**PHYS 2320: Physics IV – Modern Physics term: S25** CRN 20299

**General Information**

**Instructors:** R Michalak PS 215 email: rudim@uwyo.edu

**TAs** Discussion TA Rachel Wood tbd rbower2@uwyo.edu

Grader Rachel Wood tbd rbower2@uwyo.edu

**Office hours**: W 1200-100 pm, R 1000-1130, or by appointment

**Course webpage**: [www.physics.uwyo.edu/~rudim](http://www.physics.uwyo.edu/~rudim)

**Lecture**: MWF 110 - 200 pm, CR 105

**Required Text:** ‘Modern Physics for Scientists and Engineers’ 2nd edition, Taylor/Zafiratos

Recommended text:

‘Atomic Physics’, Max Born available as a free download on archive.org or as a 20$ reprint by Dover Books.

**Course pre-requisite**: Phys 1220. In order to make the course accessible as an elective for the largest possible number of students, we have kept the pre-requisite low. That said, you should expect that math and physics beyond the formal expectation is used sparingly. All of physics is inter-connected, and all of math is going to be used in physics at some point or another. Generally, our course is more concept heavy than math intensive, but there are a few exceptions.

Whenever we will reach a cross road of math that you may not know, I will try to ease you into any material that the average student has not yet mastered. It is perfectly fine to carry any remedial questions into office hours. It is not a bother when students come by with questions about the material.

*All following information is tentative and subject to revision at my discretion. Any changes will be announced during lecture and will be made to keep the class average on course. It is your responsibility to keep up to date with such announcements:*

**Course Content:**

This course is an introduction to modern physics.

We cover the fields of Relativity, basic Quantum Mechanics, Atomic and Nuclear Physics. Time permitting we will look into the fundamental concepts of Statistical Mechanics, Solid State Physics, and Particle Physics (sub-nuclear), leading to the Standard Model of Physics.

Key concepts/Learning Goals:

Appreciating the differences between classical and modern physics and between various

Space, time, mass in modern terms

Overview and interconnection of modern physics models

Inertial Frames of Reference and Lorentz Transformation, Simultaneity, Space-time

Michelson-Morley Experiment, Young double-slit Interference Experiment

Mass/Energy Relation

Dynamics in Relativity

Photoelectric Effect, Millikan, Rutherford, Compton, Franck-Hertz, and Thomson e/m

etc. landmark experiments

Quantization of Light and Atomic Energy Levels, the Hydrogen Atom

Wave Nature of Matter, de Broglie waves, and Uncertainty Relation

Schroedinger Equation

Spin and Angular Momentum of Elementary Particles

Zeeman Effect, Pauli Principle

How to create the Periodic Table of Elements

Nuclear models

Nuclear decay law, half-life time

Radioactivity and radiation penetration into matter

Optional: Geometry and General Relativity

Atomic Nature of Matter

The Particle Zoo & the Standard Model of Physics

Quarks and Quantum-Chromodynamics: a qualitative first introduction

Maxwell-Boltzmann Distribution vs. Quantum Statistics

Electrons in Metals and Semiconductors

Band Theory of Solids

**Lecture**

The lecture will roughly follow the required book. Some chapters will be left out and others will be expanded on beyond what the books present. Thus, taking lecture notes is important. Announcements pertaining to the course will be made in lecture. If you cannot attend any particular lecture, make sure to catch up with your peers on announcements that have been made.

This term, I have decided to offer a recommended text in addition to a standard textbook. The additional text is comparatively cheap and it has been written by a scientist who was eminent in the field when it was new. I hope that you will find, too, that no one can tell a story better than someone who has lived through it! This author knew why work was done and why it was done in a certain sequence or with certain methods and his writing reflects it. The author describes developments in Relativity, Atomic, and Nuclear Physics as they interrelate and motivate each other. That cannot be found in a standard textbook. The recommended text will serve you for a variety of upper level physics courses (Quantum Mechanics, StatMech, Solid State); so hold on to it.

In lecture, I plan to build on some pre-reading that you will have done before lecture. Check the tentative schedule at the end of the syllabus for what is up next and the detailed chapter reference for each text, and come prepared enough so that we can deal with the more complicated aspects of a topic in lecture, and can lead you to your post-reading, which must be done with these difficult concepts to get a lasting understanding.

