	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
(COMPETENCY GOAL 1 is listed at the end of this document, since it does not address physics content.)				
COMPETENCY GOAL 2: The learner will build an understanding of linear motion.				
Objective				
2.01 Analyze velocity as a rate of change of position:	2.3 - 2.5	2.3 - 2.5	2.3 - 2.5	
• Average velocity.	2.4	2.4	2.4	
• Instantaneous velocity.	2.5	2.5	2.5	
Content Description				
Identify a frame of reference for measurement of position and identify the initial position of the object.	2.1	2.1	2.1	·Skee-Ball
Develop the definition of velocity as the rate of change of position conceptually, mathematically and graphically (see 2.04).	2.3 - 2.8, 2.13 - 2.14	2.3 - 2.8	2.3 - 2.7	·Skee-Ball
Apply the equation developed to several applications where objects are moving with constant velocity: $v = \Delta x / \Delta t$ $x_f = x_i + vt$	2.3 - 2.8	2.3 - 2.8	2.3 - 2.7	·Skee-Ball
Objective				
2.02 Compare and contrast as scalar and vector quantities:				
• Speed and velocity.	2.3	2.3	2.3	
• Distance and displacement.	2.2	2.2	2.2	
Content Description				
Define *vector* and *scalar*, incorporating magnitude and direction.	3.1 - 3.2	3.1 - 3.2	3.1 - 3.2	
Apply concepts of speed and velocity to solve conceptual and quantitative problems.	2.37, 4.29	2.33, 4.27	2.23	·Skee-Ball
Distinguish between distance and displacement conceptually and mathematically.	2.2	2.2	2.2	·Skee-Ball
Clarify that a positive value for velocity indicates motion in one direction while a negative value indicates motion in the opposite direction.	2.2 - 2.3	2.2 - 2.3	2.2 - 2.3	·Skee-Ball
Objective				
2.03 Analyze acceleration as rate of change in velocity.	2.10 - 2.12	2.10 - 2.12	2.8 - 2.10	
Content Description				

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Develop the definition for constant (uniform) acceleration as the rate of change of velocity conceptually, mathematically, and graphically (see 2.04).	2.10 - 2.13, 2.16 - 2.18	2.10 - 2.12, 2.14 - 2.16	2.8 - 2.13	·Skee-Ball
Analyze visual representations of constant and changing velocity. (see 2.04)	2.9, 2.18	2.9, 2.16	2.13	·Skee-Ball
Use kinematics equations for acceleration: $x_f = x_i + vt + (1/2)at^2$ $a = \Delta v/\Delta t$ $v_f^2 = v_i^2 + 2a\Delta x$	2.16 - 2.18, 2.20 - 2.25	2.14 - 2.16, 2.18 - 2.22	2.11 - 2.13, 2.15 - 2.17	·Skee-Ball
Apply concepts of constant (uniform) acceleration to objects in free fall.	2.26 - 2.29	2.23 - 2.26	2.18 - 2.19	·Firing a cannon ·Juggling objects

Objective

2.04 Using graphical and mathematical tools, design and conduct investigations of linear motion and the relationships among:
- Position.
- Average velocity.
- Instantaneous velocity
- Acceleration.
- Time.

	Chapter 2	Chapter 2	Chapter 2	

Content Description

Constant velocity:				
Measure position versus time of an object moving with constant velocity.	2.6 - 2.8, 2.15	2.6 - 2.8, 2.13	2.6 - 2.7	·Skee-Ball
Plot a position versus time graph of the measurements.	2.6 - 2.8	2.6 - 2.8	2.6 - 2.7	
Recognize that the relationship is linear and construct a best-fit line.	2.6 - 2.8	2.6 - 2.8	2.6 - 2.7	
Identify the slope of the line as the change in position over time (velocity) and the y-intercept as the initial position for the given time interval.				
Using the slope y-intercept equation (y = mx + b) from the graphs above, derive the mathematical relationships:				
*final position=average velocity*time + initial position*				
*final position - initial position=average velocity*time*				
$v = \Delta x/\Delta t$				
Define change in position as *displacement* and show the average velocity equation (v = Δx/Δt)	2.2 - 2.4	2.2 - 2.4	2.2 - 2.4	·Skee-Ball
Constant acceleration:				
Measure position and time of an object moving with constant acceleration.	2.28	2.25		·Skee-Ball

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Plot a position vs. time graph of the measurements.	2.28	2.25		
Recognize that the relationship is not linear but fits the shape of a parabola indicating that position is proportional to time squared.	2.28	2.25		
At various points on the curve, draw lines tangent to the curve and develop the concept of instantaneous velocity (represented by the slope of the tangent line at that time instant).	2.6	2.6	2.6	
Give several examples of and compare position vs. time, velocity vs. time and acceleration vs. time graphs.	2.6 - 2.9, 2.12 - 2.14	2.6 - 2.9, 2.12	2.6 - 2.7, 2.10	
Recognize that the slope of the line on an instantaneous velocity vs. time graph is the acceleration.	2.12	2.12	2.10	
Develop the equations for objects that are experiencing constant acceleration (rolling down an inclined plane or objects falling toward the earth): $x_f = x_i + vt + (1/2)at^2$ $a = \Delta v/\Delta t$ $v_f^2 = v_i^2 + 2a\Delta x$	2.19 - 2.20, 2.24	2.17 - 2.18	2.14 - 2.15	·Skee-Ball ·Firing a cannon ·Juggling objects

COMPETENCY GOAL 3: The learner will build an understanding of two-dimensional motion including circular motion.

