

CURRICULUM VITAE OF
NANNAPANENI NARAYANA RAO
October 2008



PERSONAL DETAILS

Present Position: **Edward C. Jordan Professor Emeritus of Electrical and Computer Engineering (ECE),** University of Illinois at Urbana-Champaign (UIUC) Urbana, Illinois, U.S.A.
Distinguished Amrita Professor of Engineering Amrita Vishwa Vidyapeetham (University) Ettimadai, Coimbatore, Tamil Nadu, INDIA

Office Address, Phone, and E-Mail: 353 Everitt Laboratory
1406 West Green Street
Urbana, IL 61801

Telephone and Fax: Tel: (217) 333-4183
Fax: (217) 244-7075

E-Mail: nnrao@illinois.edu

Home Page URL: <http://faculty.ece.uiuc.edu/rao/nutshell.html>

Citizenship Status: U.S. Citizen

Home Address and Phone: 2509 South Lynn
Urbana, IL 61801
(217) 328-2451

BIOGRAPHICAL SKETCH

Birthplace, Education, and Joining UIUC

Nannapaneni Narayana Rao was born in Kakumanu, Guntur District, Andhra Pradesh, India. Prior to coming to the United States in 1958, he attended the Presidency College, Madras, receiving the B.Sc. Degree in Physics from the University of Madras in 1952, and then the Madras Institute of Technology, receiving the Diploma in Electronics from that Institute in 1955. In the United States, he attended the University of Washington, receiving the M.S. and Ph.D. Degrees in Electrical Engineering in 1960 and 1965, respectively. In 1965, he joined the faculty of the Department of Electrical Engineering, now Department of Electrical and Computer Engineering (ECE), of the University of Illinois at Urbana-Champaign, Urbana, Illinois, accepting an offer from the then Department Head, the late Edward C. Jordan.

Research, Teaching, Writing, and Service at Home and Abroad

At the University of Illinois at Urbana-Champaign, Professor Rao has carried out research in the general area of ionospheric propagation, taught a wide spectrum of courses, and developed courses in electromagnetic fields and radio wave propagation. He is the author of the undergraduate textbooks, BASIC ELECTROMAGNETICS WITH APPLICATIONS (Prentice Hall, 1972), six editions of the widely used ELEMENTS OF ENGINEERING ELECTROMAGNETICS (Prentice Hall, 1977, 1987, 1991, 1994, 2000, and 2004), and the Indian Edition of ELEMENTS OF ENGINEERING ELECTROMAGNETICS, Sixth Edition, published by Pearson Education, India, in 2006. He has pioneered the use of personal computers for teaching electromagnetics and has developed interactive software to enhance the learning of basic concepts. He has been influential in changes in the curriculum at the University of Illinois and has engaged in international activities, participating in a World Bank Education project for institutional development at the University of Indonesia in Jakarta, Indonesia, in 1985-86, among other contributions. In July-August 2006, he visited India's AMRITA University as the first professor to teach a course, under the Indo-US Inter-University Collaborative Initiative in Higher Education and Research. He is currently the Edward C. Jordan Professor. He also holds the honorary position of Distinguished AMRITA Professor of Engineering at AMRITA VISHWA VIDYAPEETHAM, Ettimadai, Coimbatore, India.

Membership in Professional Societies

Professor Rao is a Life Member of the ASEE, the U.S. Commission 3 of the URSI (International Scientific Radio Union), and of the Antenna and Propagation, and Education Societies of the IEEE. He is a Life Fellow of IEEE and served as an IEEE ABET evaluator.

Awards and Honors prior to 1994

Professor Rao has received numerous awards and honors for his teaching and curricular activities. During the period prior to 1994, these include the first Award in Engineering in 1983 from the Telugu Association of North America (TANA), an association of Telugu-speaking people of origin primarily in the State of Andhra Pradesh (population 75 million), India, with the

citation, *"Dedicated teacher and outstanding contributor to electromagnetics;"* a plaque of highest appreciation from the Faculty of Technology, University of Indonesia in Jakarta, Indonesia, for curriculum development in 1985-86; the campus Undergraduate Instructional Awards in 1982 and 1988, the Everitt Award for Teaching Excellence from the College of Engineering in 1987, the Campus Award for Teaching Excellence and the first Oakley Award for Innovation in Instruction in 1989, and the Halliburton Award for Engineering Education Leadership from the College of Engineering in 1991, all at the University of Illinois at Urbana-Champaign; election to the Fellow grade of the IEEE in 1989 for contributions to electrical engineering education and ionospheric propagation; the AT&T Foundation Award for Excellence in Instruction of Engineering Students from the Illinois-Indiana Section of the ASEE (American Society for Engineering Education) in 1991; and the ASEE Centennial Certificate in 1993 for exceptional contribution to the ASEE and the profession of engineering.

The IEEE Technical Field Award in Undergraduate Teaching in 1994

In 1994, Professor Rao received the IEEE Technical Field Award in Undergraduate Teaching, one of two highest awards given by IEEE for teaching, with the citation, *"For inspirational teaching of undergraduate students and the development of innovative instructional materials for teaching courses in electromagnetics."*

Boss of the Year Award in 1998

In 1998, Professor Rao received the Boss of the Year Award from the Secretariat, the association of the secretarial staff of the University of Illinois at Urbana-Champaign, having been nominated jointly by nine secretaries in the Department of Electrical and Computer Engineering. The criteria for the Award are: (1) Perform his/her duties well and enthusiastically support the University and its programs; (2) Routinely show consideration and support of others -- staff, colleagues, students, and visitors to office/campus; (3) Perform courtesies beyond his/her daily responsibilities; and (4) Exhibit other qualities that exemplify good leadership and organizational abilities. In order to facilitate unbiased evaluations of each nomination letter, the nominee is always referred to as he or she, and not by name. Mention of department names or colleges is also not allowed.

TANA Award for Excellence in Education, in 1999

In 1999, Professor Rao received the Award for Excellence in Education from TANA for his outstanding contributions to engineering education, making him the first Telugu American to have received two awards from TANA.

Fifth Edition of ELEMENTS OF ENGINEERING ELECTROMAGNETICS in 1999

Also in 1999, he achieved a milestone in the world of academic publishing with the publication of the fifth edition of his book "Elements of Engineering Electromagnetics," by Prentice Hall with a year 2000 copyright. Professor Rao dedicated this book to the memory of Edward C. Jordan in deep appreciation of the profound influence Jordan had on his professional career. The dedication reads: In deep appreciation of the profound influence on my professional career by

the late Edward C. Jordan (1910 - 1991), renowned author of the famous text book, "Electromagnetic Waves and Radiating Systems," first published in 1950 by Prentice Hall, and revered head of my department for 25 years (1954 - 1979).

Recognition by Colleagues in 2001

In Fall 2001, Professor Rao received a plaque of recognition from his faculty colleagues of the Space Science and Remote Sensing Laboratory of the ECE Department. The plaque reads: "IN APPRECIATION Of the many years of faithful and untiring service in the Department of Electrical and Computer Engineering; Of his nurturing of many generations of students in electromagnetic theory through his teaching and pedagogical writing; Of his collegiality and technical contributions to the ionospheric research program of this laboratory. We, the faculty of the Space Science and Remote Sensing Laboratory of the University of Illinois at Urbana-Champaign, do hereby present N. Narayana Rao this token of our affection and esteem, Given this 10th day of November 2001, Urbana, IL."

