SOUTH DAKOTA BOARD OF REGENTS

Academic and Student Affairs

AGENDA ITEM: 6 – B
DATE: May 10, 2022

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SUBJECT

New Program Request – SDSMT – PhD in Data Science and Engineering

CONTROLLING STATUTE, RULE, OR POLICY

BOR Policy 2:23 – Program and Curriculum Approval
BOR Policy 2:1 – External Review of Proposed Graduate Programs

BACKGROUND / DISCUSSION

South Dakota School of Mines and Technology (SDSMT) requests permission to offer a PhD program in Data Science and Engineering. The PhD in Data Science and Engineering will be an interdisciplinary degree that would span across many existing and emergent technical fields, including Machine Learning and Artificial Intelligence, Data Mining and Big Data, Data Analytics and Applied Statics, Data Engineering, and Data Visualization. The proposed program will leverage collaborative opportunities with the following three departments on the SDSMT campus: 1) Computer Science & Engineering, 2) Mathematics, and 3) Industrial Engineering.

The Board approved the Intent to Plan at the August 2021 meeting. Per BOR Policy 2:1, an external review of the program was conducted and the final report of the reviewers is included in Attachment II. SDSMT's response to the external review is included within the program proposal.

IMPACT AND RECOMMENDATION

SDSMT requests authorization to offer the program on campus. There are 14 new courses associated with the program, but only two of the proposed courses are being added specifically for this program. The others are associated with other programs at SDSMT, and many have already been offered as topics courses. SDSMT does not request new state resources. SDSMT anticipates 12 enrolled students and 3 graduates within four years.

Board office staff recommends approval of the program.

ATTACHMENTS

Attachment I – New Program Request: SDSMT – PhD in Data Science and Engineering
Attachment II – External Program Review Report

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DRAFT MOTION 20220510_6-B:

I move to authorize SDSMT to offer a PhD in Data Science and Engineering, as presented.

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Graduate Degree Program

Use this form to propose a new graduate degree program. The Board of Regents, Executive Director, and/or their designees may request additional information about the proposal. After the university President approves the proposal, submit a signed copy to the Executive Director through the system Chief Academic Officer. Only post the New Graduate Degree Program Form to the university website for review by other universities after approval by the Executive Director and Chief Academic Officer. The university should consult the "Campus Guide to the New Graduate Program Approval Process" for information on specific aspects of the approval process.

UNIVERSITY:	SDSM&T
PROPOSED GRADUATE PROGRAM:	**Data Science and Engineering**
EXISTING OR NEW MAJOR(S):	**New**
DEGREE:	**Doctor of Philosophy**
EXISTING OR NEW DEGREE(S):	**Existing**
INTENDED DATE OF IMPLEMENTATION:	Fall 2022
PROPOSED CIP CODE:	**30.7001**
SPECIALIZATIONS: *Note: If the new proposed program includes specific specializations within it, complete and submit a New Specialization Form for each proposed specialization and attach it to this form. Since specializations appear on transcripts, they require Board approval.*	**N/A**
IS A SPECIALIZATION REQUIRED (Y/N):	**No**
DATE OF INTENT TO PLAN APPROVAL:	**8/21/2021**
UNIVERSITY DEPARTMENT:	**Computer Science & Engineering**
BANNER DEPARTMENT CODE:	**MCSC**
UNIVERSITY DIVISION:	**SDSMT Science & Letters**
BANNER DIVISION CODE:	**4L**

☒ **Please check this box to confirm that:**

- The individual preparing this request has read AAC Guideline 2:10, which pertains to new graduate degree program requests, and that this request meets the requirements outlined in the guidelines.
- This request will not be posted to the university website for review of the Academic Affairs Committee until it is approved by the Executive Director and Chief Academic Officer.

University Approval

To the Board of Regents and the Executive Director: I certify that I have read this proposal, that I believe it to be accurate, and that it has been evaluated and approved as provided by university policy.

	Click here to enter a date.
President of the University	Date

1. What is the nature/purpose of the proposed program? Please include a brief (1-2 sentence) description of the academic field in this program.

The South Dakota School of Mines & Technology (South Dakota Mines) requests approval to offer a Ph.D. in Data Science and Engineering. The proposed program will leverage collaborative opportunities between three different departments on the South Dakota Mines campus; the department of Computer Science & Engineering (CSE), the department of Mathematics (MATH), and the department of Industrial Engineering and Engineering Management (IE).

The purpose of the proposed degree program is to provide Ph.D.-level graduate students with the education and research training needed to be successful in the field of Data Science and Engineering. This program will be an interdisciplinary degree that would span across the many existing and emergent technical fields involving Machine Learning and Artificial Intelligence, Data Mining and Big Data, Data Analytics, Applied Statistics, Data Engineering and Data Visualization. Because Data Science and Engineering is multidisciplinary in nature (originating in the operations research area, to computational statistics, and now computing and computer science), the program would enable many collaborative opportunities within the South Dakota Mines campus, across the state of South Dakota, and throughout the U.S. Data Science is a rapidly growing interdisciplinary field that involves researchers from many STEM disciplines and applications can be found throughout science and engineering. Moreover, with the recent advances is business analytics, Data Science and Engineering continues to provide business leaders with valuable insights never before attainable. Our graduates would be able to participate in five emerging areas of Data Science: 1. Data Analytics, 2. Data Engineering, 3. Machine Learning & Artificial Intelligence, 4. Data Visualization, and 5. Operations Research.

The proposed program supports the BOR System strategic goals, and will enable South Dakota regental institutions to form strong collaborations in academic, scholarly research and economic growth activities across the state. The primary purposes of the proposed program are:

1. to enable South Dakota Mines to compete for more/larger federal research grants spanning the broad fields of machine learning/artificial intelligence, data science, data engineering, data visualization, and data analytics;
2. to enable an increase in research productivity from both junior and senior level faculty in three key departments at South Dakota Mines (two of which currently only offer a M.S. degree, and one that currently only offers a B.S. degree);
3. to make career opportunities at South Dakota Mines more attractive to top-tier faculty within the three aforementioned departments, thus improving faculty recruitment and retention efforts;
4. to support research commercialization prospects, drive innovation, and increase entrepreneurial opportunities;
5. to attract industry partners to collaborate on cutting-edge research, leading to increased job opportunities for students, increased job growth within South Dakota, and improvements in economic development across the state;
6. The program would increase collaboration between the three aforementioned departments on the South Dakota Mines campus, as well as providing a terminal degree option for the many existing B.S./M.S. offerings at other regental universities in the general

areas of computational statistics, data science, computer science, electrical engineering, industrial engineering, and mathematics.

This Ph.D. aligns well with the core mission of South Dakota Mines---to educate the next generation of leaders in Science and Engineering as well as supporting many research programs on campus. Students in this program would be expected to take coursework in multiple disciplines, work on interdisciplinary research, and complete a dissertation on that research.

2. How does the proposed program relate to the university's mission and strategic plan, and to the current Board of Regents Strategic Plan 2014-2020?

BHSU:	*SDCL § 13-59*	*BOR Policy 1:10:4*
DSU:	*SDCL § 13-59*	*BOR Policy 1:10:5*
NSU:	*SDCL § 13-59*	*BOR Policy 1:10:6*
SDSMT:	*SDCL § 13-60*	*BOR Policy 1:10:3*
SDSU:	*SDCL § 13-58*	*BOR Policy 1:10:2*
USD:	*SDCL § 13-57*	*BOR Policy 1:10:1*

Board of Regents Strategic Plan 2014-2020

Under SDCL 13-60, the primary purpose of South Dakota Mines is to educate scientists and engineers to address global challenges, innovate to reach our creative potential, and engage in partnerships to transform society. The emerging fields of Data Science and Data Engineering resides directly within this purpose. Moreover, a Ph.D. in Data Science and Engineering is consistent with the university mission statements in BOR policy 1:10:3 (South Dakota School of Mines & Technology). The university has Ph.D. programs in other disciplines.

The proposed Ph.D. in Data Science and Engineering is also in alignment with the South Dakota Mines 2019 – 2023 Strategic Plan as outlined in Table 1.

Table 1: South Dakota Mines strategic plan alignment.

Academic & Co-Curricular Excellence	Create and maintain distinctive majors, minors, certificates relevant to electrical and electronics fields that are responsive to **changing industry and societal needs.**
Research & Innovation	Obtain a **Doctoral Research University** Carnegie classification, Identify and pursue both government and non-governmental **research funding opportunities** in both fundamental and applied research. Increase knowledge and skills in proposal preparation and promote a culture of **collaboration and support**. Develop plans to integrate **undergraduate research** in the curriculum. Develop **state-of-the-art facilities** that bolster the research, instructional, and communication needs of the campus community.

As outlined in Table 2, Section 3, the proposed Ph.D. in Data Science and Engineering is directly aligned with the South Dakota Science & Innovation strategy and the South Dakota 2020 Vision that provides a framework for driving research and economic development within the state. Increasing annual research expenditures will advance knowledge, enhance technology transfer to

industry, aid in future commercialization efforts (potentially resulting in research start-ups and spin-offs), and catalyze economic development.

The Ph.D. in Data Science and Engineering supports the following System strategic goals (Policy 1:21):

- 2.1. South Dakota's population will be more highly educated;
- 2.2. South Dakotans will have increased access to continuing education opportunities needed to upgrade their credentials while remaining in the workforce;
- 2.4. The South Dakota economy will benefit from significant increases in university and associated research-derived commercialization activities;
- 3.1.1.1. Grow the number of undergraduate and graduate degrees awarded.
- 3.2.1.3. Continue to approve new graduate programs
- 3.2.2.3. Encourage student engagement in research and service.
- 3.3.1.1. Increase grant and contract expenditures.
- 3.3.1.2. Increase the number of invention disclosures.
- 3.3.1.3. Increase the number of signed license agreements.
- 3.3.1.4. Increase the number of licenses signed with start-up companies.
- 3.3.1.5. Increase the number of graduates from STEM programs.
- 3.3.2.1. Support the universities' efforts to enhance research and development productivity through grants and contracts in key research sectors, recognizing the mission of each of the Regental universities.
- 3.3.2.2. Expand educational opportunities in the areas of science, technology, engineering, and mathematics.
- 3.3.2.3. Contribute to the state's workforce and economic development.

The South Dakota Mines vision is to develop world-class leaders in science and engineering to benefit society. As stated in Section 3 (below), Data Science and Engineering is one of the fastest growing fields ***globally*** and plays a central role in a multitude of ***science and engineering*** application domains. New innovative research in these emerging areas will enable our graduate students to reach their ***creative potential*** and engage in ***multidisciplinary partnerships to help transform society***.

The fastest growing component in STEM is Data Science. It is emerging as the "fourth fundamental pillar of the scientific method" with the other three being: theory, experimentation, and computation. One only needs to look at the recent calls for proposals at the National Science Foundation (NSF), National Institute of Health (NIH), the Department of Energy (DOE), and other federal agencies to see that Data Science, along with Artificial Intelligence and Machine Learning appear in increasing frequency. In addition to Industrial Engineering, this new program will be tightly connected with other engineering disciplines, including Chemical, Biological, Environmental, and Metallurgical, as they are seeing an explosion of data-science based research. The same is true for science disciplines like Physics, Chemistry and Biology - all requiring expertise in data science. Given the long-standing presence of these engineering and science disciplines at South Dakota Mines, the university is well-positioned to integrate Data Science into STEM fields.

South Dakota Mines has a long history of interdisciplinary collaboration in STEM research and academic programs. Two of the earliest Ph.D. programs offered at South Dakota Mines (Materials Engineering & Science, Ph.D. and Atmospheric & Environmental Sciences, PhD), were

each created and launched as collaborative endeavors involving numerous departments at the university. Interdisciplinary programs are incredibly efficient and effective, as they allow a university to utilize existing faculty expertise, facilities, and resources, and encourage cross-department cooperation and engagement. This culture will enable and encourage researchers at South Dakota Mines to engage in multidisciplinary data-science enable research. This cooperative culture will also encourage faculty and researchers to reach out to sister institutions to build statewide collaborations in science and engineering.

This new degree program is consistent with the BOR strategic plan as the intent is to train both scientists and engineers in Data Science and Engineering to address significant challenges in industry, research, and economic development. A Ph.D. in Data Science and Engineering will increase the state's national and international reputation in data science research. This program will make South Dakota Mines Computer Science and Engineering, Mathematics, and Industrial Engineering faculty more competitive in the pursuit of external funding because they will be able to put together research proposals that include doctoral students as well as postdoctoral researchers from collaborative multi-disciplinary teams. The Ph.D. program would also make South Dakota Mines more attractive when recruiting faculty members within these three disciplines, because leading researchers typically seek positions in departments with a Ph.D. program.

3. Describe the workforce demand for graduates of the program, including national demand and demand within South Dakota.

The growth of computing, networking, and high-fidelity sensing; the increase in data driven science and engineering; and the growth in data collection in business marketing, sales, agriculture, energy, medicine, and the entire Department of Defense are all producing vast amounts of data at unprecedented rates. In most of the aforementioned fields, there is more data available to be processed than can be performed by the current labor pool. Moreover, as data collection continues to grow in a multitude of application areas, new theories and algorithms need to be developed in an effort to: a) keep pace with current demand, b) help industries discover new insights from data and c) use these insights to provide data-driven solutions to current industry and governmental problems.

Agriculture has been and will continue to be a very important part of the South Dakota economy. To stay competitive, SD Ag producers are looking to automation and robotics to improve efficiency and raise yields. These technologies rely on machine learning at data. Data science will be pivotal to achieve these goals. South Dakota's finance and healthcare industries will continue to require access to data for business analytics, market research, customer development and security. During a global pandemic, many healthcare professionals rely more and more on Data Science and Data Engineering to understand, track/trace, and help mitigate Covid-19 [1]. Much of the needed technologies do not exist, thus the need for experts to develop the tools required by SD businesses.

Current analyses suggest that many more data scientists are needed to adequately process the tremendous volumes of information that are being generated. According to the world economic forum *"future of jobs report"* [2], technological advances resulting from Big Data analytics, machine learning, artificial intelligence, and data engineering is transforming the workplace. In fact, in the same report, *"data analysis and science"* made the top of the list of the emerging workforce in 2020 with Artificial Intelligence and Machine Learning coming in at number two

[2]. According to Glassdoor in their 50 Best Jobs in America for 2020, Data Scientist ranks #2 with a median salary of $113,736 with Machine Learning Engineer at #17 with a median salary of $104,837 and Data Analyst at #35 with a median salary of $70,000 [3]. Moreover, according to the U.S. Bureau of Labor Statistics 20 fastest growing occupations, Statisticians are at #14 with a growth rate of 35% and Data Scientists and Mathematical Science Occupations ranks #29 with a growth rate of 31% [4].

A search of indeed.com (10/13/2021) using the key words "Data Science" brought up 42,625 listings on Data Science, Data Engineer and Statistics [5]. Companies/agencies involved in their search for talent in these areas includes NSA, GMAD, Blue Owl, USAA, Johns Hopkins, Twitter, UCSF, Amazon, Booz Allen Hamilton, Apple, CDW, Pinterest, Facebook, General Dynamics IT, IQVIA, Microsoft, SAIC, Capital One, Accenture, Lockheed Martin, AETNA, Guidehouse and many more. Glassdoor has an equally impressive list of companies looking to hire Data Science and Engineers.

Regarding South Dakota, arguably, two of the largest economic sectors are agriculture and energy. In addition to job opportunities in the global market, local companies have seen increases in Data Science and Data Engineering needs. Indeed, Black Hills Corporation has a history of hiring data scientists from South Dakota Mines to help with business analytics, load forecasting, and data driven insights into the future of energy demand [6]. Raven Industries (focused on intelligent/autonomous agriculture) have continuously hired data science and data engineers from South Dakota Mines with expertise in Computer Vision and Machine Learning, both of which will be directly enhanced by graduates of the proposed program [7].

In addition, with the recent announcement of Ellsworth Airforce Base receiving the B-21, and Northrup (along with many sub-contractors) winning the contract to build the "US Airforce's next generation Long Range Strike Bomber (LRS-B)" [8], many opportunities for workforce development in the areas of data science and data engineering are on the horizon. Moreover, Data Science and Engineering does not require the infrastructure (expensive analytical laboratories) that other disciplines require, e.g., mining, manufacturing, agriculture, and healthcare. Similar to software engineering, Data Scientists and Data Engineers can work globally in their field while residing in the state of South Dakota, and contributing directly to the South Dakota economy. Similar to building capacity in Software Engineering, as indicated above, there is a huge market potential and opportunity for growth in South Dakota without the drawbacks of expensive investments. Furthermore, existing investments that have been made in South Dakota (e.g., the Sanford Underground Research Facility (SURF), Earth Resources Observation and Science (EROS) center, SD Fusion Center, healthcare, secure banking, intelligent agriculture, underground science, intelligent/advanced manufacturing, etc.) all have growing demands for Data Scientists and Data Engineers. In short, Data Science and Data Engineering spans the entire list of research priorities within South Dakota as outlined in the South Dakota 2020 Vision (as illustrated in Table 2) [9].

Table 2: South Dakota research goals as outlined by the South Dakota 2020 Vision.

