

Contact: Diana Gonzalez

**REQUEST FOR NEW PROGRAM AT IOWA STATE UNIVERSITY:  
MASTER OF BUSINESS ANALYTICS PROGRAM**

**Action Requested:** Consider approval of the request by Iowa State University to establish a new Master of Business Analytics Program in the Department of Supply Chain and Information Systems in the College of Business.

**Executive Summary:** The proposed program will provide training in the practice of methodical exploration of an organization's data with emphasis on statistical analysis. This proposal was reviewed by the Board Office and the Council of Provosts and is recommended for approval. No concerns were raised when it was presented to the Iowa Coordinating Council for Post-High School. The proposed program addresses the Board of Regents Strategic Plan priorities to "provide educational excellence and impact as well as economic development and vitality" and Goal #8 – "Iowa's public universities and special schools shall be increasingly efficient and productive."

**Background:**

- ◇ **Description of proposed program.** The proposed program will be an interdepartmental program to address the challenges of dealing with issues of analytics and "Big Data" intelligence. The proposed program is structured to be delivered in a blended format that combines the best elements of the interactive and team work environment of traditional classes and the flexibility and unlimited geographic reach of online education. The program provides a foundation in business process analysis, predictive modeling, sentiment analysis, knowledge discovery, analytical reporting, segmentation analysis, and data visualization. There is also a focus on applied training in such areas as fraud detection, risk management, text mining, and process improvement. The academic objective of the proposed program is to educate business professionals and future leaders with a unique ability to analyze business-related data that exhibit high volume, variety, and velocity. The program develops concepts, methods, and skills to effectively visualize and communicate business intelligence and close the gap between business managers and data scientists.

The proposed program will include a cohort of participants from industry (working professionals) who will progress together. The program requires 30 credits of graduate level courses and is expected to be completed in 21 months. Students will start the program with a one-week on-campus initiation class and revisit campus once during the middle of the program and at the end to complete and graduate on campus, while taking online classes during the rest of the time. The following outcomes are expected.

- ⇒ Understand and apply quantitative modeling techniques, including probability, statistics, and optimization to the solution of business problems.
- ⇒ Design cross-functional solutions for business problems, using standard and advanced business analytics technologies and software.
- ⇒ Evaluate data management methods and technologies used for business analytics.
- ⇒ Develop skill in data visualization.
- ⇒ Develop skill in modeling and quantifying in unstructured or new environments.

- ⇒ Develop team and project management skills in Big Data context
- ⇒ Communicate analytical findings effectively orally and in writing.

- ◇ Need for proposed program. The digital revolution empowered by the Internet and computer networking technology in business during the last several decades has generated unimaginable amounts of data in the form of digital records stored in databases and file servers. The volume, velocity, and variety of these data have produced a new set of problems and challenges to businesses and organizations. This challenge has also created opportunities for businesses and organizations to discover, model, and serve their customers and partners in new and unique ways. Businesses that are able to master the data deluge (known as Big Data in industry) will have significant competitive advantage over their competitors. For example, Amazon, Google, Facebook, and other traditional and high-tech companies are already reaping benefits from developing and implementing innovative “Big Data” analytic solutions.

As the trend to implement data analytic solutions grows, demand for professionals who understand and are capable of working with and exploring Big Data has grown significantly in recent years. According to McKinsey Global Institute, by 2018, “the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of Big Data to make effective decisions.”

ISU offers undergraduate programs related to business analytics in multiple departments, including Statistics, Industrial and Manufacturing Systems Engineering, Supply Chain and Information Systems, and Computer Science. The Department of Supply Chain and Information Systems in the College of Business created a Business Analytics concentration in its Management Information Systems major for undergraduate students in 2012; it has since become the most popular choice for MIS undergraduates.

However, a significant segment of graduate studies in the business analytics market has not been fully explored by the university. Letters of support from corporate partners<sup>1</sup> show potential demand for graduates of the program. ISU has well-established brand recognition in this region; alumni who work as business analysts or related professionals in companies across the country, but especially in the Midwest region will likely embrace a graduate degree in business analytics. Furthermore, given the current economic landscape and innovative education delivery technology, traditional full-time on-campus graduate programs are no longer the optimal form of obtaining advanced education for the majority of working professionals.

