GRADUATE CERTIFICATE IN APPLIED MATHEMATICS

New Interdisciplinary Certificate Program Application

A Statement of need

The objectives of the proposed interdisciplinary certificate program focus on providing the graduate students of Kansas State University with both fundamental applied mathematics training as well as experience in applying this training to relevant problems in science and engineering disciplines. Applied mathematics research lies at the heart of an increasing number of research programs both inside academia and outside; the U.S. Departments of Energy and Defense as well as the National Science Foundation, for example, all have specific programs to sponsor applied mathematics and interdisciplinary research. Thus, the analytical and computational skills provided by the proposed program form a firm foundation for the careers of graduate students in mathematics, statistics, engineering and the sciences by preparing these students to participate in cutting-edge multidisciplinary research projects.

Despite the significance of the subject area, Kansas State University currently has no applied mathematics component within its graduate program. This stands in stark contrast to all seven of the benchmarking institutions identified as part of the K-State 2025 planning process (see the Benchmarking presentation link under Phase 2 at `http://www.k-state.edu/2025/resources/`). As summarized below, each of these seven universities has an applied mathematics component within its respective graduate program.

- Auburn University offers a **Masters of Applied Mathematics** (`http://www.auburn.edu/academic/cosam/departments/math/grad/`).
- Clemson University offers a **PhD degree in Mathematics with concentration in Applied and Computational Analysis** (`http://www.clemson.edu/ces/math/graduate/degree.html`).
- Oklahoma State University offers a **PhD degree in Applied Mathematics** (`http://www.math.okstate.edu/phd_applied_math`).
- Oregon State University, offers a **PhD degree in Mathematics with emphasis in Applied Mathematics** (`http://www.math.oregonstate.edu/grad_programs`). The largest research group in the Mathematics Department at OSU is the Applied Mathematics group (`http://www.math.oregonstate.edu/research_groups`).
- Colorado State University offers a **Masters in Computational and Applied Mathematics** (`http://www.math.colostate.edu/programs/graduate/`).

- Iowa State University offers both a **Masters degree and a PhD degree in Applied Mathematics** (`http://www.math.iastate.edu/Graduate/Programs.html`).
- North Carolina State University offers a **PhD degree in Applied Mathematics** along with a **specialized track in Interdisciplinary Mathematics** (`http://www.math.ncsu.edu/grad/brochure/grad_study.php`). Additionally, their PhD students can acquire early research experience by participating in the **Industrial Applied Mathematics Program** (`http://www.ncsu.edu/crsc/iamp.html`).

The introduction of a Graduate Certificate in Applied Mathematics therefore marks an important first step in the development of a competitive applied mathematics program at Kansas State University.

B Educational objectives

The proposed Certificate in Applied Mathematics is intended to meet the needs described in Section A through the pursuit of three principal objectives:

1. To introduce students from mathematics, science, and engineering to a common foundational set of tools from modern mathematical analysis, and
2. To prepare the students to use these tools for the analysis and solution of mathematical model equations arising in interdisciplinary research.

C Certificate courses

The required coursework for the Certificate in Applied Mathematics will consist of a minimum of 12 credit hours, including 6 credit hours in two required core mathematics courses and at least 6 additional credit hours in elective courses from various disciplines. The core courses and elective courses in each discipline are listed below.

C.1 Core courses (6 credit hours)

MATH 715 Applied Mathematics I — 3 credits — Fall.
MATH 716 Applied Mathematics II — 3 credits — Spring.

C.2 Elective courses (minimum of 6 credit hours)

Mathematics

MATH 615 Introduction to Digital Image Processing — 3 credits — Spring.
MATH 635 Dynamics, Chaos, and Fractals — 3 credits — Fall.
MATH 789 Combinatorial Analysis — 3 credits — Spring (alternate years).

Industrial and Manufacturing Systems Engineering

IMSE 881 Linear Programming — 3 credits — Fall (odd years).

IMSE 882 Network Flows and Graph Theory — 3 credits — Spring (odd years).

