JOHNS HOPKINS
UNIVERSITY

September 1, 2022

James D. Fielder, Jr., PhD
Secretary
Maryland Higher Education Commission
6 N. Liberty Street, 10th Floor
Baltimore, MD 21201

Dear Dr. Fielder:

On behalf of Provost Kumar, I write to request your review and endorsement of the enclosed proposal. The Whiting School of Engineering proposes a new **Master of Science in Global innovation and leadership through engineering.**

The university will offer the Master of Science in Global innovation and leadership through engineering as a flexible in-person and online program, making it available to a broad population of students seeking to understand and apply the concepts and methodologies of global innovation to real world systems and processes.

The course content will be based on management, design, strategy, and innovation with a focus on how these foundational skills are applied in the global setting. Additional courses will include a focus on topics specifically related to data, systems, and cyber both domestically and abroad.

The proposed program is consistent with the Johns Hopkins mission and the State of Maryland's Plan for Postsecondary Education. The proposal is fully endorsed by The Johns Hopkins University.

Should you have any questions or need further information, please do not hesitate to contact Westley Forsythe at (410) 516-0188 or wforsythe@jhu.edu.

Thank you for your support of Johns Hopkins University.

Sincerely,

Janet Simon Schreck, PhD
Senior Associate Vice Provost for Academic Affairs

cc: Dr. Sunil Kumar
Dr. Westley Forsythe

Enclosures

Office Use Only: PP#

Cover Sheet for In-State Institutions
New Program or Substantial Modification to Existing Program

Institution Submitting Proposal	The Johns Hopkins University

Each action below requires a separate proposal and cover sheet.

- (●) New Academic Program
- ( ) New Area of Concentration
- ( ) New Degree Level Approval
- ( ) New Stand-Alone Certificate
- ( ) Off Campus Program
- ( ) Substantial Change to a Degree Program
- ( ) Substantial Change to an Area of Concentration
- ( ) Substantial Change to a Certificate Program
- ( ) Cooperative Degree Program
- ( ) Offer Program at Regional Higher Education Center

Payment Submitted: (●) Yes ( ) No

Payment Type: ( ) R*STARS # 11956719 (●) Check # 11956719

Payment Amount: $850

Date Submitted: 9/1/2022

Department Proposing Program	Whiting School of Engineering	
Degree Level and Degree Type	Master of Science	
Title of Proposed Program	Global innovation and leadership through engineering	
Total Number of Credits	34	
Suggested Codes	HEGIS:	CIP:
Program Modality	( ) On-campus	(●) Distance Education (*fully online*)
Program Resources	(●) Using Existing Resources	( ) Requiring New Resources
Projected Implementation Date	( ) Fall (●) Spring ( ) Summer	Year: 2023
Provide Link to Most Recent Academic Catalog	URL: https://e-catalogue.jhu.edu/	
Preferred Contact for this Proposal	Name: Westley Forsythe	
	Title: Academic Compliance Officer	
	Phone: (410) 516-0188	
	Email: wforsythe@jhu.edu	
President/Chief Executive	Type Name: Sunil Kumar	
	Signature: Sunil Kumar	Date: 09/01/2022
	Date of Approval/Endorsement by Governing Board:	

Revised 1/2021

The Johns Hopkins University
G.W.C. Whiting School of Engineering
Proposal for a New Academic Program
Master of Science in Global innovation and leadership through engineering

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A. Centrality to Institutional Mission and Planning Priorities

1. Provide a description of the program, including each area of concentration (if applicable), and how it relates to the institution's approved mission

The Johns Hopkins University/Whiting School of Engineering is pleased to submit a proposal for a new Master of Science in Global Innovation and Leadership through Engineering. This program is an outgrowth of the established Master of Science in Engineering Management curricula within the Whiting School of Engineering. This Master of Science in Global Innovation and Leadership through Engineering will be offered as a flexible in-person and online program, making it available to a broad population of students seeking to understand and apply the concepts and methodologies of global innovation to real world systems and processes.

The course content will be based on management, design, strategy, and innovation with a focus on how these foundational skills are applied in the global setting. Additional courses will include a focus on topics specifically related to data, systems, and cyber both domestically and abroad. If approved, the program would commence as soon as possible (Fall 2022 or Spring 2023).

The specific tracks that will be initially offered (Cybersecurity, Data Analytics, Engineering Management, Healthcare Systems Engineering, Systems Engineering, and Environmental Planning and Management) have been selected because they parallel the strengths of Johns Hopkins and confirmed needs in the marketplace.

The mission of The Johns Hopkins University is to educate its students and cultivate their capacity for life-long learning, to foster independent and original research, and to bring the benefits of discovery to the world. In addition, the mission of the JHU Whiting School of Engineering is to provide educational programs of the highest quality that will attract the most qualified and driven students and faculty and will be a world-recognized leader in engineering education. Additionally, WSE aims to lead in the creation and dissemination of knowledge, and to translate those educational and research activities into solutions to important societal problems. The proposed degree program aligns with both of these missions as discussed below.

2 Explain how the proposed program supports the institution's strategic goals and provide evidence that affirms it is an institutional priority

A strategic priority of the JHU Whiting School of Engineering is to provide students with innovative and distinctive educational opportunities. Part of the mission of the JHU Whiting School of Engineering is to "provide an outstanding engineering education that is innovative, rigorous, and relevant, and that prepares its graduates to be 21st century leaders." The Whiting School of Engineering supports this mission by developing contemporary master's degree offerings, for full- and part-time students, with flexible formats that respond to the needs of industry in both the domestic and international markets. It is clear that a program offering in-person and online courses, internships (or capstone projects), domestic and abroad, and the opportunity for hands-on experience offers a flexible format and enables this program to more easily reach the international markets cited in this goal.

Johns Hopkins University's programs in the field of engineering are amongst the oldest and largest in the United States. Administered by the Whiting School of Engineering, these programs offer state-of-the-art courses combined with the convenience, flexibility, and accessibility that make these educational opportunities unparalleled.

In recent years, JHU has moved steadily into the field of distance education, offering more and more courses online. This development meets two needs: (1) it contributes to the convenience and flexibility of existing offerings, by allowing students to take a mix of classroom and online courses, and (2) it opens this educational opportunity to a much larger market, enabling students throughout the country and, indeed, the world to take courses at Johns Hopkins University. The proposed program aims to capitalize on the current infrastructure that the Whiting School of Engineering has built in order to provide flexibility to students.

Johns Hopkins University is recognized as providing world-class education and research in computer science and related fields such as information systems engineering, cybersecurity, and data analytics. Through this program, JHU will continue its leadership role in preparing students with the knowledge and skills to apply innovation and design skills and concepts in a global setting. This degree will be coordinated by the Whiting School of Engineering.

Through this proposed degree, talented students will develop the skills needed to apply innovation and leadership skills in the development of products and processes in the future. The program will provide in-depth knowledge and technical skills in the fields of Cybersecurity, Data Analytics, Engineering Management, Healthcare Systems Engineering, Systems Engineering, and Environmental Planning and Management, all through the perspective of innovation and entrepreneurship in order to prepare students for careers within the United States and abroad.

3. Provide a narrative of how the proposed program will be adequately funded for at least the first five years of program implementation

The Whiting School of Engineering sets aside a portion of its tuition revenue each year as part of its budgeting process to fund the development of new programs and new courses.

In addition, the tuition revenue from enrollments in the courses in any program is used to cover the instructional costs of the program before any excess is used for other Whiting School of Engineering efforts. If a new program finds that its instructional costs are greater than the tuition revenue, funds are allocated from elsewhere in the Whiting School of Engineering's programs to cover the startup program's shortfalls during the first five years. Additional related information is provided in section I.

4. Provide a description of the institution's commitment to:

a. Ongoing administrative, financial, and technical support of the proposed program

The Whiting School of Engineering does a careful program viability study for new programs based on prospective student and employer feedback, as well as the sort of information provided elsewhere in this proposal addressing market demand. The Whiting School of Engineering greatly values these online graduate offerings and the impact that they provide to the engineering community and society. The proposed program would receive the same sort of administrative, financial, and technical support as all other programs in its portfolio.

b. Continuation of the program for a period of time sufficient to allow enrolled students to complete the program

The Whiting School of Engineering is committed to providing all enrolled students the opportunity to complete the degree program, including under circumstances of low demand. Again, a historical example is the best evidence for this commitment. In the early 2000s, the part-time undergraduate programs administered by the Whiting School of Engineering were discontinued after six decades due to a reduction of interest in the programs by both employers and students. After ceasing enrollment of new students, the program developed plans for each remaining student to complete the degree at significant cost to the Whiting School of Engineering, since many classes needed to be offered with only two or three students attending.

B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan

1. Demonstrate demand and need for the program in terms of meeting present and future needs of the region and the State in general

The Whiting School of Engineering is focusing on the "need for advancement and evolution of knowledge" in the state of Maryland with this program. The Maryland Department of Labor Licensing and Regulation (DLLR), Maryland Long Term Occupational Projections (2018-2028) does not have an occupational category for Global Innovation and Leadership through Engineering so we will report the job data for the two occupations that are most closely related to innovation and leadership. These occupational categories are management analysts, and management as an occupation. The

Maryland Long Term Occupational Projections (2018-2028) show: 1) a need for up to 5,299 management analysts (percent change of 18.1%) and 2) a need for up to 26,425 electrical engineers (percent change of 11.0%).

2. Provide evidence that the perceived need is consistent with the Maryland State Plan for Postsecondary Education

The proposed degree is well aligned with the 2017–2021 Maryland State Plan for Postsecondary Education. The MS in Global Innovation and Leadership through Engineering is intended to prepare highly trained professionals to work in organizations where they can contribute to the rapidly evolving needs of society.

Specifically, the proposed degree aligns with Goal 5, "Economic Growth and Vitality," which is centered on supporting a knowledge-based economy through increased education and training. The proposed degree will prepare highly qualified technical professionals and engineers to contribute to the economic growth and vitality of Maryland by providing life-long learning to technical professionals and engineers so they can maintain the skills they need to succeed in the workforce.

C. Quantifiable and Reliable Evidence and Documentation of Market Supply and Demand in the Region and State:

1. Describe potential industry or industries, employment opportunities, and expected level of entry (*ex: mid-level management*) for graduates of the proposed program

The proposed program aims to create managers and leaders in the following industries:

1. Cybersecurity
2. Data Analytics
3. Engineering Management
4. Healthcare Systems Engineering/Environmental Health
5. Systems Engineering
6. Environmental Planning and Management

2. Present data and analysis projecting market demand and the availability of openings in a job market to be served by the new program

Cybersecurity

"Cyber-security is the practice of defending computers, servers, mobile devices, electronic systems, networks, and data from malicious attacks. It's also known as information technology security or electronic information security. The term applies in a variety of contexts, from business to mobile computing, and can be divided into a few common categories." - Kaspersky

Job Statistics:

- 6000+ Jobs in 2019 on Linkedin
- 3000+ Entry level Cyber Security Jobs in Indeed
- 9000+ Cyber Security Analyst positions on Glassdoor
- 32% expected growth between 2018-2028 (US Department of Labor Statistics)
- There are over three million jobs for these occupations, and they are forecasted to experience strong growth of 14.7% by 2029
- Salary Range: $85,000 - $150,000+
- Average hourly rate for related professionals is currently $48.39, or $100,651 annually
- Worldwide spending on information security products and services reached more than $114 billion in 2018, up 12.4% from 2017 [Gartner]
- Organizations are spending more money to combat cybercrime, as the average cost per organization grew 62.5% from 2013 to 2017 [Accenture]
- Eight projections by Cisco point to a global shortage of two million cybersecurity
- professionals by the end of 2019. [Cisco]

Sub-disciplines:

- Network Security
- Application Security
- Cloud Security
- Information Security
- Operation Security

Examples of job titles in the Industry:

1. Security Engineer
2. Security Architect
3. Security Software Developer
4. Security Consultant
5. Security Analyst
6. Security Auditor
7. Intrusion Analyst
8. Vulnerability Assessment Analyst/Engineer
9. Security Operations Engineer

Examples of companies hiring:

1. Apple
2. Google
3. Amazon
4. Microsoft
5. Lockheed Martin
6. Northrop Grumman
7. Boeing

8. Cisco
9. Intel

Data Analytics

"The ability to take data — to be able to understand it, to process it, to extract value from it, to visualize it, to communicate it — that's going to be a hugely important skill in the next decades."- Hal Varian, chief economist at Google and UC Berkeley professor of information sciences, business, and economics

"Data science is an interdisciplinary field that uses scientific methods, processes, algorithms, and systems to extract value from data. Data scientists combine a range of skills—including statistics, computer science, and business knowledge—to analyze data collected from the web, smartphones, customers, sensors, and other sources." – Oracle

In essence, there are two different markets for data science and analytics jobs. Across the ecosystem, we see two broad families: analytics-enabled jobs and data science jobs.