- ◇ Link to institutional strategic plan. Several U.S. government agencies, including the Defense Advanced Research Projects Agency (DARPA), National Science Foundation (NSF), U.S. Department of Agriculture (USDA), National Security Agency (NSA), Federal Drug Administration (FDA), and the Department of Energy (DOE) are investing heavily in Big Data initiatives. The USDA Agricultural Research Service, DARPA X-data, National Institutes of Health (NIH) initiative, NSF Big Data, and research collaboration in the private sector present unique opportunities for collaborative and contract research. Big data and analytics typically lead to the creation of new science.

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<sup>1</sup> Kingland Systems, Boeing, Principal Financial Group, C. H. Robinson.

Currently, the College of Business offers high quality, undergraduate and graduate programs and has nationally recognized research scholars and a strong research reputation in selected fields. The proposed program would make a significant contribution to the College's strategic goals. The College's 2010-2015 Strategic Plan Vision is to "provide students with skills and experiences needed to succeed in a complex, technology-driven, global society." The proposed program will contribute to this goal by preparing students with an advanced set of tools and training in business analytics and data science to address the challenges of today's complex business world. The Supply Chain and Information Systems (SCIS) Department and affiliated departments of Statistics, Computer Engineering, Computer Science, and Industrial and Manufacturing Systems Engineering have the quality of faculty and facilities to sustain a collaborative graduate program. The proposed program will contribute to the educational mission and reputation of the university. The proposed program supports the University's 2010-2010 Strategic Plan goal to "provide exceptional undergraduate, graduate, professional, and outreach programs that prepare students and citizens for leadership and success."

- ◇ Relationship to existing programs at ISU. The proposed program will establish synergies with existing master's programs in the College of Business, such as the MBA, Master of Science in Information Systems (MSIS), Master of Science in Information Assurance, and Master of Science in Human Computer Interaction. Students in these and related program will benefit from the expanded course offerings in Information Systems, Statistics, and Computer Science at the graduate level. The SCIS department currently offers six elective classes at the graduate level which are taken primarily by MBA and MSIS students. Statistics offers a number of courses that focus on data analyses and visualization. Courses in IMSE, Software Engineering, and Computer Science also address different but related areas of analytics. These courses will be repurposed to be delivered online. Specialized electives will also serve as a recruiting tool for the proposed program as well as other programs to attract students. There is likely to be a positive impact on the visibility of other graduate programs as the depth and quality of business analytics and data science specialization will be enhanced.

The College expects the impact of the proposed programs on the undergraduate program to also be favorable – (1) the proposed program will not require a reduction in the number of course offerings in the undergraduate program; the department currently offers a track in business analytics through two elective courses; (2) exceptional undergraduate students will be able to take additional graduate level courses to fulfill their undergraduate degree requirements and will likely benefit from the more rigorous course offerings; and (3) undergraduate students interested in furthering their business analytics and data driven decision-making will be able to continue their education at ISU.

- ◇ Relationship to existing programs at other colleges and universities. Neither the University of Iowa nor the University of Northern Iowa has a master's program in business analytics at this time; SUI is proposing a similar program using a face-to-face delivery format targeting students in eastern Iowa. Loras College has an MBA Analytics program offered on the ground in an accelerated format. ISU is well positioned to deliver a high quality product that can be completed in 21 months of study. Special features or conditions at ISU such as the High Performance Computing cluster, and proximity and access to client data, make the institution an appropriate place to initiate such a degree program. There is great potential for ISU and SUI to collaborate on this program by taking advantage of the unique features in content and delivery of each of the programs if both proposals are approved.

ISU is known for the quality of its engineering, statistics, and information technology programs and has one of the larger colleges of engineering in the nation. The College of Business and the College of Engineering have excellent reputations with industry for their quality of education, as demonstrated by the size of the engineering and business career fairs each fall (the largest indoor career fair with over 270 employers represented). A typical student in this program will be a distance education student who is taking classes part-time while full-time employed. The College of Engineering has a long tradition of offering distance education courses and has an excellent infrastructure in place in the Engineering-LAS Online (ELO) learning unit. There are a number of successful distance masters of engineering programs such as the Systems Engineering program which has approximately 100 distance students active in the program every year. Recently the College of Business has grown its distance education efforts; the two colleges have worked together to offer some of the College of Business courses to online engineering programs.