I show a variety of video excerpts during lecture time, especially for the Relativity topic. You find them on youtube, marked as ‘Annenberg’ and you can review these at home in your own time if you want. I will only use parts of the videos in lecture.

Let’s not forget the most important aspect of our course: For a physics and astronomy major this should be pure fun! It is the stuff that made you want to become one of us in the first place! No more boxes sliding down inclines – let’s find out about the more interesting things!

And if you are taking this course as an elective in your major, let us find out whether a double major in physics can possibly interest you – this course will definitely tell you! Try to keep an open mind when I will tell you that mass is not mass, space is not space, and time is not time; at least not in the way how our trusty Newtonian Mechanics and Maxwellian Electromagnetism have always told us. And while we’re at it: Let’s convince ourselves why those older fields are not completely obsolete either. We just need to find out when thy can be used and when not.

***How advanced physics courses are different from what you are used to:***

In physics, we are at least as interested in the evaluation of core conceptual questions, and the evaluation of landmark experiments and their consequences for theory, as we are interested in solving numerical problems. And we do also hold stakes in our students being able to derive why certain equations hold true and to discuss the range of validity for which they are true. This lecture and the tasks I will set in hw and exam will reflect that interest. There will be certain points, especially in Relativity and in the basic Quantum Mechanics of the hydrogen atom, where this will ring particularly true.

**Grading**

Details of grading (subject to revision):

Exams: 3 63 %

Homework: 7 28 %

Kritik: peer eval mini essays 9 9 %

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100%

**Scale:**

A > 90.0% GPA 4.0

B > 80.0% 3.0

C > 70.0% 2.0

D > 60.0% 1.0

F < 60% 0.0

*How to calculate your overall GPA change after a class: find total credit hours before class times old GPA; find our course’s new GPA contribution by multiplying course credit hours times letter grade GPA (say you get an A, then add 3credit hours\*4GPA = 16 to the old total, then divide by new total credit hours). Say you had GPA old 2.85 and 65 credit hours before: 2.85\*65 = 185.25, plus 16 🡪 201.25, /(65+3)🡪 2.96 new GPA*

I reserve the right to curve the exams and the final grade.

**Discussion**

I have acquired special department funds to offer a discussion section, which is to be scheduled on the first day of class. It will be led by an undergraduate TA and will run for a regular 50 minutes once a week.

**Exams**

The exams will contain both quantitative and conceptual problems. The exams will be closed book and closed notes. I will provide certain formulas, but will expect that you can derive certain others from them.

Expect to find questions about landmark experiments and conceptual aspects of the material in the exams.

None of the grades will be dropped or replaced. The exams will be held at the following times and cover the following topics:

Exam 1 – midterm 1 R 3/6 500 pm *tba topics: Relativity, Atomic Physics*

Exam 2 – midterm 2 R 4/10 500 pm *tba* *topics: Atomic, preQ, Quantum*

Exam 3 – final F 5/16 115 pm CR105 *topics: cumulative*

**Homework** (hereafter hw)

A typical hw will consist of six to eight problems. Students are not allowed to work in hw groups and hand in their own solution. Students are allowed to consult other students *for the method how to solve* a hw problem but not to solicit the actual solution. See below for comments on AI use in hw.

***All hw*** ***and exam*** problems will require a certain amount of explanation or discussion of the result, even when not explicitly stated in the problem. In particular, you are expected to explain what the result actually means as that is not always obvious in Modern Physics.

***The deadlines*** are indicated ***for each homework*** in the tentative schedule below. To receive full credit, your homework must be complete, correct, legible, on time, and the logic must be easy to follow.

***Late penalty:*** Incomplete work will receive reduced credit. A penalty of 10% per 12 hours late applies, if homework is turned in after the deadline. The late penalty stays at 30% after 36 hours. Late hw is accepted not later than the week before dead week. After this extended deadline, no late submissions will be accepted.

