A request to offer a new degree program

Master of Science in Applied Mathematics and Statistics

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Submitted by the
Department of Mathematical Sciences
Charles E. Schmidt College of Science
Florida Atlantic University

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0 Introduction

The last quarter century has seen a remarkable development in the world, the *information revolution.* No one could have predicted the speed with which information technology would produce "a super-microcomputer on each desk", the electronic global economy, the internet, and myriads of applications and services, previously unimaginable. Information technology is where the action is, where the breakthroughs are occurring, especially at the interface with other disciplines, where the smartest young men and women are choosing to study and work.

The Mathematical Sciences are at the core of this information technology revolution which is driving our economy and transforming the way we live, work and play. This is because each science contributing to this unprecedented revolution is firmly based on the mathematical sciences. Every corner of the mathematical spectrum is put to work in today's leading sciences from number theory and elliptic curves, to algebra, combinatorics, geometry, harmonic analysis, probability, statistics, and dynamical systems. The Mathematical Sciences Department, coupled with other outstanding programs at FAU can participate and enjoy the fruits of this scientific revolution. In education, research, and technology transfer, the Department can help define the future. The National Science and Technology Council which reports to the President identified six fundamental and over-reaching goals for all federal science and technology investments: i) a healthy, educated citizenry, ii) enhanced national security, iii) world leadership in science, engineering and mathematics, iv) improved environmental quality, v) job creation, and economic growth, and vi) harnessing information technology to support all the other goals.

The Department of Mathematical Sciences at Florida Atlantic University includes a number of world class scholars recognized nationally and internationally for their contributions to their areas of research, and teaching. The Department has produced many graduates who went on to succeed in industry, government or academia. In its desire to better serve its students, its service region in Southeast Florida and society in general, the Department is presently proposing a *Master of Science in Applied Mathematics and Statistics* program which aligns itself with the strengths of the Department, strengths in other programs at FAU, and with student, industrial and societal needs. Four tracks are proposed in this program as follows: 1) *Continuous Modeling*, 2) *Cryptology and Information Security*, 3) *Biostatistics*, and 4) *Scientific Visualization.* These areas are of central national importance, with thousands of job openings available now and more projected in the future. Implementation of the program is intended to incur little or no cost to the university, but instead represents a reorientation and redeployment of existing resources within the Department of Mathematical Sciences to develop this program to meet current and projected societal needs in information technology.

We are confident that by the end of its five year inaugural period this will be a vibrant, healthy and productive program making significant scholarly and societal contributions, especially in training a workforce to sustain the economic development in Southeast Florida and beyond.

1 I. The Program

1.1 Program Description

Describe the degree program under consideration, including its level, emphasis (including tracks or specializations), and number of credit hours (total, and required for the major).

The Department of Mathematical Sciences at Florida Atlantic University proposes to offer a program in applied mathematics and statistics leading to the Master of Science Degree. This program builds on and compliments already existing successful undergraduate and graduate programs in Mathematical Sciences, but now offers a graduate program with special emphasis in Applied Mathematics and Statistics with tracks that are especially tailored to meet the needs of the university's service region, as well as the national needs of a burgeoning commercial environment centered around information technology. Built around a common core of contemporary and traditional courses in applied and pure mathematics, the program will have tracks in continuous modeling, cryptology, biostatistics, and scientific visualization. The tracks in cryptology and continuous modeling will be introduced in the Fall 2002, followed by the tracks in biostatistics and scientific visualization in the Fall of 2003. At later dates, tracks in bioinformatics and mathematical finance will be added but to begin no sooner than Fall 2004/5 and are not included in this current program proposal. These various tracks will afford the students the opportunity to interact with faculty from diverse disciplines including the Center for Information Technology & Operations Management in the College of Business, the Center for Applied Stochastics Research in the College of Engineering, and with the Center for Molecular Biology & Biotechnology, the Center for Complex Systems and Brain Sciences, and the Environmental Sciences Program in the Charles E. Schmidt College of Science. To our knowledge, no other university in the United States offers such a diverse curriculum to meet the national need, and certainly no other university in the State of Florida does so. Other master's programs in applied mathematics, such as at the University of Florida or Florida State University follow more traditional curricula. The MS program in Applied Mathematic and Statistics will require students to complete 30 credit hours of required courses and an additional 6 credit hours of industrial internship or thesis.

2 II. Institutional Mission

Is the proposed program listed in the current State University System Master Plan? How do the goals of the proposed program relate to the institutional mission statement as contained in the Master Plan.

The proposed program is listed in the current State University System Master Plan and has been assigned the CIP reference number 27.0301. As stated in the Institution's mission statement, this master's degree program will add another area of strength to already strong

programs in the areas of engineering, science, informatics and applied technology. To quote from the FAU Mission Statement: "*Its mission is to serve its region, state, and nation by preparing students to make meaningful contributions in an increasingly complex global society, by encouraging reflection on and evaluation of emerging needs and priorities, and by supporting research and service that enhances economic, human, and cultural development*", and "*With its graduate and professional programs, Florida Atlantic University offers advanced education responsive to evolving societal needs. These programs promote original scholarship and basic and applied research, thereby contributing to the new knowledge and approaches needed to respond effectively to complex and critical issues. By working closely with faculty in the classroom, laboratory, studio, and field, students experience first-hand the ways in which knowledge is discovered, applied and extended.*" Clearly, the proposed MS in Applied Mathematics and Statistics speaks to the essence of FAU's Mission Statement by providing advanced graduate training and stimulation of economic development in a rapidly growing industrial sector of the service region. As already stated in the introduction and program description above, the MS in Applied Mathematic and Statistics will require original scholarship and basic and applied research necessary to respond to complex and critical issues, and to train an effective workforce to meet societal needs in its service region and beyond.

The proposed MS program will help FAU meet this mission through its unique curriculum which will include close interactions with the Center for Information Technology & Operations Management in the College of Business, with the Center for Applied Stochastics Research in the College of Engineering, and with the Center for Molecular Biology & Biotechnology, the Center for Complex Systems and Brain Sciences, as well as the Environmental Sciences Program in the Charles E. Schmidt College of Science. In addition to complimenting these already strong programs within the colleges, the MS program will should also help enhance economic development in this region through interactions with new innovative companies in information technology attracted to the *FAU Research Park* and Southeast Florida in general. Graduates of the MS program in Applied Mathematics and Statistics will be highly sought after workers, skilled in applied mathematics, cryptology and information security, statistics and computational mathematics. At the same time, the presence of the Park on our campus will have a very positive influence on the proposed program.

3 III. Planning Process and Timetable

Describe the planning process leading up to submission of this proposal. Include a chronology of activities, listing the university personnel directly involved and any external individuals who participated in planning. Provide a timetable of events for the implementation of the proposed program.

Under the leadership of Professor Tomas Schonbek, the Department of Mathematical Sciences began drafting a program in applied mathematics and statistics in 1997. It is fair to say that almost every member of the faculty of the Department has been involved in the

planning process at some time or another. The tracks in *Cryptology*, *Continuous Modeling*, and *Biostatistics* were included from the beginning of the planning process, and the track in *Scientific Visualization* was added in 2000. In 1998 two committees were set up to discuss all aspects of the program. The first committee is constituted of members of the faculty of the Department of Mathematical Sciences and has met several times over the past three years. Its current membership is as follows:

Jose Andres Correa,	Assistant Professor of Mathematical Sciences
Mingzhou Ding,	Professor of Complex Systems and Brain Sciences & Professor of Mathematical Sciences
Frederick Hoffman	Professor of Mathematical Sciences
William Kalies	Assistant Professor of Mathematical Sciences
Yuandan Lin	Associate Professor of Mathematical Sciences
Spyros Magliveras (current chair)	Professor of Mathematical Sciences
Ronald Mullin	Professor of Mathematical Sciences
Heinrich Niederhausen	Professor of Mathematical Sciences
Lianfen Qian	Associate Professor of Mathematical Sciences
Markus Schmidmeier	Assistant Professor of Mathematical Sciences
Tomas Schonbek (first chair)	Professor of Mathematical Sciences
Yuan Wang	Professor of Mathematical Sciences

At the same time, an *extended* committee was created and updated over time. The extended committee consists of all members of the above departmental committee, faculty members from other closely related departments with interests in applied mathematics and prominent members of local and national industrial entities. The extended committee will become increasingly more active once the program is underway. With an updated membership and with an increased participation from industry, it will become the *Advisory Board* for the program. There will be annual Advisory Board meetings beginning in the Spring of 2003. In addition to the members mentioned above, other committee members are:

Ravi Shankar,	(Professor, Computer Science & Engineering)
Prabir Bhattacharya,	(Principal Scientist, Panasonic Networking Research)
Manhar Dhanak,	(Ocean Engineering)
Paul Hart,	(Director, Center for Information Technology & Operations Management)
Yukweng Lin,	(Eminent Scholar, Engineering)
Manos Menayas,	(VP - IBM - Global Services)
Ram Narayanan,	(Center for Molecular Biology & Biotechnology)
Zvi Roth,	(Electrical Engineering)

The Department has received full support from the Office of the Dean of Science in developing this much needed new program. Indeed, with this programmatic shift in the Department of Mathematical Sciences in mind, the department has hired several junior and senior faculty members whose specific interests will contribute significantly to the MS in Applied Mathematics and Statistics. The hiring dates for these individuals are listed in the table below. In particular also, Dr. Gary Perry, Director of Graduate Programs in the Charles E. Schmidt College of Science, has participated in several stages of the process. In Fall 2000, Professor Spyros Magliveras joined the Mathematics Faculty and assumed the chair of the Faculty Program Committee, as well as much of the task of revising and finalizing the draft of this Request to Implement a New Program. Once approved, Professor Magliveras will assume the role of Director of the Program. This proposal is the outcome of these efforts.

