SELF STUDY – 2005

DEPARTMENT OF PHYSICS
LAWRENCE UNIVERSITY

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EXECUTIVE SUMMARY

In an attempt to increase departmental vitality and visibility, the number of physics majors, and the level of professional activity, the Department of Physics at Lawrence University—perhaps without initially recognizing it—began in the mid 1980s to develop a foundation on which to base a coherent program of improvement. By the early 1990's, this endeavor had broadened considerably, and the Department began openly to declare its goal of becoming one of the premier small physics departments in the country. The conviction that our entire program, not just our courses, required attention guided our pursuit of this goal. Certainly, a comprehensive, well-taught spectrum of courses for majors and non-majors alike was critical, but we also needed to develop greater departmental distinctiveness, to recruit prospective majors, to expand faculty and faculty-student research, to arrange frequent departmental visitors, and to provide up-to-date facilities. In addition, recognizing that the personal is as important as the academic, we decided to create a departmental environment that supports and nurtures as well as challenges all students. That we have achieved some success is evidenced by the growth in the number of majors from an average of five per year in the 1980's to about ten per year currently, the growth of scholarship within the Department, the growth in faculty from three in the mid 1980's to five, and the substantial national recognition that our efforts have attracted. Along the way, we have learned that pursuing our goal requires a continuing, long-term, broadly based departmental commitment. We have come to appreciate that major improvements cannot be accomplished in a year or two by one or two members working alone and that the improvements should impact the entire departmental program, not just the curriculum and certainly not just a few courses.

Now, as Professors John Brandenberger and David Cook approach retirement, the Department faces new opportunities. The Department needs to balance a reasoned incorporation of new and bold plans with a thoughtful but critical preservation of what have come to be our distinctive features at present. We probably should capitalize at least in part on our substantial investments in computation and in laser and optical hardware, but we should not thoughtlessly clone the current ways in which we employ those resources. And we need to plan carefully to assure a smooth transition. In contemplating these matters, we need to re-evaluate what we mean by a strong and thriving department and re-examine our conception of the character and content of both curricular and extra-curricular components of such a program. The outside review for which this self study has been prepared is designed to stimulate and inform that process.

Lawrence University
Department of Physics
MISSION STATEMENT – 2005

The Department of Physics at Lawrence University strives to be one of the best undergraduate physics departments in the country. To that end, we teach physics and practice it. In teaching physics, we acquaint students with the fundamental principles, major accomplishments, current challenges, and contemporary tools of theoretical, experimental, and computational physics. Since physics comprises an important component of the liberal arts, we seek to communicate a coherent scientific world view to all members of the Lawrence community. In practicing physics, faculty members continually engage in scholarly activities that contribute new knowledge to the discipline, maintain our professional vitality, enrich the curriculum, and involve students in collaborative physics research.

More specifically, we help science students

- develop skills in applying physical principles and in working with the tools of physics;
- appreciate the underlying unity of physics;
- appreciate contemporary developments in physics and related interdisciplinary areas and become acquainted with the primary research literature;
- demonstrate a command of spoken and written English and understand the traditions of scientific discourse;
- pursue scientific studies professionally, effectively, and independently;
- become part of a vigorous, supportive, and stimulating local science community that introduces them to the global scientific enterprise.

The Department of Physics introduces the wider college community to the power and scope of the methods of physics through courses that explore contemporary topics in astronomy, in the nature of light, in the physics of musical instruments, in the analysis of energy problems, and other topics. Our goal is to have a majority of Lawrence students enroll in a physics course in their quest to become scientifically literate citizens. In addition to these departmental courses, we lend our scientific perspective to the Freshman Studies program on a regular basis.

The faculty will maintain a vital environment by pursuing research opportunities in selected areas of contemporary physics and by engaging in curricular development and pedagogical innovation. Wherever feasible, Lawrence students will collaborate in these efforts.

Our graduates will be well prepared

- for advanced study and careers in physics, other physical sciences and interdisciplinary areas, engineering, law, or medicine;
- for entry into a secondary school science teaching career;
- direct entry into research positions in industrial and government laboratories;
- for pursuit of careers for which the substantive knowledge and/or skills of a physicist are pertinent.

Finally, the Department of Physics enthusiastically commits to support and advance the larger educational aims of Lawrence University.

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1 Introduction

Perhaps unconsciously at the start twenty years ago but consciously and explicitly for the past fifteen years, the Department of Physics at Lawrence University has set its sights on becoming a premier small physics department. While opinions may vary as to what constitutes such a department, we believe that the distinguishing characteristics include excellent teaching, a reasonably comprehensive curriculum, faculty research that is recognized elsewhere, the presence of a critical mass of serious and able students actively learning physics and engaging in undergraduate research, significant impact on the host institution and elsewhere with outreach efforts, a departmental environment that engages and challenges majors and non-majors alike, and up-to-date facilities and equipment. Although good teaching and a strong curriculum are obviously essential, we have come over the years to place considerable emphasis on the notion that effecting a substantial elevation of a department—and in particular increasing the department's attractiveness to prospective majors—requires much more than tinkering with course offerings and more than a major overhaul of these offerings. On the basis of that realization, we have for some years been persuaded that raising a department to a new level requires paying attention to the *entire* departmental program, not just to the curriculum (i.e., the courses offered). We argue that building a program that attracts and retains majors requires that attention be given to

- Building and maintaining a number of distinctive specialties within the Department.
- Attracting, retaining, and supporting a professionally active and personally engaging faculty.
- Providing attractive and ample spaces for teaching and research.
- Assembling and maintaining a rich collection of up-to-date equipment for teaching and research.
- Building a curriculum that remains up-to-date and serves well all constituencies that depend on the Department.
- Recruiting strong majors actively, aggressively, and continuously.
- Supporting faculty and student research.
- Nurturing the extra-curriculum (advising, departmental colloquia, provision of student-owned spaces in the department, student/faculty and student/student social interactions, ...).
- Building library holdings.
- Raising funds continuously and aggressively.

In this self study, we describe the evolution of the physics program at Lawrence as it has come to incorporate these elements, present evidence that our efforts over the past decade and a half have achieved considerable success, enumerate several guidelines we have come to adopt over the years, and lay out our current vision for the next decade or so, including partial answers to a number of questions with which we are wrestling as we seek to extend that vision.

2 Signature Programs

The decision some years ago to give particular attention to building several distinctive areas of special focus has catalyzed the transformation of our department. We begin this self-study, therefore, with a description of what we have come to call *signature programs*. Currently, such programs in laser and computational physics are well established, a program in surface physics is in its beginning stages, and a program in plasma physics is anticipated in the future.

Historically, our efforts to improve our Department began modestly in the mid-1980's. At that time, Professors Brandenberger and Cook questioned the drawing power of our program. To address that concern, they decided to build several distinctive specialties within the Department, confidently expecting those developments to serve as vehicles to attract a larger number of good students. Professor Brandenberger started with a major effort to build a local specialty in laser physics. A year or so later, Professor Cook followed his lead with a similar effort to build a local specialty in computational physics. Importantly, we already had some local expertise in these areas. Even more important for the objective of attracting students, both areas were exciting and appealing to prospective students. Further, while both areas were still largely underrepresented in undergraduate physics nationally, we believed—correctly, as it has turned out—that each would come to be a critical component in undergraduate programs nationwide within a very few years.

To develop facilities, enhance our local expertise, and build curricular components that would bring these two specialties to a position of prominence in our Department, we sought outside support. We assured our sources of funding—mainly the NSF, the General Electric Foundation, the Pew Charitable Trust, the Keck Foundation, and the Sloan Foundation—that developments at Lawrence would be pace-setting and would be disseminated widely, thus extending the impact of our efforts beyond Lawrence. In short, we undertook to conduct *pilot* projects that, beyond stimulating the *local* environment, had the potential to help other institutions incorporate similar components in their own programs. Over the first few years, we secured roughly half a million dollars of outside money and gifts in kind. Together with support from Lawrence, these funds provided equipment, supported summertime developmental efforts involving faculty members and students, and allowed our two signature programs to move forward rapidly. The Lawrence Laser Physics Laboratory and the Lawrence Computational Physics Laboratory were created, and several curricular modifications were implemented. In keeping with the commitment to disseminate, Professors Brandenberger and Cook gave invited and contributed talks at national meetings and accepted invitations to give colloquia at a number of colleges and universities. Further, each convened a small ($\approx$ 20 participants) Sloan-supported conference at Lawrence. Both conferences produced reports and proceedings that were distributed *gratis* to all undergraduate physics departments nationwide. These efforts began to identify us as innovators in undergraduate physics instruction. Even more, they fostered a heightened sense of local pride, and they left us with specialized facilities that, with regular updating over the years, remain largely unmatched in other institutions, including large ones.

Somewhere along the line, we began to refer to these special areas of focus within the Department as *signature programs*, a notion that has proven to be difficult to define. Even though we have long attributed departmental vitality and improvement to the stimulation provided by these programs, many on our home campus still don't understand this notion. Here, however, is what we say by way of an attempt at a definition: Unique and innovative, *signature programs* are showcase teaching endeavors that focus on contemporary topics and are taught in especially well-equipped laboratories. Because of their pedagogic dimensions, they are not identical to faculty research, but they are related to that research, and many components of these programs emerge from that research. Signature programs affect the total departmental program in several ways: they generate specialty courses that lend distinctiveness and identity to the department; they intensify student/student and student/faculty interaction; they increase departmental pride; they support a variety of student projects; they increase the spectrum of up-to-date equipment available for teaching and for student projects; and—most important for the long range future of the Department—they serve as a staging area for active student recruitment. *We do not hesitate to contend that these programs have been the single most important component of our overall activities of the past twenty years as we have worked towards becoming a premier undergraduate physics department.*

3 Faculty and Support Staff

The Department of Physics at Lawrence University is staffed by five Ph.D. physicists, each of whom is described briefly in this section. Detailed *curricula vitae* are included in Appendix A. Professors Brandenberger, Collett, Cook, and Stoneking are in tenured positions; Professor Dunn is in a continuing position whose occupant changes every two or three years, a position that was added in 1996 and is further discussed in Section 7. Collectively, we have particular expertise in laser and atomic physics, surface physics, computational physics, plasma physics, and cosmology. Hence, we offer our students about as varied a menu of special areas as possible in a department of our size.

In addition, an electronics technician devotes 60% of his time to supporting physics, we share an eight-hour per week machinist with the other science departments, and we share two full-time secretaries (and several student helpers) with the 40 or so faculty members in the natural and social sciences.

Alice G. Chapman Professor of Physics **John R. Brandenberger**, whose *curriculum vitae* appears in Appendix A.1, holds degrees from Carleton College and Brown University. He joined the Lawrence faculty in 1968. His interests lie in atomic physics, modern optics, and laser spectroscopy. He has played a leading role in the development of our advanced laboratory program. His efforts in teaching stem largely from his research involvement in quantum-beat, saturated absorption and time-resolved fluorescence spectroscopy. Much of his research efforts have been pursued with undergraduates at Lawrence, where he has conducted research in atomic physics and laser spectroscopy for over thirty years. His recent efforts in teaching have focused on the accumulation of $500K of research-grade laser and spectroscopic equipment as described in Appendix C.1. Since joining the Lawrence faculty, he has spent sabbaticals at Harvard, Oxford, Reading, and MIT. His research and pedagogical activities, his chairing of the Physics/Astronomy Division of the Council on Undergraduate Research, and his service on the steering, educational, and prize committees of the Division of Laser Science of the American Physical Society led to requests for the refereeing of manuscripts, the reviewing of proposals, the appearance on panels, invitations to small conferences, the planning of national meetings, and the reviewing of and consulting to undergraduate physics departments. His mounting of a Sloan-supported conference in

1987 prompted the NSF to recommend that he offer faculty enhancement workshops on lasers in 1989 and 1991. In 1990, he received Fulbright support to visit the Institute of Electronic Structure and Lasers in Crete. Starting in 1994, he directed Lawrence's five-year departmental development program supported by Research Corporation. In 1999, he was elected a fellow of the American Physical Society.

Associate Professor of Physics **Jeffrey A. Collett**, whose *curriculum vitae* appears in Appendix A.2, holds degrees from St. Olaf College and Harvard University. He joined the Lawrence faculty in 1995. His interests lie in solid state physics, especially properties of liquid crystal films, surfaces and interfaces. A councilor on the Council on Undergraduate Research (CUR) since 1999 and chair of CUR's Physics/Astronomy Division in 2001–03, Professor Collett uses x-ray diffraction to study phase transitions in liquid crystals. Since joining Lawrence, he has maintained an active research program that has been supported by Research Corporation and the Petroleum Research fund and that has produced four presentations by students at the APS March Meeting (two oral presentations, two posters) as well as a major Physical Review E publication with a student coauthor. These research projects all have involved x-ray scattering from freely suspended smectic liquid crystal films using an x-ray diffractometer with an area detector. He and his students have used the Computational Physics Laboratory to develop a software application in IDL that produces three-dimensional maps of x-ray scattering structure factors in reciprocal space by combining the data from hundreds of area detector exposures. These reciprocal space maps are a powerful teaching tool as well as a productive research tool for understanding the relationship between structure and scattering. The liquid crystal work has given Professor Collett experience with the effects of the liquid crystal to air interface on structure. His postdoctoral experience at IBM involved x-ray structural studies of thin layers on crystalline surfaces. The signature laboratory theme of surface physics involving scanning probe microscopy incorporates an important new experimental technique that complements the existing x-ray and optical experiments on liquid crystals and broadens the range of condensed matter physics that the laboratory can address.

Professor of Physics, Philetus E. Sawyer Professor of Science, and current chair of the Department of Physics **David M. Cook**, whose *curriculum vitae* appears in Appendix A.3, holds degrees from Rensselaer Polytechnic Institute and Harvard University. He joined the Lawrence faculty in 1965. His interests lie in mathematical physics, computational physics, uses of computers in the upper-division physics curriculum, and musical acoustics. Professor Cook has played a leading role in the development of the computational components of our curriculum. Indeed, he has used computers in instruction and in research ever since he joined the Lawrence faculty. On his first sabbatical in 1971–72, he was an NSF Faculty Fellow at Dartmouth College, where he studied how Dartmouth physicists were incorporating time-shared computing—then a new idea—into their curriculum. Until the creation of a math-computer science major in the mid 1980s, he nurtured computer usage and contributed to the computer studies curriculum at Lawrence. He is the author of *The Theory of the Electromagnetic Field* (Prentice-Hall, 1975), one of the first intermediate-level physics texts to include treatment of numerical approaches to field plotting and trajectory problems—a book that was republished in 2003 by Dover Publications. In the period 1978–81, he directed a faculty development project supported by the NSF CAUSE program and designed to expand computer skills in the Lawrence faculty. Since 1988, he has been the director of the Lawrence Computational Physics Laboratory and of the signature program described in Appendix C.2. In 1990 (*before* the present burgeoning of interest in using computational resources in upper-level physics), Professor Cook organized a Sloan-supported conference that brought twenty active teacher/scholars to Lawrence, and he contributed to, edited, and published the proceedings of that conference. He served as associate editor of *Computers in Physics* from 1994 to 1998, and he served a three-year term (1991–94) as an elected member of the Committee on Computers in Physics Education of the American Association of Physics Teachers. In February, 2000, he received a $177K NSF grant to support the assembling of the extensive instructional materials developed at Lawrence into a textbook titled *Computation and Problem Solving in Undergraduate Physics*, a book whose writing, which began in the late 1980s, has been assisted by 24 different Lawrence students, most of them in full-time summer research appointments. As part of the evaluation of that project, Professor Cook conducted faculty workshops in the summers of 2001, 2002, and 2003. A total of 70 faculty members from around the country came to Lawrence for an intensive week of exposure to the Lawrence approach to introducing physics majors to computational resources. The book runs to over 900 pages and is completed but, because of requirements of fairly microscopic customizability, has not yet found a commercial publisher. Instead, Professor Cook is self-publishing the book, which has attracted requests for examination copies from 43 individuals and has through the 2004–05 academic year been used for courses at 14 institutions.

Associate Professor of Physics **Matthew R. Stoneking**, whose *curriculum vitae* appears in Appendix A.4, holds degrees from Carleton College and the University of Wisconsin–Madison. He joined the Lawrence faculty in 1997. His interests lie in plasma physics, especially the behavior of non-neutral plasmas. Professor Stoneking's research on trapping of pure electron plasmas in a toroidal magnetic field has been supported by grants from Research Corporation and the U.S. Department of Energy, and is currently supported by a grant from the National Science Foundation. Nine undergraduate students have participated in Professor Stoneking's research project since its inception in 1997. Students made seven poster presentations at APS (Division of Plasma Physics) meetings and coauthored two peer-reviewed publications (*Physics of Plasmas* and *Physical Review Letters*), and two conference proceedings papers. Professor Stoneking is a frequent reviewer for *Physics of Plasmas*, and an occasional reviewer for *Nuclear Fusion* and of proposals to the National Science Foundation and the U.S. Department of Energy.

Assistant Professor of Physics **James O. Dunn**, whose *curriculum vitae* appears in Appendix A.5, holds degrees from the University of Illinois and the University of North Carolina. He joined the Lawrence faculty in 2004. His interests lie in cosmology, especially dark energy. Most of his work has involved studying the properties of dark energy using the cosmic microwave background anisotropy and type Ia supernovae. He has also done work on the origin of ultra-high energy cosmic rays. Previously, he was a visiting assistant professor at Hampden-Sydney College in Virginia.

4 Facilities/Major Equipment/Budget/Grants

Major efforts at building a department cannot, of course, be successful without appropriate funding. Over the years, the Department has enjoyed working with a supportive administration, which has encouraged our several efforts and has regularly provided an annual budget—currently $31.5K—to support routine expenses for supplies, equipment, maintenance of our computational facilities, entertainment of guests, etc. In addition, as shown

1987+	$300K	Many	JRB	Lasers/optics
1987	$24K	Sloan	JRB	Laser conference
1988	$200K	Keck	DMC	Computation lab
1988	$50K	NSF-ILI	DMC	Computation lab
1989	$24K	Sloan	DMC	Computation conference
1990	$30K	NSF-ILI	JEG	Workshop physics
1992	$250K	Keck	DMC	Comp/Adv labs
1992	$50K	NSF-ILI	DMC	Computation lab
1992	$3K	Cryst Pnt	JRB	Summer assistant
1993	$3K	Cryst Pnt	JRB	Summer assistant
1994	$60K	Siemens	SML	Piece of XRD
1994	$37K	Perk-Elm	SML	DSC
1994	$40K	RC	SML	Research
1995	$46K	NSF-ROA	JRB	Sabbatical support at MIT
1995	$300K	RC	JRB	Dept Dev Grant
1995	$80K	NSF-ILI	SML *et al.*	SEM
1995	$20K	PRF	SML	Research
1995	$5K	Exxon	JAC	Research
1995	$3K	LSTG/APS	JRB	Summer assistant
1996	$37K	RC	JAC	Research
1996	$20K	PRF	JAC	Research
1997	$19K	NSF-ILI	DMC	Physics of Music
1998	$37K	RC	MRS	Research
1998	$225K	DOE	MRS	Research
2000	$177K	NSF-CCLI	DMC	Publish book
2002	$400K	Keck	DMC,JRB,JAC	Signature programs
2003	$4K	NSF-CCLI	DMC	Supplement to 2000 grant
2003	$178K	NSF	MRS	Research
2003	$100K	NSF-NUE	JAC/KRN/DH	Nanoscience initiative
	$2722K			

Table 1: Grants Received. Contributions made by Lawrence University to these activities have amounted to an additional $600K in the time period covered above.

in Table 1, we have over the years been fortunate to receive substantial outside support (amounting to over $2.7M since 1987) both for curricular development and for research. Administrative support of these funding ventures is evidenced in the $600K or so beyond our regular budget that has been provided in the form of matching or other institutional commitments to departmental activities in funded proposals. Substantial grants have been received from the W. M. Keck Foundation, the National Science Foundation, the Department of Energy, Research Corporation, the Sloan Foundation, the Pew Charitable Trusts, the General Electric Foundation, Lawrence University, and other sources. Smaller grants or grants in kind have also been received from various corporations and foundations and from the American Physical Society. Broadly, we espouse the importance and discipline of having one or two proposals pending all the time, though we don't always live up to that stated objective.

In the fall of 2001, the Department of Physics moved into renovated and substantially expanded spaces, mostly in Youngchild Hall of Science ($\approx$ 13000 ft^2) but also partly in New Science Building ($\approx$ 4000 ft^2). In the new configuration, each of the four tenured faculty members has an office, ample space for a signature laboratory, and a research laboratory. These four offices, a fifth office for our short-term faculty appointee, a sixth office for use by an emeritus faculty member, a student commons room, an office/workshop for the department's electronics technician, and storage area for electronic components are located in close proximity to the faculty offices. A 24-seat classroom, 8-station introductory laboratory, advanced laboratory, 10-station electronics laboratory (which also provides overflow space for the introductory laboratory in two of our three terms), modest storage spaces near to some of these laboratories, and three rooms that can accommodate a total of about ten student projects complete the departmental spaces. Finally, we have first claim on the use of a 196-seat lecture hall which, technically, is shared with the entire campus but most often with geology, chemistry, and biology. A floor plan of departmental spaces is presented in Appendix B.

Three of the four available signature laboratories are already active. The Laser Physics Laboratory, described more fully in Appendix C.1, and the Computational Physics Laboratory, described more fully in Appendix C.2, have been in existence for nearly two decades. The Surface Physics Laboratory, described in Appendix C.3, was started in 2002. A Plasma Physics Signature Laboratory is anticipated in the next five to ten years.

We are fortunate to have a well equipped machine shop (two lathes, two overhead mills, band saws, equipment for working with sheet metal, drill press, numerous hand tools, good stock of materials and fasteners, etc.).

Finally, we are also fortunate to have a wide spectrum of up-to-date equipment. A list of the major equipment currently available to faculty and students at Lawrence is presented in Appendix D. Our holdings include laser, x-ray, and computational facilities; general-purpose electronic instrumentation (test instruments, meters, signal generators, frequency counters); multichannel analysers; nuclear modules; laboratory computers; optical benches; research grade lock-in amplifiers; lasers; oscilloscopes; spectrometers; light intensity meters; telescopes; scanning tunneling microscopes, and atomic force microscopes. Much of this equipment was acquired with support from one or another grant for signature programs; some has been acquired through research grants; and Lawrence on its own has been generous both with a regular budget and with matching funds for NSF and other grants. Some equipment has been acquired as gifts in kind from various vendors, and some has come our way in consequence of keeping a careful eye on offerings of government surplus programs.

5 Curriculum

5.1 Courses Offered

The physics curriculum at Lawrence offers courses in a variety of different categories in an attempt to serve several constituencies. Throughout our curriculum, the Department emphasizes that students develop fully-documented problem solutions, keep careful laboratory records, give oral presentations (of problem solutions, end-of-term projects, and capstone projects) and write formal papers. Thus, we make sure that majors and non-majors alike hone their skills in oral and written communication of scientific results even as they are learning the substance of the discipline.

In the following listing and grouping of courses offered by the Department, we include titles, course numbers, frequency of offering, typical enrollments, typical instructor, recent text used, etc. Detailed course descriptions can be found in the *Lawrence Course Catalog*, which accompanies this self-study. More microscopic year-by-year patterns of enrollment are contained in Appendix E. Syllabi for recent offerings are compiled in a separate binder. Presently, we offer

- Outreach courses for students wishing to fulfill the general science requirement:

    - *Light! More Light!* (Physics 103, Brandenberger),
    - *Physics of Music* (Physics 107, Cook),
    - *Astronomy* (Physics 110, Collett or Stoneking), and
    - *Aspects of Physics* (Physics 115, staff), offered with a variety of topics (e.g., Energy and the Environment, Relativity, ...).

  In the past, only *Light! More Light!* fulfilled the *laboratory* science requirement for graduation. Starting with its offering in 1997–98, *Physics of Music* also fulfilled that requirement. *Astronomy* is offered (almost) every year, and *Physics of Music* is offered every other year; the remaining outreach courses are offered on an irregular schedule.

Text	Physics 103: Feynman, *QED* and Davies and Brown, ed., *The Ghost in the Atom* Physics 107: Rossing, *The Science of Sound* Physics 110: Chaisson and McMillan, *Astronomy Today*
Frequency	two outreach courses per year
Enrollment	10–50 per course
Teaching Units[1]	2–4

- A two-term, terminal, algebra-based introductory course in classical and modern physics with laboratory:[2]

    - *Fundamentals of Physics I* (Physics 120, staff) and
    - *Fundamentals of Physics II* (Physics 130, staff).

  This course draws its enrollment mostly from students in biology and chemistry, particularly from those anticipating careers in medicine. Since it has no prerequisites in physics or mathematics beyond what Lawrence expects of entering freshmen, the course is accessible to most students and can be taken in fulfillment of the general education requirements.

[1] Meeting a lecture course three times a week for a term constitutes one teaching unit; meeting two three-hour laboratory sections each week for a term constitutes one unit as well. Teaching units indicated are those allocated when the department is fully staffed at 5 FTE. Lawrence faculty members are eligible for full-year sabbaticals at 70% pay after six years of full-time teaching, though the sabbatical can be taken entirely in a single year or taken one term in each of three years (at 90% pay in each of those years). Tenure-track faculty members are eligible for one term of sabbatical after reappointment, which occurs at the end of year three of service.

[2] Prior to the introduction of this two-term course in 1995–96, the role it now plays was filled by the combination of the predecessor to Physics 120 and the predecessor to Physics 160 (see next item).

Text	Giancoli, *Physics*
Frequency	annually, with three (Physics 120) or two (Physics 130) laboratory sections each term
Enrollment	≈ 40 in Physics 120; ≈ 25 in Physics 130
Teaching Units	4.5

- A two-term calculus-based introductory course in classical and modern physics with laboratory:

  - *Principles of Classical Physics* (Physics 150, staff) and
  - *Principles of Modern Physics* (Physics 160, staff).

  This course draws its enrollment mostly from freshmen contemplating a major in physics but is also taken by chemistry and mathematics majors and by students planning transfer to an engineering school under our three-two engineering program. The entry point into a major in physics, this course is offered in the winter and spring terms so that freshman can take one term of calculus *before* enrolling in Physics 150; the course therefore lists calculus as a *pre*requisite, not a corequisite, and it can start at a somewhat higher level and move a bit more rapidly than a more conventional freshman course. Because of that positioning, because of its rapid pace, and because of the particular importance of its laboratory to later physics courses, only occasionally will an entering freshman be placed beyond Physics 150. Very rarely will an entering student be placed beyond Physics 160.

Text	Physics 150: Young and Freedman, *University Physics* Physics 160: Tipler, *Elementary Modern Physics*
Frequency	annually, with three laboratory sections each term
Enrollment	≈ 35–45 per course
Teaching Units	5

- A spectrum of courses in the central areas of theoretical and experimental physics:

  - *Electronics* (Physics 220, Brandenberger),
  - *Computational Mechanics*[3] (Physics 225, Cook),
  - *Intermediate Electromagnetic Theory* (Physics 230, Stoneking, Dunn),
  - *Quantum Mechanics* (Physics 310, Cook or Brandenberger), and
  - *Advanced Laboratory* (Physics 330, Brandenberger, Collett, or Stoneking).

  These five courses are required for the major, and some of them are occasionally elected by students in other departments, particularly by chemistry and mathematics majors. Two (*Electronics* and *Advanced Laboratory*) are essentially experimental; three (*Computational Mechanics*, *Intermediate Electromagnetic Theory*, and *Intermediate Quantum Mechanics*) are theoretical. Beyond the introductory courses, all laboratories are separate courses; the theoretical courses have no attached laboratory. In the aggregate, these five courses constitute the core of the physics major and provide intermediate-level exposure to most of the important theoretical principles, to

[3] *Computational Mechanics* was introduced in 2002–03 and replaced both a long-standing required course in classical mechanics and an elective course titled *Computational Tools in Physics*. In the new course, some of the computational topics treated in "Comp Tools" were combined with some of the topics in the mechanics course, thereby creating *required* exposure to our computational resources. The topics removed from the mechanics course, mainly Lagrangian mechanics and rigid body dynamics, are now covered in the junior-senior elective course *Advanced Mechanics*.

numerous experimental techniques, and to computational approaches alongside traditional analytic approaches. So that students can work individually, have extended, uncontested access to the apparatus for each experiment, and have adequate attention from the instructor, Physics 330 is offered twice each year, with half the junior class enrolling in each offering. With the exception of Physics 220, these courses list *Calculus I, II, III* and *Differential Equations and Linear Algebra* (Mathematics 140, 150, 160, and 210) as prerequisites.

Text	Physics 220: Horowitz and Hill, *The Art of Electronics* Physics 225: Cook, *Notes for Computational Mechanics* (comparable to Barger and Olson) and Cook, *Computation and Problem Solving in Undergraduate Physics* Physics 230: Griffiths , *Introduction to Electrodynamics* Physics 310: Griffiths, *Introduction to Quantum Mechanics* Physics 330: Mellisinos and Napolitano, *Experiments in Modern Physics*
Frequency	annually
Enrollment	10–15 per course
Teaching Units	6.5

- An assortment of elective upper-level courses:

  - *Thermal Physics* (Physics 320, Brandenberger or Collett),
  - *Optics* (Physics 340, Brandenberger or Collett),
  - *Advanced Mechanics* (Physics 410, Dunn),
  - *Advanced Electromagnetic Theory* (Physics 430, Collett or Cook),
  - *Mathematical Methods of Physics* (Physics 440, Cook),
  - *Advanced Modern Physics* (Physics 460, Brandenberger),
  - *Special Topics in Physics* (Physics 500), whose topics in recent years have included heavy ion physics, high energy physics, and elementary particles,
  - *Plasma Physics* (Physics 520, Stoneking),
  - *Solid State Physics* (Physics 530, Collett),
  - *Computational Physics* (Physics 540, Cook), and
  - *Laser Physics* (Physics 550, Brandenberger).

Courses numbered in the 300s and 400s are offered every other year; those numbered in the 500s are offered every two or three years. All are accessible to both junior and senior majors. One of these courses (Physics 320) provides for study of a central area that we simply can't offer annually; three (Physics 410, 430, and 460) provide for a second term of study of important theoretical subdisciplines; and the rest offer students a spectrum of opportunities in areas that are less central to the discipline but are important either to a faculty member's special interests or to some areas that students might want to pursue in graduate school. In particular, they provide contexts in which students are able to see the breadth of applicability of the more general principles discussed in the required courses.

Text	Physics 320: Kittel and Kroemer, *Thermal Physics* Physics 340: Hecht, *Optics* Physics 410: Marion and Thorndike, *Classical Dynamics of Particles and Systems* Physics 430: Griffiths, *Introduction to Electrodynamics* Physics 440: Arfken and Weber, *Mathematical Methods for Physicists* Physics 460: Leighton, *Principles of Modern Physics* Physics 520: Chen, *Introduction to Plasma Physics and Controlled Fusion* Physics 530: Kittel, *Introduction to Solid State Physics* Physics 540: Cook, *Computation and Problem Solving in Undergraduate Physics* Physics 550: Svelto and Hanna, *Principles of Lasers*
Frequency	bi-annually or irregularly
Enrollment	8–18 per course
Teaching Units	5–3

- Opportunities for tutorials in areas of particular interest to one or more students (Physics 190, 390, 590, 690, staff) and for independent studies and capstone projects (Physics 199, 399, 599, 699, staff). These one-on-one opportunities are available at several levels and, occasionally, low-level tutorials will be elected by non-majors.

Frequency	annually
Enrollment	4–6 per faculty member per year
Teaching Units	5 (for capstone supervision)

- Freshman Studies (staff).

Frequency	two sections per year
Enrollment	15–17 students per section
Teaching Units	2

In summary, the Department annually allocates its 30 teaching units[4] as shown in Table 2 and distributes its offerings over the three terms[5] of Lawrence's academic year as shown in Table 3. From yet another perspective, each faculty member teaches six courses a year, typically Freshman Studies or an outreach course (1 unit); one term of an introductory course (1 unit), two sections of an introductory laboratory (1 unit), a course in the core curriculum (1 unit), and one of the elective advanced courses (1 unit). In addition, since a 1994 Departmental Development Grant from Research Corporation, each faculty member receives 1 unit of capstone credit, which recognizes time spent in supervising tutorials and independent studies as well as time spent attending to some of the non-curricular elements of our overall program.