Value Added Agriculture and Agribusiness [10]
As discussed above, Raven industries is one of the leading companies paving the way towards intelligent agriculture and agribusiness (see attached letter of support). The Ph.D. in Data Science and Engineering would provide may different opportunities to aid in these efforts, a subset of specific examples include: 1) solving complex problems in computer vision, 2)

learning mathematical models for autonomous tractor swarms, 3) analyzing/forecasting crop production and demand through data fusion, 4) providing insights into business analytics for the end producers, etc.

Energy and Environment [11]

As discussed, Black Hills Corporation has a history of hiring data scientists with advanced degrees (Ph.D. preferred) for a variety of big data analytics problems (see attached letter of support). The Ph.D. in Data Science and Engineering would certainly provide the requisite expertise to advance the energy sector within South Dakota through development of 1) statistical models for load-flow forecasting, 2) smart-grid integration and intelligent energy usage, 3) failure modeling of distribution systems, 4) outage detection and prediction, etc.

Materials and Advanced Manufacturing [12]

The future of materials and advanced manufacturing is deeply connected to data science and machine learning. Indeed, the current estimates of data science in manufacturing was valued at over $900 million in 2019 with expected growth to $4.55 billion by 2025 [13]. It is said that the manufacturing industry is *"currently going through a 4th industrial revolution where data from machines, environment, and products are being harvested to get closer to that simple goal of Just in Time"*. The Ph.D. in Data Science and Engineering proposed here would enable graduates to aid in this revolution through 1) predictive maintenance, 2) computer vision, 3) sales, development, logistics, and supply chain forecasting, 4) quality assurance, 5) smart manufacturing, etc. For example, Rapid City-based companies RPM and Associates [14] (a global leader in 3D printing of metals), VRC Metal Systems (advanced manufacturing) and B9 Creations [15] (novel development of 3D printers), are well suited to hire graduates of the proposed program.

Human Health and Nutrition [16]

Human health and nutrition have a history of producing vast amounts of data at an exponential rate. Gaining insight from this data has received significant attention in recent years requiring advanced algorithms ranging from natural language processing to deep convolutional neural networks. In fact, Sanford health is revolutionizing the healthcare industry through advanced data analytics and electronic medical records [17]. The Ph.D. in Data Science and Engineering proposed here would produce graduates that could pave the way toward many different advancements in human health and nutrition such as 1) data driven diets, 2) patient anomaly detection, 3) advanced analytics in pharmaceutical care, 4) computer vision and automated analysis, 4) food science and food manufacturing, etc.

Information Technology/Cybersecurity/Information Assurance [18]

By definition, Information Technology/Cybersecurity/Information Assurance is directly aligned with the Data Science and Engineering Ph.D. vision. As stated above, there are a multitude of opportunities within this particular thrust for graduates of the proposed program (too many to list). Furthermore, the Ph.D. program will directly benefit a recently (July 2021) established SD Governor's Center (Center for Understanding and Disrupting the Illicit Economy) where collaborative workforce development is underway with Black Hills Information Security [19] (see attached letter of support).

Plant and Animal Bioscience [20]

Plant, animal, and bioscience in general has seen significant increases in using data science for scientific advancement. Indeed, the current NSF EPSCoR Track 1 Infrastructure Development research (collaboration between multiple South Dakota Universities) focused on biofilms, biofuels, and bioscience has a significant need for research in analysis and prediction of bioscience states. Graduates of the proposed Ph.D. would be able to aid researchers in biology, biomedical engineering, and bioscience in general through 1) using machine learning to

understand the genome to phenome processes (one of the NSF Big Ideas – "Understanding the Rules of Life" [20], consequently so is "Harnessing the Data Revolution"), 2) automated drug delivery, 3) genome sequencing, 4) generative biological structures for advance pharmaceutics, etc.
Underground Science and Engineering [21]
Similar to the aforementioned research foci, underground science and engineering is currently producing more data than research teams can analyze. As stated in [21], *"over the centuries, chemistry, geoscience, physics, and their various sub-disciplines have generated and exploited among the largest and most complex data sets known to mankind"*. Similarly, as indicated state by the South Dakota Mines Physics Department Head Dr. Schnee, *"...all (or at least nearly all) of the experiments ongoing or to be sited at SURF will benefit from advanced analytical tools for data analysis"*. Graduates of the proposed program would enable researchers in underground science and engineering to solve previously unsolved problems, such as 1) data-driven modeling of complex behavior, 2) physics-enabled machine learning for analysis of complex events, 3) event detection and classification, 4) particle modeling and collision forecasts, etc.
Visualization [22]
As data science and data engineering continues to grow, being able to interpret, explain, and visualize said data is of continued importance, here data science and data visualization go hand in hand. EROS for example requires data visualization for massive amounts of satellite imagery to aid in analysis and interpretation of global tracking, change, and forecasting of the earth's resources. As the antic goes, "a picture is worth a thousand words", nothing is truer when dealing with large amounts of data and trying to understand trends, patterns, or anomalies in said data. Students enrolled in the Data Science and Engineering Ph.D. proposed here would be trained in more than the development of new data science algorithms but also new visualization techniques to present the results of said algorithms to the scientific community as whole. As such, they will at a minimum investigate problems related to 1) enhancing STEM education through data visualization, 2) data analytics and graphic design, 3) generative art (data generated intelligent art/music/etc. – sometimes referred to as deep fakes [23]), business analytics and exploratory visualization, etc.

It has been stated by Dr. Martha Pollack (provost at the University of Michigan, Ann Arbor) that "*Data Science has become a fourth approach to scientific discovery, in addition to experimentation, modelling, and computation*" [24]. It is important to note however, that many new jobs created for graduates of the proposed Ph.D. program in Data Science and Engineering are new enough that they are not listed on the South Dakota Department of Labor's (SDoL) website or the U.S. Bureau of Labor Statistics (BLS). These types of positions include Machine Learning Engineers, Data Scientists, and Applied AI Specialists mentioned earlier from the Indeed resource.

Recently U.S. Sens. John Thune (R-S.D.) and Gary Peters (D-Mich.), members of the Senate Committee on Commerce, Science, and Transportation, introduced bipartisan legislation to help ensure the federal government can attract experts in the artificial intelligence (AI) field to public service. [25] Graduates of our Data Science and Engineering Ph.D. will have extensive training in multiple disciplines within A.I. There is a clear and present need for experts in Data Science in South Dakota and the surrounding states.

Footnotes

[1] https://ncbiinsights.ncbi.nlm.nih.gov/2020/03/26/cord-19-a-new-machine-readable-covid-19-literature-dataset/
[2] https://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf
[3] https://www.glassdoor.com/List/Best-Jobs-in-America-LST_KQ0,20.htm
[4] https://www.bls.gov/emp/tables/fastest-growing-occupations.htm
[5] https://www.indeed.com/jobs?q=Data+Science&l=
[6] https://careers.blackhillsenergy.com/search/data-analyst/jobs/in/sd-south-dakota
[7]https://jobs.ravenind.com/search/?createNewAlert=false&q=machine+learning&locationsearch=
[8] https://www.defensenews.com/home/2015/10/27/northrop-grumman-wins-air-force-s-long-range-strike-bomber-contract/
[9] https://sdepscor.org/wp-content/uploads/2015/07/2020-Vision.pdf
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[11] https://activewizards.com/blog/top-10-data-science-use-cases-in-energy-and-utilities/
[12] https://medium.com/@ODSC/data-science-in-manufacturing-an-overview-e6d648bf9c08
[13] "Big Data Analytics in Manufacturing Industry Market — Growth, Trends, and Forecast (2020–2025)," Mordor Intelligence, 2020.
[14] https://www.rpmandassociates.com
[15] https://www.b9c.com
[16] https://www.siliconrepublic.com/innovation/data-science-analytics-nutrition
[17] https://research.sanfordhealth.org/services/sanford-data-collaborative
[18] https://blog.insightdatascience.com/data-scientist-a-profession-for-quantitative-biologists-b95a6428abd7
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[22] https://towardsdatascience.com/10-viz-every-ds-should-know-4e4118f26fc3
[23] https://aiartists.org/ai-generated-art-tools
[24] "50 Years of Data Science", David Donoho, Journal of Computational and Graphical Statistics, 2017. Pre-Print available here:
https://courses.csail.mit.edu/18.337/2015/docs/50YearsDataScience.pdf
[25] https://www.thune.senate.gov/public/index.cfm/press-releases?ID=AB719FAD-D250-4C9B-9AA5-B41FFE39E2FD

4. How will the proposed program benefit students?

The program will benefit students by engaging them in an interdisciplinary program curriculum that brings together the best of what several disciplines have to offer at the university. Further, the program will prepare students for employment in a rapidly growing field, and it will provide them with advanced skills and knowledge from doctoral level studies to set them apart from other job-seekers who only have bachelor or master's degrees. Finally, the program will benefit students by expanding the ability to seek external grant funding, engaging them in graduate research where problems of today and tomorrow are explored and solved, and providing the necessary qualifications and experience for graduates of the program to educate others in industry and academia who have an interest in data science.

With a Ph.D. program in Data Science and Engineering in place, three different departments on the South Dakota Mines campus are brought together to provide a superior in-person state-of-the-art degree program. The collaboration of the science and engineering departments expands the applications and curriculum beyond those found in CS or Math programs alone. In other words, students are exposed to a wide range of applications since multiple departments and research groups are involved.

Data Science and Engineering credentials opens the door for jobs in a wide range of industries. The Data Science Council of America (DASCA) provides certification exams which allow

individuals to demonstrate their data science expertise. Once this Ph.D. program is approved, we can engage with DASCA to automatically provide Data Science credentials to the graduates increasing their employability in a dynamic market.

As mentioned, Data Science and Engineering is a rapidly growing discipline. Students at the undergraduate and Master's level must compete with others who have degrees in Computer Science, Computer Engineering, and Electrical Engineering. A Ph.D. in Data Science will provide the credentials to be competitive in the marketplace.

This program will be more attractive to both students and faculty from top-tier universities. From enhanced external financial support made possible by having a Ph.D. program, all three departments will be able to provide a greater number of assistantships to qualified graduate students, one of which (the Department of Mathematics) has no current graduate program and thus has no opportunity for graduate training or advisement.

With this research experience, the students in the proposed program will enjoy strong job prospects as outlined in Section 3. Moreover, with the massive growth in Data Science-like undergraduate and graduate programs (both within the State of South Dakota, the US, and the World), there is a massive shortage of terminal degree faculty available to advise and educate the future workforce in these areas. The proposed program will help fill this void in both the industrial and academic setting. Moreover, the proposed Ph.D. program will attract both students and faculty from top-tier universities. Current and future Mines students will have access to said faculty and collaborate with said students on undergraduate and graduate research. Finally, the proposed Ph.D. program will allow faculty to attract larger research grants in support of Ph.D. level research. Strong research programs have both monetary and educational benefit throughout the entire spectrum of student body (from undergraduate through the Ph.D. programs).

Finally, with each department offering graduate-level courses based on their unique areas of expertise, when combined, the students within all three departments will see a significant increase in graduate course offerings. In addition, this will promote multidisciplinary collaborations between the departments, helping students gain an appreciation for multidisciplinary teams while focusing on a specific research question within their chosen field of study.

As outlined in Sections 1 & 2, the proposed Ph.D. program in Data Science and Engineering will benefit students from three different departments on the South Dakota Mines campus. While complementary in nature, the research expertise (and thus research thrusts) within each of the three departments are not necessarily overlapping. Student will have the opportunity to select from a wide range of Data Science applications and research. In particular, research thrusts within the Math department will focus more on computational statistics and time-series forecasting, Industrial Engineering will focus on game theory, dynamic programming, and operations research, and Computer Science will focus on machine learning, artificial intelligence, and network analysis. The three programs mentioned above are the only departments without a pathway to a Ph.D. degree program. So this opens the door to students who would not otherwise have the option to pursue their studies. In addition, the new Ph.D. program will help fully establish South Dakota Mines as a comprehensive STEM university and help move the campus to our goal of achieving an R2 Carnegie Classification (Doctoral University-High Research Activity).

5. Program Proposal Rationale:

A. If a new degree is proposed, what is the rationale[1]

No new degree is requested; South Dakota Mines is authorized to offer the Doctor of Philosophy (Ph.D.) degree.

B. What is the rationale for the curriculum?

Data Science and Engineering is a relatively new area of study that is extremely interdisciplinary in nature, therefore, the curriculum for most data science programs is highly dependent on the department from which the degree is being offered. For example, as outlined in "The 50 years of Data Science" [1], data science originated in Operations Research with heavy involvement from the Statistics community. As such, there are Ph.D. programs within either the Industrial Engineering community (Operations Research) or Mathematics Community (Computational Statistics). Over the last two decades, the field evolved to the Computer Science community with a focus on Machine Learning and Artificial Intelligence (generally this shift came about with the push toward computational cost associated with Big Data and Deep Learning). The proposed program for the Ph.D. in Data Science and Engineering at South Dakota Mines is (to the best of our knowledge) the first of its kind being offered in a truly collaborative fashion, with collaborations spanning Computer Science, Mathematics/Statistics, and Industrial Engineering/Operations Research. Historically, these three disciplines have laid the foundation for different aspects of the field. This level of collaboration is purposeful and intentional to both capitalize on efficiencies by utilizing existing faculty, facilities, and resources as well as leverage existing content expertise within those departments.

With the aforementioned details in mind, the South Dakota Mines Ph.D. program in Data Science and Engineering closely follows other existing Ph.D. programs offered on the South Dakota Mines campus. The curriculum provides a balance of coursework and dissertation credits while allowing for: 1) flexibility of individual plans of study; 2) the ability to develop depth of expertise; and 3) cross-disciplinary engagement and collaborations across three different departments on the South Dakota Mines campus. Such collaborations will allow for course sharing across all three departments, as well as several courses in related areas offered from a multitude of departments on the South Dakota Mines campus (outlined in Section 5-D below). In addition, such collaborations will enable shared access to experimental and laboratory resources by making these resources within each department available to a wider group of students and researchers. Finally, such collaborations will enable cross-disciplinary program committee members for student within the program itself. This approach will make optimal use of the state's investments in the public university system. The curriculum also allows for sufficient flexibility to accommodate the continually evolving areas of research within the data science and engineering community.

C. Demonstrate/provide evidence that the curriculum is consistent with current national standards.

Data Science is relatively new as an academic area. Nationally, curriculum in data science programs around the country vary drastically depending on which department the program is being administered from (as outlined in the table below). The proposed curriculum is headed towards the emerging standards seen in the leading accreditation organizations.

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[1] *"New Degree" means new to the university. Thus if a campus has degree granting authority for a Ph.D. program and the request is for a new Ph.D. program, a new degree is not proposed.*

The leading computer science accreditation organization is CSAB (csab.org). CSAB is the member society responsible for ABET Computing Accreditation Commission (CAC) accreditation. ABET-CAC is currently evaluating potential criteria for accreditation for baccalaureate programs named Data Science or similar (with CSAB as the lead society). The current timeline puts initial ABET CAC accreditation for a Data Science program in 2023-2024 review cycle. Obviously since ABET is focused on undergraduate programs this does not directly impact the proposed Ph.D. However, it is important to understand the relation between the proposed ABET curriculum and the proposed curriculum for the Ph.D. in Data Science and Engineering.

ABET is considering the following fundamental topics:

a) Data acquisition and representativeness
b) Data management
c) Data preparation and integration
d) Data analysis
e) Model development and deployment
f) Visualization and communication of the knowledge obtained from the data

and the following applied topics:

a) Data ethics including legitimate use and algorithmic fairness.
b) Governance including privacy, security, and stewardship
c) Statistics and mathematics including inference, modeling, linear algebra, probability and optimization
e) Computing including data structures and algorithms

The Ph.D. in Data Science and Engineering will cover these topics in the required courses: Introduction to Data Science and Engineering, Data Analysis, Optimization Techniques, and Seminar. Additional depth in these topics is gained in the electives courses. The mathematics, statistics, and computing content would be background content since this is common in science and engineering degree programs (which is the background for admission to the proposed PhD program). The core difference, which is discussed below, is that an undergraduate program will expect the student to gain mastery of the core topics above. A Ph.D. program will expect the student to develop new tools, methods and concepts which will eventually be added to the toolkit of the working data scientist. The difference with the Ph.D. is that B.S. degrees in related fields do not generally require the student to make original contributions to the field, conduct independent research, understand and evaluate current literature, etc., and those activities are the defining characteristics of a Ph.D. program.

Master's degree students are generally required to master a given research topic but not make original contributions to the field. As such, they may understand related literature but likely cannot critically evaluate said literature. Students in the proposed PhD program will be required to make a significant contribution to the field of Data Science and Engineering in addition to what would be required of a master's level student in a similar field. That said, ABET accredits undergraduate programs; therefore, we would expect the ABET outcomes to be different than the outcomes present for a Ph.D. program.

Another organization that is involved in data science certification and accreditation at the baccalaureate and master's level is DASCA. Requirements for the highest level of

certification would be covered by our curriculum, which include: Data Sciences, Machine Learning, Artificial Intelligence, Time Series, Predictive/Prescriptive Analytics, Information Technology, Computer Science, Mathematics, Statistics, Data Visualization, Data Mining, Data Warehousing and application domains. While neither ABET nor DASCA have identified accreditation standards for programs at the doctoral level, the proposed Ph.D. curriculum is consistent with the emerging standards they are pursuing, which is in alignment with where the field is moving.

