Section Summary

5.1 Vector Addition and Subtraction: Graphical Methods

- The graphical method of adding vectors A and **B** involves drawing vectors on a graph and adding them by using the head-to-tail method. The resultant vector **R** is defined such that **A** + **B** = **R**. The magnitude and direction of R are then determined with a ruler and protractor.
- The graphical method of subtracting vectors **A** and **B** involves adding the opposite of vector **B**, which is defined as −**B**. In this case, **A** – **B** = **A** + (–**B**) = **R**. Next, use the head-to-tail method as for vector addition to obtain the resultant vector R .
- Addition of vectors is independent of the order in which they are added; **A** + **B** = **B** + **A**.
- The head-to-tail method of adding vectors involves drawing the first vector on a graph and then placing the tail of each subsequent vector at the head of the previous vector. The resultant vector is then drawn from the tail of the first vector to the head of the final vector.
- Variables in physics problems, such as force or velocity, can be represented with vectors by making the length of the vector proportional to the magnitude of the force or velocity.
- Problems involving displacement, force, or velocity may be solved graphically by measuring the resultant vector's magnitude with a ruler and measuring the direction with a protractor.

5.2 Vector Addition and Subtraction: Analytical Methods

- The analytical method of vector addition and subtraction uses the Pythagorean theorem and trigonometric identities to determine the magnitude and direction of a resultant vector.
- The steps to add vectors A and B using the analytical method are as follows:
  1. Determine the coordinate system for the vectors. Then, determine the horizontal and vertical components of each vector using the equations
     $A_x = A\cos\theta$
     – $B_x = B\cos\theta$
     and
     $A_y = A\sin\theta$
     $B_y = B\sin\theta.$
  2. Add the horizontal and vertical components of each vector to determine the components R_x and R_y of the resultant vector, R.
     – $R_x = A_x + B_x$
     and
     $R_y = A_y + B_y$.

3. Use the Pythagorean theorem to determine the magnitude, R, of the resultant vector R.
- $R = \sqrt{R_x^2 + R_y^2}$
4. Use a trigonometric identity to determine the direction, θ, of R.
- $\theta = \tan^{-1}(R_y/R_x)$

5.3 Projectile Motion

- Projectile motion is the motion of an object through the air that is subject only to the acceleration of gravity.
- Projectile motion in the horizontal and vertical directions are independent of one another.
- The maximum height of an projectile is the highest altitude, or maximum displacement in the vertical position reached in the path of a projectile.
- The range is the maximum horizontal distance traveled by a projectile.
- To solve projectile problems: choose a coordinate system; analyze the motion in the vertical and horizontal direction separately; then, recombine the horizontal and vertical components using vector addition equations.

5.4 Inclined Planes

- Friction is a contact force between systems that opposes the motion or attempted motion between them. Simple friction is proportional to the normal force **N** pushing the systems together. A normal force is always perpendicular to the contact surface between systems. Friction depends on both of the materials involved.
- μ_s is the coefficient of static friction, which depends on both of the materials.
- μ_k is the coefficient of kinetic friction, which also depends on both materials.
- When objects rest on an inclined plane that makes an angle θ with the horizontal surface, the weight of the object can be broken into components that act perpendicular ($\mathbf{w}_\perp$) and parallel ($\mathbf{w}_{||}$) to the surface of the plane.

5.5 Simple Harmonic Motion

- An oscillation is a back and forth motion of an object between two points of deformation.
- An oscillation may create a wave, which is a disturbance that propagates from where it was created.
- The simplest type of oscillations are related to systems that can be described by Hooke's law.
- Periodic motion is a repetitious oscillation.
- The time for one oscillation is the period T.
- The number of oscillations per unit time is the frequency

- A mass m suspended by a wire of length L is a simple pendulum and undergoes simple harmonic motion for amplitudes less than about 15 degrees.