Several features of the Lawrence curricular arrangement, many of them depending critically on our three-term calendar, are worth highlighting. In particular,

- The curriculum for majors is a three-level curriculum. The introductory course (Physics 150–160) is brief but sophisticated and covers both classical and modern

[4] 5 faculty members × 6 teaching units per faculty member per year

[5] Our entire program—curricular and extra-curricular—is structured within a three-term calendar. In each ten-week term, full-time students take three courses. Class periods are 70 minutes long, and—officially—courses at Lawrence are declared to be equivalent to 3-1/3 semester hour courses, though—unofficially—laboratory courses are more closely equivalent to 4-semester hour courses.

Group	Teaching Units	% Load	Enrollment	% Enrollment
Outreach	2.0–4.0	≈ 7–14%	55	≈ 16%
Intro algebra-based	4.5	≈ 15%	65	≈ 19%
Intro calculus-based	5.0	≈ 16%	75	≈ 22%
Required core	6.5	≈ 22%	65	≈ 19%
Adv electives/Tutorials	5.0–3.0	≈ 17-10%	50	≈ 15%
Capstone offerings	5.0	≈ 16%	10	≈ 3%
Freshman Studies	2.0	≈ 7%	20	≈ 6%
TOTAL	30		340	

Table 2: Annual allocation of teaching units. Because we do not have on-campus programs in such areas as engineering, secondary or elementary education, and nursing, we do not devote an enormous fraction of our teaching capacity to service courses. Our service obligations are focused on offerings that attract pre-medical students, majors in other sciences, and students choosing to satisfy Lawrence's general education requirement in science with a course in physics.

	Term I	Term II	Term III
Outreach	[2–1]		[1–2$\frac{1}{2}$]
Intro	[2$\frac{1}{2}$] Physics 120	[2] Physics 130 [2$\frac{1}{2}$] Physics 150	[2$\frac{1}{2}$] Physics 160
Core	[1$\frac{1}{2}$] Electronics [1] Quantum Mechanics	[1] Comp Mech [1] Advanced Lab	[1] Int E and M [1] Advanced Lab
Electives	[0–1] Adv Course	[2] Adv Course	[2] Adv Course
Capstone	[2-3]	[1]	[2–1]
Fr Studies	[1]	[1]	
	[10]	[10$\frac{1}{2}$]	[9–9$\frac{1}{2}$]

Table 3: Normal distribution of courses over the three terms of the academic year. Numbers in square brackets are allocated teaching units.

physics. Chemistry and biology majors who elect this course therefore in *two* terms are introduced to the contemporary topics that are the subject of the typical *third* course on a semester calendar with a two-level curriculum.

- The introductory survey for majors is over by the end of the freshman year, permitting an intermediate level pass through subareas of physics to begin in the fall of the sophomore year, by which time the students mathematical background is ready for intermediate level treatments.

- The core of the major is completed in December of the junior year, which means that
  - majors have *five* terms in which to pursue a variety of electives,

- majors are especially well prepared for significant summer research projects in the summer after their junior year,
- majors are especially well prepared for significant senior capstone projects, whether they be theoretically or experimentally or computationally inclined,
- we can make effective use of alternate year junior/senior offerings to expand the options beyond what would be possible if we were obliged to offer everything every year, and
- we can structure a curriculum in which majors can clear one term (winter or spring of the junior year) of courses required for the major and can therefore participate in valuable off-campus/international programs for a term without jeopardizing progress in the major.

While the Department does not give interdisciplinary activities first priority, we do participate in the interdisciplinary major in the sciences and we support students in other disciplines like chemistry, whose majors must take a calculus-based physics course, we provide the required physics course for students—physics majors or majors in other disciplines—who elect to pursue a 3–2 or 4–2 engineering option, and we support premedical students who need a physics course as part of their preparation for medical school. Occasional students in chemistry and mathematics elect courses in physics beyond the introductory courses. In recent years, we have offered a course in energy and the environment, which is cross-listed as an option within the Lawrence-offered major in environmental studies, and Professor Collett contributes expertise and occasional classes and laboratory exercises to an emerging program in nanoscience. In 2004–05, for example, Professor Collett contributed two and a half weeks of classes to the team teaching of a course in nanoscience based in the Department of Chemistry.

We readily admit that our program of course offerings and our expectations for our majors are quite traditional. Certainly, we are conscious of physics education research. In the late 1980s, Professor John Gastineau, a Lawrence physics graduate who was at that time a member of our faculty, guided the introduction of some components of Priscilla Laws' workshop physics into our introductory laboratory program, and computers have played an appropriate supporting role in those laboratories for 15–18 years. Further, we have adopted efforts (*a la* Eric Mazur and others) to increase student participation in lecture courses. But we can't claim to be leading the way in any of those developments, or to be particularly innovative in course design or teaching styles. Nor have we—we would firmly argue—changed the nature of our expectations for majors.

5.2 Typical Student Program

The program of courses typically undertaken by a student pursuing a minimum major in physics is shown in Table 4. Seven to ten of the twenty—the Capstone experience is not required—electives will be spent satisfying institutional distribution requirements; the remaining 13–10 of the electives are completely free. In particular, students anticipating graduate studies in physics or related areas will regularly take two or three more than the minimum number of courses for a major indicated in this program. Two further observations:

- We will usually respond favorably to petitions from a physics major to substitute one

	Term I	Term II	Term III
Fresh	FS	FS	*Elective*
	Elective	Intro Phys (Classical)	Intro Phys (Modern)
	Calc I	Calc II	Calc III
Soph	Electronics	Computational Mechanics	E and M
	Diff Eq/Lin Alg	*Elective*	*Elective*
	Elective	*Elective*	*Elective*
Junior	Quantum	Phys Elective	Adv Lab
	Elective	*Elective*	Phys Elective
	Elective	*Elective*	*Elective*
Senior	Capstone	Phys Elective	*Elective*
	Elective	*Elective*	*Elective*
	Elective	*Elective*	*Elective*

Table 4: Typical program of minimum physics major.

or two advanced courses in other areas for one or two of the required physics electives, if the student can persuade us that the resulting program is more appropriate for whatever the student plans to do after graduation.

- A few years ago, we introduced a minor in physics, which consists of a total of four courses in physics beyond the calculus-based introductory course, including *Computational Mechanics* and three additional courses, at least two of which must be chosen from *Electronics*, *Intermediate Electricity and Magnetism*, and *Quantum Mechanics* and no more than one of which can be an outreach course. Mathematics through the course in ordinary differential equations and linear algebra is also required.

6 Recruiting Workshops

The creation of signature programs in laser physics and computational physics was invigorating for the Department, but that activity was only a first step. By 1987, we felt these programs were sufficiently developed to begin helping us attract students. In 1987, we held two weekend workshops for high school seniors from around the country—students with strong interests in physics. These workshops have continued annually to the present day. Our Office of Admissions handles all of the paperwork and mailings, and underwrites all costs ($15–18K), including travel by air for attendees who live further than comfortable driving distance from Appleton.[6] In the first decade or so, several thousand descriptive flyers were sent out to students on our mailing lists, to high school physics teachers and

[6] Full coverage of air fares stopped for the workshop in the winter of 2004, being replaced by a policy of reimbursing half of the air fare up to a maximum of $250. The new policy is consistent with policies already in place for other kinds of activities (e.g., scholarship competition) that bring prospective students to campus.

guidance counselors, and others. More recently, the number of pieces mailed has been reduced. For the workshop in 2005, for example, 1053 flyers were mailed to prospectives who had inquired about Lawrence, 646 pieces were mailed to promising prospectives who had not (yet) inquired about Lawrence, 2025 pieces were mailed to high school physics teachers, and guidance counselors were left out of the mailings altogether. To apply for the workshop, interested participants must complete a regular application to Lawrence University, so the workshops directly help generate applications for admission to Lawrence. Typically, we will have 35–70 applicants from all over the country. From 1987 to 1996, inclusive, we offered two workshops with 20 participants each; more recently we have offered a single workshop with 20–30 participants. Participants

- arrive on a Friday in late February or early March,
- join us for a get-acquainted dinner and open house Friday evening, at which the main event is a series of introductions and a tour of the Department,
- engage on Saturday in a full day of a rapidly paced round-robin in which pairs of participants circulate through ten or a dozen activities,[7]
- join our majors for a social evening on Saturday, and
- return home on Sunday.

Housing for the weekend is provided in our residence halls, and participants are guests of current physics majors.

These annual weekend-long workshops play a critical role in the total physics program at Lawrence. They increase our applicant pool; each year, they expose 20–30 strong applicants to the *academic* environment at Lawrence; and they prompt many prospective students from 50 states and beyond to consider Lawrence as an attractive place to study physics. For maximum immediate payoff, they are timed not so much to attract new applicants as to induce seriously interested applicants to choose Lawrence as their college. Roughly 30% of the workshop attendees matriculate. And, as a second benefit, these workshops provide an opportunity for us to involve current majors as laboratory assistants. *These workshops, which are now a well established annual activity, have transformed our Department.* Our Director of Admissions has even been known to claim that, dollar for dollar, their annual cost represents a more productive spending of his dollars than almost any other recruiting activity that his office undertakes.

While these workshops constitute our most substantial effort at recruiting majors, we also regularly

- meet with visiting prospectives in our offices,
- call or email prospectives at the request of admissions officers, and
- make presentations about our department at half a dozen Admission Office Visit Days each year (and join the visitors for lunch).

In addition, under the supervision of officers of admission, physics majors call applicants interested in physics to offer information and insight about our program.

[7] Laser spectroscopy, laser beam characteristics, polarization of light, hologram, speed of light, atomic spectroscopy, computational chaos, x-ray diffraction, plasma confinement, imaging with scanning tunneling microscopes, ...

7 Faculty and Student Research

By early 1990's, we had experienced some success in attracting more strong students; we had two signature programs in place; and we had achieved a number of curricular improvements reflecting the impact not only of these signature programs but also of a separate project that modernized and brought some aspects of Workshop Physics to our introductory laboratories. Furthermore (and more significantly), by this time our initial *modest* goal of developing signature programs had grown to the much more grandiose and all-encompassing objective of becoming one of the premier small undergraduate physics departments in the country. We envisioned a department that would provide students with strong backgrounds in theoretical, experimental, and computational physics and that endorsed a significant capstone activity in the senior year. We endorsed individually the shared ethic that each tenured and tenure-track faculty member would establish and maintain an ambitious, continuously active program of scholarly research that would complement and supplement our pedagogical efforts and that each tenured faculty member would also create a signature program that would generate additional identity for the Department, strengthen our capacity to recruit students, and provide the facilities and expertise for the offering of special elective courses at the junior/senior level.

As that vision emerged, we also realized that curricular development had dominated our activities in the 1980's and early 1990's. Except for our outreach offerings, which were still limited (and since have been expanded), we concluded that—at least temporarily—we should set aside further efforts on the curricular front and focus on other elements of our program, especially on faculty and faculty/student research and the requisite infrastructure. To be sure, undergraduate research had existed at Lawrence for decades, but we judged its breadth and depth in the early 1990's to be insufficient for an outstanding small physics department. Hence, with encouragement from Research Corporation, we developed a five-year plan of departmental development designed to produce substantial improvement in many dimensions of our program. This plan included some curricular development, especially for non-majors, but focused more strongly on such elements of infrastructure as library holdings, departmental colloquia, machine-shop improvement, and expansion of departmental spaces and, most importantly, on the expanded research that that infrastructure would enable. We envisioned four separate research programs on campus,[8] and we wanted to increase both the productivity of and the student involvement in this research. Our proposal for a five-year Departmental Development Grant from Research Corporation was funded in late 1994.

One key element in the funded plan was the hiring of a Laboratory Supervisor whose teaching of introductory laboratories released approximately 1 FTE of time for our four tenured and tenure-track faculty members to devote to matters other than classroom teaching. One such other matter was to create a *capstone program* in which seniors, with substantial faculty assistance, would pursue ambitious and integrative undertakings that usually assume the form of undergraduate research projects. Other improvements in our program included substantially heightened research activities during both the summer and the academic year, and a greater number of summer research opportunities for our students.

The enhancements identified in the previous paragraph would not have been possi-

[8] At the time this Research Corporation proposal was written, our faculty had four full-time tenured or tenure-track faculty members. The fifth position was added as a component of this proposal.

ble without the expansion in teaching staff from 4 FTE to 5 FTE. The added (fifth) position is a continuing, non-tenured position to be held for periods of two or three years by a single individual before a new appointee is sought. Initially, the position was titled "Supervisor of Laboratories", and the physicist appointed was to have at least a masters degree in physics and would teach only introductory laboratories. While the first appointee conformed to that conception, we quickly found difficulties with that assignment. The second person in that position began as "Laboratory Supervisor" but, in fact, held the Ph.D. degree. In that person's second year, we expanded the teaching assignment, redistributed the introductory laboratories over the entire departmental faculty, and changed the title to "Assistant Professor of Physics", which it has remained for the third and fourth (current) holders of the position. Among the attractions of this position for its holder is the opportunity it affords to add strong teaching experience to a resume in anticipation of a subsequent search for a tenure-track position elsewhere. The two Ph.D. holders of this position who have moved on are currently in tenure-track positions at Seattle University and Marquette University, and the first of those recently received his first research grant from Research Corporation. A third recent two-year assistant professor (leave replacement) is now in a tenure-track position at Misericordia College (Dallas, PA). For the first two years, the costs for this position were borne by the grant; since then Lawrence has underwritten the salary of this fifth person in the department.

Another important element in our Research Corporation-supported program involved annual visits by two consultants, Professors Robert Hilborn (Amherst College) and Robert Hallock (University of Massachusetts–Amherst), as well as by officials of Research Corporation (initially Brian Andreen, then Michael Doyle, and at the end Humberto Campins). Over the years these individuals became well acquainted with us and our context, and hence they provided well-informed, sympathetic but also challenging input to our improvement (or lack thereof). Their annual visits helped immensely in motivating us regularly to measure our progress against the targets stated in the proposal, because we knew that—come the next visit—we would be expected to give a good accounting. These consultants did a fabulous job of playing a difficult dual role: they were, on the one hand, our sympathetic and encouraging friends and supporters in this endeavor; they were, on the other hand, representatives of Research Corporation charged with seeing to it that we lived up to our end of the "contract" represented by the funded proposal. In addition, they effectively represented the Department and Research Corporation in annual conversations with the Lawrence President and Dean. They were able to remind our administrators of commitments made, chastising or praising as appropriate; they were able to convey some of our thoughts more forcefully to the administration than we could ourselves; and they were able to interpret administrative perspectives to the Department. This grant has now run its official course. As part of the project, however, we enjoyed one more visit from the team of consultants a year or two after the activities of the grant had been completed. During that visit we—and our administration—demonstrated that we had continued in the immediate post-grant years to live up to our part of the bargain. We cannot state too forcefully that these annual visits by the *same* team were valuable on several fronts. The occasional departmental review once every ten-years or so, while very valuable, is unlikely to have the impact of regular visits by the same competent team over a period of several years.

While these efforts met with some success (see Appendices A, F.3, and G), we feel that we have failed to measure up to one or two of our stated goals, especially regarding faculty and student faculty productivity in research.

8 The Extra-Curriculum

To achieve our goal of becoming a premier undergraduate physics department, we believe that we must pay attention to the extra-curriculum, which includes not only student/student and faculty/student interactions outside of course contacts but also the nurturing of a departmental atmosphere that is professional and challenging but also supportive and non-threatening. In addressing this multifaceted dimension of a strong program,

- We operate with an open-door policy, taking time to advise students individually on career choices, summer research opportunities, graduate school opportunities, undergraduate and graduate fellowships, and many other issues.

- We consciously seek to increase student involvement in departmental affairs. Students now contribute regularly to curricular discussions, to interviewing of candidates for positions, to entertaining visitors, and to assisting with laboratories, drop-in help sessions, and review sessions in the introductory courses. Beyond attracting the next year's class, our annual recruiting workshops offer a particularly effective vehicle to involve many current students as assistants, providing a way for us to convey *to* them our confidence *in* them and giving them partial ownership of the process of perpetuating the strength of the Department.

- We support regular social gatherings such as twice-weekly teas, an annual departmental picnic, and an annual departmental retreat at Lawrence's 400 acre, rural Door County estate on Lake Michigan—all of which foster departmental rapport. Among other features, these events encourage significant interactions across class years. We expect increasingly active chapters of the Society of Physics Students (SPS) and a local group called Women of Physics (WOP) to play important roles in this area as well.

- Among the more important components of our extra-curriculum, we arrange an annual series of departmental colloquia given by seniors conducting research projects, by faculty members, and by outside visitors. In particular, we try to arrange three or four visits by outside individuals each year. (Table 5 lists individuals who have visited in recent years.) Each such visit lasts at least a day and a half, preferably two days. We ask each visitor to give a general colloquium aimed at all science departments and a more technical talk aimed at, say, junior majors. Even more important, through scheduled appointments and meals, we will make sure the visitor has several opportunities to interact with individual students and groups of students *with no faculty members present*. We also arrange an all-department social evening. Increasingly SPS and WOP are participating in the arranging of these visits. Our students are fully aware that giving them opportunities to begin to behave like professional physicists is a prominent objective for these visits, and they have never disappointed us.

- We have made sure, especially in the recent renovation, that we have spaces within the Department that the students can call their own. These spaces and the 24/7 access to them that we provide for majors play an important role in helping us nurture both academic and social vigor among our students.

Michael Turner	Jeff Kimble	Thomas Baer
Daniel Kleppner	Catherine Garmany	Diandre Leslie-Pelecky
Dudley Herschbach	Thomas Rossing	Steve Feller
Leon Lederman	James Lawler	Elizabeth Simmons
David Griffiths	Chris Quigg	Caty Pilachowski
Robert Hallock	Stewart Prager	Eric Cornell
Robert Hilborn	Cliff Will	Gregory Exarhos
Harry Swinney	Wendy Bauer	James Truitt
Howard Georgi	Steve Lundeen	Daniel Den Hartog
Peter Collings	David Bishop	Michael Brown
Kate Kirby	Jay Lockman	Sean Carroll
Robin Selinger	Brian Greene	Jennifer Herek
Stephen Leone	Robert Byer	David Newman
Steven Ackerman	Robert Merlino	James Callen
Thad Walker	Steve Kawaler	Raymond Fonck
Edward Kolb	David Munro	Yoriko Morita
Eugen Merzbacher	Jack Schendel	John Goree
David Wineland	Sarah Gilbert	Renee Lemke Nesnidal

Table 5: Recent Colloquium Speakers From Outside Lawrence.

9 Library Resources

The current year's library budget for physics acquisitions is similar to the budget we have been allocated for years past. Once in awhile the budget has been held constant from one year to the next; always we are asked to examine the list of journal subscriptions for possible deletions; but normally there has been a modest increase each year. For 2004–05, the total budget is $48197, with the lion's share ($46547) being directed to journal subscriptions and the rest going to monographs ($1072) and standing orders ($550). These funds are above and beyond the departmental operating budget of (currently) $31500 and are managed by the library staff, not the department chair. Table 6 lists those physics-related journals to which the Lawrence library has a current subscription. Back issues are available for numerous other journals, subscriptions to which have been discontinued as the costs of library subscriptions have continued to rise.

We also have online access to several archives of technical and professional journals, including INSPEC, which librarians can search on request from faculty members, and those data bases listed in Table 7, which facultry members can search for themselves by accessing the library's electronic resources page.

10 Measures of Success

Our ambition to become a premier undergraduate physics department is surely ambitious—and perhaps unrealistic. Even so, we have made progress towards revitalizing our program

Journal	Cost in 2004–05
American Journal of Physics	515
British Journal for the History of Science	177
Bulletin of the Atomic Scientists	40
Computing in Science and Engineering	575
Journal for the History of Astronomy	192
Journal of Physics, Parts A, B, and G	15240
Optics Communications	6322
Physical Review, A, B, C, D, and E	13465
Physical Review Letters	2915
Physical Review/Physical Letters Index	196
Physics Teacher	309
Physics Today	345
Reviews of Modern Physics	525
Sky and Telescope	35
Total Cost in 2004–05	40851

Table 6: Physics-related journals currently received in hardcopy by the Lawrence Library.

- `arXiv.org` e-Print archive. An e-print service in the fields of physics, mathematics, non-linear science and computer science. From Cornell University.
- ISI Basic Science Index. A multi-disciplinary citation index in the sciences.
- `ArticleFirst`. Searchable tables of contents from more than 16,000 general titles.
- Academic Search Elite. Multidisciplinary database with pretty good coverage in physics.

Table 7: Data bases accessible directly by faculty members.

and achieving that goal. Among the indicators of that progress, we cite the following:

- Growth in Enrollments and Number of Majors:
  - Every year, ≈30% of the participants in our annual recruiting workshops matriculate as freshmen at Lawrence. Many of these students ultimately major in physics, but these recruiting activities also bring able students who end up majoring in other areas, including the conservatory. Our recruiting efforts benefit not only the Department but also Lawrence as a whole.
  - As shown in Fig. 1, the average number of physics graduates per year—9.8—since 1991 (the classes affected by our recruiting) is (nearly) double that—5.1—in the decade prior to 1991.

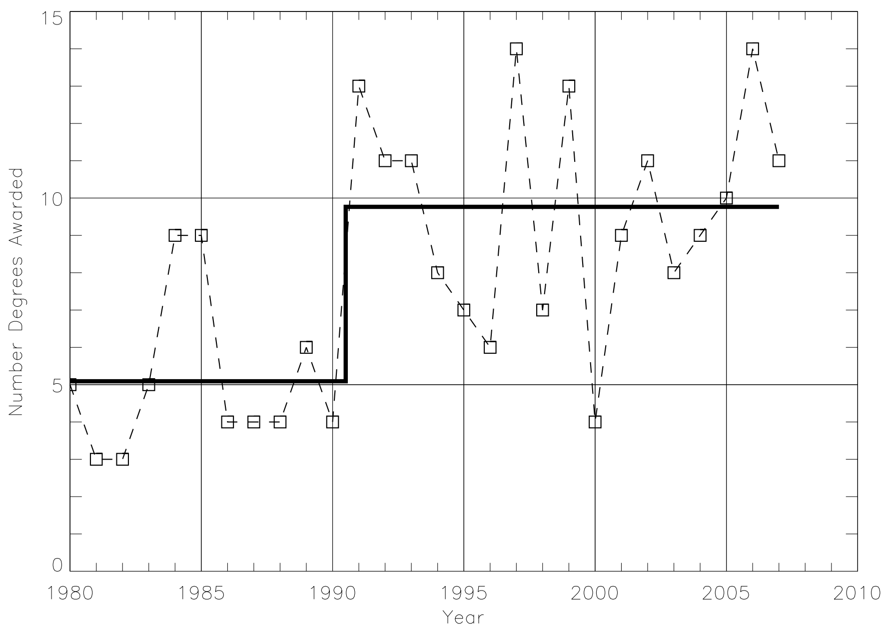

Figure 1: Number of graduates versus year. The average number of graduates per year in the period 1980–1990 is 5.1; the average number in the period 1991–2007 is 9.8. Note that the ordinates for 2005, 2006, and 2007 reflect current enrollments in senior, junior, and sophomore courses.

- We have 10–12 senior majors, 10–12 junior majors, and 12–15 sophomore prospective majors each year.
- Enrollment in *intermediate* courses is 10–18 students, including occasional students from chemistry and math.
- Elective advanced courses enroll 6–18 students.
- Enrollment in outreach courses is *way* up. Physics of Music and Astronomy are both frequently over-subscribed (> 35 in the first, > 32 in the second). Indeed, we now routinely offer *three* laboratory sections in *Physics of Music* so as to be able to accommodate 48 students, and occasionally enrollment goes beyond that number as well.
- We are now attracting more than a token number of women, graduating 1–3 in each class. In a recent year, Professor Cook taught his upper-level mathematical methods course to a class of seven junior and senior majors, four of them women. He doesn't believe he has *ever* before taught an *upper*-level course whose enrollment was more than 50% women.

Several statistics related to enrollments are shown in Table 8. Detailed year-by-year enrollments in various courses are tabulated in Appendix E.

Year	# Workshop Participants	# Matric-ulating	# Majors Graduating	# CAP/IS	# Summer Students	# Receiving Honors
2005	19	?	10	9	—	—
2004	25	8	9	5	1	1
2003	21	7	8	9	6	2
2002	21	12	11	7	4	6
2001	24	6	9	15	4	3
2000	29	10	4	10	5	3
1999	25	4	13	7	5	8
1998	26	6	7	5	7	4
1997	24	10	14	18	4	5
1996	35	13	6	11	7	3
1995	40	12	7	12	5	5
1994	40	12	8	5	6	5
1993	40	9	11	9	1	4
1992	40	11	11	19	4	
1991	40	10	13	12	4	
1990	30	10	4	3	4	
1989	40	9	6	3	3	
1988	40	12	3	3	?	
1987	39	9	3	?	?	

Table 8: Various Statistics on Department. Recruiting workshops began in 1987, so the class of 1991 was the first class that contained some of these recruits. Note that the column labeled '# Matriculating' contains the number *of workshops participants* matriculating in the fall of the given year, not the total number of prospective physics majors matriculating in that year. In the period 1987–2004, 579 prospective students participated in the workshop and 170 of those matriculated the following fall; average yield for this effort is 29%.

- Activities of Graduates:
  - GRE scores have risen significantly.
  - Approximately 50% of our majors pursue advanced studies in physics. During the past decade, Lawrence physics majors have been offered graduate admission and support at Harvard, Stanford, Columbia, Cal Tech, MIT, Stony Brook, Cornell, Wisconsin, Oxford, Colorado, Oregon, Minnesota, Virginia, Michigan, Arizona, Kentucky, Princeton, UT-Austin, UC–Berkeley, UC–San Diego, UC–Davis, UC–Santa Cruz, UC–Irvine, UCLA, Illinois, Duke, Northwestern, Colorado State, Montana State, Georgia Tech, Rochester, Kansas State, Iowa, Vanderbilt, Washington, and Chicago, among others we are not remembering.
  - One or two Lawrence physics majors each year seek degrees in engineering at such places as Washington University, Rensselaer, Columbia, Dartmouth, Iowa State, Northwestern, Purdue, Minnesota, Illinois, Lehigh, Penn State, and Wisconsin. We have formal affiliations with the first three of these institutions; our 3-2 arrangement with the rest is less formal, involving simply transfer of credits

back and forth.

- Occasional physics majors pursue advanced study in medicine, law, environmental engineering, religion, robotics, biophysics, or computer science.
- One graduate every couple of years seeks certification to teach physics in secondary school.
- In 1992, one of our physics majors was awarded a Rhodes Scholarship and, since then, four additional physics majors have been nominated by Lawrence to the Rhodes competition. In the last half-dozen years, three physics majors have received Goldwater scholarships; two have received Clare Boothe Luce scholarships; one has received a Hertz scholarship for graduate study; and three have been offered NSF graduate fellowships.
- Since the start of our efforts in the mid 1980's, five graduates (that we know of) have accepted tenure-track appointments at colleges around the country. Three of the five are women.

Detailed information about the activities of our graduates is tabulated in Appendix H.

- Student Research:

  - The number and quality of independent studies and capstone projects have increased considerably. Recent projects have addressed two-fluid interfaces, nonsequential ionization, geometrodynamics, saturated absorption laser spectroscopy, phase-transitions in Ge-Sn alloys, phase transitions in liquid crystals, theoretical analysis of three- and four-state atomic systems, chaos in electronic circuits, population dynamics in laser systems, coherent population trapping, electron excitation cross sections, robotics, diode laser tuning, time-resolved laser spectroscopy, mapping astrophysical data, vibrations of thin plates, sonoluminescence, properties of elementary particles in nuclear media, temperature dependence of resistivity, EPR studies of crystal vacancies, determination of asteroid orbits, and plasma confinement. Year-by-year statistics on enrollments for capstone and independent projects are presented in Table 8 and in Appendix E.
  - Summer research by students has also increased substantially from its level when our efforts at improvement were initiated. Four to six students serve each summer as research assistants to one or another of our faculty members and three to five pursue summer research elsewhere, e.g., at Washington, Oregon, Virginia, Oxford, Kansas State, Michigan, Michigan State, Indiana, Colorado, Northwestern, Baylor, Chicago, Pacific Northwest National Laboratory, Sandia National Laboratory, JILA, NASA-Langley Laboratory, IBM-Yorktown Heights, IBM-Almaden, Oak Ridge, and others we are not remembering. Year-by-year statistics on summer research by students are presented in Table 8; a listing of actual activities undertaken is presented in Appendix F.
  - As attested to by the data in Appendix F, student presentations at national meetings and at undergraduate research symposia are now frequent, and papers with student co-authors are published now and again.

- Departmental atmosphere: Assessment of changes in departmental atmosphere is necessarily qualitative and subjective. Nonetheless, those of us who have been around for a long time firmly feel that the sense of identity within the department, both among students and among faculty, has become stronger as our program of improvement has moved forward. Interactions among students and between students and faculty are cordial and friendly. Departmental teas and our annual picnic and our annual winter retreat both contribute to nurturing departmental "ambience". In broad terms, we genuinely like being with one another, students with students, faculty with faculty, and students with faculty—and the ambience contributes to a firm sense of collective effort in the study of physics.

- Outside Funding: Since 1987, we have received two-dozen grants—see Table 1 on page 14—totaling $2.7M from various outside agencies, funding that Lawrence has supplemented with another $600K. We espouse the importance and discipline of having one or two proposals pending all the time, although we don't always live up to that objective.

- Publication Record: Faculty research, faculty and student presentations at national meetings and at undergraduate conferences (PEW, NCUR, Argonne), and publications have increased, but we have—we must admit—fallen somewhat short of our original target, which was an average of one paper a year per faculty member. A tabulation of activity is presented in the *curricula vitae* in Appendix A and in Appendix G.

- Recognition Beyond the Home Campus: Most satisfying to us is growing recognition of and interest in our efforts beyond the home campus. We have given several papers at professional meetings, PKAL meetings, and various colleges and universities; we have distributed proceedings of the laser and computational conferences held at Lawrence with Sloan support; we participated as a case-study school in the physics revitalization conference held in 1998; an article by our President appeared in a recent Research Corporation publication titled *Academic Excellence*; Professor Cook gave an invited talk at the April, 2001, meeting of the APS; the feature article by Kate Kirby in the April, 2001, issue of *Physics Today* carried a sidebar about our program; the back-page article in the November, 2002, issue of APS News mentioned the Lawrence physics program; in April, 2002, Lawrence hosted a visit by a team from the National Task Force on Undergraduate Physics; Professor Brandenberger gave an invited talk at the May, 2002, meeting of the Canadian Association of Physicists; Professor Brandenberger arranged a session and gave an invited talk and Professor Cook gave an invited talk and participated in a panel discussion at another session at the March, 2004, APS meeting in Montreal; and Professors Brandenberger and Collett gave an invited presentation on signature programs at the June, 2004, meeting of the Council on Undergraduate Research, in LaCrosse, WI.

11 Guidelines

By way of summary, we enumerate here several guiding principles that we have found to encapsulate the way in which we have tried to nurture all aspects of our program over the years. For compactness, we state them as imperatives.

- Don't expect immediate improvements. Adopt a plan for the long haul and stick with it.

