**Course Title:** NUCLEAR PHENOMENA FOR ENGINEERING APPLICATIONS  
**Number:** MANE-2830, CRN 73737  
**Credit Hours:** 4  
**Semester/Year:** Spring/2011  
**Meeting Days:** Mon & Thu 2-3:50PM  
**Place:** SAGE 3101  
**Prerequisites:** Physics I&II or equivalent  
**Instructor:** Li (Emily) Liu, Assistant Professor  
**Office Location:** JEC 5046  
**Office Telephone:** (518) 276-8592  
**Office Hours:** Thu 10AM-1:30PM  
**Email Address:** liue@rpi.edu  
**Teaching Assist:** Tianyu Liu  
**TA Office:** JEC 2001  
**TA Office Hours:** Tue 3:30 - 5:00PM or make appointment  
**TA Email:** liut4@rpi.edu

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**Course Text and other Materials (required)**  
**Book of Lecture Notes for Nuclear Phenomena for Engineering Applications,** available online in RPI LMS or can be requested through email. Rensselaer Polytechnic Institute: Troy, New York.

Text available from the bookstore:  

Minimum operating system and hardware requirements: Windows 98 SE - 266 MHz PIII processor; Macintosh OSX 10.2.6 - 233 MHz PowerPC G3 processor; 128 MB RAM

Internet browser: MS IE 5, 5.5, 6; NN 6.2.x, 7, 7.1; AOL 7, 8, 9; Mozilla 1.5, 1.6

Internet access: 56 Kbps minimum, broadband highly recommended (cable, DSL, or LAN)

Software applications: Adobe Acrobat Reader 5.0+

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**Additional Materials (not required)**  

Written by a brilliant scientist whose work ranged from proposing the “big bang” theory to mathematically modeling DNA, this is a humorous look at how the universe might appear if, for example, the speed of light was slow enough that we might easily observe relativistic effects in our everyday lives. Many eminent scientists have credited these stories as a major influence in their decision to pursue science.


This textbook is often used for the Rensselaer course “Applied Atomic and Nuclear Physics”, the next level up from this one.
**Course Objectives**
The realm of the problems you will encounter is the very small (atomic and nuclear dimensions), and sometimes the very fast (large fractions of the speed of light). These are realms you cannot directly experience, and so a secondary objective is that you shall
- become proficient at “seeing” the very small and the very fast at an intuitive level through their mathematical models.

The overall objectives of this course are to:
- enlighten your perspective of the universe; and
- enhance your analytic savvy.

The definition of “enlightenment” includes both “intellectual understanding” and “freedom from prejudice”. When someone mentions “Einstein’s special theory of relativity”, “quantum mechanics”, or “wave-particle duality”, it is usually in the context of something beyond the comprehension of mere mortals, and is often dismissed with a woeful roll of the eyes. We will begin this course by dismissing such prejudice and showing you that applying these “big concepts” amounts to little more than understanding the two languages they are most often expressed in: mathematics and jargon. By “analytic savvy” we mean both the culture and the practical intelligence you bring to problem solving.

**Course Learning Outcomes**
In particular, you shall be able to:
- demonstrate ability to solve nano-structure problems; and relativistic issues/problems.
- apply the methods of “modern” physics to explain and analyze existing and future technologies and engineered products involving nuclear phenomena; and
- discuss how atomic and nuclear phenomena apply to our everyday lives through technology and the environment.

**Course Assessment/Measures and Grading Criteria**

<table>
<thead>
<tr>
<th></th>
<th>Typical Number (may vary)</th>
<th>Per-Item Weighting</th>
<th>Course Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exams (1, 2, and 3 combined)</td>
<td></td>
<td></td>
<td>75%</td>
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<tr>
<td>Assignments (including attendance)</td>
<td></td>
<td></td>
<td>25%</td>
</tr>
<tr>
<td>In-class quiz</td>
<td>11</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Attendance</td>
<td>14</td>
<td>5</td>
<td></td>
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<tr>
<td>Homework</td>
<td>11</td>
<td>10</td>
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</tbody>
</table>