Objective

3.01 Analyze and evaluate projectile motion in a defined frame of reference. 4.8 - 4.22 | 4.7 - 4.21 | 4.3 - 4.14

Content Description

Resolve vectors into vertical and horizontal components.	3.4, 4.1 - 4.6	3.4, 4.1 - 4.6	3.4, 4.1 - 4.2	·Firing a cannon ·Juggling objects
Evaluate the motion of a projectile both horizontally and vertically.	4.8	4.7	4.3	·Firing a cannon ·Juggling objects
Recognize that the horizontal component of velocity does not change (neglecting air resistance).	4.8	4.7	4.3	·Firing a cannon ·Juggling objects
Recognize that the vertical component of velocity does change due to gravity at the rate of 9.8m/s^2 downward.	4.8	4.7	4.3	·Firing a cannon ·Juggling objects

Objective

3.02 Design and conduct investigations of two-dimensional motion of objects. Chapter 4 | Chapter 4 | Chapter 4

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Content Description				
Select appropriate measurements for an investigation of projectile motion.	4.15	4.14	4.10	·Firing a cannon ·Juggling objects
Identify factors that may affect results.	4.15, 4.21	4.14, 4.20	4.10	
Predict and measure the path of the projectile including horizontal range, maximum height, and time in flight (such as a projectile launched horizontally or from the ground at a given angle).	4.8 - 4.21	4.7 - 4.20	4.3 - 4.13	·Firing a cannon ·Juggling objects
Objective				
3.03 Analyze and evaluate independence of the vector components of projectile motion.	4.8 - 4.21	4.7 - 4.20	4.3 - 4.13	
Content Description				
Recognize that vector components are independent of each other.	4.8	4.7	4.3	·Firing a cannon ·Juggling objects
Apply the equations of uniform velocity to the horizontal component.	4.8 - 4.21	4.7 - 4.20	4.3 - 4.13	·Firing a cannon ·Juggling objects
Apply the equations of accelerated motion to the vertical component of velocity.	4.8 - 4.21	4.7 - 4.20	4.3 - 4.13	·Firing a cannon ·Juggling objects
Relate height, time in air and initial vertical velocity (such as a projectile launched horizontally or from the ground at a given angle).	4.8 - 4.21	4.7 - 4.20	4.3 - 4.13	·Firing a cannon ·Juggling objects
Relate range of projectile, time and initial horizontal velocity (such as a projectile launched horizontally or from the ground at a given angle).	4.8 - 4.21	4.7 - 4.20	4.3 - 4.13	·Firing a cannon ·Juggling objects
Relate height and time in the air to the initial vertical velocity	4.8 - 4.21	4.7 - 4.20	4.3 - 4.13	·Firing a cannon ·Juggling objects
Relate range of projectile to time in flight and initial horizontal velocity	4.8 - 4.21	4.7 - 4.20	4.3 - 4.13	·Firing a cannon ·Juggling objects
Objective				
3.04 Evaluate, measure, and analyze circular motion.	Chapter 9	Chapter 9	Chapter 8	
Content Description				
Recognize that an object may move with constant speed but changing velocity.	9.1	9.1	8.1	·Navigating race tracks
Recognize that the directions of the velocity and acceleration vectors are perpendicular to each other.	9.4	9.4	8.3	·Navigating race tracks
Understand that centripetal acceleration is a consequence of the changing velocity due to change in direction.	9.4	9.4	8.3	·Navigating race tracks
Design and conduct investigations of circular motion.	9.0	9.0	8.0	·Navigating race tracks

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Experimentally verify the proportional relationships described in 3.06.				·Navigating race tracks
Combine proportional relationships into a single equation.	9.4 - 9.5, 9.7	9.4, 9.6	8.3, 8.5	
Calculate velocity using radius or circumference of the circle and time to complete one or more circuits.				
Calculate centripetal acceleration as the velocity squared divided by the radius.	9.4	9.4	8.3	·Navigating race tracks

Objective

3.05 Analyze and evaluate the nature of centripetal forces. 9.7 - 9.14 | 9.6 - 9.13 | 8.5 - 8.7

Content Description

Evaluate and understand that a net force is required to change the direction of a velocity vector.	9.7	9.6	8.5	
Understand that for uniform circular motion the net force is called the centripetal force.	9.7	9.6	8.5	
Understand that the centripetal force is not the result of circular motion but must be provided by an interaction with an external source.	9.7	9.6	8.5	
Evaluate the direction of the force and acceleration vectors as pointing to the center of the circle in the case of constant speed but not constant acceleration.	9.7, 10.17	9.6, 10.14	8.5	

Objective

3.06 Investigate, evaluate and analyze the relationship among: Chapter 9 | Chapter 9 | Chapter 8

- Centripetal force.
- Centripetal acceleration.
- Mass.
- Velocity.
- Radius.

