

# PHYSICS 481: QUANTUM MECHANICS II

Spring 2024

---

<b>Instructor:</b> David Rubin, WAT 228	<b>Time:</b> T Th 12:00–1:15
<b>Email:</b> <a href="mailto:drubin@hawaii.edu">drubin@hawaii.edu</a>	<b>Place:</b> WAT 114

Please put “PHYS 481” in the subject line!  
Please e-mail me again if I don’t get back to you within a few days.

---

**Class Format:** The current plan is to have the class in person.

**Office Hours:** T Th 1:15–1:45 at least

**Course Pages:**

- Laulima

**Textbooks:**

- Main reference: David H. McIntyre’s *Quantum Mechanics: A Paradigms Approach*
- (Recommended: David Griffith’s *Introduction to Quantum Mechanics*)

**Learning Outcomes:**

“An approximate answer to the right problem is worth a good deal more than an exact answer to an approximate problem.”

–John Tukey (possibly paraphrased)

- Physics 480 is mostly about formalism; this class is all about practical applications.
- Some relatively realistic problems will have analytic solutions (e.g., the hydrogen atom).
- Mostly, we will be using a range of approximation techniques to solve.

**Prerequisites:** Physics 480

**Grading Policy:** Homework (40%), Exam 1 (30%), Exam 2 (30%). On some occasions, I may decide that an answer goes above and beyond the question and assign extra credit for it.

**Important Dates:**

Exam 1 ..... Thursday, 29-Feb  
Exam 2 ..... Finals week, TBD

**Course Policies:**

- Homeworks are due at the beginning of the Thursday class (on weeks where we have homework due). You can upload your work electronically on Laulima, or hand it in on paper.
- It is okay to use Mathematica (etc.) for the homeworks (e.g., for integrals), but please show your work step-by-step and you are responsible for understanding what the computer is doing. Please don’t rely on Mathematica for  $\int_{-\infty}^{+\infty} x e^{-x^2} dx$  and then run out of time on the exams! It’s really better to use Mathematica to check your work than to do your work.

- Advice: learn to work together for better understanding (but don't just copy). You never really understand something until you have to explain it to someone else!
- If you are unable to turn in an assignment on time due to illness or extracurricular obligations, let me know ASAP and I'll work around it.
- To help you focus on understanding, rather than memorizing, please bring a page of notes to the exams, but they have to be your own notes.