The College of Business has close ties with many programs in the Colleges of Engineering and Liberal Arts and Sciences. The interdisciplinary programs in Information Assurance, Human Computer Interaction, and Engineering Management, represent a growing collection of collaborative programs. These strong ties provide an excellent environment for the proposed program which requires cooperation among business, liberal arts and sciences, and engineering. Another distinguishing feature of the proposed program is the unique combination of engineering, science, and business courses. The College of Business has worked closely with these colleges to take this approach to distinguish this program from similar programs in the country. The program provides a unique opportunity to emphasize the STEM relationship among the participating units with the added attractiveness to women and underrepresented population. Additionally, the proposed program fits with the recommendations made by The Commission on the Future of Graduate Education.<sup>2</sup>

- ◇ Unique features. ISU's strengths in Engineering, Statistics, Computer Science, and Business underscore the potential for the proposed program. ISU has prioritized its resources to hire new faculty in the area of Big Data during the last two years. Existing facilities and technology will be able to support the needs of the proposed program.
- ◇ Duplication. The University of Iowa intends to propose a Master of Science Program in Business Analytics. Loras College has established an undergraduate program, a graduate certificate, and an evening specialty MBA in business analytics. There are no other blended Master of Business Analytics programs at other Iowa institutions.

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<sup>2</sup> "Wendler, C., Bridgeman, B., Markle, R., Cline, F., Bell, N., McAllister, P., and Kent, J. (2010). The Path Forward: The Future of Graduate Education in the United States. Princeton, NJ: Educational Testing Service."

- ◇ Opportunities for collaboration. On December 22, 2014, the following areas of cooperation were included in a memorandum of cooperation between Iowa State University and the University of Iowa. (Attachment A)
  - ⇒ *Articulation of courses.* A student enrolled in either of the two programs may take up to nine credits of approved courses in the other program for credits in the home program; students will pay the tuition to the institution that offers the articulated courses at the rate of the offering institution. The approved course list will be determined, published, and maintained by each institution independently.
  - ⇒ *Referral of prospective students.* Prospective students may have different needs and constraints that favor one program over another. The two institutions will refer prospective students to each other based on providing the maximum benefits to students.
  - ⇒ *Sharing of course materials and ideas.* The dynamic nature of the data science and business analytics field requires continuous improvement of course content, learning tools, pedagogy, and delivery mechanisms. The two institutions will hold an annual summer workshop for faculty in the two programs to share syllabi, trends, tools, instructional ideas, and training opportunities. The location will alternate between the two campuses, and the host institution will cover the cost of the workshop.
  
- ◇ Student demand. More than 30 colleges and universities offer a master's degree in business analytics or a related field such as data science. These programs range from full-time on campus to part-time online. They also range in coverage from business focus to data science. As of 2012, these programs graduated approximately 1,300 students. All programs are currently operating at capacity and are unable to meet the growing demand for more graduates. The tuition charged varies across institutions; the average is \$36,127. A recent report by McKinsey shows an unmet demand of "1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions" in the U.S. alone.<sup>3</sup> The cost of the proposed program at ISU will be \$15,600 for in-state students and \$32,800 for non-resident students (based on current ISU tuition schedule).

Workforce need/demand. The Gartner group predicts that nearly 85% of Fortune 500 organizations will be unable to exploit Big Data for competitive advantage because of a severe shortage of trained workforce<sup>4</sup>. They report that by 2015 there will be 4.4 million Big Data jobs created. The 2014 study by IDG stated that nearly half of their respondents are either implementing or planned to implement big data projects<sup>5</sup>.

U.S. News and World Report ranked ISU third in the nation in job placement rates among full-time 2010 MBA graduate students. Specifically, 96% of job-seeking ISU MBA graduates accepted job offers within three months of graduating. The placement rate indicates that the College of Business is producing well trained, quality graduates. Though the strong job market for graduates of MBA programs is likely to carry over to graduates of the proposed program, the focus for this program is to enhance the analytics and data science qualifications of current employees at firms.

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<sup>3</sup> Big Data: The next frontier for innovation, competition, and productivity," Manyika, James, M. Chui, B. Brown, J. Bughin, R. Dobbs, C. Roxburgh, and A. H. Byers, Report, McKinsey Global Institute, May 2011.