IMSE 884 Integer Programming and Combinatorial Optimization — 3 credits — Spring (even years).

IMSE 982 Nonlinear Programming — 3 credits — Summer (even years).

Electrical and Computer Engineering

ECE 840 Computer Engineering Methods for Analysis, Simulation, and Design — 3 credits — Spring and online (every year).

ECE 861 Noise Theory — 3 credits — Fall and online (every year).

ECE 963 Signal Detection Theory — 3 credits — Spring (odd years).

ECE 965 Information Theory — 3 credits — Fall (even years).

Statistics

STAT 704 Analysis of Variance — 2 credits — Fall, Spring, Summer.

STAT 705 Regression and Correlation Analysis — 2 credits — Fall, Spring, Summer

STAT 710 Sample Survey Methods — 2 credits — Fall (even years)

STAT 713 Applied Linear Statistical Models — 4 credits - Fall

STAT 716 Nonparametric Statistics — 2 credits — Fall (odd years).

STAT 717 Categorical Data Analysis — 3 credits — Spring.

STAT 720 Design of Experiments — 3 credits — Spring, Summer.

STAT 722 Experimental Design for Product Development and Quality Improvement — 3 credits — Fall.

STAT 730 Multivariate Statistical Methods — 3 credits — Spring.

STAT 736 Bioassay — 2 credits — Spring (odd years).

STAT 745 Statistical Graphics — 3 credits — Spring (even years).

Civil Engineering

CE 803 Numerical and Analytic Techniques for Engineers — 3 credits — Fall.

D How the courses meet the stated objectives

The core and elective courses support Objectives 1 and 2 stated in Section B. In these courses, the students will learn to use techniques from applied and computational mathematics to solve a number of relevant problems arising in various disciplines. These courses, which were chosen based on their incorporation of advanced mathematical theory and techniques, offer the students an opportunity to directly explore the practical use of applied mathematics within different disciplines.

E Certificate program administration

The certificate program will be administered within the Department of Mathematics and through the offices of the Center for the Integration of Undergraduate, Graduate and Postdoctoral Research (I-Center). A program coordinator will have primary responsibility for administering the program with the support of a Certificate Supervisory Committee chaired by him/her. The I-Center Director will be part of the Supervisory Committee. Since the Certificate will be housed by the Mathematics Department, the Certificate program coordinator will respond to the Head of the Mathematics Department.

To gain admission to the certificate program, the student must be approved for admission by the Certificate Supervisory Committee and by the Graduate School. Students should apply directly to the coordinator of the graduate certificate program, who will forward the Certificate Supervisory Committee's recommendation for admission to the Graduate School. Admission requires evidence of completion of a bachelor's degree from an accredited university with minimum GPA as established by the Graduate School; or concurrent enrollment in a graduate degree program at Kansas State University or an accredited University. In instances where the graduate certificate program is not linked with a graduate degree program at Kansas State University, the student must meet the entrance requirements for graduate study, including English language proficiency requirements as specified in Chapter 1 of the Graduate School Handbook and relevant documentation must be forwarded to the Graduate School before the student can be admitted.

F Estimated budget

With the exception of the two core courses, all courses included within the proposed certificate's program of study are taught routinely within their respective departments. In addition to serving as the core of the proposed certificate, the courses MATH 715 and MATH 716 are a part of an ongoing effort within the mathematics department to offer a much-needed applied mathematics curriculum to its students. These courses would be offered even if the proposed certificate were not approved. Moreover, the certificate committee and program coordinator will serve voluntarily, as part of their professorial duties at Kansas State University. Thus, the proposed certificate program will utilize only existing resources and will not incur additional costs for any department involved.

G Associated and contributing faculty

Supervisory Committee: Nathan Albin (Chair), Todd Easton, Diego Maldonado, Virginia Naibo (I-Center Director), Balasubramaniam Natarajan, and Haiyan Wang.

Nathan Albin PhD, Assistant Professor, Department of Mathematics, KSU.

