Preface

This book is mainly for primary and middle school inservice and preservice teachers who are already familiar with constructivist methods in science education, including inquiry-based teaching strategies, formative assessment techniques, and the design of lesson plans consistent with state science standards. While such teaching methods are not addressed in this book, at least not directly, familiarity with such methods would definitely complement the more practical focus of this book. This is a nuts-and-bolts resource book for the primary or middle school teacher who is looking to design or is in the process of designing lesson plans or units in specific areas in physical science. This book would also be a valuable resource for home-schooling parents or guardians who are looking to augment or develop science lessons at home with a greater emphasis on hands-on activities and relevant examples from the everyday world. This book may also be of value to the high school physics teacher who is looking to extend his or her repertoire of classroom demonstrations and real-world examples in topic areas often taught at the secondary level.

Each chapter presents succinct descriptions of the physical science concepts. This narrative is followed by a description of many engaging activities that illustrate those concepts. This in turn is followed by a list of interesting everyday examples that support and complement those activities. I feel that the activities and everyday examples are essential to constructing an understanding of the concepts. Each chapter ends with a circus of activities that could be used to initiate the unit and some sample investigable questions that could be used to begin a full cycle of inquiry.

This book is not a set of lesson plans, nor does this book give any kind of prescriptive, day-to-day teaching outline. The unit design and teaching methodology, as they should be, are in the capable hands of the classroom teacher. This was done purposefully so the classroom teacher would not feel constrained by a single delivery system and could choose a variety of uses for the book's contents within his or her teaching style and context.

INERTIA AND NEWTON'S FIRST LAW OF MOTION

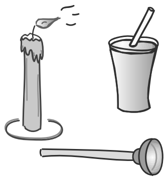
Concepts

All material objects are stubborn in *two* senses of the word. On the one hand, an object at rest (not moving at all) tends to remain at rest. Examples of this aspect of the concept of inertia are all around us – a book resting on a table, a house resting on the ground. On the other hand, an object moving in a straight line with constant speed (not increasing or decreasing its speed and/or turning) tends to remain moving in the same straight line with the same constant speed. Examples of this aspect of the concept of inertia are a little harder to identify – a spaceship drifting in interstellar space far from gravitating objects, a hockey puck moving freely across the ice. These *two* tendencies make up the *concept of inertia.* Historically, recognising this duality was a key to unlocking our present understanding of motion. The scientists most responsible for its discovery and clarification, respectively, were Galileo (1564–1642) and Newton (1642–1727).

An object with a larger quantity of matter (say, a jumbo jet) possesses more of these tendencies – that is, possesses more inertia than an object with a lesser quantity of matter (say, a Ping-Pong ball or other table-tennis ball). In other words, both a jumbo jet and a Ping-Pong ball at rest tend to stay at rest, and both a jumbo jet and a Ping-Pong ball moving in a straight line with constant speed tend to remain doing that, but the jumbo jet has much more of these two tendencies than the Ping-Pong ball. The jumbo jet is said to have more *mass, mass being the quantitative (numerical) measure of inertia.*

Mass is also a measure of the amount of "stuff" (matter) that makes up an object. In other words, the mass value for an object gives a numerical value for the quantity of matter as well as for the tendency an object has to remain at rest and for the tendency an object has, if moving in a straight line with constant speed, to remain doing that. In the metric system of units (International System of Units), mass is measured in *kilograms (kg).*

Mass is a distinct concept from and more fundamental than *weight.* Weight is a measure used to quantify the strength of the gravitational force of attraction an object experiences when in the vicinity of the earth, moon or any other astrophysical body. In other words, weight is a gravitational force and not a measure of inertia. For example, out in interstellar space, far away from any gravitating astrophysical body, a jumbo jet and a Ping-Pong ball would both be *weightless* (would have the same weight of zero) but would still possess greatly different amounts of inertia. In fact, each would have the same amount of inertia (each would have the same mass



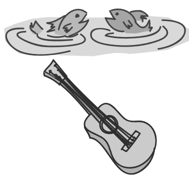
Activities

Suction Cup Fun: You will need to locate suction cups of various sizes. You should also purchase two large suction cups of the type used to pull out car door dents or to carry panes of glass (e.g. Atmospheric Pressure Cups, Arbor Scientific). You might also want to purchase a couple of plumber's helpers (toilet plungers). Stick two suction cups together. By forcing the air out of the space between the cups, you reduced the number of molecules (N). When the suction cups spring back, the volume (V) is also increased. Both of these factors (smaller N and larger V) reduce the pressure inside of the cups. Since the atmospheric pressure outside the cups has not changed, the pressure difference is enough to hold the cups firmly together. You can try to "stick" the suction cups to various surfaces (a window, a table, your forehead, etc.). Try repeating the activity after making a small hole in one of the suction cups.

