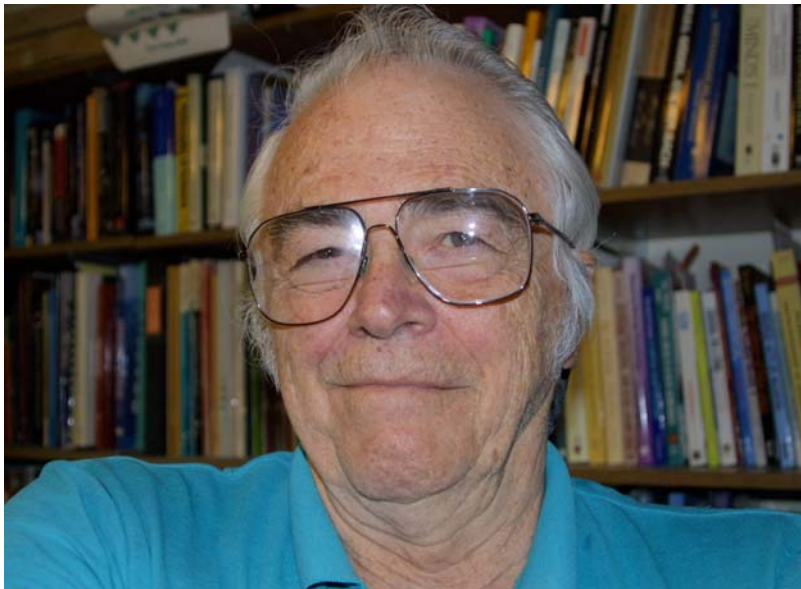


**Richard Robb Hake**  
Curriculum Vitae (2 July 2007)

HAKE, Richard Robb, Emeritus Professor, Department of Physics, Indiana University, Bloomington, Indiana 47405, <rrhake@earthlink.net>, <<http://www.physics.indiana.edu/~hake/>> PHYSICS. Born: Denver, Colorado, July 15, 1927; married, three children. Education: B.S. (Physics Engineering) University of Colorado, 1950; M.S. (Physics), University of Illinois, 1951; Ph. D. (Physics), University of Illinois, 1955. United States Navy, 1945-46. Research Associate, University of Illinois, 1955-56. Senior Research Physicist, Atomics International Division of North American Aviation, 1956-62. Member of the Technical Staff, North American Rockwell Science Center, 1962-70. Consultant, Los Alamos Scientific Laboratories, 1970-73. Professor of Physics, Indiana University, 1970-1995, Emeritus Professor, 1996 - present. Visiting Professor, University of California at San Diego, 1987-88. Visiting Scholar, Arizona State University, 1992. Oversight Committee, Conceptual Core Curriculum for Physics, 1994-1998. Editorial Board, *The Physics Teacher*, 1993-1996: Visiting Committee, NSF - Harvard University On-line Server for Educational Resources. Forum participant - Promoting Rigorous Outcomes in Mathematics and Science Education (PROM/SE) <<http://www.promse.msu.edu/>>, 2005-2006. Member: Pi Mu Epsilon, Sigma Pi Sigma, Sigma Tau, Tau Beta Pi, American Physical Society (Fellow), American Association of Physics Teachers, American Educational Research Association. Research Areas: condensed matter and low-temperature physics, electronic properties, superconductivity, magnetism, cryogenics, science education.

Richard R. Hake



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\*The reference is: Hake, R.R. 2007. VITA (2 July 2007), online at <<http://www.physics.indiana.edu/~hake/VITA-070207h.pdf>>. All URL's are hot-linked. I welcome comments and suggestions addressed to <rrhake@earthlink.net>.  
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Dr. Hake has made significant contributions in the following areas:

### **1. Effects of Pressure and Isotopic Mass Variation in Superconductors**

Dr. Hake and coworkers at the University of Illinois made precise measurements<sup>2,3</sup> of the isotope effect in the superconducting transition temperature of lead which showed that previous measurements were in error and that the actual isotope shift was as predicted on the basis of early electron-phonon interaction theories of Frohlich and Bardeen. They also measured<sup>1</sup> the pressure-induced transition-temperature shift of lead and discussed how this shift might be influenced by effects of pressure on both the electronic structure and the vibrational spectrum.

### **2. Electronic and Magnetic Properties of Transition Metals**

Hake (with T.G. Berlincourt and D.H. Leslie) made the most detailed investigation<sup>4-6</sup> to date of the electronic transport properties of that class of bcc Ti-, Zr- and Hf-base transition metal alloys which display high and anomalously temperature and concentration dependent electrical resistivities of a type which are even today not fully understood. Hake (with Berlincourt, Leslie, and J.A. Cape)<sup>10,11,20-22</sup> discovered negative magnetoresistance, resistance minima, Curie-Weiss susceptibility, and low-temperature specific heat anomalies in certain dilute hcp Ti-, Zr-, and Hf-base alloys, and emphasized the importance of such observations to theories of transition metals, magnetism, and superconductivity. This work was among the earliest studies of localized-moment phenomena in transition-metal-base alloys. Such studies were then extended to the spin-glass state in Zr-Mn alloys.<sup>42</sup> Hake was the first to provide definite evidence<sup>5,6</sup> in support of Pines's interpretation of the Matthias regularities for transition metal superconductors in terms of the Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity. Hake's calorimetric measurements<sup>5,6</sup> gave the first evidence of the BCS-type energy gap in the electronic excitation spectrum of superconducting alloys, in agreement with P.W. Anderson's theory of "dirty" superconductors.

