CALCULUS-BASED PHYSICS w/Lab
*PHY*C221*
Course Overview

Course Description: 4 credits (3 class hours and 3 laboratory hours per week)

Physics 221 is designed primarily for physics, chemistry, mathematics and engineering majors. The use of cognitive and mathematical problem solving skills employed by scientists and engineers will also be a central focus of this course, students enrolled in Physics 221 will be expected to apply the knowledge of differential and integral calculus to solve physics problems. The subject areas include, but are not limited to; kinematics, dynamics, energy and momentum for the three primary forms of motion; translational, rotational and harmonic. The use of computers, analysis software, and electronics sensors will be an integral part of this course.

Prerequisite: PHY 221 - MAT* 254 with a grade of "C" or better.

Goals:

The goals of this course are to develop the students' abilities to understand, utilize, and apply a significant portion of the physics discipline. This course will provide students with an opportunity to demonstrate an understanding of the fundamental principles, concepts, and knowledge of the natural laws of classical (Newtonian) mechanics, assist students in applying these principles to the student's area of interest, and to develop analytical problem-solving skills important to scientists and engineers. We will utilize the derivative and integral in both conceptual definitions and problem solving.

Outcomes:

Upon successful completion of this course, each student must have demonstrated understanding and competency in each of the following topics and techniques (through in-class testing of each individual student independently and collaborative lab-work):

1. Relate the basic concepts of physics and the methods scientists use to explore natural phenomena, including observation, hypothesis development, measurement and data collection, experimentation, evaluation of evidence, and employment of mathematical analysis.
2. Demonstrate the numerical evaluation of algebraic results rapidly and accurately, using appropriate units for physical quantities, including scientific notation.
3. Analyze data to assess the relationships between variables with the objective of drawing logical conclusions from the analysis.
4. Describe simple physical systems by graphing system variables, and interpret graphs of system variables.
5. Represent and interpret quantitative information symbolically, graphically, numerically, verbally, and in written form:
    a. Interpret graphical representations of data illustrating such important concepts as distance vs. time and force vs. acceleration.
    b. Represent, in graphical form, results from computational or experimental methodologies
6. Devise, perform, and analyze properly controlled experiments to test hypotheses regarding basic physics principles.
7. Describe Newton's laws of motion, state physical examples of each law, apply them to simple mechanical systems and demonstrate them through experimentation.

. Explain the concept of force
   a. Define the displacement and average velocity of a particle in motion.
   b. Define the instantaneous velocity and understand how this quantity differs from average velocity.
   c. Define average acceleration and instantaneous acceleration.
   d. Construct position versus time and velocity versus time graphs for a particle in motion along a straight line. From these graphs, determine both average and instantaneous values of velocity and acceleration.
   e. Obtain the instantaneous velocity and instantaneous acceleration if the position of a particle is given as a function of time.
   f. Recognize that the equations of kinematics apply when motion occurs under constant acceleration
   g. Describe what is meant by a body in free fall. Recognize that the equations of kinematics apply directly to a freely falling object where the acceleration is given by a = - g.
   h. Apply the equations of kinematics to any situation where the motion occurs under constant acceleration.
   i. Describe the displacement, velocity, and acceleration of a particle moving in the x-y plane.
   j. Explain the nature of the acceleration of a particle moving in a circle with constant speed.
   k. Describe the components of acceleration for a particle moving on a curved path, where both the magnitude and direction of v are changing with time.
   l. Discuss the concept of force and the effect of an unbalanced force on the motion of a body.
   m. Discuss the concepts of mass and inertia and understand the difference between mass and weight.
   n. Become familiar with the SI units of force (N), mass (kg) and acceleration (m/s2), and the relation of these units to the English units.
   o. Discuss the nature of the fundamental forces in nature (gravitational, electromagnetic and nuclear) and characterize the properties and relative strengths of these forces.

8. Explain the physical concepts of energy and momentum, the conservation of both concepts, and how they relate to different physical systems.
   a. Define the work done by a constant force.
   b. Recognize that the work done by a force can be positive, negative, or zero, and describe at least one example of each case.
   c. Describe the work done by a force that varies with position.
   d. Define the kinetic energy of an object of mass m moving with a speed v.
   e. Relate the work done by the net force on an object to the change in kinetic energy. The relation $W = \Delta K = K_f - K_i$ is called the work - energy theorem.
   f. Define the concepts of average power and instantaneous power (the time rate of doing work)
   g. Discuss the properties of conservative and non-conservative forces.

h. Explain the distinction between kinetic energy, potential energy, and the total mechanical energy of a system.
i. State the law of conservation of mechanical energy, noting that mechanical energy is conserved only when conservative forces act on a system.
j. Compute the potential energy function associated with a conservative force such as the force of gravity and the spring force.
k. Recognize that the gravitational potential energy function, $U_g = mgy$, can be positive, negative or zero, depending on the location of the coordinate system used to measure y.
l. Recognize that the spring potential energy function, $Us = \frac{1}{2}kx^2$, is either positive or zero.
m. Explain the concept of linear momentum of a particle and the relation between the resultant force on a particle and the time rate of change of its momentum.
n. Recognize that the impulse of a force acting on a particle over some time interval equals the change in momentum of the particle, and understand the impulse approximation which is useful in treating collisions.
o. Recognize that the linear momentum of any isolated system is conserved.
p. Describe and distinguish the two types of collisions that can occur between two particles, namely elastic and inelastic collisions.
q. Recognize that a perfectly inelastic collision is an inelastic collision in which the colliding particles stick together after the collision.
r. Understand the fact that conservation of linear momentum applies not only to head-on collisions (one-dimensional) but also to glancing collisions (two or three-dimensional).

