Course Number and Name: Physics 213, Mechanics

Credits and Contact Hours: 3 credits (three 50-minute classes each week); an additional 2 contact hours each week (during office hours); optional 1 credit supplemental instruction.

Instructor or Course Coordinator Name: Michaela Burkardt

Textbook: D. Young & R. A. Freedman, *University Physics with Modern Physics*, Pearson/Addison Wesley, 12th Edition, 2008

a) other supplemental materials: Mastering Physics for Young and Freedman, 12th edition.

Specific Course Information:

a) **catalog description:** Newtonian Mechanics

b) **prerequisites or co-requisites:** MATH 191G

c) This course is required for majors in Physics and Engineering Physics as well as Chemistry; (alternative: PHYS215G, *Engineering Physics I*)

Specific Goals of the Course:

a) **specific outcomes of instruction:** This course sets the foundation for undergraduate physics and engineering curriculum. It provides the fundamental ideas underlying classical mechanics, the application of these ideas to quantitative physics problems, and the relationship between models physicists use and real-world phenomena.

b) related ABET Outcomes: PHYS 213 addresses Program Outcome a) *apply knowledge of math, science and engineering.*

Brief List of Topics Covered:

The course covers material from Chapters 1-13, 15 of Young and Freedman's textbook. Number of lectures spend on each section are indicated.

Chapter 1: Units, Physical Quantities, and Vectors, Sec. 1-10: *(2 lectures)*
Chapter 2: Motion Along a Straight Line, Sec. 1-5: *(3 lectures)*
Chapter 3: Motion in Two or Three Dimensions, Sec. 1-5: *(3.5 lectures)*
Chapter 4: Newton's Laws of Motion, Sec. 1-6: *(2 lectures)*
Chapter 5: Applying Newton's Laws, Sec. 1-4: *(4.5 lectures)*
Chapter 6: Work and Kinetic Energy, Sec. 1-4: *(1 lecture)*
Chapter 7: Potential Energy and Energy Conservation, Sec. 1-5: *(4 lectures)*
Chapter 8: Momentum, Impulse, and Collisions, Sec. 1-6: *(5 lectures)*
Chapter 9: Rotation of Rigid Bodies, Sec. 1-6: *(2 lectures)*
Chapter 10: Dynamics of Rotational Motion, Sec. 1-7: *(3 lectures)*
Chapter 11: Equilibrium and Elasticity, Sec. 1-3, 5 *(1 lectures)*
Chapter 12: Gravitation, Sec. 1-5: *(2 lectures)*
Chapter 13: Periodic Motion, Sec. 1-8: *(3 lectures)*

Chapter 15: Mechanical Waves, Sec. 2-3, 6-8: (2 lectures)

Prepared by Michaela Burkardt, Spring 2012.

Course Number and Name: Physics 213L, Experimental Mechanics

Credits and Contact Hours: 1 credits (one 2-1/2 hour lab per week).

Instructor or Course Coordinator Name: Chris Pennise

Textbook: The lab materials were developed by Dr. Steve Kanim of the NMSU Department of Physics. They are distributed on the on the course website. Lab one is printed out for the students; students are responsible for printing out other lab and homework materials

Specific Course Information:

a) **catalog description:** Laboratory experiments associated with the material presented in PHYS 213.

b) **prerequisites or co-requisites:** PHYS 213 *(co-requisite)*.

c) This course is the companion laboratory to Physics 213, Mechanics. It is required by all physics and engineering physics majors. Engineering Physics major can satisfy the requirement by taking PHYS 215L instead.

Specific Goals of the Course:

a) specific outcomes of instruction: Students in this course perform a series of experiments that apply the principles and concepts highlighting the main objectives covered in the coursework for PHYS 213.

b) related ABET Outcomes: PHYS 213L addresses program outcome *b) an ability to design and conduct experiments.*

Brief List of Topics Covered:

Experiments are performed, data collected and analyzed encompassing: kinematics, dynamics, energy, work, momentum, and their conservation concepts and rotational motion and extended body problems. Below is the list of labs covered over the course of the semester:

Descriptions of motion
Acceleration in one dimension
Motion in two dimensions
Forces
Addition of forces
Newton's second law
Energy
Conservation of momentum
Rotational motion
Torque
Simple harmonic motion
Standing waves

Prepared by Heinz Nakotte, Spring 2012.

Course Number and Name: Physics 214, Electricity and Magnetism

Credits and Contact Hours: 3 credits (three 50-minute classes each week); an additional 2 contact hours each week (during office hours); optional 1 credit supplemental instruction (50-minute workshop) available.

Instructor or Course Coordinator Name: Michaela Burkardt

Textbook: D. Young & R. A. Freedman, *University Physics with Modern Physics*, Pearson/Addison Wesley, 12th Edition, 2008

a) other supplemental materials: MasteringPhysics for Young and Freedman, 12th edition.

Specific Course Information:

a) **catalog description:** : Electricity and Magnetism.

b) **prerequisites:** PHYS 213 or PHYS 215G
prerequisites or co-requisites: MATH 192G

c) This course is required for majors in Physics and Engineering Physics as well as Chemistry; (alternative: PHYS216G, *Engineering Physics II*)

Specific Goals of the Course:

a) **specific outcomes of instruction:** This course teaches the fundamental ideas underlying electricity and magnetism, the interplay between these ideas of physics and mathematics, and the application of these ideas to quantitative physics problems and real-world phenomena.

b) related ABET Outcomes: PHYS 214 addresses Program Outcome a) *apply knowledge of math, science and engineering.*

Brief List of Topics Covered:

The course covers material from Chapters 1-13 of Young and Freedman's textbook. Number of lectures spend on each section are indicated.

Chapter 21: Electric Charge and Electric Field, Sec. 1-7: *(7 lectures)*
Chapter 22: Gauss's Law, Sec. 1-5: *(3 lectures)*
Chapter 23: Electric Potential, Sec. 1-5: *(3 lectures)*
Chapter 24: Capacitance and Dielectrics, Sec. 1-6: *(2 lectures)*
Chapter 25: Current, Resistance and Electromotive Force, Sec. 1-6: *(2 lectures)*
Chapter 26: Direct-Current Circuits, Sec. 1-5: *(3 lectures)*
Chapter 27: Magnetic Field and Magnetic Forces, Sec. 1-9: *(4 lectures)*
Chapter 28: Sources of Magnetic Fields, Sec. 1-8: *(3 lectures)*
Chapter 29: Electromagnetic Induction, Sec. 1-7: *(4 lectures)*
Chapter 30: Inductance, Sec. 1-6: *(2 lectures)*
Chapter 31: Alternating Current, Sec. 1-6: *(2 lectures)*
Chapter 32: Electromagnetic Waves, Sec. 1-4: *(2 lectures)*

Prepared by Michaela Burkardt, Spring 2012.

Course Number and Name: Physics 214 L, Electricity and Magnetism Laboratory

Credits and Contact Hours: 1 credits (one 2-1/2 hour lab per week).

Instructor or Course Coordinator Name: Chris Pennise

Textbook: Tutorials in Introductory Physics and Homework Package, by McDermott and Shaffer, Addison-Wesley Publishers, 2002.

Specific Course Information:

a) **catalog description:** Laboratory experiments associated with the material presented in PHYS 214.

b) **prerequisites or co-requisites:** Pa C or better in PHYS 213L or PHYS 215GL. *(pre-requisites)* and PHYS 214G *(co-requisite)*.

c) This course is the companion laboratory to Physics 214, Electricity and Magnetism. It is required by all physics and engineering physics majors. Engineering Physics majors can satisfy the requirement by taking PHYS 216L instead.