Common analytics-enabled jobs are Chief Executive Officer, Chief Data Officer, Director of IT, Human Resources Manager, Financial Manager and Marketing Manager. The immediate payoff for raising the analytics IQ in these roles is greater productivity and operational efficiency. These are the people with the know-how to identify customer wants using social analytics, or unusual network activity from real-time dashboards or how to forecast inventory using predictive analytics. It's not surprising that 67% of the job openings are analytics-enabled and require functional or domain expertise outside of data science at the core. What analytics-enabled jobs require is hands-on experience with reporting and visualization software to aid in the collection and examination of data.

Job Statistics:

- Top job in the US for the years 2016,2017,2018 (US Dept of Labour Statistics)
- 33% growth expected by the year 2026 (US Dept of Labour Statistics)
- 4,000+ jobs in 2018 in Linkedin
- Data Scientist was also ranked as 2019 most promising job by LinkedIn in January 2019.
- 5,000+ Data Scientist Jobs in Indeed
- Recent CareerCast (2019) report ranked Data Scientist as the top job in USA, with very good work environment, low stress, high projected growth, and median salary of $114,520

- By 2020, data science and analytics (DSA) job openings are predicted to grow to 2.7 million, representing a $187 billion market opportunity. [Springboard.com Blog]
- Median Salary: ~$100,000

Sub-disciplines:

- Data Mining
- Data Modelling
- Data Analysis
- Data Visualization

Examples of job titles in the Industry:

1. Data Analyst
2. Data Engineer
3. Data Scientist
4. Big Data Consultant
5. Big Data Developer

Examples of companies hiring:

1. Accenture
2. Amazon
3. Apple
4. Facebook
5. Google
6. Fidelity Investments
7. Intel
8. Microsoft
9. Twitter
10. Paypal

Engineering Management

Engineering Management is where graduates build links among engineering, technology, and management. The global economy has become more project-oriented, as the practice of project management expands within industries that were traditionally less project-oriented, such as health care, publishing and professional services. [PMI]

Estimates are that project-related jobs would number 52.4 million by 2020. By early 2017, the number of project management jobs had already reached almost 66 million, exceeding that original projection. [PMI]

Newly created positions are expected to occur each year in project management-oriented industries in the 11 countries analyzed. "Hence the need is global" [PMI]

Examples of job titles in the Industry:

1. Business Analyst
2. Product Manager
3. Financial Analyst
4. Business Development Manager

Job Statistics:

1. *Business Analyst (U.S. Bureau of Labor Statistics)*

    - There were 876,000 business/management analyst positions in 2018
    - *B*usiness Analyst role expected grow by 14% between 2018-2028

2. Product Manager (*U.S. Bureau of Labor Statistics)*

    - Growing demand for PM roles in Technology companies
    - Average salary $109,319
    - Expected to growth by 10% in the next 6 years
    - 3000+ jobs on Linkedin

3. Financial Analyst (*U.S. Bureau of Labor Statistics)*

    - 329,500 number of jobs in 2018
    - Median Salary ~$86,000
    - 10.8% growth in the next 10 years (Datausa.io)
    - 18000+ jobs available on Linkedin

4. Business Development Manager (*U.S. Bureau of Labor Statistics)*

    - Expected to grow by 8% by 2028
    - Median Salary ~$111,000
    - 2000+ jobs in the USA currently on Linkedin

Healthcare Systems Engineering/Environmental Health

"Health care systems engineering is an area of research in health care delivery science that examines system and process design. Researchers in health care systems engineering seek to increase efficiency, reduce errors, and improve access and overall quality of health care." - Mayo Clinic

Healthcare employment growth continued throughout 2019 at a torrid pace, adding 402,000 jobs in the 12 months ending in October, and climbing to a total of more than 16.5 million in total employment, according to the latest data from the US Bureau of Labor Statistics Current Employment Statistics. These jobs are related to having project managers and Data professionals in the Healthcare industry

Examples of job titles in the industry:

1. Healthcare consultant
2. Health Data Analyst
3. Process Engineer
4. Corporate Development & Innovation Associate
5. Program Manager
6. Healthcare IT Manager

Examples of companies hiring:

1. Mayo Clinic
2. LEK Consulting
3. PwC
4. ZS Consulting
5. Deloitte
6. JHU APL
7. Merck
8. FDA
9. University Hospitals
10. Pharma Companies

Job Statistics:

- 3000+ jobs on Linkedin
- Around 1700 jobs available in Maryland within Healthcare systems (Indeed)
- Median Salary around $ 78,000 (Glassdoor)

Systems Engineering

"Systems engineering is the art and science of developing an operable system capable of meeting requirements within often opposed constraints. Systems engineering is a holistic, integrative discipline, wherein the contributions of structural engineers, electrical engineers, mechanism designers, power engineers, human factors engineers, and many more disciplines are evaluated and balanced, one against another, to produce

a coherent whole that is not dominated by the perspective of a single discipline."
-NASA

Nowadays, systems engineering has expanded to focus in on software and IT systems. Job responsibilities now also include designing, developing, testing, deploying, and monitoring systems across many industries.

Job Statistics:

1. 50,000+ Jobs on LinkedIn
2. 25,000+ Entry Level Jobs on Indeed
3. 5-9% expected growth between 2016-2026 (US Bureau of Labor Statistics)
4. $100,842 average salary (Indeed)
5. Salary ranges from $58,000-$126,000 (PayScale)

Sub-disciplines:

1. Industrial Engineering
2. Systems Architect
3. Security Engineering
4. Software Engineering
5. Cybersecurity

Examples of job titles in the Industry:

1. Systems Engineer
2. Systems Architect
3. Field Engineer
4. Chief Engineer
5. Infrastructure Engineer
6. IT Engineer

Examples of companies hiring:

1. Google
2. Amazon
3. Facebook
4. Lockheed Martin
5. Northrop Grumman
6. Deloitte
7. Visa
8. Cisco
9. 3M
10. Texas Instruments

Environmental Planning and Management

"Environmental engineering is the branch of engineering that is concerned with protecting people from the effects of adverse environmental effects, such as pollution, as well as improving environmental quality. Environmental engineers work to improve recycling, waste disposal, public health, and water and air pollution control, according to the U.S. Bureau of Labor Statistics." -Live Science

Environmental engineering is not new, but in our current global, urbanizing world, challenges are larger and more complex. Environmental engineers must be clever in utilizing engineering principles to shift the focus from productivity and efficiency, to sustainability and safety.

Job Statistics:

1. 6,500+ Jobs on LinkedIn
2. 700+ Entry Level Jobs on Indeed
3. 3% expected growth between 2019-2029 (US Bureau of Labor Statistics)
4. $88,860 median salary (US Bureau of Labor Statistics)
5. Salary ranges from $51,000-$98,000 (PayScale)

Sub-disciplines:

1. Water/Wastewater Engineering
2. Civil Engineering
3. Geo-technical Engineering
4. Transportation Engineering
5. Hydraulics Engineering

Examples of job titles in the Industry:

1. Environmental Engineer
2. Quality Engineer
3. Environmental Scientist
4. Environmental Safety Officer

Examples of companies hiring:

1. Amazon
2. 3M
3. CIA
4. US Department of the Interior
5. John Deere
6. ExxonMobil
7. Northrop Grumman

8. US Air Force
9. GM
10. Chevron

3. Discuss and provide evidence of market surveys that clearly provide quantifiable and reliable data on the educational and training needs and the anticipated number of vacancies expected over the next 5 years

Global Innovation and Leadership is an emerging discipline that will play an increasingly important part in the engineering and computer science workforce in this region. We expect the interest from students in this Master of Science in Global Innovation and Leadership through Engineering to be strong.

4. Provide data showing the current and projected supply of prospective graduates

There are no Maryland schools that currently offer a graduate program in Global Innovation and Leadership through Engineering so there are no past data to present.

D. Reasonableness of Program Duplication

1. Identify similar programs in the State and/or same geographical area. Discuss similarities and differences between the proposed program and others in the same degree to be awarded

There are no Maryland schools that offer a graduate program in Global Innovation and Leadership. Several Maryland universities offer courses related to Global Innovation and Leadership. Some even offer concentrations or specializations in Global Innovation and Leadership related areas or study abroad programs as supplement to related degrees. This degree appears to be unique in Maryland higher education.

Programs in Data Sciences are becoming more common. For example, both Loyola University Maryland and UMBC now offer MS degrees in data sciences; UMBC also has a certificate program. Neither school, however, offers a program with the breadth that Hopkins is proposing as well as a focus on innovation and design.

2. Provide justification for the proposed program

This Master of Science in Global Innovation and Leadership through Engineering is unique in terms of the content and offering modality. The broad set of online innovation and leadership courses (with in-person options for some courses) available to engineers and computer scientists will attract a broad range of students. JHU is highly regarded as having expertise in these areas by practitioners and researchers alike, such that the value proposition of reputation, quality, and convenience is readily understood. There is no Global Innovation and Leadership master's degree program offered in the State of Maryland. In view of the market demand for such a program, the offering of the Master

of Science in Global Innovation and Leadership through Engineering clearly meets a currently important need in the region.

E. Relevance to High-demand Programs at Historically Black Institutions (HBIs)

1. Discuss the program's potential impact on the implementation or maintenance of high-demand programs at HBI's

There is no comparable degree program offered at any of the Historically Black Institutions in Maryland.

F. **Relevance to the identity of Historically Black Institutions (HBIs)**

It is not anticipated to have any impact upon HBCUs' identity.

1. Discuss the program's potential impact on the uniqueness and institutional identities and missions of HBIs

The proposed program would not directly affect the implementation, maintenance, uniqueness, identity or mission of these institutions.

G. Adequacy of Curriculum Design, Program Modality, and Related learning outcomes (as outlined in COMAR 13B.02.03.10):

1. Describe how the proposed program was established, and also describe the faculty who will oversee the program

The MS in Global Innovation and Leadership through Engineering will be taught by faculty in the Center for Leadership Education in the Whiting School of Engineering. The degree will leverage existing courses in the CLE also taken by MS Engineering Management students as well as through dedicated new courses created for this program.

2. Describe educational objectives and learning outcomes appropriate to the rigor, breadth, and (modality) of the program

Educational Objectives

Upon graduation, graduates from this program will be able to:

- Implement innovation and leadership strategies in global settings, both in industry and government.
- Lead diverse innovation teams in industry and government settings.

Within 2-5 years after graduation, graduates from this program will be able to:

- Continue to apply and develop global innovation and leadership theoretical concepts and practical methodologies in the development of effective and efficient systems and processes for the measurable improvement of outcomes in industry, government and personal settings.
- Continue to apply and implement practical methodologies in the development of innovation ecosystems in industry and government, in order to develop new products, services, and policies.
- Continue to be change agents in their organizations.

