PHYSICS 555. Fundamental Nuclear Physics.

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Office:	CP273.
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Textbook:	Introductory Nuclear Physics, Kenneth S. Krane, Publ. John Wiley & Sons.
Office hours:	T 2:00 - 3:00. R 2:00 - 3:00.

This course is a one semester introduction to nuclear physics for advanced undergraduates and graduate students.

Course Content and Objectives.

This course is about nuclear structure. To understand nuclear structure, from the tiny deuteron (one proton and one neutron) to the monstrous lead-208 (82 protons and 126 neutrons), we will build nuclear models. We will, for example, discover models of nuclei as gases and liquids, and explain nuclear characteristics on the one hand by a single neutron or proton, and on the other hand many neutrons and protons acting together. Nuclear structure is rich, diverse, and quite intriguing.

This course is also about the nuclear force which binds neutrons and protons together to make nuclei. The nuclear force is much richer and more complex than the electromagnetic force of PHY416 and 417 (worse still we have to work with it using the tools of quantum not classical physics). In fact, although the exploration of the nuclear force between neutrons and protons has been a massive effort over the past fifty years, it is still not fully understand. We shall examine some of the interesting features of the nuclear force, use them to explore how the nuclear force works, and see how these features are revealed in nuclear structure.

Course Prerequisites.

The prerequisite for this course is introductory quantum mechanics - PHY520.

Course Structure.

PHY555 meets M-W-F from 10:00 to 10:50 in room CP287. The following pages show the topics we will cover during the semester. To prepare for a lecture read the relevant sections in the textbook.

Course Grading.

Your final grade will be based on the homework, two tests and a cumulative final in the following proportions: homework 20%, each test 20% and final 40%. Each weekly homework assignment will comprise about six problems of which two will be collected, at random, the following Monday. The solutions must be both logical and readable. You are encouraged to get together with your fellow students to discuss the homework problems but your solutions must be written-up independently. Late homework is not accepted.

Date	Topic	Ch. Sec
W Jan 10	Quantum review 1 - the Schrodinger equation and a few 3-D potential wells.	2.4
F Jan 12	Quantum review 2 - angular momentum, parity, and identical particles.	2.5-8
M Jan 15	Martin Luther King Jr. Birthday	
W Jan 17	The distribution of charge and mass in the nucleus.	3.1
F Jan 19	Nuclear masses and energies.	3.2-3
M Jan 22	Nuclear J^{π}'s and electric and magnetic moments.	3.4-5
W Jan 24	The simplest nucleus - the deuteron. Its J^{π}, magnetic dipole moment, electric quadrupole moment, and what it tells us about the NN force.	4.1
F Jan 26	The formalism of NN scattering - phase shifts, scattering lengths and effective ranges.	4.2
M Jan 29	NN scattering and what it tells us about the NN force.	4.3-4
W Feb 31	Pion exchange and boson exchange models of the NN force.	4.5
F Feb 02	The atomic and nuclear shell models - shells, magic numbers, core and valence particles.	5.1
M Feb 05	The mysterious spin-orbit force.	5.1
W Feb 07	Explaining nuclear J^{π} and magnetic dipole and electric quadrupole moments.	5.1
F Feb 09	Vibrating nuclei - systematics of the nuclear data, J^{π}'s and electromagnetic moments etc.	5.2
M Feb 12	Vibrating nuclei - a macroscopic model of vibrating nuclei.	5.2

Date	Topic	Ch. Sec
W Feb 14	Rotating nuclei - a macroscopic model of rotating nuclei.	5.2
F Feb 16	Rotating nuclei - systematics of the nuclear data J^{π}'s and electromagnetic moments etc.	5.2
M Feb 19	Microscopic models of vibration and rotation.	5.3
W Feb 21	Microscopic models of vibration and rotation.	5.3
F Feb 23	**Test One.**	
M Feb 26	Review of Test One.	
W Mar 28	The radioactive decay law.	6.1, 6.3-4
F Mar 01	The quantum mechanics of the radioactive decay law.	6.2
M Mar 04	Introducing the types of radioactive decay - α, β, γ, N, fission and more.	6.5
W Mar 06	Terminology and systematics of alpha particle decay.	8.1-3
F Mar 08	The theory of alpha particle decay.	8.4
M Mar 11	Spring Break.	
W Mar 13	Spring Break.	
F Mar 15	Spring Break.	
M Mar 18	J^{π} in alpha particle decay.	8.5
W Mar 20	Terminology and systematics of beta particle decay.	9.

Date	Topic	Ch. Sec
F Mar 22	The theory of beta particle decay. Are neutrinos massless?	9.2-3
M Mar 25	J^{π} in beta particle decay.	9.4
W Mar 27	The non-conservation of parity - theory and experiment.	9.9
F Mar 29	The classical and quantum theories of gamma radiation.	10.1-2
M Apr 01	J^{π} in gamma decay.	10.4, 10.7
W Apr 03	**Test Two.**	
F Apr 05	Review of Test Two.	
M Apr 08	Energy and momentum conservation in nuclear reactions.	11.1-2
W Apr 10	Isospin and its conservation and non-conservation in nuclear reactions.	11.3
F Apr 12	The cross section and its definition. The scattering of point-like charged particles.	11.4-7
M Apr 15	The formal theory of scattering - partial waves and phase shifts.	11.8
W Apr 17	The optical model - diffraction, interference, and superposition.	11.9
F Apr 19	Compound nuclear reactions.	11.10
M Apr 22	Direct nuclear reactions.	11.11
W Apr 24	Protons and neutrons are not elementary particles - the world of pions and deltas.	see handout
F Apr 26	Pions and deltas in nuclei.	see handout
F May 03 8:00-10:00	Final.	