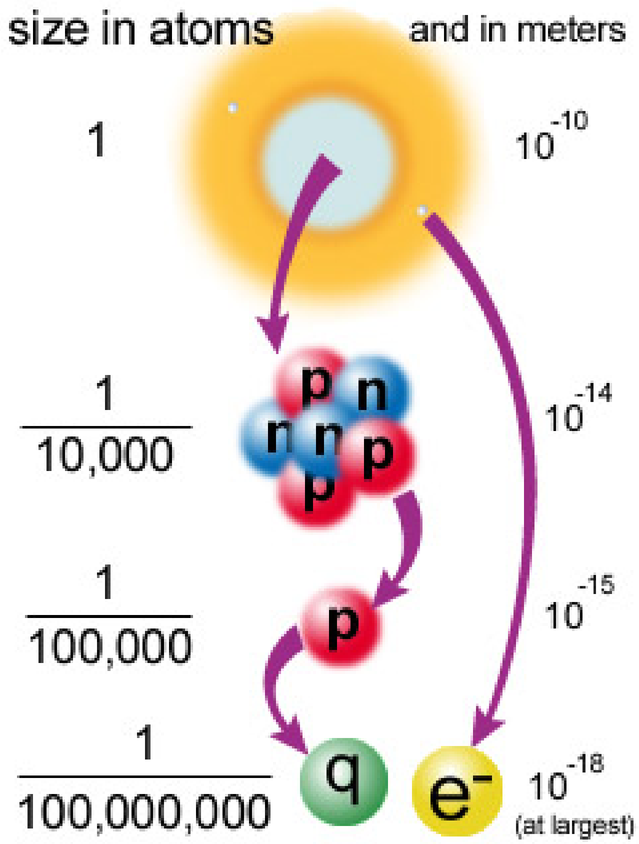
NUCLEAR PHYSICS

308351 – SPRING 2003

By

Dr. Ilham Y. Al-Qaradawi

Physics Department



General Information:

Time: Sunday, Tuesday 16:30 – 18:00, Room S249

Course Lecturer:

Dr. Ilham Y. Al-Qaradwi, Physics Department.

How to contact me:

Office telephone: ext. 2126

E-mail address: ilham@qu.edu.qa

My Personal Web Page: http://www.ilhamalqaradawi.com
Course Web Page: http://www.ilhamalqaradawi.com/courses/351

Office Hours: Saturday 11:30-12:30, Mon & Wed 09:30-10:30, Sun & Tue 15:30 – 16:30 (by appointment pleas) all in positron lab room S113.

Midterm tests: Tue 1st April, Sun 4th May 2003.

Final Exam: Monday June 9th, 2003, 11:00-13:00.

Textbooks:

- Introductory Nuclear Physics, Kenneth Krane, Wiley.
- *University Physics,* Hough D. Young, 8th Edition, Addison Wesley.
- Concepts of Modern Physics, Beiser, McGrawHill.
- (or any similar nuclear or modern physics book).

Syllabus:

The syllabus is given out with these notes. There is also a calendar showing approximately the topics that will be covered during each lecture.

Discussion Sessions (Tutorials)

There will be regular discussion sessions (tutorials), which will take place normally on Mondays for the second half of the session. Those sessions will focus on developing good problem solving ability, and concentrate on further explaining the more difficult subjects of the course. They are also a good chance for asking questions.

Course Requirements

1. **Homework Assignments:**

Every week or two homework problems will be assigned. Problems are to be returned on the date indicated. Problems returned after the deadline will receive a grade of 0. Solutions to the homework problems will be given in the discussion sessions in the classroom as well as posted on the Web.

You are encouraged to work together with fellow students to **discuss homework concepts**, and you are allowed to work out the solutions together. Each problem set handed in should include **EITHER** the ***honour pledge*** (if you did it by yourself) **OR** a statement indicating the name of the student with whom the work was done. Be aware that, when working together with a fellow student, you should actually attempt to solve the problems together, not just copy answers and solutions. Homework will count for 15% of the final grade.

---

2. Projects

It is hoped that some active work on the students' side could be achieved to encourage students to search for information on a certain subject and then organize this information in an interesting way and present it with explanation to their fellow students during lectures or lab sessions. Each student should prepare an essay, poster, presentation or a website that explains the assigned subject in a clear, concise, and attractive way. There will be voting at the end of term for the best three projects. Those will be assigned 1st, 2nd, and 3rd places. The proposed subjects are part of the material that will be covered in this course. A tentative list follows:

- Radioactive Clocks.
- Proton and Neutron Discovery.
- Mysteries of Alpha Decay.
- The neutrino mass and the universe.
- The Gamma Decay and Mossbauer Effect.
- Track Detectors.
- Semiconductor Detectors.

