# AC 2009-2203: A SPECIALIZATION IN FINANCIAL SYSTEMS IN SYSTEMS SCIENCE AND INDUSTRIAL ENGINEERING DEPARTMENT

**Nagen Nagarur, State University of New York, Binghamton**

Dr. Nagen Nagarur is an Associate Professor in the department of Systems Science and Industrial Engineering at Binghamton University. Dr. Nagarur has a B.Tech. in Chemical Engineering from the Regional Engineering College, Warangal, India. He has an M.S. degree in Industrial Engineering from Wichita University, Kansas, and he obtained his Ph. D. degree in Industrial Engineering and Operations Research at Virginia Polytechnic Institute and State University. Dr. Nagarur has been with the Binghamton University since 2001, and prior to that, he was at the Asian Institute of Technology, Thailand. Dr. Nagarur had been a visiting professor at Kansas State University, University of Technology at Eindhoven, the Netherlands, Thammasat University, Bangkok, and Bangkok University.

Dr. Nagarur's areas of research interest are operations management of supply chains, option pricing and risk assessment of financial systems, and clustering techniques for cell formations. His teaching interests include supply chains, stochastic processes, and financial engineering.

**Krishnaswami Srihari, State University of New York, Binghamton**

Distinguished Professor Srihari is currently the Chairman of the Department of Systems Science and Industrial Engineering at the State University of New York at Binghamton, New York. He is also the Director of the Watson Institute for Systems Excellence at Binghamton. Dr. Srihari completed his Bachelors in Engineering (with Honors) in Production Engineering from the College of Engineering, University of Madras in 1983. Later, he obtained his MS (1985) and PhD (1988) in Industrial Engineering and Operations Research from the Virginia Polytechnic Institute and State University (VPI&SU) at Blacksburg, Virginia.

Dr. Srihari's research team includes over 50 graduate students, both at the Masters and the Doctoral level, working on externally sponsored research. His group receives about 1.8 million dollars in external funding every year. Dr. Srihari has published over 325 technical papers in leading peer-reviewed journals and at conferences, and authored over 950 technical reports. He has directed and graduated over 175 graduate students, both at the MS and the PhD level.

**Sarah Lam, State University of New York, Binghamton**

Sarah S. Lam is an Associate Professor in the Systems Science and Industrial Engineering Department at the State University of New York at Binghamton. She is an Assistant Director of the Watson Institute for Systems Excellence at Binghamton. She received a B.A. (HONS) degree in quantitative analysis for business from the City University of Hong Kong, an M.S. degree in operations research from the University of Delaware, and a Ph.D. degree in industrial engineering from the University of Pittsburgh. Her current research involves adaptive optimization, data mining, stochastic simulation, and neural networks. She is a member of IIE and IEEE.

# A Specialization in Financial Systems in Systems Science and Industrial Engineering Department


## Abstract

The role of the service sector, as a segment of economy, is increasing. This is in contrast to more traditional domains, such as manufacturing systems. Globalization is also acting as a catalyst in this transition.

Financial systems are increasingly becoming more important. Consequently, there is a significant need for our graduates to be educated for careers in the financial sector. Industrial analysis indicates that this is a three trillion dollar industry, with a significant rate of increase. Our graduates in *Industrial and Systems Engineering (ISE)* can excel in the financial sector by applying engineering, optimization, decision making, and statistical methods to this growing domain.

This paper addresses the design and development of a curriculum that would provide for a specialization in Financial Systems that will be housed within the Systems Science and Industrial Engineering Department at Binghamton University. In addition to courses that would be "core" for the ISE graduate program, courses that would help establish the specialization would be delineated and discussed along with electives that would help enhance the breadth and depth of a graduate student's educational experience. The proposed curriculum could require the graduate student to take courses in the School of Management, Department of Economics, and the Mathematics and Statistics Departments. The proposed specialization would be an inter-disciplinary program with a home in the Systems Science and Industrial Engineering Department.

