9th edition

Physics for Scientists and Engineers

Serway/Jewett

International Edition

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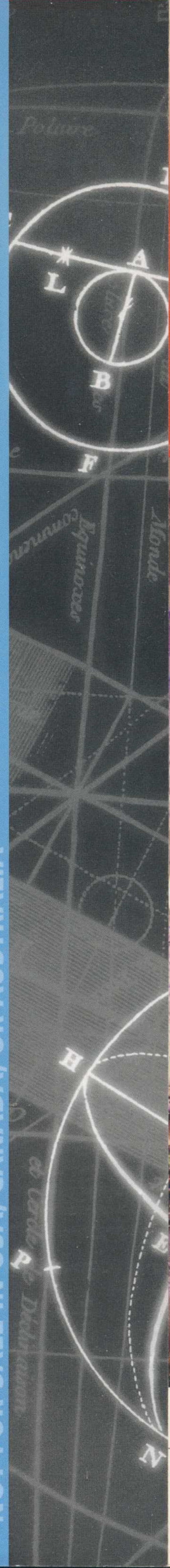

Pedagogical Color Chart

Mechanics and Thermodynamics

Displacement and position vectors

Displacement and position component vectors

Linear ($\vec{\mathbf{v}}$) and angular ($\vec{\boldsymbol{\omega}}$) velocity vectors

Velocity component vectors

Force vectors ($\vec{\mathbf{F}}$)

Force component vectors

Acceleration vectors ($\vec{\mathbf{a}}$)

Acceleration component vectors

Energy transfer arrows W_{eng} Q_c Q_h

Process arrow

Linear ($\vec{\mathbf{p}}$) and angular ($\vec{\mathbf{L}}$) momentum vectors

Linear and angular momentum component vectors

Torque vectors ($\vec{\boldsymbol{\tau}}$)

Torque component vectors

Schematic linear or rotational motion directions

Dimensional rotational arrow

Enlargement arrow

Springs

Pulleys

Electricity and Magnetism

Electric fields

Electric field vectors

Electric field component vectors

Magnetic fields

Magnetic field vectors

Magnetic field component vectors

Positive charges +

Negative charges –

Resistors

Batteries and other DC power supplies + –

Switches

Capacitors

Inductors (coils)

Voltmeters V

Ammeters A

AC Sources

Lightbulbs

Ground symbol

Current

Light and Optics

Light ray

Focal light ray

Central light ray

Converging lens

Diverging lens

Mirror

Curved mirror

Objects

Images

Some Physical Constants

Quantity	Symbol	Value[a]
Atomic mass unit	u	$1.660\,538\,782\,(83) \times 10^{-27}$ kg $931.494\,028\,(23)$ MeV/c^2
Avogadro's number	N_A	$6.022\,141\,79\,(30) \times 10^{23}$ particles/mol
Bohr magneton	$\mu_B = \dfrac{e\hbar}{2m_e}$	$9.274\,009\,15\,(23) \times 10^{-24}$ J/T
Bohr radius	$a_0 = \dfrac{\hbar^2}{m_e e^2 k_e}$	$5.291\,772\,085\,9\,(36) \times 10^{-11}$ m
Boltzmann's constant	$k_B = \dfrac{R}{N_A}$	$1.380\,650\,4\,(24) \times 10^{-23}$ J/K
Compton wavelength	$\lambda_C = \dfrac{h}{m_e c}$	$2.426\,310\,217\,5\,(33) \times 10^{-12}$ m
Coulomb constant	$k_e = \dfrac{1}{4\pi\epsilon_0}$	$8.987\,551\,788 \ldots \times 10^{9}\ \mathrm{N \cdot m^2/C^2}$ (exact)
Deuteron mass	m_d	$3.343\,583\,20\,(17) \times 10^{-27}$ kg $2.013\,553\,212\,724\,(78)$ u
Electron mass	m_e	$9.109\,382\,15\,(45) \times 10^{-31}$ kg $5.485\,799\,094\,3\,(23) \times 10^{-4}$ u $0.510\,998\,910\,(13)$ MeV/c^2
Electron volt	eV	$1.602\,176\,487\,(40) \times 10^{-19}$ J
Elementary charge	e	$1.602\,176\,487\,(40) \times 10^{-19}$ C
Gas constant	R	$8.314\,472\,(15)\ \mathrm{J/mol \cdot K}$
Gravitational constant	G	$6.674\,28\,(67) \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2}$
Neutron mass	m_n	$1.674\,927\,211\,(84) \times 10^{-27}$ kg $1.008\,664\,915\,97\,(43)$ u $939.565\,346\,(23)$ MeV/c^2
Nuclear magneton	$\mu_n = \dfrac{e\hbar}{2m_p}$	$5.050\,783\,24\,(13) \times 10^{-27}$ J/T
Permeability of free space	μ_0	$4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$ (exact)
Permittivity of free space	$\epsilon_0 = \dfrac{1}{\mu_0 c^2}$	$8.854\,187\,817 \ldots \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$ (exact)
Planck's constant	h	$6.626\,068\,96\,(33) \times 10^{-34}\ \mathrm{J \cdot s}$
	$\hbar = \dfrac{h}{2\pi}$	$1.054\,571\,628\,(53) \times 10^{-34}\ \mathrm{J \cdot s}$
Proton mass	m_p	$1.672\,621\,637\,(83) \times 10^{-27}$ kg $1.007\,276\,466\,77\,(10)$ u $938.272\,013\,(23)$ MeV/c^2
Rydberg constant	R_H	$1.097\,373\,156\,852\,7\,(73) \times 10^{7}\ \mathrm{m^{-1}}$
Speed of light in vacuum	c	$2.997\,924\,58 \times 10^{8}$ m/s (exact)

Note: These constants are the values recommended in 2006 by CODATA, based on a least-squares adjustment of data from different measurements. For a more complete list, see P. J. Mohr, B. N. Taylor, and D. B. Newell, "CODATA Recommended Values of the Fundamental Physical Constants: 2006." *Rev. Mod. Phys.* **80:**2, 633–730, 2008.