The project grading however, does not depend only on how good it is compiled, but also on how much you have understood the subject and how good your presentation is. The main issue being preparing what you have been asked to prepare. If you prepare an essay or a poster on a different subject from the one allocated to you, your grade will be **<u>zero</u>** no matter how good your poster is.

---

3. **Midterm Exams:**

There will be two closed book midterm exams, given **only** on the dates shown in the syllabus, each lasting an entire class period, and each counting 20% of the final grade. The exams will consist of various types of questions as well as problems.

---

4. **Final Exam:**

The Final exam will be given **only** on the date shown in the syllabus. It will consist of multiple choice questions as well as short questions and problems addressing **<u>all</u>** the material covered in the course.

---

5. Extras:

- Short assignments are given frequently during lecture or most probably at the end of a lecture in preparation for the next topic to be discussed.
- Those should normally be one page or less but need to be handed in the following lecture in most cases.
- This is useful for developing your search skills and can gain you some marks.

Grading:

Final grades will be determined by the following components:

Homework	15%
Project	5%
1st midterm exam	20%
2nd midterm exam	20%
Final exam	40%
Extras	not fixed
TOTAL	100%

Useful web sites:

You may use the internet to search for your essay topic or to help you with the course material. There is loads of useful and interesting material to help you. I list here only some of those sites:

http://physicsweb.org/TIPTOP/

http://www.pparc.ac.uk/

http://www.nucphys.nl/

http://hepweb.rl.ac.uk/ppUK/

http://www.ph.rhbnc.ac.uk/course_materials/PH352/index.html

http://av1.physics.ox.ac.uk/www/users/scooper/pp3/
http://www.hep.ucl.ac.uk/~jthomas/notes3c24.html
http://hepwww.rl.ac.uk/

http://www.cern.ch/Physics/HEP.html

http://www.eagle.co.uk/news/ppnews.html
http://www.cern.ch/
http://vlib.org/Physics.html
http://www.cern.ch/CERN/Experiments.html
http://dir.yahoo.com/Science/Physics/
http://www.ucl.ac.uk/Resources/MAPS/Physics.html

With my best wishes for Happy Surfing.

P.S.: if you're interested you can find a more comprehensive list on my website. If you come across another useful website you may send the link to me by email.

Feedback:

Your comments, questions, and suggestions about this course are always welcomed. You may use either the attached form or during office hours or send an email.
If you wish you may send an email message to me to establish contact. You will receive some interesting sites and useful information whenever I come across them on the web.

What's on your mind?

Course Web Page:

You are encouraged to visit the course website at: http://www.ilhamalqaradawi.com/courses/351
You will find updated information about the course, which you may print or download. You will also find a number of educational links related to the course material which could be quite useful in emphasizing the theoretical ideas and principles. Some might contain solved problems and examples as well.

With my very best wishes for your physics' success

Dr. Ilham Al Qaradawi

Introductory Nuclear Physics

308 351: Course Outline

(1) Basic Concepts : (4 weeks)

1.1 Overview and History.
1.2 Terminology : • The proton-electron hypothesis.
• Neutron Discovery
1.3 Classification of Nuclei : The Segre` Chart
Magic numbers
1.4 Nuclear Properties
1.5 Units and Dimensions.
1.6 Binding Energy.
1.7 The Nuclear Force.
1.8 Nuclear Structure.

Assignment (1)

First periodical test

(2) Radioactive Decay : (5 weeks)

2.1What is Radioactivity? and Why?.
2.2 Nuclear Transformations.
2.3 Radioactive Decay Law : Secular Equilibrium.
2.4 Radioactive Series.
2.5 Radioactive Dating.
2.6 Units and Biological Effects.
2.7 Types of Radioactive Decay : (a) α-Decay
(b) β-Decay
(c) γ-Decay
2.8 Uses of radioactivity

Assignment (2)

Second periodical test

(3) Radiation Detection : (3 weeks)

3.1 Interactions of radiation with matter.
3.2 Gas filled detectors.
3.3 Scintillation detectors.
3.4 Semiconductor detectors.
3.5 Track Detectors.