Content Description

Design and conduct an investigation of circular motion.				·Navigating race tracks
Apply the proportional relationship between force and speed squared when radius is constant.	9.7 - 9.14	9.6 - 9.13	8.5 - 8.7	
Apply the inverse relationship between force and radius when speed is constant.	9.7 - 9.14	9.6 - 9.13	8.5 - 8.7	

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Apply the formula for centripetal force as mass times centripetal acceleration using the following equations: $a_c = v^2/r$ $F_c = mv^2/r$	9.7 - 9.14	9.6 - 9.13	8.5 - 8.7	

COMPETENCY GOAL 4: The learner will develop an understanding of forces and Newton's Laws of Motion.

Objective

4.01 Determine that an object will continue in its state of motion unless acted upon by a net outside force (Newton's First Law of Motion, The Law of Inertia).	5.2	5.2	5.2	

Content Description

Observe motion and draw force diagrams for objects moving at constant velocity with very little friction (examples: air track, air puck, balloon puck, dry ice)	5.2	5.2	5.2	·Helicopters in flight
Identify that the state of motion must be a constant velocity, including zero velocity, unless acted upon by a net force.	5.2	5.2	5.2	·Helicopters in flight
Define inertia.	5.2 - 5.3	5.2 - 5.3	5.2 - 5.3	

Objective

4.02 Assess, measure and calculate the conditions required to maintain a body in a state of static equilibrium.	Chapters 5, 6 and 12	Chapters 5, 6 and 12	Chapters 5, 6 and 11	

Content Description

Describe forces as interactions between two objects, including contact and forces at a distance.	5.1	5.1	5.1	
Recognize that force is a vector quantity.	5.1	5.1	5.1	·Helicopters in flight
Define normal force.	5.11	5.11	5.11	
Represent the forces acting on an object using a force diagram.	5.14	5.14	5.14	·Helicopters in flight
Analyze force diagrams to calculate the net force on an object.	5.14 - 5.17, Chapters 5 & 6	5.14 - 5.17, Chapters 5 & 6	5.14 - 5.15, Chapter 5	
Determine that the net force acting on an object in static equilibrium is zero.	12.1	12.1	11.1	·Helicopters in flight
Design and conduct investigations of objects in static equilibrium. *(Torque and rotational equilibrium are enrichment topics.)*	Chapters 6 & 12	Chapters 6 & 12	Chapter 11	·Helicopters in flight

Objective

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
4.03 Assess, measure, and calculate the relationship among the force acting on a body, the mass of the body, and the nature of the acceleration produced (Newton's Second Law of Motion).	5.5 - 5.9	5.5 - 5.9	5.5 - 5.9	
Content Description				
Design and conduct investigations of force and acceleration.				·Helicopters in flight
Experimentally verify the proportional relationships among acceleration, force and mass.				·Helicopters in flight
Apply proportional reasoning to the relationship between force and acceleration when mass is constant.	Chapters 5 & 6	Chapters 5 & 6	Chapter 5	·Helicopters in flight
Apply proportional reasoning to the inverse relationship between mass and acceleration when force is constant.	Chapters 5 & 6	Chapters 5 & 6	Chapter 5	·Helicopters in flight
Analyze force diagrams for accelerating objects. (solve for mass, acceleration, various forces)	Chapters 5 & 6	Chapters 5 & 6	Chapter 5	·Helicopters in flight
Calculate the net force on an object: $F_{net} = ma$	Chapters 5 & 6	Chapters 5 & 6	Chapter 5	·Helicopters in flight
Objective				
4.04 Analyze and mathematically describe forces as interactions between bodies (Newton's Third Law of Motion).	5.10	5.10	5.10	
Content Description				
Identify interaction pairs of forces for contact forces and forces at a distance.	5.10 - 5.13	5.10 - 5.13	5.10 - 5.13	
Analyze Newton's Third Law as the relationship evidenced by $\text{Force}_{\text{ of Object A on Object B}} = -\text{Force}_{\text{ of Object B on Object A}}$	5.10	5.10	5.10	
Observe and experimentally measure equal and opposite forces using pairs of spring scales or force sensors.				
Objective				
4.05 Assess the independence of the vector components of forces.	Chapters 5 & 6	Chapters 5 & 6	Chapter 5	
Content Description				
Resolve forces into components.	5.23 - 5.27, Chapter 6	5.23 - 5.27, Chapter 6	5.21 - 5.22	·Helicopters in flight
Apply Newton's Laws of Motion to the perpendicular components of force in the following examples:				