Student Learning Outcomes

By the end of this program, students will be able to:

- Communicate and implement global innovation and leadership theoretical concepts and practical methodologies to improve the processes, products, and services of their organizations
- Increase entrepreneurial activities both within existing organizations and in new ventures in a global setting
- Cultivate and develop leaders on their teams
- Develop a comprehensive decision-making framework to account for the needs of disparate stakeholders, business objectives, and ethical principles in global, economic, environmental, and societal contexts

- Build values into the culture and operation of an organization
- Communicate effectively, both orally and in writing, with a diverse, multinational audience.
- Lead multinational teams to implement and act upon new (i.e. innovative) business ventures
- Lead multinational teams to successfully implement and act upon new (i.e. innovative) policy ventures

3. Explain how the institution will:

a. **Provide for assessment of student achievement of learning outcomes in the program**

During the design of the program's courses, the instructional designers at the CLE work with the instructors in preparing learning assessments (assignments, projects, papers, exams, etc.) that are carefully linked to the program's learning outcomes. The instructors then provide direct and immediate feedback to students in order to indicate the achievement level of each learning outcome. The goal is to allow students to continually assess their progress, improve their performance, and gain proficiency.

b. **Document student achievement of learning outcomes in the program**

The learning assessment scores are retained for the purposes of accreditation, course and program improvements. Faculty use consistent record-keeping systems, including Canvas, to log individual assessment scores. Assessment results are available to the students through the LMS and AMS and final grades are accessible to students through the student information system of record. Annual program reviews are conducted to determine effectiveness of learning outcomes.

c. **Provide a list of courses with title, semester credit hours and course descriptions, along with a description of program requirements**

A full course listing with course titles and descriptions is provided in Appendix B.

Admission Requirements

General admission requirements for master's degree candidates and others seeking graduate status are as follows: applicants must be in the last semester of undergraduate study or hold a bachelor's degree from a regionally accredited college or university.

Applicants typically have earned a grade point average of at least 3.0 on a 4.0 scale (B or above) in the latter half of their undergraduate studies. Prior education must include prerequisites as determined on a track-by-track basis, generally to include Calculus I and II, Statistics and Probability, and Python. Applicants whose prior education does not include the prerequisites listed above may still be admitted under provisional status, followed by full admission once they have completed the missing prerequisites. Missing prerequisites may be completed with Johns Hopkins Engineering or at another regionally

accredited institution. These prerequisite courses do not count toward the degree or certificate requirements. Transcripts from all college studies must be submitted.

Transcripts from all college studies must be submitted. International students will be required to submit a TOEFL score (minimum of 100) or IELTS (minimum 7.5) and GRE scores will be considered. All applicants will be required to submit three letters of recommendation, a resume, unofficial transcripts, and a statement of purpose. When reviewing an application, the candidate's academic and professional background will be considered..

Degree Requirements

In order to earn a Master of Science in Global Innovation and Leadership through Engineering, the student must complete 34 approved credits within five years. Typically, students should be able to complete the degree within 3-4 semesters (approximately 2 years). The curriculum consists of 16 credits of core courses (see options below) and 18 or more credits of electives (see options below). An elective may be substituted for a required course if the student has previously completed an equivalent graduate-level course. Typically, only one grade of C and one P grade can count toward the master's degree. All course selections are subject to advisor approval.

Required core courses (*subject to change by department assessment)*

- 605.601 Management and Global Team Leadership (3 credits)
- 605.621 Project Management (1.5 credits)
- 605.623 Financial Management (3 credits)
- 605.645 Design and Innovation in a Global Setting (3 credits)
- 605.651 Seminar (1 credit)
- 605.xxx Global Innovation IP Protection (1.5 credits)

One of

- 605.650 Internship (3 credits)
- 605.660 Design and Innovation Capstone (3 credits)

Minimum of six (6) elective courses from the list of track-specific courses.

Examples of Technical Courses

Cybersecurity

605.621 – Foundations of Algorithms (required for certificate)
695.601 – Foundations of Information Assurance
695.612 – Operating Systems Security
695.641 – Cryptology
695.614 – Security Engineering
695.615 – Cyber Physical System Security
650.656 – Computer Forensics
605.649 – Introduction to Machine Learning

605.731– Survey of Cloud Computing Security

Data Analytics

625.603 – Statistical Methods and Data Analysis
685.621 – Algorithms for Data Science
605.641 – Principles of Database Systems
605.649 – Introduction to Machine Learning
605.662 – Data Visualization
625.613 – Introduction to Optimization
625.664 – Computational Statistics
625.661 – Statistical Models and Regression
685.648 – Data Science

Engineering Management

595.660 - Planning and Managing Projects
595.662 - Technical Organization Management
595.665 - Strategic Communications in Technical Organizations
595.676 - Finance, Contracts, and Compliance for Technical Professionals
595.781 – Executive Technical Leadership

Healthcare Systems Engineering

655.662 - Intro to Healthcare Systems Engineering
655.667 - Management of Healthcare Systems Projects
655.767 - Healthcare System Conceptual Design
655.768 - Healthcare System Design & Integration
655.769 - Healthcare System Test and Evaluation
655.800 - Healthcare Systems Engineering Capstone Project
585.613 - Medical Sensors & Devices
585.619 - Regulation of Medical Devices

Systems Engineering

535.641 - Mathematical Methods for Engineers
565.604 - Structural Mechanics
565.606 - Geotechnical Engineering Principles
565.619 - Advanced Structural Analysis
565.616 - Advanced Finite Element Methods
565.628 - Preservation Engineering 1: Theory and Practice
565.636 - Lateral Forces: Analysis and Design of Building Structures
565.633 - Investigations, Diagnosis, and Rehabilitation

Environmental Planning and Management

575.604 - Principles of Environmental Engineering

575.658 - Natural Disaster Risk Modeling
575.735 - Energy Policy Planning and Modeling
575.714 - Water Resources Management
575.745 - Physical and Chemical Processes for Water and Wastewater Treatment
575.715 - Subsurface Fate and Contaminant Transport
575.721 - Air Quality Control Technologies
575.620 - Solid Waste Engineering and Management
575.742 - Hazardous Waste Engineering and Management

4. **Discuss how general education requirements will be met, if applicable**

   Not applicable.

5. **Identify any specialized accreditation or graduate certification requirements for this program and its students**

   Not applicable.

6. **If contracting with another institution or non-collegiate organization, provide a copy of the written contract**

   Not applicable.

7. **Provide assurance and any appropriate evidence that the proposed program will provide students with clear, complete, and timely information on the curriculum, course and degree requirements, nature of faculty/student interaction, assumptions about technology competence and skills, technical equipment requirements, learning management system, availability of academic support services and financial aid resources, and costs and payment policies**

   All specific course-related information (e.g., course requirements, nature of faculty/student interaction, assumptions about technology competence and skills, and technical equipment requirements) is provided in the syllabus for each course and is available on the Canvas course site. Program-related information (e.g., degree requirements, learning management system information, availability of academic support services, financial aid resources, and tuition payment policies) can be found on a website specific to the Master's degree, which includes a detailed student advising manual. Links to these resources are emailed to all admitted and continuing students annually.

   Provide assurance and any appropriate evidence that advertising, recruiting, and admissions materials will clearly and accurately represent the proposed program and the services available.

   We affirm that these materials represent a good faith effort to be totally clear and

transparent in all our communications with current and new students. Incidentally, this also applies to the employers who are a very important factor in supporting our students in their academic pursuits.

H. **Adequacy of Articulation**

Not applicable.

I. **Adequacy of Faculty Resources (as outlined in COMAR 13B.02.03.11).**

1. Provide a brief narrative demonstrating the quality of program faculty. Include a summary list of faculty with appointment type, terminal degree title and field, academic title/rank, status (full-time, part-time, adjunct) and the course(s) each faulty member will teach (in this program)

See Appendix C for a representative list of faculty who will teach in the proposed program. The program currently has identified highly-qualified faculty members. Each is a distinguished and experienced professional and all have advanced degrees (MS or PhD) in their fields of expertise. Each has demonstrated a strong commitment to excellence in teaching. All listed faculty will be involved in advising students. The existing courses in this area are taught by existing Whiting school faculty.

2. Demonstrate how the institution will provide ongoing pedagogy training for the faculty in evidenced-based best practices, including training in: a. Pedagogy that meets the needs of the students, b. The learning management system and c. Evidenced-based best practices for distance education, if distance education is offered

a) and b) Faculty support for the development and instruction of courses is provided by the Center for Educational Resources professional staff. CER staff expertise includes instructional design, instructional technology, educational research, software development, and graduate student professional development. Faculty have multiple opportunities to receive training on the Canvas learning management system, and in the pedagogy of classroom learning. These opportunities are presented at various times throughout the year at events such as fall/spring annual faculty meetings, training webinars, and privately-scheduled training sessions. https://cer.jhu.edu/
c) See Section P.

J. **Adequacy of Library Resources (as outlined in COMAR 13B.02.03.12).**

Students have access to the Milton S. Eisenhower Library on the Homewood campus, which is ranked as one of the nation's foremost facilities for research and scholarship. Its collection of more than three million bound volumes, several million microfilms, and more than 13,000 journal subscriptions has been assembled to support the academic efforts of the University. The interlibrary loan department makes the research collection of the nation available to faculty and students. The library also provides easy access to a wide selection of electronic information resources, including the library's online catalog, and numerous electronic abstracting and indexing tools. Many of the databases are accessible remotely. Librarians help students electronically and the library maintains an extensive web site to take visitors through all of its services and materials. To this are added more than 10,000 audiovisual titles available for on-site consultation.

K. **Adequacy of Physical Facilities, Infrastructure and Instructional Equipment (as outlined in COMAR13B.02.03.13)**

1. Provide an assurance that physical facilities, infrastructure and instruction equipment are adequate to initiate the program, particularly as related to spaces for classrooms, staff and faculty offices, and laboratories for studies in the technologies and sciences. If the program is to be implemented within existing institutional resources, include a supportive statement by the President for adequate equipment and facilities to meet the program's needs

This master's degree will have no discernible impact on the use of existing facilities and equipment beyond the standard requirements already in place; it will be housed in existing classrooms in the Center of Leadership Education and online. Internships and capstone projects will take place globally with industry providers, leveraging their facilities and resources.

2. Provide assurance and any appropriate evidence that the institution will ensure students enrolled in and faculty teaching in distance education will have adequate access to: a) an institutional electronic mailing system, and b) a learning management system that provides the necessary technological support for distance education

a) Students will have access to the JHU email system.
b) Students will have access to the Canvas learning management system, the Zoom videoconferencing system, and the university's document storage and collaborative platform.

L. **Adequacy of Financial Resources with Documentation (as outlined in COMAR 13B.02.03.14)**

See Appendix D.

M. **Adequacy of Provisions for Evaluation of Program (as outlined in COMAR 13B.02.03.15).**

1. **Discuss procedures for evaluating courses, faculty and student learning outcomes**
2. **Explain how the institution will evaluate the proposed program's educational effectiveness, including assessments of student learning outcomes, student retention, student and faculty satisfaction, and cost-effectiveness.**

Response to 1 and 2 above. Once the degree is launched, its courses will enter the course evaluation system. Course evaluation surveys ask students to reflect on the course structure, the course content, and the instructor's performance. Additionally, data concerning time to completion and placement post-graduation (as accessible) will be collected for evaluation. Summary data will be reviewed by faculty members, the program chair, and the Whiting School administration to determine whether changes are necessary.

As described in section G.3, student learning outcomes are carefully and deliberately linked to in-class learning assessments (assignments, projects, papers, exams, etc.) throughout the curriculum. The instructors then grade these assessments using grading rubrics. The assessment grades indicate the achievement level of each learning outcome. If learning outcomes are not met in a given year, the program is expected to change the way the outcome is taught in the related class and then reassess post adjustment.

All of this information will be reviewed periodically by the CLE Advisory Board (See Appendix A).

