**PHYS 2320: Physics IV – Modern Physics Term: Sum22**

online class

**General Information**

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

**Office hours**: tbd

**Course webpage**: <http://physics.uwyo.edu/~rudim/index_2320.html>

**Lecture**: synchronous Zoom runs during in-person lecture; video posted same day in Wyocourses under Announcements for asynchronous use; attendance only counts for synchronous attendance for the full lecture or in-person.

**Recommended Texts:**

I do not require that you have any specific texts, but I recommend two:

‘Modern Physics for Scientists and Engineers’ 2nd edition, Taylor/Zafiratos

This is the text I use during regular term. It is a typical textbook with worked out examples. My lecture will follow the book more or less. I do more work on Relativity than the text does and I leave some material out that is in the text (see below).

‘Atomic Physics’, Max Born

This is not a typical textbook. Or rather, it was, in the 1930s to 50s. You will find that it differs from modern textbooks in a number of ways. The reason why I use it is that Max Born was one of the original makers of modern physics.

Born does not compartmentalize the material in neat drawers: Relativity, atoms, nuclei – he tells the story as it happened and shows inter-connections. The extensive index works also that way, it points forward and backward – very useful. The book is available as a free pdf at the university libraries archive site:

<https://archive.org/details/AtomicPhysics8th.ed>.

Scroll down and choose the download type.

Most of the difficult math is hidden in the extensive appendices of Born. Almost 30% of the book is appendices. You do not need to read the appendices for this course. I recommend to physics/astronomy majors to hang on to the book and use it again in the Quantum Mechanics, Modern Lab, and Stat Mech classes and then read the appendices.

You can find a rich array of other original books for free on archive.org when you search for authors whose names come up in Born or in my lecture.

**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 all of physics is inter-connected, and all of math is going to be used in physics at some point or another. One cannot delay taking physics courses until one has gone through all math courses, consequently, there may be a few rough edges. Generally, our course is more concept heavy than math intensive, but there are a few exceptions.

Whenever we will reach such a cross road, I will try to ease you into any material that the average student has not yet encountered. It is perfectly fine to carry any 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 via email. The announcements on tape do not apply to the online 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: Inertial Frames of Reference and Lorentz Transformation, Simultaneity, Space-time

Michelson-Morley Experiment, Young double-slit Interference Experiment

Mass/Energy Relation

Dynamics in Relativity

Geometry and General Relativity

Atomic Nature of Matter

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

Maxwell-Boltzmann Distribution vs. Quantum Statistics

Electrons in Metals and Semiconductors

Band Theory of Solids

The Particle Zoo & the Standard Model of Physics

Quarks and Quantum-Chromodynamics: a qualitative first introduction

Standard Model of Physics

**Lecture**

The lecture will roughly follow the Taylor 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 also 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 the course webpage and you can review these at home in your own time, but you may have to download a free player that can display the material.

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 they can be used and when not.

***How 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.

**For the Summer Online Course:**

**Grading**

Details of grading (subject to revision):

Exams: 2 60 %

Homework: 4 30 %

Attendance: 20 4% (attendance and participation)

Letters to Self 3 6 % (emailed to me on Tuesday of week one, at the end of the Relativity chapter, and at the end of the course)

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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

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

**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.

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. I will discuss the exam day and time at the first day of classes with the class. Tentatively, I post these times:

Exam 1 – midterm F 17 June 1100-1240 or 110-250,

*topics: Relativity, Atomic Physics landmark expt*

Exam 2 – final F 15 Jul 1100-1240 or 110-250,

*topics: cumulative*

**Homework**

A typical homework will consist of six problems. Students are allowed to work in hw groups of up to two students. A group hands in one solution and every student is only allowed to put their name on the hw if they actually participated actively in all tasks. No student can be part of more than one hw group. Students can change groups from hw to hw.

Most 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***. For this part of the task, you take a broader perspective than just repeating what you have done. Typically, the results has implications for other fields, experiments, etc. That is what you comment on.

***The deadlines*** are indicated ***for each homework*** in the tentative schedule below. To receive full credit, your homework must be legible, on time, and the logic must be easy to follow. We have a grader for our term work and her contact information is added on page one.

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 one week after the deadline. After this extended deadline, no late submissions will be accepted.

Email hw solutions to [rudim@uwyo.edu](mailto:rudim@uwyo.edu) by the deadline. Inbox arrival time is what counts.

**General requirements and expectations for the course:**

**This section is required by the new university syllabus rules.**

**Required texts, readings, and special tools or materials:**

I do not require that you have any specific texts, but I recommend two:

‘Modern Physics for Scientists and Engineers’ 2nd edition, Taylor/Zafiratos

‘Atomic Physics’, Max Born

Excerpts of French ‘Special Relativity’ will be uploaded to the course webpage

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Grading Scale and Grading Policies:

90-80-70-60 scale.

