Courses: 1963-2015

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1 Introduction

There have only been a few instances when I have been accused of being a “great teacher,” allegations that most of my students and I would readily deny. Nevertheless, my pedagogical experiences over more than half a century may merit some notice, if only for the variety and number of distinct courses that I have taught, a record for this Department that might be unique in its breadth. Most of these courses had existing structures before I taught them. Some assignments were in response to solicitations from students, but very few were requested by me, except to repeat a course in order to capitalize on a prior experience. Repetitions seldom resulted in less work for me, but usually led to an improved product. A few courses were created anew with new titles, syllabi, and a fresh set of notes.

In Section 2, I will point out some issues that were relevant to major changes in our undergraduate and graduate programs, noteworthy circumstances about particular courses, and which courses reflected my research interests or, in a few instances, led to new research initiatives.

For the sake of perspective, it might also be useful to note that:

- The first class that I ever taught, in anything at any place, was graduate-level classical mechanics in the Fall of 1963 at Case Institute of Technology. I had fellowships with no specific duties throughout my graduate career.

- It was a while before I taught at the undergraduate level for one unit of a multi-section, introductory course, I believe Mechanics, with someone else in charge.

- Although I taught many independent-study courses, usually for a single student, all of them were given in response to student requests. Moreover, virtually all of these courses were based on subjects that I had taught previously in the conventional way: lecture notes, problem sets, and exams and to some extent the office meetings were followed the earlier class-room model.
2 Courses from Fall 1963 to Spring 2015

2.1 Undergraduate

- Introductory Physics:
  None of the courses in this category were by my request. In the particularly egregious case of FSNA 138 this meant the creation of the topic and structure of the course on relatively short notice, balanced by the considerable freedom to suggest any topic acceptable to the SAGES administration, as well as a choice as to the degree of writing instruction collaboration.

  - Small-lecture section format (C.I.T. and early CWRU) and the recitation sections of large-lecture format courses (Later CWRU) of all extant freshman and sophomore introductory courses on mechanics, electromagnetism, and modern physics from mid-1960’s on, numerous times, including hour- and final-exam grading. I kept no easily accessible record of when I taught these courses.
  - In-Charge (Large Lecture Format): General Physics 121, Mechanics, spring 2005.
  - In-Charge (Large Lecture Format): Modern Physics 221, fall 2005.
  - FSNA 138: Light, SAGES, First Seminar Natural Science.
    - Created this course for fall 2012 when it was taught collaboratively with a writing instructor fall: 2012g, 2013.
    - Taught with a writing instructor, but in a non-collaborative mode, fall 2014.
    - Established as a “permanent” SAGES first seminar, after a favorable internal peer review, in the fall of 2014 fortuitously preceding the 2015 International Year of Light.
    - Organized this course and presented several classes as well as supervising the staging of all of the others with a format motivated by a different rationale from that of the previous years.
For the first time in the history of the course every physics professor on the faculty presented a class within the academic year, some of these faculty for the first time, abandoning the more selective, repetitive formats, over the fall and spring terms, of the previous years. Moreover, this was the first time that some of the faculty were even canvassed about presenting one of the classes. Since there were more speaking slots than regular faculty, there were a few repetitions in the fall and spring and, in addition, a few classes were given by Instructors and Adjunct Faculty.

This course was distinguished as the setting my last classroom lecture at CWRU, Physics at the Highest Energies, April 27, in the spring of 2015, prior to my retirement the next month, that briefly referred to my experiences in experimental particle physics, mainly at Fermilab, as well as a review of the “highest energies” from the 19th century through the present LHC era and latest cosmic-ray and other astrophysical facilities.

Computational Physics:
Of all my teaching experiences this one proved to be the most tumultuous from the time in the 1970’s when I proposed such a course, to be taught by someone else, of course, until the first time that I was actually assigned to teach it in 1998 and every year afterwards for 7 consecutive years, followed by encores in 2010 and 2011, with almost yearly reviews of the course by the Undergraduate Committee.