As outlined in Section 5-B (above), the proposed Ph.D. in Data Science and Engineering is, to the best of our knowledge, the first of its kind being offered in a truly collaborative cross-disciplinary fashion with collaborations spanning Computer Science, Mathematics/Statistics, and Industrial Engineering/Operations Research. As such, there is no single curriculum in a nationally recognized Ph.D. program in Data Science that is an ideal comparison program. The "closest" model for the proposed curriculum is that of New York University's Ph.D. in Data Science (an NSF-NRT sponsored program) and is listed first in the table below.

South Dakota Mines chose to create a unique program due to the cross-disciplinary nature and collaboration of the proposed PhD degree. Nearly all other existing programs, while described as multidisciplinary, are housed and managed within a single program/department at their university. Our goal is a truly collaborative Ph.D. across the three aforementioned separate departments at the university.

While the proposed program curriculum is unique in South Dakota, the program curriculum is consistent with the emerging standards in data science around the nation. Within South Dakota, the closest Ph.D. program would be the Computational Statistics at SDSU. Computational Statistics is now a distinct academic discipline from data science. In addition, the program structure of the proposed Ph.D. (i.e., research credit, elective credit, core credits, and a series of examinations) is common among all Ph.D. programs in the table below (as well as on the South Dakota Mines campus). The core and elective credits have been chosen to be similar to the programs listed below when the program is being administered within either Math, Computer Science, or Industrial Engineering departments.

New York University	https://cds.nyu.edu/Ph.D.-curriculum-info/
Boise State University	https://www.boisestate.edu/computing/emphasis/data-science/data-science-phd/
Bowling Green State University	https://www.bgsu.edu/graduate/graduate-programs/data-science.html
Indiana University	https://soic.iupui.edu/degrees/data-science/data-science-phd/pos/
Stevens Institute of Technology	https://www.stevens.edu/school-business/business-phd-programs/phd-data-science/curriculum-overview
University of Southern California	https://www.marshall.usc.edu/programs/phd-program/departments/data-sciences-and-operations/requirements
University of Tennessee	https://bredesencenter.utk.edu/program-requirements-dse/
University of Washington	https://escience.washington.edu/education/phd/advanced-phd-data-science-option/
Worcester Polytechnic University	https://www.wpi.edu/academics/study/data-science-phd

D. Summary of the degree program (complete the following tables):

Ph.D. in Data Science and Engineering	Credit Hours	Percent
Required courses	12	15.2%
Electives	24	34.7%
Dissertation	36	50%
Total Required for the Degree Total	72*	100%

* Subject to approval of the student's graduate advisory committee and compliance with South Dakota Mines Graduate Education policies, students may apply up to 24 credits of coursework and up to 6 credits of research from a previous graduate study to the Ph.D. requirements.

Required Courses

Prefix	Number	Course Title *(add or delete rows as needed)*	Credit Hours	New (yes, no)
CSC	559	Introduction to Data Science and Engineering	3	Yes
MATH	543	Data Analysis	3	No
ENGM	535	Optimization Techniques	3	No
CSC	790	Seminar	3	No
CSC/IENG/MATH	898	Dissertation	36	No
		Subtotal	48	

Elective Courses:
The student may choose elective courses from the following lists of Computer Science, Industrial Engineering, Engineering Management, Mathematics, and other elective course options. The student's Graduate Advisory Committee must approve the selected elective courses the student plans to take in fulfillment of the Ph.D. requirements.

The following courses are available as **Computer Science electives** offered in the Computer Science and Computer Engineering department at South Dakota Mines.

It is important to note that six CSC courses in the chart are identified as being new (noted with an asterisk); however, they have been taught previously at South Dakota Mines under the "Topics" heading. As such, no course content was needed to be developed for these courses. There are only three truly new courses; CSC 745, CSC 780 and CSC 715 (which is cross-listed as IENG 715).

Prefix	Number	Course Title	Credit Hours	New (yes, no)
CSC	512	Cryptology	3	No
CSC	514	Introduction to Computer Vision	3	No
CSC	516	Advanced Algorithms for Robotics	3	No
CSC	517	Scientific Computing	3	Yes*
CSC	523	Computer Graphics Fundamentals	3	No
CSC	524	Digital Image Processing	3	No
CSC	526	Cybersecurity	3	No
CSC	540	Parallel Programming and Implementation	3	No

		for Science and Engineering		
CSC	541	Network and Data Communications	3	No
CSC	545	Theory of Computation	3	No
CSC	547	Artificial Intelligence	3	No
CSC	548	Machine Learning	3	No
CSC	549	Advanced Topics in artificial Intelligence	3	No
CSC	554	Data Mining Theory	3	No
CSC	568	Graphical User Interface Programming	3	No
CSC	576	Mobile Computing Development	3	No
CSC	578	Multimedia Security	3	No
CSC/IENG	715	Data Visualization	3	Yes
CSC	730	Anomaly Detection	3	Yes*
CSC	745	Bayesian Inference	3	Yes
CSC	752	Computer Vision	3	No
CSC	755	Reinforcement Learning	3	Yes*
CSC	757	Natural Computing	3	Yes*
CSC	760	Deep Learning	3	Yes*
CSC	761	Advanced Artificial Intelligence	3	No
CSC	775	Network Science	3	Yes*
CSC	780	Advanced Data Engineering	3	Yes

The following courses are available as **Industrial Engineering/Engineering Management electives** offered in the Industrial Engineering department at South Dakota Mines.

The courses IENG 420/520 and IENG 620 are identified as being new; however, they have previously been offered as "Topics" courses, so no curriculum development was needed for these two courses.

Prefix	**Number**	**Course Title**	**Credit Hours**	**New (yes, no)**
IENG	420/520	Game Theory Applications	3	Yes*
IENG	506	Occupational Biomechanics	3	No
IENG	515	Decision Analysis	3	No
IENG	555	Supply Chain Management and Logistics	3	No
IENG	620	Human Information Processing	3	Yes*
IENG/CSC	715	Data Visualization	3	Yes
IENG	735	Advanced Linear Programming	3	Yes
IENG	736	Nonlinear Optimization	3	Yes
IENG	737	Stochastic Programming	3	Yes
ENGM	615	Nonparametric Statistics	3	No
ENGM	621	Statistical Process Control	3	No
ENGM	663	Engineering Economics for Managers	3	No
ENGM	745	Forecasting for Business and Technology	3	No

The following courses are available as **Math electives** offered in the Mathematics department at South Dakota Mines.

Prefix	Number	Course Title	Credit Hours	New (yes, no)
MATH	513	Abstract Algebra	3	No
MATH	515	Advanced Linear Algebra	3	No
MATH	521	Complex Analysis	3	No
MATH	523	Advanced Calc I	3	No
MATH	532	Partial Differential Equations	3	No
MATH	547	Design of Experiments	3	No
MATH	551	Math Modeling	3	No
MATH	742	Mathematical Statistics	3	**Yes**
STAT	560	Time-Series Forecasting	3	No

The following courses are available as **other electives** offered in other departments at South Dakota Mines.

Prefix	Number	Course Title	Credit Hours	New (yes, no)
AES	519	High-Performance Computing in the Earth Sciences	3	No
AES	520	Remote Sensing for Research	3	No
AES	560	Atmospheric Dynamics I	3	No
AES	615	Earth Systems Modeling	3	No
AES	651	Measurement and Instrumentation	3	No
AES	660	Atmospheric Dynamics II	3	No
AES	744	Numerical Weather & Climate Prediction	3	No
EE	757	Intelligent Control Systems	3	No
EE	756	Advanced Linear Systems Theory	3	No
EE	655	Linear Systems Theory	3	No
EE	623	Random Signals and Noise	3	No
EE	621	Information and Coding Theory	3	No
GEOL	728	Linear Inverse Methods in Geology	3	No
ME	534	Sensors and Instrumentation	3	No
ME	555	Advanced Applications in Computational Mechanics	3	No
ME	673	Applied Engineering Analysis I	3	No
ME	773	Applied Engineering Analysis II	3	No
MES	600	Cyber-Physical-Social System for Understanding & Thwarting the Illicit Economy	1	No
PHYS	545	Statistical Mechanics	3	No
PHYS	581	Mathematical Physics	3	No
PHYS	777	Introduction to Quantum Information	3	No
PHYS	779	Group Theory	3	No

[1] "50 Years of Data Science", David Donoho, Journal of Computational and Graphical Statistics, 2017. Pre-Print available online: https://courses.csail.mit.edu/18.337/2015/docs/50YearsDataScience.pdf

6. Student Outcomes and Demonstration of Individual Achievement

A. What specific knowledge and competencies, including technology competencies, will all students demonstrate before graduation?

The proposed Ph.D. in Data Science and Engineering program objectives are to equip individuals to demonstrate the following knowledge and competencies before graduation:

1. Acquire and apply the knowledge and skills to make an original contribution to the field of Data Science and Engineering.
2. Conduct independent research within a supportive multidisciplinary framework.
3. Understand and critically evaluate the relevant literature in Data Science and Data Engineering.
4. Communicate relevant Data Science and Engineering principles and theories by written, oral, and visual means.
5. Apply Data Science and Engineering principles and procedures to the recognition, interpretation, and understanding of prior and current knowledge in the field.
6. Exhibit and appropriate awareness of and commitment to the ethical conduct of research.

	Program Courses that Address the Outcomes								
Individual Student Outcome (Same as in the text of the proposal)	CSC 570*	CSC 690*	Math 543*	IENG 579*	CSC/ Math/ IENG 798	Electives	Qual Exam	Comp Exam	Diss. Defense
1. Acquire and apply the knowledge and skills to make an original contribution to the field of Data Science and Engineering.	X		X		X				
2. Conduct independent research within a supportive multidisciplinary framework.					X		X	X	X
3. Understand and critically evaluate the relevant literature in Data Science and Data Engineering.	X		X		X	X			
4. Communicate relevant Data Science and Engineering principles and theories by written, oral, and visual means.	X	X	X		X	X		X	X
5. Apply Data Science and Engineering principles and procedures to the recognition, interpretation, and understanding of prior and current knowledge in the field.	X	X	X		X	X	X	X	X
6. Exhibit and appropriate awareness of and commitment to the ethical conduct of research.				X	X			X	X

B. Are national instruments (i.e., examinations) available to measure individual student achievement in this field? If so, list them.

While DASCA has not identified accreditation standards for programs at the doctoral level, the proposed Ph.D. curriculum is consistent with the emerging standards they are pursuing, which is in alignment with where the field is moving. As such, graduates of the proposed Ph.D. program would be eligible to sit for the DASCA Data Scientist Certification.

The DASCA Data Scientist certification is a robust industry recognizable certification that will be valuable for graduates to possess, and which could be incorporated as a component of the overall program assessment plan to ascertain student learning and achievement in the field.

C. How will individual students demonstrate mastery? Describe the specific examinations and/or processes used, including any external measures (including national exams, externally evaluated portfolios, or student activities, etc.). What are the consequences for students who do not demonstrate mastery?

Mastery will be demonstrated by assessing the outcomes identified in the previous table and adherence to the existing policies of the South Dakota Mines Graduate Education, particularly section VIII. Ph.D. Degree Requirements as outlined here:
https://ecatalog.sdsmt.edu/content.php?catoid=20&navoid=4466

The curriculum of the proposed program is rigorous. Students pursuing the Ph.D. will be required to complete 72 credit hours of coursework, approved by the student's Graduate Advisory Committee, with passing grades in each course and a 3.0 or better cumulative GPA. Students will also be required to demonstrate significant contributions to research, resulting in the production of an acceptable dissertation, covering original research, followed by an oral examination in defense of the dissertation.

Mastery of the material is ensured while working with the Graduate Advisory Committee to complete the coursework and the dissertation, and through performance on the written and/or oral examinations.

Advancement to Ph.D. candidacy will be based on satisfactory performance on a qualifying examination, coursework, and available information on research abilities and potential for success. The qualifying examination normally must be completed within the first two years of the Ph.D. program and is one of the best direct assessment instrument to measure student performance and mastery.

Students who exhibit unsatisfactory performance on the qualifying examinations may appeal for a second attempt. Such appeals will be evaluated and acted upon, as appropriate, by a committee of program faculty members.

7. What instructional approaches and technologies will instructors use to teach courses in the program?

In the proposed Ph.D. program in Data Science and Engineering, graduate courses can be taken from a variety of departments on the South Dakota Mines campus as per approval from the student's departmental advisor. Utilization of technology such as distance delivery (when needed, e.g., seminar) will be accomplished via. The Access Grid or the Dakota Digital Network (DDN) and D2L. In addition, faculty expertise at other regental institutions (e.g., DSU, SDSU, USD, etc.) may be drawn upon when appropriate to teach specialty courses in the program or to serve on graduate dissertation committees.

8. Did the University engage any developmental consultants to assist with the development of the curriculum? Did the University consult any professional or accrediting associations during the development of the curriculum? What were the contributions of the consultants and associations to the development of curriculum?

As Ph.D. programs in data science and engineering are relatively new with a wide array of curricular ideas, the university did not engage any developmental consultants to assist with the development of the curriculum. Moreover, there are no professional or accrediting associations to assist with the development of the curriculum.

In lieu of developmental consultants and/or accrediting associations, the university has consulted with numerous industry professionals working in the field of data science and data engineering to guide the curriculum: Brian Fehrman, Javier Arceo, Kate Lemay, and Shane Swedlund. In addition, the Computer Science and Engineering department (i.e., the administrating department of the proposed degree) aims to establish an Industrial Advisory Board to help steer data science and engineering curricular activities from the undergraduate specialization through Ph.D. to ensure alignment with current industry trends. Letters of support from key industry partners are attached in Appendix E.

Finally, while not directly aligned with data science and engineering, existing graduate programs at South Dakota Mines include components of foundational coursework that will nicely support the proposed PhD program. The graduate curriculum in the Computer Science and Engineering department is the Computer Science and Engineering (MS) program and it has a heavy emphasis on machine learning, data visualization, and data science. In addition, two graduate programs in the Industrial Engineering and Engineering Management department currently exist as Engineering Management (MS) and Industrial Engineering (MS) and each have a heavy emphasis on operations research, optimization, and data science. There is no current graduate curriculum in Mathematics at South Dakota Mines; however, undergraduate research trends within the department are largely in the areas of computational statistics and data science.

9. Are students enrolling in the program expected to be new to the university or redirected from other existing programs at the university? Complete the table below and explain the methodology used in developing the estimates (*replace "XX" in the table with the appropriate year*)?

	Fiscal Years*			
	1st	**2nd**	**3rd**	**4th**
Estimates	FY 23	FY 24	FY 25	FY 26
Students new to the university	2	1	2	2
Students from other university programs	2	1	1	1

Continuing students	0	4	6	9
=Total students in the program (fall)	4	6	9	12
Program credit hours (major courses)**	80	120	180	240
Graduates	0	0	0	3

**Do not include current fiscal year.*
***This is the total number of credit hours generated by students in the program in the required or elective program courses. Use the same numbers in Appendix B – Budget.*

10. Is program accreditation available? If so, identify the accrediting organization and explain whether accreditation is required or optional, the resources required, and the University's plans concerning the accreditation of this program.

None

11. Does the University request any exceptions to any Board policy for this program? Explain any requests for exceptions to Board Policy. *If not requesting any exceptions, enter "None."*

None

12. Delivery Location

A. Complete the following charts to indicate if the university seeks authorization to deliver the entire program on campus, at any off campus location (e.g., USD Community College for Sioux Falls, Black Hills State University-Rapid City, Capital City Campus, etc.) or deliver the entire program through distance technology (e.g., as an online program)?

	Yes/No	***Intended Start Date***
On campus	Yes	Fall 2022

	Yes/No	***If Yes, list location(s)***	***Intended Start Date***
Off campus	No	NA	Choose an item. Choose an item.

	Yes/No	***If Yes, identify delivery methods*** *Delivery methods are defined in AAC Guideline 5.5.*	***Intended Start Date***
Distance Delivery (online/other distance delivery methods)	No		Choose an item. Choose an item.
Does another BOR institution already have authorization to offer the program online?	No	**If yes, identify institutions:**	

B. Complete the following chart to indicate if the university seeks authorization to deliver more than 50% but less than 100% of the program through distance learning (e.g., as an online program)? *This question responds to HLC definitions for distance delivery.*

	Yes/No	*If Yes, identify delivery methods*	*Intended Start Date*
Distance Delivery (online/other distance delivery methods)	No	NA	Choose an item. Choose an item.

13. Cost, Budget, and Resources: Explain the amount and source(s) of any one-time and continuing investments in personnel, professional development, release time, time redirected from other assignments, instructional technology & software, other operations and maintenance, facilities, etc., needed to implement the proposed major. Address off-campus or distance delivery separately. *Complete Appendix B – Budget and briefly summarize to support Board staff analysis.*

The program budget is provided in Appendix B and is built on the understanding that existing resources (human and fiscal) must be utilized and no new funding is available. Much of the infrastructure and resources necessary to offer this program are in place. Sharing of courses and expertise between the CSE, Math, and IE programs at South Dakota Mines will allow for efficient use of resources. Existing university assistantship funds will be prioritized between the three departments to support Ph.D. students with teaching assistantships. Moreover, new faculty hires that are currently in the pipeline will be selected to support Ph.D. level research topics within the Data Science and Engineering space.

