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>100 PRINT FNJ(N,X),FNY(N,X),FNI(N,X),FNK(N,X) FOR N=0.5 FOR X=1.3
>110 STOP
>RUN
.76519775      8.8256863E-02  1.2660658      .42102427
2.3939377E-04 -260.40585      2.8279444E-04  360.96056
-.26005194     .37685       4.8807926      3.4739483E-02
.4.3028397E-02 -1.9059459      9.1206582E-02  .93777341

```

Fig. 2. Test program and results.

The function  $Y_n(x)$  is the same as the  $N_n(x)$  used in some texts; all four functions are consistently normalized so that they can be mixed in expressions like the example given above. The normalization is Weber's, which now appears to be standard; if comparisons with NBS or Jahnke and Emde's tables are made, a factor  $\pi/2$  will have to be supplied in some cases [e.g., Jahnke and Emde's  $iH_0^{(1)}(ix)$  is  $(2/\pi)K_0(x)$ ].

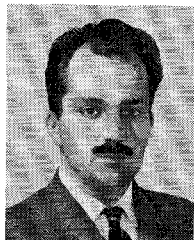
**CHECK:** After copying the routine given in Fig. 1 (lines 10–20

are unessential), the correctness may be checked by entering the two-line "main program" in Fig. 2 and obtaining the results shown. Some time-sharing systems may give results differing in the 5th place but this is insignificant.

## REFERENCES

- [1] G. B. Collins, Ed., *Microwave Magnetrons*, Columbia Radiation Laboratory Series, vol. 6. New York: McGraw-Hill, 1948, p. 78.
- [2] G. N. Watson, *Theory of Bessel Functions*. Cambridge, England: Cambridge, 1958.

## Contributors



**John C. Beal** (M'66) was born in London, England, on July 15, 1933. He received the B.Sc. and Ph.D. degrees in electrical engineering, both from University College, London, England, in 1958 and 1964, respectively.

From 1962 to 1965 he was a Research Engineer with Redifon, Ltd, England. He then became Assistant Professor of Electrical Engineering at Colorado State University, Fort Collins, Colo. In 1967 he joined the staff of Queen's University, Kingston, Ont., Canada, where he is now Associate Professor of Electrical Engineering and engaged in research on surface waves and numerical techniques applied to waveguides.

Dr. Beal is a member of the Institution of Electrical Engineers of London.

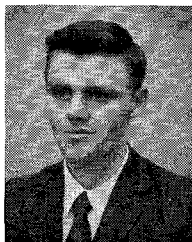


**William E. Courtney** was born in Lurgan, County Armagh, N. Ireland, on October 3, 1936. He received the B.Sc. degree with honors in physics, and the Ph.D. degree in electrical engineering from the Queen's University of Belfast,

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From 1963 to 1966, he was a Department of Scientific and Industrial Research and Ministry of Aviation Post-Doctoral Research Fellow in the Department of Electrical Engineering, University of Leeds, England. From 1966 to 1968, he was a Post-

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**William J. Dewar** was born in Toronto, Ont., Canada, on June 11, 1946. He received the B.Sc. and M.Sc. degrees in electrical engineering from Queen's University, Kingston, Ont., Canada, in 1968 and 1969, respectively.

He is currently engaged in research work on microwave filters at the Research and Development Laboratory, Northern Electric Company, Limited, Ottawa, Ont., Canada.



**Robert L. Gallawa** (S'57–M'59) was born in Scottsbluff, Nebr., on May 9, 1929. He received the B.S.E.E. and M.S.E.E. degrees from the University of Nebraska, Lincoln, in 1958 and 1961, respectively.

He received the Ph.D. degree from the University of Colorado, Boulder, in 1964, where he was a National Defense Education Act Fellow.

In 1963 he joined the Central Radio Propagation Laboratory of the National

Bureau of Standards (now the Institute for Telecommunication Sciences, Environmental Science Service Administration Research Laboratories), Boulder, Colo., where he is currently doing telecommunications related research. During 1968–1969 he was a Visiting Assistant Professor of Electrical Engineering, University of Toronto, Toronto, Ont., Canada.