Specific Goals of the Course:

a) specific outcomes of instruction: Students in this course perform a series of experiments that apply the principles and concepts highlighting the main objectives covered in the coursework for PHYS 214.

b) related ABET Outcomes: PHYS 214L addresses program outcome *b) an ability to design and conduct experiments.*

Brief List of Topics Covered:

Experiments are performed, data collected and analyzed encompassing: electrostatics, electric circuits, magnetism, electromagnetism and light, including geometrical and physical optics. Below is the list of labs covered over the course of the semester:

Charge
Electric field and flux
Gauss's Law
Electric potential difference
Circuits I
Circuits II
Magnets and fields
Magnetic interactions
Lenz's law
Faraday's law
Plane and curved mirrors
Ray diagrams and convex lenses

Prepared by Heinz Nakotte, Spring 2012.

Course Number and Name: Physics 215G, Engineering Physics I

Credits and Contact Hours: 3 credits (two 75-minute lectures each week); an additional contact hour each week (during office hours). Evening review sessions before exams. Tutoring room assistance and supplemental instruction also available (optional).

Instructor or Course Coordinator Name: Stephen Pate

Textbook: H.D. Young and R.A. Freedman, *University Physics*, 14th edition, Pearson, 2016

a) other supplemental materials: available at https://learn.nmsu.edu

Specific Course Information:

a) **catalog description:** Calculus-level treatment of kinematics, work and energy, particle dynamics, conservation principles, simple harmonic motion.

b) **prerequisites or co-requisites:** MATH 191G *(pre-requisite)*

c) This course (or the equivalent PHYS 213) is required for all majors in the College of Engineering (except Eng. Tech.), all Physics majors and some Chemistry majors.

Specific Goals of the Course:

a) **specific outcomes of instruction:** PHYS 215 introduces students to the discipline of problem-solving using the elementary principles of mechanics. We will study the motion of masses in 1, 2 and 3 dimensions, including the important case of rotation about a fixed axis. Students will learn to understand and manipulate the fundamental concepts of energy, linear momentum, and angular momentum.

b) **related ABET Outcomes:** This course supports ABET outcome a) *an ability to apply knowledge of mathematics, science, and engineering.*

Brief List of Topics Covered:

The course covers the following chapters in the Young & Freedman textbook. The number of lectures spent on each section are indicated.

Chapter 1, Sec. 1-10: Units, physical quantities and vectors (2 lectures)
Chapter 2, Sec. 2-5: Motion along a straight line (2 lectures)
Chapter 3, Sec. 1-4: Motion in two or three dimensions (2 lectures)
Chapter 4, Sec. 1-6: Newton's laws of motion (2 lectures)
Chapter 5, Sec. 1-5: Applying Newton's laws (3 lectures)
Chapter 6, Sec. 1-4: Work and kinetic energy (2 lectures)
Chapter 7, Sec. 1-5: Potential energy and energy conservation (3 lectures)
Chapter 8, Sec. 1-5: Momentum, impulse, and collisions (2 lectures)
Chapter 9, Sec. 1-5: Rotation of rigid bodies (2 lectures)
Chapter 10, Sec. 1-6: Dynamics of rotational motion (2 lectures)
Chapter 11, Sec. 1-3: Equilibrium and statics (1 lecture)
Chapter 13, Sec. 1-5: Gravitation (1 lecture)
Chapter 14, Sec. 1-5: Periodic motion (2 lectures)
Chapter 15, Sec. 1-4: Mechanical waves (1 lecture)

Prepared by Stephen Pate, Spring 2018.

Course Number and Name: Physics 215GL, Engineering Physics I Laboratory

Credits and Contact Hours: 1 credit (one 2-1/2 hour lab per week, up to 12 labs).

Instructor or Course Coordinators Name: Thomas Hearn

Textbook: The lab materials were developed by Dr. Steve Kanim of the NMSU Physics Department. They are distributed on the on the course website. Lab one is printed out for the students; students are responsible for printing out other lab and homework materials

Specific Course Information:

a) catalog description: Laboratory experiments associated with the material presented in PHYS 215G. Co-requisite: PHYS 215G. Students wishing to use the PHYS 215G-216G sequence to satisfy the basic natural science general education requirement must register for either PHYS 215GL or PHYS 216GL.

b) prerequisites or co-requisites: PHYS 215*(pre/co-requisite)*.

c) This course is the companion laboratory to Physics 215, Engineering Physics I. It is required by all engineering majors, with the exception of Engineering Technology.

Specific Goals of the Course:

a) specific outcomes of instruction: Students in this course perform a series of experiments that apply the principles and concepts highlighting the main objectives covered in the coursework for PHYS 215.

b) related ABET Outcomes: PHYS 215L addresses program outcome *b) an ability to design and conduct experiments.*

Brief List of Topics Covered:

Experiments are performed, data collected and analyzed encompassing: kinematics, dynamics, energy, work, momentum, and their conservation concepts and rotational motion and extended body problems. Below is the list of labs covered over the course of the semester:

Descriptions of motion
Acceleration in one dimension
Motion in two dimensions
Forces
Addition of forces
Newton's second law
Energy
Conservation of momentum
Rotational motion
Torque
Simple harmonic motion
Standing waves

Prepared by Tom Hearn, Spring 2018.

Course Number and Name: Physics 216G, Engineering Physics II

Credits and Contact Hours: 3 credits (three 50-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Lauren Waszek

Textbook: Young and Freedman, University Physics with Modern Physics, 14th Ed.

a) other supplemental materials: *Mastering Physics* online homework for Young and Freedman, 14th edition.

Specific Course Information:

a) **catalog description:** A calculus-level treatment of topics in electricity, magnetism, and optics.

b) **prerequisites or co-requisites:** PHYS 213 or 215G, MATH 192G *(pre-reqs)*.

c) This course is required for most engineering disciplines, except Engineering Technology and Survey Engineering. It can also substitute PHYS214 for Engineering Physics majors.

Specific Goals of the Course:

a) **specific outcomes of instruction:** This course provides a calculus-based introduction to electricity, magnetism, basic electronic circuits, and basic optics. PHYS 215G and PHYS 216G prepare students for upper-division courses in engineering and physical sciences.

b) **related ABET Outcomes:** PHYS 216G addresses Program Outcome a: an ability to apply knowledge of mathematics, science, and engineering.

Brief List of Topics Covered:
The course covers all of the material from Chapters 21-35 of the textbook. Approximate numbers of lectures spent on each chapter are indicated.

Chapter 21: Electric Charge and Electric Field, 3
Chapter 22: Gauss' Law, 3
Chapter 23: Electric Potential, 3
Chapter 24: Capacitance and Dielectrics, 3
Chapter 25: Current, Resistance, and Electromotive Force, 3
Chapter 26: Direct-Current Circuits, 3
Chapter 27: Magnetic Field and Magnetic Forces, 3
Chapter 28: Sources of Magnetic Field, 3
Chapter 29: Electromagnetic Induction, 3
Chapter 30: Inductance, 1
Chapter 31: Alternating Current, 1
Chapter 32: Electromagnetic Waves, 2
Chapter 33: The Nature and Propagation of Light, 3
Chapter 34: Geometric Optics, 3
Chapter 35: Interference, 1
Examination review sessions: 4
Mid-terms: 2

Prepared by Lauren Waszek, Fall 2017.

Course Number and Name: Physics 216GL, Engineering Physics II Laboratory

Credits and Contact Hours: 1 credits (one 2-1/2 hour lab per week).

Instructor or Course Coordinator Name: Heinz Nakotte

Textbook: Tutorials in Introductory Physics and Homework Package, by McDermott and Shaffer, Addison-Wesley Publishers, 2002.

Specific Course Information:

a) catalog description: Laboratory experiments associated with the material presented in PHYS 216G.

b) prerequisites or co-requisites: PHYS 213L or 215GL *(pre-requisites)* and PHYS 216G *(co-requisite)*.

c) This course is the companion laboratory to PHYS 216G, Engineering Physics II. It is required by all engineering majors, with the exception of Engineering Technology. EP majors can satisfy this requirement by taking PHYS 214L instead.