**Kritik Peer Review Platform**

*Much of the information you will be exposed to in our course needs some digesting, especially if you had not known about the ideas of modern physics before this course. To facilitate your direct and repeated engagement with these new ideas (and sometimes they are positively weird and confusing!), I set up the Kritik platform. Unlike last term, I will experiment more with different task types to help you find ways to enjoy the experience. For this course, a variety of task types seems appropriate.*

This term, we will be using Kritik ([www.kritik.io](http://www.kritik.io)), a peer-to-peer learning and evaluation platform. Kritik puts you, the student, at the center of your learning. Kritik is focused on an important goal: to help you in developing critical thinking and communication skills, which in turn set you up for success both in and out of the classroom. AI use is not allowed for the Kritik work.

#### Each Kritik activity has three unique stages:

Stage 1: Create → Follow the instructions, read the provided rubric and create a submission

Stage 2: Evaluate → Anonymously score your peers based on the rubric, and provide constructive written comments

Stage 3: Feedback → Provide your peer evaluators anonymous feedback in relation to how motivational and critical/helpful their written comments were

Based on my experience with Kritik last term, I want to give you a pointer: Students tend to lose points by missing some of the frequent deadlines because of the three-stage process. Create a system that reminds you in good time of pending deadlines.

The overall process simulates what working in teams in industry and academia is like and, as such, is good, welcome practice.

#### Registration/Support

An email invitation will be sent to your **school email account** that contains information on how to register for a Kritik account and enroll in the course. You should see Kritik integrated into your Wyocourse platform.

**How to get help:** If you have any questions about Kritik, please use **their live chat** first. A human agent will respond promptly within a few minutes from 9am-5pm eastern time Monday to Friday. Outside of these hours, you’ll receive a reply that Kritik will be back the next business day - but don’t worry! They monitor around the clock and will still respond to urgent requests within a few hours. You can also visit <https://help.kritik.io> to view their help articles.

**Substantive changes to syllabus**:

*All deadlines, requirements, and course structure are subject to change if deemed necessary by the instructor. Students will be notified verbally in class, on our WyoCourses page announcement, and via email of these changes.*

***General Syllabus Content (as per Academic Affairs Syllabus Template 11/25/24)***

The cursive parts are from the default document. Non-cursive information is my addition within the sections.

**Classroom Behavior Policy:**

*At all times, treat your presence in the classroom and your enrollment in this course as you would a job. Act professionally, arrive on time, pay attention, complete your work in a timely and professional manner, and treat all deadlines seriously. You will be respectful towards your classmates and instructor. Spirited debate and disagreement are to be expected in any classroom and all views will be heard fully, but at all times we will behave civilly and with respect towards one another. Personal attacks, offensive language, name-calling, and dismissive gestures are not warranted in a learning atmosphere. As the instructor, I have the right to dismiss you from the classroom, study sessions, electronic forums, and other areas where disruptive behavior occurs.*

*Electronic devices such as mobile phones should be set to silent and not answered during class. Laptops are allowed for note-taking purposes; those who require laptops for accommodation of disabilities, work with Disability Support Services and me to accommodate your needs. No unauthorized video or audio recording during class is allowed to protect the privacy of your fellow students; for those who require recording for accommodation of disabilities, work with Disability Support Services and me to accommodate your needs.*

**AI Technology**

*AI is an emergent technology* and one can expect that your future employers will require that you will be versatile with it*.* While it is possible that your learning is affected by its use if you supplement AI work for your work, it is also possible that there can be beneficial effects if you exercise higher thinking skills in integrating the AI material into your own work. Note though that during exams you will not be able to use AI and that you want to be able to do the tasks asked for in homework yourself.

Therefore, students are permitted to use advanced automated artificial intelligence or machine learning tools on homework assignments in this course; however, special documentation and citation is required for each instant. What we will grade is what you did with the AI work, not what the AI work stated. Be advised that AI is still an emergent technology and it is known that it does not always get science assignments right. It is your responsibility to check the work of AI and to quote and cite it properly so that it is clear which part of the submitted work is yours.

