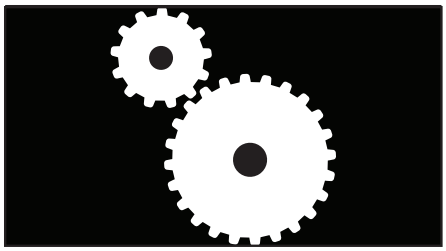
Hands-On Science



Simple Machines

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Hawker Brownlow
EDUCATION

Contents

To the Teacher

This is one in a series of hands-on science activity books for Years 7–10 students. A survey of students of that age found that:

- more than half listed science as their favourite subject
- more than half wanted more hands-on activities
- 90 per cent stated that the best way for them to learn science was to do experiments themselves.

The books in this series seek to capitalise on these findings. These books are not texts but supplements. They offer hands-on, fun activities that will turn some students on to science. Most of these activities can be done in school, and some of them can be done at home. Most of the authors are teachers who have field-tested the activities in secondary schools.

In this book, lessons explore the operations and applications of simple machines. Students will examine the concepts of force, work, power, efficiency and mechanical advantage. They will also discover how simple machines such as ramps, wedges, levers, pulleys and gears operate. Students will begin to appreciate the diverse applications of simple machines, especially in everyday life. Activities range from the simple *(Work (the Physics Kind))* to the advanced *(How Do Pulleys Work Together to Make a Better Machine?)*. There is something for every student. We strongly recommend that you try these activities yourself before asking your students to perform them.

The activities can be used

- to provide hands-on experiences pertaining to textbook content
- to give verbally limited children a greater chance to succeed
- as the basis for class or school science projects or for other science competitions
- to involve students in science activities
- as homework assignments
- to involve parents in their children's science education and experiences
- to foster an appreciation for science.

This book provides hands-on activities in which students

- manipulate equipment
- interpret data
- evaluate experimental designs
- draw inferences and conclusions
- make predictions
- apply the methods of science.

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Each activity has a Teacher Resource section that includes – besides helpful hints and suggestions – a scoring rubric, as well as internet resources for those students who wish to go further and carry out the Follow-Up Activities. Each activity also includes a list of relevant Australian Curriculum: Science content descriptions from Years 7–10, to help align the science concepts addressed in this book to the curriculum framework.

These activities are designed to stand alone as supplements to your instruction. While the activities can be performed in any order according to your teaching plans, please note that some activities are similar in matter and set-up to others.

For example, *Activity 11: What Mechanical Advantage Do Stairs Provide?* and *Activity 12: How Much Power Do You Have in Your Legs?* Both involve measurements of stairs and the power required to climb those stairs. Also, *Activity 8: How Does a Pulley Work?* and *Activity 9: How Do Pulleys Work Together to Make a Better Machine?* pair well together. It would save you time and effort and reinforce student understanding to perform them in conjunction with each other.

Much of science is a combination of problem solving, the scientific method and just plain hard work. Properly used, this book can be fun for students while still helping them strive to reach the high standards that you expect from them in your classroom.

Explanation Of Activities

In all activities, it is recommended that students who need extra challenges should complete the Follow-Up Activity and the Extension Option, as well as helping and encouraging struggling students as needed. Students who need extra help should be allowed to work with a partner if necessary.

Activity 1: What Is a Force?

In physics, force has a very specific meaning: A force is either a push or a pull that causes an object to change its speed and/or direction of motion.

In this activity, students will balance the weight of an object (a downward force) with the upward force that a spring supplies. Students will see how a spring supplies more force – or more pull – as they stretch it more and more. Students will observe how different springs exert forces of different strengths. Finally, students will test Newton's first law.

Similar activities include:

- *Activity 2: Work (The Physics Kind)*

Activity 2: Work (The Physics Kind)

In physics work has a very specific meaning. Mechanical work is defined as the amount of energy transferred either to or away from an object, by a force, over a distance.

In this activity students will measure the amount of work required to move objects, in this case books.

Similar activities include:

- *Activity 1: What Is a Force?*
- *Activity 3: What is Power?*

Activity 3: What is Power?

In physics, power is defined as the rate at which work is performed or energy is converted. The units of measurement for energy conversion are called joules and watts. The joule is equal to the energy expended (or work done) in applying a force of one newton through a distance. The watt measures the rate of energy conversion. It is defined as one joule per second.

In this activity students will measure the amount of power that is required to lift a variety of objects from the floor to the top of a table, and the amount of time taken.

Similar activities include:

- *Activity 2: Work (The Physics Kind)*
- *Activity 12: How Much Power Do You Have in Your Legs?*

Activity 4: How Strong a Nutcracker Is a Door?

A simple machine is something that helps us do work by changing either the direction or the amount of force we apply. A door used as a nutcracker does both. The door is acting as a simple machine called a lever.

In this activity, students will take measurements of the door. With these measurements, students will be able to calculate the door's mechanical advantage, the amount by which the applied force is multiplied by a machine.