<sup>4</sup> Gartner Survey Reveals That 64 Percent of Organizations Have Invested or Plan to Invest in Big Data in 2013, press release.

<sup>5</sup> 2014 Big Data Research by IDG Enterprise, IDG research presentation.

The strong record of job placement should help in recruiting prospective students for the program. The strategy of offering a strong technical skill set that is well suited to areas such as Big Data, marketing analytics, and sentiment analysis should also distinguish graduates with the Master of Business Analytics degree from the broad-based MBA degree and other specialized masters. In order to gauge demand for this type of degree program, many of area employers were contacted, including Pioneer, John Deere, Union Pacific, Kingland Systems, IBM, General Dynamics, and Principal Financial. The proposed program was outlined and they were asked for feedback on the perceived demand for such a skill set. The responses ranged from positive to enthusiastic, and contained several suggestions which have enhanced the proposal.

These responses are considered the best indicator of potential market demand for the proposed program. The Education Advisory Board on Big Data has said<sup>6</sup>, “The biggest barrier to realizing Big Data’s potential is a nascent skill shortage.” Hundreds of thousands of “data scientists” – professionals combining programming, statistics and business domain skills – will be needed in the years ahead, with millions of traditional white-collar jobs in management, sales, marketing and HR likely to require the ability to pose and interpret sophisticated data analysis. Many think continuing, professional, and online education units are ideally positioned to help their institutions respond to this opportunity, because the terrain is inherently interdisciplinary, spans undergraduate, working adult, and international student populations; many established programs are likely to benefit from Big Data curriculum concentrations or extensions.

- ◇ Resources. A typical student will be a distance education students. The College of Engineering has an excellent infrastructure to offer distance education courses, including (1) distance education classrooms with the necessary technology for recording distance education courses; (2) technicians with experience to provide professional delivery of lectures to students; and (3) experienced support staff in the Engineering-LAS Online learning unit. The faculty have many years of experience delivering distance education courses. ISU has long been recognized for excellent distance education programs.

New courses are being developed which will complement existing courses to build the curriculum. ISU has embarked on an effort to hire a cluster of high caliber faculty to lead the effort in Big Data research and education. With the addition of the faculty cluster and existing faculty with expertise in the area of analytics and data science, the colleges are equipped to offer the proposed program. The proposed program will have a dedicated program coordinator in the College of Business to ensure a high level of success.

- ◇ Cost. The new costs for the proposed program include .5 FTE staff, graduate assistant stipends, and faculty salaries which will total \$301,340 in Year One and \$226,741 in Year Seven. The department anticipates that college reallocation and new tuition revenue will cover the cost for the proposed program. The proposed program will be self-sustaining after the first year as the enrollment rises to 40-student cohorts.

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<sup>6</sup> Opportunities for Continuing and Professional Education in the Next Decade, Industry Insights – Big Data, Education Advisory Board, March 2013.

- ◇ Projected enrollment. The projected enrollment in Year One is 20, increasing to 80 by Year Seven.
- ◇ Anticipated sources of students. Students are likely to come from industrial partners within and around the state of Iowa, such as Kingland Systems, Principal Financial, and Boeing. The history of ISU online graduate programs began with sources from Iowa industry and grew to sources well beyond state borders. The proposed program will likely parallel this experience. The College may market and promote the program through external consultants and advisory services to the national and international markets.
- ◇ Off-campus delivery. The proposed program will be offered primarily through distance education. Engineering-LAS Online learning unit will provide the technical support to capture and deliver courses to students around the world. The three one-week on-campus experience will be delivered in Ames. All HLC requirements for off-campus delivery will be met.
- ◇ Potential for accreditation. The College of Business's regular accreditation process will include the proposed program.
- ◇ Articulation agreement. A Memorandum of Cooperation with SUI includes an articulation agreement between the two programs to provide maximum flexibility for students to complete their degrees and training at either institution.
- ◇ Faculty and facilities. Faculty from the Colleges of Business, Engineering, and Liberal Arts and Sciences will teach the courses in the proposed program. A new initiative hiring 12 faculty in 2014 to form a big data cluster has provided the additional faculty resources to meet the teaching and research demands of the program. The courses will be offered through the Engineering-LAS Online (ELO) learning facilities. ELA's facilities are excellent for offering distance education courses and have the necessary capacity to handle the additional course load, especially because many of the courses required for the proposed program are currently offered through ELO.

