

## Energy, Machines, and Motion Pacing Guide (63 instructional days)

Lesson	Recommended Number of Periods	Focus Questions	Concepts
<b>Lesson 1:</b> Circuit of Inquiries: A Pre-Assessment	3	<ul style="list-style-type: none"> <li>What do you know about energy and about forces?</li> </ul>	<ul style="list-style-type: none"> <li>Energy can be converted from one form to another.</li> <li>Different forces exist and act on bodies in different ways.</li> <li>Machines help people do work.</li> <li>Unbalanced forces change the motion of an object.</li> <li>Plotting and analyzing graphs of collected data can determine relationships among objects.</li> </ul>
<b>Lesson 2:</b> Making a Battery	2	<ul style="list-style-type: none"> <li>How do you make a battery?</li> <li>How do you know a battery works?</li> </ul>	<ul style="list-style-type: none"> <li>A battery consists of two separate metal electrodes immersed in an ionic solution.</li> <li>Batteries supply energy to operate devices (and that energy can be used up).</li> <li>The electrical energy that a battery supplies is the result of chemical reactions between the electrodes and the electrolyte in the battery.</li> <li>A battery contains a limited amount of energy.</li> </ul>
<b>Lesson 3:</b> Rechargeable Batteries	2	<ul style="list-style-type: none"> <li>What evidence do we have that energy is stored in a battery?</li> <li>How can we change the amount of energy stored in a battery?</li> </ul>	<ul style="list-style-type: none"> <li>Energy (not electricity) can be stored in a battery.</li> <li>Energy can be transformed from one form to another.</li> <li>Different devices use energy at different rates.</li> </ul>
<b>Lesson 4:</b> Storing and Using Energy in a Battery	3	<ul style="list-style-type: none"> <li>How does charging time affect the stored energy in a rechargeable battery?</li> </ul>	<ul style="list-style-type: none"> <li>The amount of energy stored in a rechargeable battery is proportional to the time the battery is charged.</li> </ul>
<b>Lesson 5:</b> Introduction to Forces	3	<ul style="list-style-type: none"> <li>What is a force?</li> <li>How are mass and weight (force of gravity) related?</li> </ul>	<ul style="list-style-type: none"> <li>A force is a push or a pull on an object.</li> <li>Physical qualities such as force and mass are measured in units defined in measuring systems.</li> <li>Weight and mass are different characteristics of an object and are measured in different units.</li> <li>Mass is related to the amount of matter in a body.</li> <li>Weight is a measure of the force of gravity on a body.</li> <li>For small displacements, the elastic force a rubber band exerts is proportional to how much the rubber band stretches.</li> <li>The gravitational force on a body is directly proportional to the mass of the body.</li> </ul>

<b>Lesson 6: The Force of Friction</b>	<b>3</b>	<ul style="list-style-type: none"> <li>• What are the factors that affect the force of friction?</li> <li>• How is pulling force related to the force of friction (when pulling at a steady rate)?</li> </ul>	<ul style="list-style-type: none"> <li>• Friction is the force that resists motion between two surfaces in contact with each other.</li> <li>• The force needed to move an object across a horizontal surface at a constant speed is equal in magnitude, but opposite in direction, to the force of friction.</li> <li>• Frictional forces depend on the types of surfaces in contact.</li> <li>• The frictional force on an object moving across a horizontal surface is directly proportional to the weight of the moving object.</li> <li>• The frictional force on an object moving across a surface does not depend on the base area of the object in motion.</li> </ul>
<b>Lesson 7: The Force Exerted by a Motor</b>	<b>4</b>	<ul style="list-style-type: none"> <li>• What are the operating conditions that produce the maximum force from a motor?</li> <li>• What is the evidence that energy is being transformed and transferred in the system?</li> </ul>	<ul style="list-style-type: none"> <li>• The arrangement of the batteries determines the performance of a motor.</li> <li>• Motors exert forces and the forces can be measured.</li> <li>• An experiment has both an independent and a dependent variable.</li> </ul>
<b>Lesson 8: Work and the Motor</b>	<b>3</b>	<ul style="list-style-type: none"> <li>• What is the relationship between force applied and the work that is done?</li> </ul>	<ul style="list-style-type: none"> <li>• Scientists define work as the product of a force times the distance over which that force acted (<math>w = f \times d</math>).</li> <li>• The metric unit of measure for work is the newton-meter (n-m), which is also called the joule (J).</li> </ul>
<b>Lesson 9: Power of a Motor</b>	<b>3</b>	<ul style="list-style-type: none"> <li>• How do scientists describe the term power?</li> </ul>	<ul style="list-style-type: none"> <li>• Power is the rate at which work is done.</li> <li>• Power is calculated by dividing the work done by the time to do the work.</li> <li>• The watt is the common unit of measure for power.</li> <li>• One watt is equivalent to one joule per second.</li> <li>• Energy transformations take place when forces do work on objects.</li> <li>• Power is a measure of the rate at which energy transformations take place.</li> </ul>
<b>Lesson 10: Assessing What You Know</b>	<b>3</b>	<ul style="list-style-type: none"> <li>• What energy changes allow a falling body to light a bulb?</li> </ul>	
<b>Lesson 11: The Inclined Plane</b>	<b>3</b>	<ul style="list-style-type: none"> <li>• What is a machine?</li> <li>• Why is an inclined plane a machine?</li> </ul>	<ul style="list-style-type: none"> <li>• The work needed to lift an object is the weight of the object multiplied by the distance it is lifted.</li> <li>• Machines can decrease the magnitude of the effort force needed to do work.</li> <li>• Machines reduce effort force and increase effort distance when doing work.</li> <li>• Frictional forces add to the work that must be done to perform a task.</li> <li>• Wheels reduce friction.</li> </ul>
<b>Lesson 12: The Pulley</b>	<b>3</b>	<ul style="list-style-type: none"> <li>• How do pulleys work?</li> <li>• Why are pulleys machines?</li> </ul>	<ul style="list-style-type: none"> <li>• A pulley is a simple machine.</li> <li>• A pulley makes work easier by changing the magnitude and/or direction of the effort force required to do work.</li> <li>• A simple machine reduces effort force and increases effort distance when doing work.</li> </ul>

