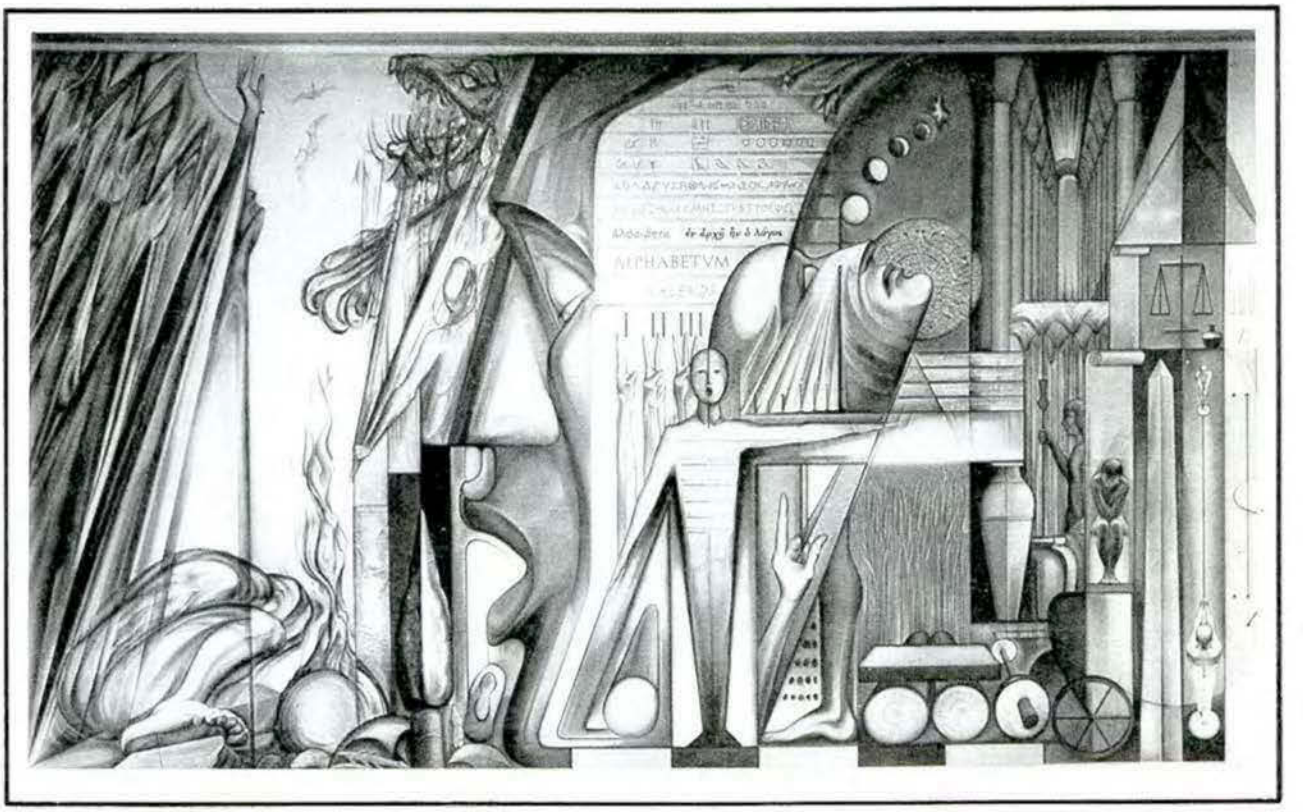
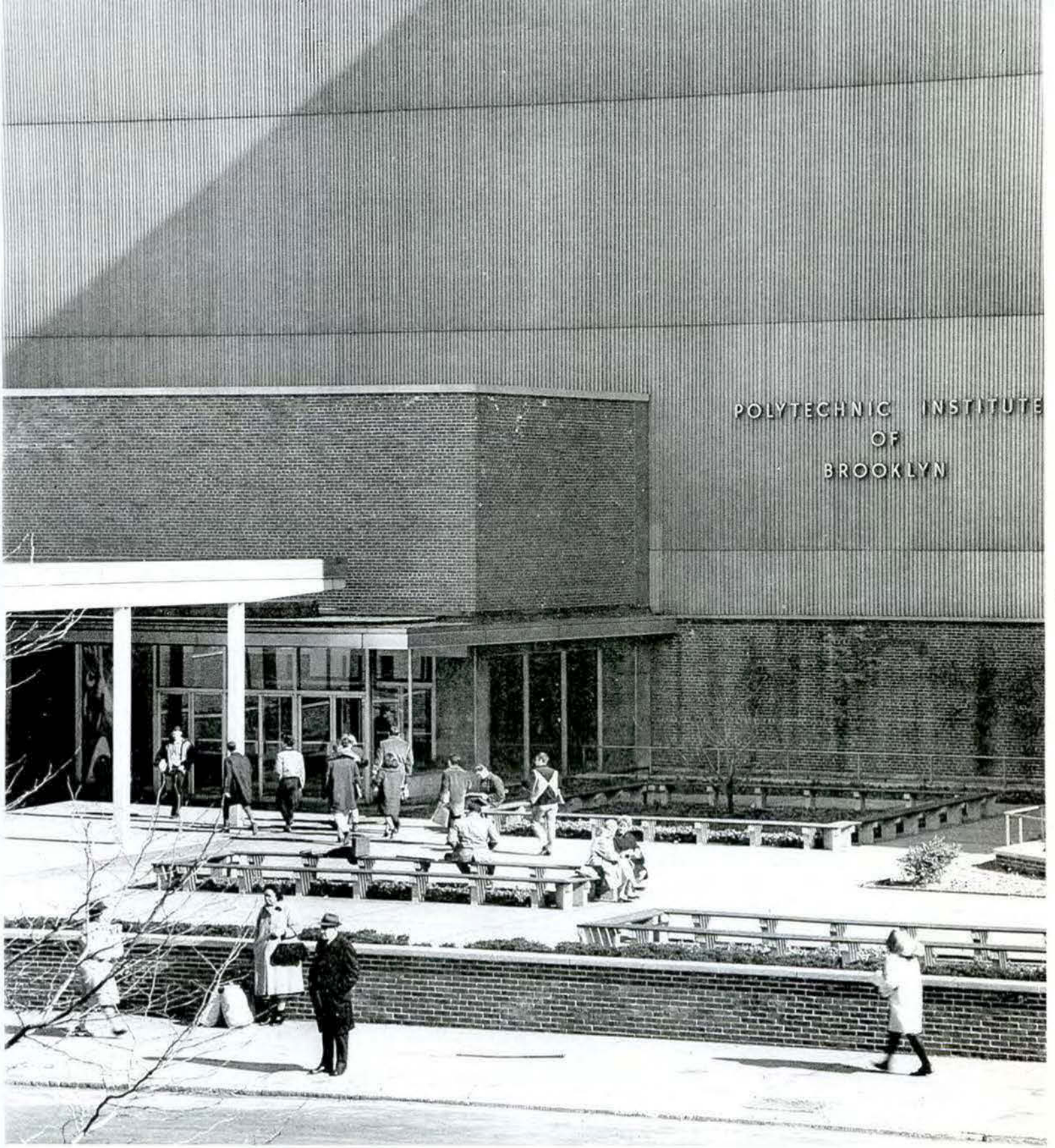