- Set sights high, maybe even a bit unrealistically so. To provide inspiration and motivation for lasting improvement, goals must be ambitious, broad, and bold; and achieving them should constitute a real stretch for the department.
- Give attention to the entire departmental program. Efforts focused on curriculum alone (and certainly efforts focused on only a few selected courses) constitute a start but, by themselves, are insufficient to effect wholesale change.
- Make sure the department has a few features that are in some sense unique, that faculty members care deeply about enhancing, and that are "sellable" and exciting. Such features are crucial to recruiting students, to maintaining faculty excitement, to attracting and retaining a strong faculty, and to attracting outside funding.
- Involve students regularly and meaningfully in departmental affairs, and nurture the social dimensions of engagement with the department along with the academic dimensions.
- Arrange for several outside visitors each year and make sure students have the opportunity to interact with each visitor in the absence of faculty.
- Seek funding from outside agencies (e.g., government and private foundations, sympathetic manufacturers of equipment, local industry) frequently and aggressively.
- Provide plenty of student spaces.
- Recruit prospective students aggressively and vigorously. Recognize, though, that these endeavors require substantial effort and will not succeed unless you have something to promote.
- Strive for student involvement in extra-course scholarship both during the academic year and during the summer.
- Make sure that the development plan has the full support of the entire department, of the administration, and of the admissions office.
- Seek frequent input from outside consultants.

We have found that revitalizing our departmental program is a lot of work, it must be carried out on several fronts, and it cannot be done in a short time. It requires a concentrated effort on the part of the entire department, and the pay-off may not be fully realized for a decade or more. But we find that the pleasure of being part of the project, the joy of working in the vital department that results, and especially the pride we take in the accomplishments of the students who have worked along with us in this effort provide considerable satisfaction.

12 Plans for the Future

This external review and the preparation of this document are in significant measure prompted at this time by the upcoming retirement of Professors Brandenberger and Cook. The current plan is for Professors Brandenberger and Cook to teach full time in the 2005–06 academic year but that that year be the last year of full-time teaching for both of them.

They each propose to remain in service to Lawrence for two more years. Professor Brandenberger will take advantage of the new two-year phased employment option starting in 2006–07, and will teach three courses in each of 2006–07 and 2007–08. Professor Cook will, in 2006–07, be eligible for his sixth sabbatical. He will combine that sabbatical with a one-year phased employment option, teaching three courses in the two-year period 2006–08. Professors Brandenberger and Cook will then retire fully at the end of the 2007–08 academic year (though each expects to be available thereafter to teach occasionally under the plans then in effect for the hiring of retired faculty members for special assignments). To implement this plan, we anticipate filling two tenure-track positions to start in September, 2006—which means conducting two searches in the 2005–06 academic year. Officially, Professor Dunn's current appointment terminates in June of 2006, so the occupant of his (short-term) position starting in September, 2006, is also to be decided.

The selection of individuals to fill these several positions must be considered very carefully, and the opportunities presented by these changes must be fully examined. We believe that our curriculum is in good order and does not need major overhaul. More pressing, however, is the need to increase our continuing commitment to scholarship with tangible results (i.e., publications) emerging on a periodic basis, mainly on the part of faculty alone but also occasionally with student collaborators. We need to recommit to the notion of having strong proposals submitted on a timely basis with new proposals pending almost all the time. Here are several questions with which we have been wrestling in the last few months, along with some *tentative* answers. A major function of the outside review is to help us address these—and probably other—questions more completely than we have addressed them to date, to add an outside perspective, and to help us come to some final answers to them.

1. What does it mean *to us* to maintain and strengthen a strong, thriving program?

   A strong, thriving program will have many dimensions, but it must be based upon a relatively large group (10-15 per year) of physics majors actively engaged in the study of physics both in and outside of the classroom. In the classroom, they will learn the fundamental principles and approaches used by professional physicists. Outside the classroom they will attend colloquia that expose them to topics at both disciplinary and interdisciplinary frontiers, meet periodically at tea and other departmental functions where (at least part of the time) physics is discussed, engage in projects related to physics, interact with departmental visitors, deliver talks and presentations, and often engage in a research collaboration with a Lawrence faculty member. Most students will gain research experience either at Lawrence or at another research location. In addition to the program for majors, the program will reach out to the general student population with topical offerings that will attract a majority of Lawrence students to enroll in a physics course during their time here.

2. To what extent do we want to preserve the computational emphasis and the laser/optics offerings within the department? In what way? Should the new members have strong inclinations toward maintaining these offerings, emphases, and facilities in their work at Lawrence?

   Lawrence has developed a national reputation based in significant measure on the laser and computational signature programs and facilities. It is probably desirable and important for the department to maintain considerable emphasis in those areas, at least until some other signature programs that are equally visible, equally distinctive, and equally applicable to the education of undergraduates are put in place. Broadly interpreted, computation and modern optics are mainstream research areas that can produce attractive offerings at the undergraduate level. We would expect that these signature programs will evolve to reflect special interests and abilities of the new faculty members but that these general areas of focus will remain a major part of our departmental program.

3. Should we strive to prepare more secondary school teachers?

   We presently produce one secondary educator every few years. Recent AIP statistics indicate that increasing numbers of high school students are studying physics, increasing the demand for competent teaching. We should consider increasing the number of secondary educators that we produce by introducing a teacher preparation track that substitutes departmental outreach courses for some of the upper-level electives in the major.

4. Should we attempt to increase the number of majors to 12–14? Is it true that we can't go much higher without real problems, for instance, in the advanced lab?

   We currently graduate about 10 majors/year, and we would like to increase that number to 12–14. If the number of majors exceeds 12–14, however, we fear we will dilute the experience in our advanced laboratory course, and we will have difficulty offering a research experience to all deserving students. The greatest opportunity for increasing the number of majors probably lies in preparing 3-2 engineers and secondary school teachers.

5. Should we become more interdisciplinary?

   The undergraduate physics major at Lawrence will maintain its disciplinary character because scientists need firm grounding in physics in order to apply it effectively in other realms. That said, it may be wise to consider faculty hires whose research lies in the physics of nanoscale or biological systems because these are major growth areas in research. We should also give some weight to the contribution we will make to the environmental studies program.

6. Do we retain our self-professed focus on professional matters?

   The answer must be an unequivocal "yes". Future grants, future promotions, future filling of chairs, and faculty viability and longevity are likely to hinge on demonstrated, tangible evidence and involvement in individual faculty research programs. For the sake of the department as well as for their own personal advancement, all members of the department must pursue scholarly activities continuously and energetically.

7. How can we strive more successfully to generate one paper every year or every other year and conference presentations involving students annually?

   In order for the Department of Physics to be nationally recognized, it is essential to maintain a professional focus, for it is through professional contacts, regular participation in meetings and conferences, and concrete, peer-reviewed, and published achievement on a continuing basis and through sending strong, well-prepared graduates to highly regarded Ph.D. programs that we acquire our reputation. A professional approach benefits all students because they gain a better understanding of what it means to be a practitioner of physics. The presence of active research programs also demonstrates that physics is still a dynamic, evolving discipline. We have fallen short of our goal of one refereed publication every year or two for each faculty member. While we have engaged students regularly in on-campus research that has led to conference presentations and some publications, there is no substitute for faculty involvement and production via one's own scholarly program. We *must* do all we can to shield new faculty members from institutional responsibilities that will hamper their ability to establish self-sustaining research programs, and continuing members must redouble their efforts and production.

8. Should we require a capstone experience of every major?

   Capstone experiences have been encouraged but not required over the last two or three decades at Lawrence and have been beneficial to many students. The ideal capstone experience looks at a research problem (often one encountered during a summer research program) in depth. The investigation inevitably requires the student to use ideas from multiple areas of physics, and it culminates in a paper and a presentation at a departmental colloquium. The experience provides a valuable addition to a summer research project and often brings it to a logical end. Sometimes, it leads to a publication, a presentation at a national meeting, and/or honors in independent study at graduation.

   While a capstone experience is especially valuable for those students planning professional physics careers, it can, however, be frustrating for students of marginal ability or for those whose interest in physics has waned. Supervising such students is also disproportionately time consuming for the faculty members. In the interest of making the best use of departmental resources, we feel best about encouraging most—around 70% of—students to undertake capstone experiences without requiring it of the remainder.

9. Should we make thermal physics required in the program of our majors?

   Thermal physics is essential in most active research areas of physics today and is, therefore, an important component of a professional physicist's theoretical repertoire. We presently do not require the course for the physics major, but instead strongly advise students with professional aspirations to choose the course as one of their elective options. We can then teach a fairly sophisticated course on an alternating year basis. If we were to require the course for the physics major, we would have to offer the course annually in order to give all 3-2 engineering students an opportunity to take the course. Staffing this course would force the elimination of one special topics elective course every other year and reduce the number of electives in the major to two from three. If we *were* to remove another requirement for the major, we would probably make the sophomore electronics course elective. The risk here, of course, is that any students who fail to take electronics will be real neophytes with respect to modern instruments. Their experimental skills will be even more underdeveloped. If, nevertheless, we were to deemphasize electronics, we might then reduce the level of the thermal physics course and offer it at the sophomore level. Some departmental members question the wisdom of this approach.

10. Have we put computation into the curriculum in the most appropriate way, or should we reassess the wisdom of sacrificing some topics in the original mechanics course to that end?

    The computational mechanics option gives all physics majors an introduction to computational tools in a way not provided by our former elective computational physics course. This benefit comes, however, at the cost of some advanced analytical topics (e.g., rigid body dynamics, accelerating coordinate systems, and Lagrangian Mechanics) in mechanics. We have now added an upper-level advanced mechanics course to fill this gap. We are in the third year of this program and do not yet have a definitive measure of its impact. Our present approach has the virtue of not adding any requirements to the major. We are inclined to leave the program as is until a new computational physicist is added to the faculty. At that point we need to reassess the situation.

11. Should we change the format and/or timing of our annual recruiting workshop?

    As has been mentioned earlier, recruiting workshops have played a crucial role in revitalizing the department and increasing the quantity and quality of physics majors. In recent years, workshop applications have been decreasing although the admissions yield that we get from the workshop is stable. Why have the number of applicants decreased? Perhaps one reason is that, only recently discovered by us, the mailings by the Admission Office have been sharply reduced in recent years. More departmental caretaking of the recruitment workshop is probably needed in a variety of ways.

    The need for a restructuring of the workshops may also be indicated by other considerations. For example, we increasingly receive requests from high school teachers who want to recommend *juniors* in their physics classes for inclusion in the workshop. These teachers maintain that top students often make their choices early in the senior year before they have an opportunity to attend the Lawrence Physics Workshop. We are in the process of considering the move from a February workshop to an October or early November workshop to capture a wider audience.

    Beyond timing, we may need to refocus the topic of the workshop to fit a new audience. The basic themes of lasers and computational chaos have been in place for many years. The program has evolved to include plasmas and surface imaging with scanning tunneling microscopes, but the program still is largely devoted to lasers and modern optics. Perhaps a new focus on nanoscience or some other trendy topic might bring in a larger applicant pool. But such a move will, of course, require considerable effort in generating a variety of activities that permit hands-on work by the prospective students. Not only must the specific activities and/or experiments be developed and tested, but handouts must also be created. Considerable lead time is required to attend to this matter. If significant changes are to be introduced, the preparations need attention far in advance of the workshop.

    As we review applications for new positions in the department, we will be looking—among many other qualifications—at how each candidate might contribute to the next generation of physics workshops.

A *Curricula Vitae* for

A.1 . . . John R. Brandenberger

Education:	A.B., Carleton College, 1961 Ph.D., Brown University, 1968
Research Interests:	Atomic physics; Laser spectroscopy; Non-linear and quantum optics

Experience:

Alice B. Chapman Professor of Physics, Lawrence University, 1999–
Assistant/Associate/Professor of Physics Lawrence University, 1968–
Visiting Fellow, Department of Physics, Harvard University, 1975–76
Visiting Professor, Department of Physics University of Reading, Reading, England, 1981
Senior Visiting Scientist, Department of Physics University of Oxford, Oxford, England, l982
Research Collaborator, Joint Institute for Laboratory Astrophysics, Boulder, CO, 1984–87
Visiting Scientist, Institute of Electronic Structure and Lasers, Crete, Greece, 1990 (visit not completed)
Visiting Scientist, Research Laboratory of Electronics and Department of Physics, M.I.T., 1995-96
Visiting Scientist, Instituut voor Atoom-en Molecuulfysica, Amsterdam, May, 2003

Memberships:

American Physical Society: Steering Committee, Laser Science Topical Group (1987)
Awards Committee, Faculty Member for Research in Undergraduate Institution (1992–95; Chair, 1993–94)
Member, Fellowship Committee, Forum on Education. Named Fellow of the Society in 1999.
Sigma Xi
Council on Undergraduate Research: Councilor (1987–94); Consultants Program in Physics/Astronomy Division (Chair, 1990–93); Chair of Physics/Astronomy Division (1993–94)

Grants/Fellowships:

Research Corporation, 1969–70
NSF, 1965, GY-616; 1969 (COSIP through Lawrence)
NSF, 1970, GY-7435
NSF, 1971-73, GY-28784
Research Corporation, 1976–79
NSF, 1978 and 1979 SPI77-25895 and SPI-7826830
Research Corporation, 1980–83, 1985–88
NSF, 1981–82, SFPD Fellowship
SERC (U.K.), 1981–82, Senior Visiting Fellowship

General Electric Foundation, 1986–89
SNC Foundation, 1986, 1990
Kurz and Root Company, 1986
Coherent, Inc., 1986
Alfred P. Sloan Foundation, 1987
NSF, 1987-88, CSI-8750076
Tektronix, Inc., 1987, 1989
NSF, 1989-90, USE-8950001; 1991
Plexus Corporation, 1985, 1989, 1990
Spectra-Physics, Inc., 1990, 1991
Fulbright Foundation Fellowship, 1990–91
Crystal Print, 1992, 1993
SNC Foundation, 1993
NASA/Wisconsin Space Grant Consortium, 1994
Departmental Development Award from Research Corporation to Lawrence University, 1994–1999
LSTG/APS, 1995
NSF ROA, 1995–96 (with Daniel Kleppner of MIT)
Foundation, 2002–2005 (joint effort with D. M. Cook, J. A. Collett, B. Giese, and R. Warch)

Publications, Abstracts, and Lectures:

Undergraduate coauthors are indicated with a dagger.

"Atomic Spectroscopy with Laser Diodes and Undergraduates", invited talk delivered at the Annual March Meeting (March 22, 2004) of the American Physical Society in Montreal.

"Surprises in the Application of Multi-Beam, Multi-step Laser Spectroscopy", physics colloquium delivered at the Frei University of Amsterdam, Amsterdam, The Netherlands, May 19, 2003.

"Applications of Multi-Beam, Multi-Step Laser Spectroscopy", colloquium delivered at the Instituut voor Atoom-en Molecuulfysica, Amsterdam, The Netherlands, May 13, 12003.

"Attracting and Holding Physics Majors", invited talk delivered to the annual meeting of the Canadian Association of Physicists, June 3, 2002, Quebec City, Canada.

"Fine-structure Splittings in ^{2}F states of Rubidium via Three-Step Laser Spectroscopy", J. R. Brandenberger, C. A. Regal†, R. O. Jung†, and M. C. Yakes†, Phys. Rev. A **65**, 42510, (May, 2002).

"An Undergraduate Physics Success Story", sidebar written in collaboration with Kate Kirby that appeared alongside the article "The Physics Job Market: From Bear to Bull In a Decade", Physics Today **54**, 36–41 (April, 2001).

"Hyperfine Splittings in ^{2}D and ^{2}F States of Rb via Multi-Step Excitation Spectroscopy", invited talk delivered to Physics Colloquium at Kansas State University (April 6, 2000).

"Departmental Considerations and Conversations", invited talk delivered at the PKAL 10th Anniversary Celebration, University of Maryland (Oct 22, 1999).

"Lande g_J Values in Atomic Argon: A Measurement of the Ratio $g_J(2p_9)/g_J(1s_5)$ by Saturation Spectroscopy", Phys. Rev. A **60**, 1336–1340 (Aug, 1999).

“Improving Physics at Lawrence”, with David M. Cook, Lawrence Today 79, 20 (1999).

“Physics at Lawrence: A Case Study of Improvement”, invited presentation delivered with David M. Cook to the Physics Revitalization Conference sponsored by AAPT, AIP, APS, NSF, and PKAL (Oct 2-4, 1998).

“Surprises in Saturated Absorption/Optical Pumping of Rb”, invited talk delivered to the Physics Colloquium, Department of Physics, Amherst College (April, 1996).

“Enhancing Diode Laser Tuning with a Short External Cavity”, P. A. Ruprecht[†] and J. R. Brandenberger, Optics Comm. **93**, 82–86 (1992).

“Hyperfine Structure in the $4p^5 5p$ Configuration of ^{83}Kr”, S. C. Parker[†] and J. R. Brandenberger, Phys. Rev. A **44**, 3354 (1991).

“From Feasibility to a Focus on Laser Physics”, invited address by J. R. Brandenberger at 1991 Annual Meeting of AAAS, Washington, D.C. (Feb. 18, 1991).

“Lasers at Lawrence: A Nexus for Teaching and Research”, invited address by J. R. Brandenberger at Project Kaleidoscope Nat. Coll., Washington, D.C. (Feb. 4-5, 1991).

“Hyperfine Structure of the $2p^6$ State of the $4p^5 5p$ Configuration of ^{83}Kr”, J. L. Herek[†] and J. R. Brandenberger, Bull. Am. Phys. Soc. **35**, 1020 (1990).

“The Multifaceted Case for Undergraduate Research”, J. R. Brandenberger, Council on Undergraduate Research Newsletter, XI, No. 2, 23 (1990).

“Hanle Effect in Spectrally Broadened Light”, K. Arnett, S. J. Smith, R. Ryan, T. Bergeman, H. Metcalf, M. W. Hamilton, J. R. Brandenberger, Phys. Rev. **41A** , 2580 (1990).

“Hyperfine Splittings in $4p^5 5p$ Configuration of ^{83}Kr Using Saturated Absorption Laser Spectroscopy”, J. R. Brandenberger, Phys. Rev. **39A**, 64 (1989).

“Lasers and Modern Optics in Undergraduate Physics A Report to Foundations, Corporations, and Undergraduate Colleges”, J. R. Brandenberger, September, 1989.

“Laser Physics and Modern Optics in Liberal Arts Colleges”, proceedings of Sloan Conference held at Lawrence University; edited by J. R. Brandenberger (1987).

“Optovoltaic Detection: A New Probe for Laser Spectroscopy”, J. R. Brandenberger, Phys. Rev. **36A**, 76 (1987).

“Hanle Effect in Yb with a Phase Diffusing Laser Field”, K. Arnett, S. J. Smith, T. Bergeman, H. Metcalf, J. R. Brandenberger, M. Hamilton, XV IQEC ’87, 41 (1987).

“Lifetime and Cross Sections of the $3p^5 4p$ States of Argon via Time-Resolved Laser Spectroscopy”, A. L. Stout[†] and J. R. Brandenberger, Bull. Am. Phys. Soc. **31**, 941 (1987).

“Optovoltaic Detection of Diode Laser Driven Resonances in Krypton Discharge”, J. R. Brandenberger, Bull. Am. Phys. Soc. **31**, 940 (1986).

“Effect of Spectrally Broadened Laser Light on the Hanle Effect in Neon”, J. R. Brandenberger, M. Hamilton, T. Bergeman, and H. Metcalf, Bull. Am. Phys. Soc. 30, 771 (1985).

“Laser Spectroscopy of Calcium Isotopes”, C. W. P. Palmer, P. E. G. Baird, S. A. Blundell, J. R. Brandenberger, C. J. Foot, D. N. Stacey, and G. K. Woodgate, J. Phys. B: At. Mol. Phys. **17**, 2197 (1984).

"Lifetimes and Collision Cross Sections in the $2p^5 5s$ and $2p^5 4d$ States of Neon", J. R. Brandenberger, Phys. Rev. **29A**, 1208 (1984).

"Lifetimes and Collision Cross Sections for the $2p^5 5s$ States of Neon", E. J. Dehm† and J. R. Brandenberger, Bull. Am. Phys. Soc. **28**, 788 (1983).

"Einstein, Podolsky, Rosen and All That!", J. R. Brandenberger, Physics Colloquium, Clarendon Laboratory, University of Oxford, May 24, l982.

"Interpretations and Paradoxes in Quantum Mechanics", J. R. Brandenberger, Physics Colloquium, Department of Physics, University of Reading, February 2, 1982.

"Lifetime of the $2p^5(^2P_{1/2})4d$ State of Neon", D. C. DeMets† and J. R. Brandenberger, Bull. Am. Phys. Soc. **26**, (1981).

"Optogalvanic Detection of Double-Quantum Resonances in Argon", C. J. Matheus† and J. R. Brandenberger, Bull. Am. Phys. Soc. **26**, (1981).

"Quantum Beat Determination of Lifetimes and Disalignment Cross Sections in Neon", J. R. Brandenberger and B. R. Rose†, Op. Comm. **36**, 453 (l981).

"Measurement of g-factors in Neon by Quantum Beat Spectroscopy", J. R. Brandenberger, Op. Comm. **30**, 181 (1979).

"Quantum Beat Measurement of g-value in Excited States of ^{20}Neon", J. R. Brandenberger, R. Peterson† and J. E. Gastineau†, Bull. Am. Phys. Soc. 23, 1092 (1978)

"Multiphoton Radiofrequency Resonances in $^4He^+$", J. R. Brandenberger, S. R. Lundeen, and F. M. Pipkin, Phys, Rev. **14A**, 341 (1976).

"Multiphoton RF Resonances in $^4He^+$", S. R. Lundeen, J. R. Brandenberger, and F. M. Pipkin, Proc. of Fifth Int. Conf. of At. Phys. July 27–30, 1976, Univ. of California, Berkeley.

"Multiple-Quantum Fine Structure Resonances in $^4He^+$", J. R. Brandenberger, Bull. Am. Phys. Soc. **21**, 98 (1976).

"Determination of the Atomic-Hydrogen Fine Structure by Level Crossing in the 2P states of Hydrogen, A Measurement of the Fine-Structure Constant", J. C. Baird, J. R. Brandenberger, K. I. Gondaira, and H. Metcalf, Phys. Rev. **5A**, 564 (1972).

A.2 . . . Jeffrey A. Collett

EDUCATION:

College:

ST. OLAF COLLEGE, NORTHFIELD, MN, B.A., Physics, Mathematics, 1972-76. *Magna Cum Laude*. Departmental distinction in both physics and Mathematics, Elected to Phi Beta Kappa.

Graduate School:

UNIVERSITY OF MINNESOTA, SCHOOL OF PHYSICS AND ASTRONOMY MINNEAPOLIS, MN, no degree, Physics, 1977-8. Teaching assistant.

HARVARD UNIVERSITY, CAMBRIDGE, MA, A.M. (1978), Ph.D. (1983), Physics, 1977-83. Experimental Condensed Matter Physics. Worked with Professor Peter S. Pershan and Professor Robert J. Birgeneau (MIT) on measurement of phase transitions in freely suspended liquid crystal films and correlations with theories of dislocation mediated melting in two dimensional solids.

Ph.D. Thesis:

X-ray Scattering Study of Liquid Crystal Thin Films

POSTDOCTORAL WORK:

IBM THOMAS J. WATSON RESEARCH CENTER, YORKTOWN HEIGHTS, NY, Physical Sciences Department, 1983-84. Worked with Dr. Paul M. Horn on development of X-ray scattering techniques for use in investigation of phase transitions in adsorbed gas monolayers on single crystal surfaces. The techniques are also applicable to structural evaluations of thin epitaxial layers such as semiconductors grown with Molecular Beam Epitaxy or thin layers of high T_c superconductors.

INDUSTRIAL WORK:

IBM APPLICATION BUSINESS SYSTEMS DIVISION, ROCHESTER, MN, Electronic Packaging Technology Development, 1984-1992. Activities included evaluation of accelerated testing techniques, solder joint and connector reliability evaluations and selection of first level packaging technology for future systems. Received an Outstanding Technical Achievement Award for the introduction of compliant-pin technology in AS/400 products. Final position was Advisory Engineer with responsibility for future high performance system packaging definition.

TEACHING:

LAWRENCE UNIVERSITY, APPLETON, WI, 1995-present.
Assistant Professor of Physics (1995-2001), Associate Professor of Physics (2001–), Physics Department. Teaching in all areas of the Physics Department.

ST. NORBERT COLLEGE, DEPERE, WI, 1994-1995.
Adjunct Assistant Professor of Physics, Division of Natural Sciences. Taught Introductory Physics sequence.

ST. CLOUD STATE UNIVERSITY, ST. CLOUD, MN, 1992-1994.
Assistant Professor of Physics, Department of Physics, Astronomy, and Engineering Science. Fixed term appointments teaching introductory physics for biomedical science majors, advanced E&M for Physics and Electrical Engineering majors, and Modern Physics.

ROCHESTER COMMUNITY COLLEGE, ROCHESTER, MN, 1989.
Taught Modern Physics course in pre-engineering curriculum.

OTHER APPOINTMENTS:

UNIVERSITY OF WASHINGTON, SEATTLE, WA, March, 1999-June, 1999.
Visiting Scholar, Physics Department
Used optical techniques to study phase diagrams of binary mixtures of liquid crystals in the hexatic phase.

PROFESSIONAL ORGANIZATIONS:

American Physical Society, including Division of Condensed Matter Physics, Division of Materials Physics, Forum on Education, Forum on Physics and Society, Group on Statistical and Nonlinear Physics.

Council on Undergraduate Research as Physics Councilor (1999–), Chair of Physics/Astronomy Division (2001-2003).

Research Interests:

Studies of hexatic ordering in liquid crystals with X-ray Diffraction. I have developed an X-ray scattering system based on a Bruker GADDS. Software developed locally allows visualization of scattering in three dimensions in reciprocal space. With IDL utilities we can extract data along any line or in any plane in reciprocal space. This system is used to measure order in hexatic phases of liquid crystals.

Research Support:

NSF-NUE (Nanoscience in Undergraduate Education), $100,000 (June, 2003), with Karen Nordell and David Hall

W. M. Keck Foundation, $400,000 (Jan., 2002) with J. Brandenberger & D. Cook

CUR Materials Science Linkage Grant for $800.00 (June, 1999)

Petroleum Research Fund Type G grant for $20,000 (June, 1996)

Research Corporation Cottrell College Science Award for $36,150 (May, 1996)

Research Corporation Departmental Development Grant

$30,000.00 University Startup Funds

Received $5000.00 Research and Training Grant from Exxon Educational Foundation for use in 1996.

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1. "Structural Study of the Smectic-I to Smectic-F Transition in Freely Suspended Liquid Crystal Films", J. A. Collett, P. T. Kondratko†, and M. E. Neubert, Phys. Rev. E **62**, 6760 (2000).
2. "SMT Solder Joint Reliability on Flexible Circuitry", J. A. Collett, Proceedings of the IPC Semi-annual Meeting, Chicago, April, 1988.
3. "X-ray and Optical Studies of the Thickness Dependence of the Phase Diagram of Liquid Crystal Films", E.B. Sirota, P.S. Pershan, L.B. Sorensen, and J. Collett, Phys. Rev. A **36**, 2890 (1987).
4. "X-ray Studies of Tilted Hexatic Phases in Thin Liquid Crystal Films", E.B. Sirota, P.S. Pershan, L.B. Sorensen, and J. Collett, Phys. Rev. Let. **55**, 2039 (1985).
5. "X-Ray Scattering Study of Restacking Transitions in the Crystalline-B Phases of Heptyloxybenzylidine Heptylaniline (7O.7)", J. Collett, L.B. Sorensen, P.S. Pershan, and J. Als-Nielsen, Phys. Rev. A **32**, 1036 (1985).
6. "Dislocation Model for Restacking Phase Transitions in Crystalline-B Liquid Crystals", J.P. Hirth, P.S. Pershan, J. Collett, and L.B. Sorensen, Phys. Rev. Lett. **53**, 473 (1984).
7. "Synchrotron X-Ray Study of the Thickness Dependence of the Phase Diagram of Thin Liquid Crystal Films", J. Collett, P.S. Pershan, E.B. Sirota, and L.B. Sorensen, Phys. Rev. Lett. **52**, 356 (1984), and **52**, 2190(E) (1984).
8. "Synchrotron X-Ray Study of Novel Crystalline-B Phases in Heptyloxybenzylidene Heptylaniline (7O.7)", J. Collett, L.B. Sorensen, P.S. Pershan, J.D. Litster, R.J. Birgeneau, and J. Als-Nielsen, Phys. Rev. Lett. **49**, 553 (1982).

Recent Presentations

1. "Signature Laboratories as a Tool for Integrating Research and Education", Jeffrey Collett & John Brandenberger, Council on Undergraduate Research—Tenth National Conference, University of Wisconsin – La Crosse, June 26, 2004.

2. "X-ray Measurements of Correlation Lengths in Hexatic Phases Using an Area Detector", Joshua D. Cross†, Jeffrey A. Collett , and Mary E. Neubert, March Meeting of the American Physical Society, Minneapolis, March, 2000.

3. "Structural Study of the Smectic-I and Smectic-F Phases in Freely Suspended Films", P. T. Kondratko†, J. A. Collett, M.E. Neubert, March Meeting of the American Physical Society, Minneapolis, March, 2000.

4. "Structures of Smectic-I and Smectic-F Phases of TB10A", J. A. Collett, presented as the weekly research seminar at the Ferroelectric Liquid Crystal Materials Research Center, University of Colorado, Boulder, August 11, 1999.

5. "Study of the Smectic-I to Smectic-F Transition in TB10A", P. T. Kondratko† and J. A. Collett, March Meeting of the American Physical Society, Atlanta, March, 1999.

6. "Three Dimensional Visualization of Diffuse Scattering in Liquid Crystals", James Truitt†, J. A. Collett, and Michael Stenner†, March Meeting of the American Physical Society, Los Angeles, March, 1998.

A.3 . . . David M. Cook

Education:	B.S. (Physics), Rensselaer Polytechnic Institute, 1959 A.M. (Physics), Harvard University, 1960 Ph.D. (Physics), Harvard University, 1965
Ph.D. Dissertation:	"Cyclotron Radiation from Plasmas in Weakly Inhomogeneous Magnetic Fields" (Advisor: Dr. Max Krook)
Research Interests:	Mathematical Physics; Computational Physics; Musical Acoustics; Computers in Physics Instruction

Experience:

Philetus E. Sawyer Professor of Science, Lawrence University, 1989–
Director, Lawrence Computational Physics Laboratory, 1988–
Professor of Physics, Lawrence University, 1979–
Associate Professor of Physics, Lawrence University, 1971–79
Assistant Professor of Physics, Lawrence University, 1965–71
Chair, Physics Department, Lawrence University, 1968–71, 1975–77, 1980–81, 1990–92, 1995–99, 2002–
Associate Editor, *Computers in Physics*, 1994–1998
Physicist, General Electric Research Laboratory, Summers 1963, 1960

Organizer and Teacher, Week long NSF-supported workshops for physics faculty from around the US, 13–20 July 2003, 7–14 July 2002, 21–28 July 2002, 8–15 July 2001

Visiting Scientist, San Diego Supercomputer Center, 3–12 November 1992

Participant, Supercomputing and Undergraduate Education Workshop, San Diego Supercomputer Center, 13–17 July 1992

Organizer and Chair, Session on uses of symbolic computation in the client disciplines at the Conference on Use of Symbolic Computation in Undergraduate Mathematics, Denison University, Granville, OH, 25–28 June 1992

Member, Committee on Computers in Physics Education of the American Association of Physics Teachers, January, 1991–January, 1994

Organizer, Sloan/Lawrence Conference on Using Computational Resources in the Upper-Division Theoretical Physics Curriculum, 13–14 July 1990

Member, Planning Committee for Conference on Computers in the Undergraduate Curricula, sponsored by the Associated Colleges of the Midwest and held at Wingspread, 27–29 October, 1983.

Director, NSF CAUSE Program at Lawrence University, 1978–81. Project focussed on computer-oriented faculty and curriculum development.

Visiting Fellow in Physics, Dartmouth College, 1971–72. Studied instructional computing and developed a library of 60–70 programs.

Member (1970–93), *Chair* or *Co-chair* (1977–1989), Lawrence Computer Science Committee.