Graduates from this program will be equipped with skill sets that would differentiate them from those who graduate from the traditional ISE program. These graduates would be employed, for example, by the investment and banking industries, and the finance departments of typical manufacturing and service companies. A proper skill set is necessary to tackle any challenges and crises such as the current situation.


## Introduction

This paper describes the proposed specialization at the graduate level in Financial Systems at the Systems Science and Industrial Engineering (SSIE) Department at the State University of New York (SUNY) at Binghamton (also known as Binghamton University).

The role of financial systems in any enterprise is increasing these days because of current market conditions, opportunities and threats offered by financial systems, and liquidity crunches. The need for designing proper financial instruments and conducting an in depth analysis of risks associated with such instruments is of paramount importance for the growth of a company, and often times, even for its very existence. Keeping this in view, the SSIE department of

Binghamton University (BU) is in the process of proposing a graduate specialization in financial systems.

Binghamton University is a state run university located in the Upstate New York. It is relatively young and small compared to the other three main SUNY universities of Stony Brook, Albany, and Buffalo. However, it has shown a remarkable growth and reputation, and is currently in the top three universities for its value. The SSIE department at BU is housed in the Thomas J. Watson School of Engineering and Applied Sciences. It started functioning as a separate department in 1994, offering Masters and Doctoral programs. Prior to this date, the Systems Science program was housed in a separate department while Industrial Engineering was housed with Mechanical Engineering. Today, the Systems Science and Industrial Engineering department has two graduate programs, namely (i) Systems Science and (ii) Industrial and Systems Engineering. The graduate programs have expertise in systems theory, fuzzy systems, data mining, electronic packaging, health systems, simulation, and supply chains.

Currently, the department has over 180 graduate students, of whom more than 75 are pursuing their PhD (the rest are working towards an MS). The department has been rather aggressive in securing external funding. Given a faculty size of 15, our department has secured a million dollars in external funding each year since 1999. Currently, our department's external research funding exceeds 2 million dollars per annum. Most of the graduate students are funded and many are imbedded into companies at distant locations. They pursue their courses via EngiNet, a very efficient distance education program. The department also started an undergraduate program in Industrial and Systems Engineering, with the first class graduating in 2001. The department believes in continuous improvement, and is consistently striving to offer better and more relevant courses. The proposed Financial Systems specialization is one such endeavor.

Finance courses have been taught in traditional business management programs. These courses typically deal with finance and investment in a company. The emphasis of our proposed curriculum is on financial aspects. Whenever an investment or other type of company needed somebody with a heavy emphasis mathematical application of financial data, they would recruit students with expertise in mathematics or physics. However, there have been major changes in recent times.

- These changes have been brought about by relaxation of market regulations and introduction of new financial instruments. The types of instruments available in the financial markets have grown exponentially over the past years. There are numerous derivatives available, with various forms of options, futures, forwards, swaps, and derivatives.
- Hedge funds are now a major player in the investment scene. The U.S. government has facilitated other types of investment and risk opportunities. Real estate mortgages securities are allowed to be dealt with by financial firms. With these types of opportunities, there is a great demand for graduating students who are not only experts in quantitative techniques, but also are fairly conversant with financial systems.

## Financial Systems/Financial Engineering Definition

With new financial instruments, there is more flexibility for companies to combine or bundle different types of risks, and handle it themselves or offer them to other financial institutions. The analysis of risks, pay offs, and pricing them goes beyond analysis of a single instrument. Such bundles or products are to be treated as new products, and handling of them involves processes of any new product, namely design of a product, its risks and pricing. Educational programs in financial systems with all such related activities as a group are sometimes called Financial Engineering.

The International Association for Financial Engineering (AIFE)[1] defines and describes Financial Engineering as, "the application of mathematical methods to the solution of problems in finance. It is also known as financial mathematics, mathematical finance, and computational finance. Financial engineering draws on tools from applied mathematics, computer science, statistics, and economic theory." In academic and business circles this field is also known as quantitative finance and people in this field are sometimes referred to as "quants".