ABRAHAM JOEL TOBIAS 1968 ©

BELL LABORATORIES CONTINUING EDUCATION PROGRAM

POLYTECHNIC INSTITUTE OF BROOKLYN



Cover: "History of Science" Abraham Joel Tobias 1968 C
Section of Mural in Progress, Polytechnic Institute of Brooklyn

BELL LABORATORIES CONTINUING EDUCATION PROGRAM

BELCEP

MODERN ENGINEERING MATHEMATICS

a program in continuing professional studies
for Bell Telephone Laboratories personnel
by
The Office of Special Programs,
Polytechnic Institute of Brooklyn

DESIGNED AND COORDINATED BY
VENKATARAMA KRISHNAN

SEPTEMBER 1968
JUNE 1970

FOREWORD

Continuing education should mean continuing self-education, not continuing instruction. A prime objective, therefore, is to help the individual impose upon himself the discipline essential to self-study in such a way that the contemplation of it is appealing and hopefully exciting as well. The greatest impediment to self-study always seems to be getting started -- a difficulty that appears formidable when there has been an interruption in the educational process.

Among the direct objectives that can be readily achieved and which help to make further self-study feasible and attractive, these are probably worth mentioning:

1. Updating one's knowledge of what there is to learn;
2. becoming well acquainted with several new fields of study and developing some skill in the use of the more important concepts;
3. becoming aware of unifying concepts and their important role in achieving understanding;
4. finding out where pertinent information exists (textbooks selected for their clarity, selected papers, instructors notes, monographs, etc.);
5. making the personal acquaintance of a group of lecturers who are experts in their chosen fields and who are potential sources for future reference.

After emerging from this two-year educational experience, it is hoped that each participant would feel renewed confidence in his ability to maintain his own technical proficiency and find stimulation for a program of continued self-study.