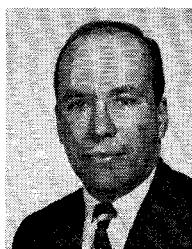


**Fred E. Gardiol** (S'68–M'69) was born in Corsier/vevey, Switzerland, on December 2, 1935. He received the degree of Physicist Engineer from the Ecole Polytechnique de l'Université de Lausanne, Switzerland,

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During 1960 and 1961, he was a Production Engineer with Transiron Electronic Corporation, Wakefield, Mass. From 1961 to 1966, he was associated with the Special Microwave Devices Operation of Raytheon Company, Waltham, Mass., where he specialized in the design and development of high-power waveguide ferrite devices. In 1966, he joined the scientific staff of the Catholic University of Louvain, Belgium, where he is presently an Assistant Professor in the Department of Electrical Engineering.

Dr. Gardiol is a member of Sigma Xi.



**Jerome I. Glaser** (S'61-M'67) was born in Athol, Mass., on September 29, 1941. He received the S.B., S.M., and Ph.D. degrees in electrical engineering in 1963, 1964, and 1967, respectively, from the Massachusetts Institute of Technology, Cambridge. He held a National Science Foundation Cooperative Graduate Fellowship from 1963 to 1965, and a National Science Foundation Research Initiation Grant from 1968 to 1970.

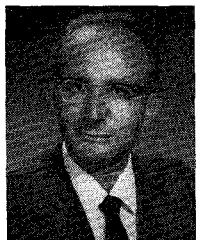
From 1964 to 1970 he was a member of the Research Laboratory of Electronics, Massachusetts Institute of Technology, where he was engaged in research on millimeter wave antennas, hollow dielectric waveguides, instrumentation for mass spectrometry, and numerical solution of boundary-value problems. From 1967 to 1970, he served as Instructor and Assistant Professor in the Department of Electrical Engineering, Massachusetts Institute of Technology. He is now a member of the technical staff of the Bell Telephone Laboratories, Inc., Murray Hill, N. J., where he is involved in research on millimeter waveguide communications.

Dr. Glaser is a member of Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.



**René J. M. Govaerts** (S'68-M'70) was born in Louvain, Belgium, on January 30, 1937. He received the electrical engineering degree from the Catholic University of Louvain, Heverlee, Belgium, in 1961.

In 1963 he joined the Electronic Research Laboratories, Catholic University of Louvain, as a Research Assistant. Since 1965 he has been doing research work in the microwave field and is preparing for the Ph.D. degree in applied sciences on computer approximations for loaded waveguide structures.



**Irving Kaufman** (S'45-A'47-M'54-SM'62) was born in Geinsheim, Germany, on January 11, 1925. He received the B.E. degree from Vanderbilt University, Nashville, Tenn., in 1945 and the M.S. and Ph.D. degrees in electrical engineering from the University of Illinois, Urbana, in 1949 and 1957, respectively.

From 1945 to 1948 he worked for RCA, Victor Division. From 1948 through 1956

he was a staff member of the Department of Electrical Engineering, University of Illinois. From 1957 to 1965 he worked in the Physical Research Division of the Ramo Wooldridge Corporation, now known as the Systems Group of TRW Inc., Redondo Beach, Calif. The last year of that tenure was spent on leave of absence at the Centro Microonde, Florence, Italy, under the auspices of a Fulbright Senior Research Grant. Since 1965, he has been Professor of Engineering at Arizona State University, Tempe, Ariz., where he is presently also Manager of the Solid State Research Laboratory.

In 1968 he was awarded the IEEE Phoenix Section Annual Achievement Award for Outstanding Contributions to Electrical Engineering.



**Horacio A. Méndez** was born in Buenos Aires, Argentina, on April 1, 1932. He was graduated as an ensign from the Argentine Naval Academy in 1952, and as an electronics officer from the Argentine Navy Post Graduate School in 1960. He received the M.S.E.E. degree from the California Institute of Technology, Pasadena, in 1964, and the degree of Engineer from the Stanford University, Stanford, Calif., in 1969.

From 1953 to 1962, he served with the Argentine Navy. In 1964 he joined the IBM Corporation, San Jose, Calif., where his specialties have been electromagnetic theory and the theory of solids. For the past three years, he has been engaged in investigating different technical problems related to electromagnetic compatibility.



**Robert Avery Moore** (S'54-M'58-SM'67) was born in Cullman, Ala., on August 12, 1932. He received the B.S. degree in electrical engineering from the University of Alabama, University, in 1954, and the M.S. and Ph.D. degrees in electrical engineering from Northwestern University, Evanston, Ill., in 1956 and 1960, respectively.

