OFFICIAL UNDERGRADUATE COURSE OUTLINE (page 1)

COURSE IMPLEMENTATION DATE:	June 1994
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 451	Faculty of Science / Physics	3
COURSE NAME/NUMBER	FACULTY/DEPARTMENT	UFV CREDITS

Advanced Quantum Mechanics

COURSE DESCRIPTIVE TITLE

CALENDAR DESCRIPTION:

Three dimensional quantum mechanics and multi-particle states, addition of angular momentum, Clebsch-Gordan coefficients, identical particles, weak and strong Pauli exclusion principle, the periodic table, and spectroscopic notation; perturbation theory, variational principle, Fermi's golden rule and time dependent potentials; quantum scattering, cross sections and computation of scattering amplitudes.

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: Once every two years
(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 Derek Harnett 2013 – 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:

- Extend the basic ideas of one dimensional quantum mechanics to the solution of three dimensional problems
- Derive the equation of continuity in three dimensions
- Distinguish the types of states necessary to describe bosonic and fermionic systems
- Explain how the fermionic nature of electrons leads to the ordering of the periodic table of the elements
- Utilize the Table of Clebsch-Gordan coefficients to write out correctly symmetrized states
- Discern the symmetry of a state by applying the permutation operator
- Apply the appropriate approximation method to solve realistic problems in quantum mechanics
- State Fermi's golden rule, and apply it to simple systems
- Evaluate first and second order perturbations to systems of interest
- Perform calculations for both time dependent and time independent potentials
- Extend calculations done using time independent perturbation theory to employ the variational method
- Use scattering theory to provide interpretations of modern experimental results in high energy physics
- Compute the scattering amplitude for a variety of potentials

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.

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:]

Texts:
Introduction to Quantum Mechanics, Griffiths, D., Pearson (2005)

References:
Quantum Mechanics with Basic Field Theory, Desai, Bipin, Cambridge (2010)
Quantum Mechanics (Vol. 1-2), Messiah, A., Dover (1999)

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. **Review of Basic Quantum Mechanics (extensions to 3 dimensions)**
   - Wave functions and state vectors in three dimensions, momentum operator in 3d, 3d quantum well, equation of continuity, Hermitian and unitary operators, expectation values, Schrodinger equation as an approximation to the Klein-Gordon equation

2. **Many-Particle States**
   - Adding orbital and spin angular momenta to incorporate them into the overall state, permutation operator, symmetric and antisymmetric states, bosons and fermions, exchange forces, Clebsch-Gordan Tables, introduction to flavor, color and isospin, explanation of the table of elements, spectroscopic notation, simple proton model

Course Content continued:

3. **Approximation Methods for Time Independent Systems**
   - Time independent perturbation theory, expansion of solutions in terms of orthogonal states, importance of the harmonic oscillator solutions (Hermite polynomials), variational principle, WKB method, applications to the helium atom and fine structure of hydrogen

4. **Approximation Methods for Time Dependent Systems**
   - Time dependent perturbation theory, Fermi's golden rule, application to two level systems, density of states and applications to nuclear and particle physics, adiabatic approximation versus sudden approximation

5. **Quantum Scattering**
   - Hard sphere scattering, impact parameter, Rutherford scattering, cross section, partial wave analysis, Born approximation, phase shifts, Green's functions and applications to scattering