W.A. Lynch

BELCEP

SPECIAL PROGRAMS STAFF

WILLIAM A. LYNCH
Dean for Special Programs

V. KRISHNAN
Associate Professor of Electrical Engineering
Academic Coordinator, BELCEP

GUNNAR K. BERGE
Instructor of System Science
Special Assistant to the Dean

No.	MEETINGS Month	8:30 - 10:15 a.m.	10:15 10:45	10:45 - 12:30 p.m.
1.	Sep. 1968	Differential Equations	COFFEE BREAK	Differential Equations
2.				
3.	Oct.			
4.				
5.	Nov.	Linear System Theory		Linear System Theory
6.				
7.	Dec.			
8.				
9.	Jan. 1969	Probability & Statistics		Matrix Analysis and Linear Algebra
10.				
11.	Feb.			
12.				
13.	Mar.			
14.				
15.	Apr.			
16.				
17.	May			
18.				
19.	June			
20.				

SUMMER RECESS

No.	MEETINGS Month	8:30 - 10:15 a.m.	10:15 10:45	10:45 - 12:30 p.m.
21.	Sep. 1969	Probability & Statistics	COFFEE BREAK	Numerical Analysis and Discrete Systems
22.				
23.	Oct.			
24.				
25.	Nov.	Filters & Estimators		
26.				
27.	Dec.			
28.				
29.	Jan. 1970			Variational Calculus and Optimization Theory
30.				
31.	Feb.			
32.				
33.	Mar.			
34.				
35.	Apr.	Mechanics		
36.				
37.	May			
38.				
39.	June			Concluding Lecture (to be announced)
40.				

PREFACE

This program is designed with a view to provide optimum correlation and cross correlation among the various subjects. The basic subjects, Differential Equations and Linear System Theory are introduced at the beginning. Since they provide the basic foundation to all the other subjects, the lectures are for the entire four hour block. After these subjects the program follows a parallel course where two different subjects are presented in the four hour block by two different lectures. The first parallel set consists of Probability and Statistics, Filters and Estimators, and Mechanics, in that order. Here Probability and Statistics feeds into Filters and Estimators. The second parallel set consists of Matrix Analysis and Linear Algebra, Numerical Analysis and Discrete Systems, and Variational Calculus and Optimization. Here each preceding subject feeds into the succeding subject.

An effort has also been made to cross correlate the two parallel sets. Matrix Analysis and Linear Algebra runs concurrently with Probability and Statistics; Numerical Analysis and Discrete Systems runs concurrently with Filters and Estimators; Variational Calculus and Optimization runs concurrently with Mechanics. Depending upon the interest and preparation of the participant he can elect to follow either one of the two parallel paths or attend only those blocks of the subject material suited to his needs. Suitable blocks to attend could be:

1. Probability and Statistics, and Filters and Estimators.
2. Matrix Analysis and Linear Algebra, and Numerical Analysis and Discrete Systems.
3. Variational Calculus and Optimization Theory, and Mechanics.

Irrespective of the course of action the participant desires to follow it is our earnest hope that he finds these courses stimulating and rewarding.

V. Krishnan

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BELL LABORATORIES
CONTINUING EDUCATION PROGRAM

INTRODUCTION

The courses in this program are designed to give a reasonable in-depth mathematical background to the engineer. Owing to the upsurge in all aspects of engineering, many fields have to be re-evaluated with the necessary de-emphasis of certain material and the corresponding re-emphasis of certain other material. As a consequence, the engineer whose formal engineering education ended some ten to fifteen years ago, finds himself facing whole new sets of concepts. These courses while taking cognizance of this fact also provide a very good review. It is also possible for the engineers who feel confident of their introductory background to skip the earlier review of basic material and go directly into the more advanced material. It is hoped that after the two years, the engineer who had gone through this program would have developed enough facility with the principles of modern mathematics to enable him to appreciate the trends and practice of some of the aspects of modern engineering.

LAYOUT OF THE PROGRAM

This program consists of eight broad categories: viz., differential equations, linear systems analysis, numerical analysis, matrix analysis and linear algebra, variational calculus and theory of optimization, mechanics, probability and statistics and finally, filters and estimators. The entire program spans a period of two years with recesses in the summer. Classes meet for four hours, twice every month. The class meeting of four hours is divided into a block of one hour, forty-five minutes, a coffee break lasting thirty minutes, followed by another block of an hour and forty-five minutes. In the first ten meetings the two blocks consist of the same subject and the same instructor, since the material covered is essentially basic. For most of the remainder of the program, the two blocks are occupied by different subjects and with different instructors. Hopefully, this arrangement affords some relief to the student and avoids the necessity of sitting through the same subject with the same

instructor for four hours. The entire program need not be considered as rigidly prescribed but could be modified depending upon the progress of the participants. The coffee hour is especially provided for a free interchange of ideas among the two instructors and the participants and could greatly help in showing the need for modification.