Specific Goals of the Course:

a) specific outcomes of instruction: Students in this course perform a series of experiments that apply the principles and concepts highlighting the main objectives covered in the coursework for PHYS 216G.

b) related ABET Outcomes: PHYS 216GL addresses program outcome *b) an ability to design and conduct experiments.*

Brief List of Topics Covered:

Experiments are performed, encompassing: electrostatics, electric circuits, magnetism, electromagnetism and light, including geometrical and physical optics. Below is the list of labs offered over the course of the semester; students will typically perform 12 out of these 14 labs:

Charge
Electric field and flux
Gauss's Law
Electric potential difference
Circuits I
Circuits II
Magnets and fields
Magnetic interactions
Measurement of e/m
Lenz's law
Faraday's law
Plane and curved mirrors
Ray diagrams and convex lenses
Interference and Diffraction

Prepared by Heinz Nakotte, Fall 2017.

Course Number and Name: Physics 217: Heat, Light, and Sound

Credits and Contact Hours: 3 credits (three 50-minute lectures each week); an additional 2 contact hours each week (during office hours); optional 1 credit supplemental instruction.

Instructor or Course Coordinator Name: Michaela Burkardt

Textbook: D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th edition, Pearson Addison-Wesley, 2016

a) other supplemental materials: numerous handouts distributed as paper copies or via Canvas course management system

Specific Course Information:

a) catalog description: Calculus-level treatment or thermodynamics, geometrical and physical optics, and sound.

b) prerequisites or co-requisites: PHYS 213 or 215G *(pre-req)*

c) This course is required for all majors in Physics and Engineering Physics.

Specific Goals of the Course:

a) specific outcomes of instruction: Students should become familiar with the concepts of waves (on a string, sound, and light), wave propagation and interference, and the description of these phenomena. Fundamentals of ray optics are discussed with applications. The section on thermodynamics in the course discusses the laws or thermodynamics and their use to describe thermal processes in engineering applications.

b) related ABET Outcomes: PHYS 217 addresses the following Program Outcome:

a) Apply knowledge of math, science, and engineering.

Brief List of Topics Covered:

The course covers material from Chapters 14 (review), 15-20, 32-36, 39 (in part) of the Young and Freedman textbook. The number of lectures spent on each section are indicated.

Chapter 14: Review Periodic Motion (2)
Chapter 15: Mechanical Waves (4)
Chapter 16: Sound and Hearing (6)
Chapter 32: Electromagnetic Waves, *Sec.1, 3-5* ***(1)***
Chapter 33: Nature and Propagation of Light (2)
Chapter 34: Geometric Optics (4)
Chapter 35: Interference (2)
Chapter 36: Diffraction (2)
Chapter 39: Particles Behaving as Waves (1) *Sec. 2, 3, 5 (Quantization of Energy, Photons)*
Chapter 17: Temperature and Heat (3)
Chapter 18: Thermal Properties of Matter (3)
Chapter 19: First Law of Thermodynamics (3)
Chapter 20: Second Law of Thermodynamics (4)
Review (3)

Prepared by Michaela Burkardt, Fall 2017.

Course Number and Name: Physics 217L: Experimental Heat, Light, and Sound

Credits and Contact Hours: 1 credit (one 150-minute lab each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Michaela Burkardt

Textbook: The lab manuals were developed in the NMSU Department of Physics for this course. Descriptions were updated and new laboratories developed by Dr. Michaela Burkardt.

a) other supplemental materials: assignments files and (optional) multimedia resources distributed via Canvas course management system

Specific Course Information:

a) catalog description: Laboratory experiments associated with the material presented in PHYS 217.

b) **prerequisites or co-requisites:** PHYS 217 *(pre/co-requisite)*

c) This course is required for all majors in Physics and Engineering Physics.

Specific Goals of the Course:

a) **specific outcomes of instruction:** Students should become familiar with the experimental exploration of basic phenomena in nature, data analysis, and the preparation of laboratory reports.

b) **related ABET Outcomes:** PHYS 217L addresses the following Program Outcome:

b) Design and conduct experiments, as well as to analyze and interpret data.

Brief List of Topics Covered:

The students perform 14 experiments during the semester, and each student writes an individual assignment report for each experiment. All assignments require analysis and interpretation of data. In addition, each assignment focusses on components of writing lab reports.

Measuring and Uncertainty Analysis
Vibrations of a String
Properties of Sound
Resonance Modes in a Tube
Linear Polarization
Reflection and Mirrors
Refraction and Lenses
Interference
Bragg Reflection
Statistics
Thermal Expansion
Thermal Radiation
Ideal Gas Laws
Calorimetry

Prepared by Michaela Burkardt, Fall 2017.

Course Number and Name: Physics 303V, Energy and Society

Credits and Contact Hours: 3 credits (online asynchronous 150 minutes each week); an additional contact hour each week (during online office hours)

Instructor or Course Coordinator Name: Edwin Fohtung

Textbook: Roger A. Hinrichs, Merlin H. Kleinbach Energy: Its Use and the Environment

a) other supplemental materials: none

Specific Course Information:

a) **catalog description:** Traditional and alternative sources of energy. Contemporary areas of concern such as the state of depletion of fossil fuels; nuclear energy, solar energy, and other energy sources; environmental effects; nuclear weapons; and health effects of radiation. Discussion of physical principles and impact on society. Focus on scientific questions involved in making decisions in these areas. No physics background required.

b) **prerequisites or co-requisites:** None

c) This course is an elective in Engineering Physics for students with Electrical and Mechanical concentrations.

Specific Goals of the Course:

specific outcomes of instruction: In this course, we will discuss topics as diverse as Home Energy Conservation, Solar Energy, Energy from Fossil Fuels, Air Pollution and Energy Use, Global Warming and Thermal Pollution, Electricity from Solar, Wind, and Hydro, Nuclear Power: Fission and Fusion, Biomass: From Plants to Garbage, and Geothermal Energy.

related ABET Outcomes: f) an understanding of professional and ethical responsibility; h) the broad education necessary to understand impact of engineering solutions in global, economic, environmental and societal context; i) a recognition of the need for, and the ability to engage in lifelong learning; j) a knowledge of contemporary issues.

Brief List of Topics Covered:

The course covers material from Chapters 1-19 Roger A. Hinrichs' andMerlin H. Kleinbach's book.

1. General Introduction
2. Energy Mechanics.
3. Conservation of Energy.
4. Heat and Work.
5. Home Energy Conservation and Heat-Transfer Control.
6. Solar Energy: Characteristics and Heating.
7. Energy from Fossil Fuels.
8. Air Pollution and Energy Use.
9. Global Warming and Thermal Pollution.
10. Electricity: Circuits and Superconductors.
11. Electromagnetism and the Generation of Electricity.
12. Electricity from Solar, Wind, and Hydro.
13. The Building Blocks of Matter:

14. Nuclear Power: Fission.
15. Effects and Uses of Radiation.
16. Future Energy Alternatives: Fusion.
17. Biomass: From Plants to Garbage.
18. Tapping the Earth's Heat: Geothermal Energy.
19. A National and Personal Commitment.

Prepared by Edwin Fohtung, Spring 2018.

Course Number and Name: Physics 305V, Search for Water in the Solar System

Credits and Contact Hours: 3 credits (two 75-minute lectures each week); an additional 2 contact hours each week (during office hours).

Instructor or Course Coordinator Name: Tom Hearn

Textbook: none required

a) other supplemental materials:
C.H. Langmuir and W, Broecker, *How to build a habitable planet: The story of the Earth from the big bang to humankind*, 2012, ISBN: 978-0602240063
T. Encrenaz, *Searching for water in the universe*, 2007, ISBN: 978-0-387-34174-3.