### **3. High-Field Superconductivity<sup>53</sup>**

With T.G. Berlincourt and D.H. Leslie, Hake was the first to observe zero electrical resistance in magnetic fields as high as 30 kilogauss.<sup>4</sup> These workers also discovered<sup>7,8,12-15,19,27</sup> the technologically important high-field superconductivity in Ti-Nb alloys, the "peak effect" and rolling plane anisotropy in high-field alloys, and the correlation of critical current anisotropy with microstructure. They constructed<sup>9</sup> the first 45 and 60 kilogauss superconducting magnets and elucidated<sup>12-15</sup> the nature of upper critical fields in terms of the Ginzburg-Landau-Abrikosov-Gor'kov (GLAG) theory of type-II superconductors. (The popular terms "peak effect" and GLAG were both coined by Hake and Berlincourt.) Hake (with W.G. Brammer)<sup>16-18</sup> made the first detailed studies of the specific heat and related thermodynamic properties of reversible type-II superconductors.

Other pioneering work in high-field superconductivity includes (1) first observation of paramagnetically limited upper critical fields (with T.G. Berlincourt),<sup>12,15</sup> (2) first observation<sup>24</sup> of mixed-state magnetocaloric cooling (with L.T. Barnes), (3) derivation<sup>17,18,30,32</sup> of the thermodynamic interrelationships of magnetization with volume and pressure effects, as well as a unified discussion of the thermodynamic properties of type-I and type-II superconductors; (4) discovery<sup>23,27,29</sup> of the mixed-state Pauli paramagnetism in extreme type-II superconductors, and (with L.J. Barnes) the calorimetric verification<sup>25,26</sup> of a bulk, reversible, paramagnetic superconducting phase, (5) discussion<sup>28</sup> of upper critical field limits which consider the spin-flip mitigation of the Pauli paramagnetic limitation; (6) first measurement<sup>31</sup> of the mixed-state Hall effect in an extreme type-two superconductor. The discovery and elucidation of high-field superconductivity<sup>12,15</sup> in Ti-Nb (the present mainstay of technological high-field applications) and other alloys by Berlincourt and Hake in the 1960's has been historically described in "Type-II Superconductivity: Quest for Understanding," T.G. Berlincourt, in *H. Kamerlingh Onnes Symposium on the Origins of Applied Superconductivity*, *IEEE MAG-23*, 403 (1987), online to subscribers at <<http://tinyurl.com/2ceytg>>; and in "Emergence of Nb-Ti as a Supermagnet Material," T.G. Berlincourt, *Cryogenics* **27**, 283 (1987).

#### 4. Fluctuation Superconductivity

Hake was the first to observe<sup>33-35</sup> fluctuation superconductivity in bulk superconductors, isothermal quenching of superconductive fluctuations in bulk materials by high magnetic fields, and fluctuation-induced conductivity enhancement up to  $3 T_c$ . With L.J. Barnes, W. Lue, A. Montgomery, and R.R. Hasing, Hake<sup>37-39</sup> obtained the first evidence for magnetic-field induced fluctuation dimensionality reduction, and for fluctuation superconductivity up to  $140 \text{ kG}$  [ $H \leq 2H_{c2} (T = 0)$ ].

#### 5. Quantum Interference Effects (Weak Localization) in Bulk Disordered Metals

Hake and co-workers made the first observations<sup>40,41,44,46,50</sup> of non-localized-magnetic-moment-related negative magnetoresistance and negative temperature coefficients of resistivity (both now known to be signatures of quantum interference effects) in highly disordered bulk crystalline and amorphous alloys at low temperatures were made. They were apparently the first<sup>44</sup> to suggest the connection of these transport anomalies with weak electronic localization.

#### 6. Superconductivity of Amorphous Metals

Hake and Karkut<sup>47-49</sup> provided the first evidence (contrary to Cal Tech and IBM work) that the temperature dependence of upper-critical fields of bulk amorphous alloys could be satisfactorily described by the standard dirty-limit Werthamer-Helfand-Hohenberg-Maki (WHHM) theory shown earlier<sup>29</sup> to be in fair accord with data for disordered crystalline alloys.

## 7. Uranium Compound and Very-High-Temperature Superconductors

During a half-year sabbatical (Spring, 1984) at the University of California - San Diego (UCSD), Hake worked with Brian Maple and his group to discover<sup>51,52</sup> four new U-compound superconductors (unfortunately, none of the heavy-fermion type). Then, in 1987-88 he collaborated<sup>55-60,62-66</sup> with this same group as a visiting professor at UCSD to investigate the new high-temperature superconductors. Among major accomplishments was the discovery<sup>58</sup> of the potential one megagauss superconductor  $\text{TmBa}_2\text{Cu}_3\text{O}_{7-d}$  and the correlation<sup>64,66</sup> of the magnetic-field alignment direction of single-crystal-grain c-axes in  $\text{RBa}_2\text{Cu}_3\text{O}_{7-d}$  ( $\text{R} = \text{Nd}, \text{Sm}, \text{Tm}, \text{Yb}$ ) with the Stevens factor  $a_j$  of the crystalline electric field Hamiltonian.

## 8. Science Education

For nearly three decades,<sup>43,54,61,67-163</sup> I have been engaged in a development, dissemination, and research program to improve introductory science education at the local, state, and national levels.

The development has consisted in the instruction of introductory physics courses with various innovations emphasizing interactive engagement of students, primarily Socratic Dialogue Inducing (SDI) laboratories.<sup>54,61,77,79,104,128</sup> Nine SDI lab manuals on introductory mechanics, most of them with accompanying teacher's guides, have now been developed. Much of this material is now available online<sup>136, 137</sup> at <http://www.physics.indiana.edu/~sdi/>, <http://www.physics.indiana.edu/~hake/>, and <http://galileo.harvard.edu/>. SDI labs have now been used successfully<sup>129,142</sup> in several universities, community colleges, high schools, and even middle schools.