N. **Consistency with the State's Minority Student Achievement Goals (as outlined in COMAR13B.02.03.05).**

Any student meeting the admissions requirements can apply to the Master of Science in Global Innovation and Leadership through Engineering. The program will work to help all accepted students improve their workplace competitiveness and reach their professional goals, an aim consistent with the State's minority student achievement goals.

O. **Relationship to Low Productivity Programs Identified by the Commission:**

Not applicable.

P. Adequacy of Distance Education Programs (as outlined in COMAR 13B.02.03.22)

1. **Provide affirmation and any appropriate evidence that the institution is eligible to provide Distance Education.**

The Global Innovation and Leadership program will be supported in the same way as the other online master's degree programs in the Whiting School of Engineering.

2. **Provide assurance and any appropriate evidence that the institution complies with the C-RAC guidelines, particularly as it relates to the proposed program**

a) Online learning is appropriate to the institution's mission and purposes

The mission of The Johns Hopkins University is to educate its students and cultivate their capacity for life-long learning, to foster independent and original research, and to bring the benefits of discovery to the world. More simply stated, it's "Knowledge for the world." An online delivery format is not just appropriate, but truly a critical requirement of disseminating knowledge to students who are unable to travel to the Baltimore campus.

The institution's plans for developing, sustaining, and, if appropriate, expanding online learning offerings are integrated into its regular planning and evaluation processes

The Whiting School of Engineering has fully embraced online education, to the extent that when a new program is developed, it is fully expected that the program will be delivered through an online modality. Both part-time and full-time online programs now report up to the Whiting School of Engineering's Vice Dean for Graduate Education, who also oversees all full-time residential graduate programs. As such, online education has increased exposure to Whiting School of Engineering leadership and is included in long-term planning, including student and faculty support systems. There is a clear vision for online education enrollment growth documented in the program's five-year budget plan.

b) Online learning is incorporated into the institution's systems of governance and academic oversight

Johns Hopkins University reviews new online program proposals using the same systems of governance and academic oversight as that for new on-site programs. Before being shared with the deans of all JHU academic divisions, all proposals must first undergo a review by internal academic bodies, including discussions of fit with School mission, program viability, program rigor, instructor quality, and redundancy with existing programs. For Whiting School of Engineering programs, this entails a review by the Whiting School Graduate Committee, a faculty body with representation from both the part-time online and full-time residential program faculty. If approved, a proposal is then forwarded to the Homewood Academic Council for review by faculty from both the Whiting School of Engineering and the Krieger School of Arts and Sciences. As discussed in M.1, once a program is launched, its courses will enter the course evaluation system. These evaluations ask students to reflect on the course structure, the course content, and the instructor's performance. Summary reports are reviewed by the faculty member, the program chair, and the administration to determine whether changes are necessary. The Program Committee will discuss these results as well to consider the broader context of the program's curriculum and course delivery mechanisms. Lastly, programs undergo a rigorous review by the Homewood Academic Council faculty every five years.

c) Curricula for the institution's online learning offerings are coherent, cohesive, and comparable in academic rigor to programs offered in traditional instructional formats

In most cases, Whiting School of Engineering online courses are first developed and run as on-site courses, and this provides a suitable benchmark for course rigor and workload. A formal online course development process is then used to support the development of all online courses. This process typically incorporates the Quality Matters™ research-based set of eight standards for quality online course design that help to ensure the academic rigor of the online course is comparable to or better than the traditionally offered course. A Whiting School of Engineering program is composed of courses that are appropriately sequenced to ensure students have adequate background for courses later in the program. Courses are offered frequently enough to ensure that students can complete a degree program within the 5-year maximum allowable timeframe. Courses are built with components such as discussion boards, etc. to facilitate student-student and student-faculty interaction.

d) The institution evaluates the effectiveness of its online learning offerings, including the extent to which the online learning goals are achieved, and uses the results of its evaluations to enhance the attainment of the goals

Once a program is launched, its courses will enter the course evaluation system. These evaluations ask students to reflect on the course structure, the course content, and the instructor's performance. Summary reports are reviewed by the faculty member, the program chair, and the administration to determine whether changes are necessary. The Program Committee will discuss these results as well to consider the broader context of the program's curriculum and course delivery mechanisms.

The assessment grades indicate the achievement level of each learning outcome. The learning assessment scores are retained for the purposes of accreditation and program improvement. Grades are kept in the gradebook in Canvas as applicable and in the Student Information System. If learning outcomes are not met in a given year, the program is expected to change the way the outcome is taught in the related class and then reassess post adjustment.

e) Faculty responsible for delivering the online learning curricula and evaluating the students' success in achieving the online learning goals are appropriately qualified and effectively supported

Any new instructor recruited to teach online must meet the same qualifications as those teaching in a traditional site-based program. They must have a graduate degree in a relevant field, and they must have professional experience related to the course content.

Faculty support for the development of online courses is provided by the Whiting School of Engineering's Center for Learning Design (CLD) and Center for Digital and Media Initiatives (CDMI) professional staff consisting of eight instructional designers and five multimedia technicians and instructional technologists. Faculty have multiple opportunities to receive training on the Canvas learning management system, and in the pedagogy of online learning. These opportunities are presented at various times throughout the year at events such as fall/spring annual faculty meetings, training webinars, and privately-scheduled training sessions. Once an instructor has been identified to develop an online course, they are given access to a set of web-based resources that cover a broad range of topics on online pedagogy, use of instructional technologies and learning management system tutorials. Throughout the online course development, the instructor receives direct support and guidance from their assigned instructional designer, as well as from the instructional technology and multimedia staff. This could take the form of course design guidance based on best practices in online learning, course production support, audio and video recording support. Once the course is built, the support staff continues to provide assistance to the faculty member, offering best practices in course instruction and help desk support. After the course runs, these teams help the instructor make updates and improvements to the course.

f) The institution provides effective student and academic services to support students enrolled in online learning offerings

The Whiting School of Engineering maintains numerous web-based resources to inform prospective and current students. These resources include: a central website (https://engineering.jhu.edu/), an online catalog (https://e-catalogue.jhu.edu/, a department resource site which will house a webpage specific to this program (https://engineering.jhu.edu/cle/) and a student life and resources website (https://homewoodgrad.jhu.edu/) which together include detailed programmatic information, academic support services, financial aid, costs, policies, etc. and specific information for program students. As new online students are admitted, they're introduced to the program and procedures through the fully online New Student Orientation, that includes information on registration, student advising, ordering textbooks, the JHU email system, and other online student services. New students are enrolled in a mandatory Academic Integrity training course -- a zero-credit, zero-tuition course that is geared towards helping students avoid behaviors linked to plagiarism, cheating and other violations of academic integrity.

Students are assigned an advisor when accepted. Students are able to work individually with the advisor to develop a course of study that meets the requirements of the program and the career goals of the student. Courses that deviate from the program plan and have not been approved by an advisor may not count toward degree requirements. All advising can be received remotely.

Students have online access to the Milton S. Eisenhower Library on the Homewood campus, ranked as one of the nation's foremost facilities for research and scholarship. The interlibrary loan department allows students access to resources at any other university in the nation. The library also provides easy access to a wide selection of electronic information resources, including the library's online catalog, and numerous electronic abstracting and indexing tools. Many of the databases are accessible remotely. Librarians are available to assist students remotely and the library maintains an extensive website to take visitors through all its services and materials.

The Johns Hopkins University is committed to making all academic programs, support services, and facilities accessible to qualified individuals with disabilities. Students with disabilities who require reasonable accommodations can contact the Disability Services Administrator and receive support remotely.

The Johns Hopkins Counseling Center is a professional counseling service that can assist students with managing problems of daily living. Stress, personal problems, family conflict, and life challenges can affect the academic progress of students. Online students may call a phone number for consultation and will be directed to the appropriate resource or office. Counseling Center service are completely confidential. The program operates under State and Federal confidentiality legislation and is HIPAA compliant.

The Whiting School of Engineering has an internal graduate student affairs office comprising (1) professional development for WSE master's students, (2) graduate non-academic programming and (3) the Office of Engineering Support and Advocacy (case management and crisis management). All services will be available and designed to support students enrolled in this program.

g) The institution provides sufficient resources to support and, if appropriate, expand its online learning offerings

The Whiting School of Engineering prepares a five-year budget every year that includes sufficient resources to maintain all online programs and expand offerings, if desired. The budget contains funding for marketing and recruitment for all programs as well as staffing all programs in terms of admissions services, students and faculty support services, finance and administration services, and instructional design and instructional technology services. The budget also contains funding for new program viability analyses, new program marketing launches, and new course development costs. Faculty and staff development costs are included, as described in greater detail in section P.2.f above.

The Whiting School of Engineering collaborates with central Johns Hopkins University Information Technology to provide a robust and scalable, but also flexible, technical infrastructure that serves student and faculty member needs. These programs are delivered via online infrastructure, which includes the Canvas course management system and the Zoom video conferencing system. These systems provide password-protected online course sites and community management systems that enable ongoing collaborative exchange and provide convenient channels for synchronous and asynchronous learning.

h) The institution assures the integrity of its online offerings

The Higher Education Opportunity Act (HEOA) enacted in 2008 requires that an academic institution that offers distance education opportunities to students 1) has a process established to verify that the student who registers is the same student who participates in and completes the offering and receives academic credit for it, 2) has a process established to verify that student privacy rights are protected, and 3) has a process established that notifies the student about any additional costs or charges that are associated with verification of student identity. In Whiting School of Engineering programs, the following actions have been taken to satisfy these requirements: 1) students may only enter the academic website for the online courses they take by providing the unique student ID and password assigned after admission, 2) all FERPA privacy rights are preserved by limiting access very specifically in the University student information system to only those permitted by law to have access to restricted student information, and 3) there are no additional costs assessed to the student for the measures we use to verify student identity.

Other measures are taken as well to assure the integrity of JHU-EP online offerings. The Whiting School of Engineering's Graduate Academic Misconduct Policy applies to all online students, it clearly defines misconduct, and it includes references to the most common online student infractions. As referenced in section P.2.g, all new students are enrolled in a mandatory Academic Integrity training course -- a zero-credit, zero-tuition course that is geared towards helping students avoid behaviors linked to plagiarism, cheating and other violations of academic integrity. Lastly, The Whiting School of Engineering has recently required that all essay-based coursework

be submitted to SafeAssign, a Canvas integrated tool used to prevent plagiarism by identifying unoriginal content and creating opportunities to help students identify how to properly attribute sources rather than paraphrase.