Program Implementation Timetable

Item or activity	Implementation Date
Faculty initiate discussions on proposed program	Spring 1997
Formation and Meetings of Faculty Committee	Fall 1997
Formation and First Meeting of Extended Committee	Spring 1998
Begin drafting request to implement new program	Spring 1998
Dr. William Kallies joins Mathematics Faculty	Fall 1998
First draft of request to implement a new program completed	Spring 1999
Dr. Jose Correa joins Mathematic Faculty	Fall 1999
Prof. Spyros Magliveras joins Mathematics Faculty	Spring 2001
Revisions of first draft of request to implement new program	Spring 2000
Completion of first draft of request to implement new program	Fall 2001
Dr. Markus Schmidmeier joins Mathematics Faculty	Fall 2001
Program approval by College Graduate Programs Committee	Spring 2002
Program approval by University Graduate Programs Committee	Spring 2002
Program approval by University Faculty Council	Spring 2002
Program approval by FAU Board of Trustees	Summer 2002
Admit first cohort of students to Continuous Modeling track	Fall 2002
Admit first cohort of students to Cryptology track	Fall 2002
First Advisory Board Meeting	Spring 2003
Admit first cohort of students to Biostatistics track	Fall 2003
Admit first cohort of students to Visualization track	Fall 2003
Advisory Board meeting	Spring 2004
First cohort of students graduate	Summer/Fall 2004

At the non too distant future, when the above four tracks are well established we plan to implement two additional tracks in *Bioinformatics* and *Mathematics of Finance*, hopefully

fully operational by 2007.

4 IV. Assessment of need and demand

4.1 [A] Documentation supporting need for program

What national, state, or local data, support the need for more people to be prepared in this program at this level? (This may include national, state or local plans or reports that support the need for this program; demand for the proposed program which has emanated from a perceived need by agencies or industries in your service area; and summaries of prospective student inquiries.) Indicate potential employment options for graduates for the program. If similar programs exist in the state, provide data that support the need for an additional program.

Holders of a Master of Science degree in applied mathematics and statistics are viewed as highly skilled professionals in the Information Technology, and Science & Engineering (IT&SE) areas. Very few businesses or industries will advertise specifically for a mathematician. Instead, they will be looking for people with specific skills and abilities. Quite often, a mathematician will be the best person for the job. The need for highly skilled IT&SE professionals is obvious and well documented. Based on data from the U.S. Bureau of Labor Statistics, the National Science Board in its report *Science and Engineering Indicators, 1998*, which can be viewed on the internet at <http://www.nsf.gov/sbe/srs/seind98/frames.htm>, estimates employment in IT&SE occupations to increase at more than three times the rate for all occupations, with most of the increase occurring in computer-related occupations. The total increase in IT&SE jobs in the decade 1996-2006 is estimated to be of the order of 44%, with a total of 1.36 million new jobs being created. It is widely perceived within American Industry that the United States will not be able to fill all these positions with American citizens or residents, and this is why before September 11, 2001, there was widespread support for the easing of immigration restrictions for highly skilled workers. Senate Bill S. 1723, *The American Competitiveness Act*, introduced by Senator Spencer Abraham (R-MI), addresses these concerns by increasing the number of temporary visas granted to highly skilled foreign workers. The same bill amends the 1965 Higher Education Act by adding a paragraph allowing states to use certain funds to establish scholarships for students seeking to "enter a program of study leading to a degree in mathematics, computer science, or engineering." After the events of September 11, immigration restrictions are less likely to be eased, and the national demand for high level S&E professionals most probably will increase dramatically.

In the Appendix I. of this proposal we attach a recent article (Dec 5, 2001), published in the *Chronicle of Higher Education* by Andrea L. Foster. In the article the author describes recent bills introduced in the U.S. House of Representatives which would budget about $7.88-billion over five years into information technology research and education re-

lated to computer and information security. Significant sums are mentioned for research and training at institutions at all levels from Ph.D. granting institutions to Community Colleges. FAU has considerable strengths in this area and would compete favorably for funding in several categories. The action considered by the House certainly speaks to the national need for the cryptology component in the proposed program.

The applied mathematics and statistics program at Florida Atlantic University is designed for students whose primary interest is mathematics and who would like to apply their mathematical talents successfully in a high technology environment. While the program includes tracks in traditional areas of applied mathematics, such as continuous modeling, it will also include tracks in contemporary, important areas of great demand, such as cryptology, and biostatistics. These areas, which distinguish the program from other applied programs in the state, are of significant local interest and are already attracting a good number of students. In the last 3 years there were 5 Master's degrees awarded in the Department with specialization in cryptology, and all of these graduates found excellent jobs in industry related to computer and information security. We currently have 5 students who are pursuing an MS degree with specialization in cryptology. Moreover, in the last two semesters 34 students have taken a graduate cryptology course, and in the spring semester of 2002, 35 students are registered for the 4000-5000 level course in coding theory, a required course for the cryptology track.

A number of local and national industries as well as some Medical organizations have expressed keen interest in the proposed MS program in Applied Mathematics and Statistics demonstrating the need for such a program and the likelihood of graduates to find employment after graduating. We mention a few of these entities: expressed support for the program: IBM, Motorola, Siemens, Matrix$N$, Panasonic, Data Warehouse. In 2001, Matsushita Electric Industrial Co., parent company of Panasonic hired us on a consulting task related to cryptography and data security. Here are a couple of excerpts ... Matrix^N: "*We believe one of the key reasons that these areas fall short of fulfilling their promise is that the professional services providers involved in bioinformatics are inadequately trained in mathematics to fulfill the complex demands of theses sectors...* ". IBM: *As you are undoubtedly aware, the subject of your proposal, data integrity, has become a very critical component in today's business environment ...*, and again : *As such, your studies in Cryptology and Information Security appear quite timely and relevant ...*" Letters from companies as well as local organizations supporting this proposal are provided in Appendix II.

The impact of the proposed program on our Ph.D. program in Mathematics will be beneficial for the following reasons: 1) There will be more students around and of better quality. Of these, a significant portion will elect to continue for the Ph.D. degree at FAU. 2) The proposed program is likely to attract increased research funding, making it easier to support graduate students for duties of great proximity to their areas of training. 3) The increased mathematical training, interaction and activity in the Department will increase the visibility of the Department and its programs, resulting in more applicants of higher quality. A survey of the students taking core senior courses in the Department indicated that from the 23 respondents, 12 would be interested in enrolling in the M.S. Applied Mathematics and Statistics Program.

The current M.S. program in mathematics will continue to serve those students who want to pursue a more theoretical direction, possibly leading to a Ph.D. program in mathematics, or via our accelerated M.S. joint program with the Department of Electrical Engineering into the Ph.D. program in Electrical Engineering. Similarly, the M.S. program in Teaching Mathematics will continue to serve those students who want to pursue a teaching career in Secondary Education. It is likely that the above two programs will remain popular and even increase in time, partially due to synergies produced by their interaction with the proposed Applied Mathematics and Statistics MS program.

We also want to emphasize that other applied mathematics M.S. programs in the state have no statistics component, with statistics being usually offered in a different department. The following table lists those universities in the State of Florida that specifically offer masters programs in applied mathematics, but none concomitantly with statistics:

Institution	Degree	Area
University of Florida	MA	Applied Mathematics
Florida State University	MA/MS	Applied Mathematics
Florida International University	Certificate	Applied Mathematics
University of South Florida	MA	Mathematics with Applied emphasis
University of Central Florida	MS	Mathematical Science with Applied emphasis area
University of Western Florida	MS	Mathematics with Applied emphasis
University of Miami	MA/MS	Mathematics with Applied emphasis

The proposed program would be the only M.S. program in Applied Mathematics and Statistics in the state of Florida.

4.2 [B] Numbers of anticipated students by source

Use the appropriate version of Table One (baccalaureate or graduate) to indicate the number of students (head-count and FTE) you expect to major in the proposed program during each of the first five years of implementation, categorizing them according to their primary sources. In the narrative following Table One, the rationale for enrollment projections should be provided and the estimated head-count to the FTE ratio explained. If, initially, students within the institution are expected to change majors to enroll in the proposed program, describe the shifts from disciplines which are likely to occur.

Please See Table One.