The research has consisted of both qualitative and quantitative studies, intermixed in such a way as to be mutually supportive.<sup>119,138</sup> The former has involved the analysis of (a) videotaped individual interviews<sup>155</sup> probing both cognitive and affective states of introductory physics students, and (b) videotaped SDI lab sessions, including discussions both among students and between Socratic dialogists and students,<sup>92,96,155</sup> (c) comments and performance of students<sup>43,54,79</sup> and non-physical-science professors<sup>61</sup> enrolled in the introductory physics course, (d) case studies<sup>108</sup> of courses in which nominally interactive-engagement methods were employed but minimal gains in conceptual understanding occurred. The qualitative research has served to uncover many unsuspected barriers to learning, suggest new paths to physics understanding, and greatly improve the effectiveness of SDI labs.

The quantitative studies have centered on student evaluations<sup>43,130</sup> and careful prepost testing for both conceptual understanding and problem solving ability.<sup>54,61,103,107,108,109,125,127,131,150,155</sup> Several years ago Hake completed a survey<sup>107,108</sup> of pre/post test data using the Halloun-Hestenes Mechanics Diagnostic MD test or more recent Force Concept Inventory FCI for 62 introductory physics courses enrolling a total number of students  $N = 6542$ . A consistent analysis over diverse student populations in high schools, colleges, and universities is obtained if a rough measure of the average effectiveness of a course in promoting conceptual understanding is taken to be the average normalized gain  $\langle g \rangle$ .

The latter is defined as the ratio of the actual average gain ( $\% \langle \text{post} \rangle - \% \langle \text{pre} \rangle$ ) to the maximum possible average gain ( $100 - \% \langle \text{pre} \rangle$ ). Fourteen “traditional” (T) courses ( $N = 2084$ ) which made little or no use of interactive-engagement (IE) methods achieved an average gain of  $\langle g \rangle_{T\text{-ave}} = 0.23 \pm 0.04$  (std dev). In sharp contrast, forty-eight courses ( $N = 4458$ ) which made substantial use of IE methods achieved average gains of  $\langle g \rangle_{IE\text{-ave}} = 0.48 \pm 0.14$  (std dev), almost two standard deviations above that of the traditional courses.

Average normalized gain differences between T and IE courses that are consistent with the work of Hake (1998a,b) have been reported by many other physics-education researchers, e.g.: Redish, Saul, & Steinberg (1997); Saul (1998); Francis, Adams, & Noonan (1998); Heller (1999); Redish & Steinberg (1999); Redish (1999); Beichner et al. (1999); Cummings, Marx, Thornton, & Kuhl (1999); Novak, Patterson, Gavrin, & Christian (1999); Bernhard (2000); Crouch & Mazur (2001); Johnson (2001); Meltzer (2002a, 2002b); Meltzer & Manivannan (2002); Savinainen & Scott (2002a, 2002b); Steinberg & Donnelly (2002); Fagan, Crouch, & Mazur (2002); Van Domelen & Van Heuvelen (2002); Belcher (2003); Dori & Belcher (2004); Hoellwarth, Moelter, & Knight (2005); Lorenzo, Crouch, & Mazur (2006); & Rosenberg, Lorenzo, & Mazur (2006) - see citations in “Design-Based Research in Physics Education Research: A Review,” ref. 155.

Results for 30 ( $N = 3259$ ) of the 62 courses in Hake’s survey<sup>107,108</sup> on the problem-solving Mechanics Baseline test of Hestenes-Wells suggest that IE strategies enhance problem-solving ability. IE strategies shown by the survey to be relatively effective are well documented in the literature,<sup>125,146,153,155</sup> can be melded together and modified so as to suit local circumstances, offer materials for their implementation,<sup>108</sup> and can successfully be brought to the masses (course enrollments greater than 100) in a cost-effective manner.<sup>107,108</sup> All of the above strongly suggests that (1) *the use of IE strategies can increase mechanics-course effectiveness well beyond that obtained with traditional methods*, (2) *physics instructors should give serious consideration to the gradual replacement of the traditional modes of mechanics instruction (and probably physics instruction generally) by IE methods*.

The survey indicates that the strenuous recent efforts to reform introductory physics instruction, enlightened by cognitive science and research in physics education, have shown very positive results in the classroom. However, history suggests the possibility that such efforts may have little lasting impact. This would be most unfortunate, considering the current imperative to (a) educate more effective science majors and science-trained professionals including teachers,<sup>115,116,120,126,132,133,153</sup> and (b) raise the appallingly low level of science literacy among the general population.<sup>116</sup> Progress towards these goals should increase our chances of solving the monumental science-intensive problems (economic, social, political, and environmental) that beset us, but major upgrading of physics education on a national scale will probably require:

(1) the interdisciplinary<sup>139,148,149,155</sup> cooperation of instructors, departments, institutions, and professional organizations. See, e.g.:

(a) R.C. Hilborn, “Guest Comment: Revitalizing undergraduate physics - Who Needs It,” *Am. J. Phys.* **65**(3), 175-177 (1997);

(b) “Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology,” Advisory Committee to the NSF Directorate for Education and Human Services, 6/96, online at <[http://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=nsf96139](http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf96139)>;

(c) “Shaping the Future, Volume II: Perspectives on Undergraduate Education in Science, Mathematics, Engineering, and Technology” at <[http://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=nsf98128](http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf98128)>] .