Plaque of Appreciation for ABET EC2K Success in 2001

Also in Fall 2001, Professor Rao received a plaque from the ECE Department "in appreciation of his outstanding leadership and tireless dedication throughout our successful ABET review process," which he accomplished by building and implementing the process as the Chair of the departmental ABET Evaluation Committee since its inception in 1998. He also received a symbolic "Doctor of ABETology" degree for his efforts, signed by the Department Head, Dean of the College, the Provost and the Chancellor of the campus.

Translation of Textbook into Indonesian

The fifth edition of ELEMENTS OF ENGINEERING ELECTROMAGNETICS (Prentice Hall, 2000) was translated into Bahasa Indonesia, the language of Indonesia. As stated in the preface, the first part of the dedication offering Salutations to Lord Ganesha (Om Shri Ganeshaya Namaha) was inspired in part by Professor Rao's visit in January 1999 to the Bandung Institute of Technology (ITB), Bandung, Indonesia, where the Image of Ganesha adorns the entrance to the Institute on Jalan Ganesha. It is only fitting that the translation into Bahasa Indonesia was done by a Professor of Physics at ITB.

Edward C. Jordan Professorship in 2003

In Fall 2003, Professor Rao was named to be the first recipient of the Edward C. Jordan Professorship in Electrical and Computer Engineering, created to honor the memory of Professor Jordan, who served as Department Head for 25 years, and to be held by a "member of the faculty of the department who has demonstrated the qualities of Professor Jordan and whose work would best honor the legacy of Professor Jordan."

The investiture ceremony for the Jordan Professorship took place on April 14, 2004, at which time Professor Rao delivered a response speech relating his connection to Professor Jordan and

expressing his gratitude to him. The response speech can be found at the url, http://www.ece.uiuc.edu/faculty/NNR_Speech_Jordan_Professorship.pdf.

Sixth Edition of ELEMENTS OF ENGINEERING ELECTROMAGNETICS in 2004

The sixth edition of ELEMENTS OF ENGINEERING ELECTROMAGNETICS was published in January 2004. Continuing the progressive nature of the revisions, Professor Rao has reorganized the topics to take into account the dramatic shift in the ratio of computer engineering majors to electrical engineering majors from about 1:4 to about 1:1 in recent years

This book served as the lead book in the new “Illinois ECE Series” of textbooks under an agreement with Prentice Hall, to provide encouragement, motivation, and impetus for faculty to convert their class notes into becoming textbooks. An introduction to the Illinois ECE Series is included in the front matter of book. “A Tribute to Edward C. Jordan” is also included.

Gnana Ratna (Jewel of Knowledge) Award in March 2004

At the 60th birthday celebrations of His Holiness Sri Sri Sri Viswayogi Viswamjee Maharaj, the Spiritual Guru (Preceptor) of Professor N. Narayana Rao, in Viswanagar near Guntur, Andhra Pradesh, India, on March 5, 2004, Professor Rao was conferred the Gnana Ratna (Jewel of Knowledge) Award by the Guru for special services rendered in his field. He was one among five recipients, the other four being residents of India, prominent in their respective fields.

Publication of the Indian Edition of ELEMENTS OF ENGINEERING ELECTROMAGNETICS, Sixth Edition, in 2006

In July 2006, Pearson Education, India, published a special “Indian Edition” of ELEMENTS OF ENGINEERING ELECTROMAGNETICS, Sixth Edition, in connection with Professor Rao’s inaugural course offering at the AMRITA University under the Indo-US Inter-University Collaborative Initiative, an agreement signed in December 2005 by the Indian government, AMRITA University, and 15 US universities. The Indian Edition includes a special message from President of India, Dr. A. P. J. Abdul Kalam; a new preface by Professor Rao; forewords by UIUC Chancellor Richard Herman, Provost Linda Katehi, and ECE Professor Nick Holonyak Jr.; and an introductory chapter called “Why Study Electromagnetics?” offering 18 very thoughtful responses to that question, most of them provided by his ECE faculty colleagues and alumni.

Distinguished AMRITA Professorship at AMRITA University in October 2006

In October 2006, AMRITA University created "a super category called DISTINGUISHED AMRITA PROFESSOR, which designates the University's highest level Professorship and also celebrated as something that is given to only very very select cases of Internationally Distinguished Scientists/Leaders, and that is handed down directly from the Chancellor, AMMA MATA AMRITANANDAMAYI DEVI," and Professor Rao has been chosen as the first individual for this honor. Since it is purely an honorary position involving voluntary service, it is held concurrently with the Edward C. Jordan Professorship from the ECE Department at UIUC.

Retirement from UIUC and awarding of Edward C. Jordan Professor Emeritus in 2007

Professor retired officially from UIUC, effective June 1, 2007, after 42 years of service on the faculty of the ECE Department. At a reception given in his honor by the ECE Department on May 11, 2007, he was presented with a plaque with the inscription, “A time to look back with admiration and pride in your accomplishments ... A time to look forward with anticipation.” On June 22, 2007, the Provost of UIUC, upon recommendation from the ECE Department, awarded to Professor Rao the honorific title of “Edward C. Jordan Professor Emeritus of Electrical and Computer Engineering.”

“Fundamentals of Electromagnetics for Electrical and Computer Engineering” and its Indian Edition, “Fundamentals of Electromagnetics for Engineering” in 2008

At his retirement reception on May 11, 2007, Professor Rao announced his plans to travel internationally, particularly to China, hoping to touch students and academics around the world with his books. In this spirit, he announced a one-semester book on fundamentals of electromagnetics, to bear his joint affiliation with Illinois and Amrita. The U.S. Edition of the book was published in May 2008 and its Indian version was published in August 2008, just in time for the first offering of a two-week, eight-day, 40-hour, intensive course for training faculty in electrical-, electronics-, communication-, and computer- related engineering departments in India, at Amrita University from August 11 to August 21, 2008.

EDUCATION

Period Attended	Institution	Certificate or Degree Completed
Secondary School:		
1943-46	Board High School Pedanandipadu, Guntur Dt. A.P., India	Third, Fourth, and Fifth Forms
1946-47	Edward Board High School Nidubrolu, Guntur Dt. A.P., India	Secondary School Leaving Certificate
Undergraduate:		
1947-49	Presidency College	Intermediate (Mathematics, Physics, and
1949-52	(University of Madras) Madras, India	Chemistry); B.Sc. (Physics)
1952-55	Madras Institute of Technology, India	D.M.I.T. (Electronics)
Graduate:		
1958-60	University of Washington, Seattle, WA	M.S. (Electrical Engineering)
1960-64	University of Washington, Seattle, WA	Ph.D. (Electrical Engineering)
Other:		
1998	University of Illinois at Urbana- Champaign	Certificate in Business Administration