**Classroom Statement on Diversity:**

*The University of Wyoming values an educational environment that supports students of all backgrounds and viewpoints. Diversity of viewpoints is considered a resource for learning. Topics may be difficult, not only intellectually but emotionally; however, discussions are essential to meeting the course’s student learning outcomes and assisting students in developing problem-solving and critical-thinking skills. During all conversations, respect and civility are of utmost importance.*

**Disability Support**:

*The University of Wyoming is committed to providing equitable access to learning opportunities for all students. If you have a disability, including but not limited to physical, learning, sensory or psychological disabilities, and would like to request accommodation in this course due to your disability, please register with and provide documentation of your disability as soon as possible to Disability Support Services (DSS), Room 128 Knight Hall. You may also contact DSS at (307) 766-3073 or* [*udss@uwyo.edu.*](mailto:udss@uwyo.edu) *It is in the student’s best interest to request accommodation within the first week of classes, understanding that accommodations are not retroactive. Visit the DSS website for more information* *at:* [*www.uwyo.edu/udss*](http://www.uwyo.edu/udss)*”*

It is my understanding that all[reasonable accommodations are provided by](https://www.uwyo.edu/udss/accommodations/academic-accommodations.html) [University Disability Support Services.](http://www.uwyo.edu/udss/information-for-faculty-and-staff/sample-syllabus-statement.html) Please let me know if you run into any difficulties.

**Academic Dishonesty Policies**

In short: Don’t cheat. In the long run you are only hurting your chances at succeeding in college because courses tend to build onto each other. Finally, cheating is of course dishonorable behavior.

*Academic dishonesty will not be tolerated in this class. Cases of academic dishonesty will be treated in accordance with UW Regulation 2-114. The penalties for academic dishonesty can include, at my discretion, an “F” on an exam, an “F” on the class component exercise, and/or an “F” in the entire course. Academic dishonesty means anything that represents someone else’s ideas as your own without attribution. It is intellectual theft – stealing - and includes (but is not limited to) unapproved assistance on examinations, plagiarism (use of any amount of another person’s writings, blog posts, publications, and other materials without attributing that material to that person with citations), or fabrication of referenced information. Facilitation of another person’s academic dishonesty is also considered academic dishonesty and will be treated identically. The use of AI is regulated as stated above. Misrepresenting AI work as your hw work by not quoting and citing it properly will be treated as academic dishonesty.*

**Duty to Report**

*While I want you to feel comfortable coming to me with issues you may be struggling with or concerns you may be having, please be aware that I have some reporting requirements that are part of my job requirements at UW.*

*For example, if you inform me of an issue of sexual harassment, sexual assault, or discrimination I will keep the information as private as I can, but I am required to bring it to the attention of the institution’s Title IX Coordinator. If you would like to talk to those offices directly, you can contact Equal Opportunity Report and Response (Bureau of Mines Room 319, 766-5200,* [*report-it@uwyo.edu,*](mailto:report-it@uwyo.edu) [*www.uwyo.edu/reportit*](http://www.uwyo.edu/reportit)*). Additionally, you can also report incidents or complaints to the UW Police Department. You can also get support from the Dean of Students, 766-3296,* [*www.uwyo.edu/dos*](http://www.uwyo.edu/dos)*, or at the or SAFE Project (*[*www.safeproject.org,*](http://www.safeproject.org/) [*campus@safeproject.org,*](mailto:campus@safeproject.org) *24-Hour hotline: 745-3556).*

*Another common example is if you are struggling with an issue that may be traumatic or unusual stress. I will likely inform the Dean of Students Office or Counseling Center. If you would like to reach out directly to them for assistance, you can contact them using the info below or going to* [*www.uwyo.edu/dos/uwyocares.*](https://www.uwyo.edu/dos/students-concern/index.html)

*Finally, know that if, for some reason, our interaction involves disruptive behavior or potential violation of policy, I inform the Dean of Students, even when you and I may have reached an informal resolution to the incident. The purpose of this is to keep the Dean apprised of any behaviors and what was done to resolve them.*

**Green Dot Program at UW:**

*Here at The University of Wyoming, we are committed to reducing and preventing power-based personal violence such as sexual assault, relationship violence, and stalking. Green Dot is a bystander intervention program to reduce these forms of violence with one thought; If everyone does one thing, no one will have to do everything. A Green Dot is your choice at any moment to make campus safer by promoting safety for everyone and letting others know that you will not tolerate violence. A Green Dot is any behavior, choice, word or attitude that sends a clear message that:*

*1. Violence is not okay with you, and*

*2. Everyone is expected to do their part.*

*Additional information on Green DOT training and resources are available at:*

[*http://www.uwyo.edu/greendot/*](http://www.uwyo.edu/greendot/)