(2) long-term classroom use, feedback, assessment, research analysis, and redesign of interactive-engagement methods [K.G. Wilson and B. Daviss, *Redesigning Education* (Henry Holt, 1994) and “Design-Based Research in Physics Education Research: A Review” (ref. 155).

More recently I have:

(a) Compiled a guide,<sup>112,113</sup> REDCUBE, that gives non-biologists (and even biologists) a point of entry into the vast literature and web resources relevant to REsearch, Development, and Change in Undergraduate Biology Education.

(b) Discussed lessons from the physics-education-reform effort<sup>125</sup> that might be significant for undergraduate education in all disciplines.<sup>146,150,151,152,153</sup>

(c) With Jeffrey Mallow<sup>135</sup> compiled “Gender Issues in Physics/Science Education (GIPSE) – Some Annotated References.” Containing about 300 references and 200 hot-linked URL's.

(d) Attempted to counter<sup>144,145</sup> the California Curriculum Commission's attempt to limit hands-on science-education activities in K-8, and to generally improve science and math education in K-12.<sup>86,115,116,120,124,132,133,135,147,150,158,159</sup> I participated in a Forum for "Promoting Rigorous Outcomes in Mathematics and Science Education" (PROM/SE) <<http://www.promse.msu.edu/>>, a Michigan State University (MSU) NSF-supported "comprehensive research and development effort to improve mathematics and science teaching and learning in grades K-12, based on assessment of students and teachers, improvement of standards and frameworks, and capacity building with teachers and administrators. . . . . The forum "included a who's who of science and education leaders including Nobel Laureate Leon Lederman, astrophysicist Carl Pennypacker, former astronaut and educator George 'Pinky' Nelson, Michigan State University president Lou Anna K. Simon. and MSU educators Joan Ferrini-Mundy, William Schmidt, George Leroi, and Charles 'Andy' Anderson."

(f) Proposed<sup>146,151,152,153</sup> that formative pre/post testing to measure the efficacy of undergraduate courses (as first employed in economics and physics; and then in astronomy, biology, chemistry, economics, geoscience, engineering, and math) be utilized more widely in nearly *all* disciplines so as to promote a badly needed improvement in university education as called for by e.g., Derek Bok, former president of Harvard University; James Duderstadt, former president of the University of Michigan; Richard Cyert, former president of Carnegie Mellon University, and Fred Reif, physics-education-research pioneer. [For the references see "Should We Measure Change? Yes!" ref. 153. ]

(f) Discussed<sup>129,156,160</sup> the "Socratic Method" of the *historical* Socrates (as researched by Gregory Vlastos and as practiced by Arnold Arons), in an attempt to counter the rampant misunderstandings engendered by Plato as in the "Meno," and by law schools as in "The Paper Chase."

(g) Consistent with "In Defense of Cross Posting,"<sup>148</sup> and "Cross-Posting - Synergistic or Sinful?",<sup>149</sup> I have continued a quixotic and generally futile attempt to tunnel through disciplinary barriers by posting on several discussion lists, e.g., AERA-A, AERA-B, AERA-C, AERA-D, AERA-H, AERA-I, AERA-J, AERA-K, AERA-L, ARN-L, ASSESS, EDDRA, EdResMeth, EvalTalk, IFETS, ITForum, PhysLrnR, POD, and various chemistry, biology, mathematics, philosophy, and psychology lists. These posts can be accessed at various discussion-list archives as indicated in "Guide to Education-related Discussion List Posts (1998 – 2007)."<sup>163</sup>

**Bibliography** [All URL's are hot linked. Tiny URL's are courtesy  
<<http://tinyurl.com/create.php>>.]

NOTE: Education-related references:

1. are prefaced by “**NE**” where **N** is the reference number and **E** = Education;
2. start with “**43E. Hake & Swihart (1979)**”;
3. are *not* formatted in the pure AIP style of non-education-related references, but in a blend of the best formatting features recommended by the AIP (American Institute of Physics), APA (American Psychological Association, and CSE (Council of Science Editors);
4. are COLOR CODED such that references in:
  - (a) **blue text** appeared in peer-reviewed journals or books;
  - (b) **violet text** appeared in non-peer-reviewed outlets or are in preparation;
  - (c) **red text** appeared in letters to editors or congressmen;
  - (d) **brown text** appeared *only* in abstracts of presentations at AAPT meetings as published in the *AAPT Announcer* or, after 2006, in online program schedules;
  - (e) **green text** indicate Workshops at AAPT Meetings or elsewhere.
  - (f) **bold text** of any color means “by invitation.
5. For a listing of major articles only see “Education Articles (1979 – 2007), ref. 162; for a guide to discussion-list posts see ref. 163.

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- 89E.** Hake, R.R. , J.W. Robson, & N.C. Steph. 1994. Workshop: Socratic Dialogue Inducing Labs (Notre Dame Meeting), *AAPT Announcer* **24**(2).
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- 91E.** Hake R.R. & N.C. Steph. 1994. Workshop: Socratic Dialogue Inducing Labs (Orlando Meeting), *AAPT Announcer* **24** (4): 25.
- 92E.** Sirochman, R. , R.R. Hake, and A. Bhattacharyya. 1994. "SDI Lab Videotape: Concept Construction through Experiment, Discussion, Drawing, and Dialogue," *AAPT Announcer* **24** (4): 85.

