Introductory Physics Textbooks

This aid to those interested in the varieties of form and content contains an extensive survey of over 50 books. Prefaces, tables of contents, general levels of mathematical and physical sophistication and the kinds of problems and other study aids are examined and commented upon.

by Peter G. Roll

DURING THE ACADEMIC YEAR 1961–62, the only year for which reliable information has been collected, almost 190 000 students were enrolled in the first term of one of approximately 1700 introductory physics courses offered by the nation's two- and four-year colleges, universities and technical institutes.[1] A reasonable extrapolation of these figures from the intervening six years suggests that this spring and summer about 2000 physics professors must decide either to continue using their present introductory texts or to select a new one from among a dozen or two that are intended for their particular kind of introductory course. These decisions determine what books are purchased by well over 200 000 students next fall, and how the $1 or $2 million gross receipts from the sale of new introductory physics textbooks are distributed among the various publishers.

Since the textbook is perhaps the most important instructional device used in introductory physics courses, its selection is a task to which many of us who teach such courses devote much time and serious thought. Furthermore the quality and contents of these books are important to the entire physics profession; for they influence the new generation of physicists in their formative stages, and, perhaps more importantly, they are a most significant factor in the image of physics possessed by the one quarter of college students who bother to take a physics course at all.[2] In recognition of this situation, a number of local and national groups have expended considerable effort over the past several years to improve the content of introductory courses,[3–5] and these efforts have contributed to an increase in the number of books available for all kinds of introductory instruction.

Invariance . . .

Were one to compare available physics texts by examining their tables of contents, one might come to the conclusion that most of them are quite similar—even including some that proclaim themselves as "new"or "modern" approaches. One can, in fact, write down a table of contents that fits, with only minor exceptions, most of today's introductory physics texts, whether they be intended for science and engineering students or for nonscientists

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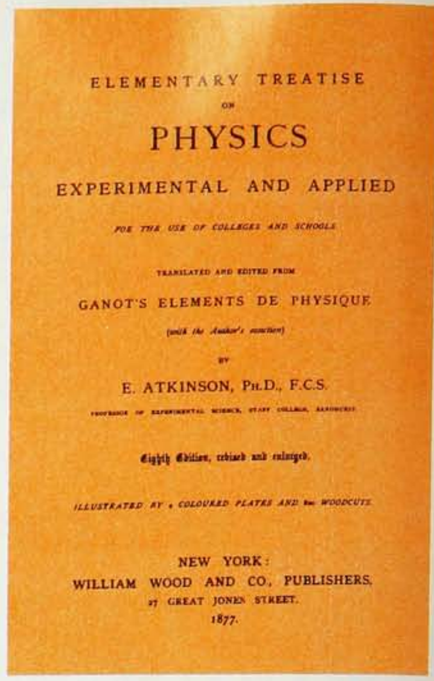
Table 1. A Universal Table of Contents for Introductory Physics Textbooks

- Introduction (measurement, units, the nature of physics)
- Vectors
- Kinematics and motion with constant acceleration (rectilinear, curvilinear and projectile motion)
- Particle dynamics (Newton's laws, friction, universal gravitation, planetary motion, centripetal forces, inertial forces, equilibrium)
- Work, energy and power (kinetic and potential energy, conservation of energy, $E = mc^2$)
- Momentum and impulse (conservation of momentum, collisions)
- Rotation (rigid bodies and center of mass, torque, moment of inertia, angular momentum, gyroscope)
- Statics and equilibrium
- Oscillations and simple harmonic motion
- Elasticity and simple bulk properties of matter
- Hydrostatics
- Hydrodynamics
- Surface tension
- Temperature (gas thermometers, thermal expansion)
- Heat (heat capacity and heat transfer, 1st law of thermodynamics)
- Thermal properties of matter (equations of state, phase change, molecules)
- Thermodynamics (laws, heat engines)
- Kinetic theory (ideal gases, equipartition, velocity distributions)
- Mechanical waves (traveling and standing, superposition, energy transport)
- Sound waves (beats, Doppler effect, acoustics)
- Electric charge, Coulomb's law
- Electric field
- Potential
- Capacitance and dielectrics
- Current, resistance, and circuits (dc)
- Electrochemistry and thermoelectricity
- Magnetic forces and fields
- Electromagnetic induction
- Magnetic properties of matter
- ac circuits and electromagnetic oscillations
- Electronics
- Electromagnetic waves
- Nature and propagation of light
- Illumination and photometry
- Geometrical optics—reflection and refraction
- Optical instruments
- Interference
- Diffraction
- Spectra
- Polarization
- Quantum phenomena
- Applications of atomic phenomena
- Radioactivity, nuclei and elementary particles

(see table 1). Among some persons involved in the development of new approaches to introductory physics it has even been fashionable to point out the similarity between the table of contents of a mid-19th-century college physics book used widely in this country and that of a typical contemporary textbook. A facsimile of the frontispiece of the eighth English edition of *Ganot's Physics*, dated 1877, is reproduced at right. This venerable book is an English translation of Adolphe Ganot's *Elements de Physique* (note that the names of physics texts have not changed much either), which first appeared in 1851 and ran through innumerable editions in French. Making due allowance for archaisms of language, Ganot's table of contents does indeed bear a surprising similarity to the list of topics in table 1. One might even remark on the prominent and early position given by Ganot to the discussion of molecular forces! Although I certainly have not carried out an historical survey, an examination of some early 20th-century texts by American physicists suggests that the tables of contents of such books have probably been relatively invariant over the years. Henry Crew's *General Physics* (MacMillan, New York, 1908) and Frederick A. Saunders's *A Survey of Physics* (Holt, New York, 1930) are two examples spanning the first half of the century.

