PHYS 3710 - Modern Physics - Fall 2020 Semester

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Lectures: Synchronous Online on D2L Collaborate Ultra.
Online Class Meetings: Tuesday, Thursday 10:00am -11:40am,

This is a Synchronous Online course.
You are expected to attend scheduled synchronous online sessions and must have the requisite technology and bandwidth to do so. You should also expect a fair number of asynchronous components to the course delivered through the D2L platform in addition to the synchronous online sessions. You are expected to be prepared for online delivery including arranging access to stable internet capable of handling streaming video demands and a computer with (internal or external) functioning webcam with microphone.

To access online lectures:

1) Log in on D2L and select PHYS3710 Fall2020 Course
2) From the Navigation Bar on top, select ``Other", and from the dropdown menu select: ``Collaborate Ultra".
3) Once in Collaborate Ultra, you will find the Modern Physics Section 51 Fall Semester 2020 CO - Course Room already in place. Click on it to enter.
4) A menu on the right will pop up. Click on ``join the session" to log in as a participant (preferred).
5) Alternatively, you can click on the link: https://us.bbcollab.com/guest/7fe8067e950e4acd924917024c9870c1
6) Enter your first and last name, and join the session as a guest.

Office hours:
Online - Friday 3pm-4pm, or by appointment (email me). I will set up an individual or group meeting online on Collaborate Ultra.

Textbook: ``Modern Physics For Scientists and Engineers" 2nd Edition, John R. Taylor, Chris D. Zafiratos, Michael A. Dubson, ISBN-13: 978-1938787751, ISBN-10: 1938787757

Auxiliary Textbooks (you don't have to buy them):
``Modern Physics'' by P. Tipler and R. Llewellyn.
``Quantum Mechanics Vol I'' by Albert Messiah.
``Introduction to Quantum Mechanics'' by David J. Griffith.
``Physics for Scientists and Engineers with Modern Physics Vol II'', Serway and Jewett, 9th Ed. Serway.
``Classical Mechanics'' by H. Goldstein, C. Poole, J. Safko.
``Classical Electrodynamics'' by J. D. Jackson.

Catalog course description
PHYS 3710 ``Modern Physics''
4 Class Hours, 0 Laboratory Hours, 4 Credit Hours.

Prerequisite: Grades of "C" or better in PHYS 2212/2212L
Students are expected to have at least knowledge of CALC II

Course Description
PHYS 3710 is an introductory course to quantum mechanics and related topics. Homework is an integral part of the course. The topics covered in this course constitute the most fundamental background in modern physics. The main objective of this course is to provide the student with a basic understanding of the physical laws and phenomena that constitute the framework leading to quantum mechanics. Students will strengthen their knowledge of special relativity and explore aspects of the quantum theory of wave/particle duality and the probabilistic interpretation. Students will learn the Schrödinger's equation, its solutions for simple potentials, and properties of the one-electron atom. Students will also study applications of quantum principles to atomic, molecular and nuclear structures.

Course material
The material is presented online by using an online whiteboard. Power Point presentations and videos will also be shown. Students are expected to take notes in class and are responsible to catch up with the material if they miss lectures.

Learning Outcomes
The topics covered in this course constitute the most fundamental background for a pathway in modern physics. The overarching objective of this course is to provide the student with a basic understanding of the physical laws and phenomena that constitute the framework on which quantum mechanics is based on.
The connection between symmetries and conservation laws in physics will also be studied in some cases.
At the end of the course students will be able to:
1. Use special relativity with 4 vectors to analyze differences in the behavior of objects as observed in different inertial reference frames and explain the equivalence of mass and energy.
2. Describe the major aspects of the most important experiments that have led to the development of quantum theory: Blackbody Radiation, Photoelectric Effect, and Compton Effect.
3. Explain the Rutherford model of the nucleus and the Bohr model of the atom.
4. Discuss wave-particle duality and Heisenberg's uncertainty principle.
5. Use Schrödinger's equation to solve various simple systems.
6. Discuss the spin of the electron orbital and shells for atoms, quantum numbers, and Pauli's exclusion principle.