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**99E. Hake, R.R. & R. Bird. 1995. “Why Doesn't The Water Fall Out Of The Bucket? Concept Construction Through Experiment, Discussion, Drawing, Dialogue, Writing, and Animations,” *AAPT Announcer* **25** (2): 70.**

**100E. Hake, R.R. 1995. “Socratic Dialogue Inducing Labs: Do They Work?” invited talk, Project Kaleidoscope Workshop “Revitalizing Introductory Physics,” Miami University, 6/22-25/95.**

**101E. Halloun, I., R.R. Hake, E.P Mosca, D. Hestenes. 1995. Force Concept Inventory (Revised, 1995); online (password protected) at <<http://modeling.asu.edu/R&E/Research.html>>. Available in English, Spanish, German, Malaysian, Chinese, Finnish, French, Turkish, Swedish, and Russian.**

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**103E. Hake, R.R. 1997. “Evaluating Conceptual Gains in Mechanics: A six-thousand-student survey of test data,” *AIP Conference Proceeding No. 399, The Changing Role of Physics Departments in Modern Universities: Proceedings of the ICUPE*, edited by E.F. Redish and J.S. Rigden, (AIP, Woodbury), p. 595-603.**

**104E.** Hake R.R. & R. Wakeland. 1997. “ 'What's F? What's m? What's a?': A Non-Circular SDI-TST- Lab Treatment of Newton's Second Law” in *Conference on the Introductory Physics Course*, Jack Wilson, ed. Wiley. pp. 277-283. [See also SDI Lab #6 “Newton's Second Law Revisited,” online at <<http://www.physics.indiana.edu/~sdi>>.]

**105E.** Hake, R.R., 1997. **Briefing on the NRC Physics Education Program Initiation Meeting of 5/13/97, delivered at the “Workshop on the Future of Condensed-Matter and Materials Physics (CMMP),” Washington, D.C. 9/11,12/97, sponsored by the Board on Physics and Astronomy of the National Research Council.**

**106E.** Hake, R.R., 1997. “Force Concept Inventory (FCI) and Mechanics Baseline (MB) Survey Results: A ‘Generalized Hawthorne Effect’? ,” *AAPT Announcer* **27**(2): 107. A response to Charles Geilker, “Guest Comment: In defense of the lecture-demonstration method.” *Am. J. Phys.* **65**: 107 (1997), who dismissed evidence for the superiority of reform pedagogy as a “generalized Hawthorne Effect.”

**107E.** Hake, R.R. 1998. “Interactive-engagement vs traditional methods: A six thousand-student survey of mechanics test data for introductory physics courses,” *Am. J. Phys.* **66**(1): 64-74; online at <<http://www.physics.indiana.edu/~sdi/ajpv3i.pdf>> (84 kB).

**108E.** Hake, R.R. 1998. “Interactive-engagement methods in introductory mechanics courses,” online at <<http://www.physics.indiana.edu/~sdi/IEM-2b.pdf>> (108 kB) - a crucial companion paper to Hake (1998a).

**109E.** Hake, R.R. 1998. “Interactive-engagement vs Traditional Methods in Mechanics Instruction,” *APS Forum on Education Newsletter*, Summer 1998, p. 5-7; online at <<http://www.physics.indiana.edu/~sdi/FOEN-1e.pdf>> (16 kB). Some criticisms of refs. 107 & 108, and of physics-education reform generally, are countered.

**110E.** Hake, R.R. 1998. A Microcomputer-Based SDI Lab Emphasizing the Graphical Interpretation of the Derivative and the Integral,” *AAPT Announcer* **28**(2): 101.

**111E.** Hake, R.R., R. Sirochman, & N. Steph. 1998. Workshop: Socratic-Dialogue-Inducing Laboratories, *AAPT Announcer* **28**(4): 62.

**112E.** Hake, R.R. 1999. “REDCUBE: REsearch, Development, and Change in Undergraduate Biology Education: A Web Guide for Non-Biologists,” online at <<http://www.physics.indiana.edu/~redcube/redcube.pdf>> (377 kB). Gives non-biologists (and even biologists) a point of entry into the vast literature and web resources relevant to research, development, and change in undergraduate biology education. It contains 47 biology-educator profiles; 446 references (including 124 relevant to general science-education reform); and 490 hot-linked URL's on

- (a) Biology Associations,
- (b) Biology Teachers Web Sites,
- (c) Scientific Societies and Projects (not confined to Biology),
- (d) Higher Education,
- (e) Cognitive Science and Psychology,
- (f) U.S. Government, and
- (g) Searches and Directories.

The references and URL's may be generally useful to teachers and education researchers, and may provide some ideas for hastening education reform.

**113E.** Hake, R.R. 1999. “What Can We Learn from the Biologists About Research, Development, and Change in Undergraduate Education?” *AAPT Announcer* **29**(4): 99 (1999); online at <<http://www.physics.indiana.edu/~hake/WhatLearn-013100g.pdf>> (204K). Page 3 shows a schematic illustrating the thus-far unrealized potential of discussion lists for promoting interdisciplinary synergy and thus hastening the glacial pace of education reform.

**114E.** Hake, R.R. 2000. “Re: An Essay,” online at <<http://listserv.nd.edu/cgi-bin/wa?A2=ind0010&L=pod&P=R20500&I=-3>>. Post of 22 Oct 2000 16:04:10-0700 to PhysLrnR, POD, & STLHE-L. A response to an insightful POD post by the late Bob Leamson who wrote: “I have said elsewhere that the word 'learning' attracts adjectives like a magnet. Jim Rhem also seems to take a wry view of 'active learning,' 'constructivist learning,' 'collaborative learning,' 'cooperative' learning, 'problem-based learning,' 'outcomes-based learning,' 'hands-on learning,' 'experiential learning,' 'asynchronous learning,' and the rest, and lumped them all under the label 'The Learnings.' . . . . I would suggest a massive re-thinking of our language, and FOR EACH OF 'THE LEARNINGS' CROSS OUT THE WORD 'LEARNING' AND SUBSTITUTE 'TEACHING.' [My CAPS.] We should have active teaching, outcome-based teaching, problem-based teaching, distance teaching and the rest.”