Similar activities include:

- *Activity 13: How Can a Class 1 Lever Work As a Catapult?*

Activity 5: How Does a Ramp Work As a Simple Machine?

A machine changes the direction and/or amount of force applied. Something as simple as a ramp, also called an inclined plane, is called a machine because it raises an object from one level to another using less force than if it had been lifted.

In this activity, students will study the mechanical advantage of an inclined plane. Students will also see how the mechanical advantage changes as they vary the tilt angle of the inclined plane. In this activity students will calculate the work done by the machine, the mechanical advantage and the efficiency.

Similar activities include:

- *Activity 7: How Does a Wedge Make Work Easier?*
- *Activity 11: What Mechanical Advantage Do Stairs Provide?*

Activity 6: What Mechanical Advantage Do You Have in Your Bicycle?

A wheel and axle is a rotating version of a lever. The axle is a circular object attached to the wheel, but it has a smaller radius. A bicycle is a compound machine because it has two or more simple machines working together.

In this activity, students will study a bicycle. The students will identify the different simple machines and how they work together to create a compound one. Students will calculate the mechanical advantage of the bicycle through measurement and calculation.

Similar activities include:

- *Activity 15: How Do Gears Work?*

Activity 7: How Does a Wedge Make Work Easier?

A wedge is an inclined plane that, unlike a ramp, moves when in use. It, too, converts force in one direction into force in another and provides mechanical advantage.

In this activity students will build, describe and demonstrate the function of the wedge as a simple machine, and demonstrate the reduction in force. In this activity students will reinforce concepts of force, weight and work.

Similar activities include:

- *Activity 5: How Does a Ramp Work As a Simple Machine?*
- *Activity 10: What Mechanical Advantage Does a Screw Provide?*

Activity 8: How Does a Pulley Work?

A pulley is a simple machine consisting essentially of a wheel with a grooved rim in which a pulled rope or chain can run to change the direction of the pull and thereby lift a load

In this activity, students will see the benefit of a pulley as a simple machine. A pulley does not multiply force, but it does change the direction. Students will investigate their use by making pulleys consisting of cords sliding over hard surfaces. This activity will demonstrate how different cord arrangements provide different mechanical advantage.

Similar activities include:

- *Activity 9: How Do Pulleys Work Together to Make a Better Machine?*

Activity 9: How Do Pulleys Work Together to Make a Better Machine?

In this activity, students will see how pulleys and pulley systems change the direction or the amount of force applied. Students will explore how they can increase the mechanical advantage of the pulley in lifting a load by adding more pulleys.

Similar activities include:

- *Activity 8: How Does a Pulley Work?*

Activity 10: What Mechanical Advantage Does a Screw Provide?

A screw, which can be thought of as a ramp wrapped around a cylinder, changes the direction and the amount of force applied. As the screw rotates one full turn, it moves forward between adjacent threads. This distance is usually small. Since effort is applied through a much longer distance, screws give a large mechanical advantage.

In this activity, students will compare the relative mechanical advantage of one screw to another.

Similar activities include:

- *Activity 5: How Does a Ramp Work As a Simple Machine?*
- *Activity 7: How Does a Wedge Make Work Easier?*

Activity 11: What Mechanical Advantage Do Stairs Provide?

A flight of stairs is an inclined plane or ramp (with steps) that acts as a machine. The inclined plane of the stairs acts to multiply the force of our legs. This is called mechanical advantage.

In this activity, students will calculate the mechanical advantage of the stairs. Students will also calculate the actual force their legs have to exert in climbing a flight of stairs, taking simple measurements and then calculating the mechanical advantage. This will enable students to calculate the actual force that their legs exert in climbing the stairs.

Similar activities include:

- *Activity 5: How Does a Ramp Work As a Simple Machine?*
- *Activity 12: How Much Power Do You Have in Your Legs?*

Activity 12: How Much Power Do You Have in Your Legs?

The speed with which work is performed is called power. This is calculated as work per unit of time. The less time it takes to do the same amount of work, the more power is produced.

In this activity, students will calculate the work that they do when they climb a flight of stairs. Students will measure the time it took to climb the stairs and calculate the power used by dividing the work done by the time taken to do it.

Similar activities include:

- *Activity 2: Work (The Physics Kind)*
- *Activity 11: What Mechanical Advantage Do Stairs Provide?*

Activity 13: How Can a Class 1 Lever Work As a Catapult?

In this activity, students will investigate how a reverse class 1 lever works as a catapult. Students will then record how high the ball is catapulted.

Similar activities include:

- *Activity 4: How Strong a Nutcracker Is a Door?*

Activity 14: How Can You Harness the Power of Wind with a Simple Machine?

A windmill creates mechanical power from the motion of the wind. The wind exerts force on the windmill blades so that they spin around an axis.

In this activity, students are tasked with building their own miniature windmill. For the students windmills, the wind of an electric fan will supply the power to turn the blades. After the students construct their windmills, they will experiment with two blade angles: high and low. They will try both of these angles in front of a fan and observe how well each works.