. . . *and change*

In all honesty, however, the comparison between old and new does not extend much beyond the table of contents. The emphasis on technical applications of qualitatively described physical phenomena and principles has been superseded, on the whole, by more quantitative emphasis on those aspects and applications of physics relevant, at the introductory level, to understanding areas of interest to contemporary physicists. Almost all of the current textbooks provide at least some discussion of the more recent theoretical concepts, phenomena and devices of physics that have captured the imagination of many students today. Some of this discussion may be incorporated into the body of a text where appropriate, but more frequently it is appended at the end, in detail ranging from a superficial chapter or two to an entire volume. A few recent textbooks represent true departures from the grand tradition—attempts to push the enthusiastic and able student to the frontiers of contemporary physics during his first college course or to capture the imagination of young people whose principal interests and talents lie elsewhere and to give them some perception of the substance, intellectual challenge and cultural and social significance of physics.


ELEMENTARY TREATISE
ON
PHYSICS
EXPERIMENTAL AND APPLIED
FOR THE USE OF COLLEGES AND SCHOOLS
TRANSLATED AND EDITED FROM
GANOT'S ELEMENTS DE PHYSIQUE
(with the Author's sanction)
BY
E. ATKINSON, PH.D., F.C.S.
[illegible]
Eighth Edition, revised and enlarged.
ILLUSTRATED BY [illegible] COLOURED PLATES AND [illegible] WOODCUTS
NEW YORK:
WILLIAM WOOD AND CO., PUBLISHERS,
27 GREAT JONES STREET.
1877.

"VENERABLE BOOK" by Adolphe Ganot, dated 1877, has a table of contents similar to modern texts but deviates from present-day emphasis.

The fact that the contents of physics textbooks (as opposed to their *tables* of contents) has changed significantly over the past 30 years is partly a reflection of changes in our knowledge of physics itself. In addition, however, the increasing fraction of young people attending college, the breadth of their interests and commitments, and the growing importance of a broader base of public understanding of physics have all undoubtedly contributed to the growth in numbers and, more particularly, to the variety among introductory physics textbooks. There is no easily discernible cause-and-effect relation between this increasing number and variety on the one hand and, on the other, the activities of the profession through conferences and publications sponsored by the American Association of Physics Teachers[4] and the Commission on College Physics.[5] There is, however, some correlation between the two. This notion can be substantiated by referring to prefaces of many texts on the market. Some of them admit the direct influence of AAPT and CCP activities while others acknowledge this influence by proclaiming adherence to a more traditional approach in spite of the trend toward new methods of presentation.

Table 2. Number of Students in First-Term Introductory Physics Courses *

	Duration of course			
Type of course	*(Less than 1 yr)*	*(1 yr)*	*(Between 1 & 2 yrs)*	*(2 yrs)*
General	4125	34 348	2698	4903
Physics and engineering	666	34 803	19 770	7523
Premedical	76	30 569	1071	0
All science majors	91	8700	2047	986
Nonscience majors	12 342	8026	53	21
Technical physics	1534	2888	924	0
Other	4411	2476	136	365

* Classified according to length of course. Figures pertain to all two- and four-year colleges, universities and technical institutes in the US for the academic year 1961–1962. These heretofore unpublished data were obtained by Fred Boercker for the 1964 AIP man. power report.[1]

Table 3. Introductory Textbooks Used in Courses for Physics Majors, 1961–62 (%) *

Authors	*Titles*	*Adoption (%)*
Sears and Zemansky	*University Physics* (2nd Ed.) and *College Physics* (3rd Ed.)	32
Halliday and Resnick	*Physics for Students of Science and Engineering*	26
Shortley and Williams	*Elements of Physics* (3rd Ed.) and *Principles of College Physics*	8
Richards, Sears, Wehr and Zemansky	*Modern University Physics* and *Modern College Physics*	7
Weber, White and Manning	*Physics for Science and Engineering* and *College Physics* (3rd Ed.)	4
Other		22

* Based on 501 responses from the 748 colleges and universities granting a physics bachelor's degree during those years. Optical Society of America survey.[4]

Selection and classification

My intention in this article is to collect together some relatively objective information on as many of the recently published college-level introductory physics textbooks as possible. This information has *not* been gleaned from a thorough reading of each of the books, a task which few mortal physicists would consider undertaking. Rather it comes from a somewhat careful examination of several aspects of each book—in particular, the preface, the table of contents, the general level of mathematical and physical sophistication, the kinds of problems and other study aids included, and the kind of treatment given to certain key topics such as conservation laws, waves, equations of electrodynamics, "modern" physics, etc. Such a collection of descriptive information may prove useful to physicists and other scientists and engineers who are interested in gaining some idea of the topics covered and the approaches used in introductory college and university physics courses today. More specifically, those who must select a textbook for such a course may find this collection of information of some value in narrowing down the large number of choices. To keep the number of books discussed within reason, I have rather arbitrarily defined "recently published" to include those books dated in their latest edition between the years 1960 and early 1967. Books intended for training engineering technicians and for physical science or other combination courses have been excluded, as have the many books intended as supplements to textbooks. In addition to these exclusions, there are probably some omissions owing to oversight or lack of communication with a publisher. For these unintentional omissions, I apologize.

To present such a mass of descriptive information in any comprehensible form, one must organize or classify it in some way. Therefore the introductory texts will be grouped as follows: (A) texts incorporating calculus, generally intended for physical science and engineering students; (B) texts that can be used with or without the calculus. These are most often aimed at students oriented toward some kind of science or engineering; (C) texts that assume no background in calculus. These books make use of simple arithmetic, algebra, geometry and usually a little trigonometry. Some of them require considerable facility with advanced high-school algebra, geometry and trig, and a few even develop and use the calculus quite extensively. In general textbooks in this class have been written for students in nonscientific or technical curricula, and often for biological science and premedical students; (D) programed instruction texts. There are two complete programed physics textbooks available at present, and two well known noncalculus textbooks have accompanying programed-instruction workbooks.

Within these major classifications, I will describe some characteristics common to many of the books and mention a few significant features of each individual textbook in table 4. Complete bibliographical information on each of the books is contained in the section headed "The textbooks," in the box on pages 66–67.