[a]The numbers in parentheses for the values represent the uncertainties of the last two digits.

Solar System Data

Body	Mass (kg)	Mean Radius (m)	Period (s)	Mean Distance from the Sun (m)
Mercury	3.30×10^{23}	2.44×10^{6}	7.60×10^{6}	5.79×10^{10}
Venus	4.87×10^{24}	6.05×10^{6}	1.94×10^{7}	1.08×10^{11}
Earth	5.97×10^{24}	6.37×10^{6}	3.156×10^{7}	1.496×10^{11}
Mars	6.42×10^{23}	3.39×10^{6}	5.94×10^{7}	2.28×10^{11}
Jupiter	1.90×10^{27}	6.99×10^{7}	3.74×10^{8}	7.78×10^{11}
Saturn	5.68×10^{26}	5.82×10^{7}	9.29×10^{8}	1.43×10^{12}
Uranus	8.68×10^{25}	2.54×10^{7}	2.65×10^{9}	2.87×10^{12}
Neptune	1.02×10^{26}	2.46×10^{7}	5.18×10^{9}	4.50×10^{12}
Pluto[a]	1.25×10^{22}	1.20×10^{6}	7.82×10^{9}	5.91×10^{12}
Moon	7.35×10^{22}	1.74×10^{6}	—	—
Sun	1.989×10^{30}	6.96×10^{8}	—	—

[a]In August 2006, the International Astronomical Union adopted a definition of a planet that separates Pluto from the other eight planets. Pluto is now defined as a “dwarf planet” (like the asteroid Ceres).

Physical Data Often Used

Average Earth–Moon distance	3.84×10^{8} m
Average Earth–Sun distance	1.496×10^{11} m
Average radius of the Earth	6.37×10^{6} m
Density of air (20°C and 1 atm)	1.20 kg/m^3
Density of air (0°C and 1 atm)	1.29 kg/m^3
Density of water (20°C and 1 atm)	1.00×10^{3} kg/m^3
Free-fall acceleration	9.80 m/s^2
Mass of the Earth	5.97×10^{24} kg
Mass of the Moon	7.35×10^{22} kg
Mass of the Sun	1.99×10^{30} kg
Standard atmospheric pressure	1.013×10^{5} Pa

Note: These values are the ones used in the text.

Some Prefixes for Powers of Ten

Power	Prefix	Abbreviation	Power	Prefix	Abbreviation
10^{-24}	yocto	y	10^{1}	deka	da
10^{-21}	zepto	z	10^{2}	hecto	h
10^{-18}	atto	a	10^{3}	kilo	k
10^{-15}	femto	f	10^{6}	mega	M
10^{-12}	pico	p	10^{9}	giga	G
10^{-9}	nano	n	10^{12}	tera	T
10^{-6}	micro	μ	10^{15}	peta	P
10^{-3}	milli	m	10^{18}	exa	E
10^{-2}	centi	c	10^{21}	zetta	Z
10^{-1}	deci	d	10^{24}	yotta	Y

Physics

for Scientists and Engineers with Modern Physics

NINTH EDITION

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About the Cover
The cover shows a view inside the new railway departures concourse opened in March 2012 at the Kings Cross Station in London. The wall of the older structure (completed in 1852) is visible at the left. The sweeping shell-like roof is claimed by the architect to be the largest single-span station structure in Europe. Many principles of physics are required to design and construct such an open semicircular roof with a radius of 74 meters and containing over 2 000 triangular panels. Other principles of physics are necessary to develop the lighting design, optimize the acoustics, and integrate the new structure with existing infrastructure, historic buildings, and railway platforms.

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Physics for Scientists and Engineers with Modern Physics, Ninth Edition
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Publisher, Physical Sciences: Mary Finch
Publisher, Physics and Astronomy: Charlie Hartford
Development Editor: Ed Dodd
Assistant Editor: Brandi Kirksey
Editorial Assistant: Brendan Killion
Media Editor: Rebecca Berardy Schwartz
Brand Manager: Nicole Hamm
Marketing Communications Manager: Linda Yip
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Manufacturing Planner: Sandee Milewski
Rights Acquisition Specialist: Shalice Shah-Caldwell
Production Service: Lachina Publishing Services
Text and Cover Designer: Roy Neuhaus
Cover Image: The new Kings Cross railway station, London, UK
Cover Image Credit: © Ashley Cooper/Corbis
Compositor: Lachina Publishing Services

Library of Congress Control Number: 2012947242

ISBN-13: 978-1-133-95405-7

ISBN-10: 1-133-95405-7

Brooks/Cole
20 Channel Center Street
Boston, MA 02210
USA

We dedicate this book to our wives, Elizabeth and Lisa, and all our children and grandchildren for their loving understanding when we spent time on writing instead of being with them.

Printed in the United States of America
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