Specific Course Information:
a) **catalog description:** Examines the formation, abundance, and ubiquity of water in our Solar System stemming from comets, Martian and Lunar poles, Earth's interior and into the outer reaches of the Solar System. Topics will include nuclear synthesis, Solar System formation, remote sensing, as well as past, present and future NASA missions for water.

b) prerequisites or co-requisites: Viewing a Wider World courses and should be taken in a student's junior and/or senior year.

c) This course is not required for majors in Physics and Engineering Physics, but may be used as an elective.

Specific Goals of the Course:

a) **specific outcomes of instruction:** This course provides an overview of water on Earth, in the solar system, and in the universe. This includes formation of the solar system and universe. Students should become proficient in combining diverse sources of knowledge and information to discuss interdisciplinary topics including nuclear synthesis, Solar System formation, remote sensing, as well as past, present and future NASA missions for water.

b) **related ABET Outcomes:** f) Professional Responsibility, h) Societal Impact, i) Lifelong Learning, j) Contemporary Issues.

Brief List of Topics Covered:

1) Scales; Big Bang
2) Nucleosynthesis; Periodic Table
3) Rocky Bodies; Water on terrestrial planets
4) The Solar System: Gas Giants; The Solar System: Icy Giants
5) Planet Formation/Accretion; Newtons Laws
6) Celestial Mechanics; Composition of Atmospheres
7) Elements of planets; Minerals.
8) Rocks; Water Properties.
9) Lakes and Oceans; Ecology.
10) Humans and Water; Habitable Zone.
11) Urey Miller; Chemical Bonding.
12) Vibrations; Detection.

13) Past NASA; Current NASA.
14) Brain Storming; Moon.
15) Mars; Extrasolar.
16) Ice, Snow, and Water on Earth; Water in the Mantle.
17) Water Terrestrial; Outer Solar System.
18) Water and Climate; Life.
19) Pollution.
20) Conservation; Food.
21) Security; Water Security.
22) Student Papers
23) Student Presentations

Prepared by Tom Hearn, Fall 2017.

Course Number and Name: Physics 315, Modern Physics

Credits and Contact Hours: 3 credits (two 75-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Stephen Pate

Textbook: Young and Freedman, *University Physics with Modern Physics*, 12th ed., Pearson Addison-Wesley; or equivalent modern physics textbook in consultation with the instructor.

a) other supplemental materials: numerous handouts distributed via web page

Specific Course Information:

a) **catalog description:** An introduction to relativity and quantum mechanics, with applications to atoms, molecules, solids, nuclei, and elementary particles.

b) **prerequisites or co-requisites:** PHYS 214 or 216, MATH 291 *(all pre-reqs)*

c) This course is required for all majors in Physics and Engineering Physics.

Specific Goals of the Course:

a) **specific outcomes of instruction:** Students should become familiar with the principles and basic equations of the special theory of relativity and quantum mechanics and their applications in simple problems in various fields of physics. This knowledge will be applied in more advanced and specialized topics to be studied in later years.

b) **related ABET Outcomes:** PHYS 315 addresses the following Program Outcomes:

a) Apply knowledge of math, science, and engineering.
f) Have an understanding of professional and ethical responsibility.
h) Understand the impact of engineering solutions in a global, economic, environmental, and societal context.
i) Recognize the need for, and have the ability to engage in, lifelong learning.
j) Have a knowledge of contemporary issues

Brief List of Topics Covered:

The course covers material from Chapters 37-44 of the Young and Freedman textbook. The number of lectures spent on each section are indicated.

Chapter 37: Relativity (3)
Chapter 38: Photons, Electrons and Atoms (4)
Chapter 39: The Wave Nature of Particles (4)
Chapter 40: Quantum Mechanics (4)
Chapter 41: Atomic Structure (4)
Chapter 42: Molecules and Condensed Matter (4)
Chapter 43: Nuclear Physics (4)
Chapter 44: Particle Physics and Cosmology (1)

Prepared by Stephen Pate, Spring 2012.

Course Number and Name: Physics 315L, Experimental Modern Physics

Credits and Contact Hours: 3 credits (two 150-minute labs each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Stephen Pate

Textbook: no textbook

a) other supplemental materials: available at https://learn.nmsu.edu

Specific Course Information:

a) **catalog description:** Elementary laboratory in modern physics which supports the subject matter in PHYS 315.

b) **prerequisites or co-requisites:** PHYS 214L or 216L *(pre-req)*; PHYS 315 *(co-req)*

c) This course is required for all majors in Physics and Engineering Physics.

Specific Goals of the Course:

a) **specific outcomes of instruction:** Students perform a series of classic experiments in quantum physics and apply techniques of measurement, interpretation, and presentation of experimental data.

b) **related ABET Outcomes:** PHYS 315L addresses the following Program Outcomes:

b) Design and conduct experiments, as well as analyze and interpret data
c) Design a system, component, or process to meet desired needs within realistic constraints
d) Function on multidisciplinary teams
f) Have an understanding of professional and ethical responsibilities
g) Communicate effectively
k) Use techniques, skills and modern tools necessary for engineering and physics practice

Brief List of Topics Covered:

The students work in teams of 3-4 people. Each team performs 8 experiments over the course of the semester. The first experiment concerns the uncertainties in counting experiments, and all students write a report on this measurement. Then comes a series of 6 short experiments; individual students are assigned to write a report for the whole team; each student writes two reports in total. Then comes a final longer experiment, lasting several weeks. The team writes a design report for this experiment, then performs the measurement, analyses the data, and makes presentation to the entire class during the last few lab meetings.

The First Experiment (done by all teams; all students write an individual report)

Counting Statistics

Short Experiments (each team does 6 of these; team reports written by individual members)

Atomic Spectroscopy
Electron Diffraction
Planck's Constant – Photoelectric Effect
The Speed of Light
Quantization of Atomic Energy Levels – Franck-Hertz Experiment

Nuclear Magnetic Resonance
Electrical Conductivity of Metals and Semi-conductors
Ruckardt's Tube – specific heat ratio in gases

Long Experiments (done by one team only; requires design report, and final results presentation, done by the whole team)

The Hall Effect
X-Ray Diffraction
Charge of the Electron – Millikan Oil Drop Experiment
The Zeeman effect
Gamma-Ray Spectroscopy
Rutherford Scattering and the Range of Alpha Particles in Matter

Prepared by Stephen Pate, Spring 2018.

Course Number and Name: Physics 395, Intermediate Mathematical Methods of Physics

Credits and Contact Hours: 3 credits (two 75-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Stephen Pate

Textbook: HELM Workbooks, available at https://learn.nmsu.edu

a) other supplemental materials: available at https://learn.nmsu.edu

Specific Course Information:

a) **catalog description:** Introduction to the mathematics used in intermediate-level physics courses. Topics include vector calculus, curvilinear coordinates, matrices, linear algebra, function spaces, partial differential equations, and special functions.

b) **prerequisites or co-requisites:** MATH 291 *(pre-req)*, MATH 392 *(pre/co-req)*

c) This course is required for all majors in Physics and Engineering Physics.

Specific Goals of the Course:

a) **specific outcomes of instruction:** Students should become proficient at these advanced mathematical topics so that they will easily understand the interplay between the mathematical tools and physics concepts. The advanced mathematics should become an aid to understanding, and not a barrier.

b) **related ABET Outcomes:** PHYS 395 addresses Program Outcome k) *use techniques, skills and modern tools necessary for engineering and physics practice.*

Brief List of Topics Covered:

The course will cover four major topic areas:

Vector Calculus -- HELM Chapters 28,29 (11 lectures)

Complex Numbers -- HELM Chapter 10 (2 lectures)

Linear Algebra -- HELM Chapters 7, 22 (9 lectures)

Differential Equations – HELM Chapter 25 (5 Lectures)

Prepared by Stephen Pate, Spring 2018.

