

Janice VanCleave's



**PHYSICS**  
**FOR EVERY KID**

**SECOND EDITION**

**Easy Activities That Make  
Learning Science Fun**

**Janice VanCleave**

ILLUSTRATIONS BY **Tina Cash Walsh**

**JOSSEY-BASS™**  
A Wiley Brand

# Table of Contents

[Cover](#)

[Title Page](#)

[Copyright](#)

[Introduction](#)

[The Activities](#)

[General Instructions](#)

[Measurements](#)

[Foreword](#)

[I: Energy Introduction](#)

[1 Energy Conservation](#)

[See for Yourself](#)

[What Happened?](#)

[2 Frequency](#)

[See for Yourself](#)

[What Happened?](#)

[3 Coupled Pendulums](#)

[See for Yourself](#)

[What Happened?](#)

[4 Sound Waves in Air](#)

[See for Yourself](#)

[What Happened?](#)

[5 Pressure Waves](#)

[See for Yourself](#)

[What Happened?](#)

[6 Pitch](#)

[See for Yourself](#)

[What Happened?](#)

## [7 Sound Transmission](#)

[See for Yourself](#)

[What Happened?](#)

## [8 The Effect of Mass on Sound](#)

[See for Yourself](#)

[What Happened?](#)

## [9 Natural Frequency](#)

[See for Yourself](#)

[What Happened?](#)

## [10 Neutral Atom](#)

[See for Yourself](#)

[What Happened?](#)

## [11 Electric Current](#)

[See for Yourself](#)

[What Happened?](#)

## [12 Conductors vs. Insulators](#)

[See for Yourself](#)

[What Happened?](#)

## [13 LED](#)

[See for Yourself](#)

[What Happened?](#)

## [14 Electrochemical Energy](#)

[See for Yourself](#)

[What Happened?](#)

## [15 Polarizing an Insulator](#)

[See for Yourself](#)

[What Happened?](#)

[16 Polarizing a Conductor](#)

[See for Yourself](#)

[What Happened?](#)

[17 Electroscope](#)

[See for Yourself](#)

[What Happened?](#)

[18 Triboelectric Effect](#)

[See for Yourself](#)

[What Happened?](#)

[19 Adhesion: Charging by Contact](#)

[See for Yourself](#)

[What Happened?](#)

[20 Light Energy](#)

[See for Yourself](#)

[What Happened?](#)

[21 Light Transmission](#)

[See for Yourself](#)

[What Happened?](#)

[22 Light Waves](#)

[See for Yourself](#)

[What Happened?](#)

[23 Interference in Thin Films](#)

[See for Yourself](#)

[What Happened?](#)

[24 Concave Lens](#)

[See for Yourself](#)

[What Happened?](#)

25 Convex Lens

See for Yourself

What Happened?

26 Plano-Convex Lens

See for Yourself

What Happened?

27 Polarized Light

See for Yourself

What Happened?

28 Filters

See for Yourself

What Happened?

29 Optical Density

See for Yourself

What Happened?

30 Refractive Index

See for Yourself

What Happened?

31 Shadows

See for Yourself

What Happened?

II: Force and Motion Introduction

32 Inertia: Newton's First Law of Motion

See for Yourself

What Happened?

33 Rotational Inertia

See for Yourself

What Happened?

34 Acceleration

See for Yourself

What Happened?

35 Impulse

See for Yourself

What Happened?

36 Gravity

See for Yourself

What Happened?

37 Friction

See for Yourself

What Happened?

38 Air Resistance

See for Yourself

What Happened?

39 Drag Force

See for Yourself

What Happened?

40 Air Pressure

See for Yourself

What Happened?

41 Torque

See for Yourself

What Happened?

42 Resultant Force of Gravity

See for Yourself

What Happened?