Do's and Don'ts
1. Regular lecture attendance is essential for success in this class. If you must miss class, it is your responsibility to get the notes you miss from another student.
2. Be on time for the lecture.
3. Cellular telephones, pagers, and similar devices must be turned off or placed in silent mode during class. Use of cell phones should be restricted to emergencies.
4. The usage of calculators able to take derivatives and integrals of functions (for example like TI-84 Plus) is strictly forbidden. You are allowed to use ONLY standard scientific calculators.
5. If you have a question or comment during the lecture, direct it to the professor by opening your microphone on Collaborate Ultra. (There is also the ``raise hand'' button that you can use.)
6. Occasionally, it may be necessary for the instructor to make corrections or changes to the syllabus. Corrections or changes to the syllabus will be announced on D2L (see below) and in class: students are expected to check D2L for announcements at least once or twice a day.

Grading policy
Three tests will be given during the semester. Your grade will be determined according to your performance on the three tests, homework and the final exam as follows:
Homework: **10%**
Tests: **60% (3 tests, 20% each)**
Final Exam: **30%**
Grades: **A >90%; B 80%-90%; C 70%-80%; D 60%-70%; F <60%**

Grading method used for Tests and Final Exam
Tests and exams are graded by assigning points for:
- Correctly identifying the physics of the problem;
- Setting up correctly all the equations (and/or graphs/diagrams) for the specific physics situation described in the problem, and commenting when necessary or relevant;
- Correctly identifying all unknown variables to be determined;
- Correctly working out all the necessary symbolic and differential calculus-based operations;
- Correctly working out all the algebraic calculations to determine the solution.

D2L (Internet-based utility)
Course information, homework solutions and announcements will be available "D2L".
This on-line course information system is accessible from http://d2l.kennesaw.edu/ .
To sign on, use your KSU Local Area Network (LAN) username and password.
Students are expected to check D2L for announcements at least once a day.

Homework Assignments.
Hand in your homework timely by sending a scanned version to: mguzzi@kennesaw.edu.
Please send all in one single file in PDF format that must not exceed 5MB of size.
You can use the following free online resources:
-To convert files into PDF format: https://www.online-convert.com/
-To merge several PDF files into one single PDF file: https://www.ilovepdf.com/merge_pdf
-To compress your PDF file if it is too large: https://www.ilovepdf.com/compress_pdf).

Homework will be assigned during the lectures. Solutions to problems will be discussed in class during lectures and will be posted on D2L.

Withdrawal, last day of class, and final exam.

- First day of classes: *Tuesday August 18, 2020.*
- Last day to withdraw without academic penalty: *Wednesday, October 7, 2020*.
- The last day of Class: *Thursday, December 3, 2020.*
- Final exam: *Thursday, December 10, 2020, 10:30am - 12:30pm, 2020*.

(This must be double checked again on the KSU office of registrar website.)

The university's withdrawal policy is explained at:
http://registrar.kennesaw.edu/student-records/registration-policy.php

The Academic Standing Appeal policy is explained at:
https://appeals.kennesaw.edu/withdrawal_appeal.php
Students are solely responsible for managing their enrollment status in a class.
Nonattendance does not constitute a withdrawal.

Tentative schedule Fall 2020 Semester

Week 1 (Special Relativity PART I)
Space and Time: Relativity of a reference frame.
Moving frames: Galilean transformations for position and velocity.
Laws of Mechanics and electromagnetism and Postulates of special relativity.
Time dilations, Length contractions.
Lorentz transformations derivation and applications
4-vectors

Week 2 (Special Relativity PART I)
Relativistic Mechanic: Mass and momentum definition and conservation laws.
Relativistic energy: Work-kinetic energy theorem.
Collisions in classical mechanics and in special relativity.
Energy and momentum relations: Massless particles (photons).
Forces in special relativity: Work-energy theorem in differential form.
The Lorentz Force.