An analysis of employment prospects and demand for graduates with "Financial Systems/Financial Engineering" in their academic portfolio indicates that there is significant dearth of resources with this knowledge base. According to the Wall Street Journal[2], most of the candidates from the top schools offering similar programs are getting absorbed in a wide range of financial organizations right after completion of their degrees. Typical examples of organizations that employ these graduates are investment banks, commercial banks, hedge funds, insurance companies, corporate treasuries, and regulatory agencies. The various opportunities available are shown in Figure 1.

## Academic Programs

Due to the increasing demand for graduates with such backgrounds, universities and institutions felt the need for developing such expertise through academic programs. According to the Wall Street Journal[2], the companies "have come to realize they really need students with strong skills in financial economics, math and computer modeling for more complex products like mortgage and asset-backed securities and credit and equity derivatives." These students would have the basic education and training while in school and would be productive right from the day they take up their jobs.

Many universities have started offering similar programs. Some of the pioneers in this area are highly ranked schools such as Cornell, Princeton, Carnegie Mellon, and UC Berkeley. Universities like Rutgers in NJ, which has a very good mathematics department, have started offering courses in Financial Engineering. In the state of New York, these programs are being offered by Columbia, NYU, Baruch College, and SUNY Stony Brook. Binghamton University would be one of the first to initiate a program in upstate New York.

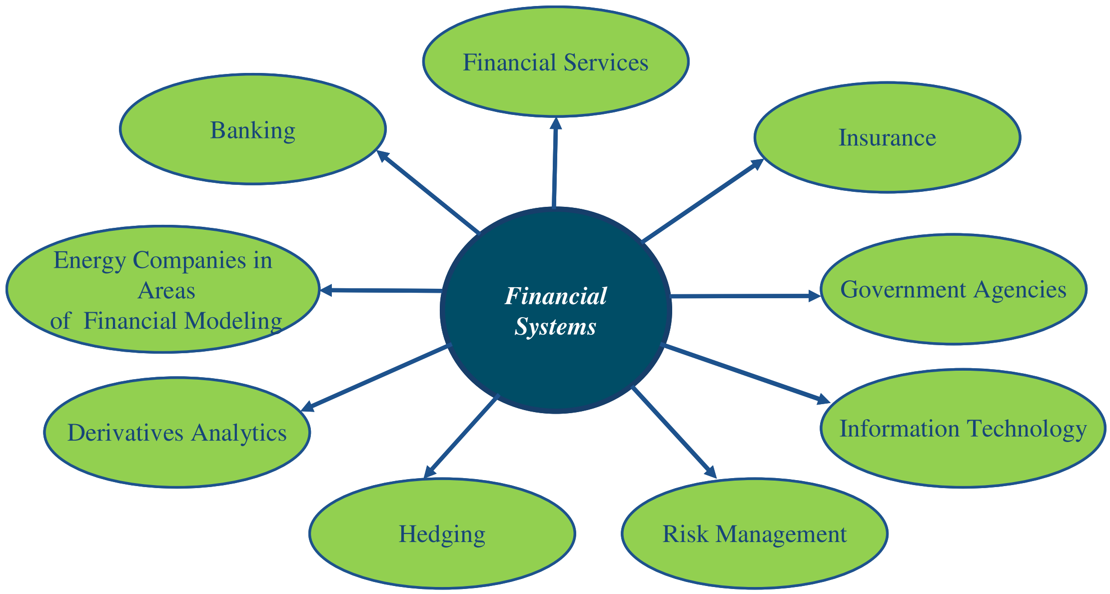


Figure 1: Career Options for Financial Systems Students[3]

**Study of Similar Programs**

A list of graduate programs in financial systems was collected and the programs were analyzed. A partial list with brief descriptions is given in Table 1. All the programs are inter-departmental, with a heavy emphasis on quantitative methods and financial theory. Most of the programs are housed in engineering, management, or mathematics departments. Some of the course descriptions are provided in Tables 2 and 3.