The approximate cost (as a percent of your course grade) of missing assignments:
- missed quiz: ~0.9%
- missed attendance: ~0.4%
- missed homework: ~0.9%
- missed exam: 25.0%
- ignore all quizzes: ~10%
- never show up: ~5%
- ignore homework: ~10%
## Course Calendar

### SCHEDULE: NUCLEAR PHENOMENA FOR ENGINEERING APPLICATIONS – SPRING 2011

<table>
<thead>
<tr>
<th>Week</th>
<th>Meeting Day / Date / Time</th>
<th>Videos and Lecture Notes</th>
<th>Text Reading [Krane, 2nd Edition]</th>
<th>Homework and Exams</th>
</tr>
</thead>
</table>
| 1    | M 01/24/2011, 2-4 pm  
     R 01/27/2011, 2-4 pm | Week 01                  | 1.0, 1.1, 1.2, 2.7               | Hwk01 given       |
| 2    | M 01/31/2011, 2-4 pm  
     R 02/03/2011, 2-4 pm | Week 02                  | 3.2, 3.4, 6.5, 4.1               | Hwk01 due  
     Hwk02 given       |
| 3    | M 02/07/2011, 2-4 pm  
     R 02/10/2011, 2-4 pm | Week 03                  | 5.1-5.4, 5.7                     | Hwk02 due  
     Hwk03 given       |
| 4    | M 02/14/2011, 2-4 pm  
     R 02/17/2011, 2-4 pm | Week 04                  | 7.1-7.3, 7.5-7.8, 8.1-8.4        | Hwk03 due  
     Hwk04 given       |
| 5    | R 02/24/2011, 2-4 pm  
     **M 02/28/2011, 2-4 pm** | Week 05                  |                                   | Hwk04 due  
     **Exam 1**       |
| 6    | R 03/03/2011, 2-4 pm  
     M 03/07/2011, 2-4 pm | Week 06                  | 12.0-12.4                        | Hwk06 given       |
| 7    | R 03/10/2011, 2-4 pm  
     **Spring Break**  
     M 03/21/2011, 2-4 pm | Week 07                  | 12.5-12.10                       | Hwk06 due  
     Hwk07 given       |
| 8    | R 03/24/2011, 2-4 pm  
     M 03/28/2011, 2-4 pm | Week 08                  |                                   | Hwk07 due  
     Hwk08 given       |
| 9    | R 03/31/2011, 2-4 pm  
     M 04/04/2011, 2-4 pm | Week 09                  |                                   | Hwk08 due  
     Hwk09 given       |
| 10   | R 04/07/2011, 2-4 pm  
     **M 04/11/2011, 2-4 pm** | Week 10                  |                                   | Hwk09 due  
     **Exam 2**       |
| 11   | R 04/14/2011, 2-4 pm  
     M 04/18/2011, 2-4 pm | Week 11                  | 13.2                              | Hwk11 given       |
| 12   | R 04/21/2011, 2-4 pm  
     M 04/25/2011, 2-4 pm | Week 12                  | 13.4, 13.5                       | Hwk11 due  
     Hwk12 given       |
| 13   | R 04/28/2011, 2-4 pm  
     M 05/02/2011, 2-4 pm | Week 13                  |                                   | Hwk12 due  
     Hwk 13 given      |
| 14   | R 05/05/2011, 2-4 pm  
     **M 05/09/2011, 2-4 pm** | Week 14                  |                                   | Hwk13 due  
     **Exam 3**       |

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**Final scores will be posted on 5/12/2011. Submission of grades: 5/13/2011.**
Course Content

Unit 1:

Week One - Review of Classical Physics; Special Relativity
Week Two - Wave-Particle Duality
Week Three - Uncertainty and the Schrödinger Equation
Week Four - The Schrödinger Model of the Atom
Week Five - Review of Unit 1

Unit 2:

Week Six - Nuclear Structure
Week Seven - Radioactive Decay
Week Eight - Nuclear Reactions I
Week Nine - Nuclear Reactions II
Week Ten - Review of Unit 2

Unit 3:

Week Eleven - Radiation Applications and Implications
Week Twelve - Nuclear Fission
Week Thirteen - Nuclear Fusion
Week Fourteen - Review of Unit 3
Course Policy on Academic Integrity

Rensselaer’s policy on academic dishonesty is explained in *The Rensselaer Handbook of Student Rights and Responsibilities*. You are expected to review and understand this information. In addition, the following policies apply specifically to this course.