Course Number and Name: Physics 451, Intermediate Mechanics I

Credits and Contact Hours: 3 credits (three 50-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Lauren Waszek

Textbook: Fowles and Cassiday, Analytical Mechanics 7th Edition, Brooks and Cole

Specific Course Information:

a) catalog description: Vector calculus, Lagrangian and Hamiltonian formulations of Newtonian mechanics. Topics include central force motion, dynamics of rockets and space vehicles, rigid body motion, noninertial reference frames, oscillating systems, relativistic mechanics, classical scattering, and fluid mechanics.

b) prerequisites or co-requisites: PHYS 213 or 215G, MATH 291G *(pre-reqs);* MATH 392 *(pre-/co-reqs)*

c) This course is required for majors in Physics and Engineering Physics (EP) with concentrations in Electrical Engineering and Chemical Engineering. It is an elective for majors in EP with concentrations in Mechanical or Aerospace Engineering.

Specific Goals of the Course:

a) specific outcomes of instruction: This course provides a more comprehensive understanding of the fundamental ideas underlying classical mechanics, including Newton's laws and conservation laws. It incorporates mathematical techniques for application of these ideas to solving problems, and alternative formulations of these basic principles (Langrangian and Hamiltonian) based on the principle of least action and on the calculus of variations.

b) related ABET Outcomes: PHYS 451 addresses Program Outcome e: develop an ability to identify, formulate, and solve engineering problems.

Brief List of Topics Covered:
The course covers all of the material from Chapters 1-10 of the textbook. Approximate numbers of lectures spent on each chapter are indicated.

Chapter 1: Fundamental Concepts: Vectors, 2.5
Chapter 2: Newtonian Mechanics: Rectilinear Motion of a Particle, 4
Chapter 3: Oscillations, 3
Chapter 4: General Motion of a Particle in Three Dimensions, 2.5
Chapter 5: Non-Inertial Reference Systems, 2.5
Chapter 6: Gravitation and Central Forces, 4.5
Chapter 7: Dynamics of Systems and Particles, 3.5
Chapter 8: Mechanics of Rigid Bodies: Planar Motions, 4
Chapter 9: Motions of Bodies in Three Dimensions, 4
Chapter 10: Lagrangian Mechanics, 5
Examination review sessions: 4
Mid-terms: 2

Prepared by Lauren Waszek, Fall 2017.

Course Number and Name: Physics 454, Intermediate Modern Physics I

Credits and Contact Hours: 3 credits (two 75-minute lectures each week); an additional contact hour each week (during office hours)

Instructor or Course Coordinator Name: Boris Kiefer

Textbook: J. S. Townsend, *A Modern Approach to Quantum Mechanics*, University Science Books, 2000.

a) other supplemental materials: none

Specific Course Information:

a) **catalog description:** Introduction to quantum mechanics, focusing on the role of angular momentum and symmetries, with application to many atomic and subatomic systems.

b) **prerequisites or co-requisites:** PHYS 315 *(pre-req.)*, PHYS 392 *(co-req.)*, and MATH 392 *(co-req.)*

c) This course is required for majors in Physics and Engineering Physics with concentrations in Aerospace, Chemical, Electrical, and Mechanical Engineering.

Specific Goals of the Course:

specific outcomes of instruction: This course provides the fundamental knowledge of quantum mechanics and related phenomena. It is an integral part of the upper-division physics core, which includes PHYs 451, 454&455 and 461&462. Students should become proficient in a wide range of problems considering Schrödinger's equations including intrinsic spin, matrix representation of wave functions and observables, time evolution, and motion in one dimension.

b) **related ABET Outcomes:** PHYS 455 addresses Program Outcome e) *develop an ability to identify, formulate, and solve engineering problems*.

Brief List of Topics Covered:

The course covers material from Chapters 1-7 of the J. S. Townsend textbook.

Chapter 1: Stern-Gerlach Experiments

1.1. Original Stern-Gerlach Experiment
1.2. Four Experiments
1.3. The Quantum State Vector
1.4. Analysis of Experiment 3
1.5. Experiment 5

Chapter 2: Rotation of Basis States and Matrix Mechanics

2.1. The Beginnings of Matrix Mechanics
2.2. Rotation Operators
2.3. The Identity and Projection Operators
2.4. Matrix Representation of Operators
2.5. Changing Representations
2.6. Expectation Values
2.7. Photon Polarization and the Spin of the Photon

Chapter 3: Angular Momentum

Prepared by Boris Kiefer, Fall 2011.

Course Number and Name: Physics 455, Intermediate Modern Physics II

Credits and Contact Hours: 3 credits (two 75-minute lectures each week); an additional contact hour each week (during office hours)

Instructor or Course Coordinator Name: Boris Kiefer

Textbook: J. S. Townsend, *A Modern Approach to Quantum Mechanics*, University Science Books, 2000.

a) other supplemental materials: none

Specific Course Information:

a) **catalog description:** continuation of topics in PHYS454

b) **prerequisites or co-requisites:** PHYS 454 *(pre-req)*

c) This course is required for majors in Physics and Engineering Physics with concentrations in Aerospace, Chemical, Electrical, and Mechanical Engineering.

Specific Goals of the Course:

specific outcomes of instruction: This course provides the fundamental knowledge of quantum mechanics and related phenomena. It is an integral part of the upper-division physics core, which includes PHYs 451, 454&455 and 461&462. Students should become proficient in a wide range of problems considering Schrödinger's equations including rotation and translation in three dimensions, solution of central potential problems, perturbation theory, physics of identical particles, scattering theory, and the interaction between photons and atoms.

b) **related ABET Outcomes:** PHYS 455 addresses Program Outcome e) *develop an ability to identify, formulate, and solve engineering problems*.

Brief List of Topics Covered:

The course covers material from Chapters 9-14 of the J. S. Townsend textbook.

Chapter 9: Translational and Rotational Symmetry in the Two-Body Problem

9.1. Elements of Wave Mechanics in Three Dimensions
9.2. Translational Invariance
9.3. Center-of-Mass Coordinated
9.4. Ground-State Energies And Uncertainty Principle
9.5. Rotational Invariance
9.6. Complete set of Commuting Variables
9.7. Vibrations and Rotations of Diatomic Molecules
9.8. Position-Space Representation of Angular Momentum
9.9. Orbital Angular Momentum Eigenfunctions

Chapter 10: Bound States of Central Potentials

10.1. Asymptotic Behavior of Wave Functions
10.2. Hydrogen Atom
10.3. The Finite Spherical Well and the Deuteron
10.4. The Infinite Spherical Well

Prepared by Boris Kiefer, Spring 2012.

Course Number and Name: Physics 461, Intermediate Electricity and Magnetism I

Credits and Contact Hours: 3 credits (three 50-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Heinz Nakotte

Textbook: D.J. Griffiths, *Introduction to Electrodynamics*, 4th edition, Prentice Hall, 2013

a) other supplemental materials: C.A. Balanis, *Advanced Engineering Electromagnetics*, 2nd edition, John Wiley & Sons, 2012.

Specific Course Information:

a) catalog description: The first part of a two-course sequence in classical electrodynamics. Covered topics include static electric and magnetic fields, Laplace's and Poisson's equations, electromagnetic work and energy, Lorentz force, Gauss's, Biot-Savart, and Ampere's laws, Maxwell's equations, as well as electric and magnetic fields in matter.

b) prerequisites or co-requisites: PHYS 214 or 216G or equivalent and MATH 291G *(pre-reqs);* MATH 392 and PHYS 395 *(pre-/co-reqs)*

c) This course is required for all majors in Physics and Engineering Physics.