Appendix A

CLE Advisory Board Contact List

Name	Title	Company	Email 1	Assistant
Matt Daimler	SVP, Engineering Team Lead	Zillow	mdaimler@gmail.com; matt@daimler.net	
Mr. Prateek Khamesra	Manager, Product Management	JP Morgan Chase	prateekkhamesra@gmail.com	
Mr. Gary S. Laben	CEO	Dynata	garyslaben@gmail.com; gary.laben@dynata.com	Jenna.Phan@dynata.com
Mr. Noah Presler	Product Manager, Office of the CEO	Google	noah@presler.me	
Charlie Moore	Co-Founder	DinnerTime	cmoore@dinnertime.com	
Mr. Derek S. Lewis	VP of Operations and R&D	Checkpoint Surgical	derek.s.lewis@gmail.com	
Mr. Peter C. Li	Co-Founder & CEO	Atlas Wearables	peter@atlaswearables.com	
Mrs. Natasha A. Porter	EVP and Customer Development Officer	Gensuite	natasha.porter@gensuitellc.com	
Mr. Phong Le	SEVP, COO, and CFO	Microstrategy	phongle00@gmail.com; phle@microstrategy.com	jchin@microstrategy.com
Cynthia Stern	Consultant	CS Consulting Solutions	cindystern@aol.com	
Beverly Waters	Sr. Manager, Talent Acquisition	Pepsico	Beverly.L.Waters@PepsiCo.com	
Alessandro Piovaccari	CTO and SVP of Engineering	Silicon Labs	piovac@gmail.com ; Alessandro.piovaccari@silabs.com	
Mr. Doug Akerson	SVP, Engineering Team Lead	Munich Re	doug.akerson@gmail.com	
Giovanna Kampouri	Independent Consultant and Board Member	AptarGroup, Puig SL, Randstad Holding	gkampouri@hotmail.com	

Appendix B

Course List and Descriptions

REQUIRED CORE COURSES

605.601 Management and Global Team Leadership
605.621 Project Management
605.623 Financial Management
605.645 Design and Innovation in a Global Setting:
605.XXX. Global Innovation Protection
605.650 Internship
605.651 Seminar
605.660 Design and Innovation Capstone

Course Name	Link	Description	EP/Homewood
605.601 Management and Global Team Leadership		Managing global teams requires communicating effectively across cultures and time zones, sometimes in person, often virtually. What characteristics and norms result in successful and productive teams? What steps can leaders take to support such teams? In this seminar-style course, students will learn best practices for global team-building and leadership, using a combination of reading, discussion, lecture, and projects.	Homewood
605.621 Project Management		As a project manager, you'll plan the scope of a project - within a broader strategy; set budgets and goals; hire, coordinate, and oversee teams who may be far from you; track their progress; troubleshoot delays; integrate design thinking and user experience needs; and communicate with clients and workers. In this course, students will explore the processes and tools available to help project managers achieve the best possible outcomes. Class time involves presentations, examples and discussion.	Homewood
605.623 Financial Management		Financial Management focuses on communication and decision making within an organization (as opposed to Financial Accounting, which focuses on accounting information for decision-makers external to the firm). This course aims to achieve two core efforts: The first, provides a fundamental introduction to financial management. This comprises of accounting concepts and objectives including planning, control, and the analysis of sales, expenses, and profits. Major topics also include cost behavior; cost allocation; product costing (including activity-based costing); standard costing and variance analysis; and operational and capital budgeting. The second core effort will teach students about the specific financial management skills needed to drive innovation, whether that is being equipped with the fundamentals to fund raise from investors (venture capitalists for example) or understanding how to leverage resources within large organizations for internal innovation endeavors. The end-state is that students will be able to translate their innovation efforts to those who speak the language of finance.	Homewood
605.645 Design and Innovation in a Global Setting		In this course, students will explore a specific domain area looking for "problems worth solving." This will teach students to think about where problems come from and how to articulate them. From there, teams will develop their ideas and choose one for exploration and validation. The curriculum will focus on the ability of students to identify market needs, validate those needs, develop appropriate solutions, and construct the business case.	Homewood
605.XXX Global Innovation Protection		In this course, you will learn both why and how to protect your innovations. You will learn why it is important to protect your innovation endeavors and how to do it. The course will cover the key global protection laws as they apply to relevant global jurisdictions as well as the national security drivers that are often associated with such laws. You will learn how to use innovation protection laws (including intellectual property laws) to your advantage, the key information to know when raising investment rounds and how to work with legal professionals whether you are in a start-up or a multinational organization.	Homewood
605.650 Internship		The Master of Science in Global Innovation and Leadership through Engineering program offers students transformative real-world experience through faculty-supervised internship projects with our innovative industry partners.	Homewood

605.651 Seminar		In this seminar-style class, visiting expert speakers will help students better understand current issues and challenges in global innovation and leadership.	Homewood
605.660 Design and Innovation Capstone		In your capstone course you will have the opportunity to bring together all of those elements you've been taught throughout the program. Using design thinking, you will first identify a problem worth solving and working in interdisciplinary teams with your fellow students you will then analyze the options to address the problem; design and create a solution(s) to your problem; assess the investment needed; articulate the user interface/experience benefits; and gauge potential global impact the success of your ideas might have. All of this will be captured in a strategy and business plan that will be the basis for you to bring your ideas to life.	Homewood

TECHNICAL COURSES

Cybersecurity/Information Security-

EP Course Catalog: https://e-catalogue.jhu.edu/engineering/engineering-professionals/cybersecurity/cybersecurity-master-science/#requirementstext

Homewood Cataloges:

Applied Mathematics & Statistics (553)- https://e-catalogue.jhu.edu/course-descriptions/applied_mathematics___statistics/

Computer Science (601)- https://e-catalogue.jhu.edu/course-descriptions/computer_science_601/

Information Security Institute (650)- https://e-catalogue.jhu.edu/course-descriptions/information_security_institute/

Foundation Courses:

EP Course: EN.605.621 Foundations of Algorithms

Homewood Option: EN.601.633 Intro Algorithms

EP Course: EN.695.601 Foundations of Information Assurance

Homewood Option: EN.650.601 Introduction to Information Security

EP Course: EN.695.612 Operating Systems Security

EP Course: EN.695.641 Cryptography

Homewood Option: EN.650.658 Introduction to Cryptography

Track Courses:

EP Course: EN.650.656 Computer Forensics (Homewood Course)

Homewood Option: EN.650.656 Computer Forensics

EP Course: EN.605.649 Introduction to Machine Learning

Homewood Option: EN.553.740 Machine Learning 1

EP Course: EN.605.731 Survey of Cloud Computing Security

Homewood Option: EN.650.663 Cloud Computing Security

Data Science

EP Course Catalog: https://e-catalogue.jhu.edu/engineering/engineering-professionals/data-science/data-science-master/#requirementstext

Homewood Catalogs:

Applied Mathematics & Statistics (553)- https://e-catalogue.jhu.edu/course-descriptions/applied_mathematics___statistics/

Computer Science (601)- https://e-catalogue.jhu.edu/course-descriptions/computer_science_601/
Foundation Courses:
EP Course: EN.625.603 Statistical Methods and Data Analysis
Homewood Option: EN.553.613 Applied Statistics and Data Analysis
EP Course: EN.685.621 Algorithms for Data Science
Homewood Option: EN.553.636 Introduction to Data Science
Required Courses:
EP Course: EN.605.641 Principles of Database Systems
Homewood Option: EN.601.615 Databases
EP Course: EN.605.649 Introduction to Machine Learning
Homewood Option: EN.553.740 Machine Learning
EP Course: EN.605.662 Data Visualization
EP Course: EN.625.613 Introduction to Optimization
EP Course: EN.625.664 Computational Statistics
EP Course: EN.625.661 Statistical Models and Regression:
EP Course: EN.685.648 Data Science

Engineering Management-

EP Course Catalog: https://e-catalogue.jhu.edu/engineering/engineering-professionals/engineering-management/engineering-management-master/#requirementstext
Homewood Course Catalog: https://e-catalogue.jhu.edu/course-descriptions/center_for_leadership_education/
Core Courses

EP Course: EN.595.660 Planning and Managing Projects
EP Course: EN.595.662 Technical Organization Management
Homewood Option: EN.662.642 Leadership & Management
EP Course: EN.595.665 Strategic Communications In Technical Organizations
Homewood Option: EN.663.618 Professional Presentations
EP Course: EN.595.676 Finance, Contracts, and Compliance for Technical Professionals
Homewood Option: EN.662.611 Strategies: Accounting & Finance
EP Course: EN.595.781 Executive Technical Leadership

Healthcare Systems Engineering/Environmental Health-

EP Course Catalog: https://e-catalogue.jhu.edu/engineering/engineering-professionals/healthcare-systems-engineering/healthcare-systems-engineering-master-science/#requirementstext
Homewood Course Catalog: https://e-catalogue.jhu.edu/course-descriptions/biomedical_engineering/
Core Courses (Only EP Options):
EN.655.662 Intro to Healthcare Systems Engineering
EN.655.667 Management of Healthcare Systems Projects

EN.655.767 Healthcare System Conceptual Design
EN.655.768 Healthcare System Design & Integration
EN.655.769 Healthcare System Test and Evaluation
EN.655.800 Healthcare Systems Engineering Capstone Project
Elective Courses:
EP Course: EN.585.613 Medical Sensors & Devices
EP Course: EN.585.619 Regulation of Medical Devices
Homewood Option: EN.580.607 Regulation of Medical Devices

Systems Engineering/Civil and Systems Engineering-

EP Course Catalog:
Civil- https://e-catalogue.jhu.edu/engineering/engineering-professionals/civil-engineering/civil-engineering-master-civil-engineering/#requirementstext
Systems- https://e-catalogue.jhu.edu/engineering/engineering-professionals/systems-engineering/systems-engineering-master-science-engineering/#requirementstext
Homewood Course Catalog: https://e-catalogue.jhu.edu/course-descriptions/civil_engineering/
Core Courses:
EP Program: EN.535.641 Mathematical Methods for Engineers
Homewood Option: EN.560.601 Applied Math for Engineers
EP Program: EN.565.604 Structural Mechanics
Homewood Option: EN.560.604 Introduction to Solid Mechanics
EP Program: EN.565.606 Geotechnical Engineering Principles
Electives:
EP Program: EN.565.619 Advanced Structural Analysis
Homewood Option: EN.560.619 Advanced Structural Analysis
EP Program: EN.565.616 Advanced Finite Element Methods
Homewood Option: EN.560.770 Advanced Finite Elements Methods and Multi-Scale Methods
EP Program: EN.565.628 Preservation Engineering 1: Theory and Practice
Homewood Option: EN.560.629 Preservation Engineering 1: Theory and Practice
EP Program: EN.565.636 Lateral Forces: Analysis and Design of Building Structures
Homewood: EN.560.636 Lateral Forces: Analysis and Design of Building Structures
EP Program: EN.565.633 Investigations, Diagnosis, and Rehabilitation
Homewood: EN.560.633 Investigations, Diagnosis, and Rehabilitation

Environmental Planning and Management/Environmental Engineering-

EP Course Catalog:
Environmental Planning- https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-planning-management-master-science/#requirementstext
Environmental Engineering- https://e-catalogue.jhu.edu/engineering/engineering-professionals/environmental-engineering-science-management-programs/environmental-engineering-master/#requirementstext
Homewood Course Catalogs:

Civil Engineering (560)- https://e-catalogue.jhu.edu/course-descriptions/civil_engineering/
Environmental Health and Engineering (570)- https://e-catalogue.jhu.edu/course-descriptions/environmental_health_and_engineering/

Required Courses:

EP Program: EN.575.604 Principles of Environmental Engineering

Minimum Five Selection Courses:

EP Program: EN.575.658 Natural Disaster Risk Modeling
Homewood Option: EN.560.658 Natural Disaster Risk Modelling
EP Program: EN.575.735 Energy Policy and Planning Modeling
Homewood Option: EN.570.607 Energy Policy and Planning Modeling
EP Program: EN.575.714 Water Resource Management
Homewood Option: EN.570.631 Collaborative Modelling for Resolving Water Resources Disputes
EP Program: EN.575.745 Physical and Chemical Processes for Water and Wastewater Treatment
Homewood Option: EN.570.644 Physical and Chemical Processes
EP Program: EN.575.715 Subsurface Fate and Contaminant Transport
Homewood Option: EN.570.651 Environmental Transport and Dispersion
EP Program: EN.575.721 Air Quality Control Technologies
Homewood Option: EN.570.657 Air Polluction
EP Program: EN.575.620 Solid Waste Engineering and Management
Homewood Option: EN.570.690 Solid Waste Engineering and Management
EP Program: EN.575.742 Hazardous Waste Engineering and Management
Homewood Option: EN.570.691 Hazardous Waste Engineering and Management