- **Committing, or attempting to commit** an act of academic dishonesty, or **assisting in the commission or attempt** of such an act, is a flagrant offense to the process and culture of education; expect our reaction to it to be harsh.
- You are expected to refrain from any academically dishonest act, and to be vigilant in protecting your work from others who might attempt to commit an act of academic dishonesty.

In this course, academic dishonesty can take the following forms.

- Taking a quiz with any assistance from another person, regardless of who they are.
- Taking an exam with any assistance from another person, regardless of who they are.
- Using any materials (such as a crib sheet or a calculator) that you did not bring for you and you alone to use on an exam, unless given explicit permission by the exam proctor (e.g., typically for extraordinary circumstances such as the failure of your calculator during a test, etc.).
- Using any materials (such as a text, extra crib sheets, a laptop, etc.) that are not explicitly permitted during an exam.
- Submission of a discussion forum response that, except for short phrases or properly referenced material (e.g., quotes, figures, etc.), consists of any content not created by and original to you.
- Submission of a paper that, except for short phrases or properly referenced material (e.g., quotes, figures, etc.), consists of any content not created by and original to you.
- Indicating someone as “present” (e.g., on an attendance sheet) who is not present in class at the time the indication is made.

The penalty for violating these policies is at the discretion of any or all members of the instructional team. In general, the penalty for any violation is

- failure of the course.

In addition, if taking this course via Rensselaer’s Malta distance education program,

- a recommendation for suspension or dismissal from the Malta program.
Course Summary

This course surveys atomic and nuclear phenomena, their applications, and implications. To achieve this, the course is presented in three units:

I. Particle collision mechanics, special relativity, particle-wave duality, and atomic quantum mechanics.
II. Nuclear structure, characteristics, and reactions: structures, forces, decay mechanics, reaction mechanics, and interaction probabilities at the nuclear level.
III. Applications and implications of nuclear phenomena: radiation effects on materials and biological systems, radiation shielding, radioisotope production, radiation detection, radiation sources, fission energy, and fusion energy.

Prerequisites

This is a sophomore/junior level course. You should have successfully completed first year courses in calculus, physics, and chemistry, and a sophomore level course in differential equations.

Course Mechanics

Focus: quiz, discussion, challenge, meeting, homework, exam.

Each “week” of the course is a distinct unit of instruction. For each week we expect you to:

- attend class in a manner that respects your fellow classmates and their desire to learn;
- at least skim the assigned reading and study the examples that are in the reading;
- take the quiz in class at the beginning of the class;
- complete any homework assignments in a clear and presentable manner; in particular, for each question that requires more than simple calculations you should try to show that
  1) you understand what the question is asking you (a picture can be worth a thousand words),
  2) you know how to answer the question,
  3) you know what the answer is, and
  4) you know what your answer means;
- submit at the beginning of the class all homework assignments due from previous weeks;
- actively participate in any discussions and challenge games in class;
- join the instructor for a meeting and raise up any questions and concerns about the class; and
- actively pursue your questions both in class and via the discussion boards in RPILMS;
Conclusions:

- the effect of missing any one assignment or quiz is small to trivial; it’s not worth cheating for;
- the effect of missing more than a few assignments or quiz is significant;
- the biggest effects on your grade are the three exams; use the assignments as preparation for these exams: do not be afraid to make a mistake on a homework assignment, but be sure to learn from your mistakes.