43 Center of Gravity

[See for Yourself](#)  
[What Happened?](#)

[44 Balance](#)

[See for Yourself](#)  
[What Happened?](#)

[45 Shifting the Center of Gravity](#)

[See for Yourself](#)  
[What Happened?](#)

[46 Action/Reaction](#)

[See for Yourself](#)  
[What Happened?](#)

[47 Normal Force](#)

[See for Yourself](#)  
[What Happened?](#)

[48 Balloon Rocket](#)

[See for Yourself](#)  
[What Happened?](#)

[49 Bounce](#)

[See for Yourself](#)  
[What Happened?](#)

[50 Coandă Effect](#)

[See for Yourself](#)  
[What Happened?](#)

[51 Bernoulli's Principle](#)

[See for Yourself](#)  
[What Happened?](#)

[52 Pressure Differences](#)

[See for Yourself](#)

[What Happened?](#)

[53 Balanced Forces](#)

[See for Yourself](#)

[What Happened?](#)

[54 Unbalanced Forces](#)

[See for Yourself](#)

[What Happened?](#)

[55 Lift Forces](#)

[See for Yourself](#)

[What Happened?](#)

[III: Simple Machines Introduction](#)

[56 First-Class Lever](#)

[See for Yourself](#)

[What Happened?](#)

[57 Equal-Arm Balance](#)

[See for Yourself](#)

[What Happened?](#)

[58 Second-Class Lever](#)

[See for Yourself](#)

[What Happened?](#)

[59 Third-Class Lever](#)

[See for Yourself](#)

[What Happened?](#)

[60 Just for Fun: Third-Class Lever](#)

[See for Yourself](#)

[What Happened?](#)

[61 Inclined Plane](#)

[See for Yourself](#)



[What Happened?](#)

[62 Screw](#)

[See for Yourself](#)

[What Happened?](#)

[63 Wedge](#)

[See for Yourself](#)

[What Happened?](#)

[64 Moveable Pulley](#)

[See for Yourself](#)

[What Happened?](#)

[65 Fixed Pulley](#)

[See for Yourself](#)

[What Happened?](#)

[66 Wheel and Axle](#)

[See for Yourself](#)

[What Happened?](#)

[IV: Magnets Introduction](#)

[67 Ferromagnetism](#)

[See for Yourself](#)

[What Happened?](#)

[68 Magnetic Field](#)

[See for Yourself](#)

[What Happened?](#)

[69 3-D Magnetic Field](#)

[See for Yourself](#)

[What Happened?](#)

[70 Mapping Magnetic Fields](#)

[See for Yourself](#)

[What Happened?](#)

[71 Temporary vs. Permanent Magnets](#)

[See for Yourself](#)

[What Happened?](#)

[72 Magnetic Permeability](#)

[See for Yourself](#)

[What Happened?](#)

[73 Compass Rose](#)

[See for Yourself](#)

[What Happened?](#)

[74 Floating Compass](#)

[See for Yourself](#)

[What Happened?](#)

[75 Magnetic Declination](#)

[See for Yourself](#)

[What Happened?](#)

[76 Electromagnet](#)

[See for Yourself](#)

[What Happened?](#)

[77 Right-Hand Rule](#)

[See for Yourself](#)

[What Happened?](#)

[78 Demagnetization](#)

[See for Yourself](#)

[What Happened?](#)

[79 Dipping Needle](#)

[See for Yourself](#)

[What Happened?](#)

[80 Magnetic Energy](#)

[See for Yourself](#)

[What Happened?](#)

[Glossary](#)

[Index](#)

[End User License Agreement](#)

## **List of Illustrations**

Chapter 1

[FIG 1](#)

[FIG 2](#)

Chapter 2

[FIG 1](#)

Chapter 3

[FIG 1](#)

Chapter 4

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 5

[FIG 1](#)

Chapter 6

[FIG 1](#)

[FIG 2](#)

Chapter 7

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 8

[FIG 1](#)

Chapter 9

[FIG 1](#)

Chapter 10

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 11

[FIG 1](#)

Chapter 12

[FIG 1](#)

Chapter 13

[FIG 1](#)

Chapter 14

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 15

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 16

[FIG 1](#)

[FIG 2](#)

Chapter 17

[FIG 1](#)

[FIG 2](#)

Chapter 18

[FIG 1](#)

Chapter 19

[FIG 1](#)

[FIG 2](#)

Chapter 20

[FIG 1](#)

[FIG 2](#)

Chapter 21

[FIG 1](#)

[FIG 2](#)

Chapter 22

[FIG 1](#)

[FIG 2](#)

Chapter 23

[FIG 1](#)

[FIG 2](#)

Chapter 24

[FIG 1](#)