CALCULUS-LEVEL TEXTBOOKS

The largest group of students enrolled in introductory physics courses is comprised of those who plan to become engineers or physical scientists, and in most colleges and universities these students are required to take a physics course that makes essential use of the calculus: A course in calculus is a prerequisite or in many cases a corequisite. Therefore calculus-level texts are the largest sellers, and we know the most about their use on a national basis. For instance, table 2 shows that, in 1961–62, although a majority of physics and engineering students were enrolled in introductory courses lasting one full year, a substantial number (including those at many of the better known universities) were studying introductory physics for up to two full academic years.

This fact implies, of course, that many of the books intended for such an audience will contain much more detail and cover considerably more material in greater depth than textbooks intended for one-year courses. From information compiled by the Optical Society of America, the leading introductory physics textbooks in 1961–62 are shown in table 3.[6] Because the information in this table is based on a 67% response to an OSA questionnaire, it is not necessarily a statistically valid sample. It is, however, the *only* real data that I have been able to find on which college-level textbooks were most widely used in any given year.

Regrettably the information in table 3 is also several years old. It does not reflect the more recent impact of the foundation-supported efforts at Cal Tech, Berkeley and MIT,[3,5] nor the work of several independent authors, to devise new, imaginative ways of

THE TEXTBOOKS

A. Calculus-level textbooks intended mainly for science and engineering students

(1) M. Alonso (Organization of American States and Georgetown U.) and E. J. Finn (Georgetown U.): *Fundamental University Physics.* (Addison-Wesley, Reading, Mass.). Vol. 1 (1967), 435 pp., $8.75. Vol. 2 (1967), 527 pp., $8.75. Vol. 3 (in preparation).

(2) The Berkeley Physics Course. Vol. 1, C. Kittel, W. D. Knight (both U. of California, Berkeley) and M. A. Ruderman (NYU): *Mechanics* (1965). 480 pp., $5.50. Vol. 2, E. M. Purcell (Harvard), *Electricity and Magnetism* (1965). 459 pp., $5.50. Vol. 3, F. S. Crawford (Berkeley): *Waves and Oscillations* (1967). 352 pp., $4.50. Vol. 4, E. H. Wichmann: *Quantum Physics* (1967). 576 pp., $4.50. Vol. 5, F. Reif (Berkeley): *Statistical Physics* (1967). 398 pp. $5.50. (McGraw-Hill, New York).

(3) S. Borowitz (NYU) and A. Beiser: *Essentials of Physics* (Addison-Wesley, Reading, Mass., 1966). 708 pp., $11.95.

(4) R. P. Feynman, R. B. Leighton (both Cal Tech), and M. L. Sands (Stanford): *The Feynman Lectures on Physics* (Addison-Wesley, Reading, Mass.). Vol. 1: *Mainly Mechanics, Radiation, and Heat* (1963), 519 pp., $8.75. Vol. 2: *Mainly Electromagnetism and Matter* (1964), 560 pp., $8.75. Vol. 3: *Quantum Mechanics* (1965), 376 pp., $6.75.

(5) G. D. Freier (U. of Minnesota): *University Physics* (Appleton-Century-Crofts, New York, 1965). 539 pp., $10.00.

(6) W. E. Hazen (U. of Michigan) and R. W. Pidd (General Atomic): *Physics* (Addison-Wesley, Reading, Mass., 1965). 628 pp., $12.50.

(7) R. F. Kingsbury (Bates College): *Elements of Physics* (Van Nostrand, Princeton, 1965). 630 pp., $9.75.

(8) R. Resnick (Rensselaer Polytechnic Institute) and D. Halliday U. of Pittsburgh): *Physics*, 2nd Ed. (Wiley, New York, 1966). Part 1, 709 pp., $7.75. Part 2, 748 pp., $7.75. Part 3 (in preparation). Combined Ed., Parts 1 and 2, 1324 pp., $13.50.

(9) J. A. Richards (Philadelphia Community College), F. W. Sears (Dartmouth, emeritus), M. R. Wehr (Drexel Institute of Technology), and M. W. Zemansky (CCNY): *Modern University Physics* (Addison-Wesley, Reading, Mass., 1960). Part 1, 400 pp., $6.50. Part 2, 623 pp., $8.50. Combined Ed., 993 pp., $12.50.

(10) F. W. Sears (Dartmouth, emeritus) and M. W. Zemansky (CCNY, emeritus): *University Physics*, 3rd Ed. (Addison-Wesley, Reading, Mass., 1964). Part 1, 564 pp., $7.50. Part 2, 512 pp., $7.50. Combined Ed., 1044 pp., $12.50.

(11) G. S. Shortley (Booz-Allen Applied Research) and D. Williams (Kansas State U.): *Elements of Physics*, 4th Ed. (Prentice-Hall, Englewood Cliffs, N. J., 1965). Vol 1, 436 pp., $7.25. Vol. 2, 548 pp., $7.25. Combined Ed., 924 pp., $11.95.

(12) R. T. Weidner (Rutgers) and R. L. Sells (State U. of New York College at Geneseo): *Elementary Classical Physics* (Allyn and Bacon, Boston, 1965). Vol. 1, 640 pp., $7.95. Vol. 2, 631 pp., $7.95. *Elementary Modern Physics* (1960). 513 pp., $9.95.

(13) H. D. Young (Carnegie Tech): *Fundamentals of Mechanics and Heat* (1964). 638 pp., $8.50. A. F. Kip (U. of California, Berkeley): *Fundamentals of Electricity and Magnetism* (1962). 406 pp., $8.95. H. D. Young: *Fundamentals of Optics and Modern Physics* (1968). 448 pp., $8.95. (McGraw-Hill, New York).

B. Physics textbooks that can be used with or without calculus

(14) A. Beiser, *The Foundations of Physics* (Addison-Wesley, Reading, Mass., 1964). 594 pp., $10.75.