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
a. objects pulled or pushed along a horizontal surface by a force at an angle to the surface;				
b. objects sliding down an inclined plane;	5.25, 5.27, 6.7	5.25, 5.27, 6.7		
c. three concurrent forces acting on an object in static equilibrium.	6.1, 6.2	6.1, 6.2		

Objective

4.06 Investigate, measure, and analyze the nature and magnitude of frictional forces. 5.18 - 5.20 | 5.18 - 5.20 | 5.16 - 5.18

Content Description

Describe friction as a contact force.	5.18	5.18	5.16	
Distinguish between static friction and kinetic friction.	5.18 - 5.20	5.18 - 5.20	5.16 - 5.18	
Solve quantitative problems with frictional forces. (*coefficient of friction is an enrichment topic*)	5.18 - 5.22, 5.24, 6.7	5.18 - 5.22, 5.24, 6.7	5.16 - 5.18, 5.22	·Navigating race tracks ·Electric golf

Objective

4.07 Assess and calculate the nature and magnitude of gravitational forces (Newton's Law of Universal Gravitation). 13.1 | 13.1 | 12.1

Content Description

Calculate gravitational force between any two masses: $F = Gm_1m_2/d^2$	13.1	13.1	12.1	·Orbiting satellites
Apply proportional reasoning to the inverse square relationship between gravitational force and the distance between the centers of two known masses.	13.1	13.1	12.1	·Orbiting satellites
Apply proportional reasoning to the direct relationship between gravitational force and the product of masses.	13.1	13.1	12.1	·Orbiting satellites
Determine the force of gravity (weight) of an object: $F = mg$	5.4	5.4	5.4	·Helicopters in flight

COMPETENCY GOAL 5: The learner will build an understanding of impulse and momentum.

Objective

5.01 Assess the vector nature of momentum and its relation to the mass and velocity of an object. 8.1 | 8.1 | 7.1

Content Description

Define momentum.	8.1	8.1	7.1	

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Identify that momentum is a vector quantity because velocity is a vector quantity.	8.1	8.1	7.1	
Recognize that momentum is proportional to mass and proportional to velocity.	8.1	8.1	7.1	
Apply the momentum equation: $p = mv$	8.1	8.1	7.1	

Objective

5.02 Compare and contrast impulse and momentum. 8.1 - 8.6 | 8.1 - 8.5 | 7.1 - 7.4

Content Description

Define impulse.	8.3 - 8.4	8.3	7.3	
State that impulse is equal to change in momentum: $F\Delta t = \Delta p = m\Delta v$	8.3 - 8.4	8.3	7.3	
Recognize that the change in momentum of an object is proportional to the force applied to the object and to the time the force is applied to the object.	8.3 - 8.4	8.3	7.3	

Objective

5.03 Analyze the factors required to produce a change in momentum. 8.1 - 8.6 | 8.1 - 8.5 | 7.1 - 7.4

Content Description

Distinguish between impulse and force.	8.3	8.3	7.3	
Determine the change in momentum of an object by finding the area under the “curve” on a force vs. time graph.	8.3 - 8.6	8.3 - 8.5	7.3 - 7.4	
Show that the larger the mass of an object, the smaller the change in velocity of an object for a given impulse.	8.3	8.3	7.3	
Apply the impulse equation in various situations: $F\Delta t = \Delta p = m\Delta v$	8.3 - 8.6	8.3 - 8.5	7.3 - 7.4	

Objective

5.04 Analyze one-dimensional interactions between objects and recognize that the total momentum is conserved in both collision and recoil situations. Chapter 8 | Chapter 8 | Chapter 7

Content Description

Verify that the total momentum before an interaction is equal to the total momentum after an interaction as long as there are no outside forces.	8.0	8.0	7.0	
Solve problems using conservation of momentum in the following instances:				
two objects initially at rest push each other apart;	8.9	8.8	7.7	