PROFESSIONAL SOCIETIES: American Physical Society; American Association of Physics Teachers

HONORS: Society of the Sigma Xi; 1990 Lawrence Outstanding Teaching Award

GRANT SUPPORT:

Individual:

NSF 2003 (CCLI-EMD) supplement to 2000 grant for workshop
NSF 2000 (CCLI-EMD) for publishing computer materials
NSF 1997 (ILI) for expanding Physics of Music to include laboratory
Cray Foundation 1992 (for participation in San Diego workshop on supercomputing)
NSF 1978–79 (LOCI) for production of instructional video tapes
Lawrence University Educational Development Grants for video tape production, 1973 and 1974
NSF 1971–72 Science Faculty Fellowship
NSF 1968 (ISEP) and 1969 (COSIP) for analog computation
NSF 1967 and 1968 (SSTP)

Institutional:

W. M. Keck Foundation 2002 for enhancing signature programs
W. M. Keck Foundation 1994 for capstone senior experiences
NSF 1993 (ILI) for computational physics
Alfred P. Sloan Foundation 1989 for computational physics conference
NSF 1988 (ILI) for computational physics
W. M. Keck Foundation 1988 for computational physics
Digital Equipment Corporation 1982 for instructional graphics

Digital Equipment Corporation 1982 for laboratory computing
NSF 1979–81 (CAUSE) for instructional computing
NSF 1969–73 (COSIP) for multidiscipline science improvement

CONSULTING:

Tenure review of scholarship for faculty member at liberal arts college in eastern US, February, 2005

Vassar College, 2,3 November 2000, discussing incorporation of computation into the undergraduate physics curriculum.

Review of two NSF RUI proposals, March, 1993

Manuscript reviews for American Journal of Physics, 1977–

Physics department reviews: Lake Forest College, 18–19 April 2005; Skidmore College, 10–12 October 1993; Kalamazoo College, 7–8 May 1990; Beloit College, 29 Feb – 1 Mar 1984; Illinois Wesleyan College, 9–11 Dec 1981.

Faculty computer graphics workshops: Carthage College, 4 May 1982; Lake Forest College, 2–3 Jun 1981; Ripon College, 15 and 17 Jan 1981; Lake Forest College, 4–5 June 1980; Alma College, 6–7 June, 1977.

Review of NSF CAUSE proposals: 22–24 Jan 1981, 30 Jan – 2 Feb 1980

PUBLICATIONS:

Undergraduate coauthors are indicated with a dagger or a year of graduation.

Solutions to Selected Exercises to accompany *Computation and Problem Solving in Undergraduate Physics*, self-published by David M. Cook and made generally available starting in the fall of 2003 through a password-protected web site. Drafting of the solutions was assisted by Danica Dralus, LU '02, Ryan Peterson, LU '03, Scott Kaminski, LU '04, Michelle Milne, LU '04, and Lauren Kost, LU '05.

Computation and Problem Solving in Undergraduate Physics, self-published by David M. Cook and made generally available starting in the fall of 2003. Full information at the web site `http://www.lawrence.edu/dept/physics/ccli`. Drafting and refinement of the text was assisted by Peter Strunk, LU '89, Kristi R. G. Hendrickson, LU '91, Todd G. Ruskell, LU '91, Stephen L. Mielke, LU '92, Ruth Rhodes, LU '92, Michelle Ruprecht, LU '92, Sandra Collins, LU '93, Mark F. Gehrke, LU '93, Karl J. Geissler, LU '94, Steven Van Metre, LU '94, Alain Bellon, LU '95, Peter Kelly Senecal, LU '95, Christopher C. Schmidt, LU '97, Michael D. Stenner, LU '97, Mark Nornberg, LU '98, Scot Shaw, LU '98, Jim Truitt, LU '98, Eric D. Moore, LU '99, Teresa K. Hayne, LU '00, Danica Dralus, LU, '02, Ryan T. Peterson, LU '03, Scott J. Kaminski, LU '04, and Michelle L. Milne, LU '04.

The Theory of the Electromagnetic Field (originally published by Prentice-Hall, Englewood Cliffs, New Jersey, second printing, December, 1981), reprinted by Dover Publications with publication date of December, 2002. (ISBN 0-486-42567-3)

"Computation in Undergraduate Physics: The Lawrence Approach", in part 1 of *Computational Science–ICCS 2001*, ed. Vassil N. Alexandrov *et al.* (Springer, Berlin, 2001) [ISBN 3-540-42232-3], pp. 1074–1083. (The proceedings of the International Conference on Computer Science–2001.)

"Improving Physics at Lawrence", with J. R. Brandenberger, Lawrence Today **79**, 3 (Spring, 1999), pp. 20–23.

"Computers in the Lawrence Physics Curriculum–Part II", Comput. Phys. **11**(4; Jul/Aug, 1997), 331–335.

"Computers in the Lawrence Physics Curriculum–Part I", Comput. Phys. **11**(3; May/Jun, 1997), 240–245.

"A Comparison of Several Symbol-Manipulating Programs—Part II", with Russell Dubisch, Glenn Sowell, Patrick Tam, and Denis Donnelly, Comput. Phys. **6**(5; Sep/Oct, 1992), 530–540.

"A Comparison of Several Symbol-Manipulating Programs—Part I", with Russell Dubisch, Glenn Sowell, Patrick Tam, and Denis Donnelly, Comput. Phys. **6**(4; Jul/Aug, 1992), 411–420.

"Motion of a Taut String/Motion of a Square Membrane", with K. R. G. Hendrickson† and R. I. Rhodes†, Proceedings of the Workshop on Computational Physics at California State University–Fullerton, published in September, 1991, by California State University–Fullerton

Editor of and contributor to *Computing in Advanced Undergraduate Physics*, 240 pages, the proceedings of a conference held at Lawrence University, 13–14 July 1990, published in November, 1990, by Lawrence University

"Computational Exercises for the Upper-Division Undergraduate Physics Curriculum", Comput. Phys. **4**(3; May/June), 308–313 (1990)

"Introducing Computational Tools in the Upper-Division Undergraduate Physics Curriculum", Comput. Phys. **4**(2; Mar/Apr), 197–201 (1990)

"The Computer: Lawrence's Teacher of the Year?", Lawrence Today **63**, 4 (Summer, 1983), pp. 2–6

Videotaped Problem Solutions for Introductory Physics, Am. J. Phys. **50**, 268–269 (1982)

The Theory of the Electromagnetic Field (Prentice-Hall, Englewood Cliffs, New Jersey, second printing, December, 1981)

"Illustrative Problems in Physics / Selected Topics in Physics", Directory of Video Tape Library, Lawrence University, September 1980.

The Theory of the Electromagnetic Field, 510 + xvii pages, and *Teachers' Manual*, 167 pages (Prentice-Hall, Englewood Cliffs, New Jersey, 1975)

Instructor's Manual to accompany J. B. Brackenridge and R. M. Rosenberg's *The Principles of Physics and Chemistry*, with several Lawrence faculty members (McGraw-Hill Book Co., New York, 1973, 276 pages).

Comment on "Analog Computer Simulation in Physics", Am. J. Phys. **40**, 210–2 (1972).

"Radiation from Charged Particles in Weakly Inhomogeneous Magnetic Fields", J. Plasma Phys. **6** (part 1), 33–51 (1971).

Editor and Contributor to *Computer Oriented Physics Problems* (Commission on College Physics, 1971) 119 pages.

"Trajectory of Charged Particles in Weakly Inhomogeneous Magnetic Fields", J. Math. Phys. **11**, 986–994 (1970).

"Least Squares Fitting of Data to Pseudolinear Relationships", with W. R. Steinbach†, Am. J. Phys. **38**, 751–4 (1970).

"Some
Electrical Properties of ZnTe-CdS Heterojunctions", with M. Aven, J. Appl. Phys. **32**, 960–1 (1961).

PAPERS AND TALKS:

"A Flexible Text in Computation for Undergraduate Physics Majors", Contributed paper presented at the summer meetings of the American Association of Physics Teachers in Sacramento, CA, 4 August 2004. The abstract for this paper was published in the *AAPT Announcer*, Volume 34, No. 2, pg. 178 (Summer, 2004).

"Computation in Undergraduate Physics: The Lawrence Approach", Poster presented at the summer meetings of the American Association of Physics Teachers in Sacramento, CA, 3 August 2004. The abstract for this paper was published in the *AAPT Announcer*, Volume 34, No. 2, pg. 131 (Summer, 2004).

"The Physics of Music", presented as a talk/workshop for students of middle and high school age in the summer piano camp at the Lawrence Academy of Music (21 July 2004)

"Computation in Undergraduate Physics: The Lawrence Approach", Invited paper presented at the March meeting of the American Physical Society in Montreal, Quebec, 25 March 2004. At the same session, the author also participated as a panelist on the topic of computation in the undergraduate curriculum.

"The Lawrence Workshop on Computation in Upper-Level Undergraduate Physics", Contributed paper presented at the summer meetings of the American Association of Physics Teachers in Rochester, NY, 23 July 2001. The abstract for this paper was published in the *AAPT Announcer*, Volume 31, No. 2, pg. 80 (Summer, 2001).

"Computation in Undergraduate Physics: The Lawrence Approach", Invited paper presented in a session titled *Computational Physics in the Undergraduate Curriculum* at the *International Conference on Computer Science–2001* in San Francisco, CA, 30 May 2001.

"Strengthening Undergraduate Physics at Lawrence University", Invited paper presented in a session titled *Recruiting and Retaining Undergraduate Physics Majors* at the April meetings of the American Physical Society in Washington, DC, 30 April 2001. The abstract for this paper was published in the *Bulletin of the American Physical Society*, Volume 46, No. 2, pg. 117 (April, 2001).

"Preparing Sophomores to Use Computation Independently as Juniors and Seniors", Invited paper presented at the winter meetings of the American Association of Physics Teachers in San Diego, CA, 8 January 2001. The abstract for this paper was published in the *AAPT Announcer*, Volume 30, No. 4, pg. 79 (Winter, 2000).

"The Physics Behind the Musical Scale", Physics colloquium presented at Vassar College, 3 November 2001.

"Strengthening Computation in Upper-Level Undergraduate Physics Programs", Contributed paper presented at the summer meetings of the American Association of Physics Teachers at the University of Guelph, Guelph, Ontario, 31 July 2000. The abstract for this paper was published in the *AAPT Announcer*, Volume 30, No. 2, pg. 74 (Summer, 2000).

“Adding Laboratories to a Course in Physics of Music”, Contributed paper presented at the summer meetings of the American Association of Physics Teachers, San Antonio, TX, 7 Aug 1999; abstract published in AAPT Announcer **29**, No. 2, 133, (Summer 1999).

“The Traditional and the Novel in Undergraduate Science Instruction”, presented in the series ‘Lunch at Lawrence’ to friends of Lawrence University, 14 May 1998.

“Physics at Lawrence: Improving a Departmental Program” (with M. R. Stoneking), presented to the Lawrence Faculty in the third Food For Thought Session on 21 April 1998.

“Physics at Lawrence: A Case Study of Improvement” (with J. R. Brandenberger), invited paper presented at the Physics Revitalization Conference: Building Undergraduate Physics Programs for the 21st Century held 2-4 October 1998, sponsored by the American Association of Physics Teachers, the American Physical Society, the American Institute of Physics, and Project Kaleidoscope, and supported by the National Science Foundation.

“The Computer-Based Components of the Lawrence Physics Curriculum”, Invited paper presented at the summer meetings of the American Association of Physics Teachers, College Park, MD, 7 Aug 1996; abstract published in AAPT Announcer **26**, No. 2, 58, (July 1996)

“Treating Partial Differential Equations in the Undergraduate Physics Curriculum”, Contributed paper presented at the summer meetings of the American Association of Physics Teachers, Spokane, WA, 12 Aug 1995; abstract published in AAPT Announcer **25**, No. 2, 105, (July 1995)

“Sample Uses of Computer Algebra in the Undergraduate Physics Curriculum”, Invited paper presented at the summer meetings of the American Association of Physics Teachers, Boise, ID, 11 Aug 1993; abstract published in AAPT Announcer **23**, No. 2, 92, (July 1993)

“Experiences with Computer Algebra in the Undergraduate Physics Curriculum”, Invited paper presented at the summer meetings of the American Association of Physics Teachers, Orono, ME, 14 Aug 1992; abstract published in AAPT Announcer **22**, No. 2, 92, (July 1992)

“Using Computational Tools in Upper Division Theoretical Physics”, Invited talk delivered at Davidson Conference on Computational Physics, Davidson Collage, Davidson, NC (3 October 1991)

“Using Computational Tools in the Upper-Division Theoretical Physics Curriculum”, Physics colloquium delivered at Michigan Technological University, Houghton, MI (12 September 1991)

“Computational Tools in the Upper-Division Theoretical Curriculum”, Invited talk presented at the spring meeting of the Pacific Northwest Association for College Physics, University of Puget Sound, Tacoma, WA (6 April 1991)

“The Sloan/Lawrence Conference on Using Computers in Upper-Division Theoretical Physics: 13–14 July 1990”, Invited paper delivered at the winter meetings of the American Association of Physics Teachers, San Antonio, Texas (21 January 1991); abstract published in AAPT Announcer **20**, No. 4, 37, (December, 1990)

"Using Computational Tools in the Upper-Division Theoretical Physics Curriculum", Physics colloquium delivered at the University of Wisconsin–Eau Claire (12 October 1990)

"Computational Tools in Intermediate Electromagnetic Theory", Contributed paper presented at the summer meetings of the American Association of Physics Teachers, Minneapolis, MN, 30 June 1990; abstract published in AAPT Announcer **20**, No. 2, 84, (May 1990)

"Computational Physics in the Upper-Division, Undergraduate Curriculum", presented as a physics colloquium at Hope College, Holland, Michigan, on 1 November 1989

"Building the Expertise of Undergraduates in Computational Physics", presented as a physics colloquium at University of Nebraska (Lincoln), 27 September 1989; presented as a physics colloquium at Kansas State University (Manhattan) 28 September 1989

"Building the Expertise of Undergraduates in Computational Physics", Invited paper presented at the summer meetings of the American Association of Physics Teachers, San Luis Obispo, CA, 30 June 1989; abstract published in AAPT Announcer **19**, No. 2, 80, (May 1989)

"The Response of Liberal Arts Curricula to Modern Computing", presented on 28 October 1983 at the ACM Wingspread Conference on Computers in the Undergraduate Curriculum.

"Video-Taped Problem Solutions for Introductory Physics", presented at meeting of the American Association of Physics Teachers, Troy, NY, 27 June 1980; AAPT Announcer, Vol. **10** (#2), 99 (May, 1980). Presentation included showing sample tapes in another session at the same meeting.

"Gravity from Newton to Einstein", presented in the Einstein Centenary, Lawrence University, 14 May 1979.

"General Relativity: Gravity = Geometry", presented as a Physics Seminar, Lawrence University, 1 March 1979.

"The Lawrence CAUSE Grant", presented to Academic Committee of Lawrence Trustees, 28 October 1978; to the President's Forum at Lawrence, 14 December 1978; to the Lawrence Business and Professional Group, 20 April 1979.

"On Particle Orbits in a Time Varying Magnetic Field", with H. C. S. Hsuan, presented at meeting of Division of Plasma Physics of American Physical Society, Madison, 16 Nov 1971; Bull. Am. Phys. Soc. Series II, Vol. **16**, 1253 (1971).

"Least Squares Fitting to Pseudolinear Relationships", presented at meeting of Wisconsin Section of American Association of Physics Teachers, Oshkosh, 7 May 1971.

A.4 . . . Matthew R. Stoneking

Education:

Ph.D. in physics, University of Wisconsin-Madison, Madison, WI, May 1994. Dissertation: *Fast Electron Generation and Transport in a Turbulent, Magnetized Plasma* Thesis Advisor: Samuel Hokin

B.A. in physics, Carleton College, Northfield, MN, June 1989.

Professional Experience:

Associate Professor, Lawrence University, 2003–present
Assistant Professor, Lawrence University, 1997–2003
Post-Doctoral Research Associate, University of Wisconsin–Madison, 1995–97
Lecturer, University of Wisconsin–Whitewater, 1994–95
Research Assistant, University of Wisconsin–Madison, 1990–93,1994
Teaching Assistant, University of Wisconsin–Madison, 1993
Demonstrator, University of Wisconsin–Madison, Wonders of Physics Show 1990–94
Instructor, University of Wisconsin–Madison, Summer Enrichment Program 1991–93
Research Intern, 3M Company, St. Paul, Minnesota, summer 1989
Laboratory Assistant/Physics Tutor, Carleton College, 1987–89
Research Intern, Eastman Kodak Company, Rochester, NY, summer 1988

Honors:

Nominated for Outstanding Academic Staff teacher at UW–Whitewater (1995)
Department of Education Fellow at the University of Wisconsin (1989–90, fall 1991)
Graduated Magna Cum Laude, Carleton College (1989)
Inducted into Phi Beta Kappa honor society (1989)
Inducted into Sigma Xi science honor society (1989)

Professional Associations: Member of the American Physical Society, Division of Plasma Physics

Grant Support:

Toroidal Confinement of Pure Electron Plasmas, NSF/U.S.Dept. of Energy Joint Partnership in Basic Plasma Sciences and Engineering for $178,000 (2003-2006).

Toroidal Magnetic Confinement of a Pure Electron Plasma, Plasma Physics Junior Faculty Development Award from the U.S. Department of Energy, Office of Fusion Energy Sciences for $225,000 (1998-2003).

Toroidal magnetic confinement of a pure electron plasma, Cottrell College Science Award from Research Corporation for $37,000 (1998-2000).

Invited Talks:

"Millisecond Confinement and Observation of the $m = 1$ Diocotron Mode in a Toroidal Electron Plasma", Workshop on Non-neutral Plasmas, Santa Fe, NM, 11 July 2003.

"Electron Plasma Confinement in a Partially Toroidal Trap", Workshop on Non-neutral Plasmas, San Diego, CA, 2 August 2001.

"Fivefold Confinement Time Increase in MST using Inductive Poloidal Current Drive", American Physical Society, Division of Plasma Physics Meeting, Denver, CO 14 November, 1996.

"Transport in MST: present understanding and remaining questions", International RFP Workshop, Madison, Wisconsin, 14 October, 1996.

"Confinement Improvement with Inductive Poloidal Current Drive in MST", Ninth Transport Task Force Workshop, Philadelphia, PA 13 March, 1996.

"Particle Transport Due to Magnetic Fluctuations in MST", Edge Turbulence Workshop, University of Texas, Austin, Texas, 27-28 October, 1992.

Colloquia, Seminars, and Public Lectures

“Einstein’s 1905 Paper on Brownian Motion” physics colloquium, Lawrence University, 20 January 2005.

“Non-neutral Plasma Physics at UC San Diego and at Lawrence University”, physics colloquium, Lawrence University, 9 November 2004.

“Feedback Suppression of the $m = 1$ Diocotron Mode in a Toroidal Electron Plasma”, plasma physics group meeting talk, University of California–San Diego, 8 July 2004.

“Toroidal Confinement of Non-neutral Plasmas”, plasma physics group meeting seminar, University of Wisconsin - Madison, 17 December 2003.

“Poloidal ExB Drift Used as an Effective Rotational Transform in a Toroidal Electron Plasma”, Plasma Physics Colloquium, Department of Applied Mathematics and Applied Physics, Columbia University, 7 November 2003.

“Between a Clock and a Hot Place: Confining Electron Plasmas in a Toroidal Magnetic Field”, Science Hall Colloquium Series, Lawrence University, Appleton, Wisconsin, 26 February 2002.

Freshman Studies Lecture on *The Structure of Scientific Revolutions*, by Thomas Kuhn, 4 February 2002.

Freshman Studies Lecture on *The Structure of Scientific Revolutions*, by Thomas Kuhn, 5 February 2001.

“Toroidal Nonneutral Plasmas–Between a [Atomic] Clock and a Hot Place (fusion reactor core)”, Physics Colloquium Auburn University, Auburn, Alabama, 3 November 2000.

“Toroidal Pure Electron Plasmas, a progress report on experiments in the Lawrence Nonneutral Torus”, plasma physics group meeting, University of Wisconsin - Madison, 19 July 2000.

“Star in a Jar; Plasma Physics and Nuclear Fusion”, Lawrence University summer research seminar, Appleton Wisconsin, 30 June 1999, repeated 12 July 2000.

“A Tour of the Universe”, Lawrence University alumni event at Barlow Planetarium, UW Fox Valley, 19 May 1999.

“How I Got Here; A Tale of Contingency, Chaos and Quantum Physics”, Mortar Board First Chance/Last Chance Lecture Series, Lawrence University, Appleton Wisconsin 18 February 1999.

“Taming Turbulence in a Hot Plasma, Physics Colloquium, Lawrence University, Appleton Wisconsin, 10 February 1997.

“Taming Turbulence in the RFP: confinement improvement with current profile control in MST”, Plasma Physics Seminar Series, University of Wisconsin–Madison, 9 September, 1996.

“Turbulent Transport in a Hot, Magnetized Plasma”, Society of Physics Students, University of Wisconsin–Whitewater, 21 March 1995.

“Prospects for Fusion Power in the 21st Century”, Universe Theatre lecture series. University of Wisconsin–Whitewater, 11 November 1994.

“Particle Transport due to Magnetic Fluctuations in MST”, Plasma Physics Seminar Series, University of Wisconsin–Madison, 31 January, 1994.

"Fusion Research and Plasma Physics", Physics Colloquium, Texas Lutheran College, Seguin, Texas, 26 October 1992.

"Plasma Physics and Fusion Research at the University of Wisconsin–Madison", Physics Colloquium, Valparaiso University, Valparaiso, Indiana, 8 February, 1991.

Refereed Papers: *Undergraduate coauthors are indicated with a dagger.*

M. R. Stoneking, M. A. Growdon†, M. L. Milne†, and R. T. Peterson†, "Poloidal ExB drift used as an effective rotational transform to achieve long confinement times in a toroidal electron plasma", Phys. Rev. Lett. **92**, 095003 (2004).

T. M. Biewer, D. J. Den Hartog, D. J. Holly, and M. R. Stoneking, "Large area avalanche photodiode detector array upgrade for a ruby-laser Thomson scattering system", Rev. Sci. Instrum. **74**, 1649 (2003).

M.R. Stoneking, P.W. Fontana, R.L Sampson†, and D.J. Thuecks†, "Electron plasmas in a 'partial' torus", Phys. Plasmas **9**, 766 (2002).

B. E. Chapman, A. F. Almagri, J. K. Anderson, C.-S. Chiang, D. Craig, G. Fiksel, N. E. Lanier, S. C. Prager, J. S. Sarff, M. R. Stoneking, and P. W. Terry, "ExB flow shear and enhanced confinement in the Madison Symmetric Torus reversed-field pinch", Phys. Plasmas **5** 1848 (1998).

M. R. Stoneking, J. T. Chapman, D. J. Den Hartog, S. C. Prager, and J. S. Sarff, "Experimental scaling of fluctuations and confinement with Lundquist number in the reversed field pinch", Phys. Plasmas **5**, 1004 (1998).

B. E. Chapman, C.-S. Chiang, S. C. Prager, J. S. Sarff, and M. R. Stoneking, "Strong ExB flow shear and reduced fluctuations in a reversed-field pinch", Phys. Rev. Lett. **80**, 2137 (1998).

D. Craig, A. F. Almagri, J. K. Anderson, J. T. Chapman, C.-S. Chiang, N. A. Crocker, D. J. Den Hartog, G. Fiksel, S. C. Prager, J. S. Sarff, and M.R. Stoneking, "Enhanced confinement with plasma biasing in the MST reversed field pinch", Phys. Rev. Lett. **79**, 1865 (1997).

M. R. Stoneking, N. E. Lanier, S. C. Prager, J. S. Sarff, and D. Sinitsyn, "Fivefold confinement time increase in MST using inductive poloidal current drive", Phys. Plasmas **4**, 1632 (1997).

J. S. Sarff, N. E. Lanier, S. C. Prager, and M. R. Stoneking, "Increased confinement and beta by inductive poloidal current drive in the RFP", Phys. Rev. Lett. **78**, 62 (1997).

M. R. Stoneking and D. J. Den Hartog, "Maximum-likelihood fitting of data dominated by Poisson statistical uncertainties", Rev. Sci. Instrum. **68**, 914 (1997).

G. Fiksel, Roger D. Bengtson, M. Cekic, D. Den Hartog, S. C. Prager, P. Pribyl, J. Sarff, C. Sovinec, M. R. Stoneking, R. J. Taylor, P. W. Terry, G. R. Tynan, and A. J. Wootton, "Measurement of magnetic fluctuation-induced heat transport in tokamaks and RFP", Plasma Phys. Control. Fusion **38**, A213 (1996).

P. W. Terry, G. Fiksel, H. Ji, A. F. Almagri, M. Cekic, D. J. Den Hartog, P. H. Diamond, S. C. Prager, J. S. Sarff, W. Shen, M. Stoneking, and A. S. Ware, "Ambipolar magnetic fluctuation-induced heat transport in toroidal devices", Phys. Plasmas **3**, 1999 (1996).

M. R. Stoneking, S. A. Hokin, S. C. Prager, G. Fiksel, H. Ji, and D. J. Den Hartog, "Particle transport due to magnetic fluctuations", Phys. Rev. Lett. **73**, 549 (1994).

G. Fiksel, S. C. Prager, W. Shen, and M. Stoneking, "Measurement of magnetic fluctuation induced energy transport", Phys. Rev. Lett. **72**, 1028 (1994).

S. Hokin, A. Almagri, M. Cekic, B. Chapman, N. Crocker, D. J. Den Hartog, G. Fiksel, J. Henry, H. Ji, S. Prager, J. Sarff, E. Scime, W. Shen, M. Stoneking, and C. Watts, "Reversed-field pinch studies in the Madison Symmetric Torus", J. of Fusion Energy **12**, 281 (1993).

J. S. Sarff, S. Assadi, A. F. Almagri, M. Cekic, D. J. Den Hartog, G. Fiksel, S. A. Hokin, H. Ji, S. C. Prager, W, Shen, K, L, Sidikman, and M, R, Stoneking, "Nonlinear coupling of tearing fluctuations in the Madison Symmetric Torus", Phys, Fluids B **5**, 2540 (1993).

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A.5 ... James O. Dunn

EDUCATION:	B.S. (Physics), University of Illinois (May 1997) Ph.D. (Physics), University of North Carolina (May 2003)
PH.D. DISSERTATION:	"Dark Energy Parameters from Type Ia Supernovae Number Counts and the Cosmic Microwave Background Anisotropy" (Advisor: Professor Paul Frampton)

TEACHING EXPERIENCE

Visiting Assistant Professor of Physics, Lawrence University, Appleton, WI, 2004–

- Courses taught in Fall 2004:
  - Physics 120: Foundations of Physics I (lectures)
  - Physics 120: Foundations of Physics I (two lab sections)
- Courses taught in Winter 2005
  - Physics 410: Advanced Mechanics
  - Physics 150: Principles of Classical Physics (one lab section)
- Courses taught in Spring 2005:
  - Physics 230: Intermediate Electromagnetic Theory

Visiting Assistant Professor of Physics and Astronomy, Hampden-Sydney College, Hampden-Sydney, VA, 2003–2004

- Courses taught in Fall 2003:
  - Astronomy 105: Astronomy of the Solar System
  - Astronomy 145: Astronomy Laboratory
  - Physics 311: Modern Physics
  - Physics 151: Physics Laboratory
- Courses taught in Spring 2004:
  - Astronomy 106: Stellar, Galactic, and Extragalactic Astronomy
  - Astronomy 146: Astronomy Laboratory
  - Physics 411: Thermodynamics and Statistical Physics

Instructor, University of North Carolina at Chapel Hill, Spring 2003

Taught introductory non-calculus based physics course in classical mechanics and thermodynamics.

Teaching Assistant, University of North Carolina, Fall 1998 to Fall 2002

Taught introductory undergraduate physics labs in mechanics and electromagnetism, including honors sections. Also taught non-calculus based labs for non-major students. Graded for undergraduate quantum mechanics and particle physics classes. Graded for graduate classical mechanics, statistical mechanics and electrodynamics. Taught recitation sections for introductory calculus-based electromagnetism course.

Additional Teaching Experience, University of North Carolina

Conducted review sessions for 2002 Ph.D written examinations. Worked in physics tutorial center. Served as teaching mentor for first year graduate student.

Teaching Assistant, Notre Dame University, Fall 1997 and Spring 1998

Taught introductory physics labs. Grader for introductory cosmology course.

Lab Instructor, University of Illinois at Urbana-Champaign, Fall 1995 to Spring 1997

Served as computer lab instructor and grader for calculus and differential equations courses taught using Mathematica.

Publications

J.L.Crooks, J.O.Dunn, P.H.Frampton, H.R. Norton, and T. Takahashi, "Cosmic Degeneracy with Dark Energy Equation of State", Astropart.Phys. **20** (2003) 361-367. [arXiv:astro-ph/0305495].

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J.L.Crooks, J.O.Dunn and P.H.Frampton, "Relic Neutrinos and Z-Resonance Mechanism for Highest-Energy Cosmic Rays", Astrophys. J. 546, L1 (2001) [arXiv:astro-ph/0002089].

Papers Presented

"Studies in Quintessence", Coral Gables in High Energy Physics and Cosmology, Fort Lauderdale, Florida, December 12-16, 2001.

Summer schools and conferences attended

Prospects in Theoretical Physics, Institute for Advanced Study, Princeton, July 1-14 2003.

TASI 2000, Flavor Physics for the Millennium, Boulder, Colorado, June 2-29, 2000.

Particles, Strings and Cosmology (PASCOS) 2001, Chapel Hill, North Carolina, April 10-15, 2001.