The 9-month FY21 salaries of eight total faculty at South Dakota Mines; four (4) in the CSE department, two (2) in the IE department, and two (2) in the MATH department were averaged arriving at $82,860. Those eight faculty are Drs. Hoover, Rebenitsch, Loveland, Akowuah, Dubey, Ha, Caudle, and Braman. Assuming each spends about 25% of their time on the program, we have an FTE amount of 2.0. It is very important to note that **this salary is not a new expense**; it is listed in the budget as an expense, then also an off-setting contribution by South Dakota Mines. The CSE, IE, and MATH departments will contribute a total of three (3) Graduate Teaching Assistants (GTAs) to the proposed PhD. The cost of the GTA is $26,744 each, so the total cost for GTAs is $80,232. This is reflected in the budget as a contribution from the university. We anticipate tenure-track faculty line and grant funding allocation (through NSF NRT and SDBOR Governor's Center Award) providing one full time Graduate Research Assistantship (4 years) – but this was not included in the budget.

Faculty members will continue to apply for external funding through federal agencies and industry collaboration to support Ph.D. level graduate students and acquire additional specialized laboratory equipment, research materials, and supplies as needed. Current funding through the National Science Foundation (multiple awards – including an extent cross-disciplinary NSF National Research Traineeship [1] involving Computer Science & Engineering and Industrial Engineering), the Department of Defense, and the SDBOR Governor's Center on modeling and disrupting the illicit economy currently has funds allocated for Ph.D. graduate students in the data science and engineering research space. An NSF Track 1 collaboration is currently in development anticipating the direction and official call April 2022. This effort would be directly in the area of data science and engineering to support the proposed Ph.D. as well as applications of data science and engineering across a multitude of disciplines within the state of South Dakota.

Any additional resources needed to bring the program to a level that is competitive with similar programs across the country (and similar degree offerings within the region) will be requested

from the university during the annual budgeting process. Additional graduate research assistantships, with competitive stipends, and operating funds, e.g., travel to funding agencies and conference, will increase faculty competitiveness leading to greater success in obtaining external funding, increasing potential for startups and spinoffs, and advertising for recruiting of new students to the university.

[1]https://www.nsf.gov/awardsearch/showAward?AWD_ID=1828462&HistoricalAwards=false

14. **Board Policy 2:1 states: "*Independent external consultants retained by the Board shall evaluate proposals for new graduate programs unless waived by the Executive Director.*" Identify five potential consultants (including contact information and short 1-2 page CVs) and provide to the System Chief Academic Officer (the list of potential consultants may be provided as an appendix). In addition, provide names and contact information (phone numbers, e-mail addresses, URLs, etc.) for accrediting bodies and/or journal editors who may be able to assist the Board staff with the identification of consultants.**

Appendix C contains a list of potential external independent consultants for the Board's consideration.

External Review of Proposed Ph.D.

The external consultants reviewed and evaluated the proposal and summarized their evaluation in a Report (Appendix F). South Dakota Mines was very pleased by the positive and supportive information contained in the report. The external consultants identified some recommendations for consideration, and we have made appropriate updates to the proposal to address the recommendations:

- **Recommendation 1: Enhance the Data Engineering content in the program**
  - University Action: Updated the title and content of Required course CSC 559 to include Data Engineering content. The updated course title is "Introduction to Data Science and Engineering".
  - University Action: Updated the title and content of an Elective course CSC 780 to include advanced Data Engineering content. The updated course title is "Advanced Data Engineering".
- **Recommendation 2: Include coursework in Visualization and Data Security**
  - University Action: Added in a new Elective course covering Data Visualization content. This course has been developed as a cross-listed course between the CSC and IE departments. In addition to being available to students in the proposed PhD program, it will also be available as an Elective course to students in the Computer Science and Engineering (MS), Industrial Engineering (MS), and Engineering Management (MS) programs.
  - University Action: Data Privacy and Security topics are of critical importance in the fields of Data Science and Engineering. As such crucial topics, content regarding privacy and security are embedded and covered in several courses throughout the curriculum. In addition to this embedded content across the curriculum, Data Security has been added as a topic within CSC 559. Additionally, the required number of Seminar credits has been increased from two to three credits (offset by a decrease in Elective credits from 25 to 24, for a net increase of 0 credits for the PhD program). The content of that increased Seminar credit will focus on ethics, which for computing professionals, includes Data Privacy and Security. The Association for Computing Machinery (ACM) has well-

documented ethical principles, including 1.6, 2.5, 2.9. which speak directly to the topics of Data Privacy and Security [1].

- **Recommendation 3: Offer a Data Science and Engineering (MS) degree that students could earn on their way to completing the PhD**
  - University Action: This is an exciting proposition, and one the university absolutely plans to consider in AY23/24 or AY24/25. While the idea of offering a Data Science and Engineering (MS) program is certainly appealing, the university wants to be judicious and pragmatic in an approach to doing so. Conducting additional research regarding employment opportunities and industry demand for master's level graduates, ascertaining student demand for master's level study, conducting appropriate analysis to ensure any new master's degree offering would draw in predominantly new students to the university (and not redirect a large number of existing students away from other South Dakota Mines graduate programs), and engage appropriate leadership (BOR, University Advisory Board, state and regional economic development agencies, etc.) to ensure a master's level offering is in alignment with strategic priorities.

[1] https://www.acm.org/code-of-ethics

15. Is the university requesting or intending to request permission for a new fee or to attach an existing fee to the program (*place an "X" in the appropriate box*)? *If yes, explain.*

[ ]	[x]
Yes	No

Explanation (if applicable):

16. New Course Approval: New courses required to implement the new graduate program may receive approval in conjunction with program approval or receive approval separately. Please check the appropriate statement:

[x] YES,
the university is seeking approval of new courses related to the proposed program in conjunction with program approval. All New Course Request forms are included as Appendix C and match those described in section 5D.

[ ] NO,
the university is not seeking approval of all new courses related to the proposed program in conjunction with program approval; the institution will submit new course approval requests separately or at a later date in accordance with Academic Affairs Guidelines.

17. Additional Information:

Please see attached letters of support from South Dakota industries expressing their strong support of the proposed Ph.D. program.

Appendix B: Budget Worksheet

South Dakota Mines, Ph.D in Data Science and Engineering

1. Assumptions		1st FY23	2nd FY24	3rd FY25	4th FY26
Headcount & hours from proposal					
Fall headcount (see table in proposal)		4	6	9	12
Program FY cr hrs, On-Campus		80	120	180	240
Program FY cr hrs, Off-Campus		0	0	0	0
Faculty, Regular FTE	See p. 3	*2.00*	*2.00*	*2.00*	*2.00*
Faculty Salary & Benefits, average	See p. 3	$103,096	$103,096	$103,096	$103,096
Faculty, Adjunct - number of courses	See p. 3	0	0	0	0
Faculty, Adjunct - per course	See p. 3	$5,000	$5,000	$5,000	$5,000
Other FTE (see next page)	See p. 3	*0.00*	*0.00*	*0.00*	*0.00*
Other Salary & Benefits, average	See p. 3	$32,380	$32,380	$32,380	$32,380

2. Budget				
Salary & Benefits				
Faculty, Regular	$206,192	$206,192	$206,192	$206,192
Faculty, Adjunct (rate x number of courses)	$0	$0	$0	$0
Other FTE	$0	$0	$0	$0
S&B Subtotal	$ 206,192	$ 206,192	$ 206,192	$ 206,192
Operating Expenses				
Travel	$0	$0	$0	$0
Contractual Services	$0	$0	$0	$0
Supplies & materials	$0	$0	$0	$0
Capital equipment	$0	$0	$0	$0
OE Subtotal	$0	$0	$0	$0
Total	**$ 206,192**	**$ 206,192**	**$ 206,192**	**$ 206,192**

3. Program Resources					
Off-campus support tuition/hr, HEFF net	GR	$399.05	$399.05	$399.05	$399.05
Off-campus tuition revenue	hrs x amt	$0	$0	$0	$0
On-campus support tuition/hr, HEFF net	GR	$287.49	$287.49	$287.49	$287.49
On-campus tuition revenue	hrs x amt	$22,999	$34,499	$51,749	$68,998
Program fee, per cr hr (if any)	$84.40	$6,752	$10,128	$15,192	$20,256
Delivery fee, per cr hr (if any)	$0.00	$0	$0	$0	$0
University redirections		$ 206,192	$ 206,192	$ 206,192	$ 206,192
Community/Employers		$0	$0	$0	$0
Grants/Donations/Other		$80,232	$80,232	$80,232	$80,232

Total Resources	**$316,175**	**$331,051**	**$353,365**	**$375,678**
Resources Over (Under) Budget	**$109,983**	**$124,859**	**$147,173**	**$169,486**

Provide a summary of the program costs and resources in the new program proposal.

Estimated Salary & Benefits per FTE		Faculty	Other
Estimated salary (average) - explain below		$82,860	$30,000
University's variable benefits rate	(see below)	0.1420	0.1420
Variable benefits		$11,766	$4,260
Health insurance/FTE, FY18		$8,470	$8,470
Average S&B		$103,096	$42,730

Explain faculty used to develop the average salary & fiscal year salaries used. Enter amount above.

The 9-month FY21 salaries of 4 people in the South Dakota Mines CSE department, 2 people in the South Dakota Mines IE department, and 2 people in the South Dakota Mines MATH Department were averaged. They are the tenured and tenure-track faculty (Drs. Hoover, Rebenitsch, Loveland, Akowuah, Dubey, Ha, Caudle, and Braman).

Explain adjunct faculty costs used in table:

0 courses per year to be taught by adjuncts at $5,000 per course (3cr*$1666.67/cr for Ph.D. terminal degree adjuncts).

Explain other [for example, CSA or exempt] salary & benefits. Enter amount above.

Staff expenses are covered by the three departments. Each department has a program assistant.

Summarize the operating expenses shown in the table:

Limited travel is currently provided to department faculty. Faculty have computational resources through the existing infrastructure in the Computer Science and Engineering department. It is expected that grants will cover additional travel, conferences, cloud computing time, etc.

Summarize resources available to support the new program (redirection, donations, grants, etc).

Cost estimates of university redirection/allocation of 3 full-time Graduate Teaching Assistantships.

State-support: Change cell on page 1 to use the UG or GR net amount.

Off-Campus Tuition, HEFF & Net	**FY19**	**HEFF**	**Net**

	Rate			
Undergraduate	$340.05	$39.11	**$300.94**	*Change cell on page 1*
Graduate	$450.90	$51.85	**$399.05**	*to point to your net*
Externally Supported	$40.00			

State-support: Change cell on page 1 to use the UG or GR net amount for your university.

	On-Campus Tuition, HEFF & Net	FY19 Rate	HEFF	Net	
	UG Resident - DSU, NSU	$243.30	$27.98	**$215.32**	*Change cell on page 1*
	UG Resident - SDSU, USD	$248.35	$28.56	**$219.79**	
	UG Resident - BHSU	$254.20	$29.23	**$224.97**	*to point to your net*
	UG Resident - SDSMT	$249.70	$28.72	**$220.98**	
	GR Resident - DSU,NSU	$319.40	$36.73	**$282.67**	*Change cell on page 1*
	GR Resident - SDSU, USD	$326.05	$37.50	**$288.55**	
	GR Resident - BHSU	$328.20	$37.74	**$290.46**	*to point to your net*
	GR Resident - SDSMT	$324.85	$37.36	**$287.49**	
	UG Nonresident - DSU,NSU	$342.40	$39.38	**$303.02**	*Change cell on page 1*
	UG Nonresident - BHSU	$355.70	$40.91	**$314.79**	*to point to your net*
	UG Nonresident - SDSU, USD	$360.50	$41.46	**$319.04**	
	UG Nonresident - SDSMT	$391.10	$44.98	**$346.12**	
x	GR Nonresident - DSU,NSU	$596.30	$68.57	**$527.73**	*Change cell on page 1*
x	GR Nonresident - BHSU	$612.40	$70.43	**$541.97**	*to point to your net*
x	GR Nonresident - SDSU, USD	$626.85	$72.09	**$554.76**	
x	GR Nonresident - SDSMT	$652.00	$74.98	**$577.02**	
	UG Sioux Falls Associate Degree	$275.40	$31.67	**$243.73**	*Change cell on page 1 to point to your net*

Variable Benefits Rates

University	FY19	
BHSU	14.64%	*Change the benefits rate cell in the table on page 2 to point to the rate for your university.*
DSU	14.36%	
NSU	14.31%	
SDSM&T	14.20%	
SDSU	14.38%	
USD	14.34%	

Rates updated February 2019 (JP)

Appendix C: New Course Requests

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Computer Science & Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 417/517	Scientific Computing	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

An introduction to current computational science with a focus on algorithmic development and implementation. Topics may include numerical linear algebra, interpolation, regression, nonlinear systems, optimization, Monte Carlo methods, finite difference methods, finite element methods, and multilevel methods.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?
((CSC 170	Programming for Engineers & Scientists	Pre-Req
Or CSC 115	Test Driven Development	Pre-Req)
	and	
Math 315	Linear Algebra	Pre-Req
Math 381	Introduction to Statistics	Pre-Req)
	Or	
ENGM 435/535	Optimization Techniques	Pre-Req

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**

If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
CSC 410/510	Parallel Computing	3
Math 415/515	Advanced Linear Algebra	3

Provide explanation of differences between proposed course and existing system catalog courses below:

CSC 410/510 is focused on improving performance through parallelization of algorithms but not necessarily on mathematical or scientific computations. Math 415/515 is focused on numerical solutions to mathematical problems but is not primarily concerned with computational issues. The proposed course has elements of the two comparable courses . This course falls between the two comparison courses and provide skills on performance oriented numerical algorithms.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form
Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating with current graduate electives.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Computer Science and Engineering

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: Fall 2022

3.6. Can students repeat the course for additional credit?

☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?

☐ Yes ☒ No

3.8. Will section enrollment be capped?

☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?

☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department Code: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 30.3001

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		Click here to enter a date.
Request Originator	**Signature**	**Date**
Jeff McGough		Click here to enter a date.
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.
   Large scale simulations and computations are core skills for many areas of science and engineering. This course is intended to offer to students, in a variety of disciplines, training in the standard tools in scientific computing.
2. Note whether this course is: ☐ Required ☒ Elective

3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A

4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. Students enrolled in the graduate section will be held to a higher standard.

5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Christer Karlsson, Associate Professor, PhD
   - Jeff McGough, Professsor, PhD

   Both faculty have backgrounds in computing, scientific computing and mathematics and are qualified to teach computation science at both undergraduate and graduate levels.
7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. Adequate.
9. Will the new course duplicate courses currently offered on this campus?
   ☐ Yes ☒ No

   If yes, provide justification.

10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Computer Science & Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 459/559	Introduction to Data Science and Engineering	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

This course will provide a hands-on introduction to Machine Learning, Data Science, and Data Engineering by developing familiarity with fundamental machine learning concepts and common programming tools such as Python, Jupyter, numpy, scipy, sci-kit learn, and Keras; as well an introduction to supervised, unsupervised and semi-supervised learning. Initial data pre-processing methods, data storage and conversion, data privacy and security will also be discussed. The course will focus on practical implementation through concrete examples and projects.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?
CSC 170	Programming for Engineers & Scientists	Pre-Req
	or	
CSC 215	Programming Techniques	Pre-Req
	and	
Math 381	Introduction to Statistics	Pre-Req

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
CSC 448/548	Machine Learning	3
CSC 454/554	Data Mining Theory	3

Provide explanation of differences between proposed course and existing system catalog courses below:

The proposed course will introduce the student to the tools used in Machine Learning and Data Mining. This course will focus on the software and tools which have become standard in the data science field and will not delve into the theory in the same manner as CSC 448/548 and CSC 454/554. This course is intended for a wide audience with the goal to provide data science skills to students outside computer science. CSC 448/548 and CSC 454/554 are aimed at computer science and computer engineering students.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating with current graduate electives.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Computer Science and Engineering

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 08/15/22

3.6. Can students repeat the course for additional credit?

☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?

☐ Yes ☒ No

3.8. Will section enrollment be capped?

☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?

☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department Code: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 30.7001

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		12/30/2021
Request Originator	**Signature**	**Date**
Jeff McGough		12/30/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.

Data Science is no longer the exclusive domain of mathematics and computer science. Machine Learning, Data Mining, Data Engineering and other related fields, collectively known as data science are important tools for many disciplines. The goal of this course is to introduce the standard tools used in data science to a much wider audience. Students can enroll in the course with a background course in Python and a course in Probability/Statistics and avoid the three semesters of computer science prerequisites required for the existing courses in machine learning and data mining. Nearly all science and engineering students will have the required prerequisites and so the course will be available to nearly all majors on campus.

2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. Students enrolled in the graduate section will be held to a higher standard.
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Randy Hoover, Associate Professor, PhD
   - Christer Karlsson, Associate Professor, Ph
   - Rohan Loveland, Assistant Professor, Ph
   - Jeff McGough, Professor, PhD

All four faculty members currently teach courses in Artificial Intelligence, Machine Learning and Data Science. These faculty are active in research in various subfields of machine learning and data science, and are qualified to teach this subject at the undergraduate and graduate levels.