Similar include:

- *Activity 6: What Mechanical Advantage Do You Have in Your Bicycle?*
- *Activity 10: What Mechanical Advantage Does a Screw Provide?*

Activity 15: How Do Gears Work?

Like other machines, gears are used to change the speed or direction of motion or to change the force applied to an object.

In this activity students will create a gear out of a foam board.

Similar activities include:

- *Activity 6: What Mechanical Advantage Do You Have in Your Bicycle?*

Activity 16: How Are Simple Machines Classified?

Simple machines together do work that helps the overall device function as intended.

In this activity, students will be taking apart broken devices that they have found. Once they have fully disassembled the machine, have the students identify all the pieces they think function as simple machines. Students will organise and put these pieces (the simple machines) into the six categories: the lever, the inclined plane, the wedge, the screw, the pulley and the wheel.

Similar activities include:

- *Activity 17: Simple Machines Everywhere*

Activity 17: Simple Machines Everywhere

By Activity 17 students have seen many examples of each kind of simple machine. They have also seen some compound machines made up of at least two, and often many, simple machines working together.

In this activity, students will research one of three topics related to simple machines. This group research activity is a chance to go beyond the ideas discussed in the other activities and to consider their effect more broadly.

Similar activities include:

- *Activity 16: How Are Simple Machines Classified?*

1. What Is a Force?

TEACHER RESOURCE PAGE

Instructional Objectives

Students will be able to

- describe the physical concept of force
- state Newton's First Law
- predict how far a spring will stretch under a given force.

Australian Curriculum: Science Content Descriptions

Year 7 / Science Understanding / Physical Science / ACSSU117
Change to an object's motion is caused by unbalanced forces, including Earth's gravitational attraction, acting on the object

Year 7 / Science Inquiry Skills / Planning and Conducting / ACSIS125
Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed

Year 7 / Science Inquiry Skills / Planning and Conducting / ACSIS126
Measure and control variables, select equipment appropriate to the task and collect data with accuracy

Year 8 / Science Understanding / Physical Science / ACSSU155
Energy appears in different forms, including movement (kinetic energy), heat and potential energy, and energy transformations and transfers cause change within systems

Year 8 / Science Inquiry Skills / Planning and Conducting / ACSIS140
Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed

Year 8 / Science Inquiry Skills / Planning and Conducting / ACSIS141
Measure and control variables, select equipment appropriate to the task and collect data with accuracy

Year 9 / Science Inquiry Skills / Planning and Conducting / ACSIS165
Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods

Year 9 / Science Inquiry Skills / Processing and Analysing Data and Information / ACSIS169
Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies

Year 9 / Science Inquiry Skills / Evaluating / ACSIS171
Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data

Year 9 / Science Inquiry Skills / Communicating / ACSIS174
Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations

Year 10 / Science Understanding / Physical Science / ACSSU229
The motion of objects can be described and predicted using the laws of physics

Year 10 / Science Inquiry Skills / Planning and Conducting / ACSIS199
Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods

Year 10 / Science Inquiry Skills / Processing and Analysing Data and Information / ACSIS203
Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies

1. What Is a Force?

TEACHER RESOURCE PAGE

YEAR 10 / SCIENCE INQUIRY SKILLS / EVALUATING / ACSIS205
Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data

YEAR 10 / SCIENCE INQUIRY SKILLS / COMMUNICATING / ACSIS208
Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations

VOCABULARY

- **force:** a push or pull that causes an object to change its speed and/or direction of motion
- **gravity:** a force that attracts all objects in the universe to one another
- **inertia:** the resistance of mass to a change in its state of motion
- **Newton's First Law:** states that objects in motion tend to stay in motion and objects at rest tend to stay at rest

MATERIALS

For each student or group:

Part 1

- laboratory stand with an attachable clamp
- two coil springs of differing stiffness
- assorted lab weights, 1–10 newtons
- spring scale (reading up to 20 newtons)
- vinyl electrical tape
- metre ruler
- safety goggles

= Safety icon

Part 2

- table tennis ball or other smooth ball
- smooth, level floor or table

HELPFUL HINTS AND DISCUSSION

Time frame: 40 minutes, or one class period
Structure: individuals or cooperative learning groups
Location: classroom

In this activity, students investigate the concept of force. They will see how a spring supplies more force the more it is stretched. Explain that gravity is also a force, which can be balanced by the upward force of the spring. Provide students with an assortment of springs of different constants, making sure before class to choose springs that stretch measurably with the available weights but do not reach the table. Be sure to check that the weights do not stretch the springs permanently. You may use individual lab weights with hooks or loops, or a slotted weight set with a weight hanger.

Encourage students to be creative in Part 2, step 2, but in no case should the ball move until step 4. If a student complains, "How can I move the ball if you won't let me do anything to it?" then the student is properly grasping the idea of Newton's First Law.