Felder & Felder, *Modern Physics:* List of Derivations

Most important derivations in the text are done in Problems. A typical such problem does not just say “derive this formula”; it carefully walks the student through the steps of the derivation. Our strong belief is that, if you really want your students to understand and retain a particular derivation, having them walk through the steps on their own will be far more effective than simply showing them the derivation, whether on paper on in class.

As an example, the formula for relativistic time dilation is presented on p. 15, and derived in a Problem on p. 22. To make this structure clear, these locations point to each other.

- The paragraph leading up to the formula on p. 15 includes the sentence:

  “In Problem 31 you will turn that formula into a general formula for time dilation.”

- The Problem on p. 22 begins with an easily identifiable boldfaced header:

  Deriving the Time Dilation Formula

This double-referencing makes it easy to connect the formula with its derivation.

If you want to show students a fully worked-out derivation, you can share with them the complete *solution* to such a problem from the book’s Solution Manual (available to logged-in professors at the Cambridge Web site).

A list of derivations in the book is provided below.

Chapter 1: Relativity I: Time, Space, and Motion

Equation	Topic	Derivation
Equation 1.3 on p. 15	Time dilation	p. 22, Problem 31
Equation 1.5 on p. 29	Simultaneity	p. 34, Problem 18
Equations 1.6 on p. 38	Lorentz transformations	Begun on p. 41 Completed in p. 44, Problem 21
Invariance of the spacetime interval on p. 40		p. 44, Problem 22
Equations 1.8 on p. 46	Velocity transformations	p. 50, Problems 16 and 17
Equation 1.9 on p. 48	Doppler effect	p. 50, Problem 18

Chapter 2: Relativity II: Dynamics

Equation	Topic	Derivation
Equation 2.4 on p. 66	Relativistic energy	p. 71, Problem 17
Expected phase shift in a Michelson interferometer		p. 103, Problem 8

Chapter 3: The Quantum Revolution I: From Light Waves to Photons

Equation	Topic	Derivation
	Bragg's law	p. 126, Problem 16
Equation 3.4 on p. 137	3D Cavity Spectrum	p. 151, Problem 39
Equation 3.6 on p. 138	Average energy of a single wave in a cavity ($E=k_BT$)	p. 148, Problem 24
Equation 3.7 on p. 139	Boltzmann distribution	*<Deferred to Section 10.4>*
	Classical blackbody spectrum	p. 148, Problem 24
Equation 3.10 on p. 144	Planck's blackbody spectrum	p. 151, Problem 38
	Stefan's law	p. 150, Problem 36
Equation 3.11 on p. 162	Compton shift	p. 168, Problem 34

Chapter 4: The Quantum Revolution II: Matter and Wavefunctions

Equation	Topic	Derivation
	Thomson Model Emission	p. 182, Problem 22
Equation 4.2 on p. 176	Bohr model energy levels	p. 182, Problem 23
Equation 4.3 on p. 176	Radii of Bohr model levels	p. 182, Problem 23
	Rydberg constant	p. 182, Problem 25
Equation 4.5 on p. 196	Discrete expectation value	p. 201, Problem 23

Chapter 5: The Schrödinger Equation

Equation	Topic	Derivation
Equation 5.2 on p. 221	Time-independent Schrödinger equation	*<Deferred to Section 6.6>*
Equation 5.18 on p. 247	Euler's formula	p. 249, Problems 22 and 23
Equation 5.20 on p. 251	Wavefunction time evolution	*<Deferred to Section 6.6>*

Chapter 6: Unbound States

Equation	Topic	Derivation
p. 280	Momentum eigenstates	p. 282
Kinetic energy probability distribution		p. 286, Problem 14
Reflection, transmission coefficients for potential step		p. 305, Problem 24

Chapter 7: The Hydrogen Atom

Equation	Topic	Derivation
Equation 7.5 on p. 324	3D time-independent Schrödinger equation	p. 331, Problem 21
Table 7.1 on p. 333	Cartesian /spherical coordinate conversions	p. 336, Problem 9
Equations 7.17, 7.18, 7.20, 7.21 on p. 337	Differential equations for the radial and angular pieces of the hydrogen atom energy eigenstates	p. 343, Problem 16
p. 339	m_l is an integer	p. 343, Problem 18

Chapter 8: Atoms

Equation	Topic	Derivation
Pauli exclusion from antisymmetry		p. 372, Problem 6

Chapter 9: Molecules: No Derivations

Chapter 10: Statistical Mechanics

Equation	Topic	Derivation
Equation 10.1 on p. 419	Binomial coefficients (*n* choose *m*)	p. 423, Problem 18
Equation 10.4 on p. 445	Boltzmann distribution	p. 453, Problem 22
Equation 10.5 on p. 461	Maxwell speed distribution	p. 465, Problem 26
Equation 10.6 on p. 468	Fermi-Dirac distribution	p. 474, Problem 23
Equation 10.7 on p. 468	Bose-Einstein distribution	p. 475, Problem 24
Equation 10.8 on p. 469	Density of states for a particle in a box	p. 476, Problem 31
Equation 10.10 on p. 481	Photon occupation number in a cavity in equilibrium	p. 486, Problem 19
Equation 10.12 on p. 482	Planck spectrum for a cavity	p. 484, Problem 20
Planck spectrum for blackbody emission		p. 486, Problem 21
	Wien’s law	p. 487, Problem 22
	Stefan’s law	p. 487, Problem 23

Chapter 11: Solids

Equation	Topic	Derivation
Equation 11.2 on p. 542	Dulong-Petit	p. 550, Problem 11
Equation 11.3 on p. 544	Average oscillator energy	p. 550, Problem 12

Chapter 12: The Atomic Nucleus: No Derivations

Chapter 13: Particle Physics: No Derivations

Chapter 14: Cosmology

Equation	Topic	Derivation
Equation 14.1 on p. 672	First Friedmann equation (Newtonian derivation)	p. 671, Exercise 14.4.1
Equation 14.2 on p. 672	Second Friedmann equation (thermodynamic derivation)	p. 681, Problem 18
p. 676	$a(t)$ and $\rho(a)$ for a matter-dominated universe	p. 681, Problem 14
p. 676	$a(t)$ and $\rho(a)$ for a radiation-dominated universe	p. 681, Problem 15