PROFESSIONAL CAREER

Period	Position	Duties and Responsibilities
6/107- Present	Edward C. Jordan Professor Emeritus of Electrical and Computer Engineering, USA Distinguished AMRITA Professor, AMRITA Vishwa Vidyapeetham, INDIA	Service for the cause of engineering education and collaboration with American universities, while continuing to teach part time as needed, as emeritus faculty member at UIUC.
10/2/06 – 6/1/07	Edward C. Jordan Professor of Electrical and Computer Engineering, UIUC, USA Distinguished AMRITA Professor, AMRITA Vishwa Vidyapeetham, Ettimadai, Coimbatore, INDIA	Transitioning into a role of service for the cause of engineering education and collaboration with American universities, while continuing on the faculty at UIUC.
8/87 – 9/06	Professor and Associate Head, ECE Department, University of Illinois at Urbana-Champaign (UIUC) Edward C. Jordan Professor from 2003	Primary responsibilities consist of (a) graduate and undergraduate instructional programs of the department involving 550 graduate students (including 45 FTE TAs), 1600 undergraduate students, over 90 faculty, and 18 undergraduate instructional laboratory facilities, (b) graduate admissions and financial aid involving over 2000 applications, and (c) ABET evaluation. Other contributions include authorship of three textbooks and software.
March 1985; 8/85 - 8/86; Summer 1987	Consultant under the MUCIA (Midwest Universities Consortium for International Activities) - Indonesia World Bank IX Education Project, University of Indonesia, Jakarta, Indonesia	Work consisted of (a) developing a new curriculum, (b) specifying modern laboratory facilities and equipment, (c) planning for staff development and utilization, and (d) teaching a course and evaluating student performance, for the EE Dept.
9/75 - 8/87	Professor, ECE Department, UIUC	Teaching, research, and committee and special assignments. Specific contributions include (a) course direction and development of introductory electromagnetics course, involving up to 600 students per year, (b) authorship of two textbooks, (c) chairmanship of curriculum-related committees, and (d) graduate coordinator during 1985-87.
9/69 - 8/75	Associate Professor, EE Department, UIUC	Teaching, Research, and committee duties. Specific contributions include (a) authorship of a textbook, and (b) numerous research publications.
9/65 - 8/69	Assistant Professor, EE Department, UIUC	Teaching, research, and committee duties. Specific contributions include a number of research publications.
12/64 - 8/65	Acting Assistant Professor, EE Department, U. of Wash.	Teaching courses and conducting research.
4/61 - 12/64 1/61 - 4/61 9/58 - 12/60	Acting Instructor Teaching Assistant Research Assistant EE Department, U. of Wash.	Teaching courses and pursuing graduate studies toward the M.S. and Ph.D. degrees.
Summers 1960 and 61	Associate Research Engineer, Boeing Airplane Company	Miscellaneous research projects.
4/56 - 8/58	Research Assistant, Electronics Faculty, Madras Inst. of Technology, India	Conducting research and teaching courses.

COMMITTEES AND SPECIAL ASSIGNMENTS

Description and Period	Duties
Associate Head of Department, 1987 - 2006	See entry under Professional Career
ABET Evaluation Committee Member, 1987 - 90, Chairman, 1994 - 2006	Responsible for report and materials for ABET evaluation visit
Graduate Admissions Committee Member, 1986 - 1987, Chairman, 1987 - 2005	Graduate admission and financial aid decisions for over 2000 applicants per year
Promotions Review Committee Member, 1988 - 2006	Provide input to committee on teaching performance of candidates, and vote on promotion decisions
Faculty Search Committee Member, 1987 - 2006	Provide evaluations of prospective faculty candidates to the Department Head
Continuing Education Committee Member, 1987 - 1995	Advise the College Executive Committee on policies of Continuing Engineering Education
Teaching Evaluation and Awards Committee, Member, 1987 - 2006	Provide input on candidates for teaching-related awards, and on formulating teaching evaluation policies.
Scholarships, Student Awards and Honors Committee, Member, 1987 - 2006	Provide budgetary input associated with undergraduate scholarships and awards
Extramural Advisor, 1987 - 1997	Advise off-campus graduate students in EE
Course Director, ECE 229 1978 - 1985, 1986 - Present	Coordinate the teaching of the multiple-section course "Introduction to EM Fields" by individual instructors
Graduate Coordinator, 1985 - 1987	Staff Graduate Counseling Office, 50% time
Course Director, ECE 358 1974 - 1985	Direct the teaching of senior-graduate level elective course, "Applications of Radio Wave Propagation"
Electromagnetic Fields Area Committee Chairman, 1982 - 1985 Member, 1974 - 1982, 1986 - 1990	Evaluate new courses proposed in the electromagnetic fields area and provide input to the Curriculum and Graduate Committees
Graduate Committee Member, 1973 - 1980, 1986 - 1987	Deliberate on graduate student related matters and evaluate graduate courses
Curriculum Committee Member, 1987 - 2006, 1981 - 1983 Chairman, 1979 - 1981, Member, 1969 - 71	Deliberate on undergraduate curriculum revisions and related matters, and perform evaluations of undergraduate courses
Research Committee Member, 1975 - 1982	Budgetary and other issues associated with the conduct of research in the department
UIUC Senator, 1987 - 1990	Participate in the deliberations of the UIUC Senate

INTERNATIONAL ACTIVITIES

Professor Rao has been involved extensively in educational development activities internationally.

Under the MUCIA (Midwest Universities Consortium for International Activities) - INDONESIA World Bank IX Education Project, he served as a consultant at the University of Indonesia in Jakarta, Indonesia. Initially, he visited the Department of Electrical Engineering during the one-month period from February 27, 1985 to March 27, 1985 to engage in preliminary discussions with the faculty of that department. As a result of the discussions, he prepared a report to the Dean of the College of Engineering summarizing the findings and his recommendations for achieving the goals outlined by the dean.

He returned to Jakarta on August 24, 1985, for a one-year consultancy. During the one-year period, he engaged in activities to implement the recommendations and begin the endeavor of upgrading the department, preliminary to the construction of and move to the new campus of the University at Depok, south of Jakarta. Specifically, he contributed to the following tasks: (a) Development of new curricula for the S1 program for the 1990's and beyond; (b) Planning of instructional laboratories, preparation of equipment lists, and assisting in preparation of specifications for these equipment; (c) Demonstration of instructional techniques and evaluation of student performance; and (d) Advising in the planning for development of manpower (faculty) required to implement the new curricula. The visit concluded with the preparation and submission to the dean of a comprehensive final report entitled, "A new Curriculum, Modern Laboratory Facilities, Staff Development, and Evaluation of Student Performance for Jurusan Elektro, Universitas Indonesia," and dated July 25, 1986. Professor Rao was presented with a plaque of highest appreciation at the conclusion of the visit.

Professor Rao's activities involving universities in Indonesia continued beyond 1986. Specifically, these consist of the following: (a) a two-month follow-up visit to the University of Indonesia during their move to Depok, in the summer of 1987; (b) a brief visit (to the new campus at Depok) in the fall of 1992; (c) hosting of a two-day visit by a delegation of Indonesian EE educators to the ECE Department at UIUC in the fall of 1997; and (d) a one-week visit to the EE Department at the Bandung Institute of Technology in January 1999 to advise them on preparation for accreditation for ABET 2000, and to explore collaborative efforts.

Other activities prior to 2000 include a brief visit to the National Central University in Taiwan in the fall of 1992, and a visit to the National University of Singapore in January 1999 to discuss plans for a cooperative Master's degree program.

