Learning Goals for UFV Physics 111 F2011 (Joss Ives)

These are things that you should concentrate on in your learning and are the things that you will be expected to be able to do on homework assignments, quizzes and exams. Learning goals should be read as "Student should be able to..."

**Part 1 – Linear Dynamics**

**Unit 1 – One-Dimensional Kinematics**

- Calculate average velocity during a specified time interval using a position-versus-time graph.
- Calculate or approximate instantaneous velocity at a specific time using the slope of a position-versus-time graph.
- Given a polynomial expression for position as a function of time, use differentiation to find the expression for velocity as a function of time or at a specific time.
- Use graphical integration (area under the curve) to find the displacement as a function of time given a velocity-versus-time curve.
- Given a polynomial expression for velocity as a function of time, use integration to find the expression for the change in displacement as a function of time. Given the displacement at a certain instant in time, find the displacement at some other time.
- Calculate or approximate acceleration at a specific time using the slope of a velocity-versus-time graph.
- Given a polynomial expression for acceleration as a function of time use integration to find the expression for the change in velocity as a function of time. Given the velocity or other necessary information at a certain instant in time, find the velocity at some other time.
- Use graphical integration (area under the curve) to find the velocity as a function of time given an acceleration-versus-time curve.
- Apply the three equations for motion with constant acceleration (i.e., \( v = v_0 + at \); \( x = x_0 + v_0t + \frac{1}{2}at^2 \); \( v^2 = v_0^2 + 2a[x-x_0] \)) to solve quantitative kinematics problems in one dimension.
- Compare and contrast the relationship between the direction of the velocity and the acceleration when an object is speeding up, slowing down, or at a turning point.
- Create and interpret motion diagrams. A motion diagram is a pictorial description of an object in motion which shows an object’s position, represented by dots, at equally spaced time intervals. The spacing between dots gives information about the object’s velocity and acceleration. For example, an object that is slowing down is represented by a continuously increasing distance between the dots in the direction that the object is traveling.
- Draw acceleration vectors based on the velocity vectors from a motion diagram, or draw future velocity vectors based on an initial velocity vector and known acceleration vectors.
- Translate between position-versus-time, velocity-versus-time, and acceleration-versus-time graphs. This includes being able to roughly draw the parabolic shape that corresponds to the integration of a linear graph. Calculate or approximate values at a specific time or average values over a specific time range from these graphs.
• Translate between and interpret the different representations of information for the motion of an object in one dimension: word descriptions of motion, kinematic graphs (position, velocity or acceleration-versus-time), motion diagrams, and numerical/symbolic equations/statements.

**Unit 2 – Two-Dimensional Kinematics**

• Compare and contrast scalars and vectors
• Add and subtract vectors graphically or mathematically by breaking the vectors into Cartesian components.
• Convert between the two major two-dimensional vector representations: Cartesian components (using x and y components along with unit vectors) and polar coordinates (magnitude and angle).
• Describe the horizontal and vertical components of velocity and acceleration at every point along the trajectory for an object undergoing projectile motion.
• Solve projectile motion problems for objects whose motion starts and ends at the same height (such as kicking a ball in a soccer field) or at different heights (such as throwing an object onto a roof or off of a bridge).
• Discuss the assumptions required to be able to correctly apply the range equation. Recognize the two following insights provided by the range equation: maximum range occurs for a launch angle of 45 degrees, and the range for complimentary angles is the same.
• Demonstrate mastery of “Unit 1 – One-Dimensional Kinematics” learning goals in two or three-dimensional situations.
• Apply the three equations for motion with constant acceleration to solve quantitative kinematics problems in two or three dimensions.

**Unit 3 – Relative and Circular Motion**

• Translate displacement and velocity between two different frames of reference.
• There are no specific learning goals for these sections.
• Relate an object’s velocity or angular velocity to its period of rotation which is the time it takes the object to make one revolution.
• Perform calculations relating an object's centripetal acceleration; its instantaneous velocity or angular velocity; and the radius of curvature of its path.
• Explain how an object can have a non-zero acceleration even if its speed is constant.
• Compare and contrast the direction of acceleration for objects undergoing constant speed circular motion and varying speed circular motion.

**Unit 4 – Newton’s Laws**

• Recognize what does and does not constitute a force. Identify the specific forces acting on an object.
• Use superposition to find the net force acting on an object.
• Qualitatively relate the net force acting on an object to its motion.
• Perform calculations using Newton’s Second Law which relates the net force on an object, the object’s mass and its acceleration.
• There are no specific learning goals for this section. Learning goals for the concept of momentum are found in the Unit 12 learning goals.
• There are no specific learning goals for this section.
• Discuss why a given reference frame is or isn’t an inertial reference frame.
• Identify the action-reaction force pairs produced by two interacting bodies.
• Recognize situations where two or more objects have the same acceleration due to maintaining contact with each other or being attached to each other. Solve problems involving these situations including finding the net force acting on each of these objects.

