D R A F T

Health Physics Topics

The Health Physics portion of the qualification exam is meant to test the student's knowledge of both the policy and technical aspect of this specialty in the NUEN department. Courses that will aid the student for this qualification exam include:

- **NUEN 604 Radiation Interactions and Shielding**
- **NUEN 605 Radiation Detection and Nuclear Materials Measurement**
- **NUEN 612 Radiological Safety and Hazards Evaluation**
- **NUEN 613 Principles of Radiological Safety**

The following outline describes the material covered by the exam:

I. Stochastic processes
   a. Independent events
   b. Poisson statistics
   c. Theoretical resolution of energy deposition
   d. Deviation from Poisson statistics – Fano factor

II. Nuclear physics basics
   a. Field descriptions
   b. Interaction of radiation with matter and interaction rates
   c. Radioactive decay
      i. Half-life, mean life, decay constant, activity
      ii. Simple decay
      iii. Composite decay
      iv. Serial decay
      v. Activation /decay relations
   d. Nuclear decay schemes
   e. Shielding and radiation attenuation

III. Ionizing radiation
   a. Types and sources
   b. Characteristics
   c. Field quantities
   d. Interaction with matter
      i. Ionization, excitation, W-value
      ii. Range, CSDA range, density thickness, mean-free path
      iii. Stopping power, linear energy transfer, lineal energy transfer

iv. Compton effect, photoelectric effect, pair production
v. Attenuation coefficients
vi. Rayleigh scattering
vii. Photonuclear interactions

e. Quantities describing interactions

viii. Kerma
ix. Absorbed dose
x. Exposure

IV. Radiation measurement and counting
a. Theory
b. Gas-filled detectors
c. Scintillation detectors
d. Semiconductor detectors
e. Special detectors

V. Dosimetry
a. Fundamentals and concepts
b. Cavity theory
i. Bragg-Gray theory
ii. Spencer cavity theory
iii. Burlin cavity theory
iv. Fano theorem
v. Other cavity theories
vi. Interfaces
c. Radiation equilibrium
d. Charged particle equilibrium
i. Distributed sources
ii. Indirectly ionizing radiation
iii. Failure of CPE
e. Transient charged particle equilibrium
f. Active and passive dosimeters
g. Mixed field measurements
h. Calibration
i. Quantities in radiation protection
i. Quality factor (radiation weighting factor)
ii. Tissue weighting factors
iii. Dose equivalent (equivalent dose)
iv. Effective dose equivalent (effective dose)

VI. Radiobiology and biological effects
a. Relative biological effectiveness
b. Cell type and radiation sensitivity
c. Molecular processes

i. Direct action
ii. Indirect action
iii. Oxygen effect

d. DNA damage
e. Repair and misrepair

VII. Models of radiation damage
a. Single hit models
b. Multi-hit models
c. Multi-target models
d. Survival curves
e. Influence of radiation quality
f. Stochastic effects
g. Deterministic effects
h. Relative and absolute risk models
i. Weaknesses and uncertainties

VIII. Statistics and other mathematics
a. pdf's and cdf's
b. binomial, Poisson, Gaussian
c. error propagation
d. pdf transforms – Monte Carlo
e. linked ODE's – Laplace transforms, STELLA, et al.
f. special functions – Bessel, F1's, E1, E2, etc.; Method of Forbenius

IX. Radioactivity transport and pathways
a. Routes of entry into the body
b. Routes of elimination from the body
c. Biological half-times
d. Systemic and metabolic models
e. Bioaccumulation

X. Instrumentation and Measurements
a. Electronics
b. Counting
i. Plastic scintillators
ii. Proportional counters
iii. Geiger-Mueller counters
iv. Gas-flow counters
v. Alpha spectrometers
vi. NaI(Tl) detectors and spectrometers
vii. HPGe and spectrometers
viii. Pulse shape discrimination
c. Dosimetry
i. Film

ii. Thermoluminescence dosimetry (TLD)
iii. Optically stimulated luminescence (OSL)
iv. Ion chambers
v. Others

d. Portable survey instruments

XI. Operational quantities and units
a. Quality factors (radiation weighting factors)
b. Dose equivalent (equivalent dose)
c. Effective dose
d. Ambient dose equivalent

XII. Regulations
a. Guidance from ICRP and NCRP
i. Foundations for recommendations
ii. Risk-based recommendations
iii. Detriment and aggregated detriment
b. 10CFR20 and 10CFR835 regulations
c. ALARA considerations
d. Radiation exposure limits
e. Quality vs. energy and type – RBE review
f. TEDE and other concepts
g. Special definitions: Skin, lens of eye, planned special exposures, declared pregnant female, etc.
h. DOT, EPA, and other federal agencies

XIII. Internal Dosimetry
a. Stochastic and deterministic radiation effects
b. Tissues at risk and tissue weighting factors
i. ICRP Publication 30
ii. ICRP Publication 60
c. Calculation of organ-averaged absorbed dose
d. Calculation of committed dose equivalent
e. Model for the respiratory system
i. ICRP Publication 30
ii. ICRP Publication 66
f. Model for the gastrointestinal tract
g. Model for the skeleton
h. Submersion in a noble gas cloud
i. Metabolic models for elements
j. Dose to the embryo/fetus
k. Reference Man
l. Limitations of approach
m. Practical applications in controlling the workplace
n. Practical applications in evaluating intakes

XIV. Operational Radiation Safety (e.g., from NCRP Report No. 127)
- a. General guidance on establishing a program
  - i. Selection and training of staff
  - ii. Responsibilities
  - iii. Radiation safety committee
  - iv. Training of users
- b. Personnel monitoring
  - i. Occupationally exposed workers
  - ii. Special exposure groups
- c. Air monitoring
  - i. Impactors, how they operate, and how to interpret their data
  - ii. General particle monitoring, collection by filtration
- d. Radiation surveys
- e. Contamination surveys
- f. Area monitoring
- g. Bioassay program
- h. Respiratory protection
- i. Environmental monitoring
- j. Accident monitoring
- k. Criticality monitoring
- l. Record-keeping
- m. Waste disposal
- n. Emergency planning and response

XV. Other topics
- a. Aerosol physics
  - i. Interpretation of aerosol properties as they apply to respiratory penetration
  - ii. Size dependence of aerosol transport properties and implications for environmental removal or transport
- b. Meteorological transport
  - i. Use and limitations of Sutton's equations
  - ii. Inferring source strength from remotely measured decay product and *vice versa* via Sutton's equation
- c. Shielding design
- d. Neutron dosimetry
- e. Space radiation
- f. Radioactive waste management
- g. Environmental radiation
  - i. Natural background
  - ii. TENRE
  - iii. NORM/NARM
- h. X-ray machines and accelerators
- i. Food irradiation
- j. Neutron radiography
- k. Radiological terrorism
- l. Radioactive waste management

m. Space radiation