# NE 495: Elements of Nuclear Engineering – Lecture Topics

1. Introduction: Overview of nuclear technology and the course

**Atomic and Nuclear Physics**

2. Atomic and nuclear characteristics: SI units, atomic masses, abundances, nuclide systematics
3. Atomic models: Thompson, Rutherford and Bohr models; line spectra
4. Modern physics: Special relativity, derivation of $E = mc^2$, momentum and kinetic energy, reduction to classical $KE = mv^2/2$.
5. Modern physics: Wave-particle duality; Implications of the photoelectric and electron scattering experiments
6. Modern physics: quantum mechanics
7. Reaction energies, exothermic/endoergic reactions, reaction Q-values, atomic mass tables, atomic vs nuclear energy
8. Binding energy, BE versus $A$, fission and fusion energetics; nuclear structure from BE vs $A$ curve, magic nuclei
9. Chart of the nuclides; nuclear structure; liquid drop model

**Radioactivity**

10. Types and energetics of radioactivity, emitted radiation.
11. Decay constant, decay/buildup equations, exponential decay, half-life, mean life
12. Decay chains, natural and human-made
13. Radiological dating and other applications

**Radiation Interaction with Matter**

14. Kinematics of nuclear reactions, threshold energy, neutron scattering
15. Photon interactions: photoelectric effect, Compton scattering, pair production
16. Neutron interactions, various types; fission products and energetics, fission-product decay chains and decay energy vs time.
17. Charged particle interactions: stopping power, range for electrons and heavy charged particles.
18. Cross sections (microscopic and macroscopic), flux density, and reaction rates
19. Attenuation of neutral particles; exponential attenuation, half-thickness, mean-free-path length, analogy to radioactive decay

**Radiation Detection and Measurement**

20. Detector principles: gas chambers, scintillation systems
21. Detector principles: spectrometers
22. Detector demonstration (spectrometry)
23. Demonstrations (shielding)

**Radiation Dosimetry and Risks**

24. Absorbed dose and related concepts, radiation damage, calculation of absorbed dose
25. Natural background doses: internal and external

26. Biological hazards and risk estimation
27. Radiation protection and standards

**Nuclear Reactors**

28. Nuclear reactors: neutron cycle in a multiplying medium, criticality and $k_{eff}$
29. Nuclear reactors: feedback effects and control
30. Tour of KSU's TRIGA Reactor and pulsing demonstration
31. Principles of reactor design: types of reactors
32. Nuclear Reactors: heat removal and electricity production
33. Nuclear fuel cycle

**Nuclear Technology in Medicine**

34. History, radiotracers, diagnostic uses, therapeutic uses of radioisotopes
35. PET, CAT and other scanners, medical irradiators,
36. Radiopharmaceuticals, metabolic dynamics, forensic analyses

**Nuclear Technology in Industry**

37. Tracers, radiation to enhance material properties, gauging, radiography, trace element identification,
38. Biological applications, wear analysis, activation analysis, autoradiography, catalysis, metallurgy applications
39. Nuclear batteries, thermionic power sources, fission cells

**Nuclear Technology in Agriculture**

40. Nutrient uptake studies, animal metabolic studies, insect control, moisture gauging, protein/elemental analysis, food preservation

**Nuclear Technology in Research**

41. Space applications (SNAP power supplies), enhanced fusion devices, nuclear lasers, advanced reactor concepts and designs
42. Radio/isotopic dating, cosmological implications, labeling of biological reagents, genetic mutations, environmental contamination analysis, remote sensing of environmental contamination