

Modern Physics II

PHYS 3606A/ PHYS 3608A

Early Summer 2023

Course Outline

1. Course calendar description and pre-requisites

This is the continuation of the departmental series of courses exploring Quantum Mechanics. In this course, the applications of the methods of Quantum Mechanics will be used to study elements of several atomic, molecular, solid-state, and nuclear systems. The results from these analyses aid to better understand the physical universe and the numerous technological applications that have emerged from these developments. Applications to other scientific disciplines will be presented. Real-world examples will be used whenever possible. See section 12 for a more complete list of the topics to be discussed.

Also offered, with different requirements as PHYS 3608 for which additional credit is precluded.

Pre-requisites: Prerequisite(s): **PHYS 2604** and **PHYS 3701** or permission of the Department.

2. Instructors contact information

Instructor office hours will be posted on Brightspace

Alan Madej	PHYS3606A lecturer (Office: HP Rm 3361)	alanmadej@cunet.carleton.ca or amadej@physics.carleton.ca
Penka Matanska	Lab Supervisor	matanska@physics.carleton.ca

In accordance with university policy, all communication with instructors and TAs must be via your Carleton email account. To get your Carleton Email you will need to activate

your MyCarletonOne account through Carleton Central. Once you have activated your MyCarletonOne account, log into the MyCarleton Portal.

To help resolve issues related to any missing term work, students must save all of their email correspondence with instructors and TAs until the course grades are finalized.

3. Course textbook

There is no assigned textbook for the course. Lecture notes originally written by Prof. T. Koffas will be used. These notes will be posted as modules on BrightSpace in advance of the lecture. Students are expected to attend the lectures, participate in the class, and take notes. For further study, a list of recommended books is given later in the course outline. These books allow a different view on the material covered and help the student to better understand the material through the approach of another author.

4. Course website

The course outline and other course information will be posted on Brightspace. We reserve the right to amend the course outline on Brightspace and will inform you if that version changes. In the event of any discrepancy between this document, and the version currently posted on the website, then the website version on Brightspace will be taken as the definitive version.

If you are unable to access Brightspace or need help with your computing account, please contact the ITS Service Desk at 613-520-3700 or email:

its.service.desk@carleton.ca

5. Course modality

This course is an **in-Person course** where attendance is required at the specified lecture room (currently Southam Hall: Rm 303) at the designated time slot (Monday and Wednesday 08:35am – 11:25am). The specific dates and activities are described further on in this course outline. Students are expected to remain up to date with the deadlines and due dates provided by the instructor.

6. Lecture schedule *

Section	Time Slot	Platform
PHYS 3606A/ PHYS3608A	Mondays and Wednesdays 08:35am – 11:25am	The classes are <u>in person only</u> in Southam Hall Rm 303 .

* All timeslots are in the Eastern Time zone

7. Labs

Labs/Tutorials start the week of **May 4, 2023 (unless otherwise noted check PHYS 3606/PHYS 3608 A1 (LAB) Brightspace page)**. Your Lab Supervisor for the Labs will be [Penka Matanska](#) for all classes. Ms. Matanska will be supported within the lab by [Maria Paula Rozo Martinez](#) and [Julie Sutton](#). Technical support will be provided by [Mike Antunes](#).

Information about the labs can be found on the PHYS 3606A1 LAB Brightspace page. The labs will occur in **Rm 3160 of the Herzberg Laboratories Building**.

It is imperative that all students attend the first introductory lab/ tutorial session. Students who might be exempt from the Lab (if they are repeating the course, for example) must **contact the Lab Coordinator**. You are not automatically given a lab exemption - you must apply for it no later than **early May, 2023**. Lab exemptions will be considered on a case-by-case basis.

Lab section	Time slot
A1 HP3160	Tuesdays and Thursdays 9:35 (9:35am) – 11:25 (11:25am)

You will be asked to keep an electronic log to demonstrate your work to set up the experiment, make the measurement and analyze the collected data. The lab policy will be reviewed in the first lab period. You will need to complete two (2) advanced level labs in Modern Physics and submit a report for each. In addition, you are expected to give a (1) presentation of your work to the class as part of your lab grade. **No grade will be dropped.**

8. Lectures and Assignments

Lectures are scheduled to begin on Monday May 8 at 08:35 am in Rm 303 of Southam Hall.

The lectures will be given in real time at the assigned time slots given for two sessions every week according to the schedule in Section 6 of this course outline. It is important that the students attend the lectures as they are given to derive the greatest benefit from the course and to obtain class participation credit. In addition to the lecture, Dr. Madej will have **Office hour sessions in person in room HP 3361** at a time decided by the class that works best with their respective schedules. In Section 12 of the course outline is a list for the topics that will be covered each week and the corresponding lectures. Students should read the necessary module material prior to attending the lecture sessions.