(15) J. Morgan (Texas Christian U.): *Introduction to University Physics* (Allyn and Bacon, Boston, 1963). Vol. 1, 513 pp., $7.95. Vol. 2, 461 pp., $7.95.

(16) R. L. Weber, K. V. Manning and M. W. White (all at Penn State U.): *College Physics*, 4th Ed. (McGraw-Hill, New York, 1965). 710 pp., $9.75.

C. Textbooks requiring no calculus pre- or corequisites

(17) A. B. Arons (Amherst): *Development of Concepts in Physics* (Addison-Wesley, Reading, Mass., 1965). 972 pp., $14.75.

(18) K. R. Atkins (U. of Pennsylvania): *Physics* (Wiley, New York, 1965). 754 pp., $9.95.

(19) A. V. Baez (UNESCO): *The New College Physics—A Spiral Approach* (Freeman, San Francisco, 1967). 739 pp., $11.75.

(20) A. Beiser: *The Mainstream of Physics* (Addison-Wesley, Reading, Mass., 1962). 468 pp., $9.75.

(21) A. Beiser: *Basic Concepts of Physics* (Addison-Wesley, Reading, Mass., 1961). 341 pp., $8.50.

(22) R. Benumof (Staten Island Community College): *Concepts in Physics* (Prentice-Hall, Englewood Cliffs N. J., 1965). 562 pp., $10.95.

(23) O. H. Blackwood (U. of Pittsburgh, emeritus), W. C. Kelly (National Academy of Science), and R. M.

presenting introductory physics to professionally motivated students. The general feeling among physicists and publishers is, however, that the first three textbooks listed in table 3 are still (in their more recent editions, that is) among the leaders. This greatly simplifies the problem of establishing a norm. On this basis, the "typical" calculus-level introductory physics textbook has the following characteristics.

The mathematical level presupposes a command of algebra, geometry and trigonometry, as well as some acquaintance with calculus, at least within a few weeks after beginning the course. Vector algebra, including scalar and vector products, is introduced early. Derivatives are introduced in the study of kinematics, and integrals are brought into the discussion of work and energy. Ordinary differential equations appear in mechanics, usually in connection with simple harmonic motion, and the partial differential equation for a wave on a string is developed and discussed. (Formal solution of such equations is not stressed, however.) Line, surface and volume integrals creep into the study of electricity and magnetism, leading to Maxwell's equations in integral form, sometimes to the introduction of the vector calculus operators, and finally to the electromagnetic

Bell (Washington and Jefferson College): *General Physics*, 3rd Ed. (Wiley, New York, 1963). 685 pp., $9.50.

(24) F. Bueche (U. of Dayton): *Principles of Physics* (McGraw-Hill, New York, 1965). 660 pp., $9.75.

(25) F. W. Constant (Trinity College): *Fundamental Laws of Physics* (Addison-Wesley, Reading, Mass., 1963). 403 pp., $8.95.

(26) F. W. Constant (Trinity College): *Fundamental Principles of Physics* (Addison-Wesley, Reading, Mass., 1967). 370 pp., $8.75.

(27) G. Gamow and J. M. Cleveland (both U. of Colorado): *Physics: Foundations and Frontiers* (Prentice-Hall, Englewood Cliffs, N. J., 1960). 551 pp., $8.95.

(28) E. S. Green (San Jose State College): *Principles of Physics* (Prentice-Hall, Englewood Cliffs, N. J., 1962). 806 pp., $9.95.

(29) G. P. Harnwell and G. J. F. Legge (U. of Pennsylvania): *Physics* (Reinhold, New York, 1967). 557 pp., $9.95.

(30) F. A. Kaempffer (U. of British Columbia): *The Elements of Physics* (Blaisdell, Waltham, Mass., 1967). 291 pp., $8.50.

(31) R. W. Kenworthy (U. of Washington): *College Physics* (Davis, Philadelphia, 1961). 671 pp., $8.50.

(32) W. W. McCormick (U. of Michigan): *Fundamentals of College Physics* (MacMillan, New York, 1965). 819 pp., $10.95.

(33) F. Miller Jr (Kenyon College): *College Physics*, 2nd Ed. (Harcourt, Brace, and World, New York, 1967). 715 pp., $10.50.

(34) J. Orear (Cornell): *Fundamental Physics*, 2nd Ed. (Wiley, New York, 1967). 472 pp., $8.95.

(35) J. A. Richards (Drexel Inst. of Tech.), F. W. Sears (Dartmouth, emeritus), M. R. Wehr (Drexel), and M. W. Zemansky, (CCNY, emeritus): *Modern College Physics* (Addison-Wesley, Reading, Mass., 1962). 1019 pp., $12.50. (Also available in 2-vol. edition.)

(36) E. M. Rogers (Princeton): *Physics for the Inquiring Mind* (Princeton U. Press, Princeton, 1960). 778 pp., $10.00.

(37) R. D. Rusk (Mount Holyoke, emeritus): *Introduction to College Physics*, 2nd Ed. (Appleton-Century-Crofts, New York, 1960). 944 pp., $9.00.

(38) F. A. Saunders (Harvard, dec.) and P. Kirkpatrick (Stanford, emeritus): *College Physics*, 5th Ed. (Holt, Rinehart, and Winston, New York, 1961). 674 pp., $10.50.

(39) F. W. Sears (Dartmouth, emeritus) and M. W. Zemansky (CCNY, emeritus): *College Physics*, 3rd Ed. (Addison-Wesley, Reading, Mass., 1960). 1024 pp., $12.50. (Also available in 2-vol. Ed.)

(40) H. Semat (CCNY): *Fundamentals of Physics*, 4th Ed. (Holt, Rinehart, and Winston, New York, 1966). 753 pp., $11.50.

(41) G. Shortley (Booz-Allen Applied Research, Inc) and D. Williams (Kansas State): *Principles of College Physics*, 2nd Ed. (Prentice-Hall, Englewood Cliffs, N. J., 1967). 863 pp., $11.95.