The quantitative group of courses includes mathematical methods, statistics, probability and stochastic processes, optimization, risk analysis, utility theory, decision making, decision making with fuzzy sets, soft computing, numerical methods, and Monte Carlo simulation.

In the financial theory group, there are domain specific courses like introduction to finance theory, investments, financial markets, economic theory, portfolio theory, and financial accounting. In some programs, there are computer-based courses such as computational tools, coding, and data mining.

**Systems Science and Industrial Engineering Department**

The department has 15 faculty members, and also takes advantage of local subject experts as adjunct professors. Binghamton area has a high number of industry experts as it is the birth place of IBM and also home to large high tech companies like Lockheed Martin, BAE, and Universal Instruments. The department from the beginning has been known for its expertise in electronic manufacturing and is one of the foremost institutes in the world for systems science and fuzzy information theory. Currently the department offers graduate programs in Industrial and Systems

Engineering, and Systems Science. The Industrial and Systems Engineering program has specializations in health systems, supply chains, and simulation.

The department offers courses in statistics, probability theory, stochastic processes, optimization, simulation, fuzzy sets, soft computing, and knowledge discovery. The faculty members teaching these courses are actively pursuing research in their areas of teaching, some of which include financial engineering.

A typical course of study would include core courses that addressed Statistical Methods, Quality Control, and Simulation. A student would then take a course titled "An Introduction to Financial Systems" along with a set of three courses from among a longer list of courses within operations research, decision making, advanced topics in simulation, statistical modeling, operations management, economics, finance, capital markets, risk management, database management, and data mining. These courses would be drawn from departments across campus. Students could obtain their Masters Degree in Industrial and Systems Engineering via a thesis route or a project oriented route. Those who use the project option for their completion requirement would need to take two more electives resulting in a total of 33 semester hours when compared to those who choose the thesis option which requires a total of 30 semester hours.

**Curriculum**

The proposed curriculum for the graduate program in ISE with a specialization in financial systems is given in the Table 4.

**Pedagogical Aspects**

All the courses will be in the form of class room teaching. There is a facility for students to take the courses via the "EngiNet," a distance education system at the school. EngiNet has already proved to be a valuable system, enabling numerous students working on projects in distant locations, and full time employees to register for the courses and earn credits. It is also envisaged to have experts come and teach relevant courses as adjunct professors. Appropriate case studies will be introduced to provide real life experience. As the new program gains momentum, it is anticipated that the program would be able to place some of the students in financial companies as interns.

**Projections**

It is planned to have the first incoming class in the fall of 2011. The estimate is 15 students in the first class. It is projected to have 50 students in the program by 2016. Judging from the robust growth of such programs elsewhere, it is believed that these projections will be met.

Table 1: Financial Systems Programs in Select Institutions[4, 5, 6, 7, 8]

| | |
|---|---|
| MIT[4] | • Focus: quantitative analysis of financial markets<br>• Three main research areas:<br>• Capital Markets<br>• Risk Management<br>• Financial Technology |
| University of Michigan[5] | • Masters degree program started in 1997<br>• Interdisciplinary course<br>• Financial Theory<br>• Mathematics<br>• Computer Technology |
| Princeton University[6] | • Operations research and financial engineering department (ORFE)<br>• Interdisciplinary association<br>• Statistics and Operations Research<br>• Applied and Computational Mathematics<br>• Bendheim Center for Finance |
| University of Illinois at Urbana-Champaign[7] | • Masters of science in finance<br>• Department of finance<br>• Established in 1958 |
| University of California at Berkeley[8] | • Masters in financial engineering program from UC Berkley School of Business<br>• Distinguished faculty from:<br>• The Haas School of Business at UC Berkley<br>• The Anderson Graduate School of Management at UCLA<br>• UC Irvine's School of Management |