TABLE ONE B

NUMBER OF ANTICIPATED MAJORS FROM POTENTIAL SOURCES *

GRADUATE DEGREE PROGRAM

NAME OF PROGRAM: MASTER OF SCIENCE IN APPLIED MATHEMATICS AND STATISTICS
CIP CODE: 27.0301

ACADEMIC YEAR	year 1		year 2		year 3		year 4		year 5	
Source of Students (Non−Duplicative Count in Any Given Year)**	HC	FTE	HC	FTE	HC	FTE	HC	FTE	HC	FTE
Individuals drawn from agencies / industries in your service area (e.g. older returning students)	2	0.66	6	2.00	8	2.64	10	3.30	12	4.00
Students who transfer from other graduate programs within the university	0	0	0	0	1	0.5	2	1.00	2	1.00
Individuals who have recently graduated from preceding degree programs at this university **	4	2.92	4	2.92	5	3.65	7	5.11	9	6.57
Individuals who graduated from preceding degree programs at other SUS universities **	2	1.46	2	1.46	3	2.19	6	4.38	7	5.11
Individuals who graduated from preceding degree pro−grams at non−SUS Florida colleges and universities **	2	1.46	2	1.46	2	1.46	4	2.92	6	4.38
Additional in−state residents	0	0	0	0	0	0	0	0	0	0
Additional out of−state residents **	2	1.46	4	2.92	4	2.92	6	4.38	7	5.11
Additional foreign residents **	2	1.46	2	1.46	4	2.92	5	3.65	7	5.11
Other (Explain) **										
TOTAL	14	9.42	20	13.68	27	16.28	40	24.74	50	31.28

** See explanation of Table One.

4.2.1 Explanations for "Table One"

The Department of Mathematical Sciences receives on average about 1200 requests per year for graduate application materials. It is estimated that 70-80 students initiate the application process each year, and approximately 40 students submit completed applications. About 75% of these students are interested in pursuing a non-teaching career in mathematics. With academic jobs scarce and not as highly paid as jobs in industry, more and more mathematically gifted students are looking to industry as the place where their talents will be put to best use, so that even now most of our non-MST graduate students take every applied course our department offers, with Cryptology already being a popular thesis area. The existence of an applied M.S. degree program will significantly increase the number of applicants, especially if it is energetically promoted. Thus, we believe that our estimate of 12 first year, full time graduate students during the first year of operation of the M.S. program, rising to about 50 in the fifth year of operation, is rather conservative. Based on previous enrollments, we estimate that our full time students will be roughly evenly distributed among the different categories, with a slightly larger number being recent FAU graduates. As the program becomes better known, it is certain to pick up graduate students from other FAU programs, but we also hope to attract a significant number of students from outside the South Florida region. We estimate that students in all tracks, except possibly for the first two, will be full time students. Students drawn from industry, agencies, etc., might be taking only a couple of courses per year. To be on the conservative side, we estimate each such student to be equivalent to 0.33 FTE's on the average. Transfer students from other programs within the university can either be full time, or take a few courses per year. We believe that a 0.5 FTE ratio is a reasonably accurate estimate.

4.3 [C] Diversity of student body

For all programs, indicate what steps will be taken to achieve a diverse student body in this program. If the proposed program duplicates programs at FAMU or FIU, provide an analysis of how the program might impact those universities relative to their ability to attract students of races different from that which is predominant on their campuses.

The Department of Mathematical Sciences has a long history of diversity in all of its programs and is committed to maintaining this diversity. As of Spring 2002, there were a total of 52 students registered in the graduate programs offered through the Department of Mathematical Sciences, of which 31 were male and 21 were female. Approximately, 69% of these

students were White, 19% were Asian, 8% were Black and 4% were Hispanic. These figures are roughly comparable with FAU as a whole in the Spring 2002 (White 62%, Asian 4%, Black 16% and Hispanic 12%). The under-represented minority participation was however, greater than that seen nationally when compared to figures published by the National Science Foundation < http://nsf.gov/srs/seind98/start.htm> for science degrees (Asian 7.8Black 3.0%, Hispanic 2.3% and White 82%). Currently, the Department of Mathematical Sciences has about 23% international students. We anticipate similar percentages to be reflected in the Master of Science in Applied Mathematics and Statistics. This program does not duplicate programs at FIU or FAMU.

The diversity in math programs, and across the University, is a reflection of the local community which is expected to be the first region in the U.S. that does not have an ethnic or racial majority by the year 2005. The local demographics further assures us that the programs in this department, and FAU in general, will continue to reflect the diversity of this region.

Paula Behul, Director, Equal Opportunity Programs	Date

5 V. Curriculum

5.1 [A] Tracks and course descriptions

For all programs, provide a sequenced course of study and list the total number of credit hours for the degree. For bachelor's programs, also indicate the number of credit hours for the major coursework, the number of credit hours required as prerequisites to the major (if applicable), and the number of hours available for electives.

Please see the description of courses beginning at the bottom of page 13 of this proposal.

PREREQUISITE: Computer Competency; Bachelor's degree in mathematics or related area; Candidates must satisfy the general Graduate School admission requirements.

Most tracks in the M.S. Program in Applied Mathematics and Statistics encompass primarily courses offered through the Department of Mathematical Sciences, but courses offered in other departments may be appropriate as electives. Students may substitute such courses with the approval of the graduate committee.

Several "*new*" courses described below will initially be offered as "*special topics*: MAT 6933". Once these courses have been fully developed we will seek "New Course" approval for these topics.

5.1.1 COMMON MATHEMATICS CORE (6 credits)

REQUIRED COURSES		CREDITS
Any two of the following 3 courses		
Introductory Analysis I	MAA 5226	3
Introductory Abstract Algebra I	MAS 5312	3
Mathematical Probability	STA 6444	3

5.1.2 CONTINUOUS MODELING TRACK (30 credits)

to start in August, 2002

REQUIRED COURSES		CREDITS
Introductory Analysis II	MAA 5227	3
Numerical Analysis	MAT 6933	3
Ordinary Differential Equations	MAT 6933	3
Industrial Mathematics I	MAT 6933	3
Elective Courses (12 hours) **Choose 4 from:**		
Industrial Mathematics II	MAT 6933	3
Real Analysis I	MAA 6306	3
Partial Differential Equations	MAP 6356	3
Control Theory & Optimization	MAT 6933	3
Dynamical Systems I	MAP 6208	3
Dynamical Systems II	MAP 6209	3
Numerical Methods for PDE's	MAT 6933	3
Advanced Linear Algebra	MAT 6933	3
		30

5.1.3 CRYPTOLOGY TRACK (30 credits)

to start in August, 2002

REQUIRED COURSES		CREDITS
Cryptography	MAD 6477	3
Cryptanalysis	MAD 6478	3
Coding Theory	MAD 6163	3
Algebraic Number Theory	MAS 6215	3
Analysis of Algorithms	COT 6401	3

Elective Courses (9 hours)
Choose 3 from:

Computer Networks	CEN 5502	3
Computability and Complexity	COT 5410	3
Combinatorics I	MAD 6203	3
Combinatorics II	MAD 6204	3
Number Theory and Cryptography	MAS 6217	3
Information Theory	EEL 6522	3
Computer Data Security	COP 6855	3
Computational Group Theory	MAT 6933	3
		30

5.1.4 BIOSTATISTICS TRACK (30 credits)

to start in January, 2003

REQUIRED COURSES		CREDITS
Mathematical Statistics	STA 6326	3
Biostatistics	STA 6176	3
Regression Analysis	STA 6208	3
Generalized Linear Models	STA 6236	3
Survival Analysis and Clinical Trials	STA 6177	3
Elective Courses (9 hours)		
Choose 3 courses from:		
Statistical Methods for Environmental Sciences	STA 6206	3
Applied Statistics Methods	STA 6207	3
Topics in Probability and Statistics*	STA 6446	3
Analysis of Multivariate Data	STA 6707	3
Survey Sampling	STA 5225	3
Analysis of Categorical Data	STA 6505	3
Applied Time Series	STA 6857	3
Statistical Computing	STA 6901	3
		30

5.1.5 SCIENTIFIC VISUALIZATION TRACK (30 credits)

to start in August, 2003

REQUIRED COURSES		CREDITS
Fundamentals of Scientific Visualization	MAT 6631	3
Applications of Scientific Visualization	MAT 6632	3
Advanced Computer Graphics	CAP 6701	3
Digital Image Processing	EEL 6820	3
Electives:		
Choose 4 from:		
Numerical Analysis	MAD 6407	3
Dynamical Systems I	MAP 6208	3
Dynamical Systems II	MAP 6209	3
Multimedia Designs	CAP 5011	3
User Interface Design	CAP 5100	3
Introduction to Neural Networks	CAP 5615	3
Multimedia Systems	CAP 6010	3
Model Based Simulation	COP 6301	3
Advanced Electronic Imaging Systems	EEL 6562	3
Geographic Information Systems	GEO 6146	3
Computational Physics	PHZ 5156	3
Biological Vision	PSB 5615	3
		30

* Starred courses may be repeated once.

Other tracks may be added, as appropriate.

5.2 [B.] Excess of credit

For bachelor's programs, if the total number of credit hours exceeds 120, provide an argument for an exception to the SUS policy of a 120 maximum.

Not Applicable

5.3 [C.] Course descriptions

Provide a one or two sentence description of each required or elective course.