◆ Competitive landscape.

<b>Institution</b>	<b>Degree</b>	<b>Structure</b>	<b>Duration</b>	<b>Delivery</b>	<b>Total Credits</b>	<b>Fee</b>
Iowa State University	Master of Business Analytics	10 courses	21 months	Blended	30 credits	\$15,600 in-state \$32,800 out-state
University of Texas at Austin	MS in Business Analytics	8 core and 8 electives	11 months	On campus full time	34 credits	\$32,000 in-state \$38,000 out-state
Michigan State	MS in Business Analytics	10 courses required	11 months	Blended	30 credits	\$36,000 in-state \$39,000 out-state
Arizona State Univ.	MS in Business Analytics	10 course lock step program	9 months	On campus, full-time	30 credits	\$29,820 in-state \$44,810 out-state
University of Tennessee	MS in Business Analytics	26 credit core, 12 credit elective	24 months	On campus, full-time	38 credits	Regular tuition
Purdue University	MBA with Business Analytic Track	4 foundation courses and 1 elective		On campus, full-time		
Louisiana State University	MS in Analytics	36 required credits		On campus, full-time	36 credits	
Indiana University	Graduate Certificate in Business Analytics			Blend (On campus + Online)	12 credits	
University of Minnesota	No Business Analytics					
University of Illinois	MS in Statistics – Analytics Concentration					
University of Nebraska	No Business Analytics graduate program					
University of Missouri	MBA with Marketing Analytics					
University of Wisconsin	No Business Analytics program					
University of Iowa	Business Analytics and Information Systems at undergraduate; Graduate program proposed	10 courses		Face-to-face	30 credits	\$665 per credit for in-state
University of Northern Iowa	No Business Analytics program					



◇ Sample curriculum.

Semester	Courses	Credits	Teaching Department	Delivery
Summer I	MIS 547: Teams, Projects, and BA Leadership	3	SCIS	<b>On campus</b>
Fall I	MIS 536: Business Analytics Foundation	3	SCIS	Online
	STAT 502: Applied Statistical Modeling	3	Statistics	Online
Spring I	STAT 581: Data Analytics and Visualization	3	Statistics	Online
	I E 583: Knowledge Discovery and Data Mining.	3	IMSE	Online
Summer II	MKT 552: Marketing Analytics with Big Data	3	Marketing	<b>On campus</b>
Fall II	MIS 546: Advanced Business Analytics	3	SCIS	Online
	COM S 535: Algorithms for Large Data Sets: Theory and Practice	3	Computer Engineering/Computer Science	Online
Spring II	MIS 556: Business Analytics Capstone Project (Capstone)	3	SCIS	<b>On campus</b>
	STAT 451: Applied Time Series (Forecasting) or STAT 510: Applied Modern Multivariate Statistical Learning	3	Statistics	Online

◇ Date of implementation. Creation of the proposed program will become effective upon approval by the Board of Regents and will be included in the University's General Catalog. The anticipated implementation date is Fall 2015.

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Iowa State University  
2000 Gerdin Business Building  
Ames, Iowa 50011

**Tippie College of Business**  
University of Iowa  
108 John Pappajohn Business Building  
Iowa City, Iowa 52242

**Memorandum of Cooperation on Graduate Business Analytics Programs**

January 15, 2015

**1. Background**

The digital revolution empowered by the Internet and computer technology in business and individual life during the last several decades has generated unimaginable amounts of data in the form of digital records stored in databases and files servers. The volume, velocity, and variety of these data have produced a new set of problems and challenges for businesses and organizations in their pursuit of competitiveness, effectiveness, and efficiency. These problems and challenges have also created unprecedented opportunities for businesses and organizations to discover, model, understand, and serve their customers and partners in ways never imagined and in details never possible before. Businesses and organizations that are able to master this data deluge, a.k.a. Big Data, will have a tremendous competitive advantage over their competition in the marketplace.

As the need for implementing data analytic solutions grows, demand for professionals who understand and are capable of working with, exploring and exploiting Big Data – the profession of business analytics – has exploded in recent years. According to McKinsey Global Institute, by 2018 “the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of Big Data to make effective decisions.”