Table 2: Comparison of Financial Engineering Courses[4, 5, 6, 7, 8]

| University Courses | MIT[4] | University of Michigan[5] | Princeton University[6] | University of Illinois at Urbana-Champaign[7] | University of California at Berkeley[8] |
|---|---|---|---|---|---|
| **Financial Engineering** | • Nonlinear time series<br>• Financial visualization | • Designing, structuring and pricing financial engineering products (including options, futures, swaps and other derivative securities)<br>• Applications to financial and investment risk management<br>• Stochastic interest rate modeling and fixed income markets<br>• Derivative trading and arbitrage<br>• International finance<br>• Risk management methodologies<br>• Multivariate stochastic calculus | • Pricing methodologies integrated with financial planning systems<br>• Linking asset and liability strategies to maximize surplus-wealth over time<br>• Modeling the organization as a multistage stochastic program, with decision strategies | • Financial derivatives<br>• Financial engineering<br>• Fixed income portfolios<br>• Enterprise risk management<br>• Black-Scholes model | • Derivatives: economic concepts<br>• Derivatives: quantitative methods<br>• Accounting and taxation of derivatives |

Table 3: Comparison of Capital Markets and Investment Strategy and Risk Management Courses[4, 5, 6, 7, 8]

| University Courses | MIT[4] | University of Michigan[5] | Princeton University[6] | University of Illinois at Urbana-Champaign[7] | University of California at Berkeley[8] |
|---|---|---|---|---|---|
| **Capital Markets and Investment Strategy** | • Artificial markets<br>• Trading costs and liquidity<br>• Derivatives<br>• Derivatives sourcebook<br>• Trading volume | • Diversification & portfolio optimization<br>• Capital asset pricing model, strategic asset allocation<br>• Basic security analysis, trading strategies | • Quantitative analysis of markets, trading strategies, risk and return profiles, and portfolio analysis<br>• Derivative modeling<br>• Analysis of trading models for various hedge fund styles<br>• Development of value-at-risk analysis of various trading systems and portfolios | • Financial intermediation<br>• Macrofinance<br>• Financial statement analysis<br>• Monetary theory<br>• The theory of monetary policy | • Pricing of derivatives<br>• The Black-Scholes formula<br>• Accounting and tax issues related to derivatives and hedging |
| **Risk Management** | • Global financial crises<br>• Nonparametric VAR<br>• Psycho-physiology of risk | • Forward & futures contracts<br>• Swaps<br>• Payoff diagrams<br>• General arbitrage relationships<br>• Option values & dividends<br>• Binomial model<br>• The Black-Scholes model<br>• Option hedging & trading strategies<br>• Delta hedging<br>• Corporate securities<br>• Exotic derivatives | • Risk diversification<br>• Planning models<br>• Market and non-market risks<br>• Portfolio effects | • Property-liability insurance<br>• Managerial financial risk for insurers<br>• Corporate risk management<br>• Employee benefit plans<br>• Enterprise risk management | • Financial risk measurement and management<br>• Market risk, credit risk, liquidity risk, settlement risk, model risk, risk, volatility risk, kurtosis risk<br>• Risk measurement techniques |

Table 4: Proposed Curriculum of Financial Systems for the MS ISE program

| | |
|---|---|
| Core Courses | SSIE 505 Applied Probability and Statistics<br>SSIE 520 Modeling and Simulation<br>SSIE 561 Quality Assurance for Engineers<br>SSIE 5xx Introduction to Financial Systems |
| Preferred Course Choices | SSIE 541 Analysis of Capital Investments<br>SSIE 550 Introduction to Systems Optimization<br>SSIE 553 Operations Research<br>SSIE xxx Risk Management<br>SSIE xxx Capital Markets<br>SSIE 605 Applied Multivariate Data Analysis<br>SSIE 621 Advanced Simulation<br>SSIE 631 Foundations of Neural Networks<br>SSIE 640 Knowledge Discovery and Decision Making<br>SSIE 644 Foundations of Adaptive Optimization<br>SSIE 650 Systems Optimization<br>SSIE 660 Stochastic Systems |
| Potential Campus Wide Electives | CS 535 Introduction to Data Mining<br>ECON 502 Econometric Methods<br>MIS 533 Database Management Systems<br>MKTG 540 Marketing Research |

