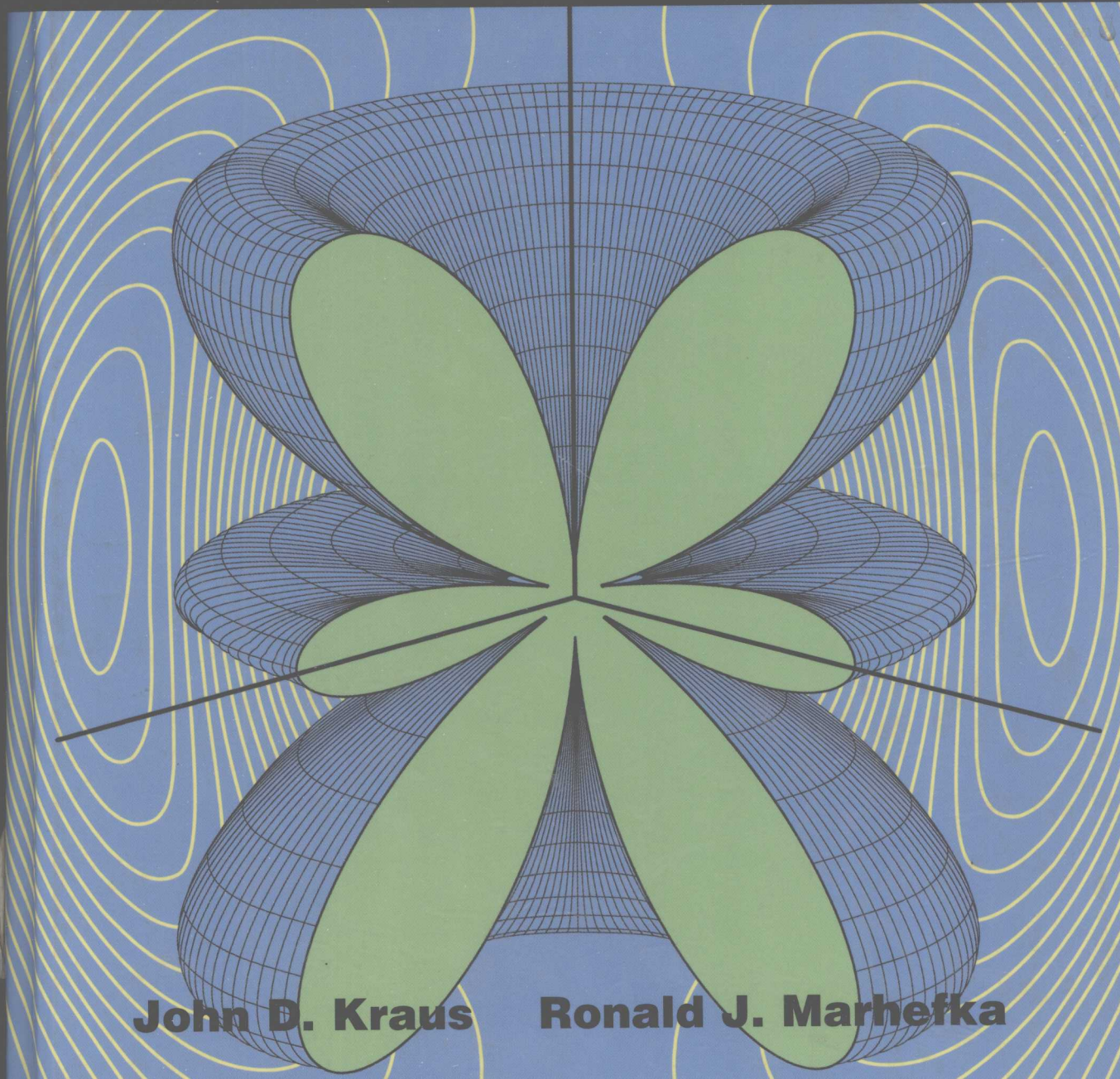
THIRD EDITION

Antennas

For All Applications



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Antennas
for All Applications

THIRD EDITION

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PREFACE

The aim of this new edition is to present the basic essentials of antennas even better than before while providing extensive coverage of the newest wireless applications. Further, the book is structured so that it can be easily divided into two courses with the first 12 chapters suitable for a first course and the last 12 for a second course. There is also flexibility that allows for a variety of assignment options.

