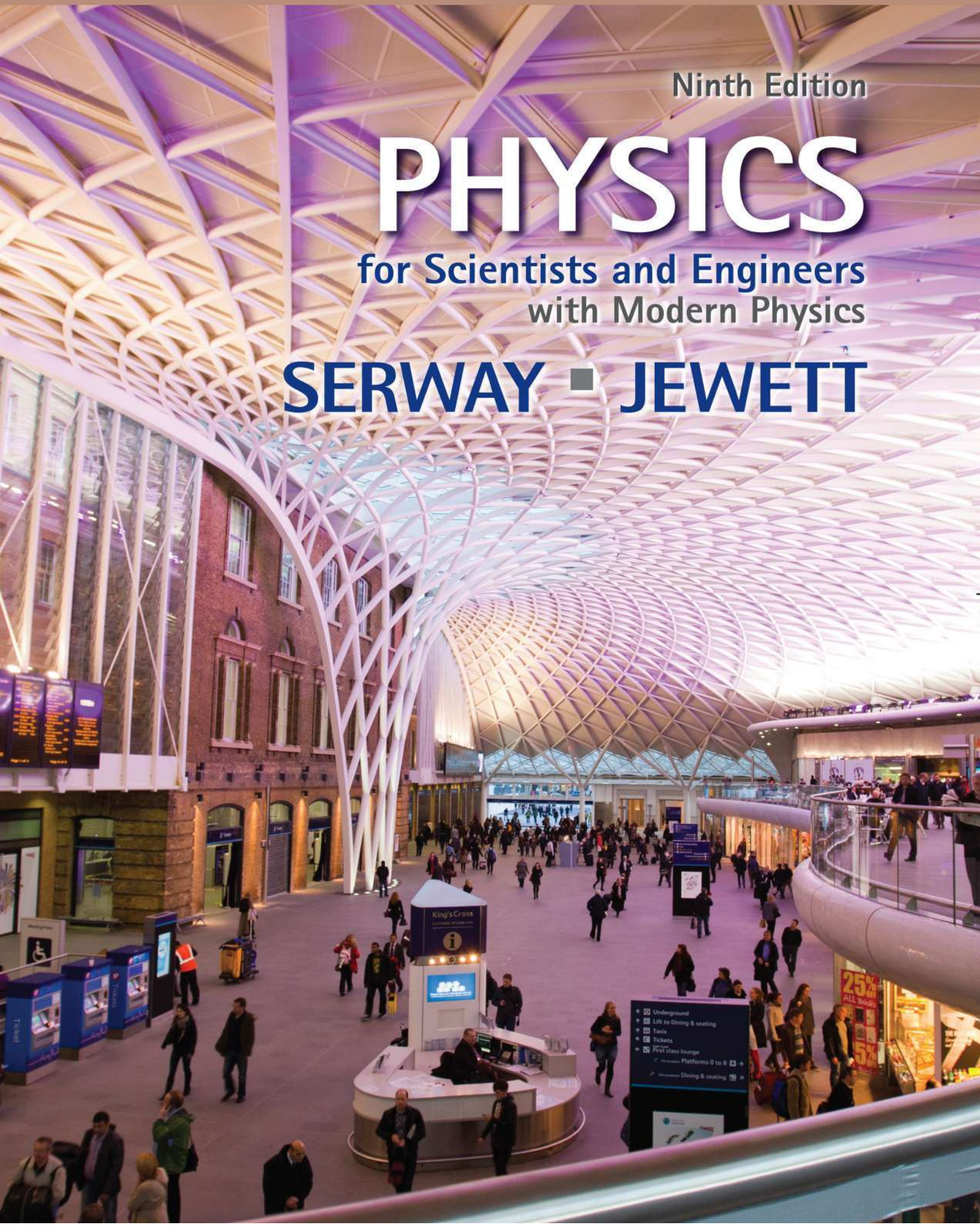


Ninth Edition

PHYSICS

for Scientists and Engineers
with Modern Physics

SERWAY ■ JEWETT



Pedagogical Color Chart

Mechanics and Thermodynamics

Displacement and position vectors



Displacement and position component vectors



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



Velocity component vectors



Force vectors (\vec{F})



Force component vectors



Acceleration vectors (\vec{a})