Course Name	Link	Descriptiopn	EP/Homewood
EN.605.621 Foundations of Algorithms	https://e-catalogue.jhu.edu/search/?P=EN.605.621	This follow-on course to data structures (e.g., 605.202) provides a survey of computer algorithms, examines fundamental techniques in algorithm design and analysis, and develops problem-solving skills required in all programs of study involving computer science. Topics include advanced data structures (red-black and 2-3-4 trees, union-find), recursion and mathematical induction, algorithm analysis and computational complexity (recurrence relations, big-O notation, NP-completeness), sorting and searching, design paradigms (divide and conquer, greedy heuristic, dynamic programming, amortized analysis), and graph algorithms (depth-first and breadth-first search, connectivity, minimum spanning trees, network flow). Advanced topics are selected from among the following: randomized algorithms, information retrieval, string and pattern matching, and computational geometry. Prerequisite(s): 605.202 Data Structures or equivalent. 605.203 Discrete Mathematics or equivalent is recommended. Course Note(s): The required foundation courses may be taken in any order but must be taken before other courses in the degree. Students can only earn credit for one of 605.620, 605.621, or 685.621.	EP
EN.601.633 Intro Algorithms	https://e-catalogue.jhu.edu/course-descriptions/computer_science_601/	This course concentrates on the design of algorithms and the rigorous analysis of their efficiency. topics include the basic definitions of algorithmic complexity (worst case, average case); basic tools such as dynamic programming, sorting, searching, and selection; advanced data structures and their applications (such as union-find); graph algorithms and searching techniques such as minimum spanning trees, depth-first search, shortest paths, design of online algorithms and competitive analysis. [Analysis]	Homewood
EN.695.601 Foundations of Information Assurance	https://e-catalogue.jhu.edu/search/?P=EN.695.601	This course surveys the broad fields of enterprise security and privacy, concentrating on the nature of enterprise security requirements by identifying threats to enterprise information technology (IT) systems, access control and open systems, and system and product evaluation criteria. Risk management and policy considerations are examined with respect to the technical nature of enterprise security as represented by government guidance and regulations to support information confidentiality, integrity and availability. The course develops the student's ability to assess enterprise security risk and to formulate technical recommendations in the areas of hardware and software. Aspects of	EP

Course Name	Link	Descriptiopn	EP/Homewood
		security-related topics to be discussed include network security, cryptography, IT technology issues, and database security. The course addresses evolving Internet, Intranet, and Extranet security issues that affect enterprise security. Additional topics include access control (hardware and software), communications security, and the proper use of system software (operating system and utilities). The course addresses the social and legal problems of individual privacy in an information processing environment, as well as the computer "crime" potential of such systems. The class examines several data encryption algorithms. Course Note(s): This course can be taken before or after 605.621 Foundations of Algorithms. It must be taken before other courses in the degree	
EN.695.612 Operating Systems Security	https://e-catalogue.jhu.edu/engineering/engineering-professionals/cybersecurity/cybersecurity-master-science/#sys	This course covers both the fundamentals and advanced topics in operating system (OS) security. Access control mechanisms (e.g., SACL/DACL), memory protections, and interprocess communications mechanisms will be studied. Students will learn the current state-of-the-art OS-level mechanisms and policies designed to help protect systems against sophisticated attacks. In addition, advanced persistent threats, including rootkits and malware, as well as various protection mechanisms designed to thwart these types of malicious activities, will be studied. Advanced kernel debugging techniques will be applied to understand the underlying protection mechanisms and analyze the malicious software. Students will learn both hardware and software mechanisms designed to protect the OS (e.g., NX/ASLR/SMEP/SMAP). The course will use virtual machines to study traditional OS environments on modern 64-bit systems (e.g., Windows, Linux, and macOS), as well as modern mobile operating systems (e.g., iOS and Android). Prerequisite(s): Familiarity with operating system concepts.	EP
EN.650.601 Introduction to Information Security	https://e-catalogue.jhu.edu/course-descriptions/information_security_institute/	This course exposes students to the cross-disciplinary and broad information security field. It surveys a range of fundamental topics of information security principles, architecture, policy and standard, risk management, cryptography, physical, operation, system and network security mechanisms, and law and ethics, among others. This course includes lectures, case studies, and homework. Students will also complete independent study class projects. Recommended Course Background: Basic knowledge of computer system and information technology.	Homewood
EN.695.641 Cryptography	https://e-catalogue.jhu.edu/search/?P=EN.601.642	Same material as 601.442, for graduate students. Modern Cryptography includes seemingly paradoxical notions such as communicating privately without a shared secret, proving things without leaking knowledge, and computing on encrypted data. In this challenging but rewarding course we will start from the basics of private and public key cryptography and go all the way up to advanced notions such as zero-knowledge proofs, functional encryption and program obfuscation. The class will focus on rigorous proofs and require mathematical maturity. [Analysis] Required course background: EN.601.231 or EN.601.631. Prerequisite(s): Students may receive credit for only one of EN.600.442, EN.601.442, EN.601.642.	EP
EN.650.658 Introduction to Cryptography	https://e-catalogue.jhu.edu/course-descriptions/information_security_institute/	Cryptography has a rich history as one of the foundations of information security. This course serves as the introduction to the working primitives, development and various techniques in this field. It emphasizes reasoning about the constraint and construction of cryptographic protocols that use shared secret key or public key. Students will also be exposed to some current open problems. Permission of instructor only. Area: Engineering	Homewood
EN.650.656 Computer Forensics	https://e-catalogue.jhu.edu/search/?P=EN.650.656	This course introduces students to the field of computer forensics and it will focus o n the various contemporary policy issues and applied technologies. Topics to be covered include: legal and regulatory issues, investigation techniques, data analysis approaches, and incident response procedures for Windows and UNIX systems. Homework in this course will relate to laboratory assignments and research exercises. Students should also expect that a group project will be integrated into this course. Area: Engineering	EP
EN.650.656 Computer Forensics	https://e-catalogue.jhu.edu/course-descriptions/information_security_institute/	This course introduces students to the field of computer forensics and it will focus o n the various contemporary policy issues and applied technologies. Topics to be covered include: legal and regulatory issues, investigation techniques, data analysis approaches, and incident response procedures for Windows and UNIX systems. Homework in this course will relate to laboratory assignments and research exercises. Students should also expect that a group project will be integrated into this course. Area: Engineering	Homewood
EN.605.649 Introduction to Machine Learning	https://e-catalogue.jhu.edu/search/?P=EN.605.649	Analyzing large data sets ("Big Data"), is an increasingly important skill set. One of the disciplines being relied upon for such analysis is machine learning. In this course, we will approach machine learning from a practitioner's perspective. We will examine the issues that impact our ability to learn good models (e.g., the curse of dimensionality, the biasvariance dilemma, and no free lunch). We will then examine a variety of approaches to learning models, covering the spectrum from unsupervised to supervised learning, as well as parametric versus non-parametric methods. Students will explore and implement several learning methods, including logistic regression, Bayesian classification, decision	EP

Course Name	Link	Descriptiopn	EP/Homewood
		trees, and feed-forward neural networks, and will incorporate strategies for addressing the issues impacting performance (e.g., regularization, clustering, and dimensionality reduction). In addition, students will engage in online discussions, focusing on the key questions in developing learning systems. At the end of this course, students will be able to implement and apply a variety of machine learning methods to real-world problems, as well as be able to assess the performance of these algorithms on different types of data sets.	
EN.553.740 Machine Learning 1	https://e-catalogue.jhu.edu/course-descriptions/applied_mathematics___statistics/	This course is the first part of a two-semester sequence that focuses on theoretical and practical aspects of statistical learning. After introducing background material on inner-product spaces, reproducing kernels and on optimization, the course discusses fundamental concepts of machine learning (such as generalization error, Bayes estimators and the bias vs. variance dilemma) and studies a collection of learning algorithms for classification and regression. The topics that are discussed include linear and kernel regression, support vector machines, lasso, logistic regression, decision trees and neural networks. Students will need a solid background in multivariate calculus, linear algebra, probability and statistics to complete the course.Recommended Course background: 553.620 and 553.630 or higher, and prerequisites for these courses.	Homewood
EN.605.731 Survey of Cloud Computing Security	https://e-catalogue.jhu.edu/search/?P=EN.605.731	The promise of significant cost savings and inherent flexibility of resources are an impetus for the adoption of cloud computing by many organizations. Cloud computing also introduces privacy and security risks that are not traditionally present in a siloed data center. This course focuses on these security concerns and countermeasures for a cloud environment. An overview of cloud computing and virtualization, the critical technology underpinning cloud computing, provides the necessary background for these threats. Additional topics vary but may include access control, identity management, denial of service, account and service hijacking, secure APIs, malware, forensics, regulatory compliance, trustworthy computing, and secure computing in the cloud. This course follows a seminar-style format where students are expected to lead class discussions and write a publication-quality paper as part of a course project.	EP
EN.650.663 Cloud Computing Security	https://e-catalogue.jhu.edu/course-descriptions/information_security_institute/	Cloud computing promises significant cost savings via economies of scale that typically are not achievable by a single organization. This course examines cloud computing in detail and introduces the security concerns associated with cloud computing. Key topics include service models for cloud computing, virtualization, storage, management, and data processing. Fundamental security principles are introduced and applied to cloud computing environments. The format of this course includes lectures and hands-on assignments. Students will complete a project and present it as part of the course. Area: Engineering, Natural Sciences	Homewood
EN.625.603 Statistical Methods and Data Analysis	https://e-catalogue.jhu.edu/search/?P=EN.625.603	This course introduces statistical methods that are widely used in modern applications. A balance is struck between the presentation of the mathematical foundations of concepts in probability and statistics and their appropriate use in a variety of practical contexts. Foundational topics of probability, such as probability rules, related inequalities, random variables, probability distributions, moments, and jointly distributed random variables, are followed by foundations of statistical inference, including estimation approaches and properties, hypothesis testing, and model building. Data analysis ranging from descriptive statistics to the implementation of common procedures for estimation, hypothesis testing, and model building is the focus after the foundational methodology has been covered. Software, for example R-Studio, will be leveraged to illustrate concepts through simulation and to serve as a platform for data analysis.Course prerequisite(s): Multivariate calculus.	EP
EN.553.613 Applied Statistics and Data Analysis	https://e-catalogue.jhu.edu/course-descriptions/applied_mathematics___statistics/	An introduction to basic concepts, techniques, and major computer software packages in applied statistics and data analysis. Topics include numerical descriptive statistics, observations and variables, sampling distributions, statistical inference, linear regression, multiple regression, design of experiments, nonparametric methods, and sample surveys. Real-life data sets are used in lectures and computer assignments. Intensive use of statistical packages such as R to analyze data. Recommended Course Background: EN.553.112 or EN.553.310 or EN.553.311 or EN.553.420. Prerequisite(s): Students may receive credit for EN.550.413/EN.553.413 or EN.553.613, but not both. Area: Engineering, Quantitative and Mathematical Sciences	Homewood
EN.685.621 Algorithms for Data Science	https://e-catalogue.jhu.edu/search/?P=EN.685.621	This follow-on course to data structures (e.g., EN.605.202 Data Structures) providing a survey of computer algorithms, examines fundamental techniques in algorithm design and analysis, and develops problem-solving skills required in all programs of study involving data science. Topics include advanced data structures for data science (tree structures, disjoint set data structures), algorithm analysis and computational complexity (recurrence relations, big-O notation, introduction to complexity classes (P, NP and NP-completeness)), data transformations (FFTs, principal component analysis), design paradigms (divide and conquer, greedy heuristic, dynamic programming), and graph algorithms (depth-first and breadth-first search, ordered and unordered trees). Advanced	EP