**115E.** Hake, R.R. 2000, “The Benezet-Berman Experiment,” online at <<http://tinyurl.com/24bkkh>>. Post of 13 Oct 2000 12:46:21-0700 to Math-Teach, Physhare, Phys-L, and PhysLrnR. See also ref. 124.

**116E.** Hake, R.R. 2000. “The General Population’s Ignorance of Science Related Societal Issues: A Challenge for the University,” *AAPT Announcer* **30**(2): 105; online at <<http://www.physics.indiana.edu/~hake/GuelphSocietyG.pdf>> (2.1MB). Based on an earlier libretto with the leitmotiv: “The road to U.S. science literacy begins with effective university science courses for pre-college teachers.” The opera dramatizes the fact that the failure of universities *throughout the universe* to properly educate pre-college teachers is responsible for our failure to observe any signs of either terrestrial or extraterrestrial intelligence.

**117E.** Hake, R.R. & R. Sirochman. 2000. “Workshop: Socratic-Dialogue-Inducing Laboratories,” *AAPT Announcer* **30**(2): 55.

**118.** Hake, R.R. 2000. “What Can We Learn from the Physics Education Reform Effort?” *ASME Mechanical Engineering Education Conference: Drivers and Strategies of Major Program Change*, Fort Lauderdale, Florida, March 26-29; online at <<http://www.physics.indiana.edu/~hake/ASME-040300e.pdf>> (436 kB).

**119E.** Hake, R.R. 2000. “Towards Paradigm Peace in Physics Education Research,” presented at the annual meeting of the American Educational Research Association, New Orleans, 24-28 April; online at <[http://www.physics.indiana.edu/~sdi/AERA-Hake\\_11.pdf](http://www.physics.indiana.edu/~sdi/AERA-Hake_11.pdf)> (168 KB). Also at that location is a pdf version <<http://www.physics.indiana.edu/~hake/ParadigmSlides.pdf>> (244 kB) of the PowerPoint slides shown at the meeting.

**120E.** Hake, R.R. 2000. “The Need for improved physics education of teachers: FCI pretest scores of graduates of high school physics courses,” *Physics Education Research Conference 2000: Teacher Education*, Univ. of Guelph, August 2-3; online at <<http://www.physics.indiana.edu/~hake/PERC2000-HSTeach-5.pdf>> (929 kB).

**121E.** Hake, R.R. 2000. “Is it Finally Time to Implement Curriculum S?” *AAPT Announcer* **30**(4): 103; online at <<http://www.physics.indiana.edu/~hake/CurrS-031501.pdf>> (1.2 MB) - 400 references & footnotes, 390 hot-linked URL's. This paper concerns improving the education of undergraduate physics majors by instituting a “Curriculum S“ for “Synthesis.“ But because that's a small part of a much larger educational problem in the U.S. there's a lot of material on the reform of P-16 education generally (P = preschool).

**122E.** Hake, R.R. 2000. “Eleven Lessons From the Undergraduate Physics Education Reform Effort” *AAPT Announcer* **30**(4): 113.

**123E.** Hake, R.R. 2000. “Using the Web to Promote Interdisciplinary Synergy” *AAPT Announcer* **30**(4): 120.



- 130E.** Hake, R.R. 2002. “Re: Problems with Student Evaluations: Is Assessment the Remedy?” online at <<http://www.physics.indiana.edu/~hake/AssessTheRem1.pdf>> (72 kB).
- 131E.** Hake, R.R. 2002. “Comment on 'How do we know if we are doing a good job in physics teaching?' by Robert Ehrlich,” *Am. J. Phys.* **70**(10): 1058-1059; online at <<http://www.physics.indiana.edu/~hake/HakeOnEhrlich-2.pdf>> (40 kB).
- 132E.** Hake, R.R. 2002. “Physics First: Precursor to Science/Math Literacy for All?” *APS Forum on Education Newsletter*, Summer 2002; online at <<http://www.aps.org/units/fed/newsletters/summer2002/index.html>>.
- 133E.** Hake, R.R. 2002. “Physics First: Opening Battle in the War on Science/Math Illiteracy?” Submitted to the *American Journal of Physics* on 27 June 2002; online at <<http://www.physics.indiana.edu/~hake/PhysFirst-AJP-6.pdf>> (220 kB).
- 134E.** Hake, R.R. 2002. “Relationship of Individual Student Normalized Learning Gains in Mechanics with Gender, High-School Physics, and Pretest Scores on Mathematics and Spatial Visualization,” submitted to the Physics Education Research Conference; Boise, Idaho; August 2002; online at <<http://www.physics.indiana.edu/~hake/PERC2002h-Hake.pdf>> (220 KB).
- 135E.** Mallow, J.V. & R.R. Hake. 2002. “Gender Issues in Physics/Science Education (GIPSE) – Some Annotated References,” online at <<http://www.physics.indiana.edu/~hake/GIPSE-4b.pdf>> (232kB), and at the APS website <<http://www.aps.org/educ/cswp/women-links.cfm>>, <<http://www.aps.org/programs/women/resources.cfm#swp/women-links.cfm>> under “Gender Issues.” Contains about 300 references and 200 hot-linked URL's.
- 136E.** Hake, R.R. 2003. Socratic Dialogue Inducing (SDI) Labs Web Site <<http://www.physics.indiana.edu/~sdi>>. Contains a brief description of SDI Labs with pertinent references and 9 SDI Lab Manuals that may be freely downloaded. Teacher's Guides for SDI Labs #0.2 “Introduction to Kinematics“ and #3 “Circular Motion and Frictional Forces“ are available on request to <[rrhake@earthlink.net](mailto:rrhake@earthlink.net)> and more Guides are in preparation. At the same site is “Introduction To SDI Lab Teacher’s Guides“ online at <<http://www.physics.indiana.edu/~sdi/IntroTchGuide.pdf>> (32 KB). See also “P201 Course Materials“ online at <<http://www.physics.indiana.edu/~sdi/P201-Course-Materials.pdf>> (12 kB).