Specific Goals of the Course:

a) specific outcomes of instruction: This course provides the fundamental knowledge of electrodynamics and related phenomena. It is an integral part of the upper-division physics core, which includes PHYS 451, 454&455 and 461&462. Students should become proficient in a wide range of problems of electro- and magnetostatics, including dielectrics and magnetic materials.

b) related ABET Outcomes: PHYS 461 addresses Program Outcome e) *develop an ability to identify, formulate, and solve engineering problems*.

Brief List of Topics Covered:
The course covers all of the material from Chapters 1-6 of Griffiths' textbook, and it provides occasional supplemental material from Balanis' textbook. Number of lectures spend on each section are indicated.

Chapter 1: Vector Analysis (3)
1.1. Vector Algebra *(1/2 lecture)*
1.2. Differential Calculus *(1/2)*
1.3. Integral Calculus *(1/2)*
1.4. Curvilinear Coordinates *(1/2)*
1.5. The Dirac Delta Function *(1/2)*
1.6. The Theory of Vector Fields *(1/2)*

Chapter 2: Electrostatics (7)
2.1. The Electric Field *(1)*
2.2. Divergence and Curl of Electrostatic Field *(2)*
2.3. Electric Potential *(1)*
2.4. Work and Energy in Electrostatics *(1)*
2.5. Conductors *(2)*

Chapter 3: Special Techniques (6)
3.1. Laplace's Equation *(1)*
3.2. The Method of Images *(1)*
3.3. Separation of Variables *(2)*
3.4. Multipole Expansion *(2)*

Chapter 4: Electric Fields in Matter (7)
4.1. Polarization *(1)*
4.2. The Field of a Polarized Object *(1)*
4.3. The Electric Displacement *(2)*
4.4. Dielectrics *(3)*

Chapter 5: Magnetostatics (5)
5.1. The Lorentz Force Law *(1)*
5.2. The Biot-Savart Law *(2)*
5.3. The Divergence and Curl of B *(1)*
5.4. Magnetic Vector Potential *(2)*

Chapter 6: Magnetic Fields in Matter (6)
6.1. Magnetization *(1)*
6.2. The Field of a Magnetized Object *(1)*
6.3. The Auxiliary Field H *(2)*
6.4. Linear and Nonlinear Media *(2)*

Student Presentations (4)

Prepared by Heinz Nakotte, Fall 2017.

Course Number and Name: Physics 462, Intermediate Electricity and Magnetism II

Credits and Contact Hours: 3 credits (two 75-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Heinrich Nakotte

Textbook: D.J. Griffiths, *Introduction to Electrodynamics*, 3rd edition, Prentice Hall, 1999

a) other supplemental materials: none

Specific Course Information:

a) **catalog description:** continuation of topics in PHYS461

b) **prerequisites or co-requisites:** PHYS 461*(pre-req)*

c) This course is required for majors in Physics and Engineering Physics with concentrations in Aerospace, Chemical and Mechanical Engineering. It is an elective for majors in Engineering Physics with a concentration in Electrical Engineering.

Specific Goals of the Course:

a) **specific outcomes of instruction:** This course provides the fundamental knowledge of electrodynamics and related phenomena. It is an integral part of the upper-division physics core, which includes PHYS 451, 454&455 and 461&462. Students should become proficient in a wide range of problems considering Maxwell's equations in vacuum and matter, magnetic induction, electromagnetic wave propagation (including reflection, refraction, absorption, dispersion), waveguides, dipole radiation and relativistic electrodynamics.

b) **related ABET Outcomes:** PHYS 462 addresses Program Outcome e) *develop an ability to identify, formulate, and solve engineering problems*.

Brief List of Topics Covered:
The course covers material from Chapters 7-12 of Griffiths textbook. Number of lectures spend on each section are indicated.
Chapter 7: Electrodynamics
7.1. Electromotive Force *(1 lecture)*
7.2. Electromagnetic Induction *(2)*
7.3. Maxwell's Equations *(2)*
Chapter 8: Conservation Laws
8.1. Charge and Energy *(1)*
8.2. Momentum *(1)*
Chapter 9: Electromagnetic Waves
9.1. Waves in One Dimension *(1)*
9.2. Electromagnetic Waves in Vacuum *(1)*
9.3. Electromagnetic Waves in Matter *(1)*
9.4. Absorption and Dispersion *(1)*
9.5. Guided Waves *(1)*
Chapter 10: Potential and Fields
10.1. The Potential Formulation *(1)*

10.2. Continuous Distributions *(1)*
10.3. Point Charges *(1)*
Chapter 11: Radiation
11.1. Dipole Radiation *(1.5)*
11.2. Point Charges *(1.5)*
Chapter 12: Electrodynamics and Relativity
12.1. The Special Theory of Relativity *(1)*
12.2. Relativistic Mechanics *(1)*
12.3. Relativistic Electrodynamics *(2)*

Prepared by Heinz Nakotte, Spring 2012.

Course Number and Name: Physics 473, Introduction to Optics

Credits and Contact Hours: 3 credits (three 50-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Michael DeAntonio

Textbook: Hecht, *Optics*, 4th edition, Addison Wesley, 2001

a) other supplemental materials: none

Specific Course Information:

a) **catalog description:** The nature of light, geometrical optics, basic optical instruments, wave optics, aberrations, polarization, and diffraction. Elements of optical radiometry, lasers and fiber optics.

b) **prerequisites or co-requisites:** PHYS 216 or 217. Cross-listed as PHYS 473.

c) This course is an elective for majors in Physics and Engineering Physics .

Specific Goals of the Course:

a) **specific outcomes of instruction:** Describe general waves and wave motion. Use the basic laws of electromagnetism to determine the wave equations for electromagnetic radiation. Calculate the energy, momentum and Poynting vector for particular electromagnetic waves. Describe the dipole source of waves including basic radiation theory and polarization. Describe the effect of waves on a dielectric by the use of simple forcing functions. Describe in detail the process of Rayleigh scattering. Calculate the angles and intensity of light after single or multiple reflection or refraction. Describe the basic process of Huygens' wavelets and Fermat's principle. Predict the final color of light when two colors are mixed in emitting sources, after reflection and after transmitting through color filters. Calculate the RGB values for primary and secondary colors on a computer. Calculate the value of the critical angle and the intensity of light under total internal reflection. Calculate the effect of multiple mirrors and lenses in a system. Determine the effects of an aperture in a complex optical system. Find the entrance and exit pupil in a complex optical system. Perform ray traces for complex optical systems graphically. Calculate the deviation of light through a prism.

b) **related ABET Outcomes:** PHYS 473 addresses Program Outcome e) *an ability to identify, formulate, and solve engineering problems*, i) *a recognition of the need for and an ability to engage in life-long learning*, j*) a knowledge of contemporary issues*, k) *an ability to use the techniques, skills, and modern engineering tools necessary for engineering physics practice*.

Brief List of Topics Covered:

The course covers material from Chapters 2-9 of Hecht's textbook. Number of lectures spent on each chapter are indicated.

Chapter 2: Wave Motion (5 lectures)

2.1. One-Dimensional Waves
2.2. Harmonic Waves
2.3. Phase and Phase Velocity
2.4. The Superposition Principle
2.5. The Complex Representation

2.6. Phasors and the Addition of Waves
2.7. Plane Waves
2.8. Three-Dimensional Differential Wave Equation
2.9. Spherical Waves
2.10. Cylindrical Waves
Chapter 3: Electromagnetic Theory, Photons and Light (4 lectures)
3.2. Electromagnetic Waves
3.3. Energy and Momentum
3.4. Radiation
3.5. Light in Bulk Matter
3.6. The electromagnetic-Photon Spectrum
Chapter 4: The Propagation of Light (7 lectures)
4.3. Reflection
4.4. Refraction
4.6. The Electromagnetic Approach
4.7. Total Internal Reflection
4.9. Familiar Aspects of the Interaction of Light with Matter
4.10. The Stokes Treatment of Reflection and Refraction
Chapter 5: Geometrical Optics (6 lectures)
5.2. Lenses
5.3. Stops
5.4. Mirrors
5.5. Prisms
Chapter 6: More on Geometrical Optics (5 lectures)
6.1. Thick Lenses and Lens Systems
6.2. Analytical Ray Tracing
6.3. Aberrations
Chapter 7: The Superposition of Waves (2 lectures)
7.1. The Addition of Waves of the Same Frequency
7.2. The Addition of Waves of Different Frequency
Chapter 8: Polarization (4 lectures)
8.1. The Nature of Polarized Light
8.2. Polarizers
8.6. Polarization by Reflection
Chapter 9: Interference (4 lectures)
9.1. General Considerations
9.2. Conditions for Interference
9.3. Wavefront-splitting

Prepared by Michael DeAntonio, Spring 2012.