Course Name	Link	Descriptiopn	EP/Homewood
		topics are selected from among the following: approximation algorithms, computational geometry, data preprocessing methods, data analysis, linear programming, multi-threaded algorithms, matrix operations, and statistical learning methods. The course will draw on applications from Data Science. Course Prerequisite(s): EN.605.202 Data Structures or equivalent, and EN.605.201 Introduction to Programming Using Java or equivalent. EN.605.203 Discrete Mathematics or equivalent is recommended. Course Note(s): This required foundation course must be taken before other 605.xxx courses in the degree. This course does not satisfy the foundation course requirement for Bioinformatics, Computer Science, or Cybersecurity. Students can only earn credit for one of EN.605.620, EN.605.621, or EN.685.621.	
EN.553.636 Introduction to Data Science	https://e-catalogue.jhu.edu/course-descriptions/applied_mathematics___statistics/	Today the term Data Science is widely used covering a broad range of topics from mathematics and algorithms to actual data analysis and machine learning techniques. This course provides a thorough survey of relevant methods balancing the theory and the application aspects. Accordingly, the material and the discussions alternate between the methodology along with its underlying assumptions and the implementations along with their applications. We will cover several supervised methods for regression and classification, as well as unsupervised methods for clustering and dimensional reduction. To name a few in chronological order, the topics will include generalized linear regression, principal component analysis, nearest neighbor and Bayesian classifiers, support vector machines, logistic regression, decision trees, random forests, K-means clustering, Gaussian mixtures and Laplacian eigenmaps. The course uses Python and Jupyter Notebook and includes visualization techniques throughout the semester. Time permitting, an introduction to the Structured Query Language (SQL) is provided toward the end of the semester. Prerequisite(s): Students may receive credit for EN.550.436/EN.553.436 or EN.553.636, but not both. Area: Engineering, Quantitative and Mathematical Sciences	Homewood
EN.605.641 Principles of Database Systems	https://e-catalogue.jhu.edu/search/?P=EN.605.641	This course examines the underlying concepts and theory of database management systems. Topics include database system architectures, transaction management, data models, query languages, conceptual and logical database design, and physical organization. The entity-relationship (ER) model, using ER diagram (ERD) and Enhanced ERD, as well as relational models, are investigated in detail. Object-oriented databases are introduced along with legacy systems based on the network. Hierarchical models as well as big data and NoSQL are also briefly described. Mappings from the conceptual level to the logical level, integrity constraints, dependencies, and normalization are studied as a basis for formal design. Theoretical languages such as the relational algebra and the relational calculus are described, and high-level languages such as SQL, triggers and Stored Procedures are discussed. An overview of file organization and access methods is provided as a basis for discussion of query optimization and execution. The course also covers the causes of performance problems and how to improve database application performance during database design and implementation.Course prerequisite(s): 605.202 Data Structures.	EP
EN.601.615 Databases	https://e-catalogue.jhu.edu/search/?P=EN.601.615	Same material as 601.415, for graduate students. Introduction to database management systems and database design, focusing on the relational and object-oriented data models, query languages and query optimization, transaction processing, parallel and distributed databases, recovery and security issues, commercial systems and case studies, heterogeneous and multimedia databases, and data mining. [Systems] (www.cs.jhu.edu/~yarowsky/cs415.html) Recommended Course Background: EN.601.226 Prerequisite(s): Students may receive credit for only one of EN.600.315, EN.600.415, EN.601.315, EN.601.415, EN.601.615.	Homewood
EN.605.662 Data Visualization	https://e-catalogue.jhu.edu/course-descriptions/computer_science_601/	This course explores the underlying theory and practical concepts in creating visual representations of large amounts of data. It covers the core topics in data visualization: data representation, visualization toolkits, scientific visualization, medical visualization, information visualization, flow visualization, and volume rendering techniques. The related topics of applied human perception and advanced display devices are also introduced. Prerequisite(s): Experience with data collection/analysis in data-intensive fields or background in computer graphics (e.g., 605.667 Computer Graphics) is recommended.	Ep
EN.625.613 Introduction to Optimization	https://e-catalogue.jhu.edu/search/?P=EN.625.615	This course introduces applications and algorithms for linear, network, integer, and nonlinear optimization. Topics include the primal and dual simplex methods, network flow algorithms, branch and bound, interior point methods, Newton and quasi-Newton methods, and heuristic methods. Students will gain experience in formulating models and implementing algorithms using MATLAB. No previous experience with the software is required. Prerequisite(s): Multivariate calculus, linear algebra. Comfort with reading and writing mathematical proofs would be helpful but is not required. Course Note(s): Due to overlap in subject matter in EN.625.615 and EN.625.616, students may not receive credit towards the MS or post-master's certificate for both EN.625.615 and EN.625.616.	EP

Course Name	Link	Descriptiopn	EP/Homewood
EN.625.664 Computational Statistics	https://e-catalogue.jhu.edu/search/?P=EN.625.664	Computational statistics is a branch of mathematical sciences concerned with efficient methods for obtaining numerical solutions to statistically formulated problems. This course will introduce students to a variety of computationally intensive statistical techniques and the role of computation as a tool of discovery. Topics include numerical optimization in statistical inference [expectation-maximization (EM) algorithm, Fisher scoring, etc.], random number generation, Monte Carlo methods, randomization methods, jackknife methods, bootstrap methods, tools for identification of structure in data, estimation of functions (orthogonal polynomials, splines, etc.), and graphical methods. Additional topics may vary. Coursework will include computer assignments. Prerequisite(s): Multivariate calculus, familiarity with basic matrix algebra and EN.625.603 Statistical Methods and Data Analysis.	EP
EN.625.661 Statistical Models and Regression:	https://e-catalogue.jhu.edu/search/?P=EN.625.661	Introduction to regression and linear models including least squares estimation, maximum likelihood estimation, the Gauss-Markov Theorem, and the Fundamental Theorem of Least Squares. Topics include estimation, hypothesis testing, simultaneous inference, model diagnostics, transformations, multicollinearity, influence, model building, and variable selection. Advanced topics include nonlinear regression, robust regression, and generalized linear models including logistic and Poisson regression. Prerequisite(s): EN.625.603 Statistical Methods and Data Analysis, multivariate calculus, and basic knowledge of matrix and linear algebra.	EP
EN.685.648 Data Science	https://e-catalogue.jhu.edu/search/?P=EN.685.648	This course will cover the core concepts and skills in the emerging field of data science. These include problem identification and communication, probability, statistical inference, visualization, extract/transform/load (ETL), exploratory data analysis (EDA), linear and logistic regression, model evaluation and various machine learning algorithms such as random forests, k-means clustering, and association rules. The course recognizes that although data science uses machine learning techniques, it is not synonymous with machine learning. The course emphasizes an understanding of both data (through the use of systems theory, probability, and simulation) and algorithms (through the use of synthetic and real data sets). The guiding principles throughout are communication and reproducibility. The course is geared towards giving students direct experience in solving the programming and analytical challenges associated with data science. Prerequisite(s): Programming experience in Python is recommended. Prerequisite(s): Principles of Algorithms	EP
EN.595.660 Planning and Managing Projects	https://e-catalogue.jhu.edu/search/?P=EN.595.660	This course concentrates on the general methodology of managing a technical project from concept to operational use, with emphasis on the functions, roles, and responsibilities of the project manager. Topics include career aspects of project management; business factors affecting the project and the manager; project organization, planning, execution, and communications; project life cycle; risk analysis; interface management; design review; design control assessment; reporting; and reaction to critical problems. Students are formed into groups, presented with a scenario that simulates the development of a high-technology system, and assigned to make decisions required of the project manager in the execution of the project. The project manager's decisions must then be effectively communicated (and perhaps defended) to a variety of audiences (represented by other students and faculty) that include top management, the customer, functional management, and members of the project team. Course Note(s): The format for this course is either online or a mixed online/live environment called Virtual Live. For the Virtual Live format, weekly lectures are provided either online or live (and recorded) on a predesignated day/time, with students/instructors joining in person or from any location via personal computer. Students can also choose to participate in person, in a classroom, at the predesignated day/time. Contact the instructors for additional information. (Formerly 595.660 Introduction to Project Management.)	EP
EN.595.662 Technical Organization Management	https://e-catalogue.jhu.edu/search/?P=EN.595.662	This course introduces the technical manager to all aspects of business management within an organization, ranging from tactical project planning and control, and contract management to higher level corporate financial and legal topics. Students will be guided through weekly topics in the areas of planning a project, scheduling, tracking and the evaluation/assessment of a project. It will also cover contractual considerations for the technical manager. The course will move from managerial business management to financial accounting topics such as direct and indirect costs, revenues, and profits; indices to financial position; use of financial reports; return on investment, net present value; internal rate of return; and financial management (including cash and funds flow statements). Finally, this course will also use the management approaches and practices above and apply them to the world of contracting and legal analysis. Tactical contracting principles, including acquisition planning, contract award, performance, and termination will be covered. Basic legal principles that a senior technical leader will encounter in their career will also be presented. Course discussions cover corporations and partnerships, professional liability, risk management, intellectual property negotiations, and ethics are presented for students to recognize issues that are likely to arise in the engineering	EP

Course Name	Link	Descriptiopn	EP/Homewood
		profession and introduces them to the complexities and vagaries of the legal profession. Prerequisite(s): 595.660 Planning & Managing Projects	
EN.662.642 Leadership & Management	https://e-catalogue.jhu.edu/course-descriptions/center_for_leadership_education/	Management and Leadership is a case, experiential and research based course intended to introduce participants to issues and solutions related to growing and managing businesses with an emphasis on entrepreneurial enterprises. The course focuses on managerial decision-making and organization building through topics that include planning and managing strategic change; finding competitive advantage; making informed decisions; dealing with uncertainty; negotiating collaborative settlements; managing/leading projects, teams and professionals; networking and forming strategic alliances; valuing differences; creating and maintaining organizational cultures; and devising performance measures. Additionally, participants master aspects of management communication as they address course content. For CBID Students only. Area: Engineering, Natural Sciences	Homewood
EN.595.665 Strategic Communications In Technical Organizations	https://e-catalogue.jhu.edu/search/?P=EN.595.665	This course covers problems and instruction in human communications within a technical organization. Topics include the nature of difficulties in human communications (perception and cognition, semantics, individual differences in processing information, and listening), techniques for effective oral and written communications and presentations, problems in communication between supervisors and subordinates, assignment of work, and reporting to management and sponsors. Students assume roles in various interpersonal situations, meetings, discussions, and conflicts calling for a supervisor to write letters and memoranda; they also deliver oral presentations and participate in group and one-on-one discussions. This course also includes writing winning proposals and developing a technical strategy aligned with the organization's business strategy. Prerequisite(s): 595.660 Planning and Managing Projects	EP
EN.663.618 Professional Presentations	https://e-catalogue.jhu.edu/course-descriptions/center_for_leadership_education/	This course is designed to help scientists and engineers improve their oral presentation skills in a practice-intensive environment. Students will learn how to hone their message, to craft presentations that address both technical and non-technical audiences, and create clear, compelling PowerPoint presentations. All presentations will be recorded for self-evaluation, and students will receive extensive instructor and peer feedback. MSEM students only. Not open to undergraduates.	Homewood
EN.595.676 Finance, Contracts, and Compliance for Technical Professionals	https://e-catalogue.jhu.edu/search/?P=EN.595.676	This course introduces the technical manager to all aspects of business management within an organization, ranging from tactical project planning and control, and contract management to higher level corporate financial and legal topics. Students will be guided through weekly topics in the areas of planning a project, scheduling, tracking and the evaluation/assessment of a project. It will also cover contractual considerations for the technical manager. The course will move from managerial business management to financial accounting topics such as direct and indirect costs, revenues, and profits; indices to financial position; use of financial reports; return on investment, net present value; internal rate of return; and financial management (including cash and funds flow statements). Finally, this course will also use the management approaches and practices above and apply them to the world of contracting and legal analysis. Tactical contracting principles, including acquisition planning, contract award, performance, and termination will be covered. Basic legal principles that a senior technical leader will encounter in their career will also be presented. Course discussions cover corporations and partnerships, professional liability, risk management, intellectual property negotiations, and ethics are presented for students to recognize issues that are likely to arise in the engineering profession and introduces them to the complexities and vagaries of the legal profession. Prerequisite(s): 595.660 Planning and Managing Projects	EP
EN.662.611 Strategies: Accounting & Finance	https://e-catalogue.jhu.edu/course-descriptions/center_for_leadership_education/	This course includes a review of financial accounting with an emphasis on the implications of GAAP selections and other managerial decisions on the financial statements. Historic financial performance is assessed using ratio analysis. Relevant cash flows are used in capital budgeting situations; projects are analyzed using discounted cash flow techniques as a measure of valuation. Managerial accounting topics of financial forecasting, cost accumulation, cost allocation, product costing, and variance analysis are used in decision making.	Homewood
EN.595.781 Executive Technical Leadership	https://e-catalogue.jhu.edu/search/?P=EN.595.781	This Capstone course explores the roles and responsibilities of technical executive leaders (VPs of Engineering, Manufacturing, CTO, CIO) in the context of a strategic framework. Topics relevant to technical executives are explored, from leading technical strategy development to tactical operations. The concepts in the course are reinforced using case studies, a team project, and fortified by interviews with practicing/retired technical executives who discuss practical career experiences. The format of this course is very different from other Engineering Management courses. Lectures are provided asynchronously online. Required weekly online seminar-type discussions guide the incremental development of a technical strategy, and include a mid-course team presentation. The semester ends with a Capstone presentation, and an executive roundtable discussion. Students will be evaluated on their application of the principles presented in the course, critical thinking applied to the issues posed in the case study,	EP

