

## Syllabus: Physics 106 – Introduction to Modern Physics

**Instructor:** Dr. Alexander R. Pettitt

**E-mail:** [pettitt@csus.edu](mailto:pettitt@csus.edu)

### Class time and location

Day/time: Monday/Wednesday/Friday, 10:00 – 10:50

SQU325, or virtual lectures via Zoom when required.

If a faculty member is not available during the semester, students will be contacted and advised how the course will proceed. This may include a change in instructor or modality.

### Catalogue Description

Basic concepts of special relativity and quantum theory of matter. Phenomenological study of atomic and molecular energy states and spectra. Elements of solid-state and nuclear physics.

### Office Hours

Mon 3 - 3:50pm, Wed 11 – 11:50am, Fri 9 – 9:50am

and by appointment when necessary. Initially all office hours are virtual, but some may transition to in-person later in the semester. See Canvas for Zoom links and details.

Office hours are held in SQU414 by default, if I am not present then I will instead be holding my office hours in the physics tutor center just downstairs (SQU238).

### Contacting the Instructor

Email is the standard route to getting in contact, but messages via Canvas also works. A dedicated Slack channel will also be available for more “live” discourse.

### Online Resources

Material will be provided by two key online tools (regardless of whether class is in-person or virtual).

- Canvas will be used extensively to deliver material and be the main point of contact for messaging the class via announcements. Zoom links to any virtual classes will also be posted here.
- Perusall will be used to access reading materials and set reading assignments.
- Slack will be used as a “live” interactive discussion tool.

### Mathematics

PHYS 106 is a calculus-based overview course of modern physics, so expect mathematics to be an integral<sup>1</sup> part of the course. As such, you will require a basic scientific calculator.

### Course Commitment

This course involves lectures/discussions three times a week, but it is expected that students read and study their texts themselves in tandem to the course. The university recommends students spend twice the lecture time as private study (be it on assessments or digestion of course

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<sup>1</sup> Pun intended.

material), which means you should plan to dedicate at least 7 – 8 hours each week on this course (2.5hr on lectures + 5hr on non-lecture activities).

## Course Goals

After completing this course, you will be able to:

- Draw spacetime diagrams showing the same events in different coordinate frames.
- Use spacetime diagrams to demonstrate various relativistic effects such as time dilation, length contraction, and relativity of simultaneity.
- Apply concepts of special relativity, such as Lorentz transformations (including velocity addition), relativistic momentum, and energy through problem solving.
- Describe the various pre-quantum-mechanics models of the atom and their limitations.
- Apply concepts of quantum mechanics such as particle-wave duality, the Heisenberg uncertainty principle, wave functions, probability density, the Pauli exclusion principle, and spin.
- Identify solutions to the Schrodinger equation for example 1-dimensional potentials, such as the infinite square well potential.
- Apply the Schrodinger equation to qualitatively sketch the wavefunction for various potential energies, such as the infinite square well, finite square well, and 1-dimensional harmonic oscillator.
- Apply the principles of wave mechanics to explain quantum mechanical phenomena, such as quantum tunneling.
- Explain some of the various applications of quantum mechanics, including the model of the Hydrogen atom, as well as other examples, such as larger atoms and nuclear physics.

## Topics

The topics we will cover are as follows, split into 4 main parts. Bracketed numbers indicate the relevant chapters in the textbook.

### Part A: Special Relativity (R1-9)

The principle of relativity, different measurements of time, spacetime diagrams, length contraction and time dilation, the speed of light, relativistic momentum.

### Part C: Quantum Mechanics (Q6,7, 9-12)

Spin and the Stern Gerlach experiment, the postulates of quantum mechanics, wavefunctions, quantum models, spectra, the Schrödinger equation.

### Part B: Wave-particle Duality (Q1-5)

Wave mechanics, the particle nature of light, the wave nature of matter, early experimental evidence of quantum mechanics.

### Part D: Nuclear physics (Q13,14)

Strong and weak nuclear forces, binding energy, radiation, decay processes, sub-atomic particles.

## Classes

Time in class will be spent covering the key points, with opportunities for open discussion. Students will be set readings before class so they are prepared for the topics covered. A large aspect of class time will be spent solving problems and putting the readings into practice. Attendance is mandatory and will make up a part of the final grade. You *must* come to class prepared and be ready to put your newfound knowledge to practice.

When required by the university the instructor will offer synchronous class meetings via Zoom at our scheduled meeting time. However, the aim is to be in-person shortly after the semester starts, so we will only be virtual for a short period.