(42) A. W. Smith (Ohio State, emeritus) and J. N. Cooper (US Naval Postgraduate School): *Elements of Physics*, 7th Ed. (McGraw-Hill, New York, 1964). 717 pp., $9.95.

(43) R. Stevenson and R. B. Moore (McGill U.): *Theory of Physics* (Saunders, Philadelphia, 1967). 795 pp., $9.75.

(44) J. G. Stipe Jr (Boston U.): *The Development of Physical Theories* (McGraw-Hill, New York, 1967). 480 pp., $10.50.

(45) F. W. Van Name Jr (Pratt Inst.): *Elementary Physics* (Prentice-Hall, Englewood Cliffs, N. J., 1966). 289 pp., $7.95.

(46) H. E. White (Berkeley): *Modern College Physics*, 5th Ed. (Van Nostrand, Princeton, 1966). 765 pp., $10.75.

(47) H. E. White (Berkeley): *Descriptive College Physics*, 2nd Ed. (Van Nostrand, Princeton, 1963). 397 pp., $8.75.

D. Programed instruction materials for physics instruction

(48) N. Ashby and S. C. Miller (U. of Colorado): *Principles of Physics: a Programmed Approach* (Allyn and Bacon, Boston, 1966). Vol. 1: *Foundations of Mechanics*, 240 pp., $5.95. Vol. 2: *Mechanics and Thermodynamics*, 258 pp., $5.95. Vol. 3: *Electricity and Magnetism* (in preparation. Vol. 4: *Modern Physics* (in preparation).

(49) A. Joseph (Bronx Community College) and D. J. Leahy (Collegiate School): *Programmed Physics* (Wiley, New York). Part 1: *Mechanics* (1965), 354 pp., $5.95. Part 2: *Electricity and Magnetism* (1965), 293 pp., $4.95. Part 3: *Optics and Waves* (1965), 212 pp., $3.95. Part 4: *Kinetic Theory and Thermodynamics* (1967), 157 pp., $4.95. Part 5: *Topics in Modern Physics* (1967), 206 pp., $4.95.

(50) J. Orear (Cornell): *Programmed Manual for Students of Fundamental Physics* (Wiley, New York, 1962). 214 pp., $5.25.

(51) H. Semat (CCNY) and R. H. Blumenthal (Grumman Aircraft): *College Physics—A Programmed Aid* (Holt, Rinehart, and Winston, New York, 1967). Vol. 1: *Mechanics* (1967), 173 pp., $3.95. Vol. 2: *Heat, Wave Motion, and Sound* (1967), 114 pp., $3.95. Vol. 3: *Electricity and Magnetism* (1967), 198 pp., $3.95. Vol. 4: *Optics Atomics, and Nucleonics* (1967), 240 pp., $3.95.

Table 4. Some Characteristics of Introductory Physics Textbooks

Authors[a]	*Mathematical level*[b]	*Contents and organization*[c]
A. Calculus-level textbooks intended mainly for science and engineering students		
(1) Alonso and Finn	Adv.; calc. delayed to chap. 5	Berkeley organiz. & level[f]
(2) The Berkeley Physics Course	Adv.	Berkeley organiz.[f]
(3) Borowitz and Beiser	Std.; no partial diff. eqs.	Std.
(4) The Feynman Lectures	Adv.; stresses physical meaning	Unique
(5) Freier	Special care introducing calc.	Std.; relativity incl. with mech.
(6) Hazen and Pidd	Std.; calc. delayed to chap. 6	Particle mech. repeated with calc.
(7) Kingsbury	Calc. introd. carefully after optics	Unusual order, beginning with optics
(8) Resnick and Halliday	Std.	Relativity & most mod. phys. in Vol. 3
(9) Richards *et al.*, *Modern Univ*——	Std.; no partial diff. eqs.	Std.; strong descrip. mod. phys.
(10) Sears and Zemansky	Std.; no partial diff. eqs.	Std.; relativity incl. with mech.
(11) Shortley and Williams, *Elements*——	Adv.; calc. introd. slowly	Std.
(12) Weidner and Sells	Std.; special care introducing calc.	Relativity & most mod. phys. in Vol. 3
(13) Young; Kip; Young	Adv.	Relativity & most mod. phys. in Vol. 3
B. Physics textbooks that can be used with or without calculus		
(14) Beiser, *Foundations*——	Little calc., no diff. eqs.	Std.; strong descrip. mod. phys.
(15) Morgan	Parallel calc. noncalc. treatments	Std.; many tech. applic., no relativity
(16) Weber, Manning and White	Std. noncalc. text, calc. in append.	Std. topics, almost Berkeley organiz.[f]
C. Textbooks requiring no calculus pre- or corequisite		
(17) Arons	Calc. concepts devel. & used	Hist.-phil.; no mod. phys.
(18) Atkins	Std.; append. on math	Std. order, stressing contemp. concepts
(19) Baez	Std.; trig, anal. geom., limits in text	Unusual spiral appr. to mech., waves
(20) Beiser, *Mainstream*——	Std.; math review append.	Std.; intended for 2-sem. course
(21) Beiser, *Basic Concepts*——	Std.; math review append.	Std.; intended for 1-sem. course
(22) Benumof	Std.	Std. except 1st 2 chaps.; many applic.
(23) Blackwood, Kelly, and Bell	Std.; math review append.	Std., incl. many applic., devices
(24) Bueche	Std.; trig devel. in text	Std.; separate chaps. on tech. applic.
(25) Constant, *Fundamental Laws*——	Std.; math review chap.	Std.; organized around 20 basic laws
(26) Constant, *Fundamental Principles*	Simple algeb. & geom.	A 1-sem. version of *Fund. Laws* **(25)**
(27) Gamow and Cleveland	Std.; trig devel. in text	40% mod. phys. & applic. to other fields
(28) Green	Std.; math review append.	Extra detail on trad. & mod. applic.
(29) Harnwell and Legge	Adv.; der. introd., used freely	Unusual; mod. concepts, phenom.
(30) Kaempffer	Requires excell. command of std. math	Compl. unconv.; emph. contemp. princ.
(31) Kenworthy	Std.; trig is limited, devel. in append.	Std.; many tech. applic., 40 pp. mod. phys.
(32) McCormick	Std.	Std.; many but not all std. applic.
(33) Miller	Algeb. assumed, trig, geom. devel.	Std.; 90 pp. on mod. phys. & applic.
(34) Orear, *Fundamental Physics*	Std.; first chap. reviews math	Std. order; 40% mod. phys., <20% E&M
(35) Richards *et al.*, *Modern College*——	Std.	Std.; 250 pp. descrip. mod. phys.
(36) Rogers	Simple algeb. & geom.	Unconv. block-&-gap appr.
(37) Rusk	Std.; trig devel., math append.	Std.; minor var. in topic order
(38) Saunders and Kirkpatrick	Std.	Std.; begins with fluid statics
(39) Sears and Zemansky, *College*——	Std.	Std., incl. most common applic.
(40) Semat	Std.	Std.; many trad. & contemp. applic.
(41) Shortley and Williams, *Principles*	Std.; trig devel. in text	Std.; relativity & quanta; most applic.
(42) Smith and Cooper	Std.	Std.; many tech. applic., devices
(43) Stevenson and Moore	Adv. noncalc. level; math append.	Mod. phys. incorp. thruout text
(44) Stipe	Calc. used thru simple diff. eqs.	Hist. details, mod. phys., & applic.
(45) Van Name	Simple arith. & algeb. only	Std.; brief, many devices descr.
(46) White, *Modern College Physics*	Std., with math append.	Std.; many applic., 300 pp. on mod. phys.
(47) White, *Descr. College Physics*	Simple algeb., prob.-solving deëmph.	Std.; basic applic., descr. of phenom.
D. Programed instruction materials for physics instruction		
(48) Ashby and Miller[h]	Std. calc. level; math review	Std.
(49) Joseph and Leahy	Std. noncalc.; num. prob.-solv. appr.	Std.; no extensive tech. applic.
(50) Orear, *Programmed Manual*——	Std. noncalc.; accompanies **(34)** above	Questions, probs. based on **(34)** above
(51) Semat and Blumenthal	Std. noncalc.; accompanies **(40)** above	Progr. text; quest.; num. probs.