Course Name	Link	Descriptiopn	EP/Homewood
		and teamwork as assessed by both the instructors and peer students. Course Note(s): In the Virtual Live format, weekly lectures are provided asynchronously online for students to view in advance of the weekly seminar sessions. The weekly seminar sessions are held at a predesignated day/time, with students/instructors joining live via web-conference using a personal device. The course also includes one Saturday Capstone session in the Baltimore, MD area at the end of the semester. In-person participation with your team is encouraged. Students unable to attend in person will be able to participate online. The Saturday session consists of student teams presenting their capstone technical strategic plan, issues, actions, and execution plans built around an evolving case study. A roundtable discussion will also be held where students have the opportunity to ask probing questions of visiting executives as part of the Capstone Day experience. Prerequisite(s): 595.660 Planning and Managing Projects, 595.662 Technical Organization Management (or 595.661 Technical Group Management or 595.663 Technical Personnel Management), 595.676 Finance, Contracts, and Compliance for Technical Organizations (or 595.664 Project Planning and Control or 595.666 Financial and Contract Management), 595.665 Strategy and Communication in Technical Organizations	
EN.655.662 Intro to Healthcare Systems Engineering	https://e-catalogue.jhu.edu/search/?P=EN.655.662	This course introduces students to the fundamental principles of healthcare systems engineering and their application to the development of complex systems. It describes how the systems engineering viewpoint differs from that of the healthcare provider, as well as the essential role that systems engineering plays as an integral component of program management. Topics include integrated systems engineering life cycle purpose and constructs, delineation of different complex system types, requirements analysis, concept definition, system synthesis, design trade-offs, risk assessment, interface definition, engineering design, system integration, and related systems engineering activities. The course defines the breadth and depth of the knowledge that the healthcare systems engineer must acquire concerning the characteristics of the diverse components that constitute the total system. Special topics such as architectures, interfaces, simulation and models, and test and evaluation are discussed in relation to the healthcare systems engineering viewpoint. Students address typical systems engineering problems that highlight important healthcare issues and methods of technical problem resolution.	Ep
EN.655.667 Management of Healthcare Systems Projects	https://e-catalogue.jhu.edu/search/?P=EN.655.667	The course addresses the management of a technical project from concept to operational use, with emphasis on the functions, roles, and responsibilities of the healthcare systems project manager. From the development of a proposal to the delivery of a product and/or service to a customer, the efforts to conceive, plan, budget, schedule, monitor, control/direct, and report the progress of the project are discussed. Throughout the project life cycle, the need for good communications, interface and configuration management, and conflict resolution is emphasized. Students assume the role of project managers who must use management tools such as WBS, EVM, and CPN and who must address typical problems that arise in the conduct of a high-technology systems project.	EP
EN.655.767 Healthcare System Conceptual Design	https://e-catalogue.jhu.edu/search/?P=EN.655.767	This course addresses in detail the healthcare systems engineer's responsibilities and activities during the conceptual phases of a healthcare system development program. Systems engineering tools commonly employed at this stage of a program are presented along with selected problems that illustrate both the applicability and limitations of commonly employed tools and procedures to the solving current healthcare issues. The course steps through conceptual design beginning with analysis of needs and objectives and proceeding to the exploration of concepts and the selection of a concept that best meets goals of performance, timeliness, and affordability. Topics include definition of operational scenarios, functional analysis, risk assessment, system trade-offs, measures of effectiveness, and requirements formulation. Emphasis is on the application of these systems engineering techniques in a team environment to a class project. Students apply systems engineering methods learned from reading and lectures to the development of a realistic system in an ongoing project in a team format. Prerequisite(s): EN.655.662 Introduction to Healthcare Systems Engineering and EN.655.667 Management of Healthcare Systems Projects, or permission of the student's faculty advisor and the course instructor.	EP
EN.655.768 Healthcare System Design & Integration	https://e-catalogue.jhu.edu/search/?P=EN.655.768	This course addresses the healthcare systems engineering objectives, responsibilities, and activities during two phases of the system development life cycle: demonstration and validation, and engineering and manufacturing development. Healthcare systems engineering procedures and tools used during these phases are identified and their use illustrated. Topics include the relationship between a system specification and the system design, risk management and patient safety, system design models, healthcare provider and patient integration into the design process, and healthcare design disciplines and practices. The course uses a healthcare system scenario extensively to illustrate systems engineering principles and specific product design issues.	EP

Course Name	Link	Descriptiopn	EP/Homewood
		Prerequisite(s): EN.655.767 Healthcare System Conceptual Design or permission of the student's faculty advisor and the instructor.	
EN.655.769 Healthcare System Test and Evaluation	https://e-catalogue.jhu.edu/search/?P=EN.655.769	This course addresses the healthcare systems engineering objectives, responsibilities, and activities during two phases of the system development life cycle: demonstration and validation, and engineering and manufacturing development. Healthcare systems engineering procedures and tools used during these phases are identified and their use illustrated. Topics include the relationship between a system specification and the system design, risk management and patient safety, system design models, healthcare provider and patient integration into the design process, and healthcare design disciplines and practices. The course uses a healthcare system scenario extensively to illustrate systems engineering principles and specific product design issues. Prerequisite(s): EN.655.767 Healthcare System Conceptual Design or permission of the student's faculty advisor and the instructor.	EP
EN.655.800 Healthcare Systems Engineering Capstone Project	https://e-catalogue.jhu.edu/search/?P=EN.655.800	This course provides the experience of applying systems engineering principles and skills learned in the formal courses to a specific practical healthcare system project that is suggested by the student and is presented in a formal proposal. The product of the system project is a final report; also required are interim reports and an oral presentation to permit review of the project objectives and approach. A student typically has a mentor who is a member of the Systems Engineering faculty. The program chair and mentor review proposals and reports. The total time required for this course is comparable to the combined class and study time for the formal courses (formerly 645.770). It is self-paced and often takes more than one semester to complete. Prerequisite(s): EN.655.769 Healthcare System Test and Evaluation	EP
EN.585.613 Medical Sensors & Devices	https://e-catalogue.jhu.edu/search/?P=EN.585.613	This course covers the basic and advanced principles, concepts, and operations of medical sensors and devices. The origin and nature of measurable physiological signals are studied, including chemical, electrochemical, optical, and electromagnetic signals. The principles and devices to make the measurements, including a variety of electrodes and sensors, will be discussed first. This will be followed by a rigorous presentation of the design of appropriate electronic instrumentation. Therapeutic instrumentation such as pacemakers, defibrillators, and prosthetic devices will be reviewed. The final part of this course will cover emerging frontiers of cellular and molecular instrumentation and the use of micro- and nanotechnology in these biotechnology fields. The lectures will be followed by realistic experimentation in two laboratory sessions where students will obtain hands-on experience with electronic components, sensors, biopotential measurements, and testing of therapeutic instrumentation.	EP
EN.585.619 Regulation of Medical Devices	https://e-catalogue.jhu.edu/search/?P=EN.585.619	Biomedical engineers are uniquely involved in many aspects of product development, from the inception of the idea to its delivery in the marketplace. This course will cover one major aspect of that process—the objectives and mechanisms of the FDA regulatory system governing the clinical use of medical devices in the United States, including regulatory pathways and device classification. Students will both analyze and discuss management of risk, and they will design controls related to cardiovascular, orthopedic, and neurological devices. By the end of the course, students will have a deep understanding of how the regulatory process is involved in every phase of medical device development.	Ep
EN.580.607 Regulation of Medical Devices	https://e-catalogue.jhu.edu/course-descriptions/biomedical_engineering/	This course introduces graduate students in Bioengineering Innovation and Design to the medical device regulatory framework, as it pertains to bringing a medical device from concept to market. Topics covered include; FDA Design Controls; Regulatory Approval mechanisms, including the 510k and PMA process; Investigational Device exemption (IDE); planning clinical trials needed for bringing a medical device to market; and postmarket surveillance. Students learn from a series of invited lecturers from the FDA as well as professionals from the medical device industry. This summer course is required for CBID masters students and is not open to any other students.	Homewood
EN.535.641 Mathematical Methods for Engineers	https://e-catalogue.jhu.edu/search/?P=EN.535.641	This course covers a broad spectrum of mathematical techniques needed to solve advanced problems in engineering. Topics include linear algebra, the Laplace transform, ordinary differential equations, special functions, partial differential equations, and complex variables. Application of these topics to the solutions of physics and engineering problems is stressed. Prerequisite(s): Vector analysis and ordinary differential equations.	EP
EN.560.601 Applied Math for Engineers	https://e-catalogue.jhu.edu/course-descriptions/civil_engineering/	This course presents a broad survey of the basic mathematical methods used in the solution of ordinary and partial differential equations: linear algebra, power series, Fourier series, separation of variables, integral transforms. Area: Engineering, Quantitative and Mathematical Sciences	Homewood
EN.565.604 Structural Mechanics	https://e-catalogue.jhu.edu/search/?P=EN.565.604	This course presents basic solid mechanics for structural engineers, including stress, strain, and constitutive laws; linear elasticity and visco-elasticity; introduction to nonlinear mechanics; static, dynamic, and thermal stresses; specialization of theory to one- and two-dimensional cases; plane stress and plane strain, rods, and beams; work and energy	EP

Course Name	Link	Descriptiopn	EP/Homewood
		principles; and variational formulations. Course Note(s): This course is a requirement for the general Civil Engineering program and the Structural Engineering focus area.	
EN.560.604 Introduction to Solid Mechanics	https://e-catalogue.jhu.edu/course-descriptions/civil_engineering/	Basic solid mechanics for structural engineers. Stress, strain and constitutive laws. Linear elasticity and viscoelasticity. Introduction to nonlinear mechanics. Static, dynamic and thermal stresses. Specialization of theory to one- and two-dimensional cases: plane stress and plane strain, rods, and beams. Work and energy principles; variational formulations.	Homewood
EN.565.606 Geotechnical Engineering Principles	https://e-catalogue.jhu.edu/search/?P=EN.565.606	This course aims to review and reinforce knowledge of soil mechanics and geotechnical engineering principles for application in a variety of structural and civil engineering projects. The course presents examples of geotechnical engineering design problems. The course then discusses the origin of soil and types of soil, and various relations between weight and volume; methods used to characterize the index properties of soil, and classification of soil; theory of compaction; Darcy's law and the role of permeability, and the theory of two-dimensional seepage; stresses induced in soil by footing and other loading; compressibility of soil, and consolidation and consolidation settlements; shear strength of soil and the laboratory methods of determining shear strength parameters; theories of lateral earth pressure and their application to the analysis of retaining walls; fundamentals of slope stability analysis; fundamentals