Course Number and Name: Physics 475, Advanced Physics Laboratory

Credits and Contact Hours: 3 credits (two 150-minute labs each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Vassilios Papavassiliou

Textbook: None

a) other supplemental materials: Instructor's handouts, equipment manuals, web resources

Specific Course Information:

a) catalog description: Advanced undergraduate laboratory, involving experiments in atomic, molecular, nuclear, and condensed-matter physics.

b) prerequisites or co-requisites: PHYS 315 and PHYS 315L *(pre-req)*

c) This course is required for majors in Physics (for the Bachelor of Science degree) and Engineering Physics

Specific Goals of the Course:

a) specific outcomes of instruction: This course is a fundamental part of the upper-division physics course sequence. Students perform complex experiments, performed extensive error analysis, and present their results in written and oral reports. The course provides up to three credits of engineering physics.

b) related ABET Outcomes: PHYS 475 addresses Program Outcomes *b) an ability to design and conduct experiments, as well as to analyze and interpret data; d) an ability to function in interdisciplinary teams; f) an understanding of professional and ethical responsibility; g) an ability to communicate effectively;* and *k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.*

Brief List of Topics Covered:
The lab includes lectures in probability, statistics, and error propagation as well as radiation safety, and lab sessions performing experiments in nuclear, particle, and condensed-matter and materials physics. The number of sessions devoted to each topic is listed. Each group performed two out of three experiments 4-6 and two out of three experiments among 7-9.
Lectures in statistical and error analysis (2 sessions)
Radiation safety lecture (1 session)
Practical exercise in statistics with Geiger counters (2 sessions)
Muon decay (4 sessions)
Gamma-gamma angular correlation (4 sessions)
Compton scattering (4 sessions)
Infrared spectroscopy (4 sessions)
Small-angle X-ray scattering (4 sessions)
X-ray fluorescence

Prepared by Vassilios Papavassiliou, Spring 2012.

Course Number and Name: Physics 476, Computational Physics

Credits and Contact Hours: 3 credits (two 75-minute lectures each week); one additional contact hour each week (during office hours)

Instructor or Course Coordinator Name: Boris Kiefer

Textbook: M. Hjorth-Jensen, *Computational Physics*, University of Oslo, 2012

other supplemental materials: W. H. Press, S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery, *Numerical Recipes in Fortran. The Art of Scientific Computing, 2nd Edition*, Cambridge University Press, 1992. M. Abramowitz and I. A. Stegun, *Handbook of Mathematical Functions*, Dover Publications, Inc. 1965. Additional in-depth materials are available as needed as pdf files on the file server for the course.

Specific Course Information:

a) **catalog description:** An introduction to finite difference methods, Fourier expansions, Fourier integrals, solution of differential equations, Monte Carlo calculations, and application to advanced physics problems.

b) **prerequisites or co-requisites:** PHYS 150 or equivalent and MATH 392 *(pre-reqs)*.

c) This is a required course for majors in Physics and Engineering Physics (EP) with the Electrical Engineering concentration. It is a possible elective for other EP concentrations.

Specific Goals of the Course:

a) **specific outcomes of instruction:** a) specific outcomes of instruction: Students should become proficient in the higher level methods of treating physics problems with a computer. The course provides an in-depth study of computational physics.

related ABET Outcomes: c) develop the ability to design a system, component, or process to meet desired needs within realistic constraint such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. k) develop the ability to use techniques, skills, and modern engineering tools necessary for engineering practices.

Brief List of Topics Covered:
The course covers all of the material from Chapters 1-11 of Hjorth-Jensen, and it provides occasional supplemental material from Numerical Recipes and The Handbook of Mathematical Functions and reading material for later chapters. Number of lectures spend on each section are indicated.

Chapter 1: Introduction (1)
Paradigms of scientific programming *(1/2)*
Scientific visualization *(1/2)*
Chapter 2: Numbers on Computers (1)
2.3. Machine numbers and round-off errors (1)
2.4. Computation of exp(-x).
Chapter 3: Interpolation (1)
3.2. Interpolation/extrapolation *(1/2)*
3.1. Finite Differences *(1/2)*

Chapter 5: Linear Algebra (2)
6.4. Linear systems *(1)*
6.5. Spline interpolation *(1/2)*
5.6. Iterative methods *(1/2)*

Chapter 4: Root Finding (2)
4.3. Secant, bisection, bracketing *(1)*
4.4. Brent, Dekker, Newton-Raphson method, multi-dimensions *(1)*

Chapter 5: Integration (2)
5.1. Classical quadrature *(1/2)*
5.2 Adaptive time step *(1/2)*
5.3 Gaussian Quadrature *(1)*

Chapter 7: Eigensystems (2)
7.2. Eigensystem problems *(1/2)*
7.4. Jacobi method, sparse matrices *(1/2)*
Supplementary topic QR/QL algorithm *(1)*

Chapter 8: Ordinary Differntial Equations (2)
8.3. Leapfrog algorithm, conservation laws (1)
8.4. Runge-Kutta method, time step control, classical dynamical systems *(1)*

Chapter 9: Two point boundary value problems (2)
9.2. Shooting method *(1)*
9.3. Numerical implementation; matching *(1)*

Chapter 10: Partial Differential Equations (2)
10.2. FTCS, BTCS, Crank-Nicholson, Numerical stability *(1)*
10.3. Laplace and Poisson's equation *(1/2)*
Supplementary topic: time-dependent Schroedinger equation *(1/2)*.

Chapter 11: Monte Carlo Method (4)
11.3. Random number generators, radioactive decay *(1)*
11.2. Integration, error estimates *(1)*
11.4. Sampling theorem, rejection and acceptance techniques *(1)*
12.5. Metropolis algorithm, 1-D ideal gas; multidimensional integrals *(1)*

Data Description and Modelling (2)
Supplementary topic: Linear models *(1)*
Supplementary topic: Non-linear models; Levenberg-Marquardt *(1)*

Min/Max and Global Minimization (2)
Supplementary topic: Brent's algorithm, Conjugate gradient; steepest descent, BFGS *(1)*
Supplementary topic: Simulated annealing *(1)*

Fast-Fourier Transform (2)
Supplementary topic: Nyquist frequency, sampling theorem, aliasing *(1)*
Supplementary topic: Interpolation *(1)*

Introduction to Machine Learning (1)
Supplementary topic: Pattern recognition, neural nets, applications *(1)*

Prepared by Boris Kiefer, Spring 2018.

Course Number and Name: Physics 480, Thermodynamics

Credits and Contact Hours: 3 credits (three 50-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Stephen Pate

Textbook: Kittel and Kroemer, *Thermal Physics*, 2nd edition, Freeman, 1980

a) other supplemental materials: available at https://learn.nmsu.edu

Specific Course Information:

a) **catalog description:** Thermodynamics and statistical mechanics. Basic concepts of temperature, heat, entropy, equilibrium, reversible and irreversible processes. Applications to solids, liquids, and gases.

b) **prerequisites or co-requisites:** PHYS 217, PHYS 315, MATH 291 *(all pre-reqs)*

c) This course is required for all majors in Physics, and those in Engineering Physics with concentration in Electrical Engineering. It is an elective for majors in Engineering Physics with a concentration in Aerospace, Chemical or Mechanical Engineering.