The 1998 assignment was a total surprise and a real learning experience for me. A difficulty with teaching the subject, particularly during that transitional time, is that, unlike with most other subjects in the curriculum, the students who took the course in the first few years that I taught it often arrived possessing considerable prior experience, even expertise in some cases, and very strong views about various aspects of computing practices. Also, the faculty then often possessed informed opinions about what such course should contain and what sort of software and operating systems were appropriate for it. Differing viewpoints in the midst of the revolutionary changes that were taking place in the development of computing software, hardware, and internet are to be expected, but typically, in this instance, provided lit-
tle of permanent relevance and this turned out to be the case. Happily, in contrast to many of my students and colleagues, I seldom felt the weight of tradition, the grip of vested interests, or any remorse that I had wasted too much time on the ephemeral.

In detail:

− Originally proposed, circa 1977, but did not teach until 1998, the course that is now 250 as a substitute, within the program for the then new Mathematical Physics major for some of the usual upper-level laboratory course requirements for the B.S. in Physics. Faculty opposition at the time was based on the idea that computing skills could be best taught within the Departmental research laboratories that contained various minicomputers, rather than as a formalized course offering.


− Redesigned Physics 250 twice for the periods 1998-2004 and 2010-2011 facilitating the transition to the modern computing epoch:
  * Proposed an approved change in course title, *Computational Methods in Physics*, from the original *Mathematics, Physics, and Computing*.
  * Oversaw the transition of the course from various higher-level languages (Basic, Pascal, Fortran) to C and then C++.
  * Transformed the course from the use of the Unix machines in the University computer laboratories on through to the era of inexpensive, powerful personal computers.
  * Changed the orientation of the course from data reduction and error analysis, to the practical implementation of computational problems in various fields of physics, particularly stochastic and Monte Carlo techniques, and a computationally-based introduction to mathematical physics including nonlinear differential equations, numerical complex analysis, and probability theory.
  * Introduced Unix modules concerning with Sun workstations at the University computing laboratory before the Linux and Mac OS X operating systems became readily available.
* Instituted a course-long emphasis in \LaTeX{} for mathematical typesetting for use in course project reports and for typesetting responses to the take-home finals.

* Promoted the incorporation of the Mathematica software program throughout the course, as opposed to Maple and Matlab, and as a more practical alternative to programming in compiled languages.

- Chaired a committee appointed by the Department Chair to explore the goals of 250 and the possibility of instituting an upper-level course with respect to computing in physics as is more typically the case at other universities.

- Granted a Presidential Award for purchase of a computer in support of my Linux- and Windows-based computing options in 250 in order to accommodate the platforms used by the majority of students before 2004, but was unnecessary after that.

- Awarded a Hewlett Fund grant to design an upper-level undergraduate course in computational physics. Funds used primarily to institute a course (taught by Dr. Peter Kernan) in the applications of scripting languages (mostly Perl) to computations in physics.

- Physics 329, fall 2008: Reading course requested by student in the use of Mathematica.

• Statistical Physics:

  - Physics 361 (now 313): Statistical Physics: fall 1971. Self-assigned the course as Chair in response to conflicts in the commitments of other faculty and the departures of faculty who had pursued major research interests in statistical mechanics.

• Relativity/General Relativity:
  General relativity was not my research specialty or that of any C.I.T. faculty, but it was of several members of the W.R.U. Physics Department shortly before its dissolution. After both Departments were combined, the former W.R.U. relativists left and it was quite a while before a real G.R. course was instituted and even longer until faculty with G.R.-related research programs were hired. Even though almost
the whole of my own G.R. experience came from teaching the former Physics 369, *Relativity*, before the astroparticle faculty began arriving in 1993, after that I still was assigned (never requested) to teach 365/465, *General Relativity*, several times. Irrespective of the various course numberings virtually all of these courses were at the undergraduate level, except for 308 at Case in 1966.

