One Hundred Resource Letters, 1962–1995

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The following list gives the authors, titles, and references to initial publication in the American Journal of Physics of the first one hundred Resource Letters, beginning with #1 on "Polarized Light" by Shurcliff in 1962 and ending with #100 on "Time and Frequency Measurement" by Hackman and Sullivan in this issue.

Many of the published Resource Letters were accompanied by the publication of a Reprint Book, containing the text of the Resource Letter itself as well as reprints of some of the key articles referred to. Although many of the early Reprint Books are now out of print, many are still available, as indicated by asterisks in the following list. In addition, reprint Books are now in preparation for some, though not all, of the recently published Resource Letters. For information, write to:

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Of these, the three most recent collections are currently available, also from the AAPT Publications Sales Department.

1.	PL-1.	Polarized Light	William A. Shurcliff	**30**(3), 227–230 (1962)
2.	PP-1.	Plasma Physics	Sanborn C. Brown	**30**(4), 303–307 (1962)
3.	SRT-1.	Special Relativity Theory	Gerald Holton	**30**(6), 462–469 (1962)
4.	ME-1.	Mössbauer Effect	G. K. Wertheim	**31**(1), 1–6 (1963)
5.	SO-1.	Kinematics and Dynamics of Satellite Orbits	Leon Blitzer	**31**(4), 233–236 (1963)
6.	QSL-1.	Quantum and Statistical Aspects of Light	P. Carruthers	**31**(5), 321–325 (1963)
7.	FC-1.	Evolution of the Electromagnetic Field Concept	William T. Scott	**31**(11), 819–826 (1963)
8.	F-1.	Friction	Ernest Rabinowicz	**31**(12), 897–900 (1963)
9.	Scy-1.	Superconductivity	D. M. Ginsberg	**32**(2), 85–89 (1964)
10.	Scr-1.	Semiconductors	Paul Handler	**32**(5), 329–333 (1964)
11.	MOP-1	Masers (Microwave through Optical) and Optical Pumping	H. W. Moos	**32**(8), 589–595 (1964)
12.	MB-1.	Experiments with Molecular Beams	Jens C. Zorn	**32**(10), 721–732 (1964)
13.	NS-1.	Nuclear Structure	M. A. Preston	**32**(11), 820–824 (1964)
14.	PhM-1.	Philosophical Foundations of Classical Mechanics	Mary Hesse	**32**(12), 905–911 (1964)
15.	NMR-EPR-1	Nuclear Magnetic Resonance and Electron Paramagnetic Resonance	R. E. Norberg	**33**(2), 71–75 (1965)
16.	SL-1.	Science and Literature	Marjorie Nicolson	**33**(3), 175–183 (1965)
17.	AT-1.	Achievement Testing	Haym Kruglak	**33**(4), 255–263 (1965)
18.	EEC-1.	Evolution of Energy Concepts from Galileo to Helmholtz	Theodore M. Brown	**33**(10), 759–765 (1965)
19.	CM-1.	Teaching of Angular Momentum and Rigid Body Motion	John I. Shonle	**33**(11), 879–887 (1965)

See also the "Correction," **34**(3), 273 (1966)

