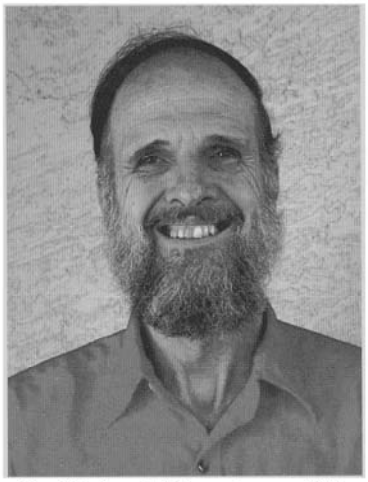
A Genuine Interdisciplinary Partnership: MAA Unveils *Mathematics for Business Decisions*

By Donald J. Albers

If your contribution to a problem can be replaced by one more line of computer code, then management will do that and buy a computer instead of hiring you. At the same time, it is unwise to ask a computer to display a number if you have absolutely no idea what it will be. Students at today's business schools often face these very problems. They find the mathematics education they receive is either insufficient or difficult to apply to the situations they face in professional settings. At the January Joint Mathematics Meetings 2003 in Baltimore, Maryland, the Mathematical Association of America will present an innovative, interdisciplinary course in mathematics for business students that not only solves these difficulties for students, but opens the door to new approaches in teaching mathematics. (See accompanying ad on page 17 for the details of this interactive presentation.) *Mathematics for Business Decisions* is a sparkling example of how interdisciplinary experiences for students can be shaped through the active collaboration of academic departments.



Dr. Richard Thompson of the mathematics department at the University of Arizona.

Dr. Chris Lamoureux of the business school at the University of Arizona.

In 1998, a group of deans and university administrators at The University of Arizona (UA) challenged Dr. Chris Lamoureux of the business school and Dr. Richard Thompson of the mathematics department to create a completely new two-course sequence of mathematics for all business and public administration majors. These new courses were to replace the traditional program of finite mathematics and brief calculus. With funding support from the National Science Foundation's Division of Undergraduate Education, Lamoureux and Thompson set themselves to the task. They first taught their creation in 1998-99. Says Thompson, "We learned that, if properly motivated and given suitable instructional material, business students can appreciate the value of mathematics in making sound business decisions." *Mathematics for Business Decisions* represents an entirely new publishing venture for the MAA, as the books for the courses are entirely electronic. The course itself is distinguished by the use of current technology and student teams rather than individual assignments. Students are allowed to embrace mathematics in a setting that more closely mirrors the professional environments they will encounter after college. Consequently their enthusiasm and retention increase.

Mathematics for Business Decisions has two parts. Part 1, *Probability and Simulation*, lays the groundwork for student understanding, while Part 2, *Calculus and Optimization*, works to finely tune student capability. The entire program consists of four substantial projects, each leading to a crucial business decision. These decisions are open ended, involving business insight as well as mathematical computation and understanding. In the capstone project, Bidding on an Oil Lease, students use computer simulation to discover a Nash equilibrium bidding strategy that is a research level result in auction theory, unknown until 2001. All mathematical and computer skills, including the use of PowerPoint, Excel, and Word, are introduced as tools for the solution of business problems and used in student presentations. Student understanding is enhanced with streaming video, computer simulations, and animations of mathematical topics.

Projects

Part 1, Probability and Simulation Loan Work Outs. Students use records from over 8,000 prior attempted work outs, along with specific characteristics of an individual borrower, to determine whether or not to enter into a work out plan. Tools: probability, Bayes' Theorem, and data searching.

Stock Option Pricing. Random variables and bootstrapping are used by students to establish a fair value for a European call option on a given stock. Tools: downloaded stock data, computer simulation, compound interest, and random sampling.

Part 2, Calculus and Optimization
Marketing Computer Drives. Students generate demand functions by fitting trend lines to test market data. Marginal analysis is used to optimize profit, and the consumer surplus is explored. Tools: trend lines, differentiation, and integration.

Bidding on an Oil Lease. Normal distributions are used with Monte Carlo simulation to find ways of defeating the winner's curse in auction bidding. Students discover a Nash equilibrium strategy for adjusting their bids. Tools: variance, expected value, normal distributions and computer simulation.

"The new *Mathematics for Business Deci-*

sions curriculum has impacted the entire business school community," says Professor Chris Lamoureux, Head of the UA Finance Department and co-author of the new courses. "Students are more engaged because they feel that the curriculum is designed specifically for them as business students. This is also manifest through a real sense of accomplishment upon completing the curriculum. Recruiters sense that a business problem-centered curriculum prepares students better for employment. Recruiters are impressed by the realism of the business projects that the students work on in a math class as freshmen and sophomores. Faculty have a sense of continuity, finding it easier to hold students responsible for what they learned in earlier classes. Faculty also appreciate the fact that students mature as business students faster because of the business focus in the required math curriculum."