**137E.** Hake, R.R. 2003. "SDI Labs," at the Harvard Galileo site <<http://galileo.harvard.edu/>> go to <<http://galileo.harvard.edu/galileo/hom/sdi/>>. The Galileo site is now undergoing transition to the "Interactive Learning Toolkit," and has been a leading resource for online teaching materials. Under "Teaching Materials" click on "Socratic Dialogue Inducing Labs" to bring up sections on: "What is SDI?," "Who Can Use SDI?," "More About SDI," "What Are the Requirements?," "Benefits," and "Resources for SDI." In addition, Teacher's Guides for SDI Labs #0.2 "Introduction to Kinematics" and #3 "Circular Motion and Frictional Forces" are at <<http://galileo.harvard.edu/>> / "Socratic Dialogue Inducing Labs" / "Resources for SDI" / "Teacher's Guides", where "/" means "click on."

**138E.** Hake, R.R. 2003. "Educational Activities (1979 - 2003)," online at <<http://www.physics.indiana.edu/~hake/EducActivity-2.pdf>> (72kB). For a update see Section 8, "Science Education," above in this VITA and refs. 162 & 163.

**139E.** Hake, R.R. 2004. "Design-Based Research: A Primer for Physics Education Researchers," submitted to the *Am. J. Phys.* on 10 June 2004; online at <<http://www.physics.indiana.edu/~hake/DBR-AJP-6.pdf>> (310kB).

**140E.** Hake, R.R. 2004. "Design Experiments: Breakthrough for Cognitive Scientists, Old Stuff for PER's," *AAPT Announcer* **34**(2): 157.

**141E.** Hake, R.R. 2004. "The Arons Advocated Method," submitted to the *Am. J. Phys.* on 24 April 2004; online at <<http://www.physics.indiana.edu/~hake/AronsAdvMeth-8.pdf>> (144 kB).

**142E.** Hake, R.R. 2004. "Re: Cool Demo for Newton's First Law?" online at <<http://tinyurl.com/2u42me>>. Post of 27 Jun 2004 20:39:44-0700 to AP-Physics, Physhare, Phys-L, and PhysLrnR. Contains praise for SDI labs by high-school teacher Simon Butterworth [see e.g., Butterworth, S. 2002, "Re: Socratic Method," Physhare post of 15 Nov 2002 18:32:46 +0200; online at <<http://tinyurl.com/37cc26>>]; and high school teacher Holly Priestly who stated that her husband and used an SDI lab successfully for gifted students in middle school [see e.g., Priestley, H. 2002, "Re: Socratic Method," PhysLrnR post of 16 Nov 2002 16:28:54-0500; online at <<http://tinyurl.com/ys7fxn>>].

**143E.** Hake, R.R. 2004. "Design-Based Research': Old PER Wine in a New Bottle," submitted on 16 July 2004 to the PERC 2004 Physics Education Research Conference, 4-5 August 2004, Sacramento, California; online at <<http://www.physics.indiana.edu/~hake/PERC2004-Hake6.pdf>> (120 kB). See also refs. 138 & 154.

**144E.** Hake, R.R. 2004. "Direct Science Instruction Suffers a Setback in California - Or Does It?" *AAPT Announcer* **34**(2): 177; online at <http://www.physics.indiana.edu/~hake/DirInstSetback-041104f.pdf> (420 KB) [about 160 references and 180 hot-linked URL's]. A pdf version of the slides shown at the meeting is also available at <http://www.physics.indiana.edu/~hake/AAPT-Slides.pdf> (132 kB).

**145E.** Hake, R.R. 2005. "Will the No Child Left Behind Act Promote Direct Instruction of Science?" *Am. Phys. Soc.* **50**: 851 (2005); APS March Meeting, Los Angeles, CA. 21-25 March; online at <http://www.physics.indiana.edu/~hake/WillNCLBPromoteDSI-3.pdf> (256 kB).

**146E.** Hake, R. R. 2005. "The Physics Education Reform Effort: A Possible Model for Higher Education?" online at <http://www.physics.indiana.edu/~hake/NTLF42.pdf> (100 kB). This is a slightly edited version of an article that was (a) published in the *National Teaching and Learning Forum* **15**(1), December, online to subscribers at <http://www.ntlf.com/FTPSite/issues/v15n1/physics.htm>, and (b) disseminated by the *Tomorrow's Professor* list <http://ctl.stanford.edu/Tomprof/postings.html> as Msg. 698 on 14 Feb 2006. For an executive summary see ref. 151.

**147E.** Hake, R.R. 2005. Review of Stephen Swidler's "Naturally Small: Teaching and Learning in the Last One-Teacher Schools," 2 June, in *Education Review* <http://edrev.asu.edu/>; online at <http://www.physics.indiana.edu/~hake/RevSwidler25.pdf> (36 kB).