Except for six months active Army duty at which time he was assigned to the Switching Devices Group, Ft. Monmouth, N. J., where he conducted research on ferrite devices, he has been employed by the Aerospace Division, Defense and Space Center, Westinghouse Electric Corp., Baltimore, Md. During this period he has conducted studies on microwave propagation and radar systems. More recently he has been con-

cerned with ferrimagnetic techniques and devices. He is presently in charge of the Solid State Microwave Group, where he is concerned with development of ferrimagnetic waveguide and integrated devices.

Dr. Moore is a member of the American Institute of Physics. He is a past Chairman of the Baltimore Chapter of IEEE Groups on Antennas and Propagations and Microwave Theory and Techniques.



**Stephen F. Payer** was born in McAdoo, Pa., on October 12, 1938. He received the B.S. degree in engineering physics from Lehigh University, Bethlehem, Pa., in 1960, and the M.S. degree in physics from St. Mary's University of San Antonio, San Antonio, Tex., in 1965.

From 1961 to 1966 he served as a lieutenant with the U. S. Air Force at Kelly AFB, San Antonio, Tex., where he worked in the field of airborne instrumentation, specializing in the application of spectral analysis and correlation techniques to aircraft random vibration problems. Since 1966 he has been employed by the Aerospace Division, Defense and Space Center, Westinghouse Electric Corp., Baltimore, Md., where he is engaged in the development of devices utilizing microwave ferrimagnetic phenomena.



**Peter H. Pincoffs** (S'50-M'57) was born in Baltimore, Md., on October 21, 1927. He received the B.E.E. degree from Cornell University, Ithaca, N.Y., in 1952, and the M.S.E. degree in electrical engineering from The Johns Hopkins University, Baltimore, Md., in 1966.

From 1952 to 1954, he was employed by the Advanced Electronics Center of General Electric Co., Ithaca, N. Y., participating in investigations concerning acoustic detection and radar systems. In 1954 he joined the Radio Division of the Bendix Corporation, Towson, Md., where he worked in research and development of missile guidance and radar systems. Since 1957 he has been with the Aerospace Division, Defense and Space Center, Westinghouse Electric Corp., Baltimore, Md., engaging in analytic studies relating mainly to signal processing and detection problems arising in research and development of a wide variety of radar and electronic systems and components.

Mr. Pincoffs is a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

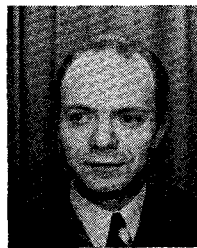


**Erich O. Schulz-DuBois** was born in Frankfurt, Germany, on March 17, 1926. In 1954 he received a Dr. phil. nat. degree in physics from Johann Wolfgang Goethe University, Frankfurt, Germany.

After some time as a postdoctorate Research Associate at Purdue University, Lafayette, Ind., and as a staff member with the Research Division, Raytheon Manufacturing Co., Waltham, Mass., he joined Bell Telephone Laboratories, Murray Hill, N. J., in 1957. He participated in the development of the microwave traveling-wave maser and is coinventor of the comb-type slow-wave structure. As supervisor of a device development group, he was responsible for the design and delivery of an appreciable number of such masers for use as low-noise front-ends in high-performance radars. In 1968 he joined IBM Zurich Research Laboratory, Rüsch-

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**André S. Vander Vorst** (M'64-SM'68) was born in Schaerbeek, Brabant, Belgium, on October 22, 1935. He received the degree of Electrical and Mechanical Engineer in 1958 and the Ph.D. degree in applied sciences in

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From 1958 to 1962 he held an Assistantship at the Catholic University of Louvain;

in 1962 he became an Assistant Professor there, working on fast switching of magnetic cores. During the 1964 to 1965 academic year he specialized in microwaves at Massachusetts Institute of Technology and during the 1965 to 1966 academic year he was a Research Associate at the Stanford Radio-Astronomy Institute, both under a NATO fellowship. In 1966 he returned to the Catholic University of Louvain to start a microwave laboratory. The main interest of this laboratory is the study of propagation in inhomogeneous media, especially waveguides, both by exact and approximate techniques with emphasis on computer-aided solutions. Since 1968 he has been an Associate Professor of electrical engineering at the Catholic University of Louvain, Belgium.

Dr. Vander Vorst is Counselor of the IEEE Student Branch at the Catholic University of Louvain, a member of the IEEE Region 8 Committee, the Société Belge des Ingénieurs de Télécommunications, and the Association Belge des Ingénieurs et Techniciens en Aéronautique.