To meet the growing demand for graduates and professionals with data analytic skills, Iowa State University and the University of Iowa have developed and implemented various flavors of business analytics programs in their undergraduate and graduate programs during the last five years. For example, the Department of Supply Chain and Information Systems in the College of Business at Iowa State University offers a business analytics track in its MIS major, and the Department of Management Sciences in the Tippie College of Business at the University of Iowa offers an undergraduate major and graduate certificate in business analytics.

In the Fall of 2014, both institutions independently developed proposals for graduate degree programs in business analytics to further expand the scope, skill, sophistication, and delivery of their business analytics offerings. While both proposals aim to deliver graduate level courses and degrees to students interested in advanced business analytics, they differ significantly in target audience and delivery methods. ISU’s Master of Business Analytics program is a 30-credit blended delivery program targeting working professionals nationally, with a mixture of online (70%) and on-campus (30%) courses. In contrast, Iowa’s Master of Science in Business Analytics program is a 30-credit evening program targeting working professionals with face-to-face courses in various locations in Iowa. However, a review of the curricula of the two proposed programs suggests that there are similarities in at least some of the courses related to the fundamentals of business analytics, providing a foundation for collaboration between the two programs.

## **2. Areas of Cooperation**

The faculty and leadership at the two institutions (the College of Business at Iowa State University and the Tippie College of Business at University of Iowa) enthusiastically embrace the idea that cooperation between the two programs will benefit first and foremost students, data science professionals, businesses, and organizations in the State of Iowa, and will enhance the quality of both programs in the long run. The two faculties have thus agreed to the following collaboration activities with the option to develop future collaboration ideas where appropriate.

### ***2.1 Articulation of Courses***

A student enrolled in either of the two programs may take up to 9 credits of approved courses in the other program for credits toward the home program, and students will pay the tuition to the institution that offers the articulated courses at the rate of the offering institution. The approved course list should be determined, published, and maintained by each institution independently.

### ***2.2 Referral of Prospective Students***

Prospective students may have different needs and constraints that favor one program to another between the two proposed business analytics programs. The two institutions agree that each program should refer prospective students deemed more appropriate for the other program to that program in order to provide the maximum benefits to the students.

### ***2.3 Sharing of Course Material and Ideas***

The dynamic nature of the data science and business analytics field requires continuous improvement of course content, learning tools, pedagogy, and delivery mechanisms. The two institutions agree to hold an annual workshop in the summer for faculty involved in the business analytics programs to share syllabi, trends, tools, instructional ideas, and training opportunities. The location will alternate between the two campuses, and the hosting institution will cover the cost of the workshop excluding travel and lodging expenses of the participants.

## **3. Additional Provisions**

This memorandum reflects the intention of the parties to establish a mutually beneficial relationship but does not create any legally binding obligations.

This memorandum is in-place for a period of five years, and may be renewed thereafter by mutual consent.

This memorandum may be terminated by either party by giving a written notice to the other party. Such termination shall not affect the final execution and conclusion of specific activities in effect. Insofar as possible, such notice will be given six months in advance of the desired termination date.

Representative of Iowa State University

Representative of University of Iowa

Name: David Spaldin  
Title: Raisbeck Endowed Dean  
Signature: David Spaldin  
Date: 1/13/15

Name: Sarah Fisher Gardial  
Title: Dean  
Signature: Sarah Fisher Gardial  
Date: 1/15/15

*Master of Business Analytics Program List of Courses*

Existing Courses

**I E 583. Knowledge Discovery and Data Mining (3-0) Cr. 3.**

Prereq: I E 148, I E 312, and STAT 231

Introduction to data warehouses and knowledge discovery. Techniques for data mining, including probabilistic and statistical methods, genetic algorithms and neural networks, visualization techniques, and mathematical programming. Advanced topics include web-mining and mining of multimedia data. Case studies from both manufacturing and service industries. A computing project and an additional project with more theoretical content are required.

**Stat 451. Applied Time Series (3-0) Cr. 3.**

Prereq: STAT 301, STAT 326, or STAT 401

Methods for analyzing data collected over time; review of multiple regression analysis. Elementary forecasting methods: moving averages and exponential smoothing. Autoregressive-moving average (Box-Jenkins) models: identification, estimation, diagnostic checking, and forecasting. Transfer function models and intervention analysis. Introduction to multivariate time series methods.

