Rowan University
Department of Mathematics
Course Proposal

Operations Research II
Math 03.512

I. Details

a) Course Title: Operations Research II

b) Sponsor: Dr. Chris Lacke, Department of Mathematics

c) Credit Hours: 3 credit hours

d) Course Level: Graduate

e) Curricular Effect: Bank B elective for the Master of Arts in Mathematics,
elective for the Master of Science in Engineering and
Computer Science.

f) Prerequisites: An undergraduate course in probability
and

1) Math 03.511 Operations Research I,
or
2) an undergraduate course in linear algebra
and
an undergraduate course in multivariate calculus
or
3) permission of the instructor.

g) Suggested Time, Implementation: This course will be offered once every other spring.

h) Resources: Faculty, equipment and library resources are adequate.

II. Rationale

The development of mathematical applications in business, government and the military during the 20th century has been phenomenal. It is no longer sufficient to find a solution to a problem, but rather to develop a methodology to provide the optimal solution to a problem. In its early days, operations research was used by the British military to find the best way to move all of its forces and equipment across the English Channel. Modern applications include portfolio theory, environmental and communication systems development, hospital staffing, and production planning. Operations researchers use their strong mathematical background to find a best solution to a problem, given a specific set of limitations, or constraints. A vast mathematical background is required, as operations researchers are required to build mathematical models that can involve virtually any type of mathematical function. Moreover, operations researchers need to be able to convert everyday phenomena to mathematical expressions. The extensive growth of the Institute for Operations Research and the Management Sciences (INFORMS) during the 1980's and 1990's has been, in large part, to the demand for qualified students in this field.

While there are a number of graduate programs in Operations Research, many Masters degree programs in Mathematics now include a pair of courses in Operations Research. At Rowan University, many of our graduate students are teachers at the secondary level. Many of the concepts and tools in Operations Research are needed at some level on the High School Proficiency Assessment (HSPA), so the class provides skills that the students can bring back to their classrooms. Moreover, the addition of Operations Research courses will increase industrial interest in our program, as those in industry will be able to use the knowledge gained in these courses on a day in, day out basis.

This is the second member of a two-course sequence designed to provide a strong introduction in Operations Research, regardless of the student's industrial or academic future pursuits. An undergraduate version of this course, 1703.4XX, Stochastic Models in Operations Research, will be offered concurrently. As is often necessary in the work place, graduate students will be expected to cover additional relevant topics outside of the class lecture. Furthermore, graduate students will be expected to produce a project that displays strong comprehension of a portion of the course's subject matter. Further details of the extra expectations placed on the graduate students are described in the following sections.

III. Essence of the Course

a) Objectives in Relation to Student Outcomes

Students in this course will become familiar with the process of Operations Research: learning how to create and validate a mathematical model, as well as the processes and optimization/sub-optimization. They will be able to create and solve Markovian and general queuing models. They will also learn how to use decision analysis to make optimal decisions in the face of uncertainty. They will learn how to determine optimal inventory policies under the assumption of variable demand. Lastly, they will learn how to model and solve a variety of problems by using computer simulation. They will complete this process for a variety of model types; however, all of the types of modeling covered in this course will be stochastic, that is, including uncertainty. Reliance on the tools in the Calculus, Linear Algebra and Probability will be substantial, but we will also examine the reasons why these tools provide us with an optimal solution in each scenario. In addition, we will examine how multiple modeling procedures can be used to arrive at the same result, as well as the benefits and pitfalls of the different techniques. Furthermore, students will learn a procedure called sensitivity analysis, which is used to determine what types of changes are necessary for our optimal solution to become sub-optimal. Use of some of the leading software in the field, which is included in the text, will be required.

b) Topical Outline (Additional graduate topics denoted by *)

1. Markov Chains

Stochastic Processes
Discrete Time Markov Chains

Chapman-Kolmogorov Equations
Transition Matrices
Steady-State Behavior
Passage Times
Absorbing and Transient States
Continuous Time Markov Chains (Markov Processes)

2. Queuing Theory

Exponential Distribution
Birth-Death Processes
Single Server Queues
Finite, Multiple Server Queues
Infinite Server Queues*
Little's Law
Finite and Infinite Capacity Queues
Non-Exponential Service Disciplines*
Throughput Analysis*

3. Decision Analysis

Decision Trees
Utility Theory*
Expected Utility Maximization*

4. Stochastic Inventory Theory

Continuous Review Models
Periodic Review Models
Models Involving Perishables

5. Stochastic Dynamic Programming and Markov Decision Processes

6. Reliability Theory

Parallel Systems
Series Systems
Mixed Systems

7. Simulation*

Random Number Generation
Transformation of Uniform Random Variates to another Probability Distribution
Spreadsheet Tools

Stopping Criteria
Statistical Analysis of Output

c) Evaluation and Grading

Students will be evaluated by traditional methods of homework, which will include analytic and computer-based problems, and written exams. Students will also be required to devise and complete a substantial project. Possible projects can come from applied problems in the student's major, an application from the individual's place of employment, applications in relevant journals, theoretical derivations of solutions, research on a topic not covered in the course, or in the form of annotated bibliographies. A presentation on the project will be required.

d) Course Evaluation

The course will be evaluated through customary student evaluations as well as regular departmental review.

IV) Consultation

The content and nature of this course was discussed with:

1. Dr. T. R. Chandrupatla , Department of Mechanical Engineering
2. Dr. Ralph Dusseau, Department of Civil and Environmental Engineering
3. Dr. Jennifer S. Kay, Department of Computer Science
4. Dr. Jooh Lee, Department of Management and M.I.S.

V) *This proposal has been reviewed by the Department of Mathematics Curriculum Committee.*

VI) Catalogue Description

1703.412 Operations Research II

(Prerequisites: An undergraduate course in probability and either 1703.5xx Operations Research I, an undergraduate course in linear algebra and an undergraduate course in multivariate calculus, or permission of the instructor.)

This course is an introduction to mathematical modeling, analysis, and solution procedures applicable to decision-making problems in an uncertain (stochastic) environment. Methodologies covered include dynamic programming, simulation, Markov chains, queuing theory, decision analysis, dynamic programming, system reliability and inventory theory. Solutions will be obtained using theoretical methods and software packages.