# Newtonian Mechanics

## B. Newton's Laws of Motion *(Ch 4)*

**Static Equilibrium (1st Law)**:

Students should be able to analyze situations in which a particle remains at rest, or moves with constant velocity, under the influence of several forces. *(4.2)*

**Dynamics of a Single Particle (2nd Law)**:

Students should understand the relation between the force that acts on an object and the resulting change in the object's velocity so they can:

- Calculate, for an object moving in one dimension, the velocity change that results when a constant force ***F*** acts over a specified time interval. *(4.3)*
- Determine, for an object moving in a plane whose velocity vector undergoes a specified change over a specified time interval, the average force that acted on the object. *(4.3)*

Students should understand how Newton's Second Law, $\boldsymbol{F} = m \cdot \boldsymbol{a}$, applies to an object subject to forces such as gravity, the pull of strings, or contact forces, so they can:

- Draw a well-labeled diagram showing all real forces that act on the object. *(4.5)*
- Write down the vector equation that results from applying Newton's Second Law to the object, and take components of this equation along the appropriate axes. *(4.5)*

Students should be able to analyze situations in which an object moves with specified acceleration under the influence of one or more forces so they can determine the magnitude and direction of the net force, or of one of the forces that makes up the net force, such as motion up or down with constant acceleration. *(4.5)*

Students should understand the significance of the coefficient of friction so they can:

- Write down the relationship between the normal and frictional forces on a surface. *(4.6)*
- Analyze situations in which an object moves along a rough inclined plane or horizontal surface. *(4.6)*
- Analyze under what circumstances an object will start to slip, or to calculate the magnitude of the force of static friction. *(4.6)*

Students should understand the effect of drag forces on the motion of an object so they can:

- Find the terminal velocity of an object moving vertically under the influence of a retarding force dependent on velocity. *(4.6)*

**Systems of Two or More Objects (3rd Law)**:

Students should:

- Understand Newton's 3rd Law so that, for a given system, they can identify the force pairs and the objects on which they act, and state the magnitude and direction of each force. *(4.4)*
- Be able to apply Newton's 3rd Law in analyzing the force of contact between two objects that accelerate together along a horizontal or vertical line, or between two surfaces that slide across one another. *(4.4)*
- Know that the tension is constant in a light string that passes over a massless pulley and be able to use this fact in analyzing the motion of a system of two objects joined by a string. *(4.4 - 4.5)*
- Be able to solve problems in which applications of Newton's laws leads to two simultaneous linear equations involving unknown forces or accelerations. *(4.4 - 4.5)*

**Equations – Newton's Laws of Motion *(Ch 4)***:

$$\sum F = F_{net} = m \cdot a \qquad\qquad F_f \leq \mu \cdot N$$

C. Work, Energy, and Power *(Ch 5)*

**Work and the Work-Energy Theorem**:

Students should understand the definition of work, including when it is positive, negative, or zero, so they can:

- Calculate the work done by a specified constant force on an object that undergoes a specified displacement. *(5.1)*
- Relate the work done by a force to the area under a graph of force as a function of position, and calculate this work in the case where the force is a linear function of position. *(5.8)*
- Use the scalar product operation to calculate the work performed by a specified constant force ***F*** on an object that undergoes a displacement in a plane. *(5.1)*

Students should understand and be able to apply the work-energy theorem so they can:

- Calculate the change in kinetic energy or speed that results from performing a specified amount of work on an object. *(5.2)*
- Calculate the work performed by the net force, or by each of the forces that makes up the net force, on an object that undergoes a specified change in speed or kinetic energy. *(5.2)*
- Determine the change in an object's kinetic energy and speed that results from the application of specified forces, or determine the force that is required in order to bring an object to rest in a specified distance. *(5.2)*

**Forces and Potential Energy**:

Students should understand the concept of potential energy so they can:

- Calculate the potential energy of one or more objects in a uniform gravitational field. *(5.3)*

**Conservation of Energy**:

Students should understand concepts of mechanical energy and total energy so they can:

- Describe and identify situations in which mechanical energy is converted to other forms of energy. *(5.4)*
- Analyze situations in which an object's mechanical energy is changed by friction or by a specified externally applied force. *(5.6)*

Students should understand conservation of energy so they can:

- Identify situations in which mechanical energy is or is not conserved. *(5.4)*
- Apply conservation of energy in analyzing the motion of systems of connected objects, such as an Atwood's machine. *(5.5)*

**Power**:

Students should understand the definition of power so they can:

- Calculate the power required to maintain the motion of an object with constant acceleration (e.g., to move an object along a level surface, to raise an object at a constant rate, or to overcome friction for an object that is moving at a constant speed.) *(5.7)*
- Calculate the work performed by a force that supplies constant power, or the average power supplied by a force that performs a specified amount of work. *(5.7)*

**Equations – Work, Energy, & Power *(Ch 5)***:

$$K = \frac{1}{2} m \cdot v^2 \qquad \Delta U_g = m \cdot g \cdot h \qquad W = F \cdot \Delta r \cdot \cos\theta$$

$$P_{avg} = \frac{W}{\Delta t} \qquad P = F \cdot v \cdot \cos\theta$$

*** AP Course Outline information is taken from the Teacher's Guide to Advance Placement Courses in Physics, published by the College Entrance Examination Board and Educational Testing Service. ***