New Courses

**COM S 535. Algorithms for Large Data Sets: Theory and Practice (3-0) Cr. 3.**

Prereq: COM S 228, COM S 330, CPRE 310, or department permission

Challenges involved in solving computational problems associated with massive data sets.

Computational problems arising in the context of web search, social network analysis, recommendation systems, and online advertising. Theoretical aspects include modeling computational problems using graphs, study of similarity measures and hash functions, and design of efficient algorithms for graphs. Practical aspects include implementation and performance evaluation of the algorithms on real world data sets. Graduate credit requires a written report on current research.

**\*MIS 547. Teams, Projects, and BA Leadership (3-0) Cr. 3.**

Prereq: Admission to the program or department permission.

Preparation of students in teamwork and project management skills, including teach cohesion, synergies, and team commitment. Emphasis on developing skills to monitor/assess motivation and enhance productivity and quality. Discussion of both leadership theory and different leadership styles; expectations about communicative protocols/methods, appropriate media, scheduling communication, and the use of templates and collaborative systems.

**\*MIS 536. Advanced Business Analytics (3-0) Cr. 3.**

Prereq: MIS 547 or department permission.

In-depth discussion of various advanced topics in Business Analytics, such as big data, text mining, web mining, and social network analysis. Extensive hands-on exercises using analytic tools to solve real world problems.

**\*MIS 546. Business Analytics Foundation (3-0) Cr. 3.**

Prereq: MIS 536 or department permission.

Introduction to basic concepts and tools in Business Analytics. Hands-on laboratory exercises and business case studies on data preparation, data representation, data visualization, and data mining. Focus on predictive analytics; descriptive and prescriptive analytics will also be explored.

**MIS 556. Business Analytics Capstone Project (3-0) Cr. 3.**

Prereq: Department permission

Syntheses of analytics concepts, skills, and practices learned during the program of study to complete a course project. Projects proposals relevant to a firm are proposed and accepted midway through the program. Student cohort teams will complete the capstone project under the supervision of an advisory team of faculty. Teams will present their projects to mark the completion of the program of study.

**MKT 552. Marketing Analytics with Big Data (3-0) Cr. 3.**

Prereq: Admission to the program or department permission

Principles and methods of market segmentation, market response models; principles of resource attribution across customer-touching points, social media marketing and mobile commerce. Current research and industry best practices, tools and methods to draw customer insights, and develop actionable marketing strategies with hands-on experiences.

**STAT 502. Applied Statistical Modeling (3-0) Cr. 3.**

Prereq: STAT 226, equivalent, or department permission

Introduction to probability concepts and distributions used in statistical decision-making. Least squares and maximum likelihood estimation, sampling distributions of estimators; confidence intervals and hypothesis testing; analysis of variance; applications of multiple regression models, logistic regression and Poisson regression; strategies for model selection; introduction to decision trees and model averaging; introduction to conditional probabilities and Bayesian analysis. Applications implemented with R statistical package. Simulations used to investigate properties of estimation procedures and assist in data analysis.

**STAT 510: Applied Modern Multivariate Statistical Learning (3-0) Cr. 3.**

Prereq: STAT 502, IE 583, MIS 546, or department permission.

Advanced application of statistical methods for modern data mining and machine learning; inference and prediction; variance-bias trade-offs and choice of predictors; kernel smoothing methods; neural networks and radial basis function networks; bootstrapping, model averaging, and stacking; support vector machines; random forests; boosting; prototype methods; unsupervised learning including clustering, principal components, and multi-dimensional scaling.

**STAT 581. Data Analytics and Visualization: (3-0) Cr. 3.**

Prereq: Admission to the program or department permission

Discussion of exploratory data analysis and visualization strategies and application to data with a focus on business processes and forecasting. Basic types of charts, time series displays, multi-layered charts, and maps. Discussion and development of interactive graphics in the form of web-based applications; cognitive principles of visualizations such as features of good graphics, important perceptual elements, and consideration of audience perception of a graphic; tools for implementing good graphics.

Note: Courses with \* are already in the experimental course catalog system.