At our discretion, we may weight individual or groups of assignments differently, including weighting some zero (in effect dropping them from the average). If we do, the new weighting will be applied identically to all students in the class. Your final grade will then be the higher of the result using the weighting described above and the result using the new weighting. That is, the new weighting can only help you, it cannot hurt you. A zero weighting will only be applied to assignments that were at least 50% complete (independent of the grade you received). In particular, we will never “drop” an assignment you did not do: a zero will always be averaged in for that assignment at its full weight.

**Late homework will be accepted with typically a 30% to 50% penalty at the discretion of the instructor.**

**Attendance and quizzes can not be made up late.**

**Excused Absences**

Requests to be excused must be made in writing (email is acceptable) and should include:

- the date and lesson week (1-14) of your absence,
- the reason for your absence, and
- the date you submitted your request.

You are responsible for obtaining all class notes, announcements, changes, etc., made in any lesson you miss as well as for completing any missed work. We will answer any specific questions you may have, but we will not re-teach the lesson.

Exams must be taken when given unless an appropriate excuse is provided. If a makeup exam is offered, it must be taken during the next class time that an instructor for this course is available unless an instructor decides on alternative arrangements (e.g., an oral exam in the instructor's campus office).

**Attitude**

I expect you to take the course seriously, to try to meet the learning objectives for the course in general and each week in particular, to put effort into the assignments, to attend class, and to be intellectually curious.

You should expect me to take the course seriously, to have reasoned and defensible learning objectives for the course, to have selected appropriate course materials, to be prepared for class, to convey information
effectively, and to be helpful and approachable.

Caveat

We cannot guarantee that the weather, the computer network, life in general, etc., will not interfere with our work to meet the objectives of this course. Please note that extenuating circumstances may require changes to the schedule and procedures in this syllabus. If you encounter any personal difficulties (e.g., medical issues, necessary travel, etc.), you must inform us as soon as possible (and before the event if you know it is coming) to make arrangements for completing your work with minimal penalty.

A Sample Study Schedule

NPEA is a 4 credit course, which means you should spend approximately 12 hours per week in and out of class working on this course. In the first few weeks you may find that you spend somewhat more as you get used to the course format. Approximately halfway through the course, however, the amount of reading drops off significantly, so you will spend less time overall.

Below is a sample study schedule based on an on-campus regular Monday & Thursday class week. Your schedule will, of course, likely be different. This example is based on a Homework-due-on-Monday schedule.

<table>
<thead>
<tr>
<th></th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
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<tbody>
<tr>
<td>8-10am</td>
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<tr>
<td>10am-12</td>
<td>Readings</td>
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<tr>
<td>12-2pm</td>
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<tr>
<td>2-4pm</td>
<td><strong>HW DUE</strong></td>
<td><strong>QUIZ</strong></td>
<td>CLASS</td>
<td></td>
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<tr>
<td>4-6pm</td>
<td><strong>CLASS</strong></td>
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<td></td>
<td>Homework</td>
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<tr>
<td>6-8pm</td>
<td></td>
<td>Readings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-10pm</td>
<td>Study</td>
<td>Homework</td>
<td>Homework</td>
<td>Homework</td>
<td>Homework and Discussion Boards</td>
</tr>
</tbody>
</table>
Some of the features of this schedule are:

1. The readings are completed close to the class meeting so the material is relatively fresh;
2. The homework is completed soon after examples are seen in class on Thursday;
3. Questions posted to the discussion board arising from Monday’s study will be answered for reading on Wednesday night; and
4. Questions posted to the discussion board arising from Friday’s homework will be answered in time for Friday’s homework session. Strongly encourage students to answer students’ questions.

Pedagogical Strategies for Meeting the Course Objectives

The semester is divided into 14 week-long units of instruction and a final exam. Two exams are given during these weeks and a third exam (not comprehensive) is given at the last class. For each of the weeks, the allocation of the up to 12 hours you are expected to devote to this four credit course will typically be as follows.

- Up to 5 hours studying course materials (notes and text) specific to the current week.
- Up to 2 hours in class for some or all of the following:
  - homework submission and review of homework solutions for the previous week;
  - remarks to put the current week in context;
  - questions and answers on the assigned course materials; and
  - in class lecture, discussion, and/or exercises to prepare you for the homework assigned for the current week.
- Up to 5 hours completing the homework assignments.