The subtitle "For *All* Applications" is, of course, presumptuous for it is an unattainable goal. However, it indicates our objective.

The Introduction (Chapter 1) presents information on symbols and notation along with useful tables. Chapter 2 (Antenna Basics) covers fundamental antenna concepts and the language of antennas. In Chapter 3 we meet the Antenna Family with concise descriptions of two dozen different types of antennas from dipoles to patches.

Chapter 4 treats Point Sources and their field, power and phase patterns. Broadside and end-fire arrays of point sources are introduced in Chapter 5, Part I. This is followed in Chapter 6 by dipoles and linear antennas, both alone and in arrays. All kinds of loop antennas and their properties are described in Chapter 7. Chapter 8 Part I is an introduction to axial-mode helical antennas and Yagi-Uda arrays. Part II goes into helical antennas in more detail.

Chapter 9 is about slot, patch and horn antennas while Chapter 10 explains flat- sheet, corner and parabolic antennas. Broadband and frequency-independent antennas are discussed in Chapter 11. Chapter 12 on antenna temperature, remote sensing and radar cross section completes the material suggested for a first course on antennas.

The chapters suggested for the second course can include sections from Chapter 5 Part II broadening the coverage of arrays of point sources, from Chapter 8 Part II with more on helical antennas and Chapter 9 with further information on slot and horn antennas. The sequence can then proceed to self and mutual impedance (Chapter 13), the cylindrical antenna (Chapter 14) and the important Fourier transform relation between aperture and far-field pattern (Chapter 15). This is followed by dipoles, apertures and arrays (Chapter 16) and lens antennas (Chapter 17).

Radomes and frequency-sensitive surfaces are explained in Chapter 18 followed by design considerations on large antennas in Chapter 19. Chapter 20 showcases some of the world's large and unique antennas. Chapter 21 features many important and novel antenna applications including sections on cell phone antennas, ILS (Instrument Landing System) antennas, LEO (Low Earth Orbit) satellite antennas and many more. Physically small antennas are featured in Chapter 22 on Terahertz Antennas. Chapter 23 presents useful information on transformers, baluns and traps. The last chapter (24) is a very complete, up-to-date discussion of antenna measurements. The Appendix has many useful tables and references to computer programs.

The book features numerous helpful graphical displays. The problem sets are thorough and challenging. The references to articles and books are extensive.

Suggested assignment schedules are listed on page vi with several options given where sections from later chapters are incorporated in the first course schedule. Thus, some topics from Chapter 21 can add timely practical examples to a first course. We invite you to visit the book's web site *antennas3.com* for special projects.

Although the book is designed as a teaching text, its wealth of information makes it a veritable "gold mine" for the practicing engineer. Hundreds of worked examples help translate theory to practice.

We gratefully acknowledge the assistance of many persons including:

Prof. Ben A. Munk, ElectroScience Laboratory, Ohio State University, for his chapters on *Frequency Selective Surfaces* and *Baluns, etc.*

Profs. Arto Lehto and Pertti Vainikainen of the Helsinki University of Technology Radio Laboratory for their chapter on *Measurements*.

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We also thank our wives Alice Kraus and Deborah Marhefka for their patience and loving support.

John Kraus and Ronald Marhefka

P.S.1: Although great care has been exercised, errors will inevitably occur. The authors would greatly appreciate notice of them via e-mail to Ronald Marhefka at Marhefka.1@osu.edu.