7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. Library is adequate.
9. Will the new course duplicate courses currently offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Computer Science & Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 715	Data Visualization	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

This course introduces the concepts, tools, and techniques for the presentation and visual analysis of data based on principles from graphic design and cognitive science to enhance the understanding of large complex data sets. We will focus on aspects of visualization related to tabular high-dimensional data, graphs, text, and other formats. The course begins with background skills, then presents an overview of principles from perception and design, visualization concepts, and then will discuss current visualization methods and software. Students will acquire hands-on experience designing and implementing interactive visualizations using cutting edge visualization libraries.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
CSC 460	Scientific Visualization	3
INFS 776	Business Intel & Visualization	3

Provide explanation of differences between proposed course and existing system catalog courses below:

CSC 460 (DSU) is focused on the visualization of mathematical and scientific models. The proposed course will address large data sets which may not arise from mathematical models and may not be strictly numerical data. INFS 776 (DSU) focuses on business applications. The proposed course will focus on concepts and methods in visualization common across engineering, science and business.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating existing graduate courses

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Computer Science and Engineering

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 08/15/2022

3.6. Can students repeat the course for additional credit?

☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?

☐ Yes ☒ No

3.8. Will section enrollment be capped?

☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☒ Yes ☐ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title
IENG 715	Data Visualization

3.10. Is this prefix approved for your university?

☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department Code: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 30.7103

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		4/13/2022
Request Originator	**Signature**	**Date**
Jeff McGough		4/13/2022
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.

Data Visualization refers to a collection of methods and tools to present, understand and analyze complex data sets. It is essential in all data intensive applications across engineering, science, business and health care. This course will serve all campus research groups that have data analysis needs.

2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Christer Karlsson, Associate Professor, PhD
   - Rohan Loveland, Assistant Professor, PhD
   - Jeff McGough, Professor, PhD
   - Lisa Rebenitsch, Assistant Professor, PhD
   - Jeff Wolstad, Professor, PhD

Dr. Wolstad has taught visualization courses previously. Drs Hoover, Karlsson, Loveland and McGough work in machine learning / data science and have extensive professional experience with analysis and visualization of large data sets.

7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. Course will utilize what is available.
9. Will the new course duplicate courses currently offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	Computer Science and Engineering
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 730	Anomaly Detection	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

The course will address anomaly detection in various types of data, ranging from single to high dimensionality, over a range of modalities. Topics will include current research developments in active and semi-supervised machine learning systems, including addressing the problems of developing high accuracy multi-class classifiers and finding rare, previously unknown classes in large datasets. The course will include both theory and a number of projects applying these techniques to a variety of real-world datasets.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
CSC 447/547	Artificial Intelligence	3
CSC 448/548	Machine Learning	3

Provide explanation of differences between proposed course and existing system catalog courses below:

Both Artificial Intelligence and Machine Learning will address supervised and unsupervised learning. Semi-supervised and active learning methods are not addressed in these courses, but are gaining ground in the Machine Learning area due to the increasing availability of large datasets containing unknown categories.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating with existing graduate courses.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.):

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture
If requesting an instructional method that is exempt from the Section Size Guidelines, please provide a brief description of how the course is appropriate for the instructional method, as defined in AAC Guidelines.

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 8/15/2022

3.6. Can students repeat the course for additional credit?
☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?
☐ Yes ☒ No

3.8. Will section enrollment be capped?
☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No
If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?
☒ Yes ☐ No
If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 30.7101

Is this a new CIP code for the university? ☐ Yes ☒ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		Click here to enter a date.
Request Originator	**Signature**	**Date**
Jeff McGough		Click here to enter a date.
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.
   Increasingly large datasets are becoming available which contain too many samples for domain experts to individually review, and these datasets often include categories which are anomalous/rare. In these cases standard Machine Learning supervised classifiers are insufficient. This course will cover the semi-supervised and active learning paradigms, which are instrumental for the detection and development of classifiers for anomalous/rare categories.

2. Note whether this course is: ☐ Required ☒ Elective

3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20

6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
7. Note whether adequate facilities are available and list any special equipment needed for the course. No special facilities required.
8. Note whether adequate library and media support are available for the course. Library is adequate.
9. Will the new course duplicate courses currently being offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined.
11. Add any additional comments that will aid in the evaluation of this request.

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Computer Science & Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 745	Bayesian Inference	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

This course focuses on the Bayesian inferential methods with emphasis on theory and applications. The recent developments of computational tools have brought Bayesian treatment of complex problems within the reach of practicing data scientists. This course will illustrate a variety of theoretical and computational methods, simulation techniques, and hierarchical models suitable for analyzing complex data. Broad topics include advanced Monte Carlo methods, asymptotic theories, adaptive methods, Bayesian nonparametrics, and POMDPs.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
STAT 553	Applied Bayesian Statistics	3
STAT 752	Advanced Data Science	3

Provide explanation of differences between proposed course and existing system catalog courses below:

STAT 553 focuses more on applications of Bayesian inference whereas the proposed course focuses more on the theoretical aspects of Bayesian inference and Bayesian classifiers. STAT 752 provides an overview of Bayesian stats as a sub-topic in the data science curriculum whereas the proposed course provides an in-depth coverage of the topic of Bayesian reasoning, inference, and classifiers.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating with existing graduate courses.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Computer Science and Engineering

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 08/15/2022

3.6. Can students repeat the course for additional credit?
☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?
☐ Yes ☒ No

3.8. Will section enrollment be capped?
☐ Yes, max per section: 20 ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?
☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department Code: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 27.0501

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		12/30/2021
Request Originator	**Signature**	**Date**
Jeff McGough		12/30/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.
   This course will bring Bayesian methods to the Data Science curriculum. It will enhance the toolkit for graduate students in data science, data engineering and in fields requiring additional computation tools.

2. Note whether this course is: ☐ Required ☒ Elective

3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20

6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Randy Hoover, Associate Professor, PhD
   - Christer Karlsson, Associate Professor, PhD
   - Larry Pyeatt, Associate Professor, PhD
7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. Library is adequate.
9. Will the new course duplicate courses currently offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Computer Science & Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 755	Reinforcement Learning	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

This course introduces students to one of the main Machine Learning paradigms where an intelligent software agent takes actions and interacts with the world in order to maximize rewards. Understanding the importance and challenges of learning agents that make decisions is of vital importance today, with more and more companies interested in interactive agents and intelligent decision-making.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
CSC 447/547	Artificial Intelligence	3
CSC 448/548	Machine Learning	3

Provide explanation of differences between proposed course and existing system catalog courses below:

Both Artificial Intelligence and Machine Learning will address supervised and unsupervised learning. Reinforcement learning, the third major machine learning paradigm is not normally addressed in these courses.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating with existing graduate courses.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Computer Science and Engineering

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 08/15/2022

3.6. Can students repeat the course for additional credit?

☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?

☐ Yes ☒ No

3.8. Will section enrollment be capped?

☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?

☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department Code: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 30.7101

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		12/30/2021
Request Originator	**Signature**	**Date**
Jeff McGough		12/30/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.

Reinforcement Learning and Deep Reinforcement Learning are fundamental topics and have emerged as front runners in data science, machine learning, and artificial intelligence research. The course will enhance both the breadth of study for future PhD level students in Data Science and Engineering as well as enhance individual research foci in and around learning from failure (a fundamental step toward building computational intelligence).

2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Randy Hoover, Associate Professor, PhD
   - Rohan Loveland, Assistant Professor, PhD
   - Jeff McGough, Professor, PhD
   - Larry Pyeatt, Associate Professor, PhD

All four of these faculty currently work in Machine Learning. Dr. Pyeatt has specialized in reinforcement learning for two decades.

7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. The library is adequate.
9. Will the new course duplicate courses currently offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Computer Science & Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 757	Natural Computing	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

The course will address two of the major themes found in Natural Computing: biologically inspired algorithms and simulation of natural systems. The course will survey Simulated Annealing, Evolutionary Algorithms, Artificial Neural Networks, Swarms, and Cellular Automata. This course will model and simulate natural systems in order to solve problems which have eluded traditional solution methods.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
CSC 447/547	Artificial Intelligence	3
CSC 448/548	Machine Learning	3

Provide explanation of differences between proposed course and existing system catalog courses below:

The Artificial Intelligence (AI) and Machine Learning (ML) courses will touch on Neural Networks and may discuss Genetic Algorithms. Simulated Annealing, Swarms, Immune Systems and others are normally not addressed. The intent of the proposed course is on developing novel algorithms using inspiration in nature. The AI and ML courses will focus more on the mathematical theory and algorithmic properties of the techniques under examination. Natural Computing focuses on the extraction of new algorithms and their relationship to the natural sciences.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating with other graduate courses.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Computer Science and Engineering

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 08/15/2022

3.6. Can students repeat the course for additional credit?

☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?

☐ Yes ☒ No

3.8. Will section enrollment be capped?

☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?

☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department Code: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 11.0102

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		12/30/2021
Request Originator	**Signature**	**Date**
Jeff McGough		12/30/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.
   Natural Computing is a field which mimics processes in nature to create novel algorithms which apply to problems which elude traditional solution techniques. It brings together researchers in biology, physics, chemistry with those in computing. Artificial Neural Networks, Evolutionary Algorithms, Swarms and Artificial Immune Systems are examples of bio-inspired algorithms. These tools comprise a significant component of modern machine learning. This course will give graduate students the background required to develop algorithms from processes found in nature.
2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Randy Hoover, Associate Professor, PhD
   - Christer Karlsson, Associate Professor, PhD
   - Jeff McGough, Professor, PhD

   Dr. McGough has taught this in the AI Topics course several times. He is currently active in bio-inspired computing research.
7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. Library is adequate.
9. Will the new course duplicate courses currently offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Computer Science & Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 758	Planning Algorithms	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

This course covers the theory and practice of motion planning. It unifies approaches found in artificial intelligence, machine learning, robotics and control theory. The course will address discrete and continuous spaces, planning under uncertainty, sample based planning, decision theory, configuration spaces and constrained planning.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
CSC 447/547	Artificial Intelligence	3
CSC 448/548	Machine Learning	3

Provide explanation of differences between proposed course and existing system catalog courses below:

The Artificial Intelligence (AI) and Machine Learning (ML) courses will address some basic concepts in search and optimization which can be applied to path planning. These courses do not address the theory of planning, the diversity of planning approaches, motion planning algorithms, probabilistic or sample based methods or planning under uncertainty.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating with other graduate courses.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Computer Science and Engineering

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 08/15/2022

3.6. Can students repeat the course for additional credit?

☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?

☐ Yes ☒ No

3.8. Will section enrollment be capped?

☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?

☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department Code: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 11.0102

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		12/30/2021
Request Originator	**Signature**	**Date**
Jeff McGough		12/30/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.
   Recent advances in Artificial Intelligence, Machine Learning, Robotics and Controls have seen a convergence in approaches to motion planning. Planning Algorithms is the emerging field that addresses the common challenges of path planning, routing, navigation and control. This course will bring together tools from search, optimization, computational geometry, machine learning, reinforcement learning, Markov methods and sample based methods to address the current engineering challenges.
2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Jeff McGough, Professor, PhD
   - Christer Karlsson, Associate Professor, PhD
   - Larry Pyeatt, Associate Professor, PhD

   Dr. McGough has taught elements of motion planning in CSC 416/516.
7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. Library is adequate.
9. Will the new course duplicate courses currently offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Computer Science & Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 760	Deep Learning	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

The course will cover a range of topics from basic neural networks, convolutional and recurrent network structures, deep unsupervised and reinforcement learning, and applications to problem domains like speech recognition and computer vision.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
CSC 447/547	Artificial Intelligence	3
CSC 448/548	Machine Learning	3

Provide explanation of differences between proposed course and existing system catalog courses below:

CSC 447/547 covers a wide range of classic AI algorithms (A*, binary search, etc.) with a brief introduction to classic neural network theory. CSC 448/548 covers a wide range of traditional machine learning approaches based on unsupervised, supervised, and semi-supervised learning. Neural networks are generally not discussed in 448/548.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating graduate courses

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Computer Science and Engineering

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 08/15/2022

3.6. Can students repeat the course for additional credit?

☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?

☐ Yes ☒ No

3.8. Will section enrollment be capped?

☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?

☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department Code: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 11.0102

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		12/30/2021
Request Originator	**Signature**	**Date**
Jeff McGough		12/30/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.
   Deep learning is one of the most powerful tools to emerge in machine learning in several decades. It has found applications in engineering, science, business and art. This course will serve all campus research groups that have data science needs which transcend the more traditional statistical and data science toolkit.
2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Randy Hoover, Associate Professor, PhD
   - Christer Karlsson, Associate Professor, PhD
   - Rohan Loveland, Assistant Professor, PhD
   - Jeff McGough, Professor, PhD

   All four faculty members currently teach courses in Artificial Intelligence, Machine Learning and Data Science. These faculty are active in research in various subfields of machine learning and data science, and are qualified to teach this subject at the undergraduate and graduate levels.
7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. The library is adequate
9. Will the new course duplicate courses currently offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Computer Science & Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 775	Network Science	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

This course aims to investigate the topology and dynamics of complex networks, aiming to better understand the behavior, function, and properties of the underlying systems. The primary focus will be the study of algorithmic, computational, and statistical methods of network science, as well as applications in communications, biology, ecology, brain science, sociology and economics.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
Math 551	Math Modeling	3
Stat 560	Time Series Analysis	3

Provide explanation of differences between proposed course and existing system catalog courses below:

While both math modeling and time series analysis techniques will be used to uncover dynamics in time-varying graphs/networks, these topics are only a small fraction of what will be covered in the proposed course. Neither delve into aspects of centrality, connected sets, community evolution, and multi-graph modeling on dynamic spatiotemporal data.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Computer Science and Engineering

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 08/15/2022

3.6. Can students repeat the course for additional credit?

☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?

☐ Yes ☒ No

3.8. Will section enrollment be capped?

☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?

☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department Code: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 11.0701

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		12/30/2021
Request Originator	**Signature**	**Date**
Jeff McGough		12/30/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.
   Current campus research in human and drug trafficking, and supply chains all use network models. This course will provide the core tools for students to contribute to the current research efforts.
2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Randy Hoover, Associate Professor, PhD
   - Kyle Caudle, Associate Professor, PhD

Both faculty members work machine learning techniques applied to network models and are qualified to teach this content at the graduate level.

7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. The library is adequate.
9. Will the new course duplicate courses currently offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Computer Science & Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
CSC 780	Advanced Data Engineering	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

This course provides an overview of the techniques and tools in Data Engineering. It introduces students to Big Data applications. Topics include how to clean and manipulate large data sets, design and develop applications using common industry tools, and utilize other Big Data ecosystem components to manipulate, analyze and perform computations on Big Data.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
CSC 454/554	Data Mining Theory	3
CSC 486/586	Data Mining Methods	3

Provide explanation of differences between proposed course and existing system catalog courses below:

Both Data Mining Theory (SDSMT) and Data Mining Methods (DSU, USD) are concerned with large data sets but focus on concepts and algorithms, and not on applications. The proposed course will focus on applications and tools.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating existing graduate courses

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Computer Science and Engineering

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 08/15/2022

3.6. Can students repeat the course for additional credit?

☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?

☐ Yes ☒ No

3.8. Will section enrollment be capped?

☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?

☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department Code: CSC

4.2. Banner Department Code: MCSC

4.3. Proposed CIP Code: 30.7001

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		12/30/2021
Request Originator	**Signature**	**Date**
Jeff McGough		12/30/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.

   Data Engineering refers to a collection of methods and tools to preprocess data required by machine learning algorithms. It is essential in all big data applications across engineering, science, business and health care. This course will serve all campus research groups that have data science needs.
2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Randy Hoover, Associate Professor, PhD
   - Christer Karlsson, Associate Professor, PhD
   - Rohan Loveland, Assistant Professor, PhD

   The three faculty members currently teach courses in Artificial Intelligence, Machine Learning and Data Science. These faculty are active in research in various subfields of machine learning and data science, and are qualified to teach this subject at the undergraduate and graduate levels.
7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. Course will utilize what is available.
9. Will the new course duplicate courses currently offered on this campus?

   ☐ Yes ☒ No

   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Industrial Engineering/IENG**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
IENG 420/520	Game Theory Applications	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

A rational agent or player maximizes their own payoff, an assumption on which several artificial and human intelligence systems are designed. Students of this class will learn to model gaming scenarios by applying theoretical concepts in coalitional game theory and competitive games to large data sets with the intent to develop decision support tools to understand how rational players would act in presence of competitive and collaborative agents. These scenarios will be used to study actions of players or decision centers in infrastructure security, transportation, autonomous systems, and competition among technical organizations.
Students enrolled in IENG 520 will be held to a higher standard than those enrolled in IENG 420.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?
IENG/MATH 381	Introduction to Probability and Statistics	Pre-Req

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
MATH 282	Mathematics of Games	3
ECON 465/565	Game Theory	3

Provide explanation of differences between proposed course and existing system catalog courses below:

The proposed game theory course focuses entirely on the application of classical game theory concepts to the area of machine learning rooted in probability and statistics. The domain of MF focuses on collection and analysis of large data sets to predict and forecast behavior of decision-making entities. The integration of decision sciences and statistics-based utility function development using large data sets are generally not covered in any existing courses, and this course will be key for students interested in integrating data driven decision making into existing system architecture. Model development and programming tools needed for simulation of rational behavior among autonomous and non-autonomous systems will be the focus of this course. Existing courses do not provide the same emphasis on employing data mining techniques on large data sets in order to design systems that are capable of making binary decisions using incentives and disincentives present in the modeling environment.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form
Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below:
Course will be offered as a rotating elective course and can be managed within existing instructional resources

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.):
Will be used as electives in the IEEM B.S. program, in the IENG and ENGM M.S. programs, and the upcoming PhD in Data Science and Engineering program.