There will be a number of weekly “**Assignments**”. These assignments will count as the assignment grade in the final course grade. The assignments will be **available to upload through Brightspace**. The assignments will be based on material studied during the lectures during that week. See the schedule for the lectures further in this document. Be vigilant and be sure to always check the due dates for the assignments.

There will be roughly one assignment every 1 week. The assignments will be posted on BrightSpace and they will generally be due one (1) week after their distribution (or as announced in class). Assignments will be collected at the beginning of the lecture. Late assignments will not be accepted without a valid reason such as documented severe illness. You may discuss the assignment problems with other

students in this course; however, the work you turn in must be your own. Feel free to consult me if you have questions (either during office hours or by setting up an appointment). The assignments are a critical part of the course and working through the problems by yourselves is essential to absorb the material. Your solutions should be thorough, self-contained, and logical, with all steps properly motivated and explained. If not typed, the assignments must be deemed legible by the marker.

Be sure always to take careful note of the units for your answer. Typically, it is expected that the answer will follow SI units (m, s, J, etc.) however there are occasions in which non-standard units will be required for the specific question. Generally, these instances will be noted in the question itself, e.g. "Express your answer in km".

Scientific Calculators:

It is highly recommended that you use and understand the functionality of a reliable scientific calculator for all calculations in lectures, assignments, and tests. It is good practice to fully understand how to use the scientific notation functionality that all scientific calculators will have available. This will save a great deal of time in all your calculations and greatly reduces mistakes.

9. Final Exam

There is no mid-term examination. The accelerated summer term does not provide sufficient time for the delivery of the course material and a mid-term test period. If you do not perform to your own satisfaction as the term progresses, it is imperative to discuss this with your lecturer during office hours or by email. Do not leave this consultation until the end of the course. Effective intervention and assistance are best applied at the beginning of term.

The final examination will be scheduled during the regular June examination period at the end of the early summer term. It is the responsibility of the student to be present during this period; in particular, holiday travel or summer work arrangements in the exam period must not be made before the examination schedule is known.

- The final exam will be 3 hours long, to be held during the final examination period in June.
- The final exam will be closed book. Exam formats will be discussed in advance. It is expected that for all questions, the solution steps will be explained in detail following a logical outline presented at the beginning of the solution and justified using all knowledge gained during the course. This will account for half (50%) of each problem's final grade.

10. Marking Scheme

Assignments	20%
Class Participation	5%
Labs (2)	40%
Final Exam	35%
Total	100%

11. Passing Condition

In order to pass the course, students must hand in a report for **all labs**. Missing labs must be accounted for by making alternate arrangements with the Lab Supervisor. In addition, you must have:

An overall mark must be **greater than 50%**, AND

Must achieve **50% or above** on *BOTH* the Theory ($\geq 30/60$ marks) *AND* the Lab ($\geq 20/40$ marks) components of the course.

(NOTE: Theory includes Assignments, Class Participation, and the Final Exam.)

12. Course Description

In this course we will examine a variety of physics phenomena and we will interpret them through the application of the fundamental methods of non-relativistic quantum mechanics.

Most of the topics that will be covered in this course form the basis of a number of sciences such as chemistry, biology and geology and of many aspects of modern engineering as a discipline. For each topic module, one (1) to two (2) lectures on average will be dedicated which will correspond to about one-half to one week for each. The following topics will be covered:

Atomic Physics

1. The Hydrogen Atom (with a brief introduction to the Polynomial Method)
2. The Periodic Table of Elements
3. Atoms in Magnetic Fields- Spin & Nuclear Magnetic Resonance (NMR)
4. The Hydrogen Atom in a Magnetic Field, Addition of Angular Momentum, The Zeeman Effect

Molecular Physics

1. The Chemical Bond I-The Amazing Properties of the Water Molecule
2. The Chemical Bond II-The Cycle of Light (optional)

Solid State Physics

1. Theory of the Energy Bands: Conductors, Semiconductors, Insulators and Superconductivity

Solid state and Cosmology

1. Fermi Energy: Gravitational Collapse-The Life of a Star

Light & Matter

1. Interaction of Light with Matter: Stimulated Transitions-Lasers
2. Interaction of Light and Matter: Scattering-The Color of the Sky (optional)

Nuclear Physics

1. Hyperfine Structure-The Most Important Line in the Universe
2. From Discrete to Continuous: The Alpha Decay and the Age of the Earth
3. α, β, γ : Nuclear Transmutations, the Sun and the Best Energy Source we have

For these notes, Prof. Koffas has created several modules which Dr. Madej has slightly revised and added to developing the theory, results, and interpretation of various physics phenomena as an application of the methods of quantum mechanics. Many of the modules are similar in their approach to some of the widely used references in quantum mechanics and their applications. It is found that these notes provide a solid discussion on each subject with some clear statements on how these results can be interpreted and how they have made an impact on science and technology. In addition, by using the same course material subject matter, this allows the different cohorts of students to access the same background and material. In this way, all students moving on to other courses will have the same knowledge base.

