of cancer death from long term low-dose exposure |  |  |
| **MODULE 4** | **\*\*\*WORK IN PROGRESS\*\*\*Radiation Detection Applications**  Learning Objective: Demonstrate knowledge of the theory and operation of instrumentation used in detecting and measuring radioactive material and radiation levels that are commonly used for radiation protection applications. | | |
| **Part** | **Outline** | **Recommended Study Materials** | **Supplemental Materials** |
| 4A. Radiation detection characteristics | Methods of radiation detection   * Detecting alpha * Detecting beta * Detecting gamma * Detecting neutrons |  |  |
| 4B. Worker Exposure Monitoring | * External   + TLD badges & rings   + OSL badges   + Historical (film badges)   + Direct reading pocket dosimeter   + Electronic personal dosimeter * Internal   + In-vitro bioassay     - Measurements of biological samples   + In-vivo bioassay     - Direct measurement of radiation emitted from the body       * Thyroid counting using NaI probe       * Whole body counting   + Airborne monitoring     - Air samplers |  |  |
| 4C. Exposure rate and dose rate monitoring | * Ion chambers   + Handheld   + Environmental * Neutron area survey meters |  |  |
| 4D. Radiation Survey | * GM detector * Gamma scintillation detectors * Alpha scintillation probes * Neutron detectors * Contamination screening   + Vehicle contamination (Plastic scintillators)   + Portal monitors (Plastic scintillators) |  |  |
| 4E. Isotope Identification | * Gross alpha/beta analysis   + Proportional detectors   + Liquid scintillators * Gamma spectroscopy   + Scintillation detectors   + Semiconductor detectors |  |  |
| **MODULE 5** | **\*\*\*WORK IN PROGRESS\*\*\* Radiation in the Environment**  Learning Objective: Discuss radiation protection measures and impact of ionizing radiation and radionuclides on the environment. Identify models relating to the release, transport, and fate of technologically enhanced naturally occurring and man-made radioactive material; demonstrate familiarity with environmental surveillance of soil, water, and airborne effluents through instrumentation and field-sampling technologies. | | |
| **Part** | **Outline** | **Recommended Study Materials** | **Supplemental Materials** |
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| 5 |  | * Part A: Overview of major radiation sources   + NCRP 160 annual dose estimates   + Summary graphic of radiation exposure situations   + Factors that dictate exposures * Part B: Cosmogenic and terrestrial radiation   + Background radiation     - Variations by elevation, geology     - Exposure in flight   + Radon     - Residential     - Occupational   + NORM/TENORM * Part C: Fate and transport   + Anthropogenic sources of radionuclides   + Movement in the environment   + Exposure routes (e.g., air, water, soil)   + Surveillance and sampling   + Analytical capabilities?   + Means of control (link to Mod. 6) * Part D: Nuclear fuel cycle   + Brief overview of cycle     - Mining   + Occupational exposure and safety concerns   + Implications for environment * Part E: Reactors and nuclear safety   + Overview of reactors   + Occupational exposure and safety concerns   + Public exposure and safety concerns   + Means of control (link to Mod. 6) * Part F: Research and industry   + Research reactors   + Accelerators     - What they are and how they’re used   + Sealed sources     - What they are and how they’re used   + Protection considerations (occupational and public) * Part G: Medical uses of radiation   + History   + Brief survey of applications     - e.g., x-ray, CT, radiotherapy, etc.   + Considerations for protection * Part H: Nuclear weapons and RDDs   + [is this the right section for this?] * Part I: Approaches to decontamination and remediation   + How do we go about “cleaning up” environmental contamination   Proposed Module 5 Arrangement from above  Part A: Sources of Radiation   * Overview of major radiation sources * Natural sources of concern   + TENORM   + Radon * Artificial sources   + Nuclear Fuel Cycle   + Reactors   + Research/industrial   + Medical   + Nuclear weapons/ RDD   Part B: Fate and Transport  Part C: Approaches to Decontamination and Remediation   * Basics of fate and transport   + Brief summaries of:   + Nuclear Fuel Cycle   + Reactors and nuclear safety   + NORM/TENORM   + Enclosures and contamination control   + Medical   + Sealed sources   + Accelerators | Idea: for each Part, include a brief (e.g., 1-2 slide) case study to highlight a real-life example of the concepts. |
| 6  EPA Radiation Authorities and Roles | Recognize and differentiate the statutes and requirements of agencies that regulate radiological hazards and their basis in underlying US and international standards  Roles and responsibilities of entities within EPA (labs, facilities, parts of RPD & ORIA, Regional folks, Superfund)  Explanation of Alphabet Soup (ICRP, NCRP, etc.) What do they do – what differentiates them?  How U.S. is different from international partners?  Normal, Occupational and emergency regulations. How does that affect what EPA does? How does EPA interact in an emergency? Point out overlap & disconnect. | * Part A: Civics 101 – Key Terminology * Part B: Creation of EPA * Part C: EPA Radiation Authorities * Part D: EPA Radiation Emergency Authorities * Part E: Government Agencies with Regulatory Roles * Part F: Non-Governmental Radiation Protection Organizations * Part G: Working Together   Intro   * A little bit of history   + Specifically, of radiation protection. E.g., discovery, recognition of health effects, early radiation protection practices. * ICRP basic recommendations   + Justification   + Optimization   + Dose limits * NCRP   Occupational   * 10 CFR 20 * OSHA   Emergency   * PAG Manual * DHS * Regulating agencies   + DOE, NRC, EPA, FDA   Environmental Radiation Regulations   * Radiation exposure concerns * DOT * Regulating agencies   + DOE, NRC, EPA, FDA, OSHA, DOT, etc.   EPA & their Roles   * 40 CFR 190 * Statutes   + CERCLA, Public Health Safety Act, Atomic Energy Act, Safe Drinking Water Act, NESHAPS etc. * Roles and responsibilities of EPA entities   + ORIA   + Regions   + Superfund | * Intro to EPA rad protection slides developed for interns (Jon N.) * PAG manual * Major Statutes Table and how it relates to EPA work (Sara has a document) * EPA webpage infographic   <https://www.epa.gov/radiation/radiation-regulations-and-laws> |