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: Lecture (R)
If requesting an instructional method that is exempt from the Section Size Guidelines, please provide a brief description of how the course is appropriate for the instructional method, as defined in AAC Guidelines.

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*:
001 Face-to-face Term Based Instruction
018 Internet Synchronous
015 Internet Asynchronous – Term Based Instruction

3.5. Term change will be effective: Fall 2022

3.6. Can students repeat the course for additional credit?
☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?
☐ Yes ☒ No

3.8. Will section enrollment be capped?
☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No
If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?
☒ Yes ☒ No
If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department: IENG

4.2. Banner Department Code: MIND

4.3. Proposed CIP Code: 27.501

Is this a new CIP code for the university? ☐ Yes ☒ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Saurav Kumar Dubey	Saurav	12/14/2021
Request Originator	**Signature**	**Date**
Jeff Woldstad	Jeffrey L. Woldstad	12/14/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.
   The following will teach upper level undergraduate and graduate students about concepts in decision sciences where competitive and collaborative actions need to be considered. The utilities or benefits of decision made by players or agents will be quantified using probabilistic and deterministic mathematical functions. More importantly, this course will teach students to design statistical utility functions from large data sets. These functions will seek to provide insight into predicted behaviors of autonomous and non-autonomous engineering systems. This course is intended at the 400/500 level. It will be used to meet elective requirements in the BS IEEM, as M.S. electives in IENG, and ENGM, as well as an elective in an upcoming PhD in Data Science and Engineering Program.
2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course?
   - **Ph.D. in Data Science**
   - **M.S. in Industrial Engineering**
   - **M.S. in Engineering Management**
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made.

Students taking the graduate version (520) will be held to a higher standard than those in 420, including but not limited to, literature-related research and project leadership responsibilities.

5. Desired section size **40**
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Saurav Kumar Dubey, Assistant Professor, PhD in Industrial Engineering
7. Note whether adequate facilities are available and list any special equipment needed for the course. **The course will use existing classroom facilities for lectures, with occasional visits to existing laboratories for demonstration purposes and project support. No new equipment will be needed.**
8. Note whether adequate library and media support are available for the course.
   The library and media support available for all courses will be sufficient.
9. Will the new course duplicate courses currently being offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification:
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined.
11. Add any additional comments that will aid in the evaluation of this request.

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

Affected Departments Form

The purpose of this document is to ensure that curriculum changes in one department that alter courses required or commonly taken by other documents get timely notification and the ability to discuss the changes with the originating department if necessary.

This document applies (1) to changes to existing courses and (2) to program-level curriculum changes. New course requests do not typically have an effect on other departments, except through program-level curriculum change.

1. Changes to Existing Courses

☐ No students from other departments take this course
No further action is needed.

☒ No other departments require this course, but students from other departments take this course
From which departments Mathematics, Computer Science and Engineering and Industrial Engineering

In general, such a change is relatively minor to the affected department, typically being related to inclusion of the course in a list of course from which some number of courses must be selected.

Please attach documents showing notification and any response from the affected department. If no response has been received within 5 working days during the spring or fall semester this may be treated as agreement with the change.

☐ Other departments require this course
Which departments: _____

In general, such a change can be a major alteration to the affected department, and, as such, significant discussion may occur.

Please attach documents showing notification and any response from the affected department. If no response has been received within 5 working days this may be treated as agreement with the change.

NOTE: If more than three (3) departments require this course, notification and discussion through ALC/Department Head meetings should occur, so that noting when the change was discussed at such meetings is sufficient.

2. Program Level Curriculum Changes

Program level changes can affect other departments, for instance with respect to staffing levels, removing a required course from your curriculum or adding/removing a course in a list of possible electives can affect how many course sections are needed

☐ Course changes do not affect any other departments
No further action is needed.

☐ Course changes affect other departments through changes in elective courses: Which departments _____

In general, such a change is relatively minor to the affected department but may still have minor affects.

Please attach documents showing notification and any response from the affected department. If no response has been received within 5 working days during the spring or fall semester this may be treated as agreement with the change.

☐ Course changes affect other departments through changes in required courses

Which departments _____

In general, such a change can be a major alteration to the affected department, and, as such, significant discussion may occur.

Please attach documents showing notification and any response from the affected department. If no response has been received within 5 working days this may be treated as agreement with the change.

NOTE: If more than three (3) departments require this course, notification and discussion through ALC/Department Head meetings should occur, so that noting when the change was discussed at such meetings is sufficient.

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Industrial Engineering**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
IENG 620	Human Information Processing	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

Mathematical models of human perception, cognition, and motor function. Topics include: Turing machines and automata, psychophysics, signal detection theory, information theory, problem solving and decision making, and movement control.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
PSYC 533	Psychology of Human Performance	3
PSYC 536	Human Performance	3

Provide explanation of differences between proposed course and existing system catalog courses below:

The proposed course will focus much more heavily on mathematical models of human performance and behavior. The intended audience is engineers and computer scientists who have an interest in psychology and human performance.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form
Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below:

Course will be offered as a rotating elective course and can be managed using existing instructional resources.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.):

- Ph.D. in Data Science (pending)
- M.S. in Industrial Engineering (current)
- M.S. in Engineering Management (current)

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: Lecture-R
If requesting an instructional method that is exempt from the Section Size Guidelines, please provide a brief description of how the course is appropriate for the instructional method, as defined in AAC Guidelines.

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*:
001- Face-to-face Term Based Instruction
018- Internet Synchronous

3.5. Term change will be effective: Fall 2022

3.6. Can students repeat the course for additional credit?
☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?
☐ Yes ☒ No

3.8. Will section enrollment be capped?
☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No
If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?
☒ Yes ☐ No
If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

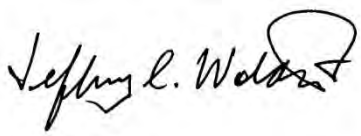
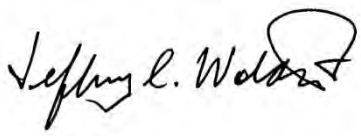
4.1. University Department: IENG

4.2. Banner Department Code: MIND

4.3. Proposed CIP Code: 11.0401

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeffrey C. Woldstad		12/21/2021
Request Originator	**Signature**	**Date**
Jeffrey C. Woldstad		12/21/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.

This course has been taught once as a special topics course. It provides needed instruction on human performance and computation within the Industrial Engineering, Engineering Management and Data Science graduate curriculums.

2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course?
   - Ph.D. in Data Science
   - M.S. in Industrial Engineering
   - M.S. in Engineering Management
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Jeffrey C. Woldstad, Professor and Department Head, Ph.D. in Industrial and Operations Engineering and Psychology
7. Note whether adequate facilities are available and list any special equipment needed for the course. Adequate facilities are available. No special equipment is needed.
8. Note whether adequate library and media support are available for the course. Adequate library and media support is available.
9. Will the new course duplicate courses currently being offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request.

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Industrial Engineering and Engineering Management**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
IENG 715	Data Visualization	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

This course introduces the concepts, tools, and techniques for the presentation and visual analysis of data based on principles from graphic design and cognitive science to enhance the understanding of large complex data sets. We will focus on aspects of visualization related to tabular high-dimensional data, graphs, text, and other formats. The course begins with background skills, then presents an overview of principles from perception and design, visualization concepts, and then will discuss current visualization methods and software. Students will acquire hands-on experience designing and implementing interactive visualizations using cutting edge visualization libraries.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
CSC 460	Scientific Visualization	3
INFS 776	Business Intel & Visualization	3

Provide explanation of differences between proposed course and existing system catalog courses below:

CSC 460 (DSU) is focused on the visualization of mathematical and scientific models. The proposed course will address large data sets which may not arise from mathematical models and may not be strictly numerical data. INFS 776 (DSU) focuses on business applications. The proposed course will focus on concepts and methods in visualization common across engineering, science and business.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below: Course will be taught on a planned rotational basis alternating existing graduate courses.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.): Industrial Engineering and Engineering Management

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: R Lecture

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*: 001 Face to Face

3.5. Term change will be effective: 08/15/2022

3.6. Can students repeat the course for additional credit?
☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?
☐ Yes ☒ No

3.8. Will section enrollment be capped?
☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☒ Yes ☐ No

If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title
CSC 715	Data Visualization

3.10. Is this prefix approved for your university?
☒ Yes ☐ No

If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

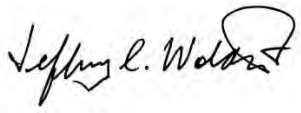
4.1. University Department Code: IENG

4.2. Banner Department Code: MIND

4.3. Proposed CIP Code: 30.7103

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Jeff McGough		4/13/2022
Request Originator	**Signature**	**Date**
Jeff Woldstad		4/13/2022
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.

Data Visualization refers to a collection of methods and tools to present, understand and analyze complex data sets. It is essential in all data intensive applications across engineering, science, business and health care. This course will serve all campus research groups that have data analysis needs.

2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? N/A
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Christer Karlsson, Associate Professor, PhD
   - Rohan Loveland, Assistant Professor, PhD
   - Jeff McGough, Professor, PhD
   - Lisa Rebenitsch, Assistant Professor, PhD
   - Jeff Wolstad, Professor, PhD

Dr. Wolstad has taught visualization courses previously. Drs Hoover, Karlsson, Loveland and McGough work in machine learning / data science and have extensive professional experience with analysis and visualization of large data sets.

7. Note whether adequate facilities are available and list any special equipment needed for the course. Facilities and equipment are adequate.
8. Note whether adequate library and media support are available for the course. Course will utilize what is available.
9. Will the new course duplicate courses currently offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request. N/A

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	Industrial Engineering
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
IENG 735	Advanced Linear Programming	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

Advanced topics in linear programming and convex optimization including theory, applications, and algorithms. Topics include convex sets and functions, geometry of linear programming, simplex method, duality theory, decomposition methods, interior-point methods, integer programming, and convex optimization. Several applications arising in data science, machine learning, artificial intelligence, and operations research will be discussed.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?
ENGM 535	Optimization Techniques	Pre-Req

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
MATH 675	Operations Research II	3
MATH 735	Numerical Modelling	3

Provide explanation of differences between proposed course and existing system catalog courses below:

The proposed course is similar to MATH 675, however, it will focus solely on linear optimization and will not consider other types of problems. In addition, the proposed course will apply these methods to problems associated with machine learning, signals and image processing, and large data sets.. Furthermore, optimization programming will be used throughout the proposed course.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below:

This course will be offered as a rotating elective course and can be managed within existing instructional resources.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.):

B.S. in Industrial Engineering and Engineering Management
M.S. in Industrial Engineering
M.S. in Engineering Management

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: Lecture - R
If requesting an instructional method that is exempt from the Section Size Guidelines, please provide a brief description of how the course is appropriate for the instructional method, as defined in AAC Guidelines.

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*:
The delivery method will be primarily face-to-face/live (001) instruction.

3.5. Term change will be effective: Fall 2022

3.6. Can students repeat the course for additional credit?
☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?
☐ Yes ☒ No

3.8. Will section enrollment be capped?
☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No
If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?
☒ Yes ☐ No
If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department: IENG

4.2. Banner Department Code: MIND

4.3. Proposed CIP Code: 27.501

Is this a new CIP code for the university? ☐ Yes ☒ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Hyeong Suk Na	Hyeong Suk Na	12/13/2021
Request Originator	**Signature**	**Date**
Jeffrey Woldstad	Jeffrey L. Woldstad	Click here to enter a date.
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.

Advanced linear programming has become a major emphasis in applications spanning data science, engineering, mathematics, and computer science. It is a class of problems for which there are both theoretically and practically fast and robust optimization techniques. Following the trend of linear programming, ever-larger groups of problems in a wide range of fields are being discovered as belonging to this class. However, there is currently no course available in the Ph.D. in Data Science curriculum to introduce graduate students to these techniques. This course will provide a comprehensive coverage of the theoretical foundation and numerical algorithms for advanced linear programming or convex optimization to prepare for more advanced coursework and research in this growing area of interest for engineers and scientists.

2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course?
   - Ph.D. in Data Science
   - M.S. in Industrial Engineering
   - M.S. in Engineering Management
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made.
5. Desired section size 30
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Suarav Kumar Dubey, Assistant Professor, Ph.D. in Industrial Engineering
   - Lin Guo, Assistant Professor, Ph.D. in Industrial Engineering
   - Hyeong Suk Na, Assistant Professor, Ph.D. in Industrial Engineering
7. Note whether adequate facilities are available and list any special equipment needed for the course. Traditional classroom facilities will be required with no special equipment needed.
8. Note whether adequate library and media support are available for the course. Adequate
9. Will the new course duplicate courses currently being offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request.

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Industrial Engineering**	
Institution	**Division/Department**	
		12/13/2021
Institutional Approval Signature		**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
IENG 736	Nonlinear Programming	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

Formulating, solving, and understanding nonlinear optimization problems. Topics include basic and advanced algorithms for solving unconstrained nonlinear optimization problems, Lagrange multiplier algorithms for solving constrained, non-convex optimization problems, feasible-point methods, and penalty and barrier methods.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?
ENGM 535	Optimization Techniques	Pre-Req

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
MATH 675	Operations Research II	3
MATH 735	Numerical Modelling	3

Provide explanation of differences between proposed course and existing system catalog courses below:

This course will focus on methods particular to solving non-linear optimization problems. The courses listed are more general and focus on a much larger range of optimization problems. In addition, the proposed course will apply these methods to problems associated with machine learning, signals and image processing, and large data sets.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below:

Course will be offered as a rotating elective course and can be managed within existing instructional resources.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.):

M.S. in Industrial Engineering
M.S. in Engineering Management

(New program: Ph.D. in Data Science)

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: Lecture-R
If requesting an instructional method that is exempt from the Section Size Guidelines, please provide a brief description of how the course is appropriate for the instructional method, as defined in AAC Guidelines.

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*:
(001) Face-to-face

3.5. Term change will be effective: Fall 2022

3.6. Can students repeat the course for additional credit?
☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?
☐ Yes ☒ No

3.8. Will section enrollment be capped?
☒ Yes, max per section: 20 ☐ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No
If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?
☒ Yes ☐ No
If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

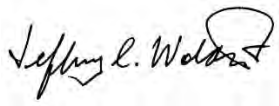
4.1. University Department: IENG

4.2. Banner Department Code: MIND

4.3. Proposed CIP Code: 27.501

Is this a new CIP code for the university? ☐ Yes ☐ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Lin Guo		12/13/2021
Request Originator	**Signature**	**Date**
Jeffrey Woldstad		Click here to enter a date.
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.

This course will help graduate students in Data Science, Industrial Engineering, and Engineering Management thoroughly understand the nature of nonlinear optimization problems, which they may encounter in their research projects relevant with non-convex optimization, deep learning, deep neural networks, and so on.

2. Note whether this course is: ☐ Required ☒ Elective

3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course?
   - Ph.D. in Data Science
   - M.S. in Industrial Engineering
   - M.S. in Engineering Management

Any students who may deal with optimization problems with nonlinearities will benefit from the course, regarding nonlinearity awareness, the formulation and approximation of nonlinear problems, solving and exploring the solution space of the problems, possible simplification techniques and metaheuristics, verification and validation of the models and solutions, and the interpretation and visualization of the results.

4. If this will be a dual listed course, indicate how the distinction between the two levels will be made. N/A
5. Desired section size 20
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Lin Guo, Assistant Professor, Ph.D. in Industrial and Systems Engineering
   - Hyeong Suk Na, Assistant Professor, Ph.D. in Industrial and Manufacturing Engineering
   - Saurav Kumar Dubey, Assistant Professor, Ph.D. in Industrial and Systems Engineering
7. Note whether adequate facilities are available and list any special equipment needed for the course. Yes, adequate facilities are available.
8. Note whether adequate library and media support are available for the course. Adequate
9. Will the new course duplicate courses currently being offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request.

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	Industrial Engineering
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
IENG 737	Stochastic Optimization	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

Advanced optimization techniques for problems under uncertainty. Topics include basic properties and theory, stochastic dynamic programming, two-stage recourse problems, multistage recourse problems, stochastic integer programs, approximation and sampling methods, and robust optimization.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?
ENGM 535	Optimization Techniques	Pre-Req

Registration Restrictions

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
MATH 675	Operations Research II	3
MATH 735	Numerical Modelling	3

Provide explanation of differences between proposed course and existing system catalog courses below:

This course will focus on methods particular to solving stochastic optimization problems. The courses listed are more general and focus on a much larger range of optimization problems. In addition, the proposed course will apply these methods to problems associated with machine learning, signals and image processing, and large data sets.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below:

This course will be offered as a rotating elective course and can be managed within existing instructional resources.

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.):

B.S. in Industrial Engineering and Engineering Management

M.S. in Industrial Engineering
M.S. in Engineering Management

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: Lecture-R
If requesting an instructional method that is exempt from the Section Size Guidelines, please provide a brief description of how the course is appropriate for the instructional method, as defined in AAC Guidelines.

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*:

The delivery method will be primarily face-to-face/live (001) instruction.