Assignment (3)

(4) Neutron Physics: (2 weeks)

5.1 Neutron Sources.
5.2 Absorption and moderation of neutrons.
5.3 Neutron detectors.
5.4 Neutron capture.

Final Exam

With my best wishes,

Dr. Ilham Al-Qaradawi

Introductory Nuclear Physics 308351

Course Calendar Spring 2003

Date \ Day	Sunday	Tuesday	Notes
Feb 15 – 19	Course overview	Historical background and introduction	
Feb 22 – 26	Terminology & discoveries	Classification of nuclei	
Mar 1 – 5	Nuclear Properties	Binding energy	1st Assignment
Mar 8 – 12	Separation energy Nuclear force	Nuclear Structure	
Mar 15 – 19	Radioactive decay	Nuclear transformation	2nd Assignment
Mar 22 – 26	Radioactive decay law	Secular equilibrium	
Mar 29– Apr 2	Radioactive series Radioactive dating	**1st periodical test**	3rd Assignment
Apr 5 – 9	Alpha decay	Alpha decay	
Apr 12 – 16	Beta decay	Gamma decay	4th Assignment
Apr 19 – 23	Mossbauer effect	Biological effects of radiation & units	
Apr 26 – 30	Uses of radiation	Semiconductor detectors	5th Assignment
May 3 – 7	**2nd periodical test**	Track detectors	
May 10 – 14	Neutron sources	Neutron diffraction	6th Assignment
May 17 – 21	Absorption of neutrons	Neutron moderation	
May 24 – 28	Neutron detectors	Revision	
May 31– Jun 4			
	Final exam: Monday 9th June 2003 11:00 –13:00		Exam papers back on Wed 11th Jun

With my best wishes,
Dr. Ilham Al-Qaradawi

Learning Objectives for Chapter (1)

After studying this chapter you should be able to:

1. Describe the beginning and progress of nuclear physics;
2. name the constituent particles of nuclei;
3. explain the proton-electron hypothesis and the discovery of the neutron;
4. describe the importance of the neutron-proton ratio and number of nucleons in determining the stability of nuclei, and the decay mode;
5. state the typical dimensions of nuclei;
6. describe the evidence from alpha particle scattering and electron diffraction experiments;
7. show how the constancy of the density of nuclear material derives from such evidence;
8. extract information about nuclear masses, isotopic abundance and half lives from tables and charts of nuclides;
9. explain the importance of NMR;
10. calculate values of nuclear masses for different nuclides;
11. calculate values of mass defect for different nuclides;
12. use Einstein's equation $E=mc^2$ to relate mass defect and binding energy;
13. describe the variation of binding energy per nucleon with nucleon number A;
14. calculate values of neutron and proton separation energies from different nuclides;
15. state the relative importance of the strong nuclear, electrostatic and gravitational forces in holding nucleons together in a nucleus;
16. describe the characteristics of the strong nuclear force between nucleons;
17. explain the significance of the terms in the semi-empirical binding energy equation;
18. explain the significant importance of the shell model in explaining the role of magic numbers;
19. explain the idea of PET;

Learning Objectives for Chapter (2)

After studying this chapter you should be able to:

1. Write equations for nuclear decays involving α, β^+ and β^- emission, and electron capture;
2. define and use the following terms: radioactive decay constant, half-life, activity;
3. appreciate the random nature of radioactive decay;
4. use the radioactive decay law to calculate the activity and number of nuclei for a radioactive source at a certain time;
5. show how nuclides are related through decay chains;
6. describe several uses of radioactive nuclides such as : tracing technique, gamma cameras; radioactive dating;
7. describe the biological effects of radiation and use the suitable units;
8. Calculate the values of the energy Q released when an unstable nucleus decays;
9. determine, from values of Q, whether or not a particular radioactive decay is possible;
10. state the following properties of α,β and γ radiations: charge, mass, penetration of air and solid materials and any other properties;
11. describe how conservation laws apply in the case of of α ,β^+ , β^-, γ emission, and electron capture;
12. describe the appropriate models to explain the mechanisms of α ,β^+ , β^-, γ emission, and electron capture;
13. describe the evidence which supports these models;
14. describe the relation between the Geiger-Nuttal rule and the tunneling of α particles;
15. account for the continuous β spectrum;
16. outline the evidence for the existence of neutrinos and whether or not they have a mass;
17. describe the big bang theory and its account to the expansion of the universe;
18. use correctly the terms Doppler effect, Red shift, open and closed universe, dark matter;
19. describe the process of internal conversion;
20. describe the relation of nuclear resonance to Mössbauer Effect.