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
a moving object collides with a stationary object and the two objects stick together;	8.20 - 8.21	8.18 - 8.19	7.13	
a moving object collides with a stationary object and the two objects move off separately;	8.12 - 8.19	8.11 - 8.17	7.9 - 7.12	
two moving objects collide and either stick together or move off separately.	8.12 - 8.21, 8.29	8.11 - 8.19, 8.24	7.9 - 7.13, 7.16	
Design and conduct investigations verifying the conservation of momentum in the four situations listed above.	8.29	8.24	7.16	
Identify the special case of an elastic collision (recoil) where the objects do not stick together *and* both momentum and kinetic energy are conserved.	8.11 - 8.19, 8.29	8.10 - 8.17, 8.24	7.8 - 7.12, 7.16	
Objective				
5.05 Assess real world applications of the impulse and momentum, including but not limited to, sports and transportation.	Chapter 8	Chapter 8	Chapter 7	
Content Description				
Use examples, such as baseball and golf, to explain that “follow through” is a strategy for increasing the impulse on the ball.	8.3	8.3	7.3	
Solve collision problems. (Momentum is conserved - assume the system is limited to the colliding objects. Example: car crash.)	8.9 - 8.21	8.8 - 8.19	7.7 - 7.13	
Recognize elastic collisions:				
ideal gas molecules collide elastically	8.19, 20.1	20.1	19.1	
billiard balls are frequently used as examples of elastic collisions.	Chapter 8	Chapter 8	Chapter 7	
COMPETENCY GOAL 6: The learner will develop an understanding of energy as the ability to cause change.				
Objective				
6.01 Investigate and analyze energy storage and transfer mechanisms:				
• Gravitational potential energy.	7.16	7.13	6.10	
• Elastic potential energy.	7.16, 15.20	7.13, 15.18	6.10	
• Thermal energy.	19.7	19.5	18.5	
• Kinetic energy.	7.8	7.6	6.4	
Content Description				
Develop the concept of energy as the ability to cause change.	Chapter 7	Chapter 7	Chapter 6	

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Describe energy transfer and storage in different physical systems, including but not limited to those involving gravitational potential energy, elastic potential energy, thermal energy, and kinetic energy.	Throughout book	Throughout book	Throughout book	·Generators and transformers
Apply proportional reasoning to the relationship between an object's kinetic energy and the object's mass and velocity according to the equation: $KE = (1/2)mv^2$	7.8	7.6	6.4	
Analyze changes in gravitational potential energy when an object's mass and/or height change: $PE = mgh$	7.16	7.13	6.10	
Apply proportional reasoning to the relationship between a spring's potential energy and its deformation, x, according to the equation: $PE = (1/2)kx^2$	15.20	15.18		
Show that PE = area under a graph of Force vs. deformation (stretch or compression), where $F = -kx$. The spring constant k is equal to the slope of the graph and is called the elastic constant.	15.20, 7.26 - 7.27	15.18		
Analyze conceptually that thermal energy increases when an object's temperature increases.	19.7, 19.9, 20.10	19.5, 19.7, 20.10	18.5, 18.6, 19.9	
Apply the idea that energy can be transferred when objects interact. (See work under 6.02)	7.7 & Throughout book	7.5 & Throughout book	6.3 & Throughout book	
Express and apply the idea that in all situations, energy tends to dissipate throughout the environment.	7.22, 7.29, 8.11, Chapter 22, 27.8, 27.13	7.19, 7.23, 8.10, Chapter 22, 27.5, 27.8	6.16, 6.20, 7.8, Chapter 21, 25.5, 25.7	
Express the concept of energy conservation by applying the idea that energy can be stored and transferred, but cannot be created or destroyed.	7.22	7.19	6.16	
Express an understanding of the conservation of energy in words as well as charts, diagrams and graphs.	7.22 - 7.32	7.19 - 7.26	6.16 - 6.20	
Objective				
6.02 Analyze, evaluate, and apply the principle of conservation of energy.	7.22	7.19	6.16	
Content Description				

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Use conceptual analysis and mathematical formulas for energy to determine amounts of energy stored as kinetic energy, elastic potential energy, gravitational potential energy, and amounts of energy transferred through work.	Chapter 7, 15.20	Chapter 7, 15.18	Chapter 6	
Analyze and investigate the relationship among kinetic, potential, and other forms of energy to see that total energy is conserved. (pendulum in various positions, ball in flight, stretching a rubber band, hand generator, turbine)	7.22 - 7.26, 13.28, 15.21, 32.17	7.19 - 7.22, 13.21, 15.19, 32.14	6.16 - 6.19, 12.17	
Solve problems relating the amounts of energy stored and transferred applying the principle of conservation of energy.	7.22 - 7.25	7.19 - 7.22	6.16 - 6.19	

Objective

6.03 Analyze, evaluate, and measure the transfer of energy by a force.

• Work.	7.1	7.1	6.1	
• Power.	7.15	7.12	6.9	

Content Description

Identify work as the transfer of energy by a force acting through a distance, when that force acts in the direction of motion of the object: $W = F\Delta x$	7.1	7.1	6.1	
Recognize that work is equal to the area under a force vs. distance graph.	7.3	7.3		
Define power as the rate of transferring energy or the rate of doing work.	7.15	7.12	6.9	
Use the power equation to solve mathematical problems involving transfer of energy through work: $P = W/\Delta t = Fv$	7.15, 7.18 - 7.19	7.12, 7.15 - 7.16	6.9, 6.12 - 6.13	
Recognize that a force must cause displacement in order for work to be done.	7.1	7.1	6.1	