Todd Easton PhD, Associate Professor, Department of Industrial and Manufacturing Systems Engineering, KSU.

Diego Maldonado PhD, Associate Professor, Department of Mathematics, KSU.

Virginia Naibo PhD, Associate Professor and I-Center Director, Department of Mathematics, KSU.

Balasubramaniam Natarajan PhD, Associate Professor, Department of Electrical and Computer Engineering, KSU.

Haiyan Wang PhD, Associate Professor, Department of Statistics, KSU.

H Program coordinator

Nathan Albin, PhD, Assistant Professor
Department of Mathematics, 138 Cardwell Hall, Kansas State University.
`albin@math.ksu.edu` 785-532-0582

Professor Albin's outstanding expertise in the field of Applied Mathematics makes him the ideal choice for this role.

I Student Learning Outcomes and Program Assessment Plan

Successful application of mathematics to a real-world problem typically requires two fundamental aptitudes: the ability to analyze mathematical equations that model the problem, and the ability to develop mathematically correct computer programs to solve the model equations.

The three KSU graduate Student Learning Outcomes are: Knowledge, Skills and Attitude and personal conduct. The SLOs of the Graduate Certificate in Applied Mathematics are:

1. To demonstrate the ability to produce correct computer algorithms for solving difficult mathematical equations, and
2. To demonstrate the ability to apply advanced analytical techniques to relevant mathematical models.
3. To demonstrate the ability to apply mathematical model equations arising in interdisciplinary research.

The following table shows the correlation between these two sets of SLOs.

Grad Certificate SLOs	Knowledge	Skill	Attitude and personal conduct
Demonstrate the ability to produce correct computer algorithms for solving difficult mathematical equations	X	X	
Demonstrate the ability to apply advanced analytical techniques to relevant mathematical models	X	X	X
Demonstrate the ability to to apply mathematical model equations arising in interdisciplinary research	X	X	X

The following table shows the measure/target and tools in the assessment for each SLO.

Grad Certificate SLOs	Indirect Measure and Target	Direct Measure and Target	Who will be assessed?
Demonstrate the ability to produce correct computer algorithms for solving difficult mathematical equations		Math 715 Final exam, see rubric in Appendix A1	All students in the program
Demonstrate the ability to apply advanced analytical techniques to relevant mathematical models		Math 716 Final exam see rubric in Appendix A2	All students in the program
Demonstrate the ability to to apply mathematical model equations arising in interdisciplinary research	GPA of 3.5 or higher in elective courses		All students in the program

The program coordinator will work together with the instructors of the core courses to ensure consistency of measurement among years. The data associated with the indirect and direct measures will be collected at the end of each semester. The certificate committee will meet once per year to discuss the results of the student assessments and to assess the effectiveness of the program as a whole. In each year, regarding SLOs 1 and 2, the Committee will consider the average score in each category mentioned in the rubric tables shown in appendices A1 and A2. The target is an average of 3 or greater in each category. If in a given year the average score in any category falls below 3, the Committee will determine the necessary program changes. A similar procedure will be implemented for assessing SLO 3, now based on the indirect measure of a GPA of 3.5 or higher in the elective courses.

To aid in the program assessment, each student will be asked to participate in an exit survey upon completion of the program. The survey, which will also include a self-evaluation part, will be designed by the committee and will be used, together with the results of the student learning outcome measurements, to identify potential improvements to the certificate program, including modifications of the core course contents and inclusion of additional elective courses. This will allow the program to naturally evolve and improve as we are assessing and reviewing not only the students but the overall program.

The following table shows where students enrolled in the program will gain exposure to the program's SLOs and where they will be assessed on these SLOs. "X" indicates Exposure or Attainment and "A" indicates assessment.