From approximately the year 2000, Professor Rao has been engaged in educational activities with institutions in India. A major activity occurred in 2006, consisting of the publication of the "Indian Edition" of "Elements of Engineering Electromagnetics," (See B8 under Publications) and the Edward C. Jordan Memorial Offering of the first course on the Indo-US Inter-University Collaborative Initiative in Higher Education and Research. This initiative has to do with a memorandum of understanding (MOU), signed in December 2005 between a number of U. S. Universities, including UIUC, and the AMRITA University, Coimbatore, India, in partnership

with the Indian Space Research Organization and the Department of Science and Technology of the Government of India. It allows for faculty from the U.S. to offer courses for e-learning on the EDUSAT Satellite Network, and to pursue collaborative research with India. The Initiative was launched by President Abdul Kalam from New Delhi on the EDUSAT Satellite Network on December 8, 2005.

In July-August 2006, Professor Rao visited AMRITA University to teach the first course of five-week duration on introductory electromagnetics. More than 850 students attended the broadcast lectures at 22 centers across India. With students taking a satellite-based course participating interactively with their teacher, it was a “first” for higher education in India.

In October 2006, Professor Rao began transitioning into a role of service for the cause of engineering education and collaboration with American universities, as Distinguished AMRITA Professor of Engineering, while continuing on the faculty at UIUC as the Edward C. Jordan Professor.

In August 2008, Professor Rao conducted at Amrita University the first offering of a two-week, eight-day, 40-hour, intensive course for training faculty in electrical-, electronics-, communication-, and computer- related engineering departments in India.

PROFESSIONAL SOCIETY MEMBERSHIP

Life Member, American Society for Engineering Education (ASEE)

Life Fellow, Institute of Electrical and Electronic Engineers (IEEE)

Member, IEEE Antennas and Propagation Society

Member, IEEE Education Society

Member, U.S. Commission G, URSI (International Scientific Radio Union)

ABET EC2K Evaluator (Past) for IEEE

AWARDS AND HONORS

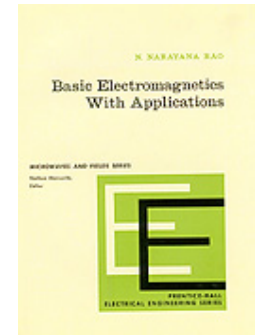
Year	Award	Institution	Recognition
1953 - 55	First rank prizes	Madras Institute of Technology, India	For securing first rank every year during the three-year diploma course in electronics
1954 - 55	Kamakoti Scholarship	Madras Institute of Technology	For securing first rank in the Institute
1982	Undergraduate Instructional Award	UIUC Campus	For development of PC-programs for electromagnetics instruction
1983	Engineering Award	Telugu Association of North America (TANA)	For dedication to teaching and outstanding contributions to electromagnetics
1986	Fakultas Teknik Award	University of Indonesia, Jakarta	For work as Consultant on MUCIA-Indonesia World Bank Education IX Project
1987	Everitt Award	UIUC College of Engineering	For Excellence in undergraduate teaching
1988	Undergraduate Instructional Award	UIUC Campus	For development of software for PC-assisted instruction of numerical techniques in introductory electromagnetics
1989	Fellow	Institute of Electrical and Electronics Engineers (IEEE)	For contributions to electrical engineering education and ionospheric propagation
1989	Undergraduate Teaching Award	UIUC Campus	For excellence in undergraduate teaching
1989	Oakley Award	UIUC Campus	For innovation in undergraduate teaching
1990	U of I Minute Broadcast	UIUC Office of Public Affairs	For teaching accomplishments at the University
1991	Halliburton Award	UIUC College of Engineering	For engineering education leadership
1991	AT&T Foundation Award	American Society for Engineering Education (ASEE), IL-IN Section	For excellence in instruction of engineering students
1993	Centennial Certificate	American Society for Engineering Education (ASEE)	For exceptional contribution to the American Society for Engineering Education and the profession of engineering
1994	Undergraduate Teaching Award	Institute of Electrical and Electronics Engineers (IEEE)	For inspirational teaching of undergraduate students and the development of innovative instructional material for teaching courses in electromagnetics
1998	Boss of the Year Award	UIUC Secretariat	
1999	Award for Excellence	Telugu Association of North America (TANA)	For excellence in (engineering) education
2001	Plaque	Space Science and Remote Sensing Group, ECE Dept., UIUC	IN APPRECIATION Of the many years of faithful and untiring service in the Department of Electrical and Computer Engineering; Of his nurturing of many generations of students in electromagnetic theory through his teaching and pedagogical writing; Of his collegiality and technical contributions to the ionospheric research program of the laboratory
2001	Plaque	ECE Dept., UIUC	In appreciation of his outstanding leadership and tireless dedication throughout the successful ABET review process
2003	Edward C. Jordan Professorship	ECE Dept., College of Engineering, and UIUC Campus	To honor the memory of Professor Edward C. Jordan, who served as Department Head for 25 years, and to be held by a "member of the faculty of the department who has demonstrated the qualities of Professor Jordan and whose work would best honor the legacy of Professor Jordan."
2004	Gnana Ratna (Jewel of Knowledge) Award	Foundation for Universal Integration for Peace	For special services rendered in his field
2006	Distinguished AMRITA Professor of Engineering	AMRITA VISHWA VIDYAPEETHAM, Ettimadai, Coimbatore	Honorary position concurrently with the Jordan Professorship at UIUC
2007	Retirement Plaque	ECE Department, UIUC	For 42 years of dedicated service and retirement

PUBLICATIONS

BOOKS:

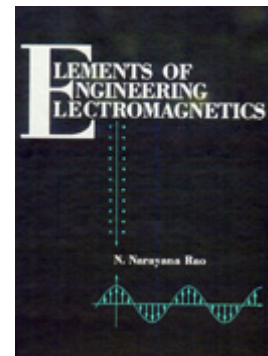
B1. N. Narayana Rao, "Basic Electromagnetics With Applications," Prentice-Hall, Inc., Englewood Cliffs, N.J., 1972, 576 pp. Treatment based on the traditional approach.

1. Vector Analysis
2. The Static Electric Field
3. The Static Magnetic Field
4. The Electromagnetic Field
5. Materials and Fields
6. Applied Electromagnetics
Part 1. Statics, Quasistatics, and Distributed Circuits
Part 2. Electromagnetic Waves



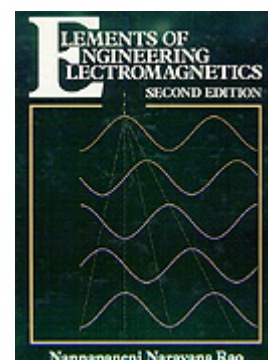
B2. N. Narayana Rao, "Elements of Engineering Electromagnetics," Prentice-Hall, Inc., Englewood Cliffs, N.J., 1977, 480 pp. A one-semester text in which the basic material is built up on time-varying fields and their engineering applications so as to enhance its utility for the one-semester student of engineering electromagnetics, while enabling the student who will continue to take further (elective) courses in electromagnetics to learn many of the same field concepts and mathematical tools and techniques provided by the traditional treatment. First book to break with tradition and be progressive.