- Physics 308 (C.I.T. Graduate): *Relativity*, spring 1966. An unrequested assignment to a course that was seldom offered at C.I.T.. I resolved the problem of what to discuss by concentrating on the physics of special relativity and the mathematical consideration of the Lorentz and Poincaré symmetry groups. A lot of time spent on the theory of continuous groups.

- Physics 369: *Relativity*, spring: 1990, 1992. Initially assigned on short notice when the instructor of record essentially decided to retire during the break between semesters. The principal focus of the course now was supposed to be general relativity.

- Physics 369: *Relativity*, 1993, 1994, 1995. (As reading course; various semesters all requested by students.)

- Physics 365/465: *General Relativity*, spring 2004, fall 2007, spring 2014. Amusingly, the 2014 assignment, after a 7-year interregnum and my earlier recommendations that the course be taught by one of the astroparticle theorists, was the result of winning a poll of the Physics Majors conducted by the Department concerning their preferences for an elective that term.

- Physical Optics:
The first assignment in 2009 seemed to have resulted from Departmental staffing constraints. Whatever the reasons, the enrollment was a record high not exceeded until the spring of 2016 after a three-year period when the course was only offered once. In 2011 and 2012 I redesigned the course, with a new text, to emphasize photonic aspects of the subject, changes that did not appear popular with students from other Departments.


- Quantum Mechanics:
Seemingly assigned because of staffing issues due to the retirement of the person who had taught the courses for several previous years.


- **Nuclear and Particle Physics:**
  A string of 13 assignments, broken only in 1987 by my sabbatical at ANL, that coincided with the transition of my research to particle physics. From 1/3 to 1/2 of this course dealt with nuclear physics, a tradition that has not been followed in the last couple of decades. This string also spanned an era when it was a required course for all physics majors.


- **Methods of Mathematical Physics:**
  If a number of publications published in the *Journal of Mathematical Physics* over nearly a half-century qualifies one as a “Mathematical Physicist,” then this course definitely benefited from my research as well as contributing to it. A number of innovations were introduced, in particular, increased emphases on the Hilbert-space and group-theoretic mathematics of quantum theory, as well as the mathematical aspects of probability theory.


- **Senior Projects:**

  - Physics 351-352-353: fall 2013 and spring 2014 [Co-In-Charge with K. Singer].
  - Physics 351-352-353: fall 2014 and spring 2015 [Co-In-Charge with R. Petschek].
2.2 Graduate

- Major re-design of First-Year Graduate Courses:
  Joint chair (with P. Taylor) of a committee to re-design selection of first-year graduate courses. Our recommendations that only one semester (now 423) of Electromagnetism be required and that Classical and Statistical Mechanics (413-414) be joined in a two-semester coordinated course were approved by the Department. This proposal was in coordination with a separate proposal by others to initiate a new graduate laboratory course (472) in the space occupied by the old 422. The former second semester of electromagnetism (422) became a graduate elective in nonlinear optics (522).

- Methods of Mathematical Physics (Graduate):
  - Physics 449: fall 2002. There was an anomalously large registration of graduate students from the Engineering School this term.

- Classical Mechanics (Graduate):
  In the 1960’s this subject comprised the fall semester of a year-long C.I.T. course in “Theoretical Physics” with the second term devoted to electromagnetism.

- Classical Electromagnetism (Graduate):
  In the 1960’s this was the spring semester of a year course in “Theoretical Physics” with the first term devoted to classical mechanics. All in all 21 courses concerning E&M.
• Statistical Mechanics:
Prior to the federation of Case and Western Reserve, there were a number of faculty in both of the two Physics Departments whose research specialties primarily involved statistical physics. After 1970 this was no longer true, for the most part, and this led to my getting involved in a subject in which I had no prior experience, except for the course that I took as a graduate student. By the mid-1980’s, however, I started a research program in thermal field theories and some aspects of probability in connection with multihadron production mechanisms, thereby providing an orientation quite different from those faculty with interests in some area of condensed-matter physics. Except for my unexpected assignment of 414 in 2007, after a long pause of 13 years, the course has reverted back to its prior associations with the broad condensed-matter community within the Department.