20.	ECAN-1.	Electronic Charge and Avogadro's Number	David L. Anderson	**34**(1), 2–8 (1966)
21.	PB-1.	Physics and Biology	D. James Baker, Jr.	**34**(2), 83–93 (1966)
22.	PA-1.	Particle Accelerators	John P. Blewett	**34**(9), 742–752 (1966)
23.	PP-2.	Plasma Physics: Waves and Radiation Processes in Plasmas	G. Bekefi and Sanborn C. Brown	**34**(11), 1001–1005 (1966)
24.	SAP-1.	Subatomic Particles	Clifford E. Swartz	**34**(12), 1079–1086 (1966)
25.	CR-1.	Cosmic Rays	J. R. Winckler and D. J. Hofmann	**35**(1), 2–12 (1967)
26.	ColR-1.	Collateral Reading for Physics Courses	Alfred M. Bork and Arnold B. Arons	**35**(2), 71–78 (1967)
27.	NR-1.	Nuclear Reactions	T. A. Griffy	**35**(4), 297–301 (1967)
28.	LH-1.	Liquid Helium	C. T. Lane	**35**(5), 367–375 (1967)
29.	NPE-1.	Nuclear Photographic Emulsions	M. W. Friedlander	**35**(12), 1105–1112 (1967)
30.	GR-1.	General Relativity	Dieter R. Brill and Robert C. Perisho	**36**(2), 85–92 (1968)
31.	OE-1.	Origin of the Elements	William A. Fowler and William E. Stephens	**36**(4), 289–302 (1968)
32.	BSPF-1.	A Bibliography of Selected Physics Films	William R. Riley	**36**(6), 475–489 (1968)
33.	SP-1.	Symmetry in Physics	David Park	**36**(7), 577–584 (1968)
34.	Rea-1.	Reactors	Paul Michael and Robert I. Schermer	**36**(8), 659–668 (1968)
35.	OEPM-1.	Ordinary Electronic Properties of Metals	D. N. Langenberg	**36**(9), 777–788 (1968)
36.	XR-1.	X Rays	Leonard Muldawer	**37**(2), 123–134 (1969)
37.	EP-1.	Educational Psychology	J. W. George Ivany	**37**(11), 1091–1099 (1969)
38.	OC-1.	Optical Resource Letter on Colorimetry	Günter Wyszecki	**37**(12), 1201–1203 (1969)
39.	OR-2.	Optical Resource Letter on Radiometry	Fred E. Nicodemus	**38**(1), 43–50 (1970)
40.	Neu-1.	History of the Neutrino	Leon M. Lederman	**38**(2), 129–136 (1970)
41.	TLA-1.	Technology, Literature, and Art since World War II	William H. Davenport	**38**(4), 407–414 (1970)
42.	PD-1.	Particle Detectors	W. Peter Trower	**38**(7), 795–805 (1970)
43.	Scy-2.	Superconductivity	D. M. Ginsberg	**38**(8), 949–955 (1970)
44.	IQM-1.	Interpretation of Quantum Mechanics	Bryce S. DeWitt and R. Neill Graham	**39**(7), 724–738 (1971)
45.	BE-1.	Biomedical Engineering	Curtis C. Johnson	**39**(12), 1423–1432 (1971)
46.	ERPEE-1.	Energy: Resources, Production, and Environmental Effects	Robert H. Romer	**40**(6), 805–829 (1972)
47.	TQE-1.	Tests of Quantum Electrodynamics	Morton M. Sternheim	**40**(10), 1363–1373 (1972)
48.	PCP-1.	Pre-College Physics Curriculum Materials	Lester G. Paldy and Clifford E. Swartz	**41**(2), 166–178 (1973)
49.	EMAA-1.	Educational Materials in Astronomy and Astrophysics	Richard Berendzen and David DeVorkin	**41**(6), 783–808 (1973)
50.	PE-1.	Physics and the Environment	John I. Shonle	**42**(4), 267–273 (1974)
51.	MPF-1.	Mechanical Properties of Fluids	R. C. Stanley	**42**(6), 440–451 (1974)
52.	TPB-1.	Theoretical Physics and Biology	N. MacDonald	**42**(9), 717–725 (1974)
53.	TLA-2.	Technology, Literature, and the Arts, Contemporary	William H. Davenport	**43**(1), 4–8 (1975)
54.	MENP-1.	Medium Energy Nuclear Physics	Morton M. Sternheim and Justus H. Koch	**43**(6), 475–481 (1975)
55.	MA-1.	Musical Acoustics	Thomas D. Rossing	**43**(11), 944–953 (1975)