One of the most important learning objectives of this course is the formation of logical deductions and the use of analytical thinking. This approach will be emphasized repeatedly during the term.

13. Suggested Reading list

(These reference texts are available on reserve at the MacOdrum library)

1. Beiser, Arthur. Concepts of Modern Physics. 2d ed. New York: McGraw-Hill, [1973: N.p., 1973. Print.
2. Yariv, Amnon. An Introduction to Theory and Applications of Quantum Mechanics. New York ;: Wiley, 1982. Print.
3. Cohen-Tannoudji, Claude et al. Quantum Mechanics. (Volumes 1 and 2) New York: Wiley, 1977. Print.
4. Tipler, Paul Allen, and Ralph A. Llewellyn. Modern Physics. 6th ed. New York: W.H. Freeman and Co., 2012. Print.
5. Wichmann, Eyvind H. Quantum Physics, Berkeley Physics Course. Volume 4 ,New York ;: McGraw-Hill, 1965. Print.
6. Herzberg, Gerhard, J. W. T. Spinks, Atomic Spectra and Atomic Structure. New York: Dover 1944. Print.
7. Anderson, Elmer E. Modern Physics and Quantum Mechanics. Philadelphia: Saunders, 1971. Print.

14. University Policies

Grade Definition:

In accordance with the Carleton University Undergraduate Calendar Regulations, the letter grades assigned in this course will have the following percentage equivalents:

A+ = 90-100 B+ = 77-79 C+ = 67-69 D+ = 57-59

A = 85-89 B = 73-76 C = 63-66 D = 53-56

A- = 80-84 B- = 70-72 C- = 60-62 D- = 50-52

F = <50

WDN = Withdrawn from the course

ABS = Student absent from final exam

DEF = Deferred

Academic Regulations, Accommodations, Plagiarism, Etc.:

University rules regarding registration, withdrawal, appealing marks, and most anything else you might need to know can be found on the university's website, here:

<http://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/>

Academic Accommodations for Students with Disabilities:

The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation.

Carleton University has launched a new academic accommodation management system, [Ventus](#). With Ventus, course instructors can view up-to-date information on their student's academic accommodation requirements and submit and manage exam booking requests with the McIntyre Exam Centre (MEC). Ventus provides students with more control over their accommodations on a per-course and per-test basis and creates an improved user experience for students and faculty with real-time data in one shared web location. Students can request and manage their academic accommodations via the [Ventus Student Portal](#). More information on using Ventus, with overviews of the student and faculty portals, can be found on [Ventus Help](#).

<https://carleton.ca/pmc/>

*The deadlines for contacting the Paul Menton Centre regarding accommodation for final exams for the Early Summer exam period is **May 26 , 2023**.

For Religious Obligations:

Students requesting academic accommodations on the basis of religious obligation should make a formal, written request to their instructors for alternate dates and/or means of satisfying academic requirements. Such requests should be made during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist, but no later than two weeks before the compulsory event.

Accommodation is to be worked out directly and on an individual basis between the student and the instructor(s) involved. Instructors will make accommodations in a way that avoids academic disadvantage to the student.

Students or instructors who have questions or want to confirm accommodation eligibility of a religious event or practice may refer to the Equity Services website for a list of holy days and Carleton's Academic Accommodation policies or may contact an Equity Services Advisor in the Equity Services Department for assistance.

carleton.ca/equity/wp-content/uploads/Student-Guide-to-AcademicAccommodation.pdf

For Pregnancy:

Pregnant students requiring academic accommodations are encouraged to contact an Equity Advisor in Equity Services to complete a letter of accommodation. The student must then make an appointment to discuss her needs with the instructor at least two weeks prior to the first academic event in which it is anticipated the accommodation will be required.

carleton.ca/equity/wp-content/uploads/Student-Guide-to-AcademicAccommodation.pdf

Academic Integrity

All work presented by a student must be her or his original work. This includes lab reports and the final exam. There will be **zero tolerance** for cheating and plagiarism. The attention of all students is directed to the Academic regulations of the University:

<https://carleton.ca/registrar/academic-integrity/>.

Examples of actions that do not adhere to Carleton's Academic Integrity Policy include:

- Plagiarism
- Accessing unauthorized sites for assignments or tests
- Unauthorized collaboration on assignment and exams

In PHYS 3606/3608 such offences will normally result in a mark of zero for the lab report or assignment, or exam in question. In addition, a report will automatically be sent to the Dean of the student's Faculty, for possible further disciplinary action.

Plagiarism:

Plagiarism is the passing off someone else's work as your own and is a serious academic offence. For the details of what constitutes plagiarism, the potential penalties and the procedures refer to the section on Instructional Offences in the Undergraduate Calendar.