1. Vectors and Fields
2. Maxwell's Equations in Integral Form
3. Maxwell's Equations in Differential Form
4. Wave Propagation in Free Space
5. Wave Propagation in Material Media
6. Transmission Lines
7. Waveguides
8. Antennas
9. Static and Quasistatic Fields
10. Special Topics



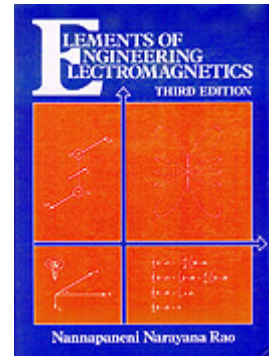
B3. N. Narayana Rao, "Elements of Engineering Electromagnetics," Second Edition, Prentice-Hall, Englewood Cliffs, N.J., 1987, 593 pp. Expanded from the first edition for two-semester usage. First book to incorporate software by including PC programs.

1. Vectors and Fields
2. Fields and Materials
3. Maxwell's Equations in Integral Form and Boundary Conditions
4. Maxwell's Equations in Differential Form and Potential Functions
5. Topics in Static and Quasistatic Fields
6. Uniform Plane Waves
7. Transmission Lines 1. Time Domain Analysis
8. Transmission Lines 2. Sinusoidal Steady-State Analysis
9. Waveguides
10. Antennas



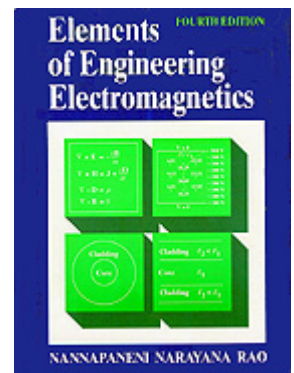
B4. N. Narayana Rao, "Elements of Engineering Electromagnetics," Third Edition, Prentice-Hall, Englewood Cliffs, N.J., 1991, 636 pp. More PC programs.

1. Vectors and Fields
2. Fields and Materials
3. Maxwell's Equations in Integral Form and Boundary Conditions
4. Maxwell's Equations in Differential Form, Potential Functions, and Energy Storage
5. Topics in Static and Quasistatic Fields
6. Uniform Plane Waves
7. Transmission Lines 1. Time Domain Analysis
8. Transmission Lines 2. Sinusoidal Steady-State Analysis
9. Waveguides
10. Antennas



B5. N. Narayana Rao, "Elements of Engineering Electromagnetics," Fourth Edition, Prentice-Hall, Englewood Cliffs, N.J., 1994, 721 pp. First book to add coverage on electromagnetic principles for photonics at introductory level.

1. Vectors and Fields
2. Fields and Materials
3. Maxwell's Equations in Integral Form and Boundary Conditions
4. Maxwell's Equations in Differential Form, Potential Functions, and Energy Storage
5. Topics in Static and Quasistatic Fields
6. Uniform Plane Waves
7. Transmission Lines 1. Time Domain Analysis
8. Transmission Lines 2. Sinusoidal Steady-State Analysis
9. Metallic Waveguides and Resonators
10. Electromagnetic Principles for Photonics
11. Antennas



B6. N. Narayana Rao, "Elements of Engineering Electromagnetics," Fifth Edition, Prentice-Hall, Upper Saddle River, N.J., 2000, 788 pp. First book to organize chapters to reflect progression of major technologies based on Maxwell's equations. Translated into Indonesian and published in two volumes (shown below the English version).

Part I. Fundamental Elements

A. Basic Field Concepts

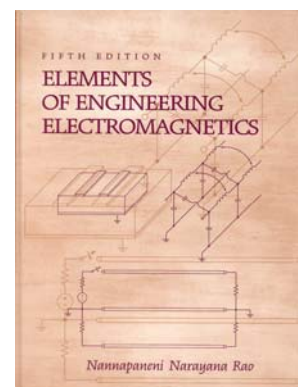
1. Vectors and Fields
2. Fields and Materials

B. Maxwell's Equations and Uniform Plane Waves

3. Maxwell's Equations in Integral Form and Boundary Conditions
4. Maxwell's Equations in Differential Form, Potential Functions, and Energy Storage
5. Uniform Plane Waves and Power Flow in an Electromagnetic Field

Part II. Applied Elements

6. Field and Line Essentials for Digital Electronics
7. Transmission Lines for Communications
8. Topics in Electric- and Magnetic-Field Systems
9. Guided Wave Principles for Electronics and Optoelectronics
10. Several Topics for Electronics and Photonics
11. Principles of Radiation and Antennas
12. Topics in Numerical Electromagnetics



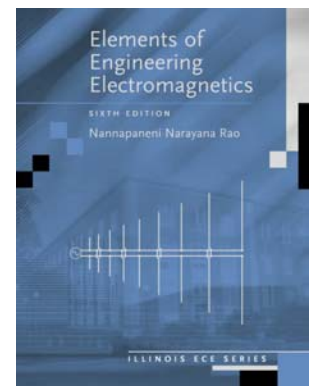
B7. N. Narayana Rao, "Elements of Engineering Electromagnetics," Sixth Edition, Pearson Prentice-Hall, Upper Saddle River, N.J., 2004, 831 pp. Lead book for the Illinois ECE Series of books to be published by Prentice Hall. An important factor guiding the revisions has been the organization of topics for usage of the book for a first course in electrical engineering as well as in computer engineering, followed by one or more required or elective courses for electrical engineering students, that build on the first course. When the first edition was written for a one-semester course to meet the needs of both groups of students, most of the students were electrical engineering majors, a situation that continued for many years. In recent years, the ratio has changed dramatically, and at present, the numbers of computer engineering majors are comparable with those for electrical engineering majors, with the ratio depending on the school and department structure. Recognizing this development, and to make the intended usage of the book even more explicit than before, the organization of the topics has been carried even further in this edition by dividing the book into two parts.

Part I. Essential Elements for Electrical and Computer Engineering

1. Vectors and Fields
2. Maxwell's Equations in Integral Form
3. Maxwell's Equations in Differential Form, and Uniform Plane Waves in Free Space
4. Fields and Waves in Material Media
5. Electromagnetic potentials and Topics for Circuits and Systems
6. Transmission Line Essentials for Digital Electronics

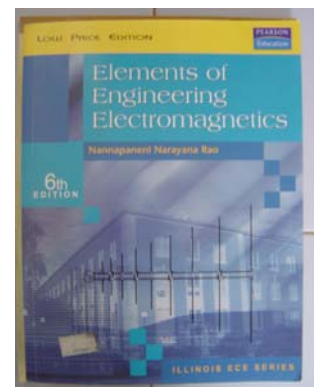
Part II. Essential/Elective Elements

7. Transmission Lines for Communications
8. Guided Wave Principles for Electronics and Optoelectronics
9. Several Topics for Electronics and Photonics
10. Principles of Radiation and Antennas
11. Several Solution Techniques



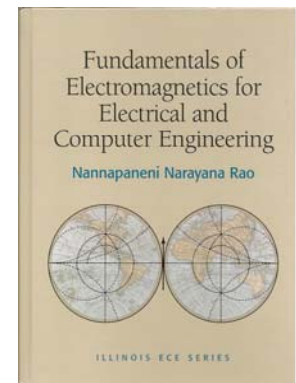
B8. N. Narayana Rao, "Elements of Engineering Electromagnetics, Sixth Edition," Low-Priced Indian Edition, Pearson Education, India, 2006, 831 pp.