MAA 5226-5227 Introductory Analysis I, II. Real and complex numbers, metric spaces, sequences and series, continuity, differentiation and integration of functions of one or more real variables.

MAA 6306 Real Analysis I. Abstract measure theory, the integral of Lebesgue and other related integrals.

MAD 5202 Introductory Combinatorics. A second course in discrete mathematics: graphs and networks, enumeration, lattices, designs, codes, applications, and proof techniques.

MAD 6163 Coding Theory Channels, Shannon's capacity theorem. Linear codes, Hamming, Reed-Muller, cyclic codes, idempotents, BCH codes, Reed-Solomon codes, quadratic residue codes, perfect codes, self-dual codes, sphere packings, the Golay codes, weight enumerators, MacWilliams' theorem, association schemes, self-orthogonal codes and designs.

MAD 6203, 6204 Combinatorics I, II. A survey of combinatorial theory including methods of enumeration, theorems on choice, existence and construction of designs, and graphs and networks.

MAD 6209 Topics in Combinatorics. Advanced treatment of topics such as block designs, coding theory, enumeration, graph theory, matroid theory, and umbral calculus.

MAD 6477 Cryptography. Shannon theory. One-way, trapdoor functions, entropy. Symmetric and public-key cryptography. Stream and block ciphers. Diffie-Hellman, RSA, El-Gamal, McEliece, Merkle-Hellman, Chor-Rivest systems and attacks. Elliptic curve systems. Lattice basis reduction attacks, NTRU. Hash functions and data integrity. Identification, digital signatures.

MAD 6478 Cryptanalysis. Information theory, entropy, probabilistic attacks. Passive and active attacks. Ciphertext-only, known-plaintext, chosen-plaintext, chosen-ciphertext attacks, adaptive attacks. Types of security. Known attacks on computati-onally-secure systems. Meet in the middle attacks. Differential and linear cryptanalysis. Random number generators, tests, analysis and weaknesses.

MAD 6933 Numerical Analysis. Numerical solution of ordinary differential equations,

interpolation, error analysis.

MAD 6933 Industrial Mathematics I, II. A sequence of two courses in applying mathematics to the solution of real world problems.

MAP 6933 Ordinary Differential Equations. The qualitative theory of ordinary differential equations: existence, uniqueness and continuous dependence, linear systems, Lyapunov functions, invariant manifolds, bifurcation theory, Floquet theory.

MAP 6205 Control Theory and Optimization. Continuous-time and discrete-time systems, controllability and observability, stability analysis, feedback and stabilization, optimal control and Pontryagin maximum principle.

MAP 6208-6209 Dynamical Systems I, II. Scalar autonomous equations, elementary bifurcations, scalar maps, multi-dimensional chaos, scalar non-autonomous equations, bifurcations of periodic equations, equations on tori and circle maps, autonomous systems, Lyapunov functions.

MAP 6356 Partial Differential Equations. Advanced topics in partial differential equations: Sobolev spaces, degree theory, regularity, evolution equations.

MAP 6933 Numerical Methods for Partial Differential Equations. Finite differences and finite elements methods.

MAS 5312 Introductory Abstract Algebra I. Basic structures of abstract algebra: groups, rings and ideals, polynomials and factorization.

MAS 6933 Advanced Linear Algebra. Vector spaces, subspaces, linear transformations, change of basis. Hermite normal form, elementary operations. Normal forms, Hom(U,V), determinants, eigenvalues, similarity, the Hamilton-Cayley theorem. Eigenvalues, eigenvectors and eigenspaces, minimum polynomial. Jordan canonical form, linear functional, bilinear and quadratic forms, orthogonal and unitary transformations.

MAT 6631 Fundamentals of Scientific Visualization. Overview of common scientific visualization techniques and algorithms: segmentation, edge and feature detection, Skeletonization, wavelet and Fourier transforms, filters, compression, animation, treatment of noise and artifacts.

MAT 6632 Applications of Scientific Visualization. Presentation of selected examples from applications to real world data (medical imaging, geophysical and remote sensed

data); and to numerical experiments (potentials, flows).

STA 5225 Survey Sampling. Simple stratified, systematic, and cluster random sampling. Ratio and regression estimation. Multistage sampling.

STA 6176 Biostatistics. Analysis of epidemiological studies, measures of morbidity and mortality, methods for rates and proportions, bioassay, longitudinal data analysis.

STA 6177 Survival Analysis and Clinical Trials. Survival analysis, Kaplan-Meier estimates, proportional hazards model, related tests, phase I, II, and III clinical trials, designs and protocols.

STA 6206 Statistical Methods for the Environmental Sciences. Fundamentals of statistical inference, fundamental issues in experiment design, types of designs, data analysis of treatment-versus-control differences, treatment-versus-control multiple comparisons, trend testing, dose-response modeling and analysis, introduction to generalized linear models, analysis of cross-classified tabular/categorical data.

STA 6207 Applied Statistics Methods. Overview of normal theory inference, nonparametric, and categorical data methods; basic concepts of experimental design; analysis of variance; introduction to factorial and nested experiments.

STA 6208 Regression Analysis. Simple linear regression; multiple regression; model selection residual analysis; influence diagnostics; multicollinearity; ANOVA and regression; generalized linear models; nonlinear regression.

STA 6326 Mathematical Statistics. Theory of inference, regression, ANOVA, robust procedures, or other selected topics.

STA 6444 Mathematical Probability. Theory of random variables, stochastic processes, Brownian motion, renewal processes, martingales, or other selected topics and applications.

STA 6446 Topics in Probability and Statistics. Advanced treatment of topics from stochastic processes, limit laws, decision theory, and sequential methods.

STA 6505 Analysis of Categorical Data. Varieties of categorical data, cross-classification tables, tests for independence. Measures of association. Loglinear models for multidimensional tables. Logit models and analogies with regression. Specialized methods for ordinal data.

STA 6857 Applied Time Series. Linear time series model building, spectral density estimation, analysis of non-stationary data, SAS package on Box and Jenkins model building and forecasting. Case studies in recent literature will be discussed.

STA 6901 Statistical Computing. Computation algorithms for random number generation, the computation of univariate statistics, multiple and nonlinear regression, maximum likelihood estimation, Monte Carlo simulation, concepts of efficient programming.

CAP 5011 Multimedia Design. This is the project-oriented course which will use the Multimedia Laboratory. Introduction to multimedia systems. Multimedia hardware and software systems. Multimedia development tools. Overview of Multimedia applications. Complete process of multimedia system specification, design, testing, and prototyping. Student projects.

CAP 5100 User Interface Design. Concepts, models and architectures underlying user interface design from both the user's and developer's perspectives. Introduces Terminology, principles, guidelines and heuristics for the design and implementation of graphical user interfaces. Examines the role and impact of user interface design in software engineering.

CAP 5615 Introduction to Neural Networks. Brief introduction to biological neural systems. Models of neural mechanisms of learning and memory. Neural net applications to image processing, pattern recognition, machine learning, optimization problems, and robotics. Hardware implementation issues.

CAP 6010 Multimedia Systems. Components of multimedia systems. Fundamental techniques for multimedia compression and multimedia synchronization. Multimedia networks. Video retrieval and indexing techniques. Overview of multimedia Tools and applications, such as on-demand services and video-conferencing.

COP 6301 Model Based Simulation. Discrete and continuous world views will be developed as a basis for efficient programs and systems simulations. Object oriented language approaches will be included.

EEL 6562 Advanced Electronic Imaging Systems. Review on Color systems: NTSC, SECAM, and PAL; gamma and colorimetry; test standards. HDTV, IDTV and EDTV; production standards; Recording; film transfer; visual perception; TV transmission; digital video compression; interference problems; HDTV distribution: satellite, fiber, cable; displays; cameras; medical imaging.

GEO 6146 Geographic Information Systems. Basic principles and methods of geographic information systems: data structures, storage, retrieval, manipulation, analysis, and display using a computer.

PHZ 5156 Computational Physics. Introduction to the use of numerical methods to solve realistic physics problems. Emphasis on good programming techniques and on obtaining insight into the problem rather than just numerical answers. Discussion of recent developments such as Distributed and symbolic computing.

PSB 5615 Biological Vision. Visual perception is studied Through its basis in retinal and cortical neurophysiology, with emphasis on the Fourier domain in early processing and cooperative neural interactions in pattern formation.

MAT 6933 Computational Group Theory. Group theoretic algorithms and their complexity. Coset enumeration, the Schreier-Sims algorithm, centralizers, normalizers and the nilpotent quotient algorithm. The Knuth-Bendix algorithm, p-Sylow calculus, conjugacy classes and characters of groups, permutation group algorithms, characters of $\mathcal{S}_n$, maximal subgroups, transitive and primitive extensions. Word problems, intractable problems.

5.4 [D.] Bachelor's programs prerequisites

For Bachelor's programs, list any prerequisites, and provide assurance that they are the same as the standard prerequisites for other such degree programs within the SUS. If they are not, provide a rationale for a request for exception to the policy of standardized prerequisites.

Not Applicable.

5.5 [E.] Limited Access status

For Bachelor's programs, if the university intends to seek formal Limited Access status for the proposed program, provide a rationale. Indicate the Limited Access

request on the EO Impact Statement.