Objective

6.04 Design and conduct investigations of:

• Mechanical energy.	Chapter 7	Chapter 7	Chapter 6	
• Power.	7.15	7.12	6.9	

Content Description

Verify through investigations the conservation of energy in situations involving transfer of energy among kinetic energy, elastic potential energy and gravitational potential energy.	Chapter 7, 15.20	Chapter 7, 15.18	Chapter 6	

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Investigate power.	7.15, 7.18 - 7.19	7.12, 7.15 - 7.16	6.9, 6.12 - 6.13	·Generators and transformers

COMPETENCY GOAL 7: The learner will develop an understanding of wave motion and the wave nature of sound and light.

Objective

7.01 Analyze, investigate, and evaluate the relationship among the characteristics of waves:				
• Wavelength.	16.5	16.5	15.5	
• Frequency.	16.6	16.6	15.6	
• Period.	16.6	16.6	15.6	
• Amplitude.	16.4	16.4	15.4	
Content Description				
Design and conduct investigations to measure the basic properties of mechanical waves: amplitude, period, frequency, wavelength and wave speed.	Chapter 16	Chapter 16	Chapter 15	·Birds on a wire
Compare and contrast mechanical and electromagnetic waves.	16.1, 35.2	16.1, 34.2	15.1, 30.2	
Understand that waves transport energy, momentum, and information.	16.1, 16.19, 35.0	16.1, 34.0	15.1, 30.0	·Birds on a wire
Draw and identify the basic characteristics of a transverse wave including: trough, crest, amplitude, frequency, wavelength, and period.	16.1 - 16.6	16.1 - 16.6	15.1 - 15.6	·Birds on a wire
Draw and label the basic characteristics of a longitudinal (compressional) wave including: period, rarefaction, and compression.	16.2, 17.1	16.2, 17.1	15.2, 16.1	
Distinguish between mechanical and electromagnetic waves in terms of the medium through which they travel.	16.1, 35.2	16.1, 34.2	15.1, 30.2	
Understand that a wave's energy is related to its amplitude.	16.19			
Apply the inverse relationship between frequency and wavelength at a constant wave speed determined by the medium.	16.7 - 16.8, 17.4	16.7 - 16.8, 17.4	15.7 - 15.8	·Birds on a wire
Solve problems relating period, frequency, wavelength and wave speed: $T = 1/f$ $v = f\lambda$	16.5 - 16.11	16.5 - 16.10	15.5 - 15.9	·Birds on a wire
Relate characteristics of waves to human perceptions of sound - such as pitch, loudness, and timbre.	17.2 - 17.3	17.2 - 17.3	16.2 - 16.3	

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Objective				
7.02 Describe the behavior of waves in various media.	Chapters 16, 17, 18, & 37	Chapters 16, 17, 18, & 36	Chapters 15, 16, 17, & 32	
Content Description				
Explain how mechanical waves, such as sound and water waves, are produced by objects vibrating in a medium.	16.1	16.1	15.1	·Birds on a wire
Qualitatively relate the speed of sound to the type of medium and its temperature.	17.4	17.4		
Show how wave speed can be calculated from a material's index of refraction and the speed of light in a vacuum: $n = c/v$	37.2	36.2	32.2	·Helicopters versus submarines
Observe water waves created by a vibrating object, and explain how the characteristics of the wave change depending on the frequency of the vibrating source.				
Objective				
7.03 Analyze the behavior of waves at boundaries between media:				
• Reflection, including the Law of Reflection.	Chapter 36	Chapter 35	Chapter 31	
• Refraction, including Snell's Law.	Chapter 37, 38	Chapter 36, 37	Chapter 32, 33	
Content Description				
Understand how a wave front reflects from and transmits through a boundary, including the speed of the wave in the new medium.	37.7, 18.6, 18.9, 16.7 - 16.8, 17.4	36.7, 18.6, 18.9, 16.7 - 16.8, 17.4	17.3, 15.7 - 15.8	·Helicopters versus submarines
Determine the speed of a wave in a new medium using the equation: $n_1 v_1 = n_2 v_2$	37.7	36.7		
Analyze and apply the Law of Reflection: $\theta_{incidence} = \theta_{reflection}$, measured from normal line.	36.5 - 36.7	35.5 - 35.7	31.5 - 31.6	·Helicopters versus submarines
Analyze and apply Snell's Law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$ where the angles are measured from the normal	37.3 - 37.6	36.3 - 36.6	32.3 - 32.5	·Helicopters versus submarines
Describe and calculate critical angles for total internal reflection: $\sin\theta_c = n_2/n_1$	37.12 - 37.14	36.11 - 36.13	32.8	·Helicopters versus submarines
Design and conduct investigations measuring angle of reflection, angle of refraction, and critical angle.	37.11, 37.14	36.10, 36.13	32.7	·Helicopters versus submarines

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Determine the relationship among the variables graphically and with equations (see inquiry support lab for this objective).				