## Schedule

Week	Topic	Reading Material	Assignment
1	Basics of relativity	Chapter R1	
2	Coordinate time	Chapter R2	Homework 1
3	Spacetime and proper time	Chapters R3, R4	Homework 2
4	Coordinate time	Chapter R5	Homework 3
5	Length contraction	Chapter R6	Homework 4
6	Velocity transforms, 4-momentum	Chapter R7, R8	Homework 5
7	Momentum conservation (Exam 1 week)	Chapter R9	Exam revision
8	Summary of wave physics	Chapters Q1, Q2, Q3	Homework 6
9	Wave-particle duality	Chapters Q4, Q5	Homework 7
10	Spin	Chapter Q6	Homework 8
11	Postulates of quantum mechanics	Chapter Q7	Homework 9
12	Wavefunctions	Chapter Q9, Q10	Homework 10
13	Atomic spectra (Exam 2 week)	Chapter Q11	Exam revision
14	Schrödinger equation	Chapter Q12	Homework 11
15	Nuclear physics	Chapters Q13, Q14	Homework 12
Finals	<b>Comprehensive Final Exam</b>		

## Important Dates

Some useful dates to keep in mind. Please note examination dates are tentative as of writing but will be confirmed several weeks in advance.

Mon. Jan 23 <sup>rd</sup>	– First class	Fri. April 21 <sup>th</sup>	– Exam 2 ( <i>tentative</i> )
Fri. Mar 3 <sup>rd</sup>	– Exam 1 ( <i>tentative</i> )	Fri. May 12 <sup>th</sup>	– Last class
March 20 <sup>th</sup> – 24 <sup>th</sup>	– Spring recess	Tues. May 16 <sup>th</sup>	– Final Exam, 8:00-10:00
Fri. March 31 <sup>st</sup>	– No class (C Chavez)		

## Required Material

- Access to a computer with a web-browser.
- Access to the internet, for out-of-class activities, readings, and virtual lectures as needed.
- Access to the *Six Ideas* textbook via Perusall.
- A scientific calculator. Note graphical calculators are not allowed in exams.

## Textbooks

It is essential you have access to the course textbook virtually via Perusall. A hard-copy is not required. Several other textbooks make suitable additional reading if required. See the list below for details and suggestions:

- *Six Ideas that Shaped Physics: Units R + Q*, Moore. **\*REQUIRED\***  
Units R and Q are two short separate textbooks on relativity and quantum mechanics, respectively. They are relatively cheap when purchased on Perusall for a subscription lasting the course. Details will be given in the first lecture of the course.
- *Modern Physics*, Taylor, Zafiratos & Dubson.  
A more traditionally structured textbook. Goes into a little more detail on some subjects than we will, but is a good supplementary text.
- *Physics: A Strategic Approach*, Knight.  
A standard undergrad physics text, with several chapters on our topics of focus (Part VII). Makes an OK source of additional questions but ultimately too low-level for our purposes. Note this can be said of any number of equally suitable entry-level physics texts (e.g. Tipler, Halliday & Resnik, Young & Freedman).

## Pre-class assignments

Pre-class assignments will be delivered via the online tool Perusall: <https://perusall.com>, which will be linked to the Canvas course. Students will need to read the assigned material and comment on any items they do not understand, or comment on other students' questions. How to access Perusall and the method of assessment will be explained early in the course.

## Participation

Taking an active part in class is paramount to getting the most out of this course. At the start each student is automatically given the maximum grade for this segment (15%). If you interact with the class (implying turning up!), do the problems and interact with your fellow students you will maintain this score. Not doing so, or giving me adequate reason for not awarding full marks (such as skipping several classes without reason) will result in this score decreasing. This component will not be measured for the first couple of weeks, allowing students a little bit of "settling in" time.

## Homework

Problems will be assigned to work on at home periodically (roughly once a week) to be handed in the following week. Students are permitted to work together, but note that answers handed in should be in the student's own words and style. The instructor takes plagiarism extremely seriously and will not hesitate to take this to a higher level if they believe blind copying has taken place. At the very least, cheating on homework will ultimately mean students do not understand the material and will perform poorly on exams.

## Exams

There will be three exams in this course, see “Important Dates” above. Two in-semester exams will take place during lectures. All exams are closed book, but a single note card will be allowed. We then have a final exam that covers the entire semester’s material, occurring in “finals week”. Make-up exams will be given only in the most extraneous of circumstances with proof provided of their necessity, and only by prior arrangement.