Not Applicable.

5.6 Learning Outcomes and Assessment

Provide expected student learning outcomes and an assessment plan to verify student learning.

All academic programs at the University are required to provide plans for assessment of student learning through defined specific outcomes, the method of assessment for those outcomes, and criterion to be reached in the assessment process. The plans for each program are reviewed and approved by the University's Academic Programs Institutional Effectiveness Committee (APIEC). Once approved, such a plan will also be developed for the Master of Science in Applied Mathematics and Statistics and submitted to the APIEC for approval.

Currently, the Department of Mathematical Sciences has such plans in place for its graduate degree programs the Master of Science in Mathematics and the Doctor of Philosophy in Mathematics. Learning outcomes for the Master of Science in Applied Mathematics and Statistics will be similar, although distinct, to those in the Master of Science in Mathematics programs. For example, students should be able to apply concepts and techniques learned in classes, and found in the literature, to the solution of problems, using language, terminology, and symbols appropriately. Such an expected learning outcome would be assessed annually by a committee of the faculty involved in the MS in Applied Mathematics and Statistics through review of student theses submitted for that year, or papers published by the students in refereed journals and scored as meeting or not meeting the criterion. In this case, the criterion might be that 100% of all theses meet this criterion, with 90% as acceptable. At least three such outcomes, assessment plans and criteria will be developed for the MS in Applied Mathematics and Statistics to be used annually and changed as needed.

6 VI. Institutional Capability

6.1 [A] Relationship of program to existing institutional strengths

How does the proposed program specifically relates to existing institutional strengths such as programs of emphasis. Other academic programs and/or institutes and centers?

A quick survey of the Department of Mathematical Sciences at FAU shows a large proportion of the faculty having received their Ph.D. degrees from top national & international universi-

ties. The faculty have been productive in research, and dedicated and acclaimed teachers to a large number of students. A world famous International Conference has been taking place for over 3 decades at FAU, organized annually by a member of the Department, and this has contributed to considerable international visibility for the Department and the University. The Department has earned international recognition in other ways, including a recent honorary Doctor of Sciences degree to a Department member, and the Euler gold medal award for mathematical research to a second member. The University should be truly proud of its mathematics department for its achievements.

The M.S. program in applied mathematics and statistics will be related, draw strength from, and provide strength to several units and programs at FAU. The relationship with existing programs in the Department of Mathematical Sciences is clear. We expect that 6 to 10 of our graduating bachelors will enroll into the program each year over the next 5 years. Moreover, since the majority of our graduate students will be taking the same mathematics courses during their first semester, we expect that a number of them will opt for the Applied M.S. option during their first year. This is already happening to a moderate degree as a number of students (at least 6) are pursuing a current M.S. programs that leads to a degree with specialization in one of the tracks under the proposed program.

The impact of the proposed program on our Ph.D. program in Mathematics will be beneficial for the following reasons: 1) There will be more students of better quality in the Department. Of these, a non-trivial ratio will elect to continue for the Ph.D. degree at FAU. 2) The proposed program is likely to attract increased research funding, making it easier to support graduate students for duties of close proximity to their areas of training. 3) The increased mathematical training, interaction and activity in the Department will increase the state and national visibility of the Department and its programs resulting in more applicants of higher quality.

The Continuous Modeling track will be under the leadership of Professors Tomas Schonbek, and Yuan Wang, and include our excellent young members as Professors Yuandan Lin, W. Kalies and Mingzhou Ding. This track involves work in the general area of differential equations & applications, control theory, and chaotic processes, and interfaces nicely with Electrical Engineering, the Center for Molecular Biology & Biotechnology, and the Biomedical Sciences.

Our Biostatistics track under the leadership of Professors Heinrich Niederhausen, Lianfen Qian and Jose Andres Correa will leverage several strengths present at Florida Atlantic, relying on strong links with the Center for Molecular Biology & Biotechnology and the Biomedical Sciences Program.

The Cryptology track will be under the leadership of Professors Ron Mullin and Spyros Magliveras, both of international reputation. The group includes excellent members as Professors Frederick Hoffman, Fred Richman, Lee Klingler, Markus Schmidmeier and Stephanie Fitchett. In view of world's ever increasing reliance on the internet and mobile communications, the Cryptology track, intimately related to communications and information security, will be nicely tied to the departments of Electrical Engineering, Computer Science & Engi-

neering, as well as the Center for Information Technology & Operations Management.

The Scientific Visualization track under the leadership of Professors Heinz-Otto Peitgen and Richard Voss is unique in the State for the expertise it provides, its considerable successes in research and external funding, and for its varied connections with numerous scientific disciplines, particularly the Biomedical Sciences, and the Center for Complex Systems and Brain Sciences.

All tracks will have close relations with the Department of Computer Science and Engineering. We expect to have strong interaction with members of the CSE Department, such as Prof. Mohammad Ilyas, Dan Zhou, and Jie Wu whose research and teaching areas are closely related to those of the proposed program.

Professors Ravi Shankar, Manhar Dhanak, Paul Hart, Yukweng Lin, Ram Narayanan, and Zvi Roth from the named departments/centers will serve on the advisory board monitoring the quality of the tracks. Courses in these departments may be allowed to substitute for approved electives in some occasions and we anticipate that their faculty will show a lively interest in our programs.

We incorporate below a brief description of each faculty member that will be involved in the program.

James W. Brewer, Ph.D. 1964 from Florida State University, has been at FAU since 1985. Recognized internationally as an expert on commutative ring theory, he has published over sixty papers in quality journals on subjects as diverse as flat ring extensions and algebraic feedback control systems. An outstanding teacher, he captivates large audiences of liberal arts mathematics students while giving them a glimpse of real mathematics and a real mathematician.

José A. Correa, Ph.D. 1995 from Carleton University, Ottawa, has been at FAU since 1999. While his early training is in classical mathematics, his doctorate is in statistics and he is well on the way of making a name for himself thanks to his work in biostatistics. He was awarded the 2000 Charles Schmidt College of Science research award and has a joint position with the Department of Biomedical Sciences. He and Professor Qian have been instrumental in creating a credible statistics program out of almost nothing.

Morris J. DeLeon, Ph.D. 1968 from Pennsylvania State University. He specializes in number theory. He has served as our Putnam Competition coach for several years and has coordinated on-campus mathematics competitions for high school students. He has received grants from the National Science Foundation to hold Student Science Training Programs for high-ability high school students.

Mingzhou Ding, Ph.D. 1990 from the University of Maryland, came to FAU in 1990 as a member of the Center for Complex Systems and Brain Sciences, with a joint appointment in the Department of Mathematical Sciences. He has done notable work in dynamical systems

and in brain sciences. He received the 1998 Researcher of the Year award from FAU. He holds or has held several grants from the National Institute of Mental Health and the Office of Naval Research.

Timothy Ford, Ph.D. 1980 from the University of Colorado, joined FAU in 1981. He is a renowned expert on the Brauer group. Other areas of interest include Azumaya algebras and commutative algebra. His work has been partially funded by the National Science Foundation.

Frederick Hoffman, Ph.D. 1963 from the University of Virginia has been at FAU since 1968. His area of expertise includes finite groups, combinatorics and their applications as well as artificial intelligence. Since his arrival, he has been the main organizer of the yearly Southeastern combinatorics, graph theory and computing conference. More recently he has organized several conferences in artificial intelligence and mathematics.

William Kalies, Ph.D. 1994 from Cornell, is at FAU since 1998. He has already done important work in dynamical systems and computational mathematics. His work is partially funded by the National Science Foundation.

Lee Klingler, Ph.D. 1984 from the University of Wisconsin, Madison, is at FAU since 1984. Has done extensive work in finite group representation theory, ring theory and commutative algebra. Other interests include cryptology and mathematics education. His work has been funded by the National Science Foundation. He spent the academic year 1989-90 at the Institute for Experimental Mathematics at the University of Essen, Germany, funded by an Alexander von Humboldt fellowship.

Yuandan Lin, Ph.D. 1992 from Rutgers University, has been at FAU since 1992. He specializes in control theory and is also one of our local experts in computer software. His work has been partially funded by the National Science Foundation.

Stephen C. Locke, Ph.D. 1982 from the University of Waterloo, Canada is at FAU since 1982. He is a well known expert in graph theory, and a superb problem solver. Professor Locke is also interested in algorithms (numerical, semi-numerical, and non-numerical) and algorithmic complexity. He is also well versed in combinatorial designs, projective geometry, and association schemes. He has a joint appointment with the Department of Biomedical Sciences.

Spyros Magliveras, Ph.D. 1970 from the University of Birmingham, England is at FAU since 2000. Having done initially important work in group theory, he is now an internationally acclaimed researcher in combinatorics and cryptology. He has received numerous honors and awards including, in 2002, the ICA Euler medal for his lifetime research contributions. Before coming to FAU, he held the *Henson Chair for Information and Communication Theory* at the University of Nebraska, Lincoln where he also served as Director of the *Center for Communications and Information Science.* His work has been funded by numerous granting agencies, including the National Science Foundation. He holds a patent for a private key

cryptosystem.