Chapter 25

[FIG 1](#)

Chapter 26

[FIG 1](#)

[FIG 2](#)

Chapter 27

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 28

[FIG 1](#)

[FIG 2](#)

Chapter 29

[FIG 1](#)

[FIG 2](#)

Chapter 30

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 31

[FIG 1](#)

[FIG 2](#)

Chapter 32

[FIG 1](#)

Chapter 33

[FIG 1](#)

Chapter 34

[FIG 1](#)

[FIG 2](#)

Chapter 35

[FIG 1](#)

Chapter 36

[FIG 1](#)

Chapter 37

[FIG 1](#)

[FIG 2](#)

Chapter 38

[FIG 1](#)

Chapter 39

[FIG 1](#)

[FIG 2](#)

Chapter 40

[FIG 1](#)

[FIG 2](#)

Chapter 41

[FIG 1](#)

[FIG 2](#)

Chapter 42

[FIG 1](#)

[FIG 2](#)

Chapter 43

[FIG 1](#)

[FIG 2](#)

Chapter 44

[FIG 1](#)

Chapter 45

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 46

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 47

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 48

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 49

[FIG 1](#)

[FIG 2](#)

Chapter 50

[FIG 1](#)



Chapter 51

[FIG 1](#)

[FIG 2](#)

Chapter 52

[FIG 1](#)

[FIG 2](#)

Chapter 53

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 54

[FIG 1](#)

Chapter 55

[FIG 1](#)

[FIG 2](#)

Chapter 56

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 57

[FIG 1](#)

Chapter 58

[FIG 1](#)

[FIG 2](#)

Chapter 59

[FIG 1](#)

[FIG 2](#)

Chapter 60

[FIG 1](#)

[FIG 2](#)

Chapter 61

[FIG 1](#)

Chapter 62

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 63

[FIG 1](#)

[FIG 2](#)

Chapter 64

[FIG 1](#)

Chapter 65

[FIG 1](#)

[FIG 2](#)

Chapter 66

[FIG 1](#)

Chapter 67

[FIG 1](#)

[FIG 2](#)

Chapter 68

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 69

[FIG 1](#)

[FIG 2](#)

Chapter 70

[FIG 1](#)

Chapter 71

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 72

[FIG 1](#)

[FIG 2](#)

Chapter 73

[FIG 1](#)

Chapter 74

[FIG 1](#)

[FIG 2](#)

Chapter 75

[FIG 1](#)

[FIG 2](#)

Chapter 76

[FIG 1](#)

[FIG 2](#)

Chapter 77

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

Chapter 78

[FIG 1](#)

Chapter 79

[FIG 1](#)

[FIG 2](#)

Chapter 80

[FIG 1](#)

[FIG 2](#)

[FIG 3](#)

# **Janice VanCleave's Physics for Every Kid**

**Easy Activities That Make Learning  
Science Fun**

**Janice VanCleave**

**Second Edition**

**J** JOSSEY-BASS™  
A Wiley Brand

Copyright © 2021 John Wiley & Sons. All rights reserved.

Illustrations by Tina Cash Walsh.

Jossey-Bass

A Wiley Imprint 111 River St, Hoboken, NJ 07030 [www.josseybass.com](http://www.josseybass.com)

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, phone +1 978 750 8400, fax +1 978 750 4470, or on the web at [www.copyright.com](http://www.copyright.com). Requests to the publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, phone + 1 201 748 6011, fax +1 201 748 6008, or online at [www.wiley.com/go/permissions](http://www.wiley.com/go/permissions).

**Limit of Liability/Disclaimer of Warranty:** Although the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

Jossey-Bass books and products are available through most bookstores. To contact Jossey-Bass directly, call our Customer Care Department within the U.S. at 800-956-7739, outside the U.S. at +1 317 572 3986, or fax +1 317 572 4002.

Wiley also publishes its books in a variety of electronic formats and by print-on-demand. Some material included with standard print versions of this book may not be included in e-books or in print-on-demand. If this book refers to media such as a CD or DVD that is not included in the version you purchased, you may download this material at <http://booksupport.wiley.com>. For more information about Wiley products, visit [www.wiley.com](http://www.wiley.com).