[a] See the list of textbooks at the end of the article for more complete bibliographical information on the books represented in each row of the table.

[b] In this column, the notation *Std.* refers to the normal mathematical level of the appropriate group of textbooks, as described in the text of the article. *Adv.* implies that the level of mathematics used goes somewhat beyond that for the norm.

[c] The notation *Std.* in this column refers to the conventional organization of subject matter shown in table 1.

[d] A plus (+) signifies a considerably larger number of problems than usual, and a minus (−) a smaller number than usual for the appropriate group of textbooks.

Problem sets[d]	*Other study aids*[e]	*Comments*
+, from num. to very sophist.	*1,2,6,9*	Extremely adv. treatment; carefully done, excell. study aids
Challenging; few easy num. probs.	*1,2,6–9,11,13*	Rather theor. appr., pushing into intermed. level
+, mostly num.	*1, 2*	Complete, esp. descrip. mod. phys., but lacks some detail, rigor
Graded num. & nonnum.; few are easy[g]	None	Edited lectures, conveying Feynman's unique style, insights
−, good num. & algeb. mix	*2,12*	A lecture demonst. handbk., incl. many brief applic.
Mostly algeb., many extending text	*1,2,4*	Rigorous; terse style; phys. often amplified in probs.
Deriv., ques., algeb. probs.	*1,2,3,6,11*	Brief; fairly complete, rigorous; much contemp. phys.
Variety of num., algeb. probs.	*1,2,3,11*	One of the std. texts; comprehen. & fairly rigorous
Mostly num.; some ques.	*1,2*	A merger of well known books publ. originally in 1955, 1959
Num.; a few proofs, algeb. probs.	*1,2*	Comprehen.; reads well; many applic. incl.
Mostly num., some "think" probs.	*1,2*	Many tech. applic., much mod. phys. thruout
Mixed num., nonnum. & ques.	*1,2,4,6,8*	Comprehen.; esp. considerate of weaknesses in math
Num. & algeb.; some very hard	*1,2*	Phys. models stressed; some unusual contemp. applic. incl.
Num.; some ques.	*1,2,4*	Prob. solv. & descrip. num. understanding stressed
Num.; a few ques., der., algeb.	*1,2*	Many nonbasic topics & applic.; microscop. expl. of phenom.
Mostly num.	*1,2,3,4,5,8*	Well illust.; good descrip. of apparatus; most trad. applic.
Verbal, quant. & interpret. probs.	*1,2,6,8,13*	Unique stress on devel. of concepts, esp. mech., atoms
Well-graded num. & nonnum. probs.	*1,2,3*	Contemp. concepts, not prob. solv. or applic.; cgs units
Num., algeb., graphic, verbal probs.	*1,2,4*	Goal is Bohr atom. Hist.-phil.-soc. implications mentioned
Mostly num.	*1,2,4,14*	Straightforward & trad.; about 30% descr. mod. phys.
Mostly num.	*1,2,4,14*	An abbreviated version of *Mainstream* **(20)**
Num.; ans. given to all probs.	*1,4*	Each chap. introd. by exptl. situation; written for jr. coll.
Well graded num. probs.	*1,2,3,4,6*	Up-to-date trad.; stresses prob.-solv., phenom.
Mostly num.	*1,2,3,4,14*	Prob.-solv. appr.; selected applic.; brief on mod. phys.
Num. & algeb. probs. & ques.	*1,2,16*	Prob.-solv. not stressed; hist.-phil. develops. incl.
Simple num., algeb. probs. & ques.	*1,2,16*	Updated abridg., with mod. phys. receiving more emph.
−, num.; some verbal interp.	*1,2*	Entertaining illust., style; mod. phys. somewhat outdated
Num. probs., self-quiz ques.	*1,2,3,4,5*	Many aids to stud.; cgs units in E&M; applic. stressed
−, ques., algeb. & order-of-mag. probs.	*1,2,6,8*	Stresses understanding of contemp. phys.; for mature students
−, a few probs., examp.; notes in ea. chap.	Very few; *6,8*	Simple math, very sophist. phys. concepts; few applic.
Num.	*1,2,4*	Elem. class. phys. & applic.; some hist. background
−, mostly num., some algeb.	*1,2*	Trad. appr.; phys. related well to phenom.
Mostly num.	*1–7,11*	Brief; select. applic., examp.; current-interest mod. phys.
Mixed num., algeb., ques.	*1,2,6,15*	Brief; simple quant. understanding of contemp. phys.; cgs units
+, mostly num.	*1,2*	Prob.-solv. appr.; merger of 2 well known texts
Probs. & other study aids are scattered	*1,3,5,8–10,12,16*	Personal hist.-phil. book; tries to involve stud. in phys.
Mostly num.	*1,2,3*	Many tech. applic.; mod. phys. (110 pp.) stresses nuclear & appl.
Mostly num.	*1,2,4,10*	Trad.; many tech. applic.; neg. current flow conv.
Mostly num.	*1,2,4*	Encycl. class. phys., weak mod. phys.; prob.-solv. appr.
Num.; some deriv., algeb.	*1,2,3,15*	Prob.-solv. appr.; comprehen. class., descr. mod. phys.
Well graded num., algeb. probs.	*1,2,4*	Prob.-solv. appr. similar to *Elements;* bases phys. on expts.
+, mostly num.	*1,2,3*	Prob.-solv. appr.; updated descendant of a venerable line
+, most num.; none in descr. chaps.	*1,2,4,11*	Stresses current theor., phenom.; last 240 pp. on applic.
Num. & algeb. probs.	*1,2,8*	Unconv. appr.; adv. math, but emph. phys. & particles
+, simple num. probs.	*1,3,4*	Brief descrip. survey of class. & mod. phys.; for 1-sem. course
Mostly num.	*1,2*	Prob.-solv. appr.; well illust.; good descrip. of mod. devices
Ques. & simple num. probs.	*1,2,3,8*	For 1-term course; much up-to-date mod. phys.; well-illust.
Linear program; prob. sets included	*4*	For science and engineering studs. See footnote.[h]
Linear program, mask to conceal ans.	Probs., rev.	To be accomp. by demonst., discussions, lab
Scrambled mtpl. choice, simple branch.	—	Multibranching & method of concealing ans. are effective
Linear program, mask to conceal ans.	—	Intended as subst. for recit. classes; useful with many texts?