Aaron Meyerowitz, Ph.D. 1986 from Colorado State University, joined FAU in 1986. His area of expertise includes tilings, extremal set theory, and combinatorics.

Mario Milman, Ph.D. 1977 from Australian National University is at FAU since 1986. He is a world renowned researcher in interpolation theory and harmonic analysis and has also done very important work in other areas of functional analysis and also in the area of partial differential equations.

Ronald Mullin, Ph.D. 1964, University of Waterloo, has been at FAU since 1996. He is a most distinguished researcher in the area of combinatorics and of cryptology whose work has been funded and supported by many agencies, both American and Canadian. He has been the recipient of many honors and awards including an Honorary Doctorate of Science from the University of Rostock, Germany, in 2001. He holds at least five patents for innovations in cryptology and finite field multipliers.

Heinrich Niederhausen, Dr. Techn. Sci. from Graz University of Technology, Austria, came to FAU in 1984 after being a post-doc at MIT, Stanford, and Toronto University. He works in non-parametric statistics and enumerative combinatorics, and is a well known expert on umbral calculus. His specialty includes lattice paths problems and exact distributions of random walks.

Heinz Otto Peitgen, Dr. rer. nat. from the University of Bremen, Germany, 1973 joined FAU in 1991. He is internationally well known for his ground-breaking work on fractals and chaos. He is at FAU only during half of the year; the other half he spends at Bremen where he directs the Center for Complex Systems and Visualization (CeVis). His work has been funded by numerous granting agencies. He is also an award winning author of textbooks on fractals and their use in the classroom.

Lianfen Qian, Ph.D. 1996 from Michigan State University is at FAU since 1996. Her research interests are in nonlinear regression modelings and environmental statistics. She is a recipient of 1997 NExT Fellow of MAA, 1998 Florida Initiation Award and 2000 Charles Schimdt College of Sciences Award. She has been indefatigable in her efforts to establish our statistics program on a solid basis, an activity in which she collaborated with Professor Correa, and has set up numerous and important links with ecologists and water management personnel.

Fred Richman, Ph.D. 1963 from the University of Chicago, joined FAU in 1990. His extensive mathematical knowledge, extending over several fields, makes him somewhat of a Renaissance mathematician. He is best known for his work in constructive mathematics, an area in which he is one of the leading researchers, and in infinite abelian group theory. He has also worked as a cryptographer.

Markus Schmidmeier, Ph.D. 1996 from Ludwig Maximilians University, Munich, Germany, joined FAU in 2001. In his research on abelian categories, he has obtained a dichotomy result for modules over artinian PI-rings: It is exactly the endofinite modules for which the methods from the representation theory of finite dimensional algebras can be applied; a result for which he has won in 1998 the Bolzano prize awarded by the Charles University (Prague, Czech Republic). In recent research, he has studied categories of subgroups of abelian groups (in joint work with Dr. Ringel, UBielefeld, Germany), and, with his research assistant, Rita Agrelo, he has implemented the cryptographic system NTRU on the internet; his manuscript about NTRU has just been accepted for publication.

Tomas P. Schonbek, Ph.D. 1970 from the Massachusetts Institute of Technology came to FAU in 1970. He specializes in partial differential equations, interpolation theory and operator theory.

Yuan Wang, Ph.D. 1990 from Rutgers University, came to FAU in 1990. Her graduate studies were partially supported by an Alfred P. Sloan doctoral fellowship. A leading researcher in the area of control theory, her work is supported by National Science Foundation grants since 1990.

Paul Yiu, Ph.D. 1985 from the University of British Columbia, Canada, has been at FAU since 1990. His research is on algebraic topology, with special interests on the geometry, topology and combinatorics of sums of squares and nonsingular bilinear maps of euclidean spaces, their relations with non-associative algebras, and their applications. In recent years, he has also developed an intense interest on triangle geometry, and publishes an electronic journal Forum Geometricorum <http://forumgeom.fau.edu> devoted to classical euclidean geometry. He is also interested in number theory and the history of mathematics, and has served as our Putnam Competition coach for many years. His work on the Hurwitz problem of composition of quadratic forms has been funded by the National Science Foundation.

Xiao-Dong Zhang, Ph.D. 1991 from the California Institute of Technology, joined FAU in 1991. His area of expertise is functional analysis, particularly invariant subspaces.

6.2 [B.] Previous program reviews

If there have been program reviews, accreditation visits, or internal reviews in the discipline pertinent to the proposed program, or related disciplines, provide all the recommendations and summarize the institution's progress in implementing the recommendations.

The mathematics program at Florida Atlantic University was reviewed in 1984 (in relation to a proposed Ph.D. program) and in 1991, and 1998 (as part of statewide reviews of programs in mathematics). Previous reviews contained some strong words about the status of statistics at FAU, including the following remarks:

1. Statistics as a discipline has been neglected at FAU.

2. The proliferation of statistics offerings is very unfortunate.

3. There is a real need for a statistical laboratory for statistical consulting.

The 1991 review did find some improvements to the situation, but felt that considerably more progress was needed. It recommended the creation of a Statistics Department. However, the 1998 review sees a significant improvement of the statistics situation. The author of that review, under "Recommendations," expresses his full support of the professed goals of the Department of Mathematics, among which the following one is relevant: Develop a strong program in applied mathematics and statistics.

6.3 [C.] Delivery system

Describe briefly the anticipated delivery system for the proposed program as it may relate to resources e.g., traditional delivery on main campus; traditional delivery at branches or centers; or non traditional instruction such as instructional technology (distance learning), self-paced instruction, and external degrees. Include an analysis of the feasibility of providing all or a portion of the proposed program through distance learning technologies. Include an assessment of the institution's own technological capabilities as well as the potential for delivery of the proposed program through collaboration with other universities. Cite specific queries made of institutions with respect to the feasibility of utilizing distance l earning technologies for this degree program.

The Department of Mathematical Sciences has incorporated technology into instruction at least since 1979, with a computer laboratory built originally around a few Apple computers. The department strives to be on the technological cutting edge on the one hand, but trying to make sure, on the other hand, that this is done in ways that (in the words of the author of the 1998 program review) "enhance but do not overshadow the core content of the subject matter." The traditional classroom lecture method will continue to be used for most of the basic courses; however, even in these courses the computer will play a major role and the resources of the internet will be extensively used, to improve communications between students and instructors, and as an important study aid. Florida Atlantic University is adequately prepared to serve most of these purposes and is conscientiously improving its technological capabilities where improvement may be needed.

Initially, traditional delivery of the curriculum is envisaged; however, as resources become available, we also expect several courses to be offered in some *distance learning* mode, almost a necessity with a student population with a significant number of working students. Once more the internet will play a major role in making these courses academically sound and keeping students and instructors in touch. At this time we anticipate that most of our tracks will be based on the Boca Raton campus; however, extension to other campuses may be possible as additional resources become available and the university fully interconnects its campuses for distance learning.

6.4 Assessment of Current and Anticipated Faculty

6.4.1 Information on existing faculty

Use Table Two to list the following information for each existing faculty member who is expected to participate in the proposed program by the fifth year: Faculty code (i.e. one of the five unofficial budget classifications as explained on the table), name, academic discipline, rank, tenure status, and highest degree earned. If the proposal is for a graduate degree, append to the table the number of master's theses directed, number of doctoral dissertations directed and the number and type of professional publications for each faculty member.

Please see Table Two.

6.4.2 Additional faculty needed

Also use the Table Two to indicate whether additional faculty will be needed to initiate the program, their faculty code, their areas of specialization, their proposed ranks, and when they would be hired. Provide in narrative the rationale for this plan; if there is no need for additional faculty explain.

The Department of Mathematical Sciences has recently hired a senior mathematician, Prof. Spyros Magliveras, who has had considerable experience in starting and leading research and teaching programs in a leading US Institution. Professor Magliveras will serve as the Program Director. We have also hired a second extremely talented person, Dr. Markus Schmidmeier, to collaborate with Prof. Magliveras in developing the Cryptology track. A renowned cryptologist and combinatorist, Prof. Ronald C. Mullin is also a member of the Department of Mathematical Sciences lending considerable strength. Many other department members are quite able to provide strength during the developing stages of the program. It is hoped however that when the program begins to grow, there will be a commensurate recognition and support from FAU, which will nurture this growth to fruition. The Department has senior faculty of extremely high quality with very strong credentials. However, of these senior members, few consider themselves as being primarily applied mathematicians. Most of the people whose teaching and research interests lie totally in applied areas are junior members of the faculty. Hiring some additional faculty at an appropriate rank would be of importance to the program when the program matures and the number of students increases. Such lines will arise when needed from replacements of retiring faculty.

6.4.3 Faculty workload estimates

Use Table Two to estimate each existing and additional faculty members workload (in percent person years) that would be devoted to the proposed program by the fifth year of implementation assuming that the program is approved. (Note: this total will carry over to Table Three's fifth year summary of faculty positions.)