Objective

7.04 Analyze the relationship between the phenomena of interference and the principle of superposition.

	Chapters 18 & 39	Chapters 18 & 38	Chapters 17 & 34	

Content Description

Explain principle of superposition.	18.1	18.1	17.1	·Playing Beethoven's Fifth Symphony
Compare and contrast constructive interference and destructive interference.	18.1	18.1	17.1	
Observe and conceptually analyze interference and superposition in traveling waves (springs, water, sound, light).	Chapters 18 & 39	Chapters 18 & 38	Chapters 17 & 34	·Playing Beethoven's Fifth Symphony

Objective

7.05 Analyze the frequency and wavelength of sound produced by a moving source (the Doppler Effect).

	17.14 - 17.20	17.12 - 17.17	16.7 - 16.8	

Content Description

Describe the perceived frequency and wavelength change when a sound source is moving toward or away from an observer.	17.14 - 17.16	17.12 - 17.13	16.7 - 16.8	
Listen to sound from moving sources and explain how the motion changes the sound.	17.14	17.12	16.7	
Observe the change in frequency and wavelength of water waves from a moving source.				

COMPETENCY GOAL 8: The learner will build an understanding of static electricity and direct current electrical circuits.

Objective

8.01 Analyze the nature of electrical charges.

• Investigate the electrical charging of objects due to transfer of charge.	23.2	23.2	22.2
• Investigate the conservation of electric charge.	23.3	23.3	22.3
• Analyze the relationship among force, charge and distance summarized in Coulomb's law.	23.9	23.9	22.8

Content Description

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Conduct investigations involving static electricity.	23.0, 23.6, 23.16, 23.17	23.0, 23.6, 23.16, 23.17	22.0, 22.5, 22.13	·Electric golf
Analyze the nature of electrical charge.				
a. The two different kinds of electric charge are defined as positive and negative.	23.1	23.1	22.1	·Electric golf
b. Like charges repel and unlike charges attract.	23.7	23.7	22.6	·Electric golf
Understand that matter is neutral when charges are balanced and becomes charged when there is a transfer of electrons.	23.1 - 23.2	23.1 - 23.2	22.1 - 22.2	
Recognize the three methods of charge transfer are friction, conduction, and induction.	23.2, 23.8	23.2, 23.8	22.2, 22.7	
Understand that electric charge is conserved (neither created nor destroyed and may be transferred from one object to another).	23.3	23.3	22.3	·Electric golf
Calculate the electrostatic force between any two point charges using the equation: $F = kq_1q_2/d^2$	23.9	23.9	22.8	·Electric golf
Apply the inverse square relationship between the force and the distance between the charges.	23.9 - 23.11	23.9 - 23.11	22.8 - 22.10	·Electric golf
Apply the proportional relationship between the force and the product of the charges.	23.9 - 23.11	23.9 - 23.11	22.8 - 22.10	·Electric golf
Cite evidence from experiments to support the existence of two kinds of charge, the neutrality of most matter, and explain charging by friction, conduction and induction.	Chapter 23	Chapter 23	Chapter 22	

Objective

8.02 Analyze and measure the relationship among potential difference, current, and resistance in a direct current circuit.	27.6	27.3	25.3	

Content Description

Develop the concept of a complete circuit.	29.1	29.1	27.1	
Develop the concept of current as the rate of flow of charge. Charge is everywhere in the circuit and does not enter or leave it.	27.1	27.1	25.1	
Develop the concept of resistance as due to the characteristics of the material.	27.6, 27.8	27.3, 27.5	25.3, 25.5	
Understand how electric potential is related to energy.	Chapter 25	Chapter 25	Chapter 24	

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Recognize that a difference in potential creates current and thus pushes charges around the circuit.	25.14 - 25.15, 29.2 - 29.3	25.11 - 25.12, 29.2 - 29.3	24.6 - 24.7, 27.2 - 27.3	
Recognize that energy is required to move charges in a circuit.	29.2 - 29.3	29.2 - 29.3	27.2 - 27.3	
Recognize that energy is dissipated by or transferred to other devices such as light bulbs or motors.	29.1	29.1	27.1	
Apply Ohm's Law: $V = IR$	27.6	27.3	25.3	
Solve simple circuit problems.	Chapters 27 & 29	Chapters 27 & 29	Chapters 25 & 27	
Graph results from investigations.				
Observe how potential difference, current and resistance affect the brightness of light bulbs in circuits with batteries.	29.0, 29.8, 29.12, 29.13, 29.23, 29.24	29.0, 29.8, 29.12, 29.13, 29.23, 29.24	27.0, 27.7, 27.11	
Design and conduct investigations to measure potential difference and current in direct current circuits with resistors and batteries.	29.0, 29.8, 29.12, 29.13, 29.23, 29.24	29.0, 29.8, 29.12, 29.13, 29.23, 29.24	27.0, 27.7, 27.11	

Objective

8.03 Analyze and measure the relationship among current, voltage, and resistance in circuits.
- Series.
- Parallel.
- Series-parallel combinations.