This book is a special "Indian Edition" of B7 above, published in connection with the offering of the inaugural course, "Electromagnetics for Electrical and Computer Engineering," under the Indo-US Inter-University Collaborative Initiative in Higher Education and Research. In addition to the chapters, as in B7, this book contains 30 pages of a significant addition, "Why Study Electromagnetics?" offering a wide range of answers to the question, from the experiences of 20 experts drawn from teachers, engineers, entrepreneurs, inventors, and even a medical doctor. In addition, the book contains a message from Dr. A. P. J. Abdul Kalam, President of India, an aeronautical engineer and accomplished scientist, and forewords by Richard Herman, Chancellor, UIUC; Linda P. B. Katehi, Provost, UIUC; and Professor Nick Holonyak, Jr., UIUC ECE Department, and 2003 IEEE Medal of Honor Recipient.



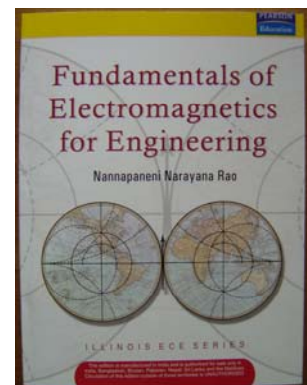
B9. N. Narayana Rao, "Fundamentals of Electromagnetics for Electrical and Computer Engineering," Pearson Prentice-Hall, Upper Saddle River, N.J., 2009, 458 pp. This compact, one-semester textbook introduces the fundamental concepts of electromagnetics for the technologies of electrical and computer engineering. It combines the approach of beginning with Maxwell's equations for time-varying fields with the treatment of the different categories of fields as solutions to Maxwell's equations and uses the thread of statics-quasistatics-waves to bring out the frequency behavior of physical structures. The text develops the bulk of the material through the use of the Cartesian coordinate system to keep the geometry simple and compassionate, yet sufficient to learn the physical concepts and mathematical tools, while employing other coordinate systems where necessary. Highlights include: (1) A unique introduction of Maxwell's equations for time-varying fields collectively, first in integral form and then in differential form; (2) Introduction of uniform plane wave propagation in free space following Maxwell's equations, and then introducing materials by considering their interaction with uniform plane wave fields; (3) Development of the transmission line and the distributed circuit concept following from the discussion of the frequency behavior of physical structures; (4) Coverage of the essentials of transmission line analysis in one chapter both in frequency domain, including Smith Chart, and in time domain; (5) A chapter on waveguide principles for both metallic waveguides and dielectric waveguides; (6) Coverage of antenna basics, beginning with obtaining complete solution to the Hertzian dipole fields through a successive extension of the quasistatic fields; and (7) A chapter on supplementary topics for optional coverage.

1. Vectors and Fields
2. Maxwell's Equations in Integral Form
3. Maxwell's Equations in Differential Form
4. Wave Propagation in Free Space
5. Wave Propagation in Material Media
6. Statics, Quasistatics, and Transmission Lines
7. Transmission-Line Analysis
8. Waveguide Principles
9. Antenna Basics
10. Supplementary Topics



B10. N. Narayana Rao, "Fundamentals of Electromagnetics for Engineering," Low-Priced Indian Edition, Pearson Education, India, 2009, 458 pp.

This book is the "Indian Edition" of B9 above, published except for a minor change in the title and the addition of a "Preface to the Indian Edition" in the front matter. It was published in time for the first offering of a two-week, eight-day, 40-hour, intensive course for training faculty in electrical-, electronics-, communication-, and computer- related engineering departments in India, at Amrita University in August 2008.



BOOK CHAPTER:

BC1. N. Narayana Rao, "Fundamentals of Engineering Electromagnetics Revisited," Chapter 1 in "Handbook of Engineering Electromagnetics," Marcel-Dekker, Inc., 2004, 52 pp.

This chapter presents in a nutshell the fundamental aspects of engineering electromagnetics from the view of looking back in a reflective fashion what has already been learnt in undergraduate electromagnetics courses as a novice. The first question that comes to mind in this context is: What constitutes the fundamentals of engineering electromagnetics? If the question is posed to several individuals, it is certain that they will come up with sets of topics, not necessarily the same or in the same order, but all containing the topic, "Maxwell's Equations," at some point in the list, ranging from the beginning to the end of the list. In most cases, the response is bound to depend on the manner in which the individual was first exposed to the subject. Judging from the contents of the vast collection of undergraduate textbooks on electromagnetics, there is definitely a heavy tilt toward the traditional, or historical, approach of beginning with statics and culminating in Maxwell's equations, with perhaps an introduction to waves. Primarily to provide a more rewarding understanding and appreciation of the subject matter, and secondarily owing to his own fascination resulting from his own experience as a student, a teacher, and an author [B1 – B7] over a few decades, the author has employed in this chapter the approach of beginning with Maxwell's equations and treating the different categories of fields as solutions to Maxwell's equations. In doing so, instead of presenting the topics in an unconnected manner, the thread of statics-quasistatics-waves is used to cover the fundamentals and bring out the frequency behavior of physical structures at the same time.

VIDEO TAPES:

V1. N. Narayana Rao, "EE 350: Lines, Fields, and Waves," 43 tapes, each of 50-minute duration, copyrighted by University of Illinois at Urbana-Champaign, Urbana, IL, 1983.

SOFTWARE:

S1. N. Narayana Rao, "Software Supplement to Elements of Engineering Electromagnetics, Second Edition," Two 5 1/4 inch, 360 kilobyte, double-sided, double-density diskettes or one 3-1/2 inch, 720 kilobyte, double-sided, double-density diskette for the IBM PC, and 64-page Users Manual, January 1989.

S2. N. Narayana Rao, "Software Supplement to Elements of Engineering Electromagnetics, Third Edition," Two 5 1/4 inch, 360 kilobyte, double-sided, double-density diskettes or one 3-1/2 inch, 720 kilobyte, double-sided, double-density diskette for the IBM PC, and 71-page Users Manual, January 1991. Also included as chapter 2, entitled "Elements of Engineering Electromagnetics," in the NSF/IEEE Center for Computer Applications in Electromagnetics Education (CAEME) Software Book, Vol. 1, Edited by Magdy Iskander, 1991.

S3. N. Narayana Rao, "Software Supplement to Elements of Engineering Electromagnetics, Fourth Edition," One 3 1/2 inch, 720 kilobyte, double-sided, double-density diskette for the IBM PC, and 73-page Users Manual, July 1994.

