COURSE #: NERS 311 **CREDITS**: 3/Required	**COURSE TITLE:** Elements of Nuclear Engineering and Radiological Sciences I
TERMS OFFERED: Fall	**For each prerequisite below, "E" denotes Enforced and "A" denotes Advis**
TEXTBOOKS/REQUIRED MATERIAL: Krane, *Modern Pl* Wiley, 2nd Edition, Wiley 1996	**PREREQUISITES: (E)** NERS 250, Phys 240, (A) at least accompanied by Math 454
INSTRUCTOR(S): Alex Bielajew	**COGNIZANT FACULTY: Alex Bielajew**
CoE BULLETIN DESCRIPTION: Photons, electrons, neutrons, and protons. Particle and wave properties of radiation. Introduction to quantum mechanics and special relativity. Properties and structure of atoms.	**COURSE TOPICS:** 1. Review of classical kinematics, 2. Relativistic kinematics, Compton Scattering, 3. Particle-wave duality, 4. Thomson and Rutherford-Bohr models of the atom, 5. Schrödinger equation, 6. 1D solutions, bound and unbound, scattering, 7. 3D solutions: the H-atom, angular momentum models, 8. Multi-electron atoms, periodic table, lasers
COURSE STRUCTURE/SCHEDULE: Lecture: 3 per week @ 50 minutes each	
COURSE OBJECTIVES For each Course Objective, links to Program Educatior Objectives are shov	1. Students will learn the background, concepts and methodology of modern physics, classical and relativistic kinematics, particle-wave duality.[1,2] 2. Students will understand atomic models, from the Thomson Model, to the Rutherford-Bohr model, acquire the abili solve the Schrödinger equation for the H-atom, 1D bound and unbound quantum states, and 3D bound states.[1,2] 3. Students will learn to apply quantum mechanics to understand the periodic table, & apply quantum mechanics to describe the basic operation of lasers. [1,2]
COURSE OUTCOMES For each Course Outcome, links to t Program/ABET Student Outcomes are identified. [#,a-	1. Analyze 2-body scattering in either non-relativistic or relativistic formalisms. [1,2,3|ABET a,k,e] 2. Employ wave-like properties of particles, including De Broglie's Hypothesis, Uncertainty relationships for classical and matter waves, Heisenberg Uncertainty Relationships, exploit the probability density and probability current density., Derive the relation between the energy, frequency, wavelength and momentum of a photon. Derive expressions for interference of wave. Apply DeBroglie's hypothesis to interference of particles, learning the Heisenberg uncertainty relationships and the properties of wave packets. [1,2,3|ABET a,k,e] 3. Justify the Schrodinger equation, describe the probability interpretation solve problems using the Schrodinger equation in one-D, describe parity in the square well potential, moments and interpretation of results. Show orthonormality of wavefunctions for different energy states, describe superposition of wavefunctions, describe plane waves, normalization and currents, the vector current. Be able to solve problems for potential barriers and wells, the impenetrable barrier, finite length barriers, steps and wells, and the "simple" harmonic oscillator. Obtain discrete energy levels for confined particles. Compute expectation values. Use Hermite polynomials and Dirac's bra-ket notation. Describe and estimate relative transition probabilities. Solve problems for the finite potential well including unbound states and bound states. Solve the Schrodinger equation in 2- and 3-D, describe degeneracy. [1,2,3|ABET a,k,e] 4. Describe the Thomson and Rutherford-Bohr atomic models, including basic properties of atoms, the Rutherford nuclear atom. Describe the Rutherford scattering distribution. Describe line spectra and deficiencies of the Bohr Model. Interpret the scattering angle for an charged particle as a function of the impact parameter. Interpret the systematic of Rutherford scattering. [1,2,3|ABET a,k,e]

	5. Solve problems involving the hydrogen atom in wave mechanics. Solve the Schrodinger equation in spherical coordinates, describe spherical harmonics, derive the hydrogen atom wavefunctions, describe radial probability densities. Describe and use angular momentum in quantum mechanics. Describe intrinsic spin, atomic energy levels and spectroscopic notation. State the Pauli Exclusion Principle. Write expression for the quantum-mechanical angular momentum, allowed values of its z-component. [1,2,3|ABET a,k,e] 6. Analyze problems in many electron atoms, electronic states in many-electron atoms. Connect this analysis to the Periodic Table and Properties of the Elements including x-ray spectra. [1,2,3|ABET a,k,e]
ASSESSMENT TOOLS For each assessmen tool, links to the C Outcomes are identified	1. Exams measure all outcomes for individual students under time constraint. [1-6] 2. Assigned problem sets measure all outcomes under less time pressure and with collaboration between students and assistance from instructor. [1-6] 3. Course evaluation by each student at the end of the course assesses all outcomes. 4. Faculty self-assessment provides self-assessment data on all outcomes.

Revision History: September, 1998; March, 2002; January, 2004;March, 2007; May 2010; September 2010