9. Explain the properties and motions of rigid bodies.
    a. Explain and describe the concept of center of mass as applied to a collection of particles or a rigid body.
    b. Define the angular velocity and angular acceleration of a particle or body rotating about a fixed axis.
    c. Recognize that if a body rotates about a fixed axis, every particle on the body has the same angular velocity and angular acceleration.
    d. Note the similarity between the equations of rotational kinematics and those of linear kinematics.
    e. Describe and understand the relationships between linear speed and angular speed ($v = r\omega$), and between linear acceleration and angular acceleration.
    f. Calculate the moment of inertia I of a system of particles or a rigid body about a specific axis, including use of the parallel-axis theorem.
    g. Describe and illustrate the concept of torque associated with a force.
    h. Discuss the work-energy theorem as it is applied to a rotating rigid body.
    i. Define the angular momentum L of a particle moving with a velocity v relative to a specified point, and the torque τ acting on the particle relative to that point.
    j. Describe and apply the total angular momentum of a system of particles and a rigid body rotating about a fixed axis.
    k. Describe the two necessary conditions of equilibrium for a rigid body.

l. Locate the center of gravity of a system of particles or a rigid body and understand the difference between center of gravity and center of mass.

10. Describe and use Newton's universal law of gravity.
    a. State Kepler's three laws of planetary motion and recognize that the laws are empirical in nature, based on astronomical data.
    b. Recognize that Kepler's second law is a consequence of conservation of angular momentum and the central nature of the gravitational force.
    c. Describe the total energy of a planet or earth satellite moving in a circular orbit about a large body located at the center of motion.
11. Analyze and solve problems for objects that exhibit Simple Harmonic Motion.
    a. Sketch or identify a graph of displacement as a function of time, and determine from such a graph the amplitude, period, and frequency of the motion.
    b. Write down an appropriate expression for displacement of the form $A\sin(\omega t)$ or $A\cos(\omega t)$ to describe the motion.
    c. Find an expression for velocity as a function of time.
    d. State the relations between acceleration, velocity, and displacement, and identify points in the motion where these quantities are zero or achieve their greatest positive and negative values.
    e. State and apply the relation between frequency and period.
    f. Recognize that a system that obeys a differential equation of the form $dx^2/dt^2=-w^2x$ must execute simple harmonic motion, and determine the frequency and period of such motion.
    g. State how the total energy of an oscillating system depends on the amplitude of the motion, sketch or identify a graph of kinetic or potential energy as a function of time, and identify points in the motion where this energy is all potential or all kinetic.
    h. Calculate the kinetic and potential energies of an oscillating system as functions of time, sketch or identify graphs of these functions, and prove that the sum of kinetic and potential energy is constant.
    i. Calculate the maximum displacement or velocity of a particle that moves in simple harmonic motion with specified initial position and velocity.
    j. Develop a qualitative understanding of resonance so they can identify situations in which a system will resonate in response to a sinusoidal external force.
    k. Apply the expression for the period of oscillation of a mass on a spring.
    l. Analyze problems in which a mass hangs from a spring and oscillates vertically or horizontally.
    m. State what approximation must be made in deriving the period.
    n. Analyze the motion of a simple, torsional or physical pendulum

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PHY*C221

Syllabus

Fall 2016

Adjunct: Keith Gregorian-Michaelsen
860-597-6227
kgregorian-michaelsen@nwcc.edu

GW 303, Mon/Wed 6:30pm – 9:36pm

Text: Sears & Zemansky's University Physics, Vol. 1, 13th Edition, ISBN: 9780321733382

Curriculum Overview:

Physics is a science, which attempts to unify elements of the natural world by means of observation, mathematics, and the use of precise language. Using methods developed by physicists, we can describe many events that occur in everyday life. The principles of physics provided a basis for most of the technologies that are an essential part of modern life. In this sense, physics is *practical*. Many laws developed by physicists, such as the law of conservation of energy, are of tremendous practical importance. These same laws also help physicists understand the very tiny constituents of matter, micro level, as well as the motions of giant clusters of galaxies, macro level. Thus the study of physics helps us understand some fundamental relationships between the matter in our surroundings and the evolution of the universe. In this sense physics is *profound*. You are about to begin your own exploration of the natural world using some of the concepts, tools, and methods commonly employed by physical scientists.