CLASS SIZE

Class size is restricted to a maximum of 28 so as to insure an effective interchange between instructor and participants.

INSTRUCTIONAL MATERIAL

Textbooks as prescribed by the individual instructors will be made available. In case the instructor does not follow the text closely, lecture notes by the instructor will be distributed.

FACULTY

The participating instructors have a wide experience in the matters concerning the modern trends in engineering and have taught extensively in the continuing education programs of the Institute. They have been apprised of the scope and objectives of this program and will, as much as possible, strike a good balance between the theoretical and the applicational aspects of engineering. They will also give homework assignments which are designed to test the understanding of the concepts and principles of the course material taught. Problems involving only long and tedious computations will be avoided as much as possible. The homework assignments will be corrected and returned to the participant. Furthermore, the participants can contact any instructor on the telephone for any problems connected with the course.

COURSE OUTLINE

1. Differential Equations:

Ordinary differential equations; first order and second order, existence theorems, solution by variation of parameters, series solution, engineering applications. Introduction to elementary difference equations; elementary ideas of solution. Introduction to partial differential equation; separation of variables, application to wave and heat equation.

(Professor Hochstadt)

2. Linear Systems Analysis:

State equations. Time domain analysis; impulse response, step response, solutions in the time domain. Frequency domain analysis; Fourier transform, Laplace transforms. Introduction to discrete-time systems, z-transforms. (Professor Krishnan)

3. Numerical Analysis and Discrete Systems:

Transition from continuous to discrete time. Solutions to difference equations and differential-difference equations. Effectiveness of the transition from continuous to discrete systems. Numerical solution to differential equations. Error bounds and convergence of difference schemes. (Professor Preiser)

4. Matrix Analysis and Linear Algebra:

Linear vector spaces; matrix analysis, matrix equations, canonic forms, quadratic and bilinear forms, application to systems.

(Professor Mendelson)

5. Variational Calculus and Optimization:

Variational calculus; Euler's equation, second variation. Examples. Lagrange multipliers and their use, gradient methods, steepest descent and ascent. Dynamic programming, Hamilton-Jacobi equations, Pontryagin maximum principle and application to aerospace problems.

(Professor Krishnan)

6. Mechanics:

Elements of vector analysis, orbital mechanics, transformations of coordinate systems, Coriolis acceleration, vector error equations.

(Professor Krishnan)

7. Probability and Statistics:

Elementary probability theorems, conditional probability and independence, combinatorial analysis, appreciation for probability models. Random variables, distributions and densities. Engineering appreciation for Poisson processes and Gaussian variates. Characteristic functions and moment analysis. Functions of random variables, sums and central limit theorem. Elementary random processes. Interval estimation, confidence limits, point estimation, elementary statistical decision theory. (Professors Boorstyn and Pickholtz)

8. Filters and Estimators

Hypothesis testing. Detection and estimation of signals in noise. Detection of signals with unknown parameters. Prediciton and filtering of stationary time series. Least squares and minimum variance filters. Recursive filtering. (Professor Haddad)

The faculty assignments shown apply for the program beginning February, 1968.

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FACULTY

Boorstyn, Robert R. - Ph.D., Polytechnic Institute of Brooklyn, Assistant Professor of Electrical Engineering, Polytechnic Institute of Brooklyn. B.E.E., City College of New York, M.S., Polytechnic Institute of Brooklyn. Fields of interest: statistical communication theory. Prior to joining Polytechnic Institute of Brooklyn, he worked as an engineer for the Advanced Studies Department of the Sperry Gyroscope Company. Member, Eta Kappa Nu, Sigma Xi and Tau Beta Pi.

Dorato, Peter - D.E.E., Polytechnic Institute of Brooklyn, Associate Professor of Electrical Engineering, Polytechnic Institute of Brooklyn. B.E.E., City College of New York, M.S.E.E., Columbia University. Fields of interest: optimal stochastic control, data processing, sensitivity analysis. He was the recipient of the National Science Foundation Faculty fellowship. He is a consultant to the U.S. Naval Applied Science Laboratory. Member, Eta Kappa Nu, Tau Beta Pi and SIAM.