Unit 5 – Forces and Free-Body Diagrams

• Compare and contrast the concepts of mass and weight.
• Correctly identify the normal force (magnitude and direction) exerted on an object by a surface with which it is in contact. Correctly identify the tension force (magnitude and direction) exerted on an object by a string, rope or other similar object with which it is in contact.
• Relate the restoring force applied by a spring to the distance which has been stretched or compressed relative to its relaxed position and the stiffness of the spring.
• Solve problems using the Universal Law of Gravitation which relates the attractive gravitational forces two objects exert on each other to their masses, the distance between them, and the universal gravitation constant.
• Draw an accurate free-body diagram of a system, which includes excluding forces which are internal to the system (such as 3rd law force pairs).
• Calculate the apparent weight of an object and relate the motion of an object to descriptions/graphs of its apparent weight. Apparent weight is the support force which would be measured by an object such as a bathroom scale (which measures the normal force applied to the object) or a rope attached to a force scale (which measures the tension force holding up the object).
• Calculate the magnitude of the gravitational force and the normal force (apparent weight) acting on a body at rest or moving in one dimension.
• Translate between expressions/graphs of net force acting on an object as a function of time and the resulting expressions/graphs for position or velocity as a function of time.

Unit 6 – Friction

• Calculate the static or kinetic friction forces acting on a body. This includes determining if it is a static of kinetic friction force that is present in a given situation.
• Given both static and kinetic friction coefficients, determine if an object is at rest or in motion relative to a surface with which it is in contact for situations such as a block on a ramp, attempting to slide an object across a surface or attempting to pull a surface out from under an object.
• Correctly identify the direction of the net force required to keep an object travelling in a circle at a constant speed.
• Solve “rounding a curve” problems that involve friction, a banked curve or both. These problems may involve finding quantities such as the radius of the curve, the speed of the object, a coefficient of friction or the angle of the bank.

Part 2 – Conservation Laws

Unit 7 – Work and Kinetic Energy

• Calculate the work done by a constant force on a body that undergoes a displacement.
• Calculate the kinetic energy of an object.
• Perform calculations using the work-kinetic energy theorem, which relates the net work done on an object to its change in kinetic energy.
• Find the dot product of two vectors using vector components, or using the magnitude of the vectors and the angle between. Use the result of a dot product to find an unknown vector component or the angle between two vectors.
• Identify if the net work done on an object is positive, negative or zero based on the relative directions of the net force being applied and the body's displacement. Relate the motion of an object (speeding up or slowing down) to the sign of the net work (positive or negative) which has been done to it.
• Calculate the net work done when many forces are applied to an object.
• Recognize the work-kinetic energy theorem as a statement of the conservation of energy.
• Calculate the work done on an object by a varying force, a technique which requires the use of integration.
• Relate the work done by a spring to the initial and final distances it has been displaced (stretched or compressed) from its relaxed position.
• Recognize that the work-kinetic energy theorem is valid for varying forces and displacements along a curved path, in addition to constant forces applied along straight paths.
• Recognize that work done by a conservative force depends only on the endpoints (initial and final positions) and not on the specific path traveled between those endpoints.

Unit 8 – Conservative Forces and Potential Energy

• Recognize that the work done by a conservative force around a closed path is zero.
• There are no new learning goals for this section.
• Recognize the distinction between conservative and nonconservative forces.
• Recognize that mechanical energy is conserved whenever the net work done by all non-conservative forces is zero.
• Calculate the change in gravitational potential energy in a system.
• Explain how two different people could get two different values for the gravitational potential energy of a system.
• Use conservation of mechanical energy to analyze mechanics problems involving kinetic and gravitational potential energies.
• Calculate the change in elastic potential energy in a system due to the compression or extension of a spring, or due to the work done on or by a spring.
• Use conservation of mechanical energy to analyze mechanics problems involving kinetic, gravitational potential energies and elastic potential energies.
• Solve problems in which both conservative and nonconservative forces act on a moving body.

Unit 9 – Work and Potential Energy

• Perform calculations involving the work done by a nonconservative force such as friction.
• We will be covering only the sections "9.2 – Box Sliding Down a Ramp" and "9.3 – Work Done by Kinetic Friction."

Unit 10 – Center of Mass

• Locate the center-of-mass of a two-body system, of a multi-body system, for continuous mass distributions, or for a system of objects. For continuous mass
distributions, the most challenging integral you will be asked to perform is the integration of a polynomial expression.