Grad Certificate SLOs	Core Courses	Elective Courses
Demonstrate the ability to produce correct computer algorithms for solving difficult mathematical equations	X, A	X,A
Demonstrate the ability to apply advanced analytical techniques to relevant mathematical models	X, A	X,A
Demonstrate the ability to to apply mathematical model equations arising in interdisciplinary research	X, A	X,A
University Graduate SLOs		
Knowledge	X	X, A
Skills	X	X, A
Attitudes and Professional Conducts	X	

J Endorsements

Peter Dorhout, Dean, College of Arts & Sciences, KSU.

John English, Dean & LeRoy C. and Aileen H. Paslay Chair, College of Engineering, KSU.

Alok Bhandari, Head, Department of Civil Engineering, KSU.

Don Gruenbacher, Head, Department of Electrical and Computer Engineering, KSU.

Bradley Kramer, Head, Department of Industrial and Manufacturing Systems Engineering, KSU.

James Neill, Head, Department of Statistics, KSU.

Louis Pigno, Head, Department of Mathematics, KSU.

Appendix A1: Rubric for SLO #1

SLO #1: Students will demonstrate the ability to produce correct computer algorithms for solving difficult mathematical equations.

Rubric:

	No Attempt 0	Incorrect 1	Partially Correct 2	Generally Correct 3	Completely Correct 4
Identification of an appropriate solution strategy					
Selection of an appropriate numerical algorithm					
Correct implementation of the numerical algorithm					
Correct interpretation of the numerical results					

Appendix A2: Rubric for SLO #2

SLO #2: Students will demonstrate the ability to apply advanced analytical techniques to relevant mathematical models.

Rubric:

	No Attempt 0	Incorrect 1	Partially Correct 2	Generally Correct 3	Completely Correct 4
Interpretation of the variables, parameters, and/or other specific information given in the model					
Selection of appropriate analytical tools					
Correct application of analytical tools					
Correct interpretation of the results of analysis					

KANSAS STATE UNIVERSITY | College of Arts and Sciences

March 29, 2012

Dr. Diego Maldonado
Department of Mathematics
Cardwell Hall
CAMPUS

Dear Dr. Maldonado:

The College of Arts & Sciences is supportive of the proposed Graduate Certificate in Applied Mathematics developed by you and your colleagues in Mathematics, Statistics, Industrial & Manufacturing Systems Engineering, and Electrical & Computer Engineering.

The proposed certificate will be of interest to graduate students in Mathematics, Statistics, and Engineering, and likely to some in computational biology or chemistry as well. Its broad-based nature will serve those students well in preparing them to work in interdisciplinary teams in a variety of settings in the future.

Best regards,

Peter K. Dorhout, Dean

117 Eisenhower Hall, Manhattan, KS 66506-1005 | (785) 532-6900 | Fax: (785) 532-7004

KANSAS STATE UNIVERSITY | Department of Mathematics

February 3, 2012

Nathan Albin, Professor
Diego Maldonado, Professor
Virginia Naibo, Professor
Department of Mathematics
Kansas State University
138 Cardwell Hall
CAMPUS

Dear Nathan, Diego and Virginia:

The Department of Mathematics is enthusiastically supportive of the proposed Graduate Certificate in Applied Mathematics. This support was first expressed in Fall 2011 when the Certificate initiative was announced and then through a faculty meeting last February 2nd as faculty overwhelmingly supported the Certificate by vote.

I approve of the courses (Math 715) Applied Math I and (Math 716) Applied Math II as core Mathematics courses. I also approve the following elective courses: (Math 615) Introduction to Digital Image Processing, (Math 635) Dynamics, Chaos, and Fractals, and (Math 789) Combinatorial Analysis.

I have appointed Nathan Albin as Chair of the Graduate Certificate Supervisory Committee due to his remarkable expertise in Applied Mathematics. In this connection, I also appreciate Maldonado and Naibo's leadership and mentoring efforts.

I approve that the Certificate be administered within the Department of Mathematics, under my direct oversight, and through the offices of the I-Center.