3.5. Term change will be effective: Fall 2022

3.6. Can students repeat the course for additional credit?
☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?
☐ Yes ☒ No

3.8. Will section enrollment be capped?
☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No
If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?
☒ Yes ☐ No
If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

4.1. University Department: IENG

4.2. Banner Department Code: MIND

4.3. Proposed CIP Code: 30.7101

Is this a new CIP code for the university? ☐ Yes ☒ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Hyeong Suk Na	Hyeong Suk Na	12/13/2021
Request Originator	**Signature**	**Date**
Jeffrey Woldstad	Jeffrey L. Woldstad	Click here to enter a date.
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.

Stochastic optimization is the approach built on mathematical programming methodology, i.e., stochastic programming that is a framework for modeling optimization problems that involve uncertainty. While deterministic optimization problems have known parameters, many real-world problems have unknown parameters and its outcome is dependent on a random event that occurs in the future. Stochastic programming extends deterministic optimization by modeling uncertainty and incorporating probabilistic statements. This field is currently developing rapidly with contributions from many disciplines including data science, operations research, mathematics, and computer science. However, there is currently no course available in the Ph.D. in Data Science curriculum to introduce students to these techniques. This course will provide a foundation for future students to enter their Ph.D. program prepared for more advanced coursework and research in this growing area of interest for engineers and scientists.

2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course?
   - Ph.D. in Data Science
   - M.S. in Industrial Engineering
   - M.S. in Engineering Management
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made.
5. Desired section size 30
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Suarav Kumar Dubey, Assistant Professor, Ph.D. in Industrial Engineering
   - Lin Guo, Assistant Professor, Ph.D. in Industrial Engineering
   - Hyeong Suk Na, Assistant Professor, Ph.D. in Industrial Engineering
7. Note whether adequate facilities are available and list any special equipment needed for the course. Traditional classroom facilities will be required with no special equipment needed.
8. Note whether adequate library and media support are available for the course. Adequate
9. Will the new course duplicate courses currently being offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined. N/A
11. Add any additional comments that will aid in the evaluation of this request.

SOUTH DAKOTA BOARD OF REGENTS
ACADEMIC AFFAIRS FORMS

New Course Request

Use this form to request a new common or unique course. Consult the system course database through for information about existing courses before submitting this form.

SDSM&T	**Mathematics**
Institution	**Division/Department**

	Click here to enter a date.
Institutional Approval Signature	**Date**

Section 1. Course Title and Description

If the course contains a lecture and laboratory component, identify both the lecture and laboratory numbers (xxx and xxxL) and credit hours associated with each. Provide the complete description as you wish it to appear in the system course database, including pre-requisites, co-requisites, and registration restrictions.

Prefix & No.	Course Title	Credits
MATH 742	Mathematical Statistics	3

NOTE: The Enrollment Services Center assigns the short, abbreviated course title that appears on transcripts. The short title is limited to 30 characters (including spaces); meaningful but concise titles are encouraged due to space limitations in the student information system.

Course Description

This course focuses on the theory of estimation to include method of moments, least squares maximum likelihood and maximum entropy methods. Completeness of statistics, Cramer-Rao bounds, asymptotic consistency, Bayesian decision rules and statistical decision theory. Theory of hypothesis testing will also be including the Neyman Pearson Lemma and uniformly most powerful tests. Applications to engineering and scientific problems as related to data science.

NOTE: Course descriptions are short, concise summaries that typically do not exceed 75 words. DO: Address the content of the course and write descriptions using active verbs (e.g., explore, learn, develop, etc.). DO NOT: Repeat the title of the course, layout the syllabus, use pronouns such as "we" and "you," or rely on specialized jargon, vague phrases, or clichés.

Pre-requisites or Co-requisites (add lines as needed)

Prefix & No.	Course Title	Pre-Req/Co-Req?

Registration Restrictions

Permission of Instructor Required

Section 2. Review of Course

2.1. **Will this be a unique or common course (*place an "X" in the appropriate box*)?**

☒ **Unique Course**
If the request is for a unique course, institutions must review the common course catalog in the system course database to determine if a comparable common course already exists. List the two closest course matches in the common course catalog and provide a brief narrative explaining why the proposed course differs from those listed. If a search of the common course catalog determines an existing common course exists, complete the Authority to Offer an Existing Course Form. Courses requested without an attempt to find comparable courses will not be reviewed.

Prefix & No.	Course Title	Credits
STAT 585	Theory of Statistics I	3
STAT 684	Statistical Inference I	3

Provide explanation of differences between proposed course and existing system catalog courses below:

The proposed mathematical statistics course will include aspects of both of these courses but is more focused on the theory associated with tests and estimation theory as it relates to data science. This course will provide graduate students with important theory in both probability theory and hypothesis testing in a one semester course vice two semesters of more in depth study. The theory will be presented in a way that focuses on applications in engineering and data science.

☐ **Common Course** *Indicate universities that are proposing this common course:*

☐ BHSU ☐ DSU ☐ NSU ☐ SDSMT ☐ SDSU ☐ USD

Section 3. Other Course Information

3.1. Are there instructional staffing impacts?

☐ **No**. Replacement of _____
(course prefix, course number, name of course, credits)
*Attach course deletion form

Effective date of deletion: Click here to enter a date.

☒ **No**. Schedule Management, explain below:
Course will be offered as a rotating elective course and can be managed within existing instructional resources

☐ **Yes**. Specify below:

3.2. Existing program(s) in which course will be offered (i.e., any current or pending majors, minors, certificates, etc.):

Will be used as electives in the IEENG MS program, CSE MS program, and upcoming PhD in Data Science and Engineering program.

3.3. Proposed instructional method by university *(as defined by AAC Guideline 5.4)*: Lecture (R)
If requesting an instructional method that is exempt from the Section Size Guidelines, please provide a brief description of how the course is appropriate for the instructional method, as defined in AAC Guidelines.

3.4. Proposed delivery method by university *(as defined by AAC Guideline 5.5)*:
001 Face-to-face Term Based Instruction
018 Internet Synchronous
015 Internet Asynchronous – Term Based Instruction

3.5. Term change will be effective: Fall 2022

3.6. Can students repeat the course for additional credit?
☐ Yes, total credit limit: _____ ☒ No

3.7. Will grade for this course be limited to S/U (pass/fail)?
☐ Yes ☒ No

3.8. Will section enrollment be capped?
☐ Yes, max per section: _____ ☒ No

3.9. Will this course equate (i.e., be considered the same course for degree completion) with any other unique or common courses in the common course system database?

☐ Yes ☒ No
If yes, indicate the course(s) to which the course will equate (add lines as needed):

Prefix & No.	Course Title

3.10. Is this prefix approved for your university?
☒ Yes ☒ No
If no, provide a brief justification below:

Section 4. Department and Course Codes (Completed by University Academic Affairs)

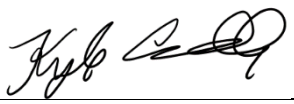
4.1. University Department: MATH

4.2. Banner Department Code: MMTH

4.3. Proposed CIP Code: 27.0502

Is this a new CIP code for the university? ☐ Yes ☒ No

NEW COURSE REQUEST
Supporting Justification for On-Campus Review

Kyle Caudle		12/14/2021
Request Originator	**Signature**	**Date**
Travis Kowalski		12/30/2021
Department Chair	**Signature**	**Date**
		Click here to enter a date.
School/College Dean	**Signature**	**Date**

1. Provide specific reasons for the proposal of this course and explain how the changes enhance the curriculum.
   The following will teach graduate students about concepts in probability and statistics as it relates to data science. The statistical theory will enable them to analyze more critically and to think more closely about the results from hypothesis tests. More importantly, this course will teach students to critically analyze data and make informed decisions. The theory gained in this course will allow them to think about how data is used to answer research questions. This course is intended at the 700 level. It will be used solely as an elective in an upcoming PhD in Data Science and Engineering Program.
2. Note whether this course is: ☐ Required ☒ Elective
3. In addition to the major/program in which this course is offered, what other majors/programs will be affected by this course? Ph.D. in Data Science
4. If this will be a dual listed course, indicate how the distinction between the two levels will be made.
5. Desired section size **5**
6. Provide qualifications of faculty who will teach this course. List name(s), rank(s), and degree(s).
   - Saurav Kumar Dubey, Assistant Professor, PhD in Industrial Engineering
7. Note whether adequate facilities are available and list any special equipment needed for the course.

The course will use existing classroom facilities for lectures, with occasional visits to existing laboratories for demonstration purposes and project support. No new equipment will be needed.

8. Note whether adequate library and media support are available for the course.
   The library and media support available for all courses will be sufficient.
9. Will the new course duplicate courses currently being offered on this campus?
   ☐ Yes ☒ No
   If yes, provide justification.
10. If this course may be offered for variable credit, explain how the amount of credit at each offering is to be determined.
11. Add any additional comments that will aid in the evaluation of this request.

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY
Affected Departments Form

The purpose of this document is to ensure that curriculum changes in one department that alter courses required or commonly taken by other documents get timely notification and the ability to discuss the changes with the originating department if necessary.

This document applies (1) to changes to existing courses and (2) to program-level curriculum changes. New course requests do not typically have an effect on other departments, except through program-level curriculum change.

1. Changes to Existing Courses

☐ No students from other departments take this course
No further action is needed.

☒ No other departments require this course, but students from other departments take this course
From which departments Mathematics, Computer Science and Engineering and Industrial Engineering

In general, such a change is relatively minor to the affected department, typically being related to inclusion of the course in a list of course from which some number of courses must be selected.

Please attach documents showing notification and any response from the affected department. If no response has been received within 5 working days during the spring or fall semester this may be treated as agreement with the change.

☐ Other departments require this course: Which departments: _____

In general, such a change can be a major alteration to the affected department, and, as such, significant discussion may occur.

Please attach documents showing notification and any response from the affected department. If no response has been received within 5 working days this may be treated as agreement with the change.

NOTE: If more than three (3) departments require this course, notification and discussion through ALC/Department Head meetings should occur, so that noting when the change was discussed at such meetings is sufficient.

2. Program Level Curriculum Changes

Program level changes can affect other departments, for instance with respect to staffing levels, removing a required course from your curriculum or adding/removing a course in a list of possible electives can affect how many course sections are needed

☐ Course changes do not affect any other departments
No further action is needed.

☐ Course changes affect other departments through changes in elective courses
Which departments _____ _____

In general, such a change is relatively minor to the affected department but may still have minor affects.

Please attach documents showing notification and any response from the affected department. If no response has been received within 5 working days during the spring or fall semester this may be treated as agreement with the change.

☐ Course changes affect other departments through changes in required courses

Which departments _____

In general, such a change can be a major alteration to the affected department, and, as such, significant discussion may occur.

Please attach documents showing notification and any response from the affected department. If no response has been received within 5 working days this may be treated as agreement with the change.

NOTE: If more than three (3) departments require this course, notification and discussion through ALC/Department Head meetings should occur, so that noting when the change was discussed at such meetings is sufficient.

Appendix D: Independent External Consultants

Dr. Mike Frey
Applied and Computational Statistics Group Lead
NIST/ITL/SED Boulder
Email: michael.frey@nist.gov

Dr. Dave Marchette
Applied Mathematics Group
Naval Surface Warfare – Dahlgren Division
Email: david.marchette@navy.mil

Dr. James Gentle
Professor of Mathematics and Statistics (retired)
George Mason
Email: jgentle@gmu.edu

Dr. George Rudolph
Professor of Computer Science
Utah Valley University
Email: rudolph@uvu.edu

Kate Lemay
Director of Enterprise Data & Analytics
Black Hills Energy
Email: Kate.Lemay@Blackhillscorp.com

Dr. Soundar Kumara
Allen E. Pearce and Allen M. Pearce Professor of Industrial Engineering
Penn State University
Email: u10@psu.edu

Dr. Hui Yang
Professor of Industrial Engineering
Penn State University
Email: huy25@psu.edu

Dr. Eunshin Byon
Associate Professor of Industrial Engineering
University of Michigan
Email: ebyon@umich.edu

Dr. Youngjun Choe
Assistant Professor of Industrial Engineering
University of Washington
Email: ychoe@uw.edu

Dr. John Kobza
Professor and Department Head of Industrial Engineering
University of Tennessee
Email: jkabza@utk.edu

Dr. Jennifer Pazour
Associate Professor of Industrial Engineering
Rensselaer Polytechnic Institute
Email: pazouj@rpi.edu

Journal Editors

Dr. Li Feifei
Associate Editor: Data Science and Engineering
Email: lifeifei@cs.utah.edu

Dr. Wang Xizhao
Editor in Chief: International Journal of Machine Learning and Cybernetics
Email: xzwang@szu.edu.cn

Dr. Jun Yan
Editor in Chief: Journal of Data Science
Email: jun.yan@uconn.edu

Dr. Longbing Cao
Editor in Chief: Journal of Data Science and Analytics
Email: longbing.cao@uts.edu.au

Dr. Francis Bach
Editor in Chief: Journal of Machine Learning Research
Email: francis.bach@ens.fr

Dr. Hendrik Blockeel
Editor in Chief: Machine Learning
Email: Hendrik.blockeel@cs.kuleuven.be

Dr. Carson Woo
Editor in Chief: Data & Knowledge Engineering
Email: carson.woo@sauder.ubc.ca

Appendix E: Letters of Support

Dr. Randy C. Hoover
Associate Professor
Computer Science & Engineering
South Dakota Mines
501 E. St. Joseph Street
Rapid City, SD 57701

Dear Dr. Hoover,

This letter is to express our strong support for your proposed collaborative "**Ph.D. program in Data Science and Engineering**."

Not only is Black Hills Information Security (BHIS) interested in this exciting new program, but we would also be interested in discussing possible collaboration on topics of interest in support of the program as well as current and future needs within BHIS. We have evaluated the proposed curriculum and it appears to be in-line with current trends and should serve the students, university, and external constituents well.

BHIS utilizes data science methods in many aspects of our day-to-day operations to help to better secure companies from threat actors. If your proposed program is approved by the South Dakota Board of Regents, we would be happy to work with your team on program structure as well as discuss current and future opportunities for students and faculty collaboration on the on-going projects of BHIS.

We are pleased to note that your proposed program is certainly aligned with current industry trends (both within and outside the security sector) and would provide ample opportunities for future graduates of the program both within and outside of South Dakota.

In summary, we are excited to support you proposed Ph.D. program and look forward to working with SDM on future projects.

Sincerely,
Brian Fehrman
Brian Fehrman
Security Analyst/Researcher/Developer
Black Hills Information Security / Active Countermeasures

Dr. Randy C. Hoover
Associate Professor
Computer Science & Engineering
South Dakota Mines
501 E. St. Joseph Street
Rapid City, SD 57701

Dear Dr. Hoover,

This letter is to express our strong support for your proposed collaborative "**Ph.D. program in Data Science and Engineering**."

Working as a data scientist for Fast and having worked at organizations like Goldman Sachs, the Commonwealth Bank of Australia, and AIG over the last 10 years, I am constantly looking for experienced talent in the data science and data engineering space. Not only am I interested in this exciting new program, I am currently discussing mechanisms for collaboration with SDM regarding senior designs, internships, co-ops, and research collaborations.

I have evaluated the proposed curriculum and it is aligned with current industry trends. If approved, the program would provide ample opportunities for future graduates both within and outside of South Dakota. Moreover, as a data scientist working in the field, I'd be happy to serve as an industrial advisor once the program is approved and the industrial advisory board is created.

In summary, we are excited to support you proposed Ph.D. program and look forward to working with SDM on future projects.

Sincerely,

Francisco Javier Arceo

Kate Lemay
Director, Enterprise Data & Analytics
Kate.Lemay@blackhillscorp.com

7001 Mt. Rushmore Rd
Rapid City, SD 57702

Dr. Randy C. Hoover
Associate Professor
Computer Science & Engineering
South Dakota Mines
501 E. St. Joseph Street
Rapid City, SD 57701

Dear Dr. Hoover,

This letter is to express our strong support for your proposed collaborative "**Ph.D. program in Data Science and Engineering**."

Not only is Black Hills Corporation (BHC) interested in this exciting new program, but we would also be interested in discussing possible collaboration on topics of interest such as energy forecasting and big data analytics applications in support of the program as well as current and future needs within BHC. We have evaluated the proposed curriculum and it appears to be in-line with current trends and should serve the students, university, and external constituents well. This program would fill a void in current Ph.D. offerings in this field.

Black Hills Corporation is actively involved in data science and data engineering at the enterprise scale and have a recently established data science team to address many different facets of data science within energy sector. If your proposed program is approved by the South Dakota Board of Regents, we would be happy to work with your team on program structure as well as discuss current and future opportunities for students and faculty collaboration in the energy sector.

We are pleased to note that your proposed program is certainly aligned with current industry trends (both within and outside the energy sector) and would provide ample opportunities for future graduates of the program both within and outside of South Dakota.

In summary, we are excited to support you proposed Ph.D. program and look forward to working with SDM on future projects.

Sincerely,

Kate Lemay
Director, Enterprise Data & Analytics

We Solve Great Challenges.

Dr. Randy C. Hoover
Associate Professor
Computer Science & Engineering
South Dakota Mines
501 E. St. Joseph Street
Rapid City, SD 57701

Dear Dr. Hoover,

This letter is to express our strong support for your proposed collaborative "**Ph.D. program in Data Science and Engineering**."

Not only is Raven interested in this exciting new program, but we would also like to discuss possible collaboration on topics of interest in support of the program as well as current and future needs within Raven. We have evaluated the proposed curriculum and it appears to be in-line with current trends and should serve the students, university, and external constituents well.