Honors and Awards

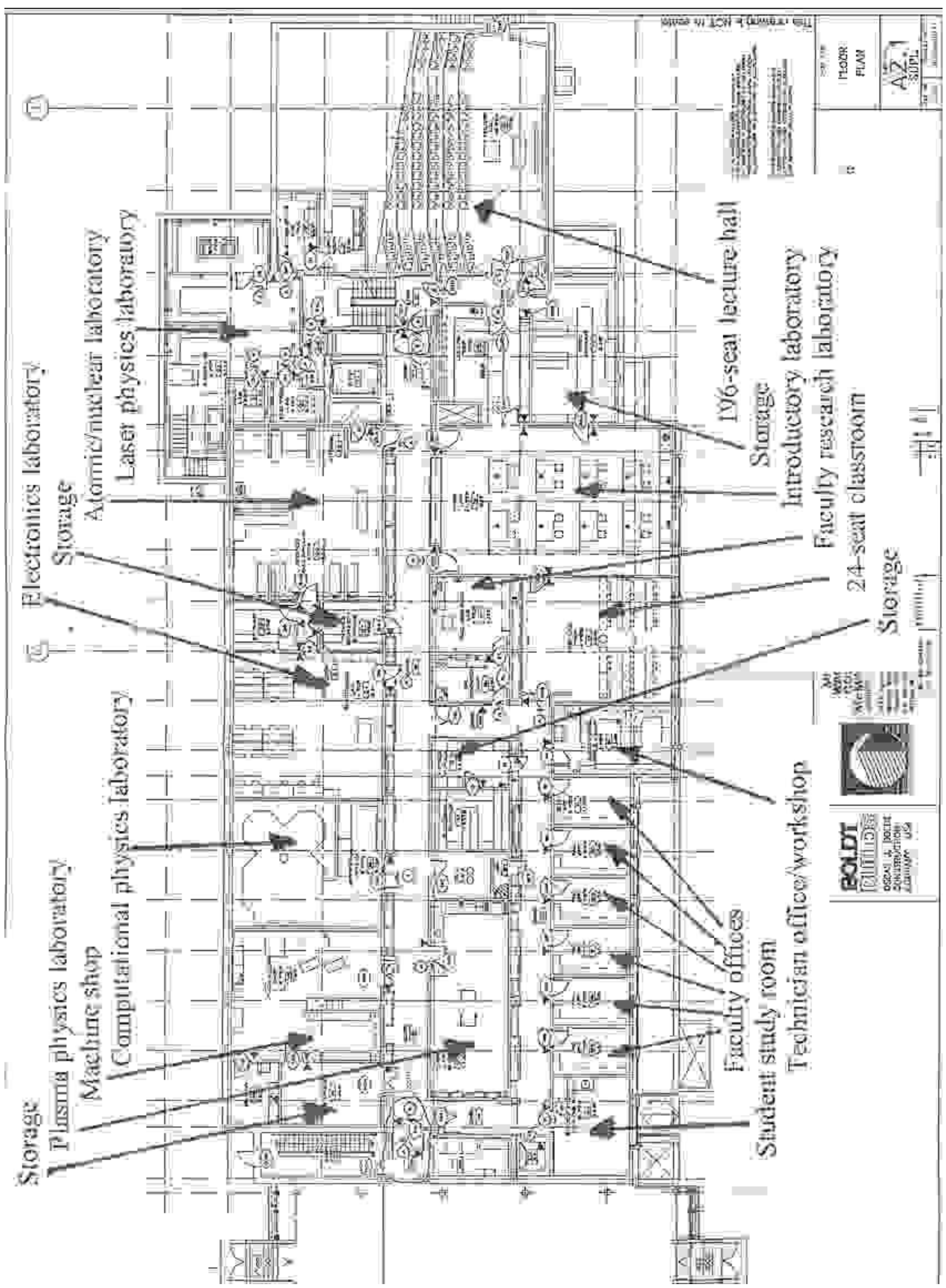
National Merit Scholar 1993

President's Award 1995-1997, University of Illinois

B Floor Plan of Departmental Spaces

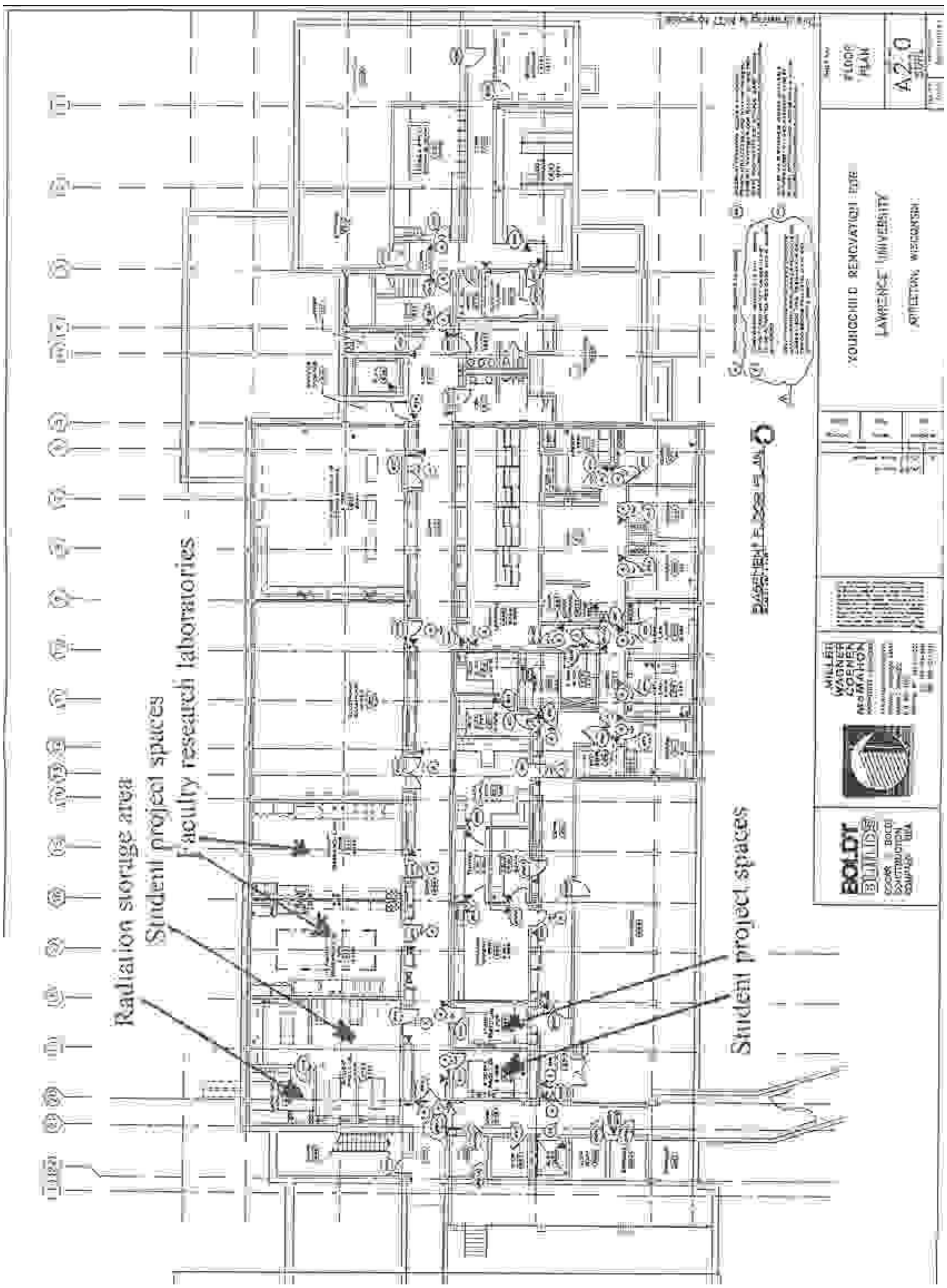
B.1 First Floor of Youngchild Hall

This floor of Youngchild Hall contains most of the territory of the Department of Physics, including faculty offices, introductory, signature, and advanced laboratories, storage spaces, one faculty research laboratory, and student study spaces.



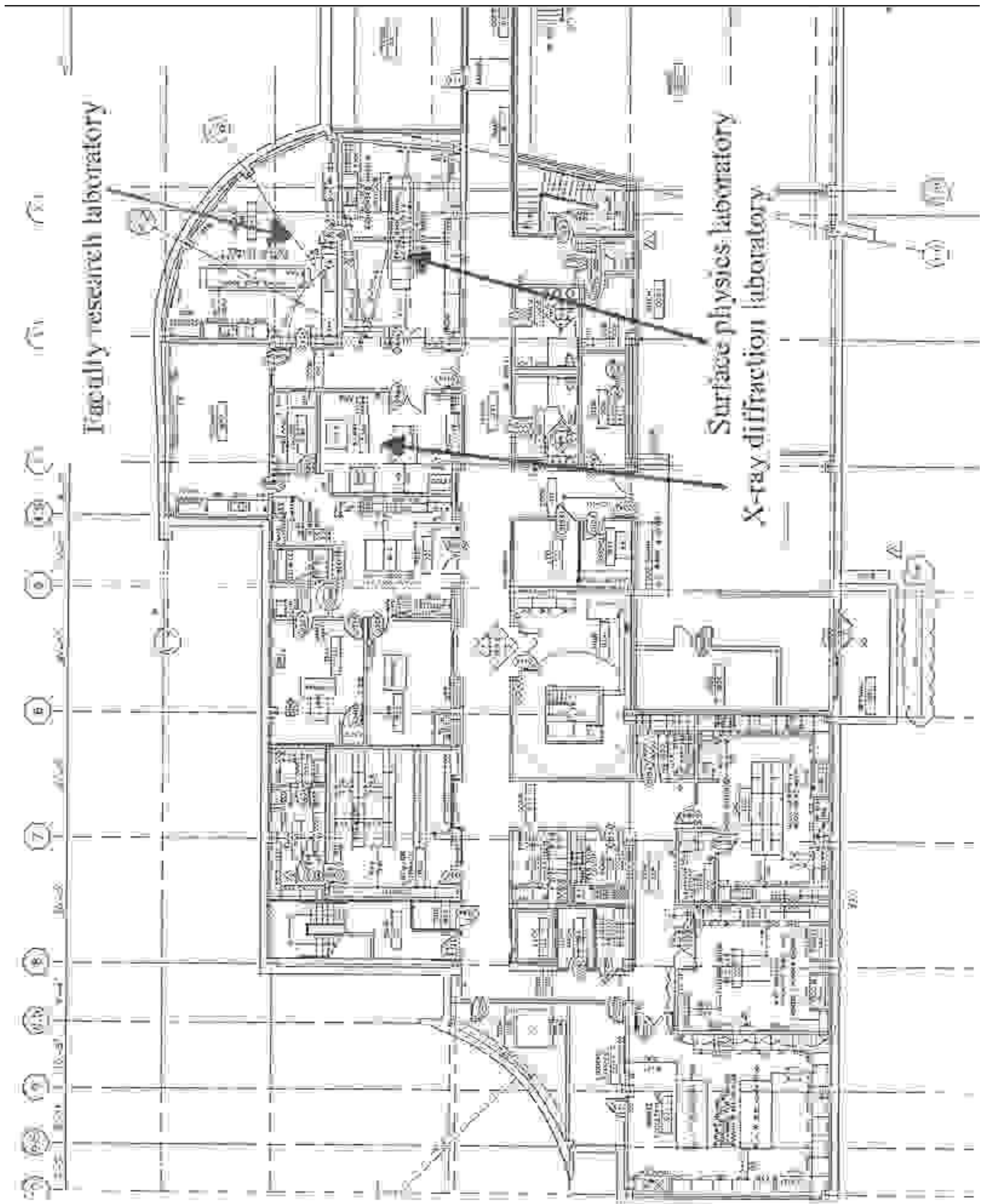
B.2 Basement of Youngchild Hall

Immediately below our main terrority on the first floor, departmental spaces include two faculty research laboratories and spaces for up to about ten student projects, including desks for theoretically inclined students.



B.3 Basement of New Science Building

The basement of New Science Building is a short tunnel away from the basement of Youngchild and contains one faculty research laboratory, one signature laboratory, and the room housing our x-ray diffractometer.



C Signature Laboratories

As discussed in Section 2, signature programs have played a crucial role in the growth of the Department of Physics at Lawrence. Each of these programs is supported by a well-equipped signature laboratory. In this appendix, we describe the three programs currently in existence, the first two of which (laser physics and computational physics) have enriched our program since the late 1980s and the third of which (surface physics) was begun in the last half-dozen years. We anticipate a fourth signature program (plasma physics) to be initiated in the next several years.

C.1 Laser Physics Laboratory

In the mid 1980's, the Department of Physics at Lawrence University recognized the widespread and growing importance of lasers in scientific research and industry but the near absence of exposure to this tool in undergraduate physics programs around the country. In response, we raised about $330K from the General Electric Foundation, the W. M. Keck Foundation, the National Science Foundation, the J. N. Pew, Jr., Charitable Trust, the Alfred P. Sloan Foundation, Coherent, Tektronix, and numerous other vendors of equipment to conduct a pilot project that explored ways to incorporate the use of lasers into undergraduate physics curricula. In support of this venture, we built the Lawrence Laser Laboratory, which gives students access to a large array of laser equipment and associated instruments and supports the performance of a rich spectrum of experiments, some of which explore the laser in its own right and some of which use lasers in the study of various physical phenomena. Beyond constructing the facility itself, this project has resulted in the development of three new courses:

- *Light! More Light!* (Goethe's exclamation and the Lawrence watchword), a low-level course (no prerequisites other than "scientific curiosity") for non-majors that examines our current understanding of light, wave-particle duality, the classical and quantum descriptions of light, the interaction of light with matter, and the basic properties of lasers and laser radiation.

- *Lasers in the Natural Sciences*, an intermediate-level course for non-majors that requires only modest prior exposure to science and emphasizes applications of lasers to physics, chemistry, and the life sciences.

- *Laser Physics*, a senior-level physics course (with prerequisites in electricity and magnetism, optics, and quantum mechanics) that addresses the fundamental mechanisms of lasers at an advanced level.

In addition, this facility plays a key role in our advanced laboratory course and our annual recruiting workshops for prospective physics majors. The laser pilot project has received national attention, being described in the several publications and invited talks enumerated in Section C.1.3. Its existence served as the basis for convening a small national conference at Lawrence (supported by the Sloan Foundation), and it supported two one-week faculty enrichment workshops (supported by the National Science Foundation) for members of the physics faculties of colleges and universities around the country.

In this section, we enumerate the several experiments now available to Lawrence students, and we catalog the hardware that has been assembled in support of these endeavors.

C.1.1 Experiments Available

Following is a list of the specific experiments currently available in the Lawrence laser facility:

- Laser Assembly and Cavity Stability
- Polarization of Laser Beams
- Use of a Spectrum Analyzer
- Transverse Character of Laser Beams
- Interference of Light
- Tunable Diode Laser System and Optovoltaic Spectroscopy
- Saturated Absorption Laser Spectroscopy
- Quantum Beats and Time-Resolved Laser Spectroscopy
- Second Harmonic Generation
- Optogalvanic Laser Spectroscopies
- Faraday Rotation
- Holography
- Polarization Spectroscopy
- Optical Zeeman Effect
- Laser Heterodyning
- Raman spectroscopy
- Populational Dynamics in a HeNe Discharge

C.1.2 Hardware Assembled

Students and faculty members in physics at Lawrence have access to the following assemblage of lasers and measuring instruments for the performance of experiments involving lasers:

Lasers

20	HeNe 1–5 mW, red, yellow, green
6	HeNe 3 mW, open frame (custom design, homebuilt)
1	Ar^+ ion and CW dye, Coherent Innova 70-4, CR-599-01
20	Tunable Diode laser system (custom design, homebuilt)
800	Diode laser, 5 mW, Mitsubishi, Sharp, Sony, Sanyo
2	Nitrogen laser, pulsed (custom design, homebuilt)
5	Pulsed dye laser (custom and commercial)
1	Ruby laser (pulsed)

Optical Equipment

3	Spectrum analyzer/controller, 7.5 GHz, Coherent 240/251, (ranges 550–650 nm, 650–775 nm, 750–875 nm)

1	Spectrum analyzer, Spectra-Physics 470-04, 550–650 nm
6	Plane-parallel Fabry-Perot (custom design, homebuilt)
5	Wavemeter, Burleigh Wavemeter jr, WA-2000, and Coherent Wavemaster
4	Laser power meter, Coherent 212 and Melles Griot
1	Laser power meter, Coherent 210
10	Photomultiplier tube, RCA 4840, Hamamatsu R212
8	PMT mount and housing (custom and commercial)
5	Monochromator, Spex 1401, Spex 1870, Cary 14 (modified), Beckman DU and Seiss (modified)
1	Holography kit, Newport HL-1 and HL-1A (less platform)
1	Fibre optics Kit, Pocatek KOP-100
4	IR beam probe, Optical Engineering, 24-3
1	IR viewer, FJW 84499 with visible filter
100	Miscellaneous mirror and lens mounts, Newport and custom
1	Iodine cell, Opthos
5	Rubidium and Cesium cell, Opthos
8	Neon, Krypton, and Xenon cell, Opthos and custom
1	Spatial filter, Newport 910-B
1	Sodium cell/oven, Klinger NA6046/KA6041
2	Rubidium hollow cathode lamp, Hamamatsu L233-37NB
8	Assorted optical breadboards
1	Optical table, 4'x6'x8" top and leg set, TMC
1	Optical top, granite slab 2.5'x4'x4.5" thick; 500 lb
250	Mirrors, beamsplitters, lenses; Newport, Edmunds, Virgo
200	Optical screw, sleeve, knob
5	Safety goggles, various types
50	Neutral density filters
15	Silicon PIN detectors
20	Interference filters
1	Beam expander telescope, X5, Spindler, Hoyer
20	Piezo transducers

Electronic Instrumentation

1	Frequency synthesizer, Hewlett-Packard
3	Digital oscilloscope, Tektronix 2432A, cart, Tektronix 340A
2	Fast/bright analog oscilloscope, Tektronix 2467, cart, camera
5	Lock-in amplifier, Stanford Research and PAR
1	Photon counter, Stanford Research SR400
1	Fast preamplifier, Stanford Research SR440
2	Chopper and controller, Stanford Research SR540
10	Frequency counter, Hewlett-Packard, Fluke
2	GPIB interface package, Tektronix GURU II+
4	X-Y recorder, Hewlett-Packard 7035B
3	Digital plotter, Tektronix HC 100
5	Microcomputer, IBM PS/2
1	RF spectrum analyzer, Tektronix

C.1.3 Publications and Talks

- "From Feasibility to a Focus on Laser Physics", invited address by J. R. Brandenberger at 1991 Annual Meeting of AAAS, Washington, D.C. (Feb. 18, 1991).
- "Lasers at Lawrence: A Nexus for Teaching and Research", invited address by J.R. Brandenberger at Project Kaleidoscope National Colloquium, Washington, D.C. (Feb. 4-5, 1991).
- "Lasers and Modern Optics in Undergraduate Physics—A Report to Foundations, Corporations, and Undergraduate Colleges", J. R. Brandenberger, September, 1989.
- "Laser Physics and Modern Optics in Liberal Arts Colleges", proceedings of Sloan Conference held at Lawrence University; edited by J. R. Brandenberger (1987).

C.2 Computational Physics Laboratory

In 1987, convinced that the scientific careers of its majors would be significantly enhanced by a broad exposure to computational approaches to problems in physics, the Department of Physics at Lawrence successfully sought support amounting to about $400K from the W. M. Keck Foundation, the National Science Foundation, and several vendors to conduct a pilot project designed to nurture both the personal initiative and the individual skills to use sophisticated computational tools intelligently and independently. To this end, we have created the Lawrence Computational Physics Laboratory, which gives 35 or so physics majors each year (typically 10 seniors, 10 juniors, 15 sophomores) and five faculty members exclusive 24-hour per day access to an impressive collection of computational hardware and software as well as a library of pertinent manuals, text books, and locally prepared documents. In addition, we have engaged in faculty development, and—most importantly—we have embedded numerous computer-based classroom demonstrations and homework exercises in many of our upper-level offerings, thereby encouraging and supporting continued independent use both in our junior/senior courses and in senior-level independent studies. This pilot project has received national attention, being described in several published papers and invited talks (see Section C.2.5). Its existence served as the basis for convening a small national conference (Summer, 1990) at Lawrence (supported by the Sloan Foundation), and it has stimulated several individual visits to the Lawrence campus.

In 1993, additional funds amounting to about $150K were received from the National Science Foundation and the W. M. Keck Foundation to permit addition of 3D graphics capabilities and color printing capabilities to the Computational Physics Laboratory initially equipped by the grants received in 1987 and 1988.

In 1998, grants from Lawrence University allowed us to begin replacing the oldest SGI equipment with up-to-date SGI equipment. This process will be ongoing, two or three older units being replaced each year with state-of-the-art equipment.

In early 2000, a grant of $177 (supplemented in 2003 with an additional $3781) from the Educational Materials and Development (EMD) track of the Course, Curriculum and Laboratory Improvement (CCLI) Program of the National Science Foundation provided support for Professor Cook to collect numerous local instructional documents into a text and conduct at Lawrence four week-long summer workshops for physics faculty members from around the United States. The resulting book, titled *Computation and Problem Solving in Undergraduate Physics* (*CPSUP*), is flexible in design. Through the inclusion of components using selected software packages, the book can be adapted to respect the particular hardware and software available at specific institutions. Details can be found at the URL `http://www.lawrence.edu/dept/physics/ccli`.

In December, 2001, the Department received a third grant from the W. M. Keck Foundation. Of the $400K total grant, $107 was allocated to further development of the Computational Physics Laboratory. The primary objectives of this infusion were to introduce a *required* sophomore course in computation and mechanics, to introduce an elective junior/senior course in computational physics, and to increase the extent to which computational resources are used throughout the physics curriculum at Lawrence. In anticipation of increased use generated by those changes in our curriculum, the grant supported an expansion of the total number of workstations in the laboratory and an upgrading of the server, the existing workstations, and the printers.

In the remainder of this section, we enumerate the current spectrum of hardware and the most frequently used pieces of software and list the several papers and presentations that have arisen in the context of developing this resource and writing *CPSUP*.

C.2.1 Hardware

Students and faculty members in physics at Lawrence have access to the following networked computer hardware:

- 1 SGI Origin200 Dual-Processor Server (640 MB memory, 52 GB disk capacity, five-cassette stacker, DAT tape drive, CD ROM)
- 5 SGI O2 Workstations (576 MB memory, 4 GB system disk, CD reader)
- 4 SGI O2+ Workstations (512 MB memory, 18 GB system disk, CD reader)
- 1 HP 4200DTN Laserjet monochrome PostScript Printer
- 1 Tektronix Phaser 350 Color PostScript Printer
- 1 Gateway Windows 2000 PC
- 1 SGI 540 NT Workstation (256 MB memory, 9 GB system disk, 18 GB second disk, DAT tape drive, CD-ROM)

Most of this hardware equips the Lawrence Computational Physics Laboratory (the CPL), which is housed in a single, attractively decorated, quiet, well lighted, and inviting room of about 1200 square feet, to which, because we issue keys, upper-division physics majors have 24-hour access.

C.2.2 Main Software

Available software in the Computational Physics Laboratory reflects a deliberate focus on professionally-developed packages and, in addition to operating systems [SGI UNIX (IRIX), Windows-2000), windowing systems (X, Windows), system utilities, language compilers (C, C++, FORTRAN), graphics support (IDL, MAPLE, IRIS/NAG Explorer, Kaleidagraph), spreadsheet (EXCEL), and text editors (jot, xemacs, nedit, notepad, pfe), includes the following primary items:

- MACSYMA (vendor now out of business)—for doing algebra and calculus symbolically.
- MAPLE (from Waterloo MAPLE Software, Inc.)—for doing algebra and calculus symbolically.
- IDL (Interactive Data Language, from Research Systems, Inc.)—for processing arrays, producing graphical displays (including animated displays), and processing and displaying images.
- IRAF (Image Reduction and Analysis Facility, from the National Optical Astronomy Observatories)—for reduction and analysis of astronomical data.
- DSS2 (from Lehigh University)—for solving ordinary and partial differential equations numerically.
- NUMERICAL RECIPES (from Numerical Recipes Software)—FORTRAN and C subroutines for doing numerical analyses.
- SPICE (from the University of California Berkeley)—for designing and analyzing electronic circuits.
- IRIS/NAG EXPLORER (from Numerical Algorithms Group, Inc.)—for examining two- and three-dimensional graphical images.
- NCAR GRAPHICS (from National Center for Atmospheric Research)—subroutines for creating two- and three-dimensional graphics displays.
- MARC/MENTAT (from MSC Software)—for setting up and solving problems in heat flow, structures, elasticity, and electromagnetics with finite element methods.
- TeX and LaTeX (from Stanford University)—for preparing technical manuscripts.

We also have single licenses for MATLAB (from the MathWorks, Inc.) and *Mathematica* (from Wolfram Associates, Inc.).

C.2.3 The CPL Library

Beyond the hardware and software in the CPL, students have access to a small library of printed materials, including an assortment of software manuals, a selection of books on computational approaches to problems in physics, and notebooks containing about 60 student-written 5–25 page documents detailing computationally based studies undertaken by students at Lawrence. While these documents are still available, many have been superceded by the book *Computation and Problem Solving in Undergraduate Physics* already mentioned. More of them will experience that evolution as our curriculum and the text evolve.

C.2.4 Network Connections

All workstations in the CPL are connected to the University network and, through a firewall, have access to the world wide web.

C.2.5 Publications and Talks

- D. M. Cook, *Computation and Problem Solving in Undergraduate Physics* (Lawrence University Press, Appleton, WI 2004). Information about this book and details regarding examination copies and orders can be found at the URL `http://www.lawrence.edu/dept/physics/ccli`.
- D. M. Cook, "Computers in the Lawrence Physics Curriculum: Part I", *Computers in Physics* **11** (3; May/Jun), 240–245 (1997); "..., Part II", *Computers in Physics* **11** (4; Jul/Aug), 331–335 (1997).
- D. M. Cook, R. Dubisch, G. Sowell, P. Tam, and D. Donnelly, "A Comparison of Several Symbol Manipulating Programs: Part I", *Computers in Physics* **6**(4; Jul/Aug), 411–420 (1992); "..., Part II", *Computers in Physics* **6**(5; Sep/Oct), 530–540 (1992).
- D. M. Cook (editor), *Computing in Advanced Undergraduate Physics*, the proceedings of a conference held 13–14 June 1990, at Lawrence University. These proceedings contain 19 papers on uses of computers in undergraduate curricula around the country and record also the discussions following each paper. The proceedings were widely distributed to institutions offering bachelors degrees in physics and continue to be occasionally requested.
- D. M. Cook, "Incorporating Uses of Computational Tools in the Undergraduate Physics Curriculum" (lead paper in the above proceedings).
- D. M. Cook, "Computational Exercises for the Upper-Division Undergraduate Physics Curriculum", Comput. Phys. **4**(3; May/June), 308–313 (1990)
- D. M. Cook, "Introducing Computational Tools in the Upper-Division Undergraduate Physics Curriculum", Comput. Phys. **4**(2; Mar/Apr), 197–201 (1990)
- Professor Cook has given invited talks at
  - the March meetings of the APS, Montreal, QB (March, 2004);
  - the International Conference on Computer Science, San Francisco, CA (May, 2001);
  - the Washington meeting of the APS, Washington, DC (April, 2001);
  - the winter meetings of the AAPT, San Diego, CA (January, 2001);
  - the *Physics Revitalization Conference: Building Undergraduate Physics Programs for the 21st Century*, Arlington, VA (October, 1998);

- the summer meetings of the AAPT, College Park, MD (August, 1996);
- the summer meetings of the AAPT, Boise, ID, (August 1993);
- the summer meetings of the AAPT, Orono, ME, (August 1992);
- the Davidson College (NC) Conference on Computational Physics, (October 1991);
- the spring meeting of the Pacific Northwest Association for College Physics, University of Puget Sound (April 1991); and
- the summer meetings of the AAPT, San Luis Obispo, CA (June 1989).

He has also given physics colloquia at

- Michigan Technological University (September 1991);
- University of Wisconsin–Eau Claire (October 1990);
- Hope College (November 1989);
- Kansas State University (September 1989); and
- University of Nebraska (September 1989);

and contributed papers at

- the summer meetings of the AAPT, Sacramento, CA (July-August, 2004);
- the summer meetings of the AAPT, Guelph, ON (July, 2000);
- the summer meetings of the AAPT, Spokane, WA (July, 1995);

C.3 Surface Physics Laboratory

Surfaces, interfaces, and reduced dimensional systems have been a major focus in condensed matter physics over the past thirty five years because new structures, phases, and phenomena emerge with the presence of a surface changes the interaction between an atom and its neighbors. With the support of a portion of a $400K grant to the Department of Physics from the W. M. Keck Foundation, a surface physics signature laboratory is being developed to complement the existing laser and computational laboratories. The laboratory is equipped with scanning tunneling and atomic force microscopes that are used in laboratory exercises at all levels of the curriculum.

C.3.1 Experiments Available

The following scanning probe microscopy experiments have been developed and are available for use.

- Introduction to Scanning Tunneling Microscopy
  - Physics Recruiting Workshop Version
    - Imaging of Graphite Surfaces
  - Introductory Modern Physics Version
    - Imaging of Graphite Surfaces
    - Dependence of Tunneling Current on Gap
    - Measuring the Density of States with Voltage Spectroscopy

  - Advanced Laboratory Version
    - Imaging Graphite
    - Physics of Quantum Tunneling

- Observation of Charge Density Waves in TaS_2.
- Imaging the Growth of Monolayers of Organic Molecules on Graphite.
- Measuring Surface Roughness of Evaporated Bismuth Films.
- Introduction to Contact Mode Atomic Force Microscopy

In addition to the scanning probe microscopy there are a several experiments that explore three-dimensional structures using x-ray diffraction.

- X-ray Powder Diffraction from Aluminum
- Exploring Single Crystal Diffraction
- Structural Studies of Liquid Crystal Thin Films
  - Fluid Smectic Phases (Sm-A, Sm-C)
  - Hexatic Smectic Phases (Sm-I, Sm-F)
  - Structural Transitions in Crystalline Phases (Crystalline Sm-B)

C.3.2 Hardware

4	Nanosurf Easyscan Scanning Tunneling Microscopes
2	Nanosurf E-line Atomic Force Microscopes
4	Personal Computers to run the instruments
1	Vibration Isolation Stage for AFM
4	Granite Slab Isolation pads for STMs
24	Highly Oriented Pyrolytic Graphite Substrates for experiments
2	Evaporated Gold Samples
1	Gold on Mica sample
1	TaS_2 Charge Density Wave Sample
1	MoS_2 Sample
1	TiS_2 Sample
1	Thermal Evaporator for Metal Films
	Pt/Ir and W wire for STM Tips
	Silicon Cantilever Tips for AFM

C.3.3 Curricular Impact

The surface physics laboratory has had impact at all levels of the Lawrence Curriculum. The scanning tunneling microscopes are used as one major activity in the Lawrence physics recruiting workshop. For the past two years we have used the scanning tunneling microscope to introduce the physics of quantum tunneling to our freshman modern physics students in the laboratory portion of the course. This year, both the scanning tunneling microscopes and the atomic force microscopes were used in a two week block of an interdisciplinary course, *Introduction to Nanoscience and Nanotechnology*, team taught by Professor Collett along with Professors Karen Nordell and David Hall of the Department of Chemistry. Both kinds of scanning probe microscopes are used in our junior advanced laboratory course. In addition, two seniors have used the laboratory as the basis of senior capstone projects.