Mathematics for Business Decisions has now been taught at UA for five years. Six other institutions, including major research universities, smaller universities, and community colleges, have used the material as well. It has been taught by over 50 different instructors, including graduate teaching assistants, adjunct faculty, and research mathematicians. More than 1200 students are currently enrolled in the courses. Says UA Mathematics Professor William McCallum, "I think the *Mathematics for Business Decisions* courses are a remarkable example of collaboration between a mathematics department and a department whose students it teaches, and should serve as a model for the way mathematics departments handle their service teaching."

The success of the *Mathematics for Business Decisions* courses is obvious. Grades are higher and student retention rates are higher than those of the traditional courses in finite mathematics and brief calculus. Homework, which is completed using a word processor, even for equations, is of high quality and the level of the students' reports is outstanding. Student attitudes toward the use of mathematics have improved greatly. They recognize that what they are doing in *Mathematics for Business Decisions* will help them directly in the rest of their business program and in their later careers. The University's Instructional Assessment and Evaluation Services asked students in one section of *Mathematics for Business Decisions* if they saw what they were learning as of use to them in the real world. *100% agreed*! "Classes in the traditional sequence of finite mathematics and brief calculus were a chore for both students and instructors. Teaching the new material to the same students is now fun," explains Thompson, who has given course demonstrations to the Arizona State Board of Regents at the invitation of Dr. Peter Likins, President of UA.

Suppose that all individual parameters of a borrower indicate a loan work out attempt, when considered separately. Is it possible for them to predict against a work out attempt, taken collectively? Hint: Bayes' Theorem is a great tool for squeezing information out of a data set. Students of *Mathematics for Business Decisions* discover this quickly.

How many of us can clearly define a 20 week European call option on Walt Disney stock, with a strike price of $23? Students in *Part 1* of *Mathematics for Business Decisions* discuss this in their reports.

The Black Scholes method of determining a fair value for a stock option requires stochastic differential equations. Do you know how to bypass this, use historical stock data to estimate volatility, and bootstrap your way to a fair option value? Freshmen in *Part* 1 of *Mathematics for Business Decisions* do this.

Do your students think that demand functions are something that one finds in books (or maybe on the walls of caves)? Students in *Part 2* of *Mathematics for Business Decisions* get demand functions by fitting polynomial trend lines to data points found in test markets. How can they do something so sophisticated as this type of regression? Excel does it for them, thereby freeing them to consider the important business question of what type of trend line to use.

Do you know what happens if everyone bids his or her estimate of the value of an item in a first price sealed bid auction? Why is the result named the "winner's curse?" Students in *Part 2* of *Mathematics for Business Decisions* discover this for themselves during classroom auctions.

How can one defeat the "winner's curse?" What is it about the auction mechanism that makes it unlikely that colluding companies will stick together? These are important questions for bidders on oil leases, communications bands, or treasure bills. Students are expected to discuss these problems in their project reports.

Do you know how to find a Nash equilibrium strategy for bidding in a first price sealed bid auction? Despite a large scholarly literature in auction theory, nobody knew how to do this until 2001. In fact, the existence of such a strategy was discovered using only simulation with the tools of *Mathematics for Business Decisions*. Students in *Part 2* cover this topic in their project reports.

Can equally correct and valid mathematical computations lead to opposite conclusions in a business question? Of course they can. Students in *Mathematics for Business Decisions* encounter this in all of their projects. There is often no "correct" solution. Teams of students must back up their decisions with business considerations and an understanding of the human assumptions on which the mathematical computations are based.

Students express enthusiasm for *Mathematics for Business Decisions* too:

"I really enjoyed your class. I felt like I learned so much. It is such a different feeling coming out of *Mathematics for Business Decisions* than when I finished other math classes. I am really glad that I got the chance to take *Mathematics for Business Decisions*." *A student in Part 2*

"Finally a math class has been created that has useful applications towards the future." *A student in Part 1*

"I can't believe how much I have learned in this class. I work at A G Edwards & Sons and some of the brokers are amazed at

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this class and its usefulness. Others also say how great an idea it is to create this class and how lucky I am to be in it because it will benefit me in real life." (Note: This student was an undergraduate intern with the brokerage.) *A student in Part 1*

"I am working at my internship at Sony Studios. You have no idea how much that project [Marketing Computer Drives] helped me for what I am doing now for my job." *A student in Part 2*

Thompson and Lamoureux are pleased by the responses of students to the new courses and they emphasize that *Mathematics for Business Decisions* contains solid mathematics and revolves around important nontrivial problems. Adds Dr. George Davis, Provost of UA, "I am particularly delighted...by the way in which subsequent generations of students are now afforded a concrete and very immediate example of the symbiotic relationship between research and teaching."

Donald J. Albers is the Associate Executive Director for Publications and Electronic Services at the MAA.