Raven is actively involved in data science, data engineering, as well as machine learning and artificial intelligence at the enterprise scale and have established development teams to address different facets of data science within Raven Applied Technology. If your proposed program is approved by the South Dakota Board of Regents, we would be happy to work with your team on program structure as well as discuss current and future opportunities for students and faculty collaboration in machine performance analytics and machine learning and artificial intelligence.

We are pleased to note that your proposed program is certainly aligned with current industry trends and would provide possible opportunities for future graduates of the program both within and outside of South Dakota.

In summary, we are excited to support you proposed Ph.D. program and look forward to working with SD Mines on future projects.

Sincerely,

Shane Swedlund
Engineering Manager
Raven Applied Technology
shane.swedlund@ravenind.com

RAVEN

205 E 6th Street, Sioux Falls, SD 57104
www.ravenind.com

APPENDIX F: GRADUATE PROGRAM EXTERNAL REVIEW REPORT

Review of the South Dakota School of Mines and Technology proposed Ph.D. Program in Data Science and Engineering

David J. Marchette[1] and George Rudolph[2]

[1]Applied Mathematics Group, Naval Surface Warfare – Dahlgren Division
[2]Department of Computer Science, Utah Valley University

April 8, 2022

Executive Summary

We have reviewed the proposed PhD program and conducted virtual interviews with the university leadership, with the department leadership for the three constituent departments involved in the proposed program, and with representative faculty from those departments. We find the proposal to be well organized, that it shows evidence of deep thought, that it describes an excellent program that will be a credit to the University. It meets an important need in the education of South Dakota students, and and provides curriculum to prepare students to perform research in data science and engineering and to meet the needs of industry and academia for experts in this field. We believe it will attract new research faculty to the University as well. We recommend that the Board of Regents accept and implement this program.

No single program can cover all the sub-fields of a large, emerging, interdisciplinary field like data science. We identified a few suggestions for improvements, which are detailed below in the relevant sections, to the proposal and the program. These suggestions are recommendations for implementation, not requirements. Likely the details will be of most interest to the department leaderships and the faculty involved.

Section 1 provides information about Data Science as an interdisciplinary field for a reader who may need it, and gives distinctions that we recommend be clarified to make the program stronger. Sections 2-5 give more detailed answers to the questions outlined in the charge letter for this review.

1 Data Science as a Discipline

There are several existing disciplines to which data science (DS) is related. It is important that a DS program can be seen to be distinct from these, although since DS is an interdisciplinary program, it will intersect with these different disciplines. In particular, we will discuss Statistics (particularly applied and computational statistics) and machine learning (ML). We feel that it is important to emphasize "data" throughout the curriculum. All courses should discuss the use of data to illustrate the ideas, to explore limitations of theory and algorithms within a real-world context, and to suggest new ideas and theories. It is also important to emphasize that, while data science and data engineering both have a practical side and require familiarity with existing tools, algorithms and languages, it is also a discipline with rich theoretical underpinnings and the theory is an active and growing area of research. Thus, a data science Ph.D. program will have both a practical, application oriented aspect, and also a theoretical and basic research aspect, allowing for both basic and applied research Ph.D. projects.

Data science is clearly an interdisciplinary field, and we feel that a Ph.D. program, as proposed, could act as a bridge between many different departments. It will obviously foster interaction between the three core departments of Mathematics, Computer Science & Engineering and Industrial Engineering. By its nature, the DS degree will encourage interactions and collaboration throughout the scientific and engineering disciplines, all of which require the services of data scientists to process and analyze data, and which may also provide the data scientists with data sources and applications from which new ideas, theory and algorithms can be discovered. More broadly, there are many areas of sociology, psychology, history, and other disciplines in which data science can play a part, provide answers, and develop new research thrusts.

1.1 Applied and Computational Statistics

There is a tendency (particularly among statisticians) to claim that DS is nothing more than a subfield of statistics, particularly of applied and computational statistics. It is true that there is considerable overlap, and one could make the case that, like Computational Statistics, Bayesian Statistics and Biostatistics, DS is a subfield of statistics. It is clear that the proposed degree program takes a broader view of DS – including computer science and engineering aspects that are rarely, if ever, considered in the other sub-disciplines, and go beyond the field of statistics.

1.2 Machine Learning

Clearly, some concepts of machine learning (ML) are important to a data science curriculum and need to be covered. Similarly, many of the concepts of data science are important to, and should be taught in a machine learning curriculum. The distinction is similar to the DS vs DE discussion below: ML is the process

of developing algorithms that adjust their parameters to solve problems through the analysis of data, without requiring specific domain knowledge to engineer the solution. Data science is much broader, in the same sense that computer science is more than learning to program.

1.3 Data Science vs Data Engineering

The material provided does not lay out a clear distinction between these, although the discussion with the leadership, department heads, and faculty clarified the distinction and their thinking on this distinction. Roughly speaking, it seems that the distinction is: Data Engineering is concerned with "how?" and perhaps "what?", and Data Science with "why?". Thus, the data engineering introductory course emphasizes tools and applications. The introductory data science is also very focused on tools and applications, which is appropriate for an introductory course, and considerable thought has gone into distinguishing these. With the optimization course, these three courses act as a "leveling" curriculum that ensures a base knowledge of the key concepts underlying the rest of the curriculum.

The proposed new courses are heavily weighted towards the data science aspect of the curriculum, with few courses proposed for the data engineering aspects. This is in part due to the fact that many of the appropriate courses already exist in the computer science and engineering departments. More discussion of these specific courses, and how they would be incorporated into a data science degree program would strengthen the proposal, and ultimately result in a stronger program.

2 Program Curriculum

1. **Does the proposed program meet or exceed current national standards and expectations for the discipline?**

   Yes, the program meets or exceeds national standards for the discipline. As discussed in the proposal and below in this document, Data Science is an emerging field. No widely agreed-upon national standards exist yet as we have for other engineering fields and professions. Nevertheless, this program is consistent with what we would expect nationally for Ph.D. programs in computer science, engineering and related fields.

2. **Does the proposed program meet accreditation requirements where applicable?**

   There are no national accrediting bodies for Ph.D. programs in Data Science. The proposal mentions ABET and DASCA as accrediting agencies, but also correctly points out that ABET does not accredit graduate programs, and that they plan to apply for DASCA accreditation if the program is implemented. This will be nice, if it can be achieved, but not necessarily required. We have more to say about DASCA in recommendations below.

3. **Will the proposed program provide students with sound preparation for their careers and serve them well as they seek employment?**

   Yes. The curriculum is a good mix of practical and theoretical, and we believe it will provide students with both the hands-on data analytics expected of data scientists and data engineers and a solid grounding in the theory. This will prepare students for academic positions if that is their preference, and to perform research in data science and engineering in the private sector. A strong focus on data, and collaborations with industry partners, will provide the students with a strong background in applications and the tools of data science.

4. **What changes, if any, do you recommend?**

   Recommended changes are discussed in the following subsections.

2.1 Recommended Changes

2.1.1 Add Master's Degree Path

The proposal does not mention an associated Master's degree. We recommend that such a degree be provided as an "off ramp" for those students who cannot complete the full Ph.D. program—for example for family or other reasons. The school may decide in the future to make the Master's degree a terminal degree rather as a stepping-stone to the Ph.D. program, but that is a decision for the University to make.

2.2 Measuring Student Achievement

Section 6.B. of the program request mentions DASCA certification as a national instrument for measuring student achievement in the program. We agree that DASCA certification for the program and for individuals is a good goal. The fast-track option that is mentioned is a great feature of the program if it becomes available. However, we believe the best measures of individual student performance and mastery remain the qualifying exam and the dissertation.

2.2.1 Create University System-wide Data Repository

We recommend that the University consider implementing a data repository or data center associated with the degree. While designed to support the course work and the research projects of SDSMT PhD students, it could be available to the University as a whole. This issue may also be better addressed via statewide cyberinfrastructure for data centers and high performance computing resources.

2.2.2 Elaborate and Clarify Program Prerequisites

In the program request, there is little information about the prerequisites required for a student to enter the program. Basic calculus and some familiarity with computers and programming seem to be the bare minimum, and the four

introductory "leveling" courses should work to ensure a common base from which the rest of the curriculum will be built.

Meetings during the onsite interviews clarified for us that four required courses CSC 559, MATH 543, ENGM 535, CSC 690 are these leveling courses. We recommend that the proposal and literature supporting the program elaborate on this to make it clear and explicit.

2.2.3 Recommendations for Specific Courses

Overall, the selection of new courses is excellent, and demonstrates a strong emphasis on data science (DS) and data engineering (DE) as a discipline distinct from computer science, statistics, and artificial intelligence/machine learning (AI/ML). Below are some suggestions/discussions about the specific courses, and some thoughts on how they relate to DS DE. Overall, the course list appears strongly biased toward DS rather than DE, in part due to the existence of courses appropriate to data engineering that already exist in the Computer Science curriculum. These courses should be called out more explicitly in the proposal.

Where possible, we suggest books that might be associated with a course in order to illustrate the material that we think are relevant, rather than to suggest that the course use the specific text. We do not suggest that any specific text we propose contains all the appropriate subjects, but rather use them as an illustration of the basic topics to cover.

Planning Algorithms -– this course is certainly relevant to AI/ML. Search algorithms are clearly relevant to DS, and planning problems provide a rich set of important problems for a data scientist. As with most of the courses, an emphasis on the data should be made clear.

Network science -– this is clearly a DS topic. We like the books by Kolaczyk, [5, 6] and Erciyes, [2]. There is a distinction between graphs as they apply to algorithms, and graphs as data. A discrete math course or "traditional" graph theory course in a mathematics department is appropriate for the former, Kolaczyk and Erciyes are appropriate for the latter. Graphs-as-data, and graphs applied to data, are important topics in DS. An important aspect of network science that might not appear in a "traditional" network science course is graph projections (spectral embeddings) and spectral clustering, which are techniques that utilize graph theory and linear algebra to analyze data. Similarly, manifold learning/manifold discovery methods often utilize graphs to estimate a lower dimensional "manifold" associated with the true extent of the data.

Advanced Linear programming, **Nonlinear programming**, **Stochastic optimization** -– clearly important core-courses for a data science curriculum. The EM (expectation-maximization) algorithm, which is often used in fitting complex statistical models to data, could presumably be taught in Stochastic optimization, but could also be taught in the advanced statistics course. Stochastic optimization might also be a prerequisite to the deep learning course.

Deep learning, **Reinforcement learning**, **Game theory** -– these, on

their face, are not really DS, more AI/ML and mathematics. Certainly they should be taught, and can count as credits toward degree, but should be made more specific to DS. Possibly the recent book by Ye, [9], to give the deep learning course more of a DS flavor. We discussed the idea that one could view farming as a game between the farmer and pests, the environment, climate, etc. Thus, while the courses as they stand don't appear to be DS courses, a small change of focus, or incorporation of data into the curriculum, could strengthen their inclusion as part of the DS curriculum.

Scientific computing (SC), **Natural computing**, **Human information processing (HIP)** -– Scientific computing teaches the basic ideas of some of the computational theory underpinning DS, and is one of the few new courses specific to DE. Certainly genetic algorithms and other ideas inspired by biology and physics are appropriate for a data science curriculum. HIP also has a strong connection to visualization. Paired with a visualization course, HIP might cover the biology of vision associated with visualization, while the visualization course could focus on the guidelines for producing good and informative graphics, and the pitfalls of poor or misleading displays. We discuss visualization below in the section on missing courses.

Mathematical statistics -– as presented, this sounds like the second course in a traditional graduate statistics program. We would like to see more focus on areas specific to DS such as high dimensional data, model selection, curse of dimensionality, etc. The book by Wainwright, [8], for example, for a theoretical perspective. For more DS-centric approaches, the books by Koch, [4], or Lederer, [7], seem to be good texts around which to build such a course. The students will likely see principal components in the introduction to data science, but might not see other methods of dimensionality reduction, multidimensional scaling, and Procrustes analysis, all of which are important tools of data science. While the theory and methods discussed in the course description are important, and should have some coverage, they are more appropriate for a graduate degree in statistics than one in data science. Again, a focus on data and how the theory provides insight into data, would strengthen the case for its addition to the curriculum.

Bayesian inference -– clearly appropriate to DS, although one could argue that if an applied statistics course is a prerequisite then this would be covered in that course. A graduate level course should really emphasize computation, Markov Chain Monte Carlo (MCMC) and related topics. The recent book by Heard, [3], might provide an outline of such a course.

Anomaly detection -– clearly relevant to data science. Curse of dimensionality issues could be covered. Maybe this would be more appropriate as a topics course? It seems that a good background in statistics might be required for this course.

2.2.4 Missing Courses

Below we discuss some courses that we would like to see in a data science/data engineering curriculum. Obviously it is impossible to provide every possible

course in a program, and so we don't suggest that these courses necessarily need to be added. Some are suggestions for the future if the program grows sufficiently to allow for them.

Some of these possibly could be special topics, "seminars in" or reading courses. These courses may already exist in some form in the Computer Science, Engineering and Mathematics departments, but are clearly appropriate for a data science degree.

Topological data analysis -– See for example, the books by Carlsson, [1], or Zomorodian, [10], although this book is already somewhat out of date. This is a growing research area in data science. For the program as it stands, we don't feel that it is necessary to cover this topic as a separate course, but it should be considered for the future of the program. The University might consider a future hire in this area for the Mathematics department.

Security and privacy -– this is a huge issue in data science. In our meeting with the faculty it was noted that this is addressed in both the DE and DS core courses to some degree, but we feel that it would be important to work towards providing a separate course devoted to the subjects of data security and data privacy. This is particularly important for students performing research in the health sciences or working with businesses and industrial partners as an aspect of their degree program.

Visualization — this is obviously covered in the introductory DS course to some degree, in HIP, and to some degree in any course utilizing data. There is a strong focus on visualization in the proposal, but we did not see a specific course in the list of new courses. We feel that this is such an important topic, that although it is covered as an aspect of many of the DS courses, there should be a course devoted to it. Paired with HIP, as discussed above, this could be a strong two-course sequence that covered all aspects of this important topic. Any project with a strong component of collaboration with industry or application would benefit from a visualization course that covered the basics of proper display of data.

3 Faculty

1. **Will the current and planned faculty be sufficient to offer a strong program?**

   Yes. The faculty is strong and dedicated to the program and we have no doubt they will implement a strong and valuable program. The request, section 17, item 1 (Assumptions) estimates 2 Full-Time Equivalent faculty to support the program, which comes from 25% time of 4 existing faculty. This should be enough to support the projected growth over the next few years as well as program kick-off.

2. **Does the program require additional expertise to implement the program at a high level of quality?**

The faculty can certainly implement this program as it stands. The team is strong, with expertise in all the aspects of the proposed curriculum. The faculty certainly have the experience and ability to advise Ph.D. candidates. As discussed above, the University could consider adding an expert in privacy and security. Similarly, the field of topological data analysis is a growing one and adding expertise in that field could be a consideration for the future.

3. **Will the teaching, research, service expectations, and related resources be competitive when recruiting new faculty to staff the proposed program?**

   We believe that they will definitely be competitive, both for recruiting faculty and staff, and for recruiting highly qualified and dedicated students.

4 Services

1. **Are the library resources and other services sufficient to support a high-quality program?**

   They are, with the caveat that we suggest the implementation of a data repository to support the research program and the courses.

5 Summary Recommendations

1. **What do you see the strengths and weaknesses of the proposed program?**

   Strenghths:

   (a) The new courses proposed define a strong program in data science and data engineering.

   (b) The overall program is well-thought-out and shows a dedication to producing a strong program and to training the next generation of data scientists and data engineers.

   (c) Teaming the mathematics and computer science and engineering departments gives the program both theoretical and practical depth, and allows for a wide range of data science and data engineering dissertation topics.

   (d) The strong interest in teaming with industry and government for students, projects and data ensures that the program will be relevant for students seeking industry employment as well as those seeking academic positions.

   Weaknesses:

   (a) We feel that the program could be strengthened by emphasizing the aspects of data analysis throughout the courses, particularly the new machine learning and game theory courses.

(b) The lack of a specific course in visualization. This should be a core course, and could be part of a two-semester sequence with the Human Information Processing course, or could be separate from it.

(c) There is no course in data privacy and security, and this is an important issue in data science.

(d) The focus of the new program is definitely more towards data science than data engineering. While the data science program can certainly stand on its own, the data engineering component strengthens the program over all, and we would have liked to have seen a bit more details of that aspect of the program.

None of the weaknesses are serious, and all were discussed during our meetings with the faculty.

2. What broader recommendations do you have for the university and the Board of Regents?

We have the following recommendations:

(a) Implement a data repository to serve as a resource for the University as a whole. It would provide a resource for students in the program to use in their research, and provide a large collection of data sets to be used in courses in the program. This should include both raw data sets and data sets that are the processed products of various projects.

(b) The forms required for the proposal seem to us to be overly restrictive. Using the content of this proposal as an example, we recommend that "data" be much more prominently discussed in each of the course descriptions, and suggest more discussion of how the courses fit together into (one or more) plans of study. An example of some "typical" course sequences for individuals with different backgrounds, interests, and research focuses, would give a better idea of how the program might work in practice. Clearly this kind of information would be provided in the course catalog, and we would have liked to see some of it in the proposal.

References

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