<b>Lesson 13: The Lever</b>	<b>3</b>	<ul style="list-style-type: none"> <li>• Why are levers machines?</li> <li>• How do levers do work?</li> </ul>	<ul style="list-style-type: none"> <li>• A lever is a simple machine.</li> <li>• Machines reduce effort force and increase effort distance in doing work.</li> <li>• On a lever, torque is the product of an applied force and the length of its lever arm.</li> <li>• A lever is balanced when the magnitude of torque (applied force multiplied by arm length) on the left lever arm equals the magnitude of torque on the right lever arm.</li> </ul>
<b>Lesson 14: The Mechanical Advantage of Machines</b>	<b>2</b>	<ul style="list-style-type: none"> <li>• What is the difference between ideal and actual mechanical advantage?</li> <li>• How are ideal and actual mechanical advantage calculated?</li> </ul>	<ul style="list-style-type: none"> <li>• Ideal mechanical advantage is the ratio of effort distance to load distance when a machine does work.</li> <li>• Actual mechanical advantage is the ratio of load force to effort force needed to lift or move a load.</li> <li>• Actual mechanical advantage is less than ideal mechanical advantage because of friction.</li> </ul>
<b>Lesson 15: The Efficiency of Machines</b>	<b>2</b>	<ul style="list-style-type: none"> <li>• What is machine efficiency?</li> <li>• How is machine efficiency calculated?</li> </ul>	<ul style="list-style-type: none"> <li>• Efficiency is the ratio of work output to work input for a machine.</li> <li>• Machines are not perfectly (100 percent) efficiency because of frictional forces.</li> <li>• The efficiency of a given machine varies according to how the machine is set up or used.</li> </ul>
<b>Lesson 16: Machines Assessment: A Technological Design Challenge</b>	<b>4</b>	<ul style="list-style-type: none"> <li>• How can simple machines concepts (forces, work, and mechanical advantage) be used to enable a small motor to lift a load?</li> </ul>	<ul style="list-style-type: none"> <li>• The goal of technology is to develop working solutions for human needs.</li> <li>• The goal of science is to develop an understanding of the natural world.</li> <li>• Technological design is a process of developing working solutions to meet human needs.</li> <li>• Scientific experimentation is a process used to develop understanding of the natural world.</li> <li>• Work is done when an applied force moves an object in the direction of the force.</li> <li>• A machine makes work easier by reducing the magnitude of the force required to do work and/or by changing the direction of the force.</li> <li>• The actual mechanical advantage of a machine is the ratio of load force to effort force.</li> <li>• Efficiency is the ratio of work output to work input.</li> </ul>
<b>Lesson 17: Introduction to the Anchor Activity</b>	<b>2</b>	<ul style="list-style-type: none"> <li>• How are machines and energy transformations utilized in everyday devices?</li> </ul>	<ul style="list-style-type: none"> <li>• There is a relationship between science and technology.</li> <li>• There are limits to science and technology.</li> <li>• Machines and energy transformations are all around us.</li> </ul>
<b>Lesson 18: Motion of a Fan Car</b>	<b>4</b>	<ul style="list-style-type: none"> <li>• What is motion?</li> <li>• What causes motion?</li> <li>• What is speed and how is it calculated?</li> </ul>	<ul style="list-style-type: none"> <li>• Motion is a change in position.</li> <li>• Unbalanced forces result in changes of motion.</li> <li>• Speed is the measure of change in position over time.</li> </ul>

<b>Lesson 19: Motion of a Mouse Trap Car</b>	<b>3</b>	<ul style="list-style-type: none"> <li>• How does the size of the force affect the motion of an object?</li> <li>• How does the duration of the force affect the motion of an object?</li> </ul>	<ul style="list-style-type: none"> <li>• Energy stored in a spring can be transformed into motion of a car.</li> <li>• When forces are balanced there is no change in motion.</li> <li>• Unbalanced forces result in a change in motion.</li> <li>• Speed is change in distance over a period of time.</li> </ul>
<b>Lesson 20: The Roller Coaster</b>	<b>2</b>	<ul style="list-style-type: none"> <li>• Why is teamwork a valued aspect of scientific investigation?</li> </ul>	<ul style="list-style-type: none"> <li>• Science is a human endeavor involving contributions from many people.</li> </ul>
<b>Lesson 21: Motion on a Roller Coaster</b>	<b>3</b>	<ul style="list-style-type: none"> <li>• What energy transformations occur as a car moves along the track of a roller coaster?</li> </ul>	<ul style="list-style-type: none"> <li>• Forces can accelerate objects.</li> <li>• Energy in a closed system is conserved.</li> <li>• Gravitational potential energy is related to the position of the object.</li> <li>• Potential energy can be converted to kinetic energy and kinetic energy can be converted to potential energy.</li> <li>• Frictional force transforms some potential and kinetic energy to heat energy.</li> </ul>
<b>Lesson 22: The Anchor Activity</b>	<b>3</b>	<ul style="list-style-type: none"> <li>• Why is sharing knowledge an important part of the scientific process?</li> </ul>	<ul style="list-style-type: none"> <li>• Research findings must be shared if knowledge is to expand.</li> </ul>