D Major Equipment Available in Department

Description	Approximate Purchase Dates	Approximate Cost
New Focus Vortex diode laser	2000	$10K
Coherent 5 Watt Argon ion laser (2)	1986,2000	$30K
Coherent 599-03 cw tunable dye laser	1986	$13K
Coherent pulsed ruby laser	1995	$10K
Melles Griot, Coherent, etc. HeNe and diode lasers (15)	1982-90	$10K
Miscellaneous diode lasers (1000)	1984-92	$20K
Custom diode laser controllers (8)	1984-2000	$15K
Custom pulsed dye lasers (5)	1979-85	$4K
Custom N2 pulsed lasers (2)	1979-83	$3K
Spex 1401 and 1870B spectrometers	1983-86	$30K
Ocean Optics CCD spectrometer	2004	$4K
Assorted monochrometers	1980-85	$18K
10", 8", and 6" electromagnets	1970-76	$15K
Bruker EPR Spectrometer	1998	$30K
Coherent Type 240 spectrum analyzers (3)	1986	$15K
Melles Griot power meters (3)	1992	$20K
Coherent Type 212 power meters (4)	1986	$5K
LEXEL laser power meters (3)	1992	$6K
Multichannel analyzers (4)	1978-82,2000	$20K
Numerous NIM modules, bins, detectors	1970-88,98	$80K
Custom Mossbaüer spectrometer	1995	$12K
Vacuum systems (4)	1966-80,95	$14K
Fabry-Perot interferometers (4)	1990,2000	$4K
Personal computers in labs (12)	2000,2003	$25K
Assorted lock-in amplifiers (5)	1987-	$12K
Numerous digital voltmeters (20)	1975-83,98	$10K
Frequency synthesizer	1987	$5K
Assorted function generators (15)	1970-85	$10K
Assorted frequency counters (10)	1987,1995	$10K
Assorted power supplies (30)	1970-85,97,02	$30K
Numerous low-frequency oscilloscopes (20)	1968-83	$30K
Digital oscilloscopes (7)	1990,2000,2004	$35K
Research grade fast oscilloscopes (10)	1987-92,95	$75K
Numerous optical benches (7)	1986	$12K
Assorted optical mounts (Newport, Thorlabs, New Focus)	1985-2000	$10K
Assorted holographic equipment (Newport)	1986	$5K

Description	Approximate Purchase Dates	Approximate Cost
Assorted optical components	1985-2005	$30K
Various time, frequency, voltage standards	1975-80	$10K
Cryogenic equipment	1973-74	$10K
Assorted strip chart and x-y recorders (8)	1975-87	$12K
Miscellaneous spectral lamps, student spectrometers	1970-75,95	$30K
Assorted strobes, filters, demonstration gear	1970-87,2000	$20K
Miscellaneous electronic instruments, power supplies	1970-2001	$30K
Miscellaneous microwave apparatus	1975-83,2003	$20K
8” Schmidt Cassegrain telescope (3)	1999	$3K
Questar telescope	1980	donated
Assorted cameras	1975-2001	$10K
Electron microscopes (shared)	1977-84	$20K
Ruby pulsed lasers (2)	1967,87	$5K
Burleigh wavemeter jr. (2)	1988-91	$10K
Stanford Research SR400 photon counter	1988	$6K
Various plotters (5) and printers (3)	1986-88,95	$10K
Programmable power supplies	1995-2001	$8K
Fiber optic trainer	1988	$2K
Squid hardware	1992	$1.5K
Hall magnetometer	2001	$2K
Radioactive sources	1970-98,2003	$20K
Vacuum hardware and instrumentation	2000	$50K
Demonstration equipment	1970-2000	$6K
Electronic components (general stock)	1975-2000	$20K
Electronic standards	1980-95	$5K
Hitachi environmental ecanning electron microscope (shared)	1995	$160K
Computational Physics Laboratory (5 Silicon Graphics O2 workstations, (4 Silicon Graphics O2+ workstations, 1 Silicon Graphics Origin200 Server 1 Gateway Windows-2000 workstation, 1 Silicon Graphics 540 NT workstation, HP laser printer Tektronix Phaser 350 color printer, much software)	1995-2002	$200K

Description	Approximate Purchase Dates	Approximate Cost
Surface Physics Laboratory		
Nanosurf scanning tunneling microscopes (4)	2002	$30K
Hewlett-Packard computers (4)	2002	$3K
Nanosurf combination scanning tunneling/ atomic force microscopes (2)	2004	$56K
Vibration isolation stage	2004	$4K
Siemens GADDS X-ray diffractometer (shared)	1996,2000	$250K
Lakeshore Model 340 temperature controllers (2)	1995-2000	$8K
Infinity long working-length telemicroscope with high resolution video camera and frame grabber		
Computer-Equipped Introductory Laboratory (8 HP/Compaq PCs, HP laser printer Vernier interfaces for data acquisition, much software)	2004	$30K
Plasma Physics Laboratory		
Toroidal vacuum chamber	1997	donated
Vacuum flanges, feedthroughs, gate valves	1997–2004	$20K
Residual gas analyzer	1997	$5K
Vacuum guages/controller	1997	$2K
Gantry, hoist, lifting gear	1997–2000	$4K
Digital multimeters (4)	1997–2003	$3K
Tektronix digital oscilloscopes (3)	1997–2002	$5K
Turbomolecular pump and controller	1998	$14K
Direct drive mechanical pump	1998	$2K
Various HV DC power supplies (5)	1998–2003	$10K
Stanford Research synthesizing generator	1999	$2K
Avtech HV pulser	1999	$10K
Cryogenic pump and compressor	2001	$10K
Kepco high voltage amplifier	2002	$2.5K
500A/20V DC power supply	2004	$2K
Custom toroidal vacuum chamber (ordered)	2005	$18K
Machine Shop		
Lathes (2)	1965,99	$13K
Overhead mills (2)	1965,99	$18K
Doall bandsaw	1965	$4K
Power hacksaw	1999	$2K
Brake, shear	1960,2000	$3K
Hand tools	1960-2000	$10K
Welder	1998	$3K

E Historical Enrollment Data

In the tables in this appendix, the following abbreviations are used for faculty members in the Lawrence Department of Physics:

ABK	Andrew Kunz	JAC	Jeffrey Collett
BJD	Brian Davis	KLH	Kevin Haglin
DMC	David Cook	MRS	Matthew Stoneking
JB^2	Bruce Brackenridge	PEB	Paul Bunson
JCK	Jessica Kintner	PWF	Paul Fontana
JOD	James Dunn	RMR	Robert Rosenberg
JRB	John Brandenberger	SML	Suzanne Lee
JEG	John Gastineau		

Further, (1) courses offered at the Lawrence London Center by JB^2 are not included, (2) enrollments in tutorials and independent studies count as full enrollments even though a few were half-course enrollments, (3) total enrollment figures near the bottom of each column do *not* include enrollment in *Freshman Studies*, (4) double asterisks in 2005–06 indicate courses scheduled for offering in that year, (5) current course numbers are conveyed in brackets,[9] and (6) course titles are very substantially abbreviated, as follows:

- *Light* = *Light! More Light!* [103].
- *Issues* = *Issues in Physics* [105].
- *Music* = *Physics of Music* [107].
- *Theo Mot* = *History of Theories of Motion* and *Plan Ast* = *History of Planetary Astronomy*. These courses were offered by Professor Brackenridge and are no longer offered by the Department.
- *Relativ* = *Relativity* [115].
- *Energy* = *Energy and the Environment* [115].
- *Algebra* = *Fundamentals of Physics* [120, 130], our algebra-based introductory course. Through the 1994-95 academic year, this two term sequence was algebra-based only in the first term and merged with the second-term of the calculus-based sequence for the second term. In 1995–96 and since, we have offered a two-term algebra-based sequence that is completely decoupled from the calculus-based sequence.
- *Calculus* = *Principles of Physics* [150, 160], our calculus-based introductory sequence.
- *Mech* = *Intermediate Mechanics* through 2001–02, thereafter *Computational Mechanics* [225].
- *Elect* = *Electronics* [220].
- *E&M* = *Electricity and Magnetism* [230].
- *CompTool* = *Computational Tools in Physics*. This elective course was normally taught throughout the year at 1/3-course per year. It was last offered in 2001–02. Thereafter, it was replaced by *Computational Mechanics*.
- *Ad Lab* = *Advanced Laboratory* [330].
- *Quantum* = *Quantum Mechanics* [310].

[9] Courses without numbers are no longer offered.

- *Mat Sci* = *Materials Science*, which was taught only a very few times. Teaching was shared between SML and George Glavee, Department of Chemistry.
- *Thermo* = *Thermal Physics* [320].
- *Adv Mech* = *Advanced Mechanics* [410].
- *Adv E&M* = *Advanced Electricity and Magnetism* [430].
- *Adv Mod* = *Advanced Modern Physics* [460].
- *Math Meth* = *Mathematical Methods of Physics* [440].
- *Solid St* = *Solid State Physics* [530].
- *Laser* = *Laser Physics* [550]. In 1988–89, JEG taught an upper-level course in lasers titled *Lasers in the Natural Sciences* and aimed at advanced science students; in 1990–91, JRB taught an upper level course in lasers titled *Laser Physics* and aimed at advanced physics majors. *Both* of these courses were offered in 1991–92.
- *Heav Ion* = *Heavy Ion Physics* [500], taught once by JCK in 1995–96.
- *Fund Part* = *Fundamental Particle Physics* [500].
- *Comp Phys* = *Computational Physics* [540], introduced in 2004–05.
- *TUT* = *Tutorial in Physics* [190, 390, 590, 690].
- *IS/CAP Independent Study in Physics* and *Capstone Project in Physics* [199, 399, 599, 699].
- *FS* = *Freshman Studies*. Here, the number in parentheses is the number of *sections* offered by the department, not the enrollment in those sections. Typical enrollment in a *Freshman Studies* section is 15–17.
- *Enrol* = *Enrollment*. This figure provides the total number of course enrollments for the year. Note that, because *Computational Tools in Physics* was a 1/3-credit course in each term of its offering, enrollments in that course count at 1/3 in tallying total enrollments.
- *Lab Super* = *Laboratory Supervisor*, a position that existed only for a short time, as described in Section 7.
- *Units Avai* = *Teaching Units Available*, in which figure one person teaching full-time for one year contributes 6.
- *Units Used*, which tallies the total number of teaching units actually used in the year. Most of the time, this figure will equal the number of units available, but occasionally the two figures will differ slightly (which implies someone had a nominal overload or underload during the year).

	1987/88			1988/89			1989/90			1990/91			1991/92			1992/93		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Outreach Courses																		
Light	–	–	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Issues	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Music	–	–	–	–	–	26	–	–	–	–	–	23	–	–	–	–	–	–
Theo Mot	–	–	–	–	–	–	–	–	6	–	–	–	–	–	10	–	–	–
Plan Ast	–	–	–	–	48	–	–	–	–	–	–	34	–	–	–	–	–	–
Astronomy	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Relativ	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Energy	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Introductory Courses																		
Algebra	22	–	–	16	–	–	31	–	–	30	–	–	36	–	–	42	–	–
Calculus	–	45	35	–	42	41	–	47	48	–	33	38	–	39	41	–	38	37
Intermediate Courses																		
Elect	–	8	–	–	26	–	–	20	–	–	20	–	–	17	–	–	19	–
Mech	5	–	–	18	–	–	17	–	–	22	–	–	16	–	–	16	–	–
E&M	–	–	4	–	–	14	–	–	16	–	–	17	–	–	9	–	–	12
CompTool	–	–	–	–	–	–	–	–	–	–	–	–	8	4	3	–	8	–
Ad Lab	–	–	7	–	–	3	–	6	8	–	4	5	–	7	7	–	6	2
Quantum	–	7	–	4	–	–	13	–	–	10	1	–	16	–	–	9	–	–
Mat Sci	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thermo	–	–	–	–	5	–	–	–	–	–	–	19	–	–	–	–	16	–
Optics	6	–	–	–	–	–	–	10	–	–	–	–	20	–	–	–	–	–
Adv Mech	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Adv E&M	–	–	2	–	–	–	–	–	8	–	–	–	–	–	14	–	–	–
Adv Mod	–	–	–	–	–	3	–	–	–	–	19	–	–	–	–	–	–	11
Math Meth	–	–	–	–	–	–	–	15	–	–	–	–	–	21	–	–	–	–
Solid St	–	8	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–
Plasma	–	–	–	–	–	–	–	–	–	–	–	–	7	–	–	–	–	–
Laser	–	–	–	9	–	–	–	–	–	11	–	–	–	14	14	–	–	–
Heav Ion	–	–	–	–	–	–	–	9	–	–	–	–	–	–	–	–	–	–
Fund Part	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Comp Phys	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TUT	–	–	–	1	2	2	–	–	–	5	3	2	1	2	4	5	4	3
IS/CAP	1	2	–	1	1	1	1	–	2	6	3	3	8	6	5	5	3	1
FS	(1)	(1)	–	(1)	(1)	–	(1)	–	–	(1)	–	–	(1)	–	–	–	–	–
Enrol		167			263			257			313			319			238	
Staff		JRB			JB^2			$\frac{1}{2}JB^2$			$\frac{2}{3}JB^2$			$\frac{2}{3}JB^2$			$\frac{1}{3}JB^2$	
		DMC			$\frac{1}{3}$ DMC			$\frac{2}{3}$ JRB			$\frac{2}{3}$ JRB			JRB			JRB	
		JEG			$\frac{2}{3}$ JRB			$\frac{2}{3}$ DMC			DMC			DMC			$\frac{2}{3}$ DMC	
		—			JEG			JEG			JEG			JEG			$\frac{1}{6}$ JEG	
		—			—			—			$\frac{1}{6}$RMR			—			—	
Lab Super		—			—			—			—			—			$\frac{7}{12}$ Tomf	
Units Avai		18			18			17			21			22			$16\frac{1}{2}$	
Units Used		18			$18\frac{1}{2}$			$17\frac{1}{2}$			$20\frac{1}{2}$			22			$16\frac{5}{6}$	

	1993/94			1994/95			1995/96			1996/97			1997/98		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Outreach Courses															
Light	–	–	–	–	–	–	–	–	–	–	–	10	–	–	–
Issues	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–
Music	–	–	20	–	–	–	–	–	32	–	–	–	–	–	33
Theo Mot	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Plan Ast	–	–	–	–	14	–	–	–	–	–	–	–	–	–	–
Astronomy	–	–	–	–	–	–	–	–	9	–	–	–	–	–	31
Relativ	–	–	–	–	–	–	–	–	–	7	–	–	–	–	–
Energy	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Introductory Courses															
Algebra	37	–	–	38	–	–	35	21	–	16	12	–	33	19	–
Calculus	–	37	36	–	18	28	–	25	27	–	29	28	–	33	26
Intermediate Courses															
Elect	16	–	–	21	–	–	12	–	–	18	–	–	9	–	–
Mech	–	14	–	–	16	–	–	7	–	–	18	–	–	10	–
E&M	–	–	10	–	–	16	–	–	8	–	–	12	–	–	8
CompTool	–	–	–	–	–	–	10	8	8	9	7	8	6	4	3
Quantum	11	–	–	9	–	–	14	–	–	7	–	–	11	–	–
Ad Lab	–	4	4	–	5	5	–	6	7	–	4	4	–	6	4
Mat Sci	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–
Thermo	–	–	–	–	7	–	–	–	–	–	13	–	–	–	–
Optics	10	–	–	–	–	–	–	10	–	–	–	–	–	9	–
Adv Mech	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Adv E&M	–	–	7	–	–	–	–	–	7	–	–	–	–	–	8
Adv Mod	–	–	–	–	4	–	–	–	–	–	3	–	–	–	–
Math Meth	–	–	–	–	–	4	–	–	–	–	–	8	–	–	–
Solid St	–	8	–	–	–	–	–	–	–	–	–	5	–	–	–
Plasma	–	–	–	–	–	–	–	–	–	–	–	–	7	–	–
Heav Ion	–	–	–	–	–	–	–	9	–	–	–	–	–	–	–
Laser	–	–	–	–	–	–	–	–	–	–	–	–	–	8	–
Fund Part	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Comp Phys	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TUT	1	2	4	–	–	1	–	6	–	2	–	3	1	–	2
IS/CAP	2	2	1	4	5	4	5	3	3	7	7	4	3	2	–
FS	–	–	–	(2)	–	–	(1)	–	–	(1)	(1)	–	(2)	–	–
Enrol		226			201			256			226			267	
Faculty		JRB			$\frac{1}{6}$JB^2			JAC			JRB			JRB	
		DMC			JRB			DMC			JAC			JAC	
		SML			$\frac{1}{3}$DMC			JCK			DMC			DMC	
		—			SML			SML			KLH			MRS	
Lab Super		–			–			–			BJD			BJD	
Units Avai		18			20			24			30			30	
Units Used		18			20			$22\frac{1}{2}$			$27\frac{1}{2}$			$27\frac{1}{2}$	

	1998/99			1999/2000			2000/01			2001/02			2002/03		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Outreach Courses															
Light	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–
Issues	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
Music	–	–	–	–	–	48	–	–	–	–	–	41	–	–	–
Theo Mot	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Plan Ast	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Astronomy	–	–	33	–	–	34	–	–	31	35	–	–	27	–	–
Relativ	23	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Energy	–	–	–	–	–	–	–	–	–	–	–	–	13	–	–
Introductory Courses															
Algebra	38	24	–	31	17	–	47	20	–	39	24	–	38	21	–
Calculus	–	36	17	–	31	22	–	32	23	–	41	29	–	49	34
Intermediate Courses															
Elect	15	–	–	13	–	–	16	–	–	11	–	–	20	–	–
Mech	–	15	–	–	12	–	–	11	–	–	12	–	–	16	–
E&M	–	–	16	–	–	11	–	–	13	–	–	11	–	–	15
CompTool	8	3	2	6	4	3	3	1	1	10	6	7	–	–	–
Quantum	6	–	–	13	–	–	8	–	–	11	–	–	9	–	–
Ad Lab	–	5	–	–	8	3	–	5	5	–	5	3	–	8	4
Mat Sci	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thermo	–	9	–	–	–	–	–	16	–	–	–	–	–	15	–
Optics	–	–	–	–	13	–	–	–	–	–	15	–	–	–	–
Adv Mech	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Adv E&M	–	–	–	–	–	9	–	–	–	–	–	9	–	–	–
Adv Mod	–	–	4	–	–	–	–	–	–	–	–	9	–	–	–
Math Meth	–	–	5	–	–	–	–	–	7	–	–	–	–	–	11
Solid St	–	–	–	–	–	–	–	–	6	–	–	–	–	–	3
Plasma	–	–	–	5	–	–	–	–	–	10	–	–	–	–	–
Heav Ion	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Laser	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fund Part	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Comp Phys	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TUT	–	–	1	1	2	2	3	–	2	2	–	4	2	3	1
IS/CAP	3	3	1	5	4	1	7	5	4	3	3	1	3	3	3
FS	–	–	–	(2)	–	–	(1)	–	–	(1)	(1)	–	(2)	–	–
Enrol	258			290			263			332			298		
Faculty	JRB			JRB			JRB			JRB			$\frac{1}{3}$JRB		
	DMC			DMC			$\frac{1}{3}$DMC			$\frac{2}{3}$DMC			$\frac{2}{3}$DMC		
	$\frac{2}{3}$JAC			JAC			JAC			JAC			—		
	MRS			MRS			$\frac{1}{2}$MRS			MRS			MRS		
	—			—			PWF			PWF			ABK		
	—			—			—			—			PEB		
Lab Super	BJD			PWF			—			—			—		
Units Avai	28			30			23			28			24		
Units Used	$27\frac{1}{2}$			29			$22\frac{1}{2}$			$27\frac{1}{2}$			$23\frac{1}{2}$		

	2003/04			2004/05			2005/06			2006/07			2007/08		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Outreach Courses															
Light	–	–	–	–	–	13	–	–	–	–	–	–	–	–	–
Issues	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Music	–	–	53	–	–	–	–	–	**	–	–	–	–	–	–
Theo Mot	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Plan Ast	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Astronomy	–	–	–	–	33	–	–	–	–	–	–	–	–	–	–
Relativ	–	–	–	–	–	–	**	–	–	–	–	–	–	–	–
Energy	21	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Introductory Courses															
Algebra	46	23	–	45	21	–	**	**	–	–	–	–	–	–	–
Calculus	–	39	43	–	36	33	–	**	**	–	–	–	–	–	–
Intermediate Courses															
Elect	11	–	–	21	–	–	**	–	–	–	–	–	–	–	–
Mech	–	15	–	–	13	–	–	**	–	–	–	–	–	–	–
E&M	–	–	16	–	–	13	–	–	**	–	–	–	–	–	–
CompTool	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Quantum	12	–	–	14	–	–	**	–	–	–	–	–	–	–	–
Ad Lab	–	–	10	–	7	4	–	**	**	–	–	–	–	–	–
Mat Sci	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thermo	–	–	–	–	14	–	–	–	–	–	–	–	–	–	–
Optics	–	16	–	–	–	–	–	**	–	–	–	–	–	–	–
Adv Mech	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–
Adv E&M	–	–	8	–	–	–	–	**	–	–	–	–	–	–	–
Adv Mod	–	–	–	–	–	–	–	–	**	–	–	–	–	–	–
Math Meth	–	–	–	–	–	14	–	–	–	–	–	–	–	–	–
Solid St	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–
Plasma	–	–	–	–	–	–	–	–	**	–	–	–	–	–	–
Heav Ion	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Laser	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fund Part	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–
Comp Phys	–	–	–	6	–	–	–	–	–	–	–	–	–	–	–
TUT	4	11	–	1	2	–	–	–	–	–	–	–	–	–	–
IS/CAP	2	2	1	4	5	–	–	–	–	–	–	–	–	–	–
FS	(1)	–	–	–	–	–	(1)	–	–	–	–	–	–	–	–
Enrol		343			309			—			—			—	
Faculty		—			JRB			JRB			$\frac{1}{2}$JRB			$\frac{1}{2}$JRB	
		$\frac{2}{3}$DMC			DMC			DMC			$\frac{1}{3}$DMC			$\frac{1}{6}$DMC	
		$\frac{2}{3}$JAC			JAC			JAC			$\frac{2}{3}$JAC			JAC	
		MRS			$\frac{2}{3}$MRS			$\frac{2}{3}$MRS			$\frac{2}{3}$MRS			MRS	
		ABK			JOD			JOD			XXX			XXX	
		PEB			—			—			YYY			YYY	
		—			—			—			ZZZ			ZZZ	
Lab Super		—			—			—			—			—	
Units Avai		26			28			28			31			34	
Units Used		$26\frac{1}{2}$			28			$28\frac{1}{2}$			–			–	

F Recent Student Independent Studies

F.1 In-Term and Capstone Projects Undertaken

2004-05

Lauren Kost, LU '05 (supervised by Professor Brandenberger), studied hyperfine structure in excited atoms using saturation spectroscopy.

April Evans, LU '05 (supervised by Professor Brandenberger), studied hyperfine, Zeeman, and isotope shifts in excited states of krypton isotopes.

Alex Dogaru, LU '05 (supervised by Professor Collett), studied field theory models of weak interactions.

Samridha Kunwar, LU '05 (supervised by Professor Collett), studied field theory models of strong interactions.

Steven Hahn, LU '05 (supervised by Professor Collett), studied plane wave calculations of band structures in solids.

Nicholas Mauro, LU '05 (supervised by Professor Stoneking), explored energy technologies.

2003-04

Dwight Mills, LU '04 (supervised by Professor Brandenberger), studied laser spectroscopy of several types.

Elizabeth Kruesi, LU '04, spent fall term at Columbia University Biosphere program studying and doing astronomy.

Megan Schendel, LU '04, spent fall term at NIST-Boulder on research project involving fiber Bragg gratings.

Nicholas Mauro, LU '05 (supervised by Professor Collett), studied hexatic liquid phases and explored the *Tricritical Phenomenon*.

Jason Levin-Loopman, LU '04 (supervised by Professor Kunz), studied magnetic correlations across point contacts.

Steven Kohlmann, LU '04 (supervised by Professor Stoneking), used astronomical data he took with the telescope at Biosphere 2 to determine the distance to open clusters of stars.

2002-03

Kimberly Robinson, LU '03 (supervised by Professor Cook), worked to develop techniques to trace field lines using IDL.

Joseph Wells, LU '03 (supervised by Professor Brandenberger), studied Raman spectroscopy.

Steven Kohlmann, LU '04, spent fall term at Columbia University Biosphere program studying and doing astronomy.

Ryan Peterson, LU '03, spent winter term at Interamerican Observatory in Cerro Tololo.

Suzanne Witt, LU '03 (supervised by Professor Collett), used a scanning tunneling microscope to make images of ordered monolayers of organic molecules deposited on a graphite substrate from an evaporating solution while the layers were forming.

Christopher Phelps, LU '03 (supervised by Professor Collett), used a scanning tunneling microscope to image electron charge density waves in TaS_2.

Ryan Peterson, LU '03 (supervised by Professor Stoneking), completed construction and initial testing of an imaging detector system he built during the summer of 2003 for the Lawrence Nonneutral Torus experiment.

Mark Growdon, LU '04 (supervised by Professor Stoneking), used the imaging detector system on the Lawrence Nonneutral Torus to acquire the first images indicating the temporal evolution of the electron plasma.

2001-02

Quinn Marksteiner, LU '02 (supervised by Professor Collett), undertook a theoretical and experimental investigation of the x-ray structure factors for novel liquid crystalline phases composed from T-shaped molecules.

Robin Sampson, LU '02 (supervised by Professor Stoneking), investigated the profile of the electron plasma in the Lawrence Nonneutral Torus experiment using a probe she constructed and installed.

Derek Thuecks, LU '02 (supervised by Professor Stoneking), used a set of "wall-patch" probes he constructed to observe oscillations in an electron plasma.

Ryan Jung, LU '02 (supervised by Professor Brandenberger), continued his work of the previous summer measuring fine structures in highly excited states of Rb.

2000-01

Cindy Regal, LU '01 (supervised by Professor Brandenberger), undertook a three-term spectroscopic investigation of fine structures in ^2F states of Rb.

Michael Yakes, LU '01 (supervised by Professor Brandenberger), undertook a study of fine structure in rubidium.

Angela Kopp, LU '01 (supervised by Professor Stoneking), undertook an investigation of instabilities in a non-neutral plasma.

Stuart Schmitt, LU '01 (supervised by Professor Collett), studied optical properties of phase transitions in liquid crystals.

Jaques Bluett, LU '01 (supervised by Professor Collett), examined electron spin resonance in several solids.

Joshua Cross, LU '01 (supervised by Professor Collett), studied optical studies of phase transitions in liquid crystals.

Joshua Vande Hey, LU '01 (supervised by Professor Collett), undertook two-term study of ways to measure asteroid orbits

1999-2000

Angela Kopp, LU '01 (supervised by Professor Stoneking), studied toroidal equilibrium in electron plasmas.

Jessica Reeves, LU '00 (supervised by Professor Stoneking), undertook half-credit study of the geodynamo.

Joshua Cross, LU '01 (supervised by Professor Collett), studied x-ray diffraction.

Jessica Reeves, LU '00 (supervised by Professor Brandenberger), investigated behavior of dark states in Rb vapor.

Teresa Hayne, LU '00 (supervised by Professor Cook), undertook a one-term study of the vibrations of violin plates.

Paul Kondratko, LU '00 (supervised by Professor Collett), continued to investigate phase transitions in liquid crystals via x-ray diffraction.

1998–99

Kurt Taylor, LU '99 (supervised by Professor Stoneking), undertook a three-term study of experimental properties of a neutral plasma.

Erik Brubaker, LU '99 (supervised by Professor Stoneking), studied experimental properties of a neutral plasma.

Paul Kondratko, LU '00 (supervised by Professor Collett), studied liquid crystals and xray diffractometry.

Tim Beck, LU '99 (supervised by Professor Brandenberger), performed spectroscopic calculations.

Eric Moore, LU '01 (supervised by Professor Brandenberger), developed diode laser controller.

1997–98

Scot Shaw, LU '98 (supervised by Professor Cook), undertook a two-term study of nonsequential ionization.

Mark Nornberg, LU '98 (supervised by Professor Stoneking), studied stability of a non-neutral plasma in a toroidal geometry.

Jim Truitt, LU '98 (supervised by Professor Collett), studied liquid crystals.

Jim Truitt, LU '98 (supervised by Professor Collett), explored mapping nonlinear data distributions onto Cartesian grids.

Mark Nornberg, LU '98 (supervised by Professor Brandenberger), studied atomic spectroscopy.

Mark Nornberg, LU '98 (supervised by Professor Stoneking), studied equilibrium in toroidal electron plasmas.

1996–97

Adam Thorne, LU '97 (supervised by Professor Brandenberger), studied speaker design.

Timothy Miller, LU '97 (supervised by Professor Brandenberger), studied electrical and optical properties of semiconductors.

Todd Thompson, LU '97 (supervised by Professor Brandenberger), undertook an experimental investigation of sonoluminescence.

Christopher Schmidt, LU '97 (supervised by Professor Cook), undertook a two-term project in mapping of astrophysical data from readings of detectors with wide apertures to the actual point by point intensity distribution in the observed field.

Jeff Feist, LU '97 (supervised by Professor Cook), studied the normal modes of oscillation of two-dimensional membranes with irregular shapes.

Michael Stenner, LU '97 (supervised by Professor Collett), undertook a two-term study of phase transitions in liquid crystals.

Wade Smith, LU '97 (supervised by Professor Haglin), studied particle properties in the nuclear environment.

Anthony Tong, LU '97 (supervised by Professor Haglin), studied general relativity.

Sheyum Syed, LU '97 (supervised by Professor Haglin), studied heavy ion collisions.

1995–96

Brian Schmalz, LU '96 (supervised by Professor Collett), conducted a year-long study the culminated in the building of a unicycle robot.

David Robertson, LU '96 (supervised by Professors Collett and Brandenberger), studied saturated absorption spectroscopy.

Alejandro Ozerkovsky, LU '96 (supervised by Professor Lee), conducted a year-long study that led to the writing of a program to facilitate fitting data from a differential scanning calorimeter to theoretical functions.

1994–95

Joshua Kriesel, LU '95 (supervised by Professor Lee), conducted a year-long study of properties of alloys of Ge and Sn.

Brian Schmalz, LU '96 and **Paul Rybski, LU '95** (supervised by Professor Brandenberger), conducted a year-long project to build voice-, touch-, and light-controlled robots.

Peter K. Senecal, LU '95 (supervised by Professor Cook), conducted a year-long analytical and numerical study of the behavior of two-fluid systems.

Alain I. Bellon, LU '95 (supervised by Professor Cook), conducted a year-long study of general relativity and the Schwarzschild metric.

1993–94

C. Tobin Deitrich, LU, '94, and Karl Grill, LU, '93 (supervised by Professor Brandenberger), developed digital control system for an electric train.

Mark F. Gehrke, LU, '94 (supervised by Professor Cook), used supercomputers and graphic visualization to study several problems in 2D and 3D electrostatics.

Karl Geisler, LU, '94 (supervised by Professor Cook), used a computer algebra system to study quantum scattering from arrays of rectangular barriers.

Mark F. Gehrke, LU '94 (supervised by Professor Brandenberger), explored laser spectroscopy with optovoltaic detection.

Yoriko Morita, LU '94 (supervised by Professor Brandenberger), constructed highly regulated diode laser controller.

1992–93

Scott Arko, LU '93 (supervised by Professor Brandenberger), investigated coherent population trapping.

Stephen Johnson, LU, '93 (supervised by Professor Gastineau), measured electron excitation cross sections.

Tom Pak, LU '93 (supervised by Professor Brandenberger), investigated optical pumping in Rb.

1991–92

Michelle Pierce, LU '92 (supervised by Professor Cook), conducted a theoretical study seeking wave solutions of the Einstein equations for the space-time metric.

Peter Ruprecht, LU '92 (supervised by Professor Brandenberger), conducted an experimental project on diode laser tuning with an external etalon.

Renée Lemke, LU '92 (supervised by Professor Cook), conducted a year-long theoretical study of several solutions to the Navier-Stokes equations of fluid mechanics.

Stephen Mielke, LU '92 and **Clinton Schneider, LU '92** (supervised by Professor Brandenberger), conducted a year-long experimental study of the chaotic behavior of several electronic circuits.

1990–91

Nelson Turner, LU '91 (supervised by Professor Cook), conducted a year-long theoretical study of chaos in laser systems described by the Maxwell-Bloch equations.

Stephen Parker, LU '91 (supervised by Professor Brandenberger), pursued work in laser measurement of hyperfine splittings in krypton.

Kristi Hendrickson, LU '91 and **Ruth Rhodes, LU '92** (supervised by Professor Cook), examined the behavior of stretched strings and membranes through numerical simulation and through summing of the standard Fourier series solutions.