RESEARCH PAPERS IN JOURNALS AND SELECTED TECHNICAL REPORTS:

- P1.** Y. V. Somayajulu and N. Narayana Rao, "Galactic Radiation at 30 Mc/s," Journal of Scientific and Industrial Research, Vol. 17A, pp. 54 - 56, December 1958.
- P2.** N. Narayana Rao and H. M. Swarm, "Lunar Tidal Variations in the Ionospheric Layers," The Trend in Engineering at the University of Washington, Vol. 12, No. 2, pp. 15 - 20, April 1960.
- P3.** A. Ishimaru and N. Narayana Rao, "Geometric Optical Approximation of Near Field of a Rectangular Aperture Backscattered from a Cylinder," Document No. D2-9348, Boeing Airplane Company, Seattle, Washington, February 1961, 62 pp.
- P4.** N. Narayana Rao, H. M. Swarm and A. E. Harrison, "Experimental Determination of the Absolute Phase Path of Radio Waves Reflected from the Ionosphere at Normal Incidence," Proc. IEEE, Vol. 52, No. 7, p. 858, July 1964.
- P5.** N. Narayana Rao, H. M. Swarm and A. E. Harrison, "Resolution of Ionospheric Valley Ambiguity in True Height Computation Using Ordinary Wave Observations," Tech. Report No. 93, Department of Electrical Engineering, University of Washington, Seattle, Washington, January 1965, 189 pp.
- P6.** K. C. Yeh and N. Narayana Rao, "Total Ionospheric Electron Content at Houghton, Michigan," Can. J. Phys., Vol. 45, pp. 1959 - 1962, May 1967.
- P7.** N. Narayana Rao, "Ionospheric Electron Content and Irregularities Deduced from BE-C Satellite Transmissions," J. Geophys. Res., Vol. 72, pp. 2929 - 2942, 1 June 1967.
- P8.** N. Narayana Rao and C. F. Stubenrauch, "Lunar Tidal Variations in the Equivalent Slab Thickness of the Ionosphere over Hawaii," J. Geophys. Res., Vol. 72, pp. 5547 - 5551, 1 November 1967.
- P9.** N. Narayana Rao and K. C. Yeh, "Large-Scale Ionospheric Irregularities Deduced from Faraday Rotation Observations at Three Stations," Space Research, Vol. 8, pp. 413 - 419, 1968.
- P10.** N. Narayana Rao and K. C. Yeh, "Comparison of Faraday and Doppler Methods of Obtaining Ionospheric Electron Content," J. Geophys. Res., Vol. 73, pp. 2447 - 2458, 1 April 1968.
- P11.** M. Y. Youakim and N. Narayana Rao, " Study of Ionospheric Electron Content from Observations at Different Stations," Tech. Report No. 34, Ionosphere Radio Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, July 1968, 109 pp.
- P12.** N. Narayana Rao, "Ray-Tracing Investigation of Direction of Arrival Observations of HF Radio Waves," Radio Science (New Series), Vol. 3, pp. 796 - 802, August 1968.

- P13.** N. Narayana Rao and J. A. Klobuchar, " Comparison of Ionospheric Electron Content Observations at Different Stations," J. Geophys. Res., Vol. 73, pp. 6373 - 6378, 1 October 1968.
- P14.** N. Narayana Rao, "Synthesis of Oblique Ionograms for a Quasi-linear Ionospheric Model and Spherical Earth-Ionosphere Geometry," IEEE G-AP Trans., Vol. AP-16. p. 771, November 1968.
- P15.** N. Narayana Rao, "Bearing Deviation in HF Transionospheric Propagation, I. Exact Computations for Some Ionospheric Models With No Magnetic Field," Radio Science (New Series), Vol. 3, pp. 1113 - 1118, December 1968.
- P16.** N. Narayana Rao, "Bearing Deviation in HF Transionospheric Propagation, II. Applications of Exact Computations," Radio Science (New Series), Vol. 3, pp. 1119 - 1123, December 1968.
- P17.** N. Narayana Rao, "Direction of Arrival of HF Radio Waves Deduced from Ionospheric Electron Content Gradients," IEEE G-AP Trans., Vol. AP-17, pp. 111 - 113, January 1969.
- P18.** N. Narayana Rao, "Bearing Deviation in HF Transionospheric Propagation, III. Ray Tracing Investigation of the Magnetoionic Effect," Radio Science (New Series), Vol. 4, pp. 153 - 161, February 1969.
- P19.** N. Narayana Rao, G. F. Lyon, and J. A. Klobuchar, "Acoustic Waves in the Ionosphere," J. Atmosph. Terrest. Phys., Vol. 31, pp. 539 - 545, April 1969.
- P20.** N. Narayana Rao, K. C. Yeh, and M. Y. Youakim, "Ionospheric Electron Content at Temperate Latitudes During the Increasing Phase of the Solar Cycle," Aust. Jour. Phys., Vol. 23, pp. 37 - 43, February 1970.
- P21.** N. Narayana Rao and L. T. Hamrick, "Simulation and Analysis of Faraday Rotation of Beacon Satellite Signals in the Presence of Traveling Ionospheric Disturbances," Radio Science, Vol. 5, pp. 907 - 912, June 1970.
- P22.** N. Narayana Rao, M. Y. Youakim, and K. C. Yeh, "Feasibility Study of Correcting for the Excess Time-Delay of Transionospheric Navigational Ranging Signals," Tech. Report No. 43, Ionosphere Radio Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, July 1971, 208 pp.
- P23.** R. E. DuBroff and N. Narayana Rao, "Determination of Exospheric Electron Content from Group Delay and Faraday Rotation Observations of Geostationary Satellite Signals," Proceedings of the Symposium on the Future Applications of Satellite Beacon Measurements, Graz, Austria, pp. 73 - 78, 29 May - 2 June 1972.
- P24.** N. Narayana Rao, M. Y. Youakim, and K. C. Yeh, "Application of Electron Content Observations in Navigational Ranging," Proceedings of the Symposium on the Future Applications of Satellite Beacon Measurements, Graz, Austria, pp. 297 - 302, 29 May - 2 June 1972.

P25. F. O. Fahlsing, A. D. Bailey, and N. Narayana Rao, "An Investigation of HF Auroral Backscatter Over a Bistatic Path," RRL Publication No. 405, Contract N00014-67-A-0305-0002, Radiolocation Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, June 1972, 140 pp.

P26. B. J. Flaherty and N. Narayana Rao, "Atlas of Electron Content Values Observed at Urbana, Illinois, for the Period December 1, 1967 through December 30, 1970," Tech. Report No. 47, Ionosphere Radio Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, July 1972, 181 pp.

P27. R. I. Beckwith, A. D. Bailey, and N. Narayana Rao, "An Investigation of Directional Propagation Effects in High-Frequency Radio Source Location," RRL Publication No. 409, Contract N00014-67-A-0305-0002, Radiolocation Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, September 1972, 251 pp.

P28. N. Narayana Rao, "Exact Ray-Calculation Analysis of Oblique Ionograms," RRL Publication No. 415, Contract N00014-67-A-0305-0002, Radiolocation Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, September 1972, 44 pp.

P29. N. Narayana Rao, "Synthesis of Three-Dimensional Ionograms," *Radio Science*, Vol. 8, pp. 449-451, May 1973.

P30. N. Narayana Rao, "A Note on the Analysis of Oblique Ionograms," *J. Atmosph. Terrest. Phys.*, Vol. 35, pp. 1561-1563, August 1973.

P31. R. I. Beckwith and N. Narayana Rao, "A Preliminary Computer Program for Automatic Position Estimate Correction," RRL Publication No. 440, Contract N00014-67-A-0305-0002, Radiolocation Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, October 1973, 145 pp.

P32. R. I. Beckwith, A. D. Bailey, and N. Narayana Rao, "Application of Ionospheric Predictions to HF Propagation in Three Dimensions," *Radio Science*, Vol. 9, pp. 379-385, March 1974.

P33. E. W. Ernst, J. D. Dyson, and N. Narayana Rao, "HF/DF Techniques Investigation," Third Quarterly and Final Reports, RRL Publications Nos. 444 and 447, Contract DAAB07-73-C-0125, Radio Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, December 1973 and May 1974; 84 and 94 pp.