P.S.2: For the statistician, the book has more than 900 pages, over 1200 illustrations, 130 worked examples, 75 tables, over 300 problems, nearly 900 references and an index of more than 2200 entries providing quick access to topics.

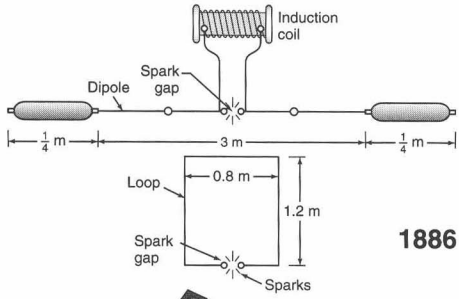
SUGGESTED ASSIGNMENTS

8 pages per class day (average)

Chapter	One semester Days/chapter	One quarter Days/chapter
1	1	1
2	5	5
3	2	2
4	2	2
5-I	4	4
Exam	1	1
6	4	2
7	3	3
8-I	4	3
9-I	4	3
10	4	2
Exam	1	
11	2	1
12	3	1
Exam		1
15	2	Total 30
21	2	
Exam	1	
	Total 45	

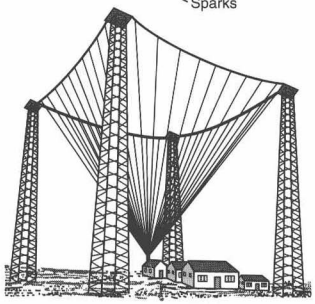
	2nd semester	2nd quarter
5-II	4	3
8-II	2	1
9-II	2	1
13	3	2
14	4	3
Exam	1	1
15	3	2
16	5	4
17	2	1
18	2	1
19	2	1
20	1	1
Exam	1	
21	5	4
22	1	1/2
23	1	1/2
24	5	3
Exam	1	1
	Total 45	30

A CENTURY OF ANTENNAS FROM HERTZ TO HAND-HELD



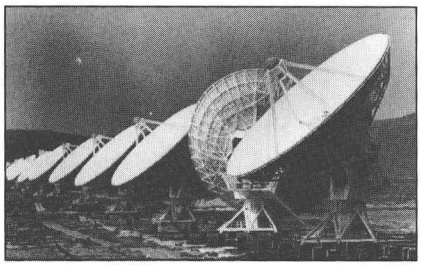
1886

Heinrich Hertz's end-loaded half-wave dipole transmitting antenna and resonant half-wave receiving loop operating at $\lambda = 8$ m in 1886. The induction coil produced sparks at the gap in the dipole, resulting in sparks at the gap in the loop at a distance of several meters in Hertz's laboratory at Karlsruhe, Germany. This was the first radio link and the dipole and loop the first radio antennas.



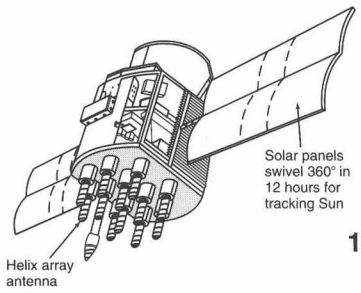
1905

Guglielmo Marconi's square conical antenna at Poldhu, England, in 1905 for sending transatlantic signals at wavelengths of 1000s of meters.



1980

Very Large Array (VLA) of 27 steerable parabolic dish antennas each 25 m in diameter operating at centimeter wavelengths for observing radio sources at distances of billions of light-years. The array is located at the National Radio Astronomy Observorro, New Mexico.



1985

Helix antenna array on one of 24 Global Position Satellites (GPS) in Medium Earth Orbit (MEO) at 20,000 km. Operating at $\lambda \cong 20$ cm, these satellites provide you on or above the earth with your position (latitude, longitude and elevation) to an accuracy of better than 1 meter.

2000

The ubiquitous, hand-held cellphone with half-wave antenna operating at $\lambda \cong 30$ cm, which connects you to everybody.

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Symbols, Prefixes and Abbreviations (Inside front cover and facing inside front cover)
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