***Library of Congress Cataloging-in-Publication Data is Available:***

ISBN 9781119654285 (paperback)

ISBN 9781119654315 (ePDF)

ISBN 9781119654292 (ePub)

Cover illustrations by Tina Cash Walsh

Cover design by Paul McCarthy

SECOND EDITION

## Introduction

Throughout the writing of this book, I have daydreamed about the fun I have teaching hands-on physics. I've pictured children and educators enjoying these science activities, while reading instructions that are clear and easy to follow and simple explanations about what happened and why. Science safety was a primary concern when designing the activities in this book. It is my fervent hope that this physics book will ignite a profound curiosity for scientific discovery in readers of all ages. The bottom line is that I want to share my passion for physics and how exciting and relevant science is to our everyday lives.

One doesn't need a degree in science to benefit from learning more about why magnets stick to the fridge door and not to a wooden door. Wonder how a parachute works? Why does a magnifying glass make things look bigger? I imagine children of all ages stopping and questioning the physical world around us. Scientific investigations help develop patterns and higher-level thinking to solve real, everyday problems.

The order of presentation is designed to provide a physics foundation upon which to build new principles of science. The activities in each specific topic spiral in content. Throughout the activities, certain words and phrases are in bold; the meanings of these are given in the Glossary at the end of the book. Working through the activities in order is suggested. However, any activity has educational value on its own merit. With the help of the Glossary, as well as introductions for various topics, you can pick and choose any investigation and be rewarded with a successful experiment. Of course, a good outcome depends upon following the procedure steps in order. Substituting

equipment can affect the results for some activities, but science is meant to be fun so trust your judgment about changes.

This book was designed to give the reader a taste of physics:

**Energy** Learn about stored energy, energy of moving objects and the transfer between them, and the study of different forms of energy including mechanical, electrical, sound, and light. Energy is simply the ability to do work, which means to change or deform or move an object, and to create heat.

**Force and Motion** Learn about the effect of forces acting on an object, and study about the force of gravity and how it affects falling objects. A study of Sir Isaac Newton's Three Laws of Motion and how they apply to our everyday lives is covered.

**Simple Machines** Learn about simple machines which are mechanical devices that change the direction and/or magnitude (size) of a force. Levers, inclined planes, wedges, wheels and axles, pulleys, and screws are studied.

**Magnets** Learn about magnets and their effect, including an invisible field around magnets responsible for the most remarkable property of a magnet, which is a force that pulls on other magnetic materials, such as iron, and attracts or repels other magnets.

## The Activities

This book is written to guide you through the steps necessary in successfully completing a science experiment and to present methods of solving problems and making discoveries.



**Introduction:** Background information provides knowledge about the topic of the investigation and generally describes cause and effect relationships that you can investigate.

**See for Yourself:** A list of common but necessary materials and step-by-step instructions on how to perform the experiment is provided.

**What Happened?** A statement of the predicted outcome is provided with a discussion of what should have happened during the activity. A scientific explanation of what was observed is provided using understandable language and technical, scientific vocabulary so that readers of any age can master the scientific principles involved and discuss their findings.

## General Instructions

1. **Read first.** Read each experiment completely before starting.
2. **Collect needed supplies.** You will experience less frustration and more fun if all the necessary materials for the experiments are ready and set up for easy access.
3. **Experiment.** Follow each step very carefully, never skip steps, and do not add your own. Safety is of the utmost importance. By reading the experiment before starting, you will be able to note any safety warnings. Then, follow instructions exactly so you can feel confident that your outcome will have the desired results.
4. **Observe.** If your results are not the same as described in the experiment, carefully reread the instructions, and start over from the beginning. Check to make sure

your materials are as described and in good working order. Use the illustrations to see if the activity is set up properly. Consider factors, such as the ambient temperature, humidity, lighting, and so on, that might affect the results.

## **Measurements**

Measuring quantities described in this book are given in imperial units followed by approximate metric equivalents in parentheses. Unless specifically noted, the quantities listed are not critical, and a variation of a very small amount more or less will not alter the results.

## Foreword

Imagine a toddler gleefully dropping a bottle off the highchair tray. Their parent returns the bottle to its rightful place only to see it dropped again. And each time the bottle falls to the floor. This toddler and Sir Isaac Newton have something in common. They both find physics delightful! Janice VanCleave knows that this toddler is learning about the laws of physics! This book is written for every kid who wants to keep dropping things, rolling things, and, most of all, wants to keep learning about the physical world.