P34. N. Narayana Rao and R. I. Beckwith, "Prediction of Azimuthal Angle of Arrival of HF Waves During the Sunrise Period," *Radio Science*, Vol. 9, pp. 617-620, June 1974.

P35. K. S. Tse and N. Narayana Rao, "Computer Simulation of Radio Source Location through the Use of Real-Time Ionospheric Observations," RRL Publication No. 448, Contract N00014-

67-A-0305-0002, Radio Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, July 1974, 91 pp.

P36. N. Narayana Rao, "Ray Tracing from an Ionogram," *Indian Journal of Radio and Space Physics*, Vol. 3, pp. 203-206, September 1974.

P37. N. Narayana Rao, "Inversion of Sweep-Frequency Sky-Wave Backscatter Leading Edge for Quasiparabolic Ionospheric Layer Parameters," *Radio Science*, Vol. 9, pp. 845-847, October 1974.

P38. N. Narayana Rao, R. I. Beckwith, and E. W. Ernst, "Prediction of Differential Time Delay Errors in HF Hyperbolic Position-Fixing Systems," *IEEE Trans. Aerospace and Electronic Systems*, Vol. AES-10, pp. 765-769, November 1974.

P39. N. Narayana Rao, "On the Synthesis of Oblique Ray-Path Parameters for a Quasiparabolic Layer," *IEEE G-AP Trans.*, Vol. AP-23, pp. 144-145, January 1975.

P40. N. Narayana Rao and R. I. Beckwith, "Reduction of Positional Estimate Errors in HF Hyperbolic Position-Fixing Systems," *IEEE Trans. Aerospace and Electronic Systems*, Vol. AES-11, pp. 113-114, January 1975.

P41. R. I. Beckwith and N. Narayana Rao, "Real Time Updating of Maximum Usable Frequency Predictions for HF Radio Communication," *IEEE Trans. Communications*, Vol. COM-23, pp. 286-288, February 1975.

P42. N. Narayana Rao, "A Large-Scale Traveling Ionospheric Disturbance of Polar Origin," *Planetary and Space Science*, Vol. 23, pp. 381-384, February 1975.

P43. N. Narayana Rao, "Analysis of Discrete Oblique Ionogram Traces in Sweep-Frequency Sky-Wave High Resolution Backscatter," *Radio Science*, Vol. 10, pp. 149-153, February 1975.

P44. N. Narayana Rao and K. E. Hoover, "Derivation of Ionospheric Layer Parameters from Elevation Angles of Arrival of HF Radio Waves," *J. Atmosph. Terrest. Phys.*, Vol. 37, pp. 1167-1169, August 1975.

P45. E. W. Ernst, J. D. Dyson, and N. Narayana Rao, "HF/DF Techniques Investigation," First, Second, and Third Quarterly, and Final Reports, RRL Publications Nos. 452, 456, 462, and 468, Contract DAAB07-74-C-0540, Radio Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, November 1974, March, July, and November 1975; 182, 32, 175, and 98 pp.

P46. C. S. Gardner and N. Narayana Rao, "The Effects of Random Path Fluctuations on the Accuracy of Laser Ranging Systems," RRL Publication No. 469, Radio Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, December 1975, 52 pp.

P47. D. L. Zanter, C. S. Gardner, and N. Narayana Rao, "The Effects of Atmospheric Refraction on the Accuracy of Laser Ranging Systems," RRL Publication No. 471, Radio Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, January 1976, 145 pp.

P48. N. Narayana Rao, K. C. Yeh, M. Y. Youakim, K. E. Hoover, P. Parhami, and R. E. DuBroff, "Techniques of Determining Ionospheric Structure from Oblique Radio Propagation Measurements," Tech. Report No. 59, Ionosphere Radio Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, December 1976, 279 pp.

P49. R. E. DuBroff, N. Narayana Rao and K. C. Yeh, "Backscatter Ionogram Inversion by Ray Tracing Methods," Tech. Report No. 62, Ionosphere Radio Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, April 1978, 106 pp.

P50. P. L. Bogler and N. Narayana Rao, "Ray Calculation Analysis of High Frequency Target-of-Opportunity Data," RRL Publication No. 486, Contract DAAB-07-76-C-1938, Radio Research Laboratory, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, April 1979, 70 pp.

P51. R. E. DuBroff, N. Narayana Rao, and K. C. Yeh, "Methods of Determining Ionospheric Structure from Oblique Sounding Data," Paper No. 13, AGARD Conference Preprint No. 263, Special Topics in HF Propagation, Lisbon, Portugal, 28 May - 1 June 1979, 15 pp.

P52. R. E. DuBroff, N. Narayana Rao, and K. C. Yeh, "Backscatter Inversion in Spherically Asymmetric Ionosphere," Radio Science, Vol. 14, pp. 837-841, September - October 1979.

P53. N. Narayana Rao, "Ionospheric Irregularities in HF Radio Source Location," Tech. Report, D. O. 1684, TCN-80-304, Battelle Columbus Laboratories, Research Triangle Park, NC, January 1981, 63 pp.

CURRICULUM-, INSTRUCTION-, AND EDUCATION- RELATED PUBLICATIONS:

C1. N. Narayana Rao. "Development of Microcomputer Programs for Graphic Displays of Electromagnetic Concepts and Phenomena," Report of Work Completed Under an Undergraduate Instructional Award, University of Illinois, Urbana, Illinois, January 1983, 116 pp.

C2. N. Narayana Rao, "Report on the Preliminary Visit to Jurusan Elektro, Fakultas Teknik, Universitas Indonesia, Jakarta, Indonesia," MUCIA-Indonesia World Bank IX Education Project, Jakarta, Indonesia, 27 March 1985, 21 pp.

C3. N. Narayana Rao, "A New Curriculum, Modern Laboratory Facilities, Staff Development, and Evaluation of Student Performance for Jurusan Elektro, Fakultas Teknik, Universitas Indonesia, Final Report of Activities, August 1985 - July 1986," MUCIA-Indonesia World Bank IX Education Project, Jakarta, Indonesia, 25 July 1986, 204 pp.

C4. N. Narayana Rao, "PC-Assisted Instruction of Numerical Techniques in Introductory Electromagnetics," Report of Work Completed Under an Undergraduate Instructional Award, University of Illinois at Urbana-Champaign, Urbana, Illinois, February 1989, 39 pp.

C5. N. Narayana Rao, "The University of Illinois Curriculum vis-à-vis Technical Depth Versus Breadth of Education," Report on the Workshop on Undergraduate Study in Electrical Engineering Sponsored by the National Engineering Consortium, Lake Buena Vista, Florida, December 7-9, 1989, pp. 45-61.

C6. N. Narayana Rao, "PC-Assisted Instruction of Introductory Electromagnetics," IEEE Trans. Education, Vol. E-33, pp. 51-59, February 1990.

C7. N. Narayana Rao, "ECE Illinois Implements Its ABET EC2K Model with Successful Outcome," Paper prepared and distributed at ECE Department Heads Association Annual Meeting, Stuart, Florida, March 2002, 8 pp.

C8. N. Narayana Rao, "Is it Time for the Motherland and the States in the Motherland to Rethink the System of Technical Education?," IEEE Technical Review, Vol. 22, No. 1, pp. 21-28, January - February 2005.