Mechanical Universe and Beyond Chapter Titles

2. The Law of Falling Bodies
Galileo's imaginative experiments proved that all bodies fall with the same constant acceleration.

3. Derivatives
The function of mathematics in physical science and the derivative as a practical tool.

4. Inertia
Galileo risks his favored status to answer the questions of the universe with his law of inertia.

5. Vectors
Physics must explain not only why and how much, but also where and which way.

6. Newton's Laws
Newton lays down the laws of force, mass, and acceleration.

7. Integration
Newton and Leibniz arrive at the conclusion that differentiation and integration are inverse processes.

8. The Apple and the Moon
The first real steps toward space travel are made as Newton discovers that gravity describes the force between any two particles in the universe.

9. Moving in Circles
A look at the Platonic theory of uniform circular motion.

10. Fundamental Forces
All physical phenomena of nature are explained by four forces: two nuclear forces, gravity, and electricity.

11. Gravity, Electricity, Magnetism
Shedding light on the mathematical form of the gravitational, electric, and magnetic forces.

12. The Millikan Experiment
A dramatic recreation of Millikan's classic oil-drop experiment to determine the charge of a single electron.

13. Conservation of Energy
According to one of the major laws of physics, energy is neither created nor destroyed.

14. Potential Energy
Potential energy provides a powerful model for understanding why the world has worked the same way since the beginning of time.

15. Conservation of Momentum
What keeps the universe ticking away until the end of time?

16. Harmonic Motion
The music and mathematics of periodic motion.

17. Resonance
Why a swaying bridge collapses with a high wind, and why a wine glass shatters with a higher octave.

18. Waves
With an analysis of simple harmonic motion and a stroke of genius, Newton extended mechanics to the propagation of sound.

19. Angular Momentum
An old momentum with a new twist.

20. Torques and Gyroscopes
From spinning tops to the precession of the equinoxes.

21. Kepler's Three Laws
The discovery of elliptical orbits helps describe the motion of heavenly bodies with unprecedented accuracy.

22. The Kepler Problem
The deduction of Kepler's laws from Newton's universal law of gravitation is one of the crowning achievements of Western thought.

23. Energy and Eccentricity
The precise orbit of a heavenly body — a planet, asteroid, or comet — is fixed by the laws of conservation of energy and angular momentum.

24. Navigating in Space
Voyages to other planets use the same laws that guide planets around the solar system.

25. Kepler to Einstein
From Kepler's laws and the theory of tides, to Einstein's general theory of relativity, into black holes, and beyond.

28. Static Electricity
Eighteenth-century electricians knew how to spark the interest of an audience with the principles of static electricity.

29. The Electric Field
Faraday's vision of lines of constant force in space laid the foundation for the modern force field theory.

30. Potential and Capacitance
Franklin proposes a successful theory of the Leyden jar and invents the parallel plate capacitor.

31. Voltage, Energy, and Force
When is electricity dangerous or benign, spectacular or useful?

32. The Electric Battery
Volta invents the electric battery using the internal properties of different metals.

33. Electric Circuits
The work of Wheatstone, Ohm, and Kirchhoff leads to the design and analysis of how current flows.

34. Magnetism
Gilbert discovered that the earth behaves like a giant magnet. Modern scientists have learned even more.

36. Vector Fields and Hydrodynamics
Force fields have definite properties of their own suitable for scientific study.

37. Electromagnetic Induction
The discovery of electromagnetic induction in 1831 creates an important technological breakthrough in the generation of electric power.

38. Alternating Current
Electromagnetic induction makes it easy to generate alternating current while transformers make it practical to distribute it over long distances.

40. Optics
Many properties of light are properties of waves, including reflection, refraction, and diffraction.

41. The Michelson-Morley Experiment
In 1887, an exquisitely designed measurement of the earth's motion through the ether results in the most brilliant failure in scientific history.

42. The Lorentz Transformation
If the speed of light is to be the same for all observers, then the length of a meter stick, or the rate of a ticking clock, depends on who measures it.

43. Velocity and Time
Einstein is motivated to perfect the central ideas of physics, resulting in a new understanding of the meaning of space and time.

44. Mass, Momentum, Energy
The new meaning of space and time make it necessary to formulate a new mechanics.

45. Temperature and Gas Laws
Hot discoveries about the behavior of gases make the connection between temperature and heat.

46. Engine of Nature
The Carnot engine, part one, beginning with simple steam engines.

47. Entropy
The Carnot engine, part two, with profound implications for the behavior of matter and the flow of time through the universe.

48. Low Temperatures
With the quest for low temperatures came the discovery that all elements can exist in each of the basic states of matter.

49. The Atom
A history of the atom, from the ancient Greeks to the early 20th century, and a new challenge for the world of physics.

50. Particles and Waves
Evidence that light can sometimes act like a particle leads to quantum mechanics, the new physics.

52. The Quantum Mechanical Universe
A last look at where we've been and a peek into the future.