Magnets and Motors Pacing Guide (30 – 32 instructional days)

Lesson	Recommended Number of Periods	Focus Questions	Concepts
Lesson 1: **Getting Started - Pre-Unit Assessment**	2	• What do students already know about magnets and motors?	
Lesson 2: **What Can Magnets Do?**	2	• What are the observable behaviors of magnets?	• Magnets work at a distance • Magnets can push and pull.
Lesson 3: **How Can You Find Out What Magnets Can Do?**	2	• What do magnets interact with?	• Magnets interact with some metals iron, cobalt, and nickel. • Magnets attract steel because steel contains iron. • Magnets do not interact with aluminum, plastic, wood, copper, brass, rubber. • Material that is not metal that behaves magnetically has metal in it such as the twist tie, pipe cleaner, audio tape.
Lesson 4: **Measuring Magnets**	2	• How can the strength of magnets be measured? • How does the number of magnets affect the strength of the magnetic interaction? • What is a fair test?	• The strength of a magnet can be influenced by number, size, composition, age, abuse • Introduction to the process of scientific investigation and the idea of a fair test.
Lesson 5: **Building a Compass**	2	• What are the characteristics (parts and properties) of magnetic compasses? • How can a compass help you know where you are going?	• The compass is used as a tool to detect a magnetic field. • The students learn how to patiently troubleshoot devices they build.
Lesson 6: **Using a Compass: Which Way Is Which?**	2	• How can we change the behavior of the compass?	• Magnets have two poles, often referred to as north and south poles. • Like poles (N/N or S/S) will repel each other. Opposite poles (N/S) attract each other. • The attraction and repelling forces from holding a third magnet or a different group's compass near the compass causes it to spin.
Lesson 7: **Creating Magnetism Through Electricity**	2	• What are two ways that we can detect that current is flowing through a circuit?	• Circuits can be open or closed. An open circuit does not have a complete path, while a closed circuit is a complete path from the battery through the wire and back through the battery. • Current flows in a path through the bulb (up from the base connection through the filament and out the side connection). • The compass is used as a tool to detect a magnetic field (specifically in this lab, detecting the magnetic field around wires carrying current). • A compass held under a wire in a complete circuit can be used (instead of a light bulb) as a tool to indicate that current is flowing through the circuit.
Lesson 8: **Making Magnets with Electricity**	2	• How can electricity produce a magnet?	• Iron, cobalt, and nickel (which are ferromagnetic materials) are metals that interact with a magnet or can be made into a temporary magnet. • The flow of electricity through a coil of wire will produce a magnetic field whose poles can be detected with a compass.

Lessons 9, 10: **Designing an Experiment to Test the Strength of an Electromagnet; Testing an Electromagnet**	**4-5**	• What variables will affect the strength of an electromagnet? • What are the steps needed to carry out a "fair test" of one variable to determine the strength of an electromagnet?	• The more turns of wire around the core the greater the strength of an electromagnet (yet this pattern only continues to a point). • Other variables affecting an electromagnet that can be tested are: core's diameter, core's length, core's material, wire's diameter/gauge (note caution page 59), the number of batteries, whether batteries are in series or parallel.
Lesson 11: **Showing Others What You Have Learned**	**2-3**	• Using the evidence from your experiment, what have you learned about the strength of electromagnets? • How are your results the same or different from the class results?	• Students collect and analyze their own data. They then put their evidence into a visual format to help them report their conclusions to their classmates.
Lesson 12: **Making a Motor**	**2**	• How can a motor be made from electricity and magnets with a student operating the switch? • How can this motor system be diagrammed to show the complete electric circuit, the power source, the switch, the electromagnet, and a rotating piece that does the motor's work?	• The basic ingredients of an electric motor are: an electric circuit, permanent magnets, electromagnets, and a way to turn the electricity on and off at the right time. • In this motor, when the switch is on the electromagnet attracts the magnet, which rotates the compass arm. When the switch is off the compass arm coasts.
Lesson 13: **Building a Spinning Coil Motor**	**2**	• How can a motor be built to run on electricity and switch automatically so that it continuously turns? • How can this motor system be diagrammed to show the complete electric circuit, the power source, the switch, the electromagnet, and a rotating piece that does the motor's work? • How does this motor compare to the spinning compass motor?	• In this motor, when the switch is on the magnet attracts the electromagnet, which rotates this coil (the electromagnet). When the switch is off the coil coasts. • In this motor, electricity is switched on and off automatically because only half of the enamel coating is sanded off. • As the coil spins it interrupts the flow of electricity and provides an automatic on/off switch that causes the coil to keep spinning.
Lesson 14: **What Is Inside an Electric Motor?**	**2**	• What are the parts of a commercial electric motor and what are their functions? • How do the commercial motor parts compare to the magnets and electromagnets built in class? • How can this motor system be diagrammed to show the complete electric circuit, the power source, the switch, the electromagnet, and a rotating piece that does the motor's work?	• The small commercial motors operate on the current from a battery. It uses two permanent magnets (attached to the inside of the case) and three electromagnets (wound around the rotor, "armature"). • The automatic switch is the "brush" and "commutator." As the magnets and electromagnets attract and repel to rotate the armature, the brushes make contact with different segments of the commutator. These segments are connected to the three electromagnets. As the motor rotates, the brushes touching different commutator segments cause the three electromagnets to be turned on and off continuously. • Many commercial motors are designed to switch the direction of the electric current, making the electromagnet alternatively attract then repel. This is efficient and smooth-running.
Lesson 15: **How Does a Motor Work?**	**2**	• How does a motor work? • Which variables affect how fast a motor turns? • How do we reassemble the commercial motors so they function again? • How can this motor system be diagrammed to show the complete electric circuit, the power source, the switch, the electromagnet, and a rotating piece that does the motor's work?	• The variables that affect a motor's function are: location of the magnets, distance of the magnets from the armature, the poles of the magnets that face the armature, the number of batteries, the direction which current flows, the presence or absence of electric current (on/off switch), the number of coils on the electromagnet, and the number or strength of the magnets.