And who hasn't wondered about how something as large as an airplane can stay up in the sky? Janice VanCleave never wants that sense of wonder to end. Written for people of all ages with a curiosity about the world around us, this book will be a treasure for the homeschooling parent or classroom teacher that wants to add easy-to-do science that promises to have kids asking, "Is it time for science yet?"

Each activity starts out with a clear explanation of a scientific phenomenon. We have all played with magnets. But did you know that you can map an invisible magnetic force field with a compass? Soon, you find yourself eagerly gathering a few common household materials because the activity is so enticing you can't wait to try it! Each science activity, often deceptively simple, is followed by an explanation that uses everyday language to explain complex principles. It is simply astounding to experiment with something that you have seen a million times, but for the first time you really understand the science. Wow.

Janice VanCleave is a teacher at heart. Her true passion is explaining science in a way that anyone can understand it.

This book is a treasure. It unlocks the mystery of physical laws that we see every moment of every day.

I can't help but think that one day the baby who dropped the bottle off the highchair tray will open this book. Then, a true adventure of science discovery and learning will take place. Once again, exploring physics will be delightful! Perhaps that kid will grow up to be the first person to walk on Mars. Anything is possible.

Mary Bowen

# Energy Introduction

**Energy** is the capacity to do work. In **physics**, work is done when a force is applied to an object causing it to move. A **force** is a pushing or pulling action on an object. Forces are measured in pounds (lb) or **newtons** (N), where  $1 \text{ lb} = 4.5 \text{ N}$ . **Work** occurs only when a force causes something to move. If you push on a tree and it doesn't move, then no work has been done even though the effort may have exhausted you. Study how work is calculated in this important equation:  $W = F \times d$ ; where  $W$  is the work done;  $F$  is a specific force and  $d$  is the distance moved. Comparatively, when the equation is  $W = F_{\text{net}} \times d$ , the work being done considers all forces ( $F_{\text{net}}$ ) that are acting on the object that is being moved, including frictional forces.

**Weight** is a measure of Earth's gravitational force pulling an object down toward the center of Earth. Gravity is the force of **attraction** between two objects with mass. Yes, your body has a force of attraction on other objects, but it is such a minute force that it is basically ineffective.

Whereas, the mass of Earth is great enough to produce a force that pulls things on or near Earth's surface down. Down means toward the center of Earth; thus, when you drop something, it falls perpendicular to Earth's surface. Forces do not always cause **linear motion**, which is motion in a straight line. **Torque** is a turning force that causes motion around a center point, such as the turning of a lid or the spinning of a merry-go-round.

**Movement** is the change of an object's physical position. Linear movement is measured in feet (ft) or centimeters

(cm), where  $1 \text{ ft} = 30 \text{ cm}$ . Not all movement is linear or rotational but rather some objects **vibrate**, meaning they move back and forth. **Frequency** is a measure of the number of times something happens in a specific amount of time. Frequency can be measured in **hertz (Hz)**, where  $1 \text{ Hz} = 1 \text{ cycle per second}$  or one back and forth vibration.

**Potential energy** is the energy an object has because of its position relative to some zero position. It is energy that has the potential to do 'work.' Two types of potential energy investigated in this book are **gravitational potential energy** and **elastic potential energy**.

**Gravitational potential energy** is the stored energy an object has because of its position above a specific ground zero. This type of potential energy is due to the force of gravity acting on the object. To obtain this energy, work had to be done on an object to raise it to a higher level above ground zero, such as placing a book on a top shelf with the floor below being ground zero. Gravitational potential energy is directly related to the mass of the object as well as its height above ground zero. When the book is dropped from a specific height, its gravitational potential energy is converted to kinetic energy as the book falls.

**Elastic potential energy** is the energy stored in an object that can be stretched or compressed. A force is needed to compress or stretch an elastic object. Consider a trampoline, which has the greatest elastic potential energy when it is stretched the most, as does a rubber band. A coiled spring stores elastic potential energy when a force compresses it as well as when a force stretches it. In both cases, when the spring is released, the spring's elastic potential energy results in the wound coils moving back to their normal position.