**Current Financial Crisis and Its Implications**

At a first glance, the recent turmoil caused by housing crisis, problems of mortgage companies, subprime lending, and financial companies does not augur well for educational programs in Financial Systems. It has a two fold impact. The first problem is that many jobs in these areas have disappeared. Some well known and well established companies like Lehman Brothers, Bear Stearns, Washington Mutual, and Merrill Lynch have either disappeared completely or have been absorbed by other companies. Hundreds of people have lost of jobs. However, once the financial quagmire is sorted out, job markets will surely be looking up again.

The second problem is the image problem. The various newly engineered financial instruments and the tremendous growth of the related disciplines fueled mutual growth. When the crisis hit the markets, these disciplines bore the criticism. A recent article in International Harold Tribune[9] on the crisis and the disciplines begins with, "The current economic turmoil, it seems, is an implicit indictment of the arcane field of financial engineering ..," and tries to trace some of the problems to explosive growth of the derivatives markets caused by the new instruments designed by the financial engineers. The article goes on to say that the markets showed an explosive growth which the financial modelers were not able to keep pace with. The blame is on the decision makers too – some of them did not understand the models well enough and there was a misalignment of application areas and the risk models that were applied for these areas. In some places, managers, instead of using these models for risk minimization and hedging, began using them for making quick profits. Financial Engineering and related programs now stand as a main culprit.

However, it is believed that the turmoil only underscores the importance of financial engineering. The instruments of derivative markets, hedge funds, and various types of swaps etc. are here to stay, albeit with more controls and regulations. Abandoning the discipline of Financial Systems would be like throwing away the baby with the bath water. The crisis only draws attention to more emphasis on educating the decision makers in the main subjects of the field. They need to know the underlying principles, the areas of application, the risks associated with the instruments, and conditions under which the underlying models perform. The discipline, on the other hand, needs an introspection to have a frank look at why some of the models failed, the limitation of the models, the human component in the formulation and application, and the need for reforms. More sober and better models need to be designed as the crisis brings in appropriate federal and state regulations. The current crisis is in a sense a wake up call for the practitioners caught up in the euphoria of their great initial success. The educational institutes have a greater role play in facilitating the necessary changes.

## Summary

Financial systems with an emphasis on quantitative methods are becoming important tools for analysis and decision making for investment firms. There has been a tremendous growth in new financial instruments in derivatives. This calls for graduating students with expertise in both finance and quantitative applications in finance. The proposed specialization in Financial Systems in the SSIE Department at Binghamton University sets to address this challenge. Similar programs in various universities were examined. The proposed program would be an inter-disciplinary program with students taking courses in the areas of industrial and systems engineering, systems science, finance, economics, mathematics, and computer science. The program and curriculum has been planned keeping the needs of the industries in mind, especially in the light of the recent economic turmoil.

**References**


1. “International Association of Financial Engineers,” http://iafe.org/html/, Accessed February 2009.
2. Alsop, Ron, “Wall Street Employers Shine to Financial Engineering Degrees,” The Wall Street Journal, November 14, 2006.
3. “Career Options,” http://interpro-academics.engin.umich.edu/fep/, 2005, Accessed September 2007.
4. “Laboratory of Financial Engineering,” http://lfe.mit.edu/, Accessed February 2009.
5. “Financial Engineering,” http://interpro-academics.engin.umich.edu/fep/, 2005, Accessed September 2007.
6. “Department of Operations Research and Financial Engineering,” http://orfe.princeton.edu/, Accessed September 2007.
7. “Masters of Science in Finance,” http://www.business.uiuc.edu/msf/, 2007, Accessed September 2007.
8. “Financial Engineering,” http://mfe.haas.berkeley.edu/description.html, 2007, Accessed September 2007.
9. Lohr, Steve, “Wall Street's Extreme Sport: Financial Engineering,” International Harold Tribune, November 5, 2008.