Miami-Dade Community College
PHY 4220 Classical Mechanics

PHY 4220

Course Description

This one-semester course will provide students with a deep understanding some fundamental topics of classical mechanics, reinforcing the concepts learned in PHY2048, and providing a sound foundation for their comprehension. Most of the topics of elementary mechanics will be studied in a rigorous manner, requiring a higher level of math. Content includes Newtonian particle mechanics, oscillations, noninertial reference frames, central forces, dynamics of systems, mechanics of rigid bodies, the Lagrangian formulation of dynamics, and an overview of the Hamiltonian formulation.
The course will emphasize problem-solving techniques and computer simulations. **3 credits**

Pre-requisites: PHY2048, PHY2049, MAP2302

Course Competencies

Competency 1- The student will demonstrate knowledge, comprehension and application of particle kinematics by:

a) Using vectors and vector operations in two and three dimensions.
b) Performing coordinate transformations using matrices.
c) Expressing and manipulating position, velocity and acceleration vectors in rectangular, cylindrical and spherical coordinates.

Competency 2- The student will demonstrate knowledge, comprehension, analysis and application of the Newtonian mechanics for a particle by:

a) Defining all the fundamental concepts associated with Newton's laws, work-energy methods and momentum methods, such as mass, work, kinetic and potential energy, momentum, etc.
b) Applying Newton's laws, momentum, and work-energy methods to situations involving constant and variable forces: time dependent, position-dependent forces and velocity-dependent forces.
c) Applying Newton's laws, momentum, and work-energy methods to projectile motion in two and three dimensions.
d) Applying Newton's laws and work-energy methods to harmonic motion in one dimension, with and without damping; with and without external forces.
e) Using Newton's laws and work-energy methods and the method of successive approximations to analyze nonlinear oscillators.

Competency 3- The student will demonstrate knowledge, comprehension, analysis and application of noninertial reference frames by:

a) Adapting the kinematics and dynamics of inertial frames to noninertial frames.
b) Applying Newton's laws of motion to a particle in a rotating frame of reference.

c) Deducing the effect of the earth's rotation on different systems such as projectiles, pendula, air masses, etc.

Competency 4- The student will demonstrate knowledge, comprehension, analysis and application of central forces by:

a) Deriving the gravitational forces generated by a spherical source.
b) Stating and deriving Kepler's Laws of planetary motion.
c) Applying work-energy methods to the gravitational field.
d) Applying Newton's laws of motion, momentum, and work-energy methods to orbits in an attractive central field and to an inverse square repulsive field.
e) Using computers to simulate orbits.

Competency 5- The student will demonstrate knowledge, comprehension, analysis and application of the dynamics of a system of particles by:

a) Applying center of mass, momentum and energy methods to systems of particles, a system of two interacting bodies, and to collisions in one and two dimensions.
b) Applying center of mass, momentum and energy methods to bodies with variable mass.

Competency 6- The student will demonstrate knowledge, comprehension, analysis and application of the mechanics of rigid bodies by:

a) Defining the fundamental concepts surrounding the mechanics of rigid bodies: center of mass, rotational inertia, torque, angular momentum, and rotational kinetic energy.
b) Applying Newton's laws, momentum and work-energy methods to the rotation of a rigid body about a fixed axis.
c) Applying Newton's laws, momentum and work-energy methods to the physical pendulum in two and three dimensions.
d) Applying Newton's laws, momentum and work-energy methods to collisions involving rigid bodies.
e) Calculating the moments and products of inertia, angular momentum and kinetic energy of a rigid body about an arbitrary axis.
f) Defining and finding the principal axes of a rigid body.
g) Stating and using Euler's equations to analyze the motion of a rigid body.
h) Analyzing the general motion of a rigid body: rolling wheel.
i) Describing geometrically the free rotation of a rigid body.
j) Applying Newton's laws, momentum and work-energy methods to the motion of a spinning top, gyroscopic precession.

Competency 7- The student will demonstrate knowledge, comprehension, analysis and application of the Lagrangian formulation of mechanics by:

a) Stating Hamilton’s variational principle.
b) Defining generalized coordinates and using them to describe and analyze the motion of mechanical systems.
c) Deriving Lagrange’s equations from Hamilton’s principle.
d) Conservation theorems and symmetry properties.
e) Energy function and the conservation of energy.
f) Applying Lagrange’s equations to mechanical systems.
g) Defining generalized momenta and ignorable coordinates and using them to describe and analyze the motion of mechanical systems.
h) Defining the Hamiltonian function.
i) Stating Hamilton’s equations and applying them to mechanical systems.

Competency 8- The student will demonstrate knowledge, comprehension, analysis and application of the dynamics of oscillating systems by:

a) Relating potential energy, equilibrium, and stability.
b) Analyzing the oscillations of a system with one degree of freedom about a position of stable equilibrium.
c) Analyzing the motion of coupled harmonic oscillators using normal coordinates.
d) Analyzing in general the motion of vibrating systems.
e) Analyzing the vibration of a continuous system and deriving the wave equation.
f) Solving, interpreting the solution, and applying the wave equation.