Specific Goals of the Course:

a) **specific outcomes of instruction:** PHYS 480 is an introduction to thermodynamics and statistical physics. The material is taught from the point of view of quantum mechanics from the very beginning, but the knowledge of quantum mechanics required of the student is in fact very slight. We will cover the fundamental topics of equilibrium thermodynamics -- entropy, temperature, energy, heat, reversible and irreversible processes -- and see applications to some simple systems.

b) **related ABET Outcomes:** PHYS 480 addresses Program Outcome e) *develop an ability to identify, formulate, and solve engineering problems*.

Brief List of Topics Covered:

The course covers material from Chapters 1-10 of the Kittel and Kroemer textbook. The number of lectures spent on each section are indicated.

Chapter 1: States of a Model System (4)
Chapter 2: Entropy and Temperature (3)
Chapter 3: Boltzmann Distribution and Helmholtz Free Energy (4)
Chapter 4: Thermal Radiation and Planck Distribution (5)
Chapter 5: Chemical Potential and Gibbs Distribution (3)
Chapter 6: Ideal Gas (5)
Chapter 7: Fermi and Bose Gases (5)
Chapter 8: Heat and Work (4)
Chapter 9: Gibbs Free Energy and Chemical Reactions (3)
Chapter 10: Phase Transformations (5)

Prepared by Stephen Pate, Spring 2018.

Course Number and Name: Physics 488/588, Introduction to Condensed Matter Physics

Credits and Contact Hours: 3 credits (two 75-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor's or Course Coordinator's Name: Edwin Fohtung

Textbook:
N. W. Ashcroft and N. D. Mermin, Solid State Physics, Thomson Publishing, 1976 *(required)*
Charles Kittel, *Introduction to Solid State Physics*, 8th ed., John Wiley & Sons, 2005 *(recommended)*
a) other supplemental materials: own hand-outs or hand-outs from other sources

Specific Course Information:
a) catalog description: crystal structure, X-ray diffraction, energy band theory, phonons, cohesive energy, conductivities, specific heats, p-n junctions, defects surfaces, and magnetic, optical, and low-temperature properties.
b) prerequisites or co-requisites: PHYS 315*(pre-req)*
c) This course is a possible technical elective for undergraduate majors in Physics and Engineering Physics with any of the concentrations. Moreover, it is cross-listed with PHYS 588, a slightly more advanced course taken by physics graduate students. The class material covered in PHYS 488 and PHYS588; however, graduate students are required to do additional (more difficult) assignments.

Specific Goals of the Course:
a) specific outcomes of instruction: This course provides a general introduction to solid state physics, such as crystal structures, diffraction techniques, type of chemical bonding, energy-band theory, phonons, electronic (transport, thermal, optical and magnetic) properties.
b) related ABET Outcomes: PHYS 488/588 is expected to address some or all of the following Program Outcomes: e) Problem Solving, f) Professional Responsibility, h) Societal Impact, i) Life-long Learning, and j) Contemporary Issues.

Brief List of Topics Covered:
The course covers material from the following topics. Each module is covered in about one week.
Module 1: Crystal Structure
Module 2: Coherent X-ray Diffraction Imaging
Module 3: Classification of Solids
Module 4: Free-Electron Theory of Metals
Module 5: Band Structure of Solids
Module 6: Lattice Vibrations
Module 7: Semiconductors
Module 8: Optical Properties
Module 9: Magnetic Properties
Module 10: Defects in Crystals
Module 11: Topological Defects

Module 12: Noncrystalline Solids

Prepared by Edwin Fohtung, Fall 2016.

Course Number and Name: Physics 489, Introduction to Modern Materials
Credits and Contact Hours: 3 credits (two 75-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Peter de Châtel

Textbook: no particular textbook required. *For some general guidance, however, Philip Ball published an excellent book called "Made to Measure - New Materials for the 21st Century" (Princeton University Press, 1999), which introduces a variety of advanced materials to the general audience*.

a) other supplemental materials: hand-outs from various sources

Specific Course Information:

a) **catalog description:** structure and mechanical, thermal, electric, and magnetic properties of materials; modern experimental techniques for the study of materials properties.

b) **prerequisites or co-requisites:** PHYS 315 *(pre-req.)*

c) This course is a possible technical elective for majors in Physics and Engineering Physics with any of the concentrations. In general, it is cross-listed with PHYS589, a slightly more advanced course taken by physics graduate students. The class material covered in PHYS 489 and PHYS589 is the same for both undergraduate and graduate students; however, graduate students are required to do additional (more difficult) assignments.

Specific Goals of the Course:

a) specific outcomes of instruction: The main goal of this course is for students to identify and understand the microscopic mechanisms responsible for an improved performance of modern materials. The materials to be discussed will be those, which have enabled recent breakthroughs in the fastest growing industries: communication and information storage, energy and aerospace industry. To understand the mechanisms alluded to above, we shall have to touch some aspects of solid state physics (magnetism, mechanical, optical and electrical properties of materials, magneto-optics and –resistivity, semiconductors). Chapters of textbooks available in the library and handouts will be provided to help students to familiarize themselves with these subjects.
b) related ABET Outcomes: PHYS 489 addresses Program Outcomes: f) *an understanding of professional and ethical responsibility*, h) *the broad education necessary to understand impact of engineering solutions in a global, economic, environmental, and societal context*, i) *a recognition of the need for and an ability to engage in lifelong learning*, and j) *a knowledge of contemporary issues*.

Brief List of Topics Covered:
Below is the list of topics covered over the course of the semester:
Weeks 1&2: Magnetism and Magnetic Materials
Week 3: Magneto-Optic Effects
Weeks 4&5: Magneto-electronic Materials and Devices
Weeks 6&7: Magnetic Multilayers and Spintronics
Weeks 8-10: Fiber Optics and Photonics
Weeks 11&12: Materials for Alternative Energy (solar, wind, batteries & fuel cells)
Weeks 13&14: Nanomaterials (in particular, carbon)

Prepared by Peter de Châtel, Spring 2012.

Course Number and Name: Physics 495, Mathematical Methods of Physics

Credits and Contact Hours: 3 credits (three 50-minute lectures each week); an additional 2 contact hours each week (during office hours)

Instructor or Course Coordinator Name: Stephen Pate

Textbook: Dennery and Krzywicki, *Mathematics for Physicists*, Dover

a) other supplemental materials: numerous handouts distributed via web page

Specific Course Information:

a) **catalog description:** Applications of mathematics to experimental and theoretical physics. Topics selected from: complex variables; special functions; numerical analysis; Fourier series and transforms, Laplace transforms.

b) **prerequisites or co-requisites:** PHYS 395, MATH 392 *(both pre-reqs.)*

c) This course is an elective for all majors in Physics and Engineering Physics.

Specific Goals of the Course:

a) **specific outcomes of instruction:** Students should become proficient at these advanced mathematical topics so that they will easily understand the interplay between the mathematical tools and physics concepts. The advanced mathematics should become an aid to understanding, and not a barrier.

b) **related ABET Outcomes:** PHYS 495 addresses Program Outcome *k) Use techniques, skills and modern tools necessary for engineering and physics practice.*

Brief List of Topics Covered:

The course covers material from Chapters 1-3 of the Dennery and Krzywicki textbook. The number of lectures spent on each section are indicated.

Chapter 1: The Theory of Analytic Functions (11)
Chapter 2: Linear Vector Spaces (18)
Chapter 3: Function Space, Orthogonal Polynomials, and Fourier Analysis (9)

Prepared by Stephen Pate, Spring 2011.