Week 3 (Atoms)
Quantization of charge and atomic parameters.
Kinetic theory of ideal gases.
Mean free path and Diffusion.
Diffusion and Random walk motion: derivation of the root-mean-square average distance. Brownian motion: Einstein's description.
The electron: J.J. Thomson and Millikan's experiments.
Rutherford and the nuclear atom: the Rutherford formula

Week 4
Quantization of Light
Black body radiation and the Maxwell-Boltzmann distribution Electromagnetic waves and simple harmonic oscillators
Rayleigh-Jeans relation and the emission spectrum of a black body Ultraviolet catastrophe: Planck's formula and energy quantization
The photoelectric effect: Einstein's explanation of photon energy quantization X-rays and Bragg diffraction
Compton effect: wave/particle duality

TEST 1: Thursday, September 17, 2020

Week 5
Quantization of atomic energy levels. Newton and Fraunhofer diffraction.
Analysis of the emission spectrum of gases. Bohr's idea of atom energy quantization.
The problem of stability of the hydrogen atom.
Bohr's solution and quantization conditions: angular momentum, orbit radius, energy: hydrogen atom.

Week 6 (Matter waves I)
Particle-wave duality: consequences of Bohr's and De Broglie statements Davisson and Germer experiment: diffraction of electrons
The quantum wave function: the Copenhagen interpretation
Probabilistic interpretation of the wave function of Max Born
Waves and wave packets
Solutions of the wave equation in 1+1 dim: dispersion relation

Week 7 (Matter waves II)
Matter waves: general considerations
Fourier analysis I: periodic functions
Periodic square wave: determination of the coefficients of the Fourier series Fourier analysis II: non-periodic functions and the Fourier integral Heisenberg indetermination principle: position and momentum
Uncertainty relation for time and energy
Velocity of a wave packet: phase velocity and group velocity

Week 8
Schrödinger equation in 1-dim I
Standing waves and stationary states.
Probability density in quantum mechanics.
Infinite square well in 1-dim: particle in a rigid box.
Time independent Schrödinger Equation (TISE) in 1-dim.
Solving the rigid box problem with the TISE: general solutions.
Boundary conditions and stationary states.
Normalization of the probability density.
Expectation value of a physical observable: expectation value of the position calculation in 1-dim.
Solutions of the TISE for a non-relativistic free particle.

Week 9
Schrödinger equation in 1-dim II
TISE for the finite square well and rounded well with x-dependent potential in 1-dim.
Simple harmonic oscillator (SHO): classical solutions and energy definition
SHO in QM: quantization of energy, zero-point energy and analysis of the first few excited states wave function Applications: vibrational motion of two atoms in a diatomic molecule (HCl - hydrochloric acid)
Tunneling: analysis of the solutions of the TISE for a potential step of finite height
Time dependent Schrödinger equation (TDSE): Energy operator and solutions in 1+1dim
Solutions of the TDSE: Particle in a 1-dim rigid box with non-stationary states

TEST 2: Tuesday, October 27, 2020

Week 10
Schrödinger equation in 3-dim
Hamiltonian operator in 3-dim and TISE in 3-dim.
The infinite square well (rigid box) in 2 and 3-dim.
The separation of variables technique in 2-dim and 3-dim. Quantization of the energy in 3-dim and degeneracy. Schrödinger equation in spherical coordinates in 3-dim. Illustration of the radial functions for the first few values of n. Definition of Shell: various examples.

Week 11-12
Spin of the electron
The Stern and Gerlach experiment.
Magnetic moment vector.
Work-energy theorem and the potential energy of a current loop in a magnetic field. Quantization of Magnetic moment and the Bohr magneton.
Normal Zeeman effect.
The Helium atom.
Anomalous Zeeman effect: the spin intrinsic angular momentum.

Fine structure of the Hydrogen atom and the spin-orbit interaction.
Spin magnetic moment.
Total angular momentum of the electron in quantum mechanics.
Sum of two quantized angular momenta.
Hydrogen atom wave function

Week 13
Multielectron atoms and Pauli exclusion principle
Schrödinger equation for two or more particles in 3-dim.
Probability density and normalization of the wave function.
Identical particles: Bosons and Fermions.
Axiom in nonrelativistic quantum mechanics: Spin and Statistics connection.
Bosons and Fermions: construction of a wave function for two identical particles in quantum mechanics.
Pauli's exclusion principle.
Calculation of the expectation value of the separation distance between two identical particles.
Exchange forces.
Complete wave function for an electron: the spin contribution (triplet and singlet configurations).