Course Philosophy:

Physics is fundamentally an experimental science. The theories, laws, and mathematical descriptions of the physical universe that have been created during the past 3000 years are based on the experience and observations of our ancestors. In this course, the lecture and laboratory elements of the course are integrated. Thus, your understanding of physics is enhanced by class discussions, as well as your own predictions, observations, and experiments. Your ability to make observations, collect data, analyze results, and document your conclusions will be enriched through the use of technology. This technology consists of electronic sensors with data collection and different software applications. This will allow you to more efficiently collect data, perform mathematical calculations, graphically analyze results, simulate physical events, and develop mathematical models that represent the physical world.

The use of direct experience, technology, and active participation will enable you to have a much more robust learning experience. In addition to mastering an important body of knowledge and learning how to solve traditional physics problems, you should be able to further develop your reasoning ability and computer and laboratory skills to a much greater extent than you would in a traditional introductory physics course.

Course Overview:

CALCULUS-BASED PHYSICS
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Syllabus

This course meets twice weekly. At each meeting we will begin with an investigation that will be followed by a class discussion on concept being investigated. Before coming to class, it is essential that you have read the sections identified in the syllabus. It is highly suggested that you take notes while you are reading. The reading and resulting notes will assist you when completing the activities and during the discussions that follow. Along with the readings, problems are assigned for each concept we will investigate. These problems represent a sample of the types of problems that you should be able to solve. You should attempt these problems after we have completed the investigation and the associated discussion. Failure to attempt the problems in a timely manner will impact your ability to learn new material since the concepts build upon each other. Any problems that you are not able to successfully complete can be discussed in class, however you must bring your work showing you have attempted to apply the problem solving process to solve the requested problem. The assigned problems will be collected in order to assess your level of proficiency. In addition, practice problems will be provided for those types of problems that are not well represented in the textbook. These problems will be posted on the class website within the appropriate content area.

Attendance:

Attendance will be taken at the beginning of each class. Students are expected to attend class regularly and are responsible for ***all*** material presented in class or assigned.

Grading Policy: The semester grade will be in accordance with the college catalog. All assignments are due on or before the due date, late assignments will receive a 20% penalty for each week they are late.

The semester grade will be calculated as follows:

Exams	30%
Laboratory Investigations	30%
Homework	10%
Final Exam	20%
Participation	10%

*There are no make-ups for missed labs.

College Policies

Plagiarism: Plagiarism and Academic Dishonesty are not tolerated at Northwestern Connecticut Community College. Violators of this policy will be subject to sanctions ranging from failure of the assignment (receiving a zero), failing the course, being removed/expelled from the program and/or the College. Please refer to your "Student Handbook" under "Policy on Student Rights," the Section entitled "Student Discipline," or the College catalog for additional information.

Americans with Disabilities Act (ADA): The College will make reasonable accommodations for persons with documented learning, physical, or psychiatric disabilities. Students should notify Dr. Christine Woodcock, the Counselor for Students with Disabilities. She is located at Green Woods Hall, in the Center for Student Development. Her phone number is 860-738-6318 and her email is cwoodcock@nwcc.edu.

School Cancellations: If snowy or icy driving conditions cause the postponement or cancellation of classes, announcements will be made on local radio and television stations and posted on the College's website at www.nwcc.edu. Students may also call the College directly at **(860) 738-6464** to hear a recorded message concerning any inclement weather closings. Students are urged to exercise their own judgment if road conditions in their localities are hazardous.

Use of Electronic Devices: Some course content as presented in Blackboard Learn is not fully supported on mobile devices at this time. While mobile devices provide convenient access to check in and read information about your courses, they should not be used to perform work such as taking tests, quizzes, completing assignments, or submitting substantive discussion posts.

Sexual Assault and Intimate Partner Violence Resource Team: NCCC is committed to creating a community that is safe and supportive of people of all gender and sexual identities. This pertains to the entire campus community, whether on ground or virtual, students, faculty, or staff.
Sexual assault and intimate partner violence is an affront to our national conscience, and one we cannot ignore. It is our hope that no one within our campus community will become a victim of these crimes. However, if it occurs, NCCC has created the SART Team - Sexual Assault and Intimate Partner Violence Resource Team - to meet the victim's needs.
SART is a campus and community based team that is fully trained to provide trauma-informed compassionate service and referrals for comprehensive care. The team works in partnership with The Susan B. Anthony Project to extend services 24 hours a day, 7 days a week throughout the year.
The NCCC team members are:

Ruth Gonzalez, Ph.D.	860-738-6315	Green Woods Hall Room 207
Susan Berg	860-738-6342	Green Woods Hall Room 223
Kathleen Chapman	860-738-6344	Green Woods Hall Room 110
Michael Emanuel	860-738-6389	Founders Hall Annex Room 308
Seth Kershner	860-738-6481	Library
Jane O'Grady	860-738-6393	Founders Hall Annex Room 212
Robin Orlomoski	860-738-6416	Business Office Room 201
Patricia Bouffard, Ex-Officio	860-738-6319	Founders Hall Room 103
Savannah Schmitt		Student Representative

At NCCC we care about our students, staff and faculty and their well-being. It is our intention to facilitate the resources needed to help achieve both physical and emotional health.