What are the Penalties for Plagiarism?

A student found to have plagiarized an assignment, lab, or test may be subject to one of several penalties including: expulsion; suspension from all studies at Carleton; suspension from full-time studies; and/or a reprimand; a refusal of permission to continue or to register in a specific degree program; academic probation; award of an FNS, Fail, or an ABS.

What are the Procedures?

All allegations of plagiarism are reported to the Dean of Faculty of Science. Documentation is prepared by instructors and/or departmental chairs.

The Dean writes to the student and the University Ombudsperson about the alleged plagiarism.

The Dean reviews the allegation. If it is not resolved at this level, then it is referred to a tribunal appointed by the Senate.

Students are expected to familiarize themselves with and follow the Carleton University Student Academic Integrity Policy (see <https://carleton.ca/registrar/academic-integrity/>).

The Policy is strictly enforced and is binding on all students. Plagiarism and cheating – presenting another's ideas, arguments, words or images as your own, using unauthorized material, misrepresentation, fabricating or misrepresenting research data, unauthorized co-operation or collaboration or completing work for another student – weaken the quality of the undergraduate degree. Academic dishonesty in any form will not be tolerated. Students who infringe the Policy may be subject to one of several penalties including: expulsion; suspension from all studies at Carleton; suspension from full-time studies; a refusal of permission to continue or to register in a specific degree program; academic probation; or a grade of Failure in the course.

Assistance for Students:

Academic and Career Development Services: <https://carleton.ca/career>

Writing Services: <http://www.carleton.ca/csas/writing-services/>

Peer Assisted Study Sessions (PASS): <https://carleton.ca/csas/group-support/pass/>

Math Tutorial Centre: <https://carleton.ca/math/math-tutorial-centre/>

Science Student Success Centre: <https://sssc.carleton.ca/>

Special Information on Pandemic Measures**Special Information on Pandemic Measures**

It is important to remember that COVID is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. There are [a number of actions you can take](#) to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you're sick, washing your hands and maintaining proper respiratory and cough etiquette. **No food or drinks are permitted in any classrooms or labs.**

Feeling sick? Remaining vigilant and not attending work or school when sick or with symptoms is critically important. If you feel ill or exhibit COVID-19 symptoms do not come to class or campus. If you feel ill or exhibit symptoms while on campus or in class, please leave campus immediately. In all situations, you must follow Carleton's [symptom reporting protocols](#).

Masks: Carleton has paused the COVID-19 Mask Policy, but continues to strongly recommend masking when indoors, particularly if physical distancing cannot be maintained. It may become necessary to quickly reinstate the mask requirement if pandemic circumstances were to change.

Vaccines: Further, while proof of vaccination is no longer required to attend campus or in-person activity, it may become necessary for the University to bring back proof of vaccination requirements on short notice if the situation and public health advice changes. Students are strongly encouraged to get a full course of vaccination, including booster doses as soon as they are eligible, and submit their booster dose information

in [cuScreen](#) as soon as possible. Please note that Carleton cannot guarantee that it will be able to offer virtual or hybrid learning options for those who are unable to attend the lectures on campus.

All members of the Carleton community are required to follow requirements and guidelines regarding health and safety which may change from time to time. For the most recent information about Carleton's COVID-19 response and health and safety requirements please see the [University's COVID-19 website](#) and review the [Frequently Asked Questions \(FAQs\)](#). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca.

Please note that failure to comply with University policies and mandatory public health requirements, and endangering the safety of others are considered misconduct under the [Student Rights and Responsibilities Policy](#). Failure to comply with Carleton's COVID-19 procedures may lead to supplementary action involving Campus Safety and/or Student Affairs.

Important Information:

- Student or professor materials created for this course (including presentations and posted notes, labs, assignments, and exams) remain the intellectual property of the author(s). They are intended for personal use and may not be reproduced or redistributed without prior written consent of the author(s).
- Students must always retain a hard copy of all work that is submitted.
- Standing in a course is determined by the course instructor subject to the approval of the Faculty Dean. This means that grades submitted by the instructor may be subject to revision. No grades are final until they have been approved by the Dean.
- Carleton University is committed to protecting the privacy of those who study or work here (currently and formerly). To that end, Carleton's Privacy Office seeks to encourage the implementation of the privacy provisions of Ontario's Freedom of Information and Protection of Privacy Act (FIPPA) within the university.
- In accordance with FIPPA, please ensure all communication with staff/faculty is via your Carleton email account. To get your Carleton Email you will need to activate your MyCarletonOne account through Carleton Central. Once you have activated your MyCarletonOne account, log into the MyCarleton Portal.

Important Dates for 2022/2023 academic year:

<https://calendar.carleton.ca/academicyear/>