	Chapter 29	Chapter 29	Chapter 27	

Content Description

Series circuits	29.6 - 29.9	29.6 - 29.9	27.5 - 27.8	
Recognize that current is the same throughout the circuit	29.6	29.6	27.5	
Recognize that voltage divides proportionally to the resistance. The sum of the voltage drops across the circuit equals the potential difference supplied to the circuit	29.7, 29.17	29.7, 29.17	27.6	
Calculate equivalent resistance: $R_{eq} = R_1 + R_2 + R_3 + ...$	29.7	29.7	27.6	
Apply Ohm's law to series circuits.	Chapters 27 & 29	Chapters 27 & 29	Chapters 25 & 27	
Parallel circuits	29.10 - 29.13	29.10 - 29.13	27.9 - 27.11	
Recognize that current divides in inverse proportion to the resistance. The sum of the current through each device equals the current supplied to the circuit	29.10, 29.11, 29.20	29.10, 29.11, 29.20	27.9, 27.10	
Recognize that the voltage drop across each branch is the same:	29.10	29.10	27.9	

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Calculate equivalent resistance: $1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3 + ...$	29.11	29.11	27.10	
Apply Ohm's law to parallel circuits.	Chapters 27 & 29	Chapters 27 & 29	Chapters 25 & 27	
Combination circuits	29.14 - 29.16, 29.19 - 29.24	29.14 - 29.16, 29.19 - 29.24	27.12 - 27.13,	
Calculate equivalent resistance.	29.14 - 29.16, 29.19 - 29.24	29.14 - 29.16, 29.19 - 29.24	27.12 - 27.13,	
Develop a conceptual understanding of voltage and current in a combination circuit.	29.14 - 29.16, 29.19 - 29.24	29.14 - 29.16, 29.19 - 29.24	27.12 - 27.13,	
Investigations				
Design and conduct investigations of series and parallel circuits, including prediction of voltage and current and testing of these predictions through measurements.	Chapter 29	Chapter 29	Chapter 27	

Objective

8.04 Analyze and measure the nature of power in an electrical circuit. 27.13 - 27.18 27.8 - 27.13 25.7 - 25.11

Content Description

Develop the concept of power using dimensional analysis (unit cancellation).				
Apply the power equation: $P = VI = I^2R = V^2/R$	27.13 - 27.18	27.8 - 27.13	25.7 - 25.11	

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Objective

1.01 Identify questions and problems that can be answered through scientific investigations.

Content Description

Develop questions for investigation from a given topic or problem.				All labs

Objective

1.02 Design and conduct scientific investigations to answer questions about the physical world.

• Create testable hypotheses.
• Identify variables.
• Use a control or comparison group when appropriate.

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
• Select and use appropriate measurement tools. • Collect and record data. • Organize data into charts and graphs. • Analyze and interpret data. • Communicate findings.				
Content Description				
Distinguish and appropriately graph dependent and independent variables.				·Helicopters in flight ·Pressure, volume and temperature ·Electric golf ·Generators and transformers
Discuss the best method of graphing/presenting particular data.				
Use technology resources such as graphing calculators and computers to analyze data.				
Report and share investigation results with others.				All labs
Objective				
1.03 Formulate and revise scientific explanations and models using logic and evidence to: • Explain observations. • Make inferences and predictions. • Explain the relationship between evidence and explanation.				
Content Description				
Use questions and models to determine the relationships between variables in investigations.				All labs
Use evidence from an investigation to support a hypothesis.				All labs
Objective				
1.04 Apply safety procedures in the laboratory and in field studies: • Recognize and avoid potential hazards. • Safely manipulate materials and equipment needed for scientific investigations.				
Content Description				
Predict safety concerns for particular experiments				
Electricity				

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics	Virtual Physics Labs
Projectiles				
Relate physics concepts to safety applications such as:				
Transportation: seat belts, air bags, speed…	8.3	8.3	7.3	
Short circuits, circuit breakers, fire hazards				

Objective

1.05 Analyze reports of scientific investigations of physical phenomena from an informed scientifically literate viewpoint including considerations of:

• Adequacy of experimental controls.
• Replication of findings.
• Alternative interpretations of the data.

Content Description

Read a variety of scientific research reports. Some appropriate sources include: Science News Online http://www.sciencenews.org/ The for Kids section of this website has great summaries with links to the next level. Science Daily http://www.sciencedaily.com/ Tuesday New York Times Science Section Scientific American				