Classroom Behaviour Policy:

Not applicable for online class

No offensive statements during online Zoom sessions or in emails.

**Classroom Statement on Diversity:** “The University of Wyoming values an educational environment that is diverse, equitable, and inclusive. The diversity that students and faculty bring to class, including age, country of origin, culture, disability, economic class, ethnicity, gender identity, immigration status, linguistic, political affiliation, race, religion, sexual orientation, veteran status, worldview, and other social and cultural diversity is valued, respected, and considered a resource for learning. “

**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 accommodations 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 accommodations 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)

**Academic Dishonesty Policies**:

*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.*

**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 at the STOP Violence program (*[*stopviolence@uwyo.edu*](mailto:stopviolence@uwyo.edu)*,* [*www.uwyo.edu/stop*](http://www.uwyo.edu/stop)*, 766-3296) (or SAFE Project (*[*www.safeproject.org*](http://www.safeproject.org/)*,* [*campus@safeproject.org*](mailto:campus@safeproject.org)*, 766-3434, 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*](http://www.uwyo.edu/dos/uwyocares)*.*

*Finally, know that if, for some reason, our interaction involves a 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.*

**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.*

*Circumstances may alter the reading and/or test schedules. You are required to check WyoCourses and your email at least twice a week a day before lab day.*

**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)

Schedule Phys 2320 Summer Course ‘22

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| --- | --- | --- | --- | --- |
|  | M  300-420 | T  300-420 | W  300-420 | deadlines |
| May 23-26 | Intro  R1 | R2 | R3 |  |
| May30–Jun3 | R4 | R5 | R6 | HW1 due  Jun 1 |
| Jun 6 – 10 | R7 | R8 | A1 |  |
| Jun 13 -17 | A2 | A3 | A4  *Midterm 17th 1100-1240 or 110-250* | HW 2 due  Jun 15 |
| Jun 20-24 | A5 | A6 | A7 |  |
| Jun27- Jul1 | N1 | N2 | N3 | HW 3 due  Jun 29 |
| Jul 4 – 8 | -  May the fourth be with you | Sol/StM1 | Sol/StM2 |  |
| Jul 11-15 | Sol/StM3 | Sub1 | Sub2  *Final 15th 1100-1240 or 110-250* | HW 4 due  Jul 13 |

**R Relativity A Atomic N Nuclear Sol/StM: Stat Mech, Solid State Sub: Particles**

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

Text reference: T = Taylor, B = Born, F = French (see course webpage)

currently under revision to match lecture videos

Intro T 1.1-1.4 review classical physics, letter to self

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

R2 T 1.7-1.9

spacetime diagrams , skateboard videos

R3 suppl: F chapter 3, p.74-82 rel: foundational for laws transferring to atomic etc.

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

R4 clocks, light-clock video

T 1.13-1.14 velocity addition formula

R5 T 2.1-2.2 mass in Relativity

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

R6 T 2.3 space billiard suppl: F p.167- 176 rel: atomic and nuclear experiments

T 2.4 E = mc2

R7 T 2.7 forces and accelerations suppl: F p.214-219

R8 T 2.10-2.11 GR (after Rindler) 4-vectors, curved spacetime, field eqn rel:

cosmology, black holes, GPS

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

T 3.10 Thomson e/m

T 3.11 Millikan

A2 T 4.1-4.3 Photoelectric Effect, Blackbody Radiation suppl: B4.2, B8.8, B 7.1+3, app.

XXVIII

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

A3 T 4.4-4.5 x-rays, Bremsstrahlung, pair creation/annihilation, wave – particle duality,

T6.1-6.5 Matter waves I,

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

A4 T 5.2-5.5 Bohr model basics, Quantization of the atom, suppl: B 4.3, B 4.3, 5.1

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

A5 T 7.1-8 (in excerpts) examples of quantum wells, B 5.4 with math ,app. XVI, XXV (for a taste)

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

A6 T 8.1-5 toward 3-dim wells, B 5.5, app. XIX

A7 T 8.6-10 angular momentum, hydrogen atom, atomic shells, B 5.7+8

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

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

N1 Nuclear T 16.2, .3 nuclear properties and force

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

N2 Nuclear T 16.7 binding energy

Nuclear T 16.8 shell model

N3 Nuclear T 17.2, .3 radioactivity, general

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

StMSol1 Large Systems or Structures

StMSol2 Classical Systems or Metals

StMSol3 Quantum Statistics or Semiconductors

Sub1 Sub-nuclear T 18.1-.7 (not exam material)

Sub2 The Standard Model