• Nonlinear, Physical, and Quantum Optics:
I am the only faculty member, through 2011, to have had taught the following courses that concern nonlinear and quantum optics. After 1991, I repeatedly recommended that a specialty course primarily concerned with lasers be offered in addition to 522, which as I taught it, was mainly concerned with the propagation of light in nonlinear materials and not on the devices for generating that light. Ironically, in the spring of 2015 I was assigned a supernumerary role with the laser course, Physics 327/427, that was eventually was offered by the Department that took up that recommendation.


• Physics 414: The second half Classical and Statistical Mechanics, spring 2007.

• Physics 426: Physical Optics, spring: 2009, 2011, 2012. (This course was offered each time simultaneously with its undergraduate mirror, 326, in order to accommodate graduate registrations, particularly from outside of Physics. The graduate course was not too different the undergraduate version, befitting the situation in which the prerequisite for both courses as listed in the University
Bulletin is 100-level Electricity and Magnetism and the description for the graduate version promises only “extra work” in addition.

- Physics 539: *Nonlinear and Quantum Optics*, fall 1991. (Created this course after proposing the need for it in our graduate curriculum with the growth of experimental modern optics research within the Department.)

- Physics 522: *Nonlinear Optics*, spring 1995 (still as 422), 1996, 1997, 2002. (Created this course as a replacement for the discontinued second semester of E&M, old 422.)

- Physics 522: *Nonlinear Optics*, given as a reading course, 1997, 1999, 2000, as requested by several of K. Singer’s research students.

• Nuclear and Particle Physics:
  In the progression to the present era, the course evolved to one customarily taken by all graduate students, to one taken only by students with research interests in astroparticle physics. In this progression, the nuclear component atrophied paralleling its demise from the research interests of the Department.


• Quantum Mechanics:


• Advanced Quantum Theory:


**Gauge Field Theory:**

– As Physics 539: *Gauge Field Theory I*, spring 1997.
– As Physics 591: *Gauge Field Theory I*, spring 2007.

**Advanced Topics in the Theory of Many-Particle Systems I and II:**
This new two-semester course was created in 1973 at the request of a group of physics graduate students with interests in theory. (I am the only faculty member, through 2011, I believe, to have had taught these two courses and no one else as a two-semester unit.) The course was well-attended and two condensed-matter theorists on the faculty attended almost all of the lectures throughout the 1973-74 year. Much of the second-quantized techniques that were the subject of this course were incorporated into the advanced quantum-theory courses that I taught over the years. Those techniques, along with the non-relativistic finite-temperature field theory methods that were taught, were also picked up more than a decade later in my research. Bound copies of the Xeroxed notes for this course were sold by the University Bookstore for several years in conjunction with several other of my courses including a repeats of 545.

– Physics 545: reading/seminar course, mid 1980s (dates uncertain) to two students.

**Leuven:**
Two one-semester graduate courses at the University of Leuven, Belgium, while on leave, as a Guest Professor. One lecture per week during the fall and spring terms. Nothing resembling these courses was ever taught at C.I.T./W.R.U. or CWRU by me, or anyone else, for that matter. Given the better background of the European students I was able to bring the level of the lectures quite close to that my of contemporary research. Several papers, a monograph, and the start of one
of the Belgian graduate students on his research career came about
directly as a consequence of these courses.

- Fall 1968: Graduate lectures on contemporary particle physics,
  mostly involving various aspects of the strong-interactions. Dis-
  persion relations and Regge poles as applied to the phenomenology
  of hadronic scattering problems.

- Spring 1969: Graduate lectures on the 3-body scattering prob-
  lem. The typeset, duplicated, and distributed notes for this course
  formed the starting point of the monograph *Dynamical Colli-
  Paperback and Electronic Editions, 509 pp., Elsevier, 2013 co-
  authored with S.K. Adhikari.