RPILMS We will be using an online course management system called RPILMS to
- facilitate the interactive nature of this course,
- organize the details about objectives and assignments for each lesson, and
- provide you with an easy to access central repository for course materials, assignments, and communications between us.

You will be introduced to this system on the first day of class. An anonymous discussion forum on RPILMS is devoted to your asking and my answering questions outside of class.

Pre-Lesson. Learning in this course begins with you. Prior to meeting in class, you will be expected to have studied all assigned course materials – typically reading the text and course notes – for a given week. Supplemental materials are also available to enhance your learning and guide you in exploring topics outside the scope of this course. These supplemental materials are not required, though some of them will be topics of discussion in class. It is imperative that you come to class so prepared.

Class. The in-class lectures, discussions, and exercises are intended to teach you certain topics “by doing”, and to assure you that you have all of the skills necessary to complete the homework assignment for that
lesson. Attendance may be recorded and can affect your grade. Only excused absences will not count against your grade.

**Homework.** The homework assignments are intended to reinforce what you learned during the lesson and to help prepare you for the tests. Homework assignments must be turned in on time to avoid a penalty. The penalty is typically a 30%-50% deduction, but may be greater. “On time” is the beginning of the next class unless we specify otherwise. You are encouraged to collaborate with other students in this class on the homework assignments, as long as the assignment is submitted with joint authorship indicated; all participants’ homework will be graded separately.

**Quiz.** The in-class quiz is intended to test on what you learned in the past week. It is closed book/closed notes/closed computer (you can only have pen, pencil, blank paper, and calculator outside).

**Exams.** The exams are closed book/closed notes/closed computer. A single two sided 8½” x 11” sheet of notes is permitted at the first exam, two sheets at the second (typically one will be your sheet from the first tests), and three sheets at the third exam (typically two will be your sheets from the first two exams). The material in the course is cumulative so, while each exam is intended to test your knowledge of the current unit only, it will necessarily assume knowledge from any preceding units. A paper or supplemental homework problems (to be determined by the instructor) may be completed to increase your grade on the first two exams.

**Instructional Team**

This Rensselaer LMS Site is based on a collaborative project between Dr. Liu, Dr. Haley, Dr. Steiner, and Dr. Huguet.

Li (Emily) Liu (MIT '05)
liue@rpi.edu

Li (Emily) Liu, Ph.D., joined RPI-NEEP program in July 2006. She has been doing research and teaching for 10 years since going to MIT. Currently, Dr. Liu teaches two courses on campus: NPEA (Spring each year), AANP (Fall each year), and IEA (spring 2009). As a nuclear physicist, her target is to bring both knowledge and fun to the classroom.

Thomas C. Haley (RPI '84 and many more....)

Thomas Haley, Ph.D., has been an instructor in various venues and at various levels for 20 years. He has been an Adjunct Assistant Professor at Rensselaer for seven years, teaching both on the main campus and at Rensselaer’s Malta campus. As a nuclear engineer at an engineering consulting firm for 16 years, Dr. Haley was a jack-of-all-nuclear-analysis-trades consultant specializing in criticality safety, numerical/statistical analysis, and software development. Currently he is a house husband providing child care. And loving it.

Marie-Pierre Huguet (SUNY Albany '08)
Marie-Pierre Huguet has been a course developer at Rensselaer since 2001. As such, she has been providing support and guidance in instructional design and instructional technologies to Rensselaer faculty who either seek to integrate emerging technologies into their face-to-face classroom, or teach Web-based or blended/hybrid courses. Ms. Huguet received a Ph.D. in Curriculum and Instruction at SUNY Albany. For the past several years, both at Rensselaer and SUNY Albany, she has been involved in several research projects that have looked at the impact of Web-based technology in education. Dr. Huguet's primary areas of interest for research and practice include instructional design, Web-based design, integration of Web-based technology, and faculty adoption of emerging technologies.

**Instructional Staff**

Tianyu Liu  

teaching assistant