Hochstadt, Harry - Ph.D., New York University. Head, Department of Mathematics, Polytechnic Institute of Brooklyn. B.Ch.E., Cooper Union M.S., New York University. Fields of interest: special functions, partial differential equations, problems of wave propagation. Formerly research engineer, W.L. Maxson Corporation. Among many publications is included the book, "Differential Equations - A Modern Approach," Holt, Rinehart & Winston, 1965. Editor, SIAM Series in Applied Mathematics. Member, American Mathematical Society, London Mathematical Society, Indian Mathematical Society, SIAM, Tau Beta Pi, Sigma Xi.

Haddad, Richard A. - Ph.D., Polytechnic Institute of Brooklyn, Associate Professor of Electrical Engineering, Polytechnic Institute of Brooklyn. B.E.E., M.E.E., Polytechnic Institute of Brooklyn. Fields of interest: Data processing, discrete-time control systems, control theory. Consultant to Bell Telephone Laboratories in digital data filtering. Member, Sigma Xi, Eta Kappa Nu, Tau Beta Pi.

Krishnan, Venkatarama - Ph.D., University of Pennsylvania, Associate Professor of Electrical Engineering, Polytechnic Institute of Brooklyn and Academic Coordinator of the BELCEP. B.Sc. (Chem.), Madras University, B.Sc. (Eng.), Banaras Hindu University, M.S.E., Princeton University. Fields of interest: Inertial navigation and guidance, systems theory, control theory. Prior to joining the Polytechnic Institute of Brooklyn, he taught in other institutions including the Moore School of Electrical Engineering, University of Pennsylvania and Princeton University. Recipient of the Orson Desaix Munn Scholoarship of Princeton University and the Fulbright Travel Grant. Member, Eta Kappa Nu, and Sigma Xi.

Mendelson, Pinchas - Ph.D., Princeton University, Professor of Mathematics, Polytechnic Institute of Brooklyn. B.S., University of Pennsylvania. Fields of interest: geometric theory of differential equations, topological dynamics, control theory, celestial mechanics. His previous teaching experience includes three years as a John Fels Ritt instructor in Columbia University and a year as visiting professor at the Institute of Mathematics and Natural Sciences at the Hebrew University, Israel. Recipient of the Bowdoin scholarship of the Institute of International Education and the Harrison scholarship of the University of Pennsylvania. Member of Sigma Xi and American Mathematical Society.

Pickholtz, Raymond L. - Ph.D., Polytechnic Institute of Brooklyn, Associate professor of Electrical Engineering, Polytechnic Institute of Brooklyn. B.E.E., M.S., City College of New York. Field of interest: communication systems. Prior to joining Polytechnic Institute of Brooklyn, his industrial experience included several years in R.C.A. Laboratories, Princeton, New Jersey, and I.T.T. Laboratories, Nutley, New Jersey. Consultant in communication systems. Member, Sigma Xi, Eta Kappa Nu.

Preiser, Stanley - Ph.D., New York University. Associate Professor of Mathematics, Polytechnic Institute of Brooklyn. Fields of interest: numerical analysis and differential equations, orthogonal polynomials and special functions. Prior to joining Polytechnic, he was Senior Mathematician, United Nuclear Corporation. Consultant to IBM Corporation and Radioptics, Inc. Member, American Mathematical Society, Mathematical Association of America, SIAM, and Association of Computing Machinery.

THE POLYTECHNIC INSTITUTE OF BROOKLYN

. . . founded in 1854, a leading urban institution located amid the many cultural, educational, and recreational advantages of New York City, with a graduate center in Farmingdale, Long Island.

. . . is accredited by all appropriate state, regional, and professional agencies.

. . . is one of the largest private science-engineering institutions in the country, with an annual registration of over 5000, about one quarter in full-time undergraduate, one quarter in part time evening undergraduate, and one half in graduate degree programs.

. . . offers four-year undergraduate programs leading to baccalaureate degrees in five science and seven engineering specialties as well as in humanities and social sciences.

. . . confers more than 800 undergraduate and graduate degrees annually.

. . . confers the Master of Science degree in nineteen disciplines, and the Doctor of Philosophy degree in fifteen disciplines.

. . . is currently in the midst of a major expansion program which will provide new buildings, additional faculty and an increased number of fellowships.

. . . is one of 15 major institutions of the country to qualify for the N.S.F. Program to establish Centers of Excellence in science and engineering. More than three million dollars was awarded by N.S.F. to enhance development in the areas of chemistry and electronics, two fields in which the Institute particularly excels.

. . . has an Office of Special Programs which conducts a broad spectrum of courses keyed to the particular needs of industry and government.

. . . has an outstanding and distinguished faculty, attracted by a challenging synthesis of high educational standards, equipment, administration, and research.

POLYTECHNIC INSTITUTE OF BROOKLYN

SEPTEMBER 1968 - JUNE 1970