Acceleration component vectors



Energy transfer arrows



Process arrow



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



Linear and angular momentum component vectors



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



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



Ammeters



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	$\mu_B = \frac{e\hbar}{2m_e}$	9.274 009 15 (23) $\times 10^{-24}$ J/T
Bohr radius	$a_0 = \frac{\hbar^2}{m_e e^2 k_e}$	5.291 772 085 9 (36) $\times 10^{-11}$ m
Boltzmann's constant	$k_B = \frac{R}{N_A}$	1.380 650 4 (24) $\times 10^{-23}$ J/K
Compton wavelength	$\lambda_C = \frac{h}{m_e c}$	2.426 310 217 5 (33) $\times 10^{-12}$ m
Coulomb constant	$k_e = \frac{1}{4\pi\epsilon_0}$	8.987 551 788 ... $\times 10^9$ N·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) J/mol·K
Gravitational constant	G	6.674 28 (67) $\times 10^{-11}$ N·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	$\mu_n = \frac{e\hbar}{2m_p}$	5.050 783 24 (13) $\times 10^{-27}$ J/T
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ T·m/A (exact)
Permittivity of free space	$\epsilon_0 = \frac{1}{\mu_0 c^2}$	8.854 187 817 ... $\times 10^{-12}$ C ² /N·m ² (exact)
Planck's constant	h	6.626 068 96 (33) $\times 10^{-34}$ J·s
	$\hbar = \frac{h}{2\pi}$	1.054 571 628 (53) $\times 10^{-34}$ J·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) $\times 10^7$ 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.

^aThe 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	—	—

^aIn 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

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NINTH
EDITION

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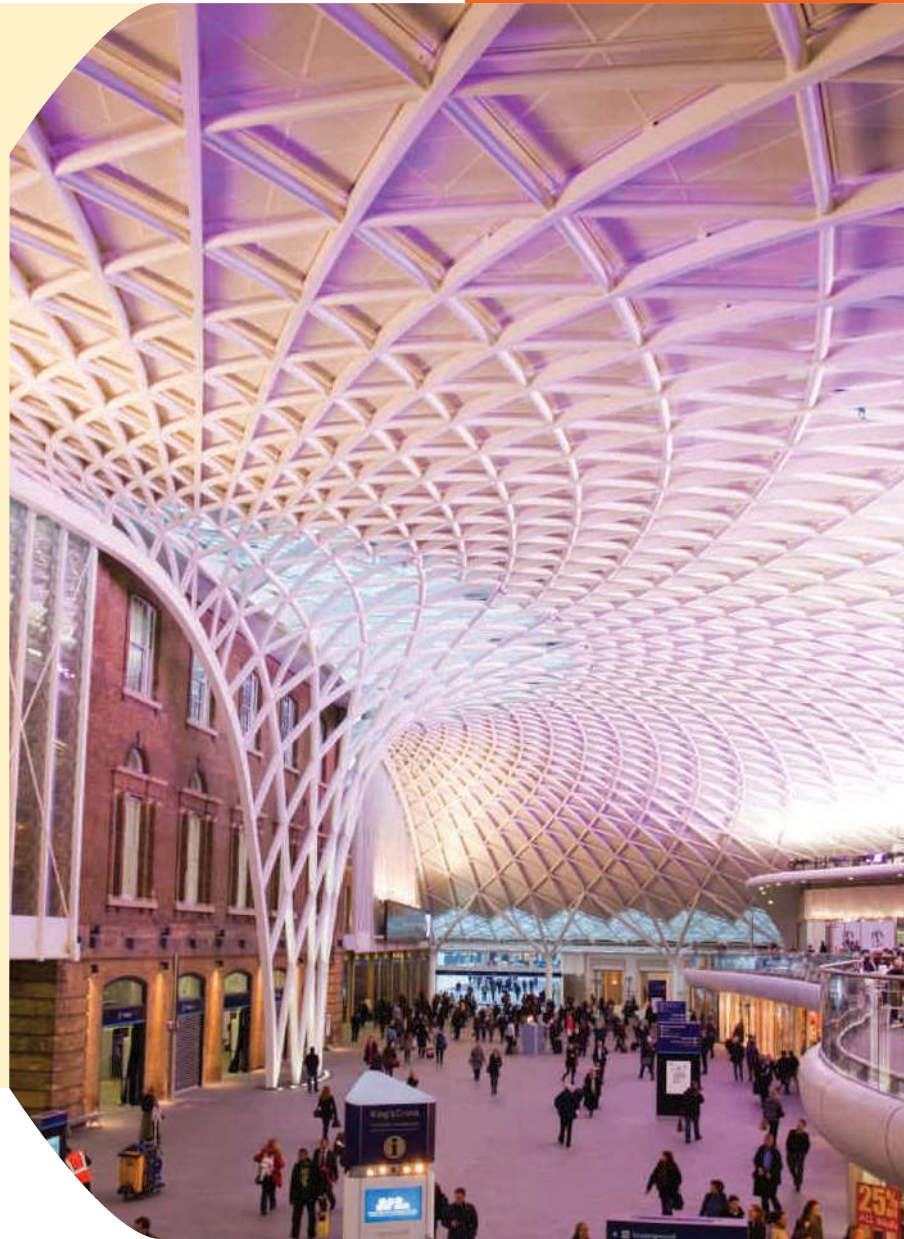
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About the Cover

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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