TEST 3: Thursday, November 19, 2020

Week 14-15 (Special Relativity PART II)
Minkowski space and 4-vectors.
Covariant and contravariant representations, the metric tensor and the dot product.
Light cone diagram: space-like, time-like, and null 4-vectors.
Lorentz transformations in matrix form for two aligned inertial reference frames.
Rapidity variable and hyperbolic rotations in 2-dim.
4-Momentum and 4-Force and their Lorentz transformations.
4-gradient and D'Alambert operator.
Invariant, Covariant, and Conserved quantities. Electromagnetism and special relativity: Lorentz Force (again) Transformations of the electric and magnetic fields

Last day of class Thursday, Dec 3, 2020 – Recap session (I encourage you to attend!)

Final Exam: *Thursday, Dec 10, 2020, 10:30am - 12:30pm*

Exams Policy
Three tests will be given in this semester plus a final exam. Exams will be posted on D2L and must be completed within a well-defined time frame. Students must hand in their exams (tests and final exam) by sending a scanned version of their work in one single PDF file (not exceeding 5MB) to: mguzzi@kennesaw.edu prior the announced deadline. The test ad final exam dates are reported on this syllabus. While taking the exams, students are expected to work on their own and must not use any type of external resource to solve problems. Non-observance of this, will be considered a violation of the Academic Integrity code reported below and actions will be taken.

Make-up Exam policy
Make-up exams will not be given. If you know ahead of time you have a conflict, let me know.
If you miss an exam because of an illness (yours of a family member's) or some other unforeseeable event, contact me as soon as you can. You can e-mail me or call the Physics Dep. Office at 470-570-4205.
You must provide documentation showing the reason for missing the exam.
Final make-up exam is ONLY for documented and excused emergencies or for scheduling conflicts with other final exams.

Academic Honesty
Every KSU student is responsible for upholding the provisions of the Student Code of Conduct, as published in the Undergraduate and Graduate catalogs. The Student Code of Conduct addresses the University's policy on academic honesty, including provisions regarding plagiarism and cheating, unauthorized access to University materials, misrepresentation/falsification of University records or academic malicious/intentional misuses of computer facilities and/or services, and misuse of student identification cards. Incidents of alleged academic misconduct will be handled through the established procedures of the Student Conduct and Academic Integrity department, which includes either an "Informal" resolution by a faculty member, resulting in a grade adjustment, or a formal hearing procedure, which may subject a student to the Code of Conduct's minimum one semester suspension requirement. The Code is available online at https://scai.kennesaw.edu/

Campus Sexual Misconduct Policy
For information about how to report sexual misconduct or how to obtain assistance, please go the following page: https://scai.kennesaw.edu/procedures/sexual-misconduct.php

COVID 19
Information on COVID-19 and university policies related to COVID-19 can be found here: https://coronavirus.kennesaw.edu/ . If you have tested positive for COVID-19, or have been exposed to someone who has tested positive for COVID-19, or had a diagnosis from a doctor of COVID-19, you should stay at home and self-isolate AND contact the KSU COVID-19 Health Helpline at 470-578-6644 and choose Option 1.

Shifting Modalities
Please note that the university reserves the right to shift teaching modalities at any time during the semester, if health and safety guidelines require it to do so. Some teaching modalities that may be used are face-to-face (F2F), Hyflex, Hybrid, or online, both synchronous and asynchronous instruction.

Attendance & Participation
Students are expected to attend all lectures, take all tests and exams, and complete all homework assignments.

Students with Disabilities
Any student with a documented disability or medical condition needing academic accommodations of class-related activities or schedules must contact the instructor immediately. Written verification from the KSU Student Disability Services (http://sds.kennesaw.edu/) is required. No requirements exist that accommodations be made prior to completion of this approved University documentation. All discussions will remain confidential.

Other Policies
See the Student Handbook (http://catalog.kennesaw.edu/index.php?catoid=37) for other policies.

Inclement Weather
For the official status of the university check the KSU website http://www.kennesaw.edu