**Student Resources:**

*DISABILITY SUPPORT SERVICES:* [*udss@uwyo.edu,*](mailto:udss@uwyo.edu) *766-3073, 128 Knight Hall,* [*www.uwyo.edu/udss*](http://www.uwyo.edu/udss) *COUNSELING CENTER:* [*uccstaff@uwyo.edu,*](mailto:uccstaff@uwyo.edu) *766-2187, 766-8989 (After hours), 341 Knight Hall,* [*www.uwyo.edu/ucc*](http://www.uwyo.edu/ucc)

*ACADEMIC AFFAIRS: 766-4286, 312 Old Main,* [*www.uwyo.edu/acadaffairs*](http://www.uwyo.edu/acadaffairs)

*DEAN OF STUDENTS OFFICE:* [*dos@uwyo.edu,*](mailto:dos@uwyo.edu) *766-3296, 128 Knight Hall,* [*www.uwyo.edu/dos*](http://www.uwyo.edu/dos) *UW POLICE DEPARTMENT:* [*uwpd@uwyo.edu,*](mailto:uwpd@uwyo.edu) *766-5179, 1426 E Flint St,* [*www.uwyo.edu/uwpd*](http://www.uwyo.edu/uwpd) *STUDENT CODE OF CONDUCT WEBSITE:* [*www.uwyo.edu/dos/conduct*](http://www.uwyo.edu/dos/conduct)

*UW TUTORING RESOURCES:* [*https://www.uwyo.edu/step/index.html*](https://www.uwyo.edu/step/index.html)

**Tentative Class Schedule Spring 2025 – 2320**

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| --- | --- | --- | --- | --- |
| **Week** | **M** | **W** | **F** | **Notes** |
| 1 Jan 20 – Jan 24 | Intro  Summary  Class Phys | R1 | R2 | *Offset by one week to 4210*  *Kritik 1* |
| 2 Jan 27 – Jan 31 | R3 | R4 | R5 | 1/27 last add 1/30 last drop  **voluntary disc. start this week**  Homework #1: due 2/2 |
| 3 Feb 3 – Feb 7 | R6 | R7 | R8 | *Kritik 2* |
| 4 Feb 10 – Feb 14 | R9 | R10 | R11 | Homework #2: due 2/16 |
| 5 Feb 17 – Feb 21 | --- | A1 | A2 | 2/17 sem. break  *Kritik 3* |
| 6 Feb 24 – Feb 28 | A3 | A4 | A5 | Homework #3: due 2/24 |
| 7 Mar 3 – Mar 7 | pQ1 | pQ2 | pQ3 | **Exam 1 *R 3/6 5pm***  *Mid semester: Mar 9 (grades due: 24th)**3/3 summer reg**Kritik 4* |
| 8 Mar 10 – Mar 14 | Q1 | Q2 | Q3 | *3/10 advsg period*  Homework #4: due 3/15 |
| 9 Mar 17 – Mar 21 | - | - | - | ***Spring break*** *APS March Meeting 16th-21st* |
| 10 Mar 24– Mar 28 | Q4 | Q5 | Q6 | *3/27 midterm grades due 3/24 Fall enroll. Starts*  *Kritik 5* |
| 11 Mar 31 – Apr4 | Q7 | Q8 | N1 | Homework #5: due 4/6  *Advising week – get your Perc*  *Last day of ind withdr.: 2nd* |
| 12 Apr 7 – Apr 11 | N2 | N3 | N4 | **Exam 2 *R Apr 10 5pm***  *Kritik 6* |
| 13 Apr 14 – Apr18 | N5 | N6 | --- | Homework #6: due 4/20  4/18 sem. break  *All School Withdr. last 4/25* |
| 14 Apr 21 – Apr 25 | Stat1\* | Stat2\* | Stat3\* | *From L36 onward we are going rather fast to cover at least an overview of subjects, which apply to later courses*  *Kritik 7* |
| 15 Apr 28 – May 2 | Sol1\* | Sol2\* | GR1 | *Homework #7: due 4/30* |
| 16 May 5 – May 9 | GR2 | Sub1 | Sub2 | *Dead week: last day of classes 9th*  *Kritik 8* |
| Finals week  May 12 – May 16 |  |  | 115-315  Grades due 5/22 | *Final exams are in the regular classroom unless otherwise announced.*  *Kritik 9: final course eval, due Saturday after final exams* |