[e] See table 5 for the kinds of study aids to which the numbers in this column refer.

[f] The Berkeley-type organization divides the subject matter of physics into five categories: mechanics (of particles and aggregates of particles), fields (electricity and magnetism), waves and oscillations, quantum physics, statistical physics. Within this framework, the actual sequence of topics and the way in which they are discussed may or may not be rather conventional.

[g] Problems are contained in separate exercise booklets.

[h] Copies of these books were not available to the author. Information here is based on a review by G. A. Snow (*The Physics Teacher* **5**, 347 (1967).

wave equation. (Again, understanding the derivation and meaning of the mathematics is usually stressed rather than the formal mathematical procedures.)

The typical science and engineering textbook follows rather closely the order of topics in table 1, with omission or deëmphasis of strictly applied topics that do not contribute significantly to later discussions of atomic and nuclear phenomena. (Surface tension, sound, electronics, photometry and geometrical optics are such topics.) Aspects of physics that do so contribute are stressed; for instance, potential energy diagrams, conservation laws as applied to microscopic phenomena, and the atomic and molecular nature of the thermal, electrical, magnetic and optical properties of matter. As indicated by the number of pages in textbooks of this type, topics are treated in considerable detail, and much of what might be called classical aspects of "modern physics" is incorporated into the text as appropriate. A few chapters at the end treat quantum, atomic and nuclear phenomena explicitly. However, the "typical" book in this class, which typically comes in a two-volume edition, is really intended to be followed by a third volume, or by another book or course, delving into atomic and nuclear physics and the structure of matter in the same depth as classical physics was treated. Indeed, several books listed in table 4 include an additional volume, either published or in preparation.

Study aids and units

As study aids, almost all of the books incorporate a substantial number of worked examples and extensive graded problem sets at the end of each chapter. In fact the dominant characteristic of most of these textbooks is the understanding of physics through problem solving. Most of the worked examples and problems are numerical. That is, the student is supplied with some numerical information about a physical situation and asked to calculate a numerical result. A few of them require algebraic calculations, proofs and derivations. Unfortunately almost none of the problems require the student to determine on his own what data he needs to solve the problem and then to go about measuring it, estimating reasonable values from his own experience, or consulting reference tables. Tables of units, conversion factors, physical constants, solar-system data, trig and log functions are found at the back of most of the books. In addition many of them include various other kinds of study aids from the list given in table 5.

The MKS system of units is strongly emphasized in all of the science and engineering textbooks. It is used exclusively in electricity and magnetism and shares the stage as a senior partner with the British system in mechanics. Cgs units are usually mentioned and defined but rarely used. In the worked examples, units are carried along with numerical values and canceled properly in most (but not all) of the texts.

In terms of these "typical" properties, some of the significant characteristics of 13 calculus-level textbooks are summarized in part A of table 4.

BOOKS WITH A CALCULUS OPTION

A few books on the market are intended to provide a preprofessional introduction to physics for science, engineering and premedical students and to give an instructor (or student) the option of using some calculus or almost completely avoiding that area of mathematics. Aside from the mathematical level, many of these books are rather similar to the typical calculus-level book described. The topics that they cover and the emphasis on physical principles rather than numerous and detailed applications are about the same although the straight calculus-level books are, as a group, longer and more detailed. The treatment of units and the study aids provided are also similar, with perhaps even more emphasis in the calculus-option texts on the solving of numerical problems.