Always,

Louis Pigno
Professor & Department Head

138 Cardwell Hall, Manhattan, KS 66506-2602 | (785) 532-6750 | Fax: (785) 532-0546 | E-mail: math@math.ksu.edu

K·STATE
Kansas State University
College of Engineering
Office of the Dean
1046 Rathbone Hall
Manhattan, KS 66506-5201
785-532-5590
Fax: 785-532-7810
E-mail: deanengr@ksu.edu
http://www.engg.ksu.edu

March 6, 2012

Diego Maldonado
Associate Professor
Director of Graduate Studies
Department of Mathematics
Cardwell Hall
CAMPUS

Dear Dr. Maldonado,

During our meeting Thursday, February 23, I had the chance to discuss with you the details for proposal on the Certificate in Applied Mathematics.

I find this interdisciplinary Certificate to be a welcome and valuable addition to our graduate program and I enthusiastically support it.

Sincerely,

John R. English, Ph.D., P.E.
Dean and the LeRoy C. and Aileen H. Paslay Chair in Engineering

cc: Byron Jones
Gary Clark
Brad Kramer
Todd Easton

Department of Civil Engineering
2118 Fiedler Hall
Manhattan, KS 66506 - 5000
785-532-5862
Fax: 785-532-7717

October 10, 2011

Dr. Virginia Naibo
Associate Professor
Department of Mathematics
CAMPUS

Dear Dr. Naibo,

The Department of Civil Engineering is supportive of the proposed Graduate Certificate in Applied Mathematics. I approve our graduate course CE 803 - Numerical and Analytical Techniques for Engineers - being listed as an elective for the certificate program.

Please feel free to contact me if more information is needed from our department.

Best regards,

Alok Bhandari
Professor and Head

Kansas State University
Department of Electrical
and Computer Engineering
261 Rathbone Hall
Manhattan, KS 66506 -5204
785-532-5600

January 23, 2012

Carol Shanklin, Dean
Graduate School
103 Fairchild Hall

Dean Shanklin,

The Department of Electrical and Computer Engineering fully endorses the new graduate certificate in applied mathematics being proposed by the Department of Mathematics. Courses in ECE that we approve for use as elective courses for this certificate are ECE 840, ECE 861, ECE 963, and ECE 965. If there are additional graduate courses in ECE that would also be valuable, we would also be happy to consider those for use as electives for this certificate program.

Sincerely,

Don Gruenbacher

George and Alice Fiedler Chair
Associate Professor and Head

---------- Original Message ----------
Subject: Re: Graduate Certificate in Applied Mathematics
From: "Bradley Kramer" <bradleyk@k-state.edu>
Date: Thu, October 13, 2011 18:05
To: "Virginia Naibo" <vnaibo@math.ksu.edu>
Cc: bradleyk@ksu.edu
teaston@ksu.edu

Do you need this on letterhead or will email work?

The IMSE faculty are pleased to support the Graduate Certificate in Applied Mathematics. We have the capacity in our classes to welcome graduate students who choose to pursue this certificate. Furthermore, I recognize and support Dr. Easton's involvement in the Certificate's supervising committee as a commitment of our department.

Regards,

Brad

Bradley A. Kramer, Ph.D.
Professor and Head, Ind.& Mfg. Systems Engineering
Ike and Letty Evans Engineering Chair
Director, Advanced Manufacturing Institute

2038 Durland Hall
Manhattan, KS 66506

Email: BradleyK@k-state.edu
Voice: (785) 532-5606
Fax: (785) 532-3738

On 10/12/2011 10:09 AM, Virginia Naibo wrote:
>
> Dear Professor Kramer,
>
> After conversations with Professor Easton, we would like to include the
> following courses as elective courses for a Graduate Certificate in
> Applied Mathematics:
>
> IMSE 881, IMSE 882, IMSE 884, IMSE 982
>
> Please see below for more information about the certificate. If your
> department agrees, then we will need an endorsement letter/email from you.
> This letter or email, stating essentially that your department supports
> the creation of the Graduate Certificate in Applied Mathematics and that
> approve the above mentioned courses being elective courses for the
> certificate, will accompany the application for the graduate certificate
> program.
>
> Please let me know if you would like to meet with me to talk in more
> detail about the certificate.
>
> Many thanks for your time and I hope to hear from you soon.
>
> Best Regards,
>