56.	RC-1.	Cosmology	Michael P. Ryan, Jr. and L. C. Shepley	**44**(3), 223–230 (1976)
57.	SE-1.	Solar Energy	D. K. McDaniels and M. J. Throop	**44**(5), 409–416 (1976)
58.	EMAA-2.	Laboratory Experiences for Elementary Astronomy	Haym Kruglak	**44**(9), 828–833 (1976)
59.	SEG-1.	Solid-Earth Geophysics	Paul A. Bender	**44**(10), 903–911 (1976)
60.	WI-1.	Weak Interactions	Barry R. Holstein	**45**(11), 1033–1039 (1977)
61.*	ENC-1.	Environmental Noise Control	Thomas D. Rossing	**46**(5), 444–454 (1978)
62.	PhD-1.	Physics Demonstrations	John A. Davis and Bruce G. Eaton	**47**(10), 835–840 (1979)
63.	NP-1.	New Particles	Jonathan L. Rosner	**48**(2), 90–103 (1980)
64.*	CCV-1.	Color and Color Vision	Paul L. Pease	**48**(11), 907–917 (1980)
65.*	SP-2	Symmetry and Group Theory in Physics	Joe Rosen	**49**(4), 304–319 (1981)
66.*	BH-1.	Black Holes	Steven Detweiler	**49**(5), 394–400 (1981)
67.*	L-1.	Lasers	Donald C. O'Shea and Donald C. Peckham	**49**(10), 915–925 (1981)
68.	SH-1.	Superfluid Helium	Robert B. Hallock	**50**(3), 202–212 (1982)
69.	GI-1.	Gravity and Inertia	P. W. Worden, Jr. and C. W. F. Everitt	**50**(6), 494–500 (1982)
70.	PNAR-1.	Physics and the Nuclear Arms Race	Dietrich Schroeer and John Dowling	**50**(9), 786–795 (1982)
71.*	SE-2.	Solar Energy	Laurent Hodges	**50**(10), 876–881 (1982)
72.*	Q-1.	Quarks	O. W. Greenberg	**50**(12), 1074–1089 (1982)
73.*	XRA-1.	X-Ray Astronomy	Claude R. Canizares	**52**(2), 111–119 (1984)
74.*	SR-1.	Synchrotron Radiation	G. Margaritondo and J. H. Weaver	**52**(7), 590–597 (1984)
75.	PWI-1.	Plasma Waves and Instabilities	Crockett L. Grabbe	**52**(11), 970–981 (1984)
76.*	MP-1.	Medical Physics	Russell K. Hobbie	**53**(9), 822–829 (1985)
77.	AHRS-1.	Atoms in High Rydberg States	F. B. Dunning	**53**(10), 944–949 (1985)
78.*	PS-1.	Physics of Sports	Cliff Frohlich	**54**(7), 590–593 (1986)
79.	CPE-1.	Computers in Physics Education	Robert G. Fuller	**54**(9), 782–786 (1986)
80.*	PPPP-1.	Physical Principles of Physiological Phenomena	Bernard Hoop	**55**(3), 204–210 (1987)
81.*	MA-2	Musical Acoustics	Thomas D. Rossing	**55**(7), 589–601 (1987)
82.*	HP-1.	History of Physics	Stephen G. Brush	**55**(8), 683–691 (1987)
83.*	IQM-2.	Foundations of Quantum Mechanics since the Bell Inequalities	L. E. Ballentine	**55**(9), 785–792 (1987)
84.*	CPP-1.	Cosmology and Particle Physics	David Lindley, Edward W. Kolb, and David N. Schramm	**56**(6), 492–501 (1988)
85.*	GI-1.	Gauge Invariance	T. P. Cheng and Ling-Fong Li	**56**(7), 586–600 (1988)
			See also the "Erratum," **56**(11), 1048 (1988)	
86.*	RMSL-1.	Recent Measurements of the Speed of Light and the Redefinition of the Meter	Harry E. Bates	**56**(8), 682–687 (1988)
87.*	FR-1.	Fractals	Alan J. Hurd	**56**(11), 969–975 (1988)
88.*	ETC-1.	Extraterrestrial Civilization	Thomas B. H. Kuiper and Glen David Brin	**57**(1), 12–18 (1989)
89.*	QHE-1.	The Integral and Fractional Quantum Hall Effects	C. T. Van Degrift, M. E. Cage, and S. M. Girvin	**58**(2), 109–123 (1990)