F.2 Undergraduate Research Participation

Summer, 2005

Duncan Ryan, '06	Lawrence	Plasma physics with Professor Stoneking
Bao Ha, '07	Lawrence	Plasma physics with Professor Stoneking
Rupesh Silwal, '06	Lawrence	Laser spectroscopy with Professor Brandenberger
Claire Weiss, '07	Lawrence	Computational physics with Professor Cook
Erik Garbacik, '08	Lawrence	Computational physics with Professor Cook
Henry McNeil, '06	Lawrence	Surface physics with Professor Collett
Kyle Dolan, '06		Observatory in Hawaii
Annemarie Exarhos, '07		Pacific Northwest National Laboratory

Summer, 2004

Rahul Bhinge, '06	Lawrence	Magnetic materials with Professor Kunz
Lauren Kost, '05		University of Washington
Nicholas Mauro, '05		University of California – Los Angeles
Duncan Ryan, '06		Coe College
Paul Schonfeld, '05		Michigan Technological Institute
Daniel Casner, '06		Engineering assistant at Miller Electric
Kyle Dolan, '06		Michigan State University
Steven Hahn, '05		Northwestern University
Matthew Stackpole, '05		National Security Admin, Washington, DC
Annemarie Exarhos, '07		Pacific Northwest National Laboratory

Summer, 2003

Jason Levin-Koopman, '04	Lawrence	at University of Nebraska with Professor Kunz
Lauren Kost, '05	Lawrence	Computers in Physics with Professor Cook
Michelle Milne, '04	Lawrence	Plasma Physics with Professor Stoneking
Nicholas Mauro, '05	Lawrence	Phase transitions with Professor Collett
Dwight Mills, '04	Lawrence	Laser Spectroscopy with Professor Brandenberger
Matthew Stackpole, '05	Lawrence	STM measurements with Professor Collett
Paul Schonfeld, '05		University of Alaska
Steven Hahn, '05		Coe College
Megan Schendel, '04		Sandia National Laboratory
Matthew Dietrich, '04		Baylor University

Summer, 2002

Michelle Milne, '04	Lawrence	Computers in Physics with Professor Cook
Scott Kaminski, '05	Lawrence	Computers in Physics with Professor Cook
Nicholas Mauro, '05	Lawrence	Liquid crystals with Professor Collett
Paul Schonfeld, '05		University of Alaska
Megan Schendel, '04		Sandia National Laboratory
Joseph Wells, '03	Lawrence	Raman effect with Professor Brandenberger
Kimberly Robinson, '03		University of Chicago
Christopher Phelps, '03		Michigan State University
Ryan Peterson, '03	Lawrence	Non-neutral plasma with Professor Stoneking
Suzanne Witt, '03		Mayo Clinic
Elizabeth Kruesi, '04		University of Chicago

Summer, 2001

Ryan Peterson, '03	Lawrence	Computers in Physics with Professor Cook
Ryan Jung, '02	Lawrence	Fine structure in Rb with Professor Brandenberger
Mark Growdon, '03	Lawrence	2D fluid flow with Professor Fontana
Robin Sampson, '02	Lawrence	Non-neutral plasma with Professor Stoneking
Derek Thuecks, '02	Lawrence	Non-neutral plasma with Professor Stoneking
Danica Dralus, '02		University of Oregon
Quinn Marksteiner, '02		University of Chicago

Summer, 2000

Robin Sampson, '02	Lawrence	Non-neutral plasma with Professor Stoneking
Derek Thuecks, '02	Lawrence	Non-neutral plasma with Professor Stoneking
Danica Dralus, '02	Lawrence	Computers in Physics with Professor Cook
Joshua Cross, '01		NASA-Langley
Jessica Reeves, '00		NASA-Langley
Michael Yakes, '01	Lawrence	Fine structure in ^{2}F state of Rb with Professor Brandenberger
Stuart Schmitt, '01	Lawrence	Phase transitions in films with Professor Collett
Cindy Regal, '01		University of Colorado
Angela Kopp, '01		University of Washington

Summer, 1999

Jaques Bluett, '01	Lawrence	EPR with Professor Brandenberger
Joshua Cross, '01	Lawrence	Liquid crystals with Professor Collett
Teresa Hayne, '00	Lawrence	Acoustics with Professor Cook
Paul Kondratko, '00		MIT
Angela Kopp, '01	Lawrence	Plasma physics with Professor Stoneking
Stuart Schmitt, '01	Lawrence	Optical pumping with Professor Brandenberger
Jessica Reeves, '00		Bell Helicopter
Cindy Regal, '01		University of Oregon

Summer, 1998

Timothy Beck, '99	Lawrence	Spectroscopic calculations with Professor Brandenberger
Erik Brubaker, '99		CERN
Paul Kondratko, '00	Lawrence	Liquid crystals with Professor Collett
Eric Moore, '99		University of Michigan
Momchil Piralkov, '01	Lawrence	Liquid crystals with Professor Collett
Jessica Reeves, '00	Lawrence	Laser spectroscopy with Professor Brandenberger
Cindy Regal, '01	Lawrence	Lipid membranes with Professor Blackwell (Chemistry)
Leta Steffen, '99	Lawrence	Embryology with Professor Wall (Biology)
Kurt Taylor, '99	Lawrence	Plasma physics with Professor Stoneking

Summer, 1997

Erik Brubaker, '99	Lawrence	Plasma physics with Professor Stoneking
Eric Moore, '99	Lawrence	Finite element methods with Professor Cook
Mark Nornberg, '98	Lawrence	Laser spectroscopy with Professor Brandenberger
Scot Shaw, '98		Oxford with Professor Burnett
Jim Truitt, '98	Lawrence	Liquid crystals with Professor Collett

Summer, 1996

Scott Murschel, '97	Lawrence	Differential calorimetry with Professor Lee
Scot E. J. Shaw, '98	Lawrence	Computer graphics and behavior of vertical string with Professor Cook
James Truitt, '98	Lawrence	Computer graphics and simulation of heat flow in 3D with Professor Cook
Wade Smith, '97	Lawrence	Muon lifetime experiment with Professors Brandenberger and Collett
Michael Stenner, '97	Lawrence	Xray diffraction and liquid crystals with Professor Collett
Timothy Miller, '97	Lawrence	Experimental saturated absorption line shapes with Professor Brandenberger
Anthony Tong, '97	Lawrence	Theoretical saturated absorption line shapes with Professor Brandenberger
Christopher Schmidt, '97		Northwestern University, Evanston, IL
Todd Thompson, '97		University of Virginia, Charlottesville, VA
Sheyum Syed, '97		Oak Ridge National Laboratory, Oak Ridge, TN

Summer, 1995

Michael Stenner, '97	Lawrence	Computer graphics and finite element methods with Professor Cook
Christopher Schmidt, '97	Lawrence	Computer graphics and finite element methods with Professor Cook
David Robertson, '96	Lawrence	Experimental saturated absorption line shapes with Professor Brandenberger
Alejandro Ozerkovsky, '96	Lawrence	Interactive fitting of calorimetric data with Professor Lee
Jacob Herbold, '98	Lawrence	Making thin carbon films with Professor Lee

Summer, 1994

Slobodan Kojcinovic, '95	Lawrence	Coherent population trapping with Professor Brandenberger
P. Kelly Senecal, '95	Lawrence	Computer graphics and finite element methods with Professor Cook
Alain Bellon, '95	Lawrence	Computer graphics and finite element methods with Professor Cook
Brian Schmalz, '96	Lawrence	Making thin carbon films with Professor Lee
Joshua Kriesel, '95	Lawrence	Phase transitions in tin with Professor Lee
Tobin Laursen, '95	Lawrence	Study of nanometer-grained iron samples with Professor Lee

Summer, 1993

Slobodan Kojcinovic, '95	Lawrence	Coherent population trapping with Professor Brandenberger
Mark Gehrke, '94		Notre Dame, X-ray studies of surfaces
Diana Ling, '94		Kansas State University, Manhattan, KS
Yoriko Morita, '94		Pacific Northwest Laboratories, Richland, WA
Steven van Metre, '94		SUNY–Stony Brook

Summer, 1992

Mark Gehrke, '94	Lawrence	Computational Physics with Professor Cook
Karl Geisler, '94	Lawrence	Computational Physics with Professor Cook
C. Tobin Deitrich '94		Indiana Cyclotron Facility, Bloomington, IN
Scott Arko, '93	Lawrence	Coherent population trapping with Professor Brandenberger
Sandra Collins, '93		IBM Research Laboratory at San Jose, CA
Stephen Johnson, '93		Northwestern University, Evanston, IL
Steven van Metre, '94	Lawrence	Biophysical studies with Professor Brandenberger

Summer, 1991

Sandra Collins, '93	Lawrence	Computational Physics with Professor Cook
Stephen Johnson, '93	Lawrence	Collisional excitation with Professor Gastineau
Michelle Pierce, '92	Lawrence	Computational Physics with Professor Cook
Peter Ruprecht, '92	Lawrence	Laser spectroscopy with Professor Brandenberger
Renée Lemke, '92		IBM Rochester, MN
Stephen Mielke, '92		University of Wisconsin, Madison
Ruth Rhodes, '92		Indiana Cyclotron Laboratories
Clinton Schneider, '92		Huntsville Lab, Huntsville, AL
Todd Zimmerman, '92		SUNY, Stony Brook
Andrea Cox, '91		Large Array Laboratory
Kristi Hendrickson, '91		IBM Yorktown Heights (APS Intern)
Matt Anderson, '91		Wisconsin Medical College

Summer, 1990

Nelson Turner, '92	Lawrence	Laser spectroscopy with Professor Brandenberger
Stephen Mielke, '92	Lawrence	Computational Physics with Professor Cook
Ruth Rhodes, '92	Lawrence	Computational Physics with Professor Cook
Clinton Schneider, '92	Huntsville	Huntsville, AL
Todd Zimmerman, '92		SUNY, Stony Brook
Renée Lemke, '92		IBM Rochester, MN
Mac Almy, '91		Michigan State Summer Research Appointment
Matt Anderson, '91		Wisconsin Medical College
Andrea Cox, '91		Astronomy, New Mexico State
Kristi Hendrickson, '91		Argonne National Labs
Steven Parker, '91	Lawrence	Laser spectroscopy with Professor Brandenberger
Carl Schwendler, '91		Notre Dame Department of Physics
Todd Ruskell, '91		Battelle Memorial Institute, WA
Troy Thornberry, '91		Montana State Department of Physics

Summer, 1989

Andrea Cox, '91		Astronomy at Michigan State
Kristi Hendrickson, '91	Lawrence	Computational Physics with Professor Cook
Peter Strunk, '89	Lawrence	Computational Physics with Professor Cook
Jenifer Herek, '91	Lawrence	Laser physics with Professor Brandenberger

F.3 Recent Talks and Papers with Undergraduate Authors/Coauthors

In this enumeration, student authors are marked with daggers (†). In addition to the national presentations here identified, students have written numerous 5–40 page locally published documents involving applications of our computational resources to a wide variety of interesting physical situations. These documents have played an important role in strengthening the computational sophistication of our students. Copies have occasionally been requested by persons at other institutions.

M. R. Stoneking, M. A. Growdon†, M. L. Milne†, and R. T. Peterson†, "Poloidal $\mathbf{E} \times \mathbf{B}$ drift used as an effective rotational transform to achieve long confinement times in a toroidal electron plasma", Phys. Rev. Lett. **92**, 095003 (2004).

Duncan Ryan†, "Structures of Lead-Gallate Glasses and Quantitative Analysis Techniques for Mass Spectroscopy", talk presented at the 2004 Pew Undergraduate Research Symposium, Washington Univ., St. Louis, Mo.

M.R. Stoneking, M.A. Growdon†, M.L. Milne†, and R.T. Peterson†, "Millisecond Confinement and Observation of the $m = 1$ Diocotron Mode in a Toroidal Electron Plasma", in Non-neutral Plasma Physics V, AIP Conf. Proc. 692, edited by M. Schauer, T. Mitchell, and R. Nebel, (American Institute of Physics, New York, 2003), p. 310.

M.R. Stoneking, M.A. Growdon†, and M.L. Milne†, "Millisecond Confinement and Observation of the $m = 1$ Diocotron Mode in a Toroidal Electron Plasma", Bull. Am. Phys. Soc. **48**, 38 (2003).

M.A. Growdon†, M.L. Milne†, and M.R. Stoneking, "Characteristics of the $m = 1$ Diototron Mode in a Trapped Toroidal Electron Plasma", Bull. Am. Phys. Soc. **48**, 144 (2003).

Jason-Levin Koopman†, "Monte Carlo Simulatiions on Magnetic Nano-Contacts", talk presented at the 2003 Pew Undergraduate Research Symposium, Univ Chicago, Chicago, IL.

Matthew Stackpole†, "Does Size Really Matter? Why I Eschew Diffraction but Love Scanning Tunneling Microscopy", talk presented at the 2003 Pew Undergraduate Research Symposium, Univ Chicago, Chicago, IL.

Lauren Kost†, "The Electrostatic Potential of Electron Mirrors", talk presented at the 2003 Pew Undergraduate Research Symposium, Univ Chicago, Chicago, IL.

Nicholas Mauro†, "X-Ray Diffraction in Thin Liquid Crystal Films", talk presented at the 2003 Pew Undergraduate Research Symposium, Univ Chicago, Chicago, IL.

M.R. Stoneking, P.W. Fontana, R.L Sampson†, and D.J. Thuecks†, "Electron plasmas in a 'partial' torus", Phys. Plasmas **9**, 766 (2002).

M.R. Stoneking, R.T. Peterson†, M.A. Growdon†, and D.J. Thuecks†, "Limitations on Confinement of a Toroidal Electron Plasma due to Field Asymmetries and the Presence of Neutrals", Bull. Am. Phys. Soc. **47**, 128 (2002).

R.T. Peterson†, M.R. Stoneking, and M.A. Growdon†, "Imaging Electron Plasmas in a Partially Toroidal Trap", Bull. Am. Phys. Soc. **47**, 154 (2002).

M.R. Stoneking, P.W. Fontana, R.L. Sampson†, and D.J. Thuecks†, "Electron Plasma Confinement in a Partially Toroidal Trap", in *Non-neutral Plasma Physics IV*, AIP Conf. Proceedings 606, edited by F. Anderegg, L. Schweikhard, and C.F. Driscoll, (American Institute of Physics, New York, 2002), p. 671.

John R. Brandenberger, Cindy Regal†, Ryan Jung†, and Michael Yakes†, "Fine Structure Splittings in ^{2}F States of Rubidium via Three-Step Laser Spectroscopy", Phys. Rev. A**65** 42510 (April, 2002).

Joseph Wells†, "Raman Spectroscopy of CCl_4", talk presented at the 2002 Pew Undergraduate Research Symposium, Washington Univ., St. Louis, Mo.

Nicholas Mauro†, "X-Ray Diffraction in Thin Liquid Crystal Films", talk presented at the 2002 Pew Undergraduate Research Symposium, Washington Univ., St. Louis, Mo.

M.R. Stoneking, P.W. Fontana, R.L. Sampson†, and D.J. Thuecks†, "Toroidal Electron Plasma Confinement and the Effects of a Horizontal Electric Field", Bull. Am. Phys. Soc. **46**, 84 (2001).

D.J. Thuecks†, R.L. Sampson†, and M.R. Stoneking, "Low-frequency Oscillations in a Toroidal Pure- electron Plasma", Bull. Am. Phys. Soc. **46**, 149 (2001).

R.L. Sampson†, M.R. Stoneking, and D.J. Thuecks†, "Measuring the Langmuir Probe Characteristic in a Pure Electron Plasma", Bull. Am. Phys. Soc. **46**, 304 (2001).

J. A. Collett, P. T. Kondratko†, and M. E. Neubert, "Structural Study of the Smectic-I to Smectic-F Transition in Freely Suspended Liquid Crystal Films", Phys. Rev. E **62** 6760 (2000).

P. T. Kondratko†, J. A. Collett, M. E. Neubert, "Structural Study of the Smectic-I and Smectic-F Phases in Freely Suspended Films", March Meeting of the American Physical Society, Minneapolis, March, 2000.

Joshua D. Cross†, Jeffrey A. Collett, and Mary E. Neubert, "X-ray Measurements of Correlation Lengths in Hexatic Phases Using an Area Detector", March Meeting of the American Physical Society, Minneapolis, March, 2000.

Michael Yakes†, "Measurements of Fine and Hyperfine Splittings in Rb Via Multi-Step Excitation", talk presented at the 2000 Pew Undergraduate Research Symposium, Washington Univ., St. Louis, MO.

Robin Sampson†, "Probe Measurements in a Toroidal Nonneutral Plasma", talk presented at the 2000 Pew Undergraduate Research Symposium, Washington Univ., St. Louis, MO.

Derek Thuecks†, "Trapping Electrons in a Toroidal Magnetic Field", talk presented at the 2000 Pew Undergraduate Research Symposium, Washington Univ., St. Louis, MO.

M. R. Stoneking, P. W. Fontana, A. J. Kopp†, R. L. Sampson†, and D. J. Thuecks†, "Controlling Toroidal Electron Plasma Equilibrium with a Horizontal Electric Field", Bull. Am. Phys. Soc. **45**, 304 (2000), presented at the APS-DPP meeting in Quebec City, Quebec, Canada.

P. T. Kondratko†, "Structural Study of the Smectic-I and Smectic-F Phases in Freely Suspended Films", presented at the 1999 PEW Undergraduate Research Symposium at the

University of Chicago, November, 1999.

Joshua D. Cross†, "X-ray Measurements of Correlation Lengths in Hexatic Phases Using an Area Detector", presented at the 1999 PEW Undergraduate Research Symposium at the University of Chicago, November, 1999.

P. T. Kondratko† and J. A. Collett, "Study of the Smectic-I to Smectic-F Transition in TB10A", March (Centennial) Meeting of the American Physical Society, Atlanta, March 22, 1999.

M. R. Stoneking, A. J. Kopp†, and K. J. Taylor†, "Toroidal Magnetic Confinement of a Pure Electron Plasma", Bull. Am. Phys. Soc. **44**, 108 (1999), presented at the APS-DPP meeting in Seattle, WA.

A. J. Kopp†, K. J. Taylor†, and M. R. Stoneking, "Confinement of an Electron Plasma in a Toroidal Magnetic Field", Bull. Am. Phys. Soc. **44**, 137 (1999), presented at the APS-DPP meeting in Seattle, WA.

Matthew Stoneking, Kurt Taylor†, and Mark Nornberg†, "Initial Results from a Toroidal Pure Electron Experiment", Bull. Am. Phys. Soc. **43**, 1805 (1998).

P. T. Kondratko†, "Study of the Smectic-I to Smectic-F Transition in TB10A", presented at the 1998 Pew Undergraduate Research Symposium at Washington University in St. Louis, MO, November, 1998.

Wade Smith† and Kevin Haglin, "Collision Broadening of the Phi Meson in Baryon Rich Hadronic Matter", Phys. Rev. C**57** 1449 (March 1998).

James Truitt†, J. A. Collett, and Michael Stenner†, "Three Dimensional Visualization of Diffuse Scattering in Liquid Crystals", March Meeting of the American Physical Society, Los Angeles, March 20, 1998.

Matthew Stoneking, Kurt Taylor†, Mark Nornberg†, and Erik Brubaker†, "Initial Results from a Toroidal Pure Electron Plasma", Bull. Am. Phys. Soc. **43**, 1805 (1998), presented at APS-DPP meeting in New Orleans, LA.

Kurt Taylor† and M. R. Stoneking, "Injection of Electrons into a Toroidal Magnetic Field", Bull. Am. Phys. Soc. **43**, 1747 (1998), presented at APS-DPP meeting in New Orleans, LA.

M. R. Stoneking and E. Brubaker†, "A Toroidal Pure Electron Plasma", Bull. Am. Phys. Soc. **42**, 1955 (1997), presented at the APS-DPP meeting in Pittsburgh, PA.

James Truitt†, J. A. Collett, and Michael Stenner†, "Three Dimensional Visualization of Diffuse Scattering in Liquid Crystals", Contributed talk at 1997 PEW Undergraduate Research Symposium at the University of Chicago, November, 1997

Mark Nornberg†, Contributed talk at 1997 PEW Undergraduate Research Symposium at the University of Chicago, November, 1997

Scot Shaw†, Contributed talk at 1997 PEW Undergraduate Research Symposium at the University of Chicago, November, 1997

Erik Brubaker† and Matthew R. Stoneking, "A Toroidal Pure Electron Plasma Experiment", Bull. Am. Phys. Soc **42**, 1955 (1997).

Wade Smith† and Kevin Haglin, "Collision Rate of the Phys Meson in Hot Baryon Rich Matter", Bull. Am. Phys. Soc. (Spring Meeting, 1997, in Washington).

Sheyum Syed†, “RF Voltage Measurements on ICRF Antenna” Bull. Am. Phys. Soc. (paper on work done at Oak Ridge and presented at Nov, 1996 meeting of Division of Plasma Physics in Denver).

Josh Kriesel† and Susanne Lee, Paper appeared in the proceedings of a meeting of the Materials Research Society, November, 1995.

David Robertson† and J. R. Brandenberger, “Saturated Absorption Laser Spectroscopy”, Argonne Symposium on Undergraduate Research, 3–4 November 1995.

Slobodan M. Kojcinovic† and J. R. Brandenberger, “Theory of the Atom-Field Interaction”, Argonne Symposium on Undergraduate Research, 4–5 November 1994.

Slobodan M. Kojcinovic† and J. R. Brandenberger, “Theory of the Atom-Field Interaction”, Proceedings of the August, 1994, Conference of the NASA/Wisconsin Space Grant Consortium.

Slobodan M. Kojcinovic† and J. R. Brandenberger, “Examination of a Four-Level Atom Interacting with Multiple Laser Fields”, National Conference on Undergraduate Research, Western Michigan University, Kalamazoo, Michigan, April, 1994.

Slobodan M. Kojcinovic† and J. R. Brandenberger, “Theoretical Examination of a Four-Level Atom Interacting with Multiple Laser Fields”, Argonne Symposium on Undergraduate Research, 5–6 November 1993.

Yoriko Morita†, Gregory J. Exarhos and Kim F. Ferris, “Study of Nonlinear Optical Response of Polymer Precursors using Degenerate Four-Wave Mixing and Theoretical Modeling” (work done on summer project at Pacific Northwest Laboratory), Argonne Symposium on Undergraduate Research, 5–6 November 1993.

Scott Arko† and J. R. Brandenberger, “Coherent Population Trapping in ^{87}Rb Vapor Using Saturated Absorption Laser Spectroscopy”, National Conference on Undergraduate Research, University of Utah, Salt Lake City, March, 1993.

Sandra R. Collins†, National Conference on Undergraduate Research, University of Utah, Salt Lake City, March, 1993.

Scott Arko† and J. R. Brandenberger, “Coherent Population Trapping in ^{87}Rb Vapor Using Saturated Absorption Laser Spectroscopy”, Argonne Symposium on Undergraduate Research, 6–7 November 1992.

Peter A. Ruprecht† and J. R. Brandenberger, “Enhancing diode laser tuning with a short external cavity”, Optics Communications **93**, 82–86 (1992).

Stephen L. Mielke†, Clinton Schneider†, and J. R. Brandenberger, “Chaotic Behavior of an RLC Circuit at Sub-Resonant Frequencies”, National Conference on Undergraduate Research, University of Minnesota, March, 1992.

Peter A. Ruprecht† and J. R. Brandenberger, “Enhancement of Diode Laser Tuning with a Short External Cavity”, Argonne Symposium on Undergraduate Research, 4–5 November 1991.

Stephen Johnson† and J. E. Gastineau, “Simultaneous Ionization and Excitation of Krypton”, Argonne Symposium on Undergraduate Research, 4–5 November 1991.

Stephen C. Parker† and J. R. Brandenberger, “Hyperfine structure in the $4p^5 5p$ configuration of ^{83}Kr”, Physical Review A, **44**, 3354–3357 (1991).

Kristi R. G. Hendrickson[†], Ruth I. Rhodes[†], and David M. Cook, "Motion of a Taut String/Motion of a Square Membrane" Proceedings of the Workshop on Computational Physics at California State University–Fullerton, September, 1991.

Stephen C. Parker[†] and J. R. Brandenberger, "Hyperfine Structure in the $4p^55p$ Configuration of ^{83}Kr", National Conference on Undergraduate Research, California Institute of Technology, March, 1991.

Todd G. Ruskell[†] and J. E. Gastineau, "Total Electron-Excitation Cross Sections of the $4p^55p$ States of Krypton and Pressure Dependence of Associated Emission Cross Sections", Bull. Am. Phys. Soc. **36**, 201, (1991).

Stephen C. Parker[†] and J. R. Brandenberger, "Hyperfine Structure in the $4p^55p$ Configuration of ^{83}Kr", Argonne Symposium on Undergraduate Research, 3–4 November 1990.

Nelson C. Turner[†], III, and J. R. Brandenberger, "High Precision Atomic Spectroscopy through Heterodyning of Diode Lasers", Argonne Symposium on Undergraduate Research, 3–4 November 1990.

Michael P. Nesnidal[†], Todd G. Ruskell[†] and J. E. Gastineau, "Electron-Excitation Cross Sections of the $4p^55p$ States of Krypton and their Pressure Dependence", Bull. Am. Phys. Soc. **35**, 1823 (1990).

Jennifer Herek[†] and J. R. Brandenberger, "Hyperfine Structure of the $2p_6$ State of the $4p^55p$ Configuration of ^{83}Kr", National Conference on Undergraduate Research, Union College, April, 1990.

Jennifer Herek[†] and J. R. Brandenberger, "Hyperfine Structure of the $2p_6$ State of the $4p^55p$ Configuration of ^{83}Kr", Bull. Am. Phys. Soc. **35**, 1020 (1990).

G Recent Faculty Talks and Publications

In this section, we enumerate recenty faculty scholarly output that has not had student coauthors.

B. E. Chapman, A. F. Almagri, J. K. Anderson, C. S. Chiang, D. Craig, G. Fiksel, N. E. Lanier, S. C. Prager, J. S. Sarff, **M. R. Stoneking**, and P. W. Terry, "$\mathbf{E} \times \mathbf{B}$ flow shear and enhanced confinement in the Madison Symmetric Torus reversed-field pinch", accepted for publication in *Physics of Plasmas* (1998).

M. R. Stoneking, J. T. Chapman, D. J. Den Hartog, S. C. Prager, and J. S. Sarff, "Experimental scaling of fluctuations and confinement with Lundquist number in the reversed field pinch", accepted for publication in *Physics of Plasmas* (1998).

B. E. Chapman, C. S. Chiang, S. C. Prager, J. S. Sarff, and **M. R. Stoneking**, "Strong radial electric field shear and reduced fluctuations in a reversed-field pinch", accepted for publication in *Phys. Rev. Lett.* (1998).

D. Craig, A. F. Almagri, J. K. Anderson, J. T. Chapman, C. S. Chiang, N. A. Crocker, D. J. Den Hartog, G. Fiksel, S. C. Prager, J. S. Sarff, and **M. R. Stoneking**, "Enhanced confinement with plasma biasing in the MST reversed field pinch", *Phys. Rev. Lett.* **79**, 1865 (1997).

J. T. Chapman, T. M. Biewer, D. J. Den Hartog, S. C. Prager, J. S. Sarff, and **M. R. Stoneking**, "Lundquist number scaling of the MHD Dynamo in the MST-RFP", *Bull. Am. Phys. Soc.* **42**, 2046 (1997).

T. M. Biewer, **M. R. Stoneking**, D. J. Den Hartog, and S. C. Prager, "Electron temperature profile evolution during a sawtooth in the MST reversed field pinch", *Bull. Am. Phys. Soc.* **42**, 2046 (1997).

P. W. Fontana, J. T. Chapman, V. Dhyani, G. Fiksel, S. C. Prager, and **M. R. Stoneking**, "Energy balance during a sawtooth in MST", *Bull. Am. Phys. Soc.* **42**, 2046 (1997).

J. S. Sarff, B. E. Chapman, N. E. Lanier, T. W. Lovell, S. C. Prager, M. Thomas, and **M. R. Stoneking**, "Inductive current profile control in MST", *Bull. Am. Phys. Soc.* **42**, 2046 (1997).

E. Uchimoto, R. W. Harvey, A. P. Smirnov, S. C. Prager, J. S. Sarff, and **M. R. Stoneking**, "Numerical simulation of lower hybrid current drive in MST", *Bull. Am. Phys. Soc.* **42**, 2048 (1997).

David M. Cook, "Computers in the Lawrence Physics Curriculum–Parts I, II", Comput. Phys. **11**(3; May/Jun, 1997), 240–245, **11**(4; Jul/Aug, 1997), 331–335.

J. Bruce Brackenridge, *The Key To Newton's Dynamics*, (University of California Press, Berkeley, 1996) ISBN 0-520-20217-1

David M. Cook, "The Computer-Based Components of the Lawrence Physics Curriculum", Invited paper presented at the summer meetings of the American Association of Physics Teachers, College Park, MD, 7 Aug 1996; abstract published in AAPT Announcer **26**, No. 2, 58, (July 1996)

J. S. Kallman, A. J. DeGroot, C. G. Hoover, W. G. Hoover, **S. M. Lee**, F. Wootenb, "Visualization Techniques for Molecular Dynamics", *IEEE Comp. Graph & Appl.* **17**, 72-77 (1995)

David M. Cook, "Treating Partial Differential Equations in the Undergraduate Physics Curriculum", Contributed paper presented at the summer meetings of the American Association of Physics Teachers, Spokane, WA, 12 Aug 1995; abstract published in AAPT Announcer **25**, No. 2, 105, (July 1995)

David M. Cook, "Sample Uses of Computer Algebra in the Undergraduate Physics Curriculum", Invited paper presented at the summer meetings of the American Association of Physics Teachers, Boise, ID, 11 Aug 1993; abstract published in AAPT Announcer **23**, No. 2, 92, (July 1993)

J. Bruce Brackenridge, "The Locke/Newton Manuscripts Revisited: Conjugates, Curvatures, and Conjectures", *Archives Internationales d'historie des Sciences* **43** 280–292 (1993)

J. Bruce Brackenridge, "The Critical Role of Curvature in Newton's Developing Dynamics" in *The Investigation of Difficult Things: Essays on Newton and the History of the exact Sciences*, (Cambridge University Press, 1992) ISBN 0-521-37435-9, pp 231–261.

David M. Cook, "A Comparison of Several Symbol-Manipulating Programs—Parts I, II", with Russell Dubisch, Glenn Sowell, Patrick Tam, and Denis Donnelly, Comput. Phys. **6**(4; Jul/Aug, 1992), 411–420, **6**(5; Sep/Oct, 1992), 530–540.