**Approximate Course Outline:**

Day	#	Date	Topics	Assignments
Tuesday	1	9-Jan	Angular momentum operators, commutation relations	
Thursday	2	11-Jan	Angular momentum: raising/lowering operators	
Tuesday	3	16-Jan	Hydrogen atom I: solve radial equation	
Thursday	4	18-Jan	Hydrogen atom I: solve radial equation	HW 1 Due
Tuesday	5	23-Jan	Hydrogen atom II: summary. Quantum numbers and their meaning. Finding probability of a given electron radius.	
Thursday	6	25-Jan	QM Harmonic Oscillator I: Raising/lowering operators	HW 2 Due
Tuesday	7	30-Jan	QM Harmonic Oscillator II. Normalization of states, expectation values	
Thursday	8	1-Feb	When is $\langle p \rangle = 0$ ? Ehrenfest's theorem.	HW 3 Due
Tuesday	9	6-Feb	QM Harmonic Oscillator III. Proof: why/when $\langle p \rangle = 0$ . N-th order Hermite polynomials.	
Thursday	10	8-Feb	Perturbation theory I. Non-degenerate.	HW 4 Due
Tuesday	11	13-Feb	Perturbation theory II. Degenerate.	
Thursday	12	15-Feb		HW 5 Due
Tuesday	13	20-Feb	Hydrogen spectral perturbations overview. Fine structure relativistic corrections.	
Thursday	14	22-Feb	Variational Principle.	HW 6 Due
Tuesday	15	27-Feb	Ground state of helium I.	
Thursday	16	29-Feb	Exam 1	(In-Class) Exam 1
Tuesday	17	5-Mar	Ground state energy of helium II. Nuclear shielding and $Z_{eff}$ for helium.	
Thursday	18	7-Mar	Addition of angular momenta and spin orbit coupling for hydrogen. Coupled vs uncoupled basis.	HW 7 Due
Tuesday	19	12-Mar	Angular momentum and constructing spin operators.	
Thursday	20	14-Mar	Addition of angular momentum. Spin 1/2 Clebsch-Gordan coefficients.	HW 8 Due
		19-Mar	Spring Break	
		21-Mar	Spring Break	
		26-Mar	Kūhiō Day	
Thursday	21	28-Mar	Time dependent perturbation theory I	
Tuesday	22	2-Apr	Time dependent perturbation theory II. Electric dipole radiation, Selection rules.	
Thursday	23	4-Apr	Multiparticle systems. How to write a multiparticle wave function. Symmetry requirements.	HW 9 Due
Tuesday	24	9-Apr	Building multiparticle wave functions.	
Thursday	25	11-Apr	Mapping previous example onto thermodynamics notation. Combinatorics.	HW 10 Due
Tuesday	26	16-Apr	Obtain thermal Maxwell-Boltzmann distribution. Also write down Fermi-Dirac, Bose-Einstein.	
Thursday	27	18-Apr	WKB approximation I. Obtaining energy estimates for bound states.	HW 11 Due
Tuesday	28	23-Apr	WKB approximation II. Tunneling formula. Apply to alpha decay.	
Thursday	29	25-Apr	Scattering I. Classical scattering. B versus theta. Define cross section. Define differential cross section.	HW 12 Due
Tuesday	30	30-Apr	Scattering II: link differential cross section to scattering amplitude. Derive Born approximation to scattering amplitude.	
Finals Week				Exam 2

## **Course Policies and Resources**

### **Email**

As mentioned above, please include “PHYS 481” in the subject line of your email. I typically receive between 50-100 emails each day, so I’ve set up my email system to divert student emails into a particular folder that I can check daily. This system only works if you include the course number in the subject line (not in the body of the email). I will make every effort to respond to you within two business days but sometimes I get really busy or I don’t see your email. If you do not hear back from me within two business days, please check that you included “PHYS 481” in the subject line and email me again reminding me of our email. I appreciate your help on this!

All important communication between student and professor should be over email so everyone has a record. If we discuss something important in office hours, send me an email following up to document that conversation so we both remember.

### **University Policies and Procedures**

The University of Hawai'i is an equal opportunity/affirmative action institution. It is committed to a policy of nondiscrimination on the basis of race, sex, victims of domestic or sexual violence, gender identity and expression, age, religion, color, national origin, ancestry, citizenship, disability, genetic information, marital status, breastfeeding, income assignment for child support, arrest and court record (except as permissible under State law), sexual orientation, national guard absence, or status as a covered veteran. For additional details, visit the UH Systemwide Policies and Procedures Information System (PPIS) site.

### **Student Conduct**

Review the UH Systemwide Student Conduct Code for more information. Review the Online Netiquette and Privacy Tips to prepare yourself when interacting online.

### **Academic Honesty**

Acts of dishonesty, including but not limited to the following:

- Cheating, plagiarism, or other forms of academic dishonesty.

Cheating is an act of academic dishonesty and includes, but is not limited to:

1. use of any unauthorized assistance in taking quizzes, tests, or examinations;
2. use of sources beyond those authorized by the instructor in writing papers, preparing reports, solving problems, or carrying out other assignments;
3. the acquisition, without permission, of tests or other academic material belonging to a member of the UH faculty, staff or student body; and
4. engaging in any behavior specifically prohibited by a faculty member in

the course

syllabus or class discussion.