90.	MD-1.	Maxwell's Demon	Harvey S. Leff and Andrew F. Rex	**58**(3), 201–209 (1990)
91.*	MM-1.	Magnetic Monopoles	Alfred S. Goldhaber and W. Peter Trower	**58**(5), 429–439 (1990)
92.*	MNG-1.	Measurements of Newtonian Gravitation	G. T. Gillies	**58**(6), 525–534 (1990)
93.	HEPP-1.	History of Elementary-Particle Physics	R. Corby Hovis and Helge Kragh	**59**(9), 779–807 (1991)
94.*	LS-1.	Laser Spectroscopy	R. Gupta	**59**(10), 874–886 (1991)
95.	AP-1.	The Anthropic Principle	Yuri V. Balashov	**59**(12), 1069–1076 (1991)
96.	MI-1.	Medical Imaging	Stephen J. Riederer	**60**(8), 682–693 (1992)
97.	RP-1.	Radio Pulsars	Joel M. Weisberg	**61**(1), 13–22 (1993)
98.	ETDSTS-1.	Experimental Tests of the Discrete Space-Time Symmetries	Eugene D. Commins	**61**(9), 778–788 (1993)
99.	GW-1.	Global Warming	John W. Firor	**62**(6), 490–495 (1994)
100.	TFM-1.	Time and Frequency Measurement	Christine Hackman and Donald B. Sullivan	**63**(4), 306–317 (1995)

Resource Letter: TFM-1: Time and frequency measurement

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This Resource Letter is a guide to the literature on time and frequency measurement. Journal articles and books are cited for the following topics: frequency standards; methods of characterizing performance of clocks and oscillators; time scales, clock ensembles, and algorithms; international time scales; frequency and time distribution; and applications. [The letter E after an item indicates elementary level or material of general interest. The letter I, for intermediate level, indicates material of somewhat more specialized nature, and the letter A indicates rather specialized or advanced material. The designations E/I and I/A are used to indicate that the article contains material at both levels, so that at least part of the article is written at the lower of the two levels.]

I. INTRODUCTION

Archeological evidence indicates that since prehistoric times man has been devising progressively better means of keeping track of the passage of time. In the earliest stages this involved observation of the apparent motion of the sun, but finer subdivision of the day later involved devices such as water clocks, hourglasses, and calibrated candles. After long development with many variations, mechanical methods for keeping time, in the form of pendulum clocks, achieved excellent precision (a fraction of a second per day). However, with the invention of the two-pendulum clock in 1921 by William Hamilton Shortt, the practical performance limit of such mechanical clocks was reached. The distinction between frequency standard and clock (between frequency and time) is easily recognized in the pendulum clock. The constant frequency of oscillation of the pendulum constitutes a frequency standard. The mechanism used to count the ticks and display their accumulation as seconds, minutes, hours, days, and years converts this frequency standard into a clock.

The modern era of timekeeping began with the development of the quartz crystal oscillator. In a 1918 patent application, Alexander M. Nicholson disclosed a piezoelectric crystal as the control element in a vacuum tube oscillator. The first clock controlled by a quartz crystal was subsequently developed in 1927 by Joseph W. Horton and Warren A. Marrison. Since the introduction of the quartz oscillator, the performance of frequency standards has advanced by many orders of magnitude, and industry and science have come to rely on the timing made possible by them.

Many modern technological applications require that geographically distributed systems have the same time (synchronization) or run at the same rate (syntonization). Thus, an important consideration in time and frequency measurement has been the precise transfer of timing between separated stations. This has led to an interplay between the development of the two key technologies, (1) frequency standards and clocks and (2) methods of time and frequency transfer. Comparisons between early quartz timepieces were accomplished with adequate precision using signals transmitted by terrestrial radio waves.

Quartz crystal oscillators remained at the performance