Since there is a choice of using or avoiding calculus, the general level of mathematical rigor is lower in these books. Facility with algebra and trigonometry is, of course, assumed. Derivatives and integrals are introduced in mechanics and used thereafter for students who can use calculus. A differential equation for the simple harmonic oscillator is also derived, and in two cases the wave equation is developed. However, few problems depend on calculus in any essential way. One of the greatest differences among the books in this category is the way in which they provide the calculus option. These and other characteristics are summarized briefly in part B of table 4.

WITHOUT CALCULUS REQUISITES

Among physicists there is some consensus on what ought to be included in an introductory course designed to reproduce our own kind. When it comes to other kinds of students, however—the bright student interested in physics as a part of culture and society, the boy who is told that he must know some physics to be a dentist or an architect or a pharmicist, and the girl who will be teaching science to elementary or junior high-school children—there is a much greater diversity of opinion. For this reason the variety and number of introductory physics textbooks aimed at such a general audience is much greater than that for physics and engineering majors. Part C of table 4 surveys some of their characteristics.

Many of the books follow the pattern and table of contents (table 1) of the traditional treatment for science majors, but some of them—particularly some of the newer ones—diverge sharply from this pattern. The only characteristic that they all appear to share is the assumption that their readers have not (necessarily) been exposed to much calculus. Where calculus is used—and it is used rather extensively in two of these books—it is developed in a brief, self-contained fashion. A similar diversity is apparent in the kinds of study aids furnished. Compared with calculus-level books, the problem sets more often emphasize relatively simple numerical exercises; the collection of tables is usually less extensive; the sections reviewing or presenting simple mathematics and problem-solving techniques are more likely to be included. However, there are important exceptions to all of these generalizations. The spectrum of basic approaches ranges from a strong historical-philosophical emphasis on ideas by Arnold Arons and Eric Rogers, to fairly sophisticated, nonmathematical presentations of concepts important at the frontiers of current research (in the books by Harnwell and Legge, Kaempffer, Stevenson and Moore, and Stipe). Many of these newer textbooks do not stress the solution of numerical problems as the way to learn physics. And a few of them (noted under "Comments" in table 4) even use cgs units in electricity and magnetism!

In addition to conventional study aids, a few of the noncalculus textbooks are accompanied by programed or semiprogramed instruction workbooks, a development that has not made its appearance among the books for engineering and physical-science students.

Table 5. Some Study Aids

1. Worked examples
2. Tables of physical constants and mathematical functions
3. Question sets
4. Chapter summaries
5. Appendices or sections on problem solving
6. Reading lists
7. Film lists
8. Historical and/or mathematical notes or sections
9. Teaching notes
10. True-false or multiple-choice questions
11. Advanced topics sections or appendices
12. Quantitative discussions of lecture demonstrations
13. Extracts from original physics papers
14. Separate study guides
15. Programed instruction manuals
16. Suggested lab experiments

PROGRAMED INSTRUCTION

Although modern technological developments have affected most areas of human activity, only recently have they begun to intrude upon the educational process in the form of programed instruction and, more recently yet, computer-assisted instruction.[7] Until now, the textbook has remained the primary device for teaching physics, and I am fairly confident that this will continue into the foreseeable future. In addition to the inherent conservatism of most physicists in such matters, both of these new forms of instruction suffer at present from a lack of sufficient research and understanding of their psychological efficacy.

Four clear examples of programed instruction in physics are now available, however. Two of these are complete programed textbooks, while the other two are workbooks to accompany books listed in part C of table 4. Three of the four examples use the technique of "linear programing," in which a small amount of material is presented to the student in a "frame." He is immediately asked a question about it, answers the question, uncovers the correct answer to obtain immediate reinforcement and proceeds to the next frame in the sequence. An alternative technique employs a multiple-choice format and some simple branching to different sections of the program, depending on which response the student has selected. On the basis of perusal and very limited use of some of these programed materials during the past year, I am inclined to believe that they may be of some significant value to students who have so much trouble with physics that they are otherwise in danger of learning nothing.

It is clear that we need to gain more experience with such materials and with other devices and systematic strategies for teaching physics. Part D of table 4 summarizes briefly the three examples of physics programing that are currently available.

New physics or old?

Considerable debate has been carried on recently, in the "Letters" columns of PHYSICS TODAY and other scientific magazines, concerning the merits of the new, innovative approaches to teaching physics and other sciences.[6] Much of this debate really does not concern the new textbook approaches themselves but rather the *objectives* of the introductory physics courses in which the textbooks might be used. It may be that the increasing diversity of physics texts reflects an increasing diversity of interests and backgrounds among college students and an increasing concern of physics teachers with the objectives of the introductory courses they offer to these students.

Are individual teachers competent to select an optimal approach to introductory physics for a large class? Is the traditional approach or one of the newer ways of presenting a first physics course more effective for the majority of students? Are the new approaches the cause of declining physics enrollment,[2] or will they reverse this dismaying trend? Are new instructional techniques such as programed instruction valuable or potentially damaging? These are questions that will not be answered by warm exchanges of letters in the columns of a magazine. However, there are two ways of obtaining answers. The first is to apply the scientific method—to undertake a controlled experiment or other systematic study to compare two or more textbook approaches. Such a research project goes beyond our professional competence into the area of educational psychology, making it an inherently interdisciplinary undertaking. This situation, together with the natural distaste of the physicist for complicated many-body problems, makes such an evaluation technique exceedingly difficult, unlikely—and challenging.

The second method of discovering answers to the above questions is simply to wait. Regardless of what is done, the questions *will* be answered by the tests of time and the market place. As is true of any uncontrolled experiment, however, the results of these tests will be rather ill defined and will leave much room for controversy. Personally I hope to see a scientific attack on this exceedingly complicated problem.

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