OFFICIAL UNDERGRADUATE COURSE OUTLINE (page 1)

COURSE IMPLEMENTATION DATE:	September 2007
COURSE REVISED IMPLEMENTATION DATE:	May 2014
COURSE TO BE REVIEWED:	May 2020
(six years after UEC approval)	*(month, year)*

OFFICIAL UNDERGRADUATE COURSE OUTLINE INFORMATION

Students are advised to keep course outlines in personal files for future use.

Shaded headings are subject to change at the discretion of the department – see course syllabus available from instructor

PHYS 458	Faculty of Science / Physics	3
COURSE NAME/NUMBER	FACULTY/DEPARTMENT	UFV CREDITS

Introduction to Nuclear Physics

COURSE DESCRIPTIVE TITLE

CALENDAR DESCRIPTION:

Nuclear sizes and range, the periodic table and isotopes; Rutherford scattering (classical and quantum), nuclear form factors, and charge distributions; liquid drop model, binding energy and the Semi Empirical Mass Formula, binding energy curve, nuclear drip lines; shell models and spin-orbit coupling, magic numbers, mirror nuclei, spin and parity states; radioactive decay, fission and fusion, half-life and nuclear stability.

PREREQUISITES: PHYS 351.
COREQUISITES:
PRE or COREQUISITES:

SYNONYMOUS COURSE(S):
(a) Replaces: **N/A**
(b) Cross-listed with:
(c) Cannot take: **N/A** for further credit.

SERVICE COURSE TO: *(department/program)*

TOTAL HOURS PER TERM: **75**

STRUCTURE OF HOURS:

Lectures:	**75**	Hrs
Seminar:		Hrs
Laboratory:		Hrs
Field experience:		Hrs
Student directed learning:		Hrs
Other (specify):		Hrs

TRAINING DAY-BASED INSTRUCTION:
Length of course:
Hours per day:

OTHER:
Maximum enrolment: **24**
Expected frequency of course offerings: On Demand
(every semester, annually, every other year, etc.)

WILL TRANSFER CREDIT BE REQUESTED? (lower-level courses only)	☐ Yes	☐ No
WILL TRANSFER CREDIT BE REQUESTED? (upper-level requested by department)	☐ Yes	☒ No
TRANSFER CREDIT EXISTS IN BCCAT TRANSFER GUIDE:	☐ Yes	☒ No

Course designer(s):	**Tim Cooper (revised by Jeff Chizma)**		
Department Head:	**Derek Harnett**	Date approved:	**August 26, 2013**
Campus-Wide Consultation (CWC)		Date of meeting:	**September 27, 2013**
Curriculum Committee chair:	**David Fenske**	Date approved:	**October 18, 2013**
Dean/Associate VP:	**Lucy Lee**	Date approved:	**October 18, 2013**
Undergraduate Education Committee (UEC) approval		Date of meeting:	**January 31, 2014**

LEARNING OUTCOMES:

Upon successful completion of this course, students will be able to:

- State the composition of nuclei and their various decay modes
- Write and interpret the composition of atoms in terms of spectroscopic notation
- Apply the techniques of quantum mechanics to scattering off of nuclei, and interpret the results
- Demonstrate the importance of both form factors and cross-sections in scattering events
- Explain the origin of the liquid drop model, and how it can be used to model binding energies
- List the five major components of the SEMF, and their functional dependence on nuclear parameters
- Perform calculations based on the SEMF to predict the stability of nuclei under various decay modes
- Show how the application of the shell model can explain the origin of the magic numbers
- Predict spin-parity states of actual nuclei based on the results of the shell model
- Identify the particles involved in alpha, beta, and gamma decay
- Provide basic explanations of the three main decay mechanisms of nuclei involved in radioactivity
- Calculate the ratio of parent to daughter nuclei in multiple decay chains
- Distinguish the difference between fission and fusion, and how they can be applied to nuclear power

METHODS: *(Guest lecturers, presentations, online instruction, field trips, etc.)*

This course will be taught using lectures, demonstrations, seminars, and student projects. Problems will be assigned and marked on a regular basis. In addition, limited computational modeling will be employed.

METHODS OF OBTAINING PRIOR LEARNING ASSESSMENT RECOGNITION (PLAR):

☐ Examination(s) ☐ Portfolio assessment ☐ Interview(s)

☒ Other (specify): Please see the Physics PLAR policy on the department's webpage.

☐ PLAR cannot be awarded for this course for the following reason(s):

TEXTBOOKS, REFERENCES, MATERIALS:

[Textbook selection varies by instructor. An example of texts for this course might be:]

Introductory Nuclear Physics, Kenneth S. Krane, Wiley (Ed. 3)

SUPPLIES / MATERIALS:

STUDENT EVALUATION:

[An example of student evaluation for this course might be:]

Assignments:	30%
Term test:	20%
Project or presentation:	10%
Final exam:	40%

COURSE CONTENT:

[Course content varies by instructor. An example of course content might be:]

1. **Introduction**
   - History and overview of nuclear physics, size and scale of nuclear physics, nucleons, quantum mechanics review, parity, total angular momentum, symmetry and multi-particle states, Pauli exclusion principle, spectroscopic notation and the atomic shell model, isospin

2. **Scattering**
   - Rutherford scattering, impact parameter, cross-section, classical results, quantum scattering, differential cross-section, Green's functions, form factors, charge density, correlation to classical results, interpretation of experimental results

3. **Liquid Drop Model of Nuclei**
   - Binding energy, surface and volume terms, Coulomb term, pairing term, exchange term, semi empirical mass formula (SEMF), atomic versus nuclear mass, binding energy per nucleon curve, alpha particles and decay, semi-leptonic decay, nuclear stability, exploring the SEMF with Maple/Mathematica

Course Content continued:

4. The Shell Model of Nuclei

- Comparison to atomic shell model, magic numbers and binding, Coulomb potential, spherical well potential, harmonic potential, Woods-Saxon potential, LS coupling and degeneracy, shell model predictions of spin-parity states, comparison with experiment, electric quadrupole moment

5. Radioactive Decay

- Alpha decay and tunneling, beta decay and Fermi's golden rule, gamma decay and nuclear shape, fission, fusion, decay chains, halflife, decay spectra, nuclear power, nuclear weapons

6. **Introduction to Particle Physics** (time dependent)

- Colour, flavour, quarks, mesons, baryons, hadrons, leptons, gluons, antiparticles, construction of a nucleon