David M. Cook, "Experiences with Computer Algebra in the Undergraduate Physics Curriculum", Invited paper presented at the summer meetings of the American Association of Physics Teachers, Orono, ME, 14 Aug 1992; abstract published in AAPT Announcer **22**, No. 2, 92, (July 1992)

David M. Cook, "Using Computational Tools in Upper Division Theoretical Physics", Invited talk delivered at Davidson Conference on Computational Physics, Davidson Collage, Davidson, NC (3 October 1991)

David M. Cook, "Using Computational Tools in the Upper-Division Theoretical Physics Curriculum", Physics colloquium delivered at Michigan Technological University, Houghton, MI (12 September 1991)

David M. Cook, "Computational Tools in the Upper-Division Theoretical Curriculum", Invited talk presented at the spring meeting of the Pacific Northwest Association for College Physics, University of Puget Sound, Tacoma, WA (6 April 1991)

David M. Cook, "The Sloan/Lawrence Conference on Using Computers in Upper-Division Theoretical Physics: 13–14 July 1990", Invited paper delivered at the winter meetings of the American Association of Physics Teachers, San Antonio, Texas (21 January 1991); abstract published in AAPT Announcer **20**, No. 4, 37, (December, 1990)

H Activities of Graduates

	Graduate/Professional School/Other	Current Status
Class of 2004		
Matthew Dietrich	U Wash	PhD student
Dimitri Gooden	U Minn	Engineer student
Mark Growdon	U Conn	Studying to be physician's assistant
Steven Kohlmann		Searching for work locally
Elizabeth Kruesi		Associate editor, Astronomy Magazine
Jason Levin-Koopman		Applying for grad study in math
Dwight Mills		Graduate student in engineering/business
Michelle Milne	Wash U	PhD student
Kit Okimoto (minor)		Family business
Megan Schendel		Scientist, Sandia Natl Lab
Class of 2003		
Valerie Curtis	Cornell	PhD student
Kristen Heitman		Engineering student
Nicholas Krupka		Engineering student
Ryan Peterson		Technical assistant, LU Dept Phys
Kimberly Robinson	U Chicago	Technician
Russel Shafer	MSOE	Completed engineering degree
Joseph Wells	Univ MN	PhD student
Suzanne Witt	UW-Madison	PhD student in medical physics
Class of 2002		
Danica Dralus	UT Austin	PhD student
	UW-Madison	PhD student
Jessica Hafer (minor)		
Loren Lief Johnson	Wash U	3-2 engineer
	Wash U	Master's student
Ryan Jung	UW-Madison	PhD student in atomic physics
Jana Lewis (minor)	UC-Santa Barbara	PhD student in physical chemistry
Quinn Marksteiner	Columbia	PhD student in plasma physics
Adam Pelzer		
Wellington Phillips	Air Force	Member of ABM research group
Robin Sampson	Cornell	Received master's degree
		Applying to be EPA Intern
Adam Theiss	Wash U	3-2 engineer
		Master's student
Derek Thuecks	U Iowa	PhD student in plasma physics
Dane Tice		
Jay Warrick	Wash U	3-2 engineer
	General Motors	Engineer

	Graduate/Professional School/Other	Current Status
Class of 2001		
Jaques Bluett	Univ Wisconsin	Received master's degree
Joshua Cross	Cornell	PhD student
Rudy Gauthier	Univ Wisconsin	Engin student
Kolin Golchert	Teaching certification	Student
Angela Kopp	UCLA	PhD student
Momchil Piralkov (minor)		
Cindy Regal	Univ Colorado	PhD student
Stuart Schmitt	UW-Madison	PhD student in geophysics
Joshua VandeHey		Full time musician
Michael Yakes	Georgia Tech; Iowa State	PhD student
Class of 2000		
Reid Bowers (minor)	Seminary student	
Daniel Drew (minor)		
Teresa Hayne	Duke University	MAT student
	Minneapolis schools	Secondary teacher
Andrew Huss (minor)		
Paul Kondratko	Harvard University	PhD student
Joshua Nichols (minor)	Anderson Consulting	Consultant
Jessica Reeves	Univ Virginia	PhD student
Ben Sezer		Starting graduate work
Class of 1999		
Timothy Beck	UC-Santa Cruz	PhD Student
Erik Brubaker	UC-Berkeley	Completed PhD
	U Chicago	Physics post doc
Luz Fernandez	Univ of Colorado (math)	Law School
W. Andrew Holst	Architectural career	Construction manager
Amie Lewandowski	Univ Minnesota	Completed 3-2 Engin
Eric Moore	Rochester (Optics)	PhD Student
	Univ Colorado	Continuing PhD
Neville Nongkynrih		Flight Instructor
Leta Steffen	Harvard (Molec Bio)	PhD Student
Brent Tamamoto	Univ of Hawaii	Medical student
Kurt Taylor	UC San Diego	PhD Student
Scott Trigg	Univ Wiscon (math)	PhD Student
Will Tourdot	Univ Wiscon Engin	Completed 3-2 Engin
Chad Walby	Univ Wiscon Engin	Engin Student

	Graduate/Professional School/Other	Current Status
Class of 1998		
Benjamin J. Bayer (minor)	Univ of Ill (philosophy)	PhD student
Terry J. Dembroski	MSOE	Completed 3-2 Engin
Michael S. Donnelly		Audio consultant
David J. Dostal	Dartmouth	Complet 3-2 Engin
Michael S. Nishimura		Completed 3-2 Engin
Mark D. Nornberg	UW Madison	PhD Student
Scot E. J. Shaw	Harvard	PhD completed 2002
	Lincoln Laboratory	Staff physicist
James L. Truitt	UW Madison	PhD completed 2004
	Lincoln Laboratory	Staff physicist
Class of 1997		
A. David Bassett	Univ Wiscon Engin	Tektronix, Denton, TX
Scott Delaney	Univ Wiscon Engin	Completed 3-2 Engin
Jeffrey Feist		Inspector, ND Div of Emergency Management
Renate Geib		
David Harrington	Iowa State	Engin Student
Timothy Miller	Vanderbilt	PhD Student
Scott Murschel	Wash Univ	Engin Student
Christopher Schmidt	Univ Wisc Madison	PhD Student
Wade Smith	SUNY-Stony Brook	Completed PhD
Michael Stenner	Duke	Completed PhD
Sheyum Syed	Columbia Univ	Grad Student - App Phys
Todd Thompson	Univ Arizona	PhD completed
	UC - Berkeley	Hubble Post-doctoral Fellowship
Adam Thorne		
Anthony Tong	Univ of Ill	PhD Student
Class of 1996		
Carolyn Joslyn		Free-lance photographer
Alejandro Ozerkovsky	Univ Minnesota	Computer Science
David Robertson	Stanford, Physics	PhD Student
Brian Schmalz	Univ Minnesota	Computer Science
Tyler Van Buren	Univ Wisc, Madison	Engin Student
Christopher Van Hoof	Univ Wisc, Madison	Engin Student

	Graduate/Professional School/Other	Current Status
Class of 1995		
Alain Bellon	Univ of Mexico	Graduate student
Barjor Gimi	Washington Univ, Engin	Completed degree
	Johns Hopkins	Research scientist
Angela Klawes	Univ Wisconsin, Mech Engin	Consultant, Milw
Slobodan Kojcinovic	UCSD (PhD math; 200)	Fac position Rochester
Joshua Kriesel	UC Berk (PhD chemistry; 2000)	Indust position
Tobin Laursen	Northwestern, Engin	Grad Student
P. Kelly Senecal	Univ Wisconsin, Physics	PhD Student
Class of 1994		
C. Tobin Deitrich	Dartmouth–B Engin	Hew Pack–San Jose
Mark Gehrke	Univ Wisconsin, Physics	M.S. completed
	Veridian Systems, Ann Arbor	
Karl Geisler	Univ Minnesota, Engin	Grad Student
Judd Lather	Washington Univ, Engin	BA/BEng completed
Jiaya Ling	Kansas State	MS completed 1998
	American River College	Asst Prof Art
Yoriko Morita	U CO (Pd.D. physics; 2000)	Administrator
Kapil Sharma		
Steven Van Metre	McKinsey Associates	Consultant
Class of 1993		
Scott Arko	CO St (M.S. physics;1996)	Government employee
Carissa Balgemann	Michigan Tech, Medical Physics	Grad Student
Sandra Collins	U of OR (M.S. physics; 1996)	Industrial scientist
Karl Grill	U CO (engineering)	Engineer
Cody Johnson		
Stephen Johnson	Stony Brook	Completed PhD 2000
		Missionary work in Africa
Rahul Kamath	Dartmouth, Engin; MBA Northwestern	Integral, Inc.
Ann Leonard	North Ill (M.S. physics, 1997)	H S physics teacher
Doo Pak	Washington Univ, Engin	B.Eng. Student
Christopher Rivera		Free-lance script writer
Randall Rogers	Univ Wisconsin, Math	PhD Student

	Graduate/Professional School/Other	Current Status
Class of 1992		
Stephen Coventry	Chicago Medical School	M.D. completed 6/98
Eric Draheim	Georgia Tech	PhD student
Andrew Kessler	Salisbury School	Physics teacher
Reneé Lemke	U WI (PhD physics; 2000)	Industrial scientist
Stephen Mielke	Stony Brook (PhD physics; 1999)	Industrial scientist
Michelle Pierce	U CO (M.S. physics; 1996)	
Ruth Rhodes	U CO (M.S. physics; 1995)	
Peter Ruprecht	Oxford (D.Phil. physics; 1997)	Rhodes scholar; Computer Scientist
Clint Schneider	Savannah River (DOE Lab)	Lab Assistant
	Clemson, Physics	PhD student
David Tomfohrde	Laboratory Supervisor (LU)	Grad Student Purdue
Todd Zimmerman	SUNY–Stony Brook, Physics	PhD student
Class of 1991		
Richard Almy	U WI (PhD physics; 1998)	Physicist at Beloit
Matthew Anderson	Medical Coll of WI, M.D.	Medical research
David Benton	Univ of Conn, M.D. 2001	Residency
Andrea Cox	U WI (PhD astrophysics; 1998)	Physicist at Beloit
Kristi Hendrickson	U WA (PhD physics; 2000)	Physicist at Puget Sound
Paul Lombardi	3-2 engineering, Wash Univ	Kimberly-Clark
Stephen Parker	U WA (PhD physics; 2001)	Post doctoral appointment
Todd Ruskell	U AZ (PhD physics; 1999)	Physicist at CO Sch Mines
Carl Schwendler	Univ of Kentucky, Physics	PhD student
Edward Smith	Private business	
James Thomas	Mechanical Engineering	Engineer
Troy Thornberry	Montana State, Physics	
	Univ Iowa, Environ Engin	PhD student
		Post-doc Toronto
Nelson Turner	UT-Austin (M.S. physics; 1997)	Industrial scientist
Class of 1990		
Stephen Broshar	Computer specialist	
Anand Deo	Washington Univ, Comp Sci	
	Univ Michigan, Biomed Engin	Self-employed consultant
Thomas Pringle	Computer specialist	
Peter Strunk	Museum staff	

	Graduate/Professional School/Other	Current Status
Class of 1989		
James Arps	Vanderbilt Univ, Physics	SW Res Instit
Aaron Bloedorn	Washington Univ, Engineering Policy	Resource Applics
Eric Bloedorn	George Mason Univ, Robotics	MS student
Michael Gee	Washington Univ, Mech Eng	
Michael Nesnidal	Univ of Wisconsin, Material Science	PhD student
Stephen Wereley	Northwestern, Engineering	PhD student
Class of 1988		
Matthew Hane	Duke University, Biology	M.S. student
Michael Renn	University of Virginia (PhD)	
	PostDoc at Univ Colorado	Corporate scientist
Frederick Slater		
Larry Torbenson	Cray Research	
Class of 1987		
Allen Ries	Northwestern, High Energy Physics	
Mary Rodgers	Univ of Wisconsin, Material Science	M.S. recipient
Omer Sayeed	Univ of Indiana, Biophysics	Post Doc Cal Tech
Munroe Sullivan	Univ of Wisconsin, Material Science	PhD recipient
Class of 1986		
John Butzow		
Sara Prince		
Andrea L. Stout	Univ of Michigan, Biophysics	PhD recipient
Tim Webster	Lake Park Seminary	Provides chaplin-like services
Class of 1985		
Ann Buschaus	Univ of Wisconsin–Milwaukee	
Michael Chobanian	Univ of Illinois, Solid State	Architect
Curt Laumann	Lawrence Livermore Lab	Technician
Minaz Mithani		
Desmond Newton	Univ of Michigan/Rand Corp	PhD recipient
Bart Ott	Banker	
John Schlager	Univ of Colorado (PhD)	PostDoc (NIST)
David Thomson	Univ of Virginia (PhD)	PostDoc
Sue Wilkinson		

	Graduate/Professional School/Other	Current Status
Class of 1984		
Spiros Alexiou	Brown Univ (PhD)	PostDoc Weizmann
Clayton Funk	Physics teacher	
Joni Johnson	Univ of Minnesota (PhD)	PostDoc Wisconsin
John Marquenski	Cornell University, E. Engineering	Bell Lab
Murray McDonough	Univ of Florida, Engineering	
Andre Olivas		
Warren Pierson	Investment banker	Baird and Co.
Sharon Roeseler	Industrial computing	
David Shepard	Univ of Wisconsin, E. Engineering	
Class of 1983		
Ellen Dehm	Dartmouth Medical School (M.D.)	Ophthalmology intern
John Ibele	Univ of Minnesota, E. Engineering	M.S. recipient
Chris Matheus	Univ of Illinois (Ph.D)	Lincoln Lab
Matthew McCutcheon	Univ of Maryland, Philosophy	Physics Teacher
Steven Nordstrom	Engineering	
Class of 1982		
D. Charles DeMets	PhD in Geology	Faculty UW Madison
Charlotte Metzger	Engineer	IBM
Paul Stieg		
Class of 1981		
Paul Aiken		
Bernard Haen		
Bruce Rose		
Class of 1980		
John Gastineau	Univ Wisconsin	PhD completed
	Vernier Software	Developer of educ software
Louis Jost	UT Austin	
David Liebtag		
Douglas Van Leuven		
Jon Zilber		Magazine editor
Class of 1979		
Juan Choy		
Scott Matsumoto		
Ronald Peterson		Electrical engineer

	Graduate/Professional School/Other	Current Status
Class of 1978		
David Brakeman		
Susan Knowles		
Gary Kohls		Statistician
Dennis Lee		
Yiannakis Manoli		
Steve Pflanze		
Class of 1977		
Mary Chan		
Marc Grunert		
Warren Lilly		
Patrick Lukens	Fermilab	Research Physicist
Paul Stinchfield		
James Vosper	Wash Univ	3-2 Civil Engineer
	Boeing	Aircraft design
Shawn Woods		
Class of 1976		
George Beshers		
Robert Bergh		
Susan Cook	Hewlett-Packard	Vice President
Robert Hanisch	U Maryland	PhD astrophysics
	STSI	Staph astrophysicist
Samuel Morris		
Gene Peterson	Leeds Univ	Marshall Scholar
	U Chicago	MD-PhD
	Anesthesiologist	Seattle
	U Washington	Professor of Medicine
William Ray III		
Christopher Reiser		
William Schindler		
James Sonderegger		

I A Brief Chronology of Departmental Growth

Note: In this listing, WPG is Professor W. Paul Gilbert, JB^2 is Professor J. Bruce Brackenridge, DMC is Professor David M. Cook, JRB is Professor John R. Brandenberger, SML is Professor Susanne M. Lee, JEG is Professor John E. Gastineau, JAC is Professor Jeffrey A. Collett, JCK is Professor Jessica C. Kintner, KLH is Professor Kevin L. Haglin, MRS is Professor Matthew R. Stoneking, PWF is Professor Paul W. Fontana. ABK is Professor Andrew B. Kunz, PEB is Professor Paul E. Bunson, JOD is Professor James O. Dunn, and BJD is Mr. Brian J. Davis, SPS stands for Society of Physics Students and WOP stands for Women of Physics, a group created by students to provide support for female students in physics. *Note that events in this tabulation are correlated with calendar year, not academic year.*

1937: • WPG joins faculty

1959: • JB^2 joins faculty

1965: • DMC joins faculty

1966: • WPG retires, takes position at Hawaii Loa College

1968: • JRB joins faculty

1970: • JRB receives research grant from Research Corporation • NSF-sponsored pilot project/feasibility study on laboratory computing with JRB as PI • NSF-URP project under JRB

1971: • DMC receives NSF Faculty Fellowship for sabbatical at Dartmouth

1973: • Gregory Hughes receives research grant from Research Corporation

1975: • JRB receives NSF support for sabbatical at Harvard • DMC's text on electrodynamics published by Prentice-Hall

1976: • JRB receives research grant from Research Corporation

1977: • DMC commences reviewing manuscripts for AJP

1978: • NSF CAUSE project begins with DMC as PI • NSF LOCI project in instructional video tapes begins with DMC as PI • NSF-URP project under JRB • JRB attends Gordon Conference

1979: • NSF-URP project under JRB

1980: • JRB receives research grant from Research Corporation for quantum beat work • DMC reviews CAUSE proposals for NSF

1981: • NSF and SERC support for JRB's sabbatical at Oxford • Second printing of DMC's book on electrodynamics • DMC member of outside review team for Illinois Wesleyan • DMC conducts workshops on computer graphics at Lake Forest College and Ripon College • DMC reviews CAUSE proposals for NSF

1982: • DMC conducts workshop on computer graphics at Carthage College

1983: • DMC member of planning committee for Associated Colleges of the Midwest Conference on Computers in the Undergraduate Curricula • DMC gives keynote address at above conference

1984: • DMC member of outside review team for Beloit College

1985: • Research Corporation and Plexus Corporation support for JRB

1986: • General Electric support for pilot project on laser physics • JRB reports first observation of optovoltaic effect and continues research involvement at JILA

1987: • NSF support for pilot project on laser physics begins with JRB as PI • Department holds first annual recruitment weekend for prospective students • JRB mounts Sloan conference on curricular uses of lasers • JEG receives research grant from Research Corporation

1988: • Keck/NSF sponsored pilot project on curricular uses of computational tools begins with DMC as PI • NSF support for Faculty Enhancement Workshop on laser spectroscopy at LU • Department holds second annual recruitment weekend for prospective students

1989: • Tektronix, NSF, Keck, and PEW support for pilot project on laser physics • Three students engaged in summer research • DMC presents invited talk at summer AAPT meetings • JRB gives plenary talk at CUR conference and serves on Education Committee of Laser Science Topical Group of APS • DMC presents physics colloquia at Hope College, University of Nebraska, and Kansas State University • Department holds third annual recruitment weekend for prospective students

1990: • Plexus and SNC Foundation support for URP-like project under JRB • Jennifer Herek, LU '90, gives talk at NCUR-II and Washington APS meeting • DMC receives Lawrence Outstanding Teacher Award • DMC mounts Sloan conference on curricular uses of computational tools • NSF sponsored project in microcomputer/workshop physics begins with JEG as PI • DMC member of outside review team for Kalamazoo College • DMC presents colloquium at University of Wisconsin-Eau Claire • NEH support for JB^2 • DMC participates in NSF workshop on computational physics • Two students give talks at Argonne Symposium • Five students engaged in summer research • JRB gives invited talks at Kaleidoscope Colloquium and AAAS meeting • Department holds fourth annual recruitment weekend for prospective students

1991: • DMC elected to membership of AAPT Committee on Computers in Undergraduate Physics Instruction • DMC presents invited talk at winter AAPT meetings • Graduated 13 majors • Fulbright award to JRB • NEH support for JB^2 • DMC presents invited talk at spring meetings of Pacific Northwest Association for College Physics • NSF support for laser workshops for college faculty • Tody Deitrich, LU '93, receives Goldwater Scholarship • Student gives talk at NCUR-III • Two students give talks at Argonne Symposium • Five students engaged in summer research • Spectra-Physics support for URP-like project under JRB • JEG mounts summer workshop for high school teachers • Four students engaged in summer research • JRB develops physics consulting service for CUR and attends Gordon Conference • DMC presents invited talk at Davidson College Conference on Computational Physics • Department holds fifth annual recruitment weekend for prospective students

1992: • Two students present joint poster at NCUR-IV • Graduated 11 majors, three *summa*, one as Rhodes scholar • NEH support for JB^2 • Crystal Print support for UPR-like project under JRB • DMC chairs session on uses of symbolic computation in client disciplines at Denison conference of mathematics educators • DMC participates in NSF/CRAY workshop on supercomputers, spends one-term sabbatical partly at San Diego Supercomputer Center • DMC presents invited talk at summer AAPT meetings • Four students engaged in summer research • DMC proposal pending before NSF-ILI project for computational physics • Andrea Murschel, LU '92, receives NSF graduate fellowship • Student gives talk at Argonne Symposium • Department holds sixth annual recruitment weekend for prospective students

1993: • JRB assumes Physics/Astronomy Division Chair of CUR and will chair APS committee to choose recipient of APS/RC prize for outstanding researcher in undergraduate institution • Graduated 11 majors • Two students give talks at NCUR-V • Department invited by Research Corporation to suggest consultants and prepare a five-year plan • SNC Foundation and Crystal Print support for URP-like project under JRB • DMC receives NSF ILI grant for 3D workstations • One student engaged in summer research • DMC presents invited talk at summer AAPT meetings • SML joins faculty and is nominated for Sloan Fellowship and for NSF Young Investigator Award • DMC submits proposal for computational physics and advanced laboratory to W. M. Keck Foundation • DMC member of outside review team for Skidmore College • Two students give talks at Argonne Symposium • SML gives invited talk at Boston MRS Conference • SML submits Perkin-Elmer and RC proposals • Department holds seventh annual recruitment weekend for prospective students

1994: • DMC receives grant for computational physics and advanced laboratory from W. M. Keck Foundation • SML receives equipment grant from Perkin-Elmer and research grant from RC • SML gives invited talk at San Francisco MRS Conference • SML consults with California company • JRB consults with local company • One student gives talk at NCUR-VI • Graduated 8 majors • Six students engage in summer research • DMC appointed Associate Editor of *Computers in Physics* • Department invited to submit proposal to RC for a Department Development Grant • One student gives talk at Argonne Symposium • Department holds eighth annual recruitment weekend for prospective students

1995: • Department is awarded RC Department Development Grant • JB^2 retires from active teaching • JRB receives Lawrence Outstanding Teacher Award • Five students engage in summer research • JAC joins faculty in tenure-track position • JCK joins faculty as sabbatical replacement • JRB takes sabbatical year with Dan Kleppner at MIT • Department holds ninth annual recruitment weekend for prospective students

1996: • Ten students engage in summer research • KLH joins faculty in one-year position • BJD joins faculty as laboratory supervisor • Department holds tenth annual recruitment weekend for prospective students

1997: • Five students engage in summer research • First fall departmental picnic arranged by Women of Physics • Condensed Matter Physicist Dr. Robin Selinger gives Science Colloquium and Physics Colloquium • Scot Shaw, Mark Nornberg, and Jim Truitt, all LU '98, give capstone physics colloquia • Leta Steffen, LU '00, receives Luce Scholarship • WOP started. • MRS joins faculty in tenure-track position • DMC submits final report to Keck Foundation • MRS submits RC proposal, receives grant • JAC attends Gordon Conference on liquid crystals • JRB attends Gordon Conference on atomic physics • SPS chapter, founded in 1969 but dormant for many years, reactivated. • Department graduates 14 majors (largest ever) • Department holds eleventh annual recruitment weekend for prospective students

1998: • Nine students engage in summer research • APS Visiting Scientist Thomas Rossing gives Science and Physics Colloquia • Plasma Physicist Stewart Prager gives Physics Colloquium • Nobel Laureate Dudley Hershbach gives Physics/Chemistry Colloquium and University Convocation • High-energy physicist Howard Georgi gives Phi Beta Kappa Lecture and Physics Colloquium • Second annual fall departmental picnic held • Tim Beck, Erik Brubaker, and Kurt Taylor, all LU '99, give capstone Physics Colloquia • Low Temperature Atom Trapper Dr. Reneé Nesnidal, LU '92, gives Physics Colloquium • X-ray diffractometer upgraded • DMC arranges first annual departmental retreat at Björklunden (Lawrence's 425-acre northern campus in Door County, WI) • Department holds twelfth annual recruitment weekend for prospective students • MRS submits DOE proposal, receives grant • Jim Truitt, LU '98, and JAC attend March APS meeting in Los Angeles; Truitt gives talk • Scot Shaw, LU '98, wins NSF graduate fellowship • Nobel Laureate Dudley Hershbach visits • Erik Brubaker, LU '99, offered summer position at CERN • Cindy Regal, LU '01, receives Luce Scholarship • JRB, JAC, and DMC attend and make presentation at the Physics Revitalization Conference

1999: • Eight students engage in summer research • PWF joins faculty as laboratory supervisor • Third annual fall department picnic • JAC gives Science Colloquium • Joshua Cross, LU '01, gives capstone Physics Colloquium, a preview of talk also given at PEW Midstates Science Colloquium • Angela Kopp, LU '01, gives Physics Colloquium, a preview of poster also presented at Seattle APS meeting • Jessica Reeves, LU '00, gives capstone Physics Colloquium • Marshall Wilt, Center College, gives Physics Colloquium • Mssrs. Hilborn, Hallock, and Campins (representing RC) make their penultimate visit as consultants and overseers of our five-year departmental development program • Eric Moore, LU '99, gives Physics Colloquium on summer work at U Michigan • JRB submits final report on our departmental development program in August • Dr. Yoriko Morita, LU '94, gives Physics Colloquium • Dr. Jay Lockman, Harlow Shapley visitor, gives Science and Physics Colloquia • Department holds thirteenth annual recruitment weekend for prospective students • JRB named Fellow of APS • DMC arranges second annual departmental retreat at Björklunden • Cindy Regal, LU '01, and Paul Kondratko, LU '00, give Physics Colloquia on summer work at U Oregon and MIT, respectively • Paul Kondratko, LU '00, delivers talk at Centennial APS meeting in Atlanta • JAC spends spring term on pretenure sabbatical at University of Washington • Department takes delivery of donated $150K EPR spectrometer • Thirteen students graduate with major or minor in physics

2000: • Nine students engage in summer research • Dr. Thad Walker gives Science and Physics Colloquia • Dr. Steven Ackerman gives Science and Physics Colloquia • Dr. David Bishop gives Science and Physics Colloquia • Dr. Michael Turner gives Physics Colloquium • Dr. Steve Lundeen gives Science and Physics Colloquia • Dr. David Newman gives Science and Physics Colloquia • DMC receives CCLI-EMD grant for writing book on computational tools • Department holds fourteenth annual recruitment weekend for prospective students • DMC arranges third annual departmental retreat at Björklunden • Third annual fall departmental picnic • Cindy Regal and Angela Kopp, both LU '01, awarded Goldwater Scholarships • Cindy Regal, LU '01, gives Physics Colloquium on summer work at U Colorado • Joshua Cross, LU '01, gives Physics Colloquium on summer work at NASA Langley • Dr. James Callen gives Physics Colloquium • Jaques Bluett, LU '01, gives capstone Physics Colloquium • Dr. Jonathan M. Aurnou gives Geology/Physics Colloquium • $18M new science building dedicated • $10M renovation of Youngchild Hall begun; Department scattered to temporary quarters • MRS takes pretenure sabbatical in fall • Dr. Kate Kirby visit arranged by Women of Physics; she gives Science and Physics Colloquia • Dr. Thomas M. Baer, LU '74 and CEO Arcturus, gives Physics Colloquium • Robin Sampson, LU '02, Derek Thuecks, LU '02, and Michael Yakes, LU '01 give Physics Colloquia on summer work at Lawrence and present also at PEW Undergraduate Symposium

2001: • Six students engage in summer research • String theorist Brian Greene gives University Convocation and Physics Colloquium • Department holds fifteenth annual recruitment weekend for prospective students • Angela Kopp, LU '01, gives capstone Physics Colloquium • Visit of Dr. Susan Babcock arranged by Women of Physics; she gives Science and Physics Colloquia • Joshua Cross and Jaques Bluett, both LU '01, give capstone Physics Colloquia • Cindy Regal, LU '01, and Leta Steffen, LU '00, receive NSF graduate fellowships • Cindy Regal, LU '01, wins Hertz Fellowship • Sidebar to article in April, 2001, *Physics Today* describes departmental successes • Dr. Robert D. Gehrz, gives Science and Physics Colloquia • Cindy Regal and Stuart Schmitt, both LU '01, give capstone Physics Colloquia • JAC awarded tenure • PWF made Visiting Assistant Professor • DMC gives invited talk on computational project at winter AAPT meeting • DMC gives invited talk on attracting and retaining physics majors at April APS meeting • DMC gives invited talk on computation in undergraduate physics at May International Conference on Computer Science • DMC conducts week-long computational workshop for 14 college physics teachers • searches launched for PWF successor and two-year sabbatical replacement • Department holds fifteenth annual recruitment weekend for prospective students • SPS arranges fourth annual departmental retreat at Björklunden • Department moves into renovated spaces with 40% more floor area • Dr. Robert L. Merlino gives physics colloquium • Dr. Raymond Fonck gives physics colloquium

2002: • 11 students engage in summer research • Department holds sixteenth annual recruitment weekend for prospective students • Department receives $400K grant from W. M. Keck Foundation to support signature programs in laser physics, computational physics, and surface physics • DMC conducts two week-long computational workshops, the first for 17 and the second for 19 college physics teachers • Fifth annual Bjorklünden retreat • PWF gives Science Hall Colloquium • MRS gives Science Hall Colloquium • SPS arranges fifth annual departmental retreat at Björklunden • Sixteenth annual recruiting workshop attended by 21 prospective physics majors • Derek Thuecks, '02, gives capstone talk • Humberto Campins, Robert Hallock, and Robert Hilborn make post-award visit after completion of RC departmental development grant • Team from NTFUP visits to learn about Lawrence success in building undergraduate physics program • Harold Varmus gives University Convocation • Quinn Marksteiner, '02, gives capstone talk • Annual reception for graduating majors and their graduation guests held at home of Professor Stoneking •Andrew B. Kunz hired into three-year position to succeed PWF •Paul E. Bunson hired as replacement for DMC, JAC, and JRB Keck-supported leaves. • Nicholas Mauro and Joseph Wells make presentations at PEW Undergraduate Symposium • Michael Omiecinski, representing Columbia University Biosphere program, visits • John Goree, University of Iowa, visits and gives physics colloquium • Andrew Kunz gives physics colloquium • Michelle Milne, '04, Scott Kaminski, '05, and Kimberly Robinson, '03, give physics colloquium on summer research projects • Christopher Phelps, '03, and Ryan Peterson, '03, give physics colloquium on summer research projects • Joseph Wells, '03, gives capstone talk • Robert Hanisch, '76 and NASA Space Telescope Institute, visits and gives physics colloquium

2003: • Sixth annual Bjorklünden retreat • Department holds seventeenth annual recruitment weekend for prospective students • Steve Kawaler, Iowa State University and AAS Harlow Shapley Lecturer visits; gives Science Hall Colloquium and Physics Colloquium • Michael Turner, University of Chicago, visits as Phi Beta Kappa lecturer; gives Science Hall Colloquium and Physics Colloquium • Suzanne Witt, '03, gives physics colloquium on summer research • Elizabeth Kruesi, '04, gives physics colloquium on summer research • Megan Schendel, '04, gives physics colloquium on summer research • David Munro, Natiional Ignition Facility at LLNL, visits and gives physics colloquium • Jack Schendel, Sandia National Laboratories, visits and gives physics colloquium • Sarah Gilbert, University of Colorado and NIST–Boulder visits and gives physics colloquium and physics seminar • Thomas Baer, '74, and CEO of Arcturus, Inc., visits and gives joint Physics/Biology colloquium • Diandre Leslie-Pelecky, University of Nebraska, visits and gives two physics colloquia • Ryan Peterson, '03, gives physics colloquium on term project at Cerro-Tololo Observatory • Suzanne Witt, '03, gives capstone talk • Mark Growdon, '04, gives capstone talk • 10 students engage in summer research • DMC conducts week-long computational workshop for 20 college physics teachers • Jennifer Herek, '90, Group Leader at FOM Institute, Amsterdam, gives summer science colloquium • Annual all-department picnic held in Sage Hall basement • Paul Schonfeld, '05, and Michelle Milne, '04. give physics colloquium on summer research • Jason Levin-Koopman, '04, and Matthew Stackpole, '05, give physics colloquium on summer research • Matthew Dietrich, '04, and Lauren Kost, '05, give physics colloquium on summer research • Lauren Kost, Jason Levin-Koopman, Nicholas Mauro, and Matthew Stackpole make presentations at PEW Undergraduate Symposium

2004: • Seventh annual Bjorklünden retreat • Department holds eighteenth annual recruitment weekend for prospective students • Megan Schendel, '04, gives physics colloquium on fall-term work at NIST-Boulder • Nicholas Mauro, '05, gives physics colloquium on summer research • Steven Hahn, '05, and Dwight Mills, '04, give physics colloquium on summer research • PEB gives informal talk on physics and mathematics of juggling • Steve Feller, Coe College, visits and gives physics colloquium on REU program at Coe • Elizabeth Simmons, Michigan State University, visits and gives both a Science Hall Colloquium and a Physics Colloquium • Elizabeth Kruesi, '04, and Megan Schencel, '04' give physics colloquium on summer research • Caty Pilachowski, Indiana University and AAS Harlow Shapley Lecturer visits and gives both a Science Hall Colloquium and a Physics Colloquium • Steve Kohlmann, '04, gives capstone talk • JAC and JRB make presentation at CUR National Conference in LaCrosse • Andrew Kunz resigns a year early to take tenure-track post elsewhere • Paul Bunson's two-year appointment comes to an end and he moves to a tenure-track post elsewhere • James O. Dunn hired to succeed Andrew Kunz • 10 students engage in summer research • Start celebration of World Year of Physics with student presentations about famous 20-th century physicists at Tuesday teas • Eric Cornell, Nobel laureate, University of Colorado, and NIST-Boulder visits and gives both a Science Hall Colloquium and a Physics Colloquium • Gregory Exarhos, '70, Associate Director of group at Pacific Northwest National Laboratory, visits and gives physics colloquium • MRS gives physics colloquium • Lawrence department hosts meeting/sharing session for a dozen physics teachers from local high schools • James L. Truitt, '98, visits and gives physics colloquium on his recently defended PhD thesis • Duncan Ryan gives presentation at PEW Undergraduate Symposium • Paul Schonfeld, '04, gives Physics/Geology colloquium on summer research at Michigan Tech

2005: • Eighth annual Bjorklünden retreat • MRS gives physics colloquium on Einstein 1905 paper on Brownian motion as part of celebration of World Year of Physics • Daniel J. Den Hartog, University of Wisconsin–Madison, visits and gives physics colloquium • Department holds nineteenth annual recruitment weekend for prospective students • Lauren Kost, '05, and Duncan Ryan, '06, give physics colloquium on summer research • Steven Hahn, '05, gives physics colloquium on summer research which he continued as a capstone project • Christina Dunn, PhD student at University College of London gives science colloquium • Samridha Kunwar, '05, and April Evans, '05, give physics colloquium on capstone projects • Dr. Volney "Bill" Wilson chats with students at tea about his experiences as a PhD student under Arthur Holly Compton at Chicago in the 1930s • Dr. Michael Brown, Swarthmore, visits and gives science and physics colloquia • DMC does outside review for Department of Physics at Lake Forest College. • Dr. Sean Carroll, University of Chicago, visits and gives science and physics colloquia in honor of World Year of Physics • Dr. Lyle Roelofs and Dr. Louis Bloomfield visit for a two-day outside review of the Department of Physics