- Analyze systems consisting of multiple bodies and/or continuous mass distributions using the center-of-mass versions of the work-kinetic energy theorem (called the center-of-mass equation) or Newton’s Second Law (called the equation of motion for the center of mass).
- Convert between the lab and center-of-mass reference frames

**Unit 11 – Conservation of Momentum**

- Calculate the momentum of an object.
- Recognize that the total momentum of a system is conserved (is constant) when the total external force applied to this system is zero.
- Analyze inelastic collisions using conservation of momentum. Note that the term collisions also includes “collisions in reverse” such as explosions and recoil.
- Recognize that kinetic energy is not conserved in inelastic collisions, and that this is a consequence of the internal forces being non-conservative. Discuss the forms of energy to which this lost kinetic energy is converted.
- Analyze inelastic collisions in the center-of-mass reference frame and recognize that the total momentum is always zero in this reference frame.

**Unit 12 – Elastic Collisions**

- Recognize that kinetic energy is conserved in elastic collisions, and that this is a consequence of the internal forces being conservative
- Analyze elastic collision collisions in the lab frame and the center-of-mass reference frame.

**Part 3 – Rotational Dynamics**

**Unit 14 – Rotational Kinematics and Moment of Inertia**

- Describe the rotation of a rigid body in terms of angular position, angular velocity, and angular acceleration.
- Analyze rigid-body rotation when the angular acceleration is constant using the rotational equations of motion.
- Translate between the linear parameters of distance, speed and acceleration to the rotational parameters of angle (angular distance), angular velocity and angular acceleration at a point on a rotating rigid body.
- Use superposition to determine the moment of inertia of a system for a number of point-like or solid objects. Although we will discuss how to find the moment of inertia of solid objects such as cylinders and spheres, you will not be asked to find the moment of inertia of these objects on your own.
- Determine the moment of inertia of a rod or other one-dimensional solid object where the calculation requires the integration of a polynomial.
- Determine the rotational kinetic energy of a system of objects of known moments of inertia about a given axis of rotation.

**Unit 15 – Parallel Axis Theorem and Torque**
• Find the cross product of two vectors using vector components, or using the magnitude of the vectors and the angle between. Use the result of a cross product to find an unknown vector component or the angle between two vectors.
• Determine the net torque about a certain point due to one or more forces.
• Use the rotational analog of Newton's second law (the net torque is equal to the product of the moment of inertia and the angular acceleration) to analyze a rotating rigid body.
• We will be covering only the sections "15.4 – Torque and Angular Acceleration", "15.5 – Example: Closing a Door" and "15.6 – Torque and the Cross Product."

Unit 16 – Rotational Dynamics

• Calculate work in a rotational system which is the integral of the net torque over the angular displacement.
• Find the total kinetic energy of a solid object which is sum of the kinetic energy of its center of mass and its rotational kinetic energy, which is due to the rotation of the object around an axis through its center of mass.
• Analyze systems consisting of both translational and rotational motion (such as a rolling ball) using dynamics and/or energy.

Unit 17 – Rotational Statics: Part 1

• Find the torque due to the weight of an object by treating it as if the entire mass of the object is located at its center of mass.
• For a system in equilibrium, find all the forces acting on the system. Some forces may need to be resolved into normal and frictional forces.

Unit 19 – Angular Momentum

• Relate the angular momentum of a system to its moment of inertia and angular velocity.
• Analyze collisions or deformation in rotating systems using conservations of momentum. Examples of collisions include a person stepping onto or off of a merry-go-round. An example of a deformation is a person on a merry-go-round making their way toward the center.

Course-Scale Learning Goals

• Be fluent with your physics vocabulary. Be able to compare and contrast, or distinguish between terms which are often used interchangeably outside of physics such as speed and velocity, or between terms which sound similar, but are completely different such as potential and potential energy.
• Use proportional reasoning. For example be able to correctly determine that an object travelling at a speed 2\(v\) has a kinetic energy \(K=mv^2/2\) that is 4 times that of when it was travelling at a speed \(v\).
• List the assumptions made for a given model and be prepared to discuss the weaknesses of each assumption.
• Perform unit conversions.
• Verify that an equation is dimensionally consistent, that is by using the appropriate unit conversions, you can verify that both sides of an equation have the same units.
• Explain and follow the rules for keeping track of significant figures in your calculation.
• Make use of graphical interpretation for situations where differentiation and integration would normally be used. Examples include finding the slope of a velocity-versus-time graph to find acceleration or integrating a force-versus-displacement graph to find work.
• Derive appropriate physical parameters of a system when presented with a graph. Examples include using the slope of a velocity-versus-time graph to find acceleration or finding the area under the curve (graphical integration) for a force-versus-displacement graph to find work.
• Transfer the techniques and concepts learned in this course to novel contexts (that is, being able to solve problems which do not map directly to those which have been previously encountered).