> Virginia Naibo
> Associate Professor
> Mathematics Department
>
> ---
>
> GRADUATE CERTIFICATE IN APPLIED MATHEMATICS
>
> The Mathematics Department is in the process of creating a Graduate
> Certificate in Applied Mathematics, which is intended to start running in
> Fall 2012. The target audience is engineering and mathematics graduate
> students.
>
> In order to get a Graduate Certificate in Applied Mathematics, a graduate
> student will need to take 12 hours of graduate credit. Six of those will
> be obtained through the certificate's core courses (Math 715 and Math 716,
> the attached files contain a description of the contents of these
> courses). The remaining hours can be obtained through the certificate's
> elective courses. The list of elective courses, most of them of 3 credits,
> will include courses from mathematics, statistics and some engineering
> departments. We intend to include a distance learning component in the
> future and expand the program as needed.
>
> A committee for the certificate has been formed: Nathan Albin (Chair,
> Math), Todd Easton (IMSE), Diego Maldonado (Math), Virginia Naibo (Math),
> Bala Natarajan (EECE).

From: "James Neill" <jwneill@k-state.edu>
Subject: Re: Graduate Certificate
Date: Fri, November 4, 2011 9:27 am
To: dmaldona@math.ksu.edu

Dear Diego,

Attached is a letter indicating agreement to participate in the proposed Graduate Certificate in Applied Mathematics. I have listed possible applied Statistics courses to serve as electives. As I note in the letter, these courses are available as on-campus offerings. As I mentioned previously, the ability to offer such courses on-line through DCE would depend on additional staffing resources.

Please let me know of any questions and thanks again for the opportunity to participate.

Best,
Jim

James W. Neill
Professor and Head
Department of Statistics
Kansas State University
Manhattan, KS 66506
785.532.0516
jwneill@ksu.edu

----- Original Message -----
From: dmaldona@math.ksu.edu
To: "James Neill" <jwneill@k-state.edu>
Cc: dmaldona@math.ksu.edu
Sent: Monday, October 31, 2011 8:53:18 AM
Subject: Graduate Certificate

Dear Jim,
This is a follow up to our nice conversation last week. In order to add the Statistics Department as a participant of the upcoming Graduate Certificate in Applied Mathematics, I would need a letter from you agreeing to be part of this initiative and indicating a list of Statistics graduate courses that can serve as elective courses for the Certificate. Thank you very much for all your and your faculty support. I'm looking forward to many more collaborative endeavors between Math and Stats.
Cheers,
Diego

--
Diego Maldonado
Associate Professor
Director of Graduate Studies
Department of Mathematics
Kansas State University
http://www.math.ksu.edu/~dmaldona/

K·STATE
Kansas State University

Department of Statistics
and Statistical Laboratory
101 Dickens Hall
Manhattan, KS 66506-0802
785-532-6883
Fax: 785-532-7736
E-mail: statdept@ksu.edu
http://www.ksu.edu/stats

November 4, 2011

Dr. Diego Maldonado
Director of Graduate Studies
Department of Mathematics
Cardwell Hall
Kansas State University
CAMPUS

Dear Diego:

Thank you for inviting the department to participate in the proposed Graduate Certificate in Applied Mathematics. The department would be pleased to be a part of this interdisciplinary endeavor. The following list of applied Statistics courses may serve as elective courses for the Certificate: 704, 705, 713 (note that a student may not receive credit for both the 704/705 sequence and 713), 710, 716, 717, 720, 722, 730, 736, 745. These courses are regularly available on-campus according to the schedule on the department website.

Please let me know of any questions regarding this list of possible electives. I look forward to further collaborations between our departments.

Best Regards,

Jim

James W. Neill
Professor and Head