Please see Table Two

TABLE TWO

FACULTY PARTICIPATION IN PROPOSED DEGREE PROGRAM BY FIFTH YEAR

Faculty Code	Faculty Name or "New Hire"	Academic Discipline/ Specialty	Master's Theses Directed	Doctoral Dissert/s Directed	Proffess. Public/s
A	Jose Correa	Statistics			4
A	Mingzhou Ding	Dynamical Systems			19
A	Frederick Hoffman	Combinatorics	17	1	33
A	William Kalies	Numerical Math.			9
A	Yuandan Lin	Control Theory			18
A	Stephen Locke	Graph Theory	3	2	27
A	Spyros Magliveras	Cryptology	22	7	65
A	Lee Klingler	Algebra	4		35
A	Aaron Meyerowitz	Combinatorics	2		18
A	Mario Milman	Harmonic Analysis	1		77
A	Ronald Mullin	Cryptology	11	20	177
A	Heinrich Niederhausen	Combinatorics	1	1	37
A	Heinz−Otto Peitgen	Math. Image Proc.			80
A	Lianfen Qian	Statistics	2		14
A	Fred Richman	Algebra	2	7	100
A	Markus Schmidmeier	Cryptology			6
A	Tomas Schonbek	Partial Diff. Equat.	2	1	25
A	Richard Voss	Math. Image Proc.			60
A	Yuan Wang	Control Theory	1		56
B	New hire	Cryptology			
B	New hire	Numerical Math.			

Faculty Code	Corresponding Faculty Position Category	Proposed Source of Funding
A	Current General Revenue	Existing Faculty − Regular Line
B	Current General Revenue	New Faculty − To be hired on an existing line
C	New General Revenue	New Faculty − To be hired on a New Line
D	Contracts & Grants	Existing Faculty − Funded on Contr. & Grants
E	Contracts & Grants	New Faculty − Funded on Contracts & Grants

TABLE TWO

PARTICIPATION IN PROPOSED DEGREE PROGRAM BY FIFTH YEAR

Faculty Code	Faculty Name or "New Hire"	Academic Discipline/ Specialty	Rank	For Existing Faculty		Initial Date for Participation in Prop. Program	5th Year Workload in Prop. Program (% person yrs)
				Contract Status	Highest Degree Earned		
A	Jose Correa	Statistics	Asst.Prof	In−Unit	Ph.D.	January 2003	25%
A	Mingzhou Ding	Dynamical Systems	Professor	In−Unit	Ph.D.	August 2002	15%
A	Frederick Hoffman	Combinatorics	Professor	In−Unit	Ph.D.	August 2003	15%
A	William Kalies	Numerical Mathematics	Asst.Prof	In−Unit	Ph.D.	August 2002	25%
A	Yuandan Lin	Control Theory	Assoc.Prof	In−Unit	Ph.D.	August 2002	15%
A	Stephen Locke	Graph Theory	Professor	In−Unit	Ph.D.	August 2003	15%
A	Spyros Magliveras	Cryptology	Professor	In−Unit	Ph.D.	August 2002	30%
A	Lee Klingler	Algebra	Professor	In−Unit	Ph.D.	August 2002	15%
A	Aaron Meyerowitz	Combinatorics	Professor	In−Unit	Ph.D.	August 2002	15%
A	Ronald Mullin	Cryptology	Professor	In−Unit	Ph.D.	August 2002	15%
A	Mario Milman	Harmonic Analysis	Professor	In−Unit	Ph.D.	August 2002	15%
A	Heinrich Niederhausen	Combinatorics	Professor	In−Unit	Ph.D.	August 2003	15%
A	Heinz−Otto Peitgen	Mathematical Image Pro	Professor	In−Unit	Ph.D.	August 2003	15%
A	Lianfen Qian	Statistics	Asst.Prof	In−Unit	Ph.D.	January 2003	25%
A	Fred Richman	Algebra	Professor	In−Unit	Ph.D.	August 2002	15%
A	Markus Schmidtmeier	Cryptology	Asst.Prof	In−Unit	Ph.D.	August 2002	25%
A	Tomas Schonbek	Partial Differential Equat	Professor	In−Unit	Ph.D.	January 2003	15%
A	Richard Voss	Mathematical Image Pro	Professor	In−Unit	Ph.D.	August 2003	15%
A	Yuan Wang	Control Theory	Professor	In−Unit	Ph.D.	January 2002	25%
B	New hire	Cryptology	Asst.Prof	In−Unit	Ph.D.	August 2005	25%
B	New hire	Numerical Mathematics	Asst.Prof	In−Unit	Ph.D.	August 2005	25%

Faculty Code	Corresponding Faculty Position Category	Proposed Source of Funding	Total 5th Year Workload by Budget Classification
A	Current General Revenue	Existing Faculty − Regular Line	350%
B	Current General Revenue	New Faculty − To be hired on existing line	50%
C	New General Revenue	New Faculty − To be hired on a New Line	–
D	Contracts & Grants	Existing Faculty − Funded on Contr. & Grants	–
E	Contracts & Grants	New Faculty − Funded on Contracts & Grants	–

Overall Total for 5th Year	400%

6.5 [D.] Assessment of Current and Anticipated Resources

Current facilities and resources

In narrative form, assess current facilities and resources available for the proposed program in the following categories:

6.5.1 Library volumes

Library volumes (Provide the total number of volumes available in this discipline and related fields.

Currently, FAU libraries hold approximately 4000 volumes in areas of mathematics that are relevant to a program in applied mathematics and statistics. An approximate classification according to track is: Continuous modeling: 2250; Cryptology: 75; ; and Statistics/Biostatistics: 1400. The library also has current holdings in fields other than mathematics that are potentially relevant to this program, such as computer science, information technology, engineering, and biomedical sciences.

6.5.2 Serials

Serials (Provide the total number available in this discipline and related fields, and list those major journals which are available at your institution.)

FAU libraries have current print subscriptions to approximately 40 Mathematics journals that are relevant to applied mathematics. Major journal subscriptions include Society for Industrial and Applied Mathematics (SIAM) Journal on Applied Mathematics, SIAM Journal on Numerical Analysis, and SIAM Review. FAU libraries do not currently hold print subscriptions to any major journals in statistics.

Electronic access to approximately 60 additional applied mathematics and statistics journals is available through databases such as Ideal, JSTOR, and Elsevier. However, it should be noted that many of these are not current subscriptions but access to articles that are 5-10 years old. Some major current electronic subscriptions include the Electronic Journal of Combinatorics, Journal of Computational and Applied Mathematics, Journal of Differential Equations, Journal of Mathematical Analysis and Applications, and Statistics and Probability Letters.

6.5.3 Teaching, laboratory and office space

Describe classroom, teaching laboratory, research laboratory, office, and any other type of space necessary and currently available for the proposed program.

The Department has office space for at most twenty graduate students; this needs to be expended to accommodate the new graduate students who will be entering the new program. We expect getting sufficient space after the current renovation phase of Science Buildings at FAU is completed.

6.5.4 Equipment

The college operates a cluster of five DEC–alpha stations and is building a BEOWULF system that runs currently with 36 processors. A National Science Foundation/ Major Research Instrumentation grant proposal will be written to acquire a cluster of 128 processors. Although acquisition of this cluster would provide for more than adequate computational facilities, the MS program can still be implemented without such equipment, and with currently existing computational facilities in the Charles E. Schmidt College of Science.

6.5.5 Fellowships

Scholarships and graduate assistantships (List the number and amount allocated to the academic unit in question for the past year.)

For the budget year 1999/2000 the Department received 20 stipends to support graduate teaching assistants, and 22 for 2000/2001. In the current academic year the Department has 21 stipends at $14,920.

6.5.6 Internship sites

Recent internships were held at the following sites: IBM, Siemens, National Council on Compensation Insurance, Panasonic.

6.5.7 Additional facilities and resources needed

Describe additional facilities and resources required for the initiation of the proposed program (e.g. library volumes, serials, space, assistantships, specialized equipment, other expenses, OPS time etc.) If a new capital expenditure for instructional or research space is required, indicate where this item appears on the university's capital outlay priority list. The provision of new resources will need to be reflected in the budget table, and the source of funding indicated.

Additional Library resources

The proposed program in applied mathematics and statistics would require additional library resources primarily in the form of current journal subscriptions. Many of these would be a renewal of subscriptions that the library held in the past, such as Communications in Pure and Applied Mathematics, Journal of Cryptology, Designs, Codes & Cryptography, the Journal of Combinatorial Designs, the Journal of Combinatorial Theory - A, Communications in Partial Differential Equations, SIAM Journal on Mathematical Analysis, and others.

The need is particularly acute in the area of statistics where the library currently holds no major subscriptions, which would include, Annals of Statistics, Journal of the American Statistical Association, Journal of the Royal Statistics Society, Statistics in Medicine, and others.

Many of these deficiencies can best be overcome through more current electronic subscriptions to entire publisher databases, such as SIAM, Springer-Verlag Link, Wiley, and

others.

Additional Space

Additional space would be required in the form of a seminar room (20 students) and laboratory space (2000 NSF) especially for the cryptology track. At the present time, the Charles E. Schmidt College of Science is experiencing tremendous growth and several of its buildings are undergoing extensive renovation and expansion. As this "new" space becomes available, office, seminar and laboratory space will become available in the Science and Engineering building in which the Department of Mathematical Sciences is housed. Some of this space will be provided to the Department to support its graduate programs.