## Course Grade

Your course grade is determined by the points you earn during the semester in each of the following categories:

Pre/post-class activities:	15%
Participation:	15%
Homework:	20%
Exam 1:	15%
Exam 2:	15%
<u>Final Exam:</u>	<u>20%</u>
<b>Total:</b>	<b>100%</b>

Students are advised *not to assume extra credit will be offered in any form during this class*. Grades will be assigned based upon a traditional grading scale:

≥ 95 %	A	≥ 77 %	B –	≥ 62%	D +
≥ 90%	A –	≥ 73 %	C +	≥ 58%	D
≥ 87 %	B +	≥ 69 %	C	≥ 55%	D –
≥ 82 %	B	≥ 66 %	C –	below 55 %	F

## Canvas

Please check announcements via email and Canvas *frequently*. Please set your Canvas announcements to automatically send you a message when an announcement has been posted. I will post details of exams, homework, lecture material etc., please don’t ignore it!

## Course Etiquette and Questions

Questions are valid at any time during a class, and are also welcome via the discussion board in Canvas or Slack. If you are unsure of something the instructor has just said, there is a very good chance that someone else is unsure as well, so help your fellow classmates by asking a question. Questions during virtual classes can be posted into the Zoom chat window or asked by unmuting your microphone and asking out loud (“excuse me Professor”) but it’s polite to use the *raise hand* option initially.

## COVID: Safety and wellness

You should be aware by now of Sacramento State’s Fall 2022 COVID 19 policies. You can find out more at Sacramento State’s [COVID-19 page](#). We will be following those policies in this classroom. Vaccines are required for everyone on campus except those who have been granted a religious or medical exemption per the [CSU’s COVID-19 vaccination requirement](#). Masks are not required at this point but are recommended indoors. Please respect your fellow students’ decision to mask or not mask. You can schedule a vaccine at [My Turn California](#) and find out more about vaccines and booster eligibility on the [CDC website](#). Remember that COVID-19 is still a threat, even for those who are vaccinated and boosted. Please practice self-care, monitor

your health for any possible symptoms of COVID-19, and contact a health care provider immediately should you believe you may be infected.

### **COVID: Attendance**

Do not come to class if you have COVID-19 symptoms or test positive. COVID-19 tests and safety supplies are available at many locations around campus, including the library and student union. The University will continue to offer free testing to students who are symptomatic through [Student Health and Counseling Services](#). To increase safety on campus, you are required to report a positive COVID-19 test. You will find a confidential reporting form on the [Student Affairs COVID-19 web page](#). Everyone who tests positive, regardless of vaccination status, is required to stay home for at least 5 days. You should stay home for up to 10 days if your symptoms are not resolved or you continue to test positive. If you come into contact with someone who has tested positive for COVID-19, please refer to this [flowchart](#). If you need to isolate, please notify me immediately.

- If you are isolating and not ill, I expect you to stay up to date with your academic work remotely as best you can. Checking in with me for assignments will be your responsibility.
- If you are ill, please contact me as soon as you are well so we can work together to catch you up with the rest of the class.
- You will find the latest updates to academic continuity during COVID-19 [here](#).

### **COVID: Flexibility**

The degree to which COVID-19 will impact the Sacramento State campus this fall is hard to predict. We want to focus on making your time as a Hornet a memorable and fulfilling experience. But patience and flexibility on all our parts will still be necessary as we navigate COVID-19 -related absences. Communicating with me in a clear and timely manner will help you stay on track academically and help all of us stay healthy.

### **Code of Conduct**

The Department of Physics and Astronomy has unanimously approved the following statement: “The faculty of the Department of Physics and Astronomy will not tolerate academic dishonesty. Falsification of data, copying, unauthorized collaboration, plagiarism, alteration of graded materials, or other actions (as described in, but not necessarily limited to the Sacramento State Policy Manual) *will be promptly reported to the Office of Student Affairs*. The offending student will be penalized on the assignment in question. Serious infractions will result in course failure and a recommendation for administrative sanctions.”

### **Netiquette**

Given that this class is partially online, it is important that we keep in mind the importance of some basic guidelines for participating in online discussion forums. You can find more info about this in our Canvas course. In short, it is very important to be clear in your messages, avoid potentially offensive comments, and generally reread your messages before posting to make sure they say what you meant to convey. You can also find more information here:

<http://www.albion.com/netiquette/corerules.html>.