R - Special Relativity 11 lectures A – Atomic Physics 5 lectures

pQ- pre Quantum 3 lectures Q – Quantum Mechanics primer 8 lectures

N – Nuclear Physics 6 lectures Stat – Statistical Mechanics 3 lectures

Sol – Solid State Physics 2 lectures GR – General Relativity 2 lectures

Sub – Subatomic Physics 2 lectures \* marks lectures I may leave out if class falls behind

**14M 15W 14F= 43**

**Tentative material list per lecture:** with future relevance commentary for majors

still needs review

Text reference: T = Taylor, B = Born , F French (see course webpage – not Wyocourses)

Intro T 1.1-1.4 review classical physics, Space-Time-Mass

R1 T 1.5-1.6 suppl: B: very dense overview app. V

R2 T 1.7-1.9

R3 spacetime diagrams , skateboard videos

R4 suppl: F chapter 3, p.74-82 rel: foundational for laws transferring to atomic etc.

R5 T1.10-1.12 proof of time dilation, meson video

R6 clocks, light-clock video

R7 T 1.13-1.14 velocity addition formula

R8 T 2.1-2.2 mass in Relativity

suppl: F chapter 1 p.16-29 rel: radioactive decay, nuclear processes

R9 T 2.3 space billiard suppl: F p.167- 176 rel: atomic and nuclear experiments

R10 T 2.4 E = mc2

R11 T 2.7 forces and accelerations suppl: F p.214-219

Leave basics of the atom to student reading, B 1.1-5

A1 T 3.9 Overview atomic physics, Brownian

suppl: B1.5-8, app.IV, B 2.1, 2.3, 4.1, p.167+171

A2 T 3.10 Thomson e/m

A3 T 3.11 Millikan

A4 T 4.1-4.3 Photoelectric Effect, Blackbody Radiation suppl: B4.2, B8.8, B 7.1+3, app.

XXVIII

A5 T 4.4-4.6 Compton Effect, suppl: B 4.4, app. X, 4.5-7

pQ1 T 4.4-4.5 x-rays, Bremsstrahlung, pair creation/annihilation, wave – particle duality,

pQ2 T6.1-6.5 Matter waves I,

pQ3 T 6.6-6.9 Matter waves II, basic quantum language, suppl: B 4.1, 4.5-7, 5.4 w/o the math

Q1 T 5.2-5.5 Bohr model basics, Quantization of the atom, suppl: B 4.3, B 4.3, 5.1

Q2 T 5.6-5.8 Bohr model details, suppl: B 5.2, app. XIV

Q3 T 7.1-8 (in excerpts) examples of quantum wells, B 5.4 with math ,app. XVI, XXV (for a taste)

Q4 T 7.9-11 Schrodinger eqn, B see above, app. XVIII

Q5 T 8.1-5 toward 3-dim wells, B 5.5, app. XIX

Q6 T 8.6-10 angular momentum, hydrogen atom, atomic shells, B 5.7+8

Q7 T 9.1-6 spin, B 6.1-3, app. XIX

Q8 T 10.1-8 building the periodic table, Pauli principle, B 6.5-8

N1 Nuclear T 16.2, .3 nuclear properties and force, Rutherford, B 1.8, 3.3, app. IX

N2 Nuclear T 16..4, .5, .6 nuclear properties and some models

N3 Nuclear T 16.7, 8 binding energy N4

N5 Nuclear T 17.2, .3 radioactivity, general

N6 Nuclear T 17.5, .7, .8 natural decay series, fission, fusion

StM1 Really big numbers, Statistics, The Partial Sum Method

StM2 Boltzmann, Fermi-Dirac and Bose Einstein Distributions, Bosons and Fermions

StM3 Statistics: T 15.3,.4,.5

Sol1 Structures, Properties

Sol2 Metals, Semiconductors, Superconductors

R12 T 2.10-2.11 GR (after Rindler) 4-vectors, curved spacetime, field eqn rel:

R13 cosmology, black holes, GPS

Sub1 Sub-nuclear, Particle Zoo, anti-Matter, Conservation Laws T 18.1-.7 (not exam material)

Sub2 Quarks and The Standard Model,