**148E.** Hake, R.R. 2005. "In Defense of Cross Posting," online at <http://listserv.nd.edu/cgi-bin/wa?A2=ind0507&L=pod&P=R13219&I=-3>. Post of 24 Jul 2005 21:54:34-0700 to AERA-C, AERA-D, AERA-G, AERA-GSL, AERA-H, AERA-I, AERA-J, AERA-K, AERA-L, ASSESS, BioLab, Biopi-L, EvalTalk, Math-Learn, PhysLrnR, POD, STLHE-L, TeachingEdPsych, & TIPS.

**149E.** Hake, R.R. 2005. "Cross-Posting - Synergistic or Sinful?" Post of 1 Nov 2005 08:37:12-0800 to ITFORUM and AERA-L. Online at <http://tinyurl.com/kleqh> .

**150E.** Hake, R.R. 2006. "Measuring Teaching and Learning Performance: Interconnected Issues," in *Proceedings of the Third International Conference on Measurement and Evaluation in Education (ICMEE 2006)*, Penang, Malaysia, 13-15 February; online at <http://www.physics.indiana.edu/~hake/ICMEEk-2006.pdf> (230 kB).

**151E.** Hake, R.R. 2006. "A Possible Model For Higher Education: The Physics Reform Effort (Author's Executive Summary)," *Spark* (American Astronomical Society Newsletter), June, online at <http://www.aas.org/education/spark/SparkJune06.pdf> (1.9MB). Scroll down about 4/5 of the way to the end of the newsletter.

**152E.** Hake, R.R. 2006. "Possible Palliatives for the Paralyzing Pre/Post Paranoia that Plagues Some PEP's," *Journal of MultiDisciplinary Evaluation*, Number 6, November, online at <[http://evaluation.wmich.edu/jmde/JMDE\\_Num006.html](http://evaluation.wmich.edu/jmde/JMDE_Num006.html)>. This even despite the admirable anti-alliteration advice at psychologist Donald Zimmerman's site <<http://mypage.direct.ca/z/zimmerma/>> to "Always assiduously and attentively avoid awful, awkward, atrocious, appalling, artificial, affected alliteration."

**153E.** Hake, R.R. 2007. "Should We Measure Change? Yes!" online as ref. 43 at <<http://www.physics.indiana.edu/~hake>>. To appear as a chapter in ref. 154. A severely truncated version appears in ref. 152.

**154E.** Hake, R.R. 2007. *Evaluation of Teaching and Student Learning in Higher Education, Monograph, American Evaluation Association* <<http://www.eval.org/>>, in preparation.

**155E.** Hake, R.R. 2007. "Design-Based Research in Physics Education Research: A Review," in A.E. Kelly, R.A. Lesh, & J.Y. Baek, (in press), *Handbook of Design Research Methods in Mathematics, Science, and Technology Education*. Lawrence Erlbaum. Online at <<http://www.physics.indiana.edu/~hake/DBR-Physics3.pdf>>.

**156E.** Hake, R.R. 2007. "The Socratic Method of the Historical Socrates, Plato's Socrates, and the Law School's Socrates," online at <<http://listserv.nd.edu/cgi-bin/wa?A2=ind0706&L=pod&O=D&P=14323>>. Post of 21 Jun 2007-0700 to AERA-J, AERA-L, AP-Physics, AP-Biology, ASSESS, Biopi-L, Biolab (rejected), Chemed-L, EdResMeth, EvalTalk, Phys-L, PhysLrnR, Physshare, POD, STLHE-L, and TIPS. This post will serve as the basis for Hake (2007f).

**157E.** Hake, R.R. 2007. "Can Scientific Research Enhance the Art of Teaching?" Greensboro AAPT meeting, invited paper DH02; abstract online at <<http://www.aapt.org/scheduler/SM2007/NameResult.cfm?Code=DH02>> ; paper online at <<http://www.physics.indiana.edu/~hake/EnhanceArt3.pdf>>.

**158E.** Hake, R.R. 2007. "How Will Bill Evers Interpret Kirschner, Sweller, & Clark?" online at <<http://listserv.nd.edu/cgi-bin/wa?A2=ind0703&L=pod&O=A&P=4786>>. Post of 8 Mar 2007 14:08:47-0800 to AERA-L, Dewey-L, PhysLrnR, POD, & SciListserv.

**159E.** Hake, R.R. 2007. "Cognitive Science and Physics Education Research: 'What we've got here is a failure to communicate'," submitted to the Physics Education Research Conference (PERC 2007), August, 2007, Greensboro, NC; abstract online as "CP-32" at <<http://web.phys.ksu.edu/perc2007/formats/contributed-posters.htm>>, article soon to be online at <<http://www.physics.indiana.edu/~hake/FailureCommunicate3.pdf>>.

- 160E.** Hake, R.R. 2007. “The Socratic Method of Arons, Vlastos, Plato, and the Law Schools,” *International Journal for the Scholarship of Teaching and Learning* <<http://www.georgiasouthern.edu/ijstol>>, online at <<http://www.physics.indiana.edu/~hake/SocraticArons3.pdf>>.
- 161E.** Hake, R.R. 2007. “Fourteen Lessons from the Physics Education Reform Effort,” *Latin American Journal of Physics Education*, online at <<http://www.physics.indiana.edu/~hake/14Lessons3.pdf>>.
- 162E.** Hake, R.R. 2007. “Education Articles (1979 – 2007),” online at <<http://www.physics.indiana.edu/~hake/EdArticles3.pdf>>.
- 163E.** Hake, R.R. 2007. “Education-related Discussion-List Posts (1998 – 2007),” online at <<http://www.physics.indiana.edu/~hake/Posts3.pdf>>.