Additional Faculty

Two additional faculty, one for the Cryptology track and one for the Continuous modeling track will be recruited. These will be on existing lines filled upon the retirement of some current faculty.

Additional Assistantships

Currently the department has sufficient OPS monies to support 21 TA positions and additional OPS money to support visitors and student assistants. As the enrollment grows in this new MS program, we fully expect the enrollment in the current MS in Mathematics to decline. Some of the Teaching Assistantships currently supporting students in the present MS program will be redirected to students in this new program. As the number of students grows in this new program, some of the OPS for visitors and student assistants can also be redirected to students in the MS program in Applied Mathematics and Statistics. In addition, as undergraduate enrollment continues to grow, additional TA's will be needed to staff undergraduate courses whose stipends will be provided from enrollment growth monies. Finally, it is expected that a number of the students enrolled in the new MS program will be professional students who will not require support during their training or will be supported by their institutions.

7 VII. Assessment of Impact on Programs Currently Offered

7.1 Budget

Assuming no special appropriation of allocation for initiation of the program, how would resources within the institution be shifted to support the new program.

The Charles E. Schmidt College of Science has anticipated the establishment of a Masters program in Applied Mathematics and Statistics by hiring new and replacement faculty (see Section 6.4) who would be capable of developing and teaching in this program. In addition, courses taught by faculty offered in several of the tracks are already offered as core

or elective courses in other programs. Faculty currently engaged in the Masters program in Mathematical Sciences who would now be included in this new program would lessen their involvement in the current program. Thus the cost for implementing this new program is marginal at best. In addition, the increased enrollment in the lower division over the past decade and the projected increases in the future make it possible to substantially leverage the increased number of graduate students in this program with the need for additional teaching assistantships to support the undergraduate program.

Use Table Three to display dollar estimates of both current and new resources for the proposed program for the first and the fifth years of the program. In narrative form, identify the source of both current and any new resources to be devoted to the proposed program.

See Table Three.

The current or continuing costs for the MS in Applied Mathematics and Statistics will rise from year 01 to year 05 and represent a reallocation of departmental resources to this new program. These resources include faculty effort which will rise from 2.4 FTE in the first year to 4.0 in the fifth year of operation. By the fifth year, it is expected that two "new" faculty will be recruited to the Department of Mathematical Sciences to replace retiring faculty, and who would be assigned 25program. While these do not represent "new" dollars requested they are new dollars to be expended in this new program. We do not anticipate the clerical/secretarial support and budget management to increase significantly with the addition of the MS in Applied Mathematics and Statistics to the department; however some effort (0.1 FTE) will be reallocated to this new program in year 01 and continued until the need requires increased program assistant effort as the student head-count increases, but not through year 05. Current expenses incurred by the existing masters program in Mathematics will be reallocated to the new program as new students enter the MS in Applied Mathematics and Statistics rather than the current MS in Mathematics. Similarly, OPS dollars expended in teaching assistantships for students following the MS in Mathematics will be reallocated as new students who choose to follow the MS in Applied Mathematics and Statistics rather than Mathematics. Since many students in the current MS in Mathematics would otherwise follow the new program, were it available, there will unlikely be a loss of students due to reduced teaching assistantships.

The only new resources requested are for the library in order rectify some deficiencies in journal subscriptions which can be best achieved through subscriptions to several publisher electronic databases as described in Section 6.5.7.

By year 05 of the program the cost per FTE is expected to be $18,532.

TABLE THREE

7.2 Impact on related programs

Describe any other projected impacts on related programs, such as prerequisites, required courses in other departments, etc.

The Masters in Applied Mathematics and Statistics will provide a complimentary focus for part of the graduate program in the Department of Mathematical Sciences, and will provide the opportunity to "pull through" potentially excellent graduate students in to the Ph.D. program currently offered in the department. While it is expected that this new program will draw some students away from the current Masters program in Mathematical Sciences, the source of students for the Masters in Applied Mathematics and Statistics will be from "new blood." Some courses, both required and electives, offered in the current Masters program in Mathematics are included in the curriculum of this proposed program and thus will not diminish, but expand enrollment in these classes. Similarly, some elective courses offered in other departments will expand their enrollment.

8 VIII. Community College Articulation.

The proposed program is a graduate level program.

9 IX. Assessment of Applicable Accreditation Standards.

Not applicable.

10 X. Productivity.

Provide evidence that the academic unit(s) associated with this new degree have been productive in teaching, research and service. Such evidence may include trends over time for average course-load, FTE productivity, student head-counts in major or service courses, degrees granted, external funding attracted, as well as indicators of excellence.

The Department of Mathematical Sciences is central to the mission of the University and provides not only a great service in graduating mathematicians at the undergraduate and graduate level, but also in service to all undergraduates in the University through the General Education requirements. As such, the annualized FTE generated by the Department

of Mathematical Sciences remains the highest in the University at a total of 603 FTE for 2000-2001. This represents an increase of over 56.5 % over the last five years. While the majority of these FTE are at the undergraduate level, the Department of Mathematical Sciences generates a significant amount of graduate FTE at about 20 annualized FTE for the past several years; this represents approximately 12 % of the graduate FTE generated in the Charles E. Schmidt College of Science. Significantly during the last 5 years there has been a nearly 60 % increase in thesis and dissertation credits in the Department. This translates into increased numbers of students graduating with graduate degrees from the Department of Mathematical Sciences. Indeed, in 1996-97, only 5 students graduated with masters degrees, whereas in 2000-01, 12 students graduated with a masters degree in Mathematics. Unfortunately this has not been also the trend for the PhD program where only two students have graduated in the last 5 years. The reasons for this are complex and attest to the great demand for mathematically gifted individuals who are often hired away from degree programs, or do not enter advanced degree programs, by companies offering financial incentives hard to refuse. We hope that the new MS in Applied Mathematics and Statistics will help revitalize the PhD program and "pull-through" students into the department's Ph.D. program.

Finally, in research, the faculty in the Department of Mathematical Sciences are productive and each publish their work regularly in recognized journals (see individual faculty vitae in Appendix 3). During the last several years the department has maintained a sponsored research level of about $1 million per annum. While most of this external funding derives from a single grant or two to a few of its faculty, the department has seen an increase in the number of faculty receiving external awards of lesser amounts. We are confident that with this new program, a new focus can be added to the department which will help it continue to grow and diversify its research efforts in order to attract even greater levels of external funding.

11 APPENDIX I. U.S. House of Representatives Proposed Support

U.S. House Members Seek to Boost Spending for Information-Technology Research

By ANDREA L. FOSTER

The Chronicle of Higher Education Wednesday, December 5, 2001

Two bills that would pump about $7.88-billion over five years into information-technology research and into guarding the nation's computer infrastructure from terrorist attacks were introduced Tuesday in the U.S. House of Representatives.

One bill, the Cyber-Security Research and Development Act, would create new research programs at the National Science Foundation and the National Institute of Standards and Technology. These programs would be worth $880-million.

The other bill, the Networking and Information Technology Research Advancement Act, would provide $7-billion over five years to several government agencies to support long-term information-technology research.

The measures, which are being pushed by the House Science Committee, would boost many colleges' information-technology programs. The committee is expected to pore over the bills' details tomorrow.

Rep. Sherwood L. Boehlert, a New York Republican who is chairman of the science committee, said the terrorist attacks of September 11 have given new urgency to investing in research that could prevent cyberterrorism. He introduced the computer-security bill.

"In an era when virtually all the tools of our daily lives are connected to and reliant upon computer networks, a cyberattack could knock out electricity, drinking water and sewage systems, financial institutions, assembly lines, and communications," he said. "We must improve our ability to respond to these threats."

Under Representative Boehlert's bill, the National Science Foundation would offer the following five-year, competitive peer-reviewed grants:

$233-million to researchers for pursuing innovative computer and network security research.

$144-million for multi-year grants to colleges to set up multidisciplinary network-security research centers. The centers could be established in collaboration with businesses or government laboratories.

$95-million to colleges to improve undergraduate and master's-degree programs related to computer security.

$6-million in grants to community colleges to enhance programs for training computer- and network-security technicians.

$90-million to establish a competitive grant program that would allow colleges to offer fellowships to students pursuing doctoral degrees in computer and network security.

The bill also encourages the National Institute for Standards and Technology to establish cybersecurity research objectives and to solicit and award grants related to them.

Over five years, the institute would spend $275-million for a grant program to support cutting-edge research by scholars who are working with industry, and $32-million for an institute-run research program in computer and network security.

The second bill, introduced by Rep. Nick Smith, a Michigan Republican, would increase spending on information-technology research by 46 percent over five years, from 2003 to 2007. The agencies receiving the money would be the Department of Energy's science office, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Institute of Standards and Technology, the National Oceanic and Atmospheric Administration, and the National Science Foundation.

Rep. F. James Sensenbrenner Jr., the former chairman of the House Science Committee, introduced a similar bill last year, but it died in the Senate.

Mr. Boehlert vowed that this year would be different. He said that Mr. Smith's legislation is more comprehensive, and provides more money to government agencies. And he said that the committee is committed to working with the Senate on the bill.

A House aide said the bills are likely to be merged by the time they reach the House floor for a vote.

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