Rubber and Soft Drink Can Mats: You will need to buy one of these amazing atmospheric pressure devices from a science supply house. One of the devices is just a square piece of rubber with a handle in the centre (e.g. Atmospheric Pressure Mat, Arbor Scientific). When you place this rubber mat on a smooth surface and attempt to pull it up off the surface using the handle, you can't. As you begin to pull on the mat, the volume of air trapped under the mat increases (V increases). This reduces the pressure under the mat compared to the atmospheric pressure on top of the mat. In fact, the pressure difference will increase the more you pull up on the handle and increase the volume. The same idea has now been used to hold a soft drink can on a table (e.g. Lil'Suctioner, Educational Innovations). You place a can into the circular mat, and the pressure difference will "hold" the can to the table.

Crushing a Bottle: Locate an empty plastic milk or soft drink bottle. Stick your mouth over the opening and suck out the air. This can be accomplished by first sucking the air out through the mouth, followed by exhausting the air through the nose. If you repeat this procedure without taking your mouth off the bottle, you can eventually crush the bottle. By reducing the number of molecules (N) inside the bottle, the pressure inside the bottle is lowered. The higher atmospheric pressure outside the bottle will crush the bottle.

Inexpensive Vacuum Canister: You will need to purchase special canisters that have been designed to prevent food spoilage (e.g. Student Vacuum Pumper and Chamber, Arbor Scientific). These relatively inexpensive can-you. Have the dangling coat hanger strike a nearby object (chair, table, etc.) and listen to the sound waves that travel through the hanger, through the string and into your ears. Repeat using dangling spoons or other metal objects. Try hanging the grill from the string and repeat, but this time have someone stroke across the grill with a spoon. Similar to the last two activities, the vibrating coat hanger, spoons or grill produce one-dimensional waves that propagate through the strings directly to your ears.



Everyday Examples

Pseudo Waves: There are a number of phenomena that *simulate* wave motion, such as "the wave" at a sporting event moving around the stadium, wind blowing "waves of grain" over an open field, or a "domino wave" caused by a chain of dominoes falling successively into each other. Since these happenings are disturbances that are not propagating because of a continuous and connected medium, they are not mechanical waves. But these pseudo or simulated waves are interesting to explore.

Ocean Waves: Large ocean waves are initiated by wind blowing over the ocean surface. As an ocean wave approaches a shoreline, the front part of the wave experiences the shallow water before the back part of the wave. Since water waves move slower in shallower water, the front part of a wave is slowed relative to the back part. This causes the wave to "break". For the same reason, shallow reefs also cause ocean waves to break over them. Besides wind-generated waves, water waves can be produced by earthquakes and rock slides.

Tsunamis: These are extremely powerful ocean waves caused by earthquakes in the ocean floor.

Waves in a Swimming Pool: People playing in or jumping into a swimming pool create lots of surface water waves. Many pools (especially those used for swimming and diving events) are designed with a special gutter around the edge to minimise the reflections of these waves. There are a number of water parks and some aquariums that mechanically generated waves in a pool to simulate ocean waves.

Waves in a Bathtub: You can create large waves in a bathtub by sloshing back and forth in the tub.

Raindrops and Pebbles in a Smooth Lake: Raindrops falling or pebbles thrown into a smooth lake create beautiful ringlets of surface water waves.

ELECTRIC AND MAGNETIC CIRCUS

The following set of activities, selected from the activities described in this chapter, could be used to begin a unit on electric and magnetism. These activities would be set up around the classroom in a circus format. Next to each activity, a simple description of how each activity is to be performed would be displayed, along with a question or questions to be answered by the student in conjunction with performing the activity. Obviously, the teacher will need to rewrite these descriptions and questions to make the language and analysis appropriate for the year level. It is suggested that students work in pairs or small groups. One option would be to have students perform the activities a few at a time and run the circus over a few days. Another option would be to use some of these activities as teacher demonstrations for whole-class discussion. In any case, students should be encouraged to probe the activities beyond the descriptions and initial questions and begin to think of additional questions they might want to investigate on their own later in the unit.

1. Attraction and Repulsion

Rub the plastic rod with fur and place it on the swivel stand. The rubbing gives an electric charge to the plastic rod. Rub another plastic rod with fur and bring it up close to, but not touching, the charged rod of the stand. What happens to the rod on the stand? Repeat with the two glass rods rubbed with silk. What happens? Now place the charged plastic rod on the stand and bring the charged glass rod close to it. What happens? What can you conclude from your observations in these three cases?

2. Charge Detector

The electroscope is a very simple instrument that can be used to detect electric charge. The electroscope is made of a metal rod that runs through a rubber stopper and into a flask. The end of the rod outside the flask has a metal ball attached. The other end of the rod, inside the flask, has a small hook over which is draped a small piece of gold foil. Bring a charged rod (fur on plastic or silk on glass) close to (but do not touch) the ball and observe what happens to the gold foil in the flask. Remove the charged rod and observe what happens to the foil. Rub a comb through your hair and bring it close to the ball to see if you can detect the charge on the comb. Rub a balloon with fur or rip a piece of Scotch tape from a dispenser and bring it near the ball to see if you can detect the charge. Try other objects that you think carry an electric charge. What happens when you actually touch the charged rod (or other charged objects) to the ball and then remove the rod? Invent an explanation for your observations in the non-touching versus the touching case?