Plagiarism is also an act of academic dishonesty and includes, but is not limited to:

- the use, by paraphrase or direct quotation, of the published or unpublished work of another person without full and clear acknowledgement.
- It also includes the unacknowledged use of materials prepared by another person or agency engaged in the selling of term papers or other academic materials.
- Furnishing false information to any UH official, faculty member, or office.
- Forgery, alteration, or misuse of any UH document, record, or form of identification.

### ***Financial Aid Statement***

As you enroll in classes, it is very important to remember that colleges are required to take steps necessary to ensure that students are academically engaged in order to justify the disbursement of federal Title IV student aid funds. If students do not begin attendance in an online course, or stop participating in a course, Title IV funds must be returned according to Federal Return of Title IV funds regulations (34 CFR 668.21(a)), which means you may have to return some financial aid that you have received. If at any time your plans change and you no longer plan to participate in the courses in which you enrolled, you must contact the financial aid office to minimize any possible negative financial impact.

For more information on financial assistance for your education, please contact your home campus financial aid office. Financial assistance may include grants, scholarships and other resources to help you pay for the cost of college. A financial aid adviser will be able to help you navigate this process to determine your eligibility for these funds.

### ***UH Title IX***

- The University of Hawai'i is committed to providing a learning, working and living environment that promotes personal integrity, civility, and mutual respect and is free of all forms of sex discrimination and gender-based violence, including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence, and stalking (UH Title IX). If you or someone you know is experiencing any of these, the University has staff and resources on your campus to support and assist you.
- If you would like to report incidents of sex discrimination or gender based violence, contact your campus Title IX Coordinator or submit the online reporting form.
- If you wish to remain ANONYMOUS, speak with someone CONFIDENTIALLY, or would like to receive information and support in a CONFIDENTIAL setting, contact your campus' confidential resource.

### ***Accommodation Statement***

The University of Hawai'i is committed to a barrier-free campus and provides

accommodations to ensure students with disabilities equal access to education. We agree to make academic adjustments to ensure non-discrimination of students with disabilities. This commitment is in accordance with applicable state and federal laws, including the Americans with Disabilities Act, and Sections 504 and 508 of the Rehabilitation Act.

Under the Americans with Disabilities Act (Title II) and the Rehabilitation act of 1973- section 504 and 508, individuals with disabilities have protections against discrimination and are assured access to programs, services and activities. For more information see “Americans with Disabilities Act” and “Rehabilitation Act of 1973 – Section 504 or Section 508”.

Students must self-identify to the appropriate Disability Services Office and complete the intake process before receiving reasonable accommodations. To ensure the prompt and effective provision of accommodations, students should contact the Disability Services Office as early as possible. Find your disability services office contact for your home campus.

#### **UH Mānoa**

Visit the KOKUA website. KOKUA can be reached at (808) 956-7511 or (808) 956-7612,

#### **Additional Accommodations**

Note that if you need any other accommodations that are not specified in these policies, please let me know by email. I cannot guarantee that I will be able to accommodate you, but I would at least like the opportunity to try. This is by no means an invitation to ask to do less work simply because you want to do less work, but is intended to recognize that we live in a quickly changing world that the university bureaucracy is not always equipped to handle. I will not offer accommodations that violate university policy, so *any accommodations relating to specific categories already covered by the university should only be guided by the above guidelines and rules. In particular, if you have KOKUA accommodations, you must go through them and cannot ask me for any additional accommodations they did not first approve.*

In any communications to me requesting additional accommodations for issues not covered by the above policies, *please protect your privacy: you do not need to divulge any information you do not wish to divulge.* Particularly during the pandemic, continuing as normal is difficult. If you run into technical challenges, family care issues, ongoing illness, etc., please let me know that you are facing “a challenge” and need to request an alternative assignment. If you would like, I will schedule a Skype or zoom call with you to discuss what sort of alternative assignment might work with your needs and resources and follow up over email documenting whatever assignment we agree on.

email: kokua@hawaii.edu.