### **Students with Disabilities (SSWD)**

Sacramento State is committed to ensuring an accessible learning environment where course or instructional content are usable by all students and faculty. If you believe that you require disability-related academic adjustments for this class (including pregnancy-related disabilities),

please immediately contact Services for Students with Disabilities (SSWD) to discuss eligibility. A current accommodation letter from SSWD is required before any modifications, above and beyond what is otherwise available for all other students in this class will be provided. Please be advised that disability-related academic adjustments are not retroactive. SSWD is located on the first floor of Lassen Hall 1008. Phone is 916-278-6955 and e-mail is [sswd@csus.edu](mailto:sswd@csus.edu). For a complete listing of services and current business hours visit <https://www.csus.edu/student-affairs/centers-programs/services-students-disabilities/>.

### **Basic Needs Support (CARES)**

If you are experiencing challenges with food, housing, financial or other unique circumstances that are impacting your education, help is just a phone call or email away. The CARES office provides case management support for any enrolled student. Email the CARES office at [cares@csus.edu](mailto:cares@csus.edu) to speak with a case manager about the resources available to you. See the CARES website for more information: <https://www.csus.edu/student-affairs/crisis-assistance-resource-education-support/>.

### **Student Health & Counseling Services (SHCS)**

Your physical and mental health are important to your success as a college student. Student Health and Counseling Services (SHCS) in The WELL offers medical, counseling, and wellness services to help you get and stay healthy during your time at Sac State. Asking for support sooner rather than later is often helpful. SHCS offers: Primary Care medical services, including sexual and reproductive healthcare, transgender care, and immunizations; urgent care for acute illness, injuries, and urgent counseling needs; pharmacy for prescriptions and over-the-counter products; mental health counseling, including individual sessions, group counseling, support groups, mindfulness training, and peer counseling; athletic training for sports injury rehabilitation; wellness services, including nutrition counseling, peerled health education and wellness workshops, and free safer sex supplies; violence and sexual assault support services. Call (916) 278-6461 and visit their website at <https://www.csus.edu/shcs/>. Most services are covered by the Health Services fee and available at no additional cost. A number of services are offered using secure remote technology if students are off-campus. If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night: 1-800-273-TALK (8255) to speak with a nurse or call 911.

### **Gender Violence Resources**

CSUS is committed to providing an environment free of all forms of discrimination and sexual harassment, including sexual assault, domestic and dating violence, and genderbased stalking. If you (or someone you know) has experienced or experiences genderbased violence (intimate partner violence, attempted or completed sexual assault, harassment, coercion, stalking, etc.), know that you are not alone. CSUS has staff members trained to support survivors in navigating campus life, accessing health and counseling services, providing academic and housing accommodations, helping with legal protective orders, and more. Please visit <https://www.csus.edu/student-affairs/crisis-assistance-resource-education-support/>.

The University requires faculty and staff to report any personal disclosures of sexual misconduct including rape, dating/domestic violence and stalking to the Title IX Coordinator. Students who do not wish to report their experience to me or the Title IX Coordinator may speak to someone confidentially by contacting Student Health and Counseling Services.

## University Standards and Procedures

- This course is subject to the university's usual ADD/DROP policy, detailed here: [Drop and Withdrawal Policy](#).
- This course uses the university's standard grade terminology, detailed here: [Grading Policy](#).

## Links to Other Campus Resources

- [Academic Advising](#)
- [Information Resources and Technology](#)
- [Support Centers and Programs](#)
- [Reading & Writing Center](#)
- [Student Rights and Responsibilities](#)

## Course FAQ

- *I was sick/overworked/absent last week, can I have a "do-over" on the homework?*  
Not in the strict sense, no. As solutions to homework are normally released soon after the submission deadline it is impossible to give extensions on a case-by-case basis. However, life often gets in the way of things, and instructors can usually offer some kind of accommodation, e.g. dropping the HW from that student's grade or offering some other substitute (if the accommodation is well-justified).
- *What is the late HW policy for the course?*  
There is no strict late HW policy (e.g. 1 day late = X% drop). See the answer above.
- *Where can I see my current grade for the course?*  
There is no single place to see a student's current grade. Canvas does keep scores for individual assessments (if the instructor utilizes this feature), but the weighting for the grade "total" may not be indicative of the actual total grade. This depends on the instructor who may apply their own unique policies for grading that may be done outside of Canvas, such as dropping lowest scoring HW. It is, however, common to inform students of their grades after midterms as a "sit-rep".
- *I really need this class for graduation, can I have a "grade bump" to a pass?*  
No. Individual requests like this violate academic integrity and amount to asking for special favors. It is not equitable, and bases grades on something other than the student's demonstrated level of performance. Instead, the student should seek help early as the instructor is normally more than happy to oblige and can give advice/extra assistance where needed. Requests like the above often come in far too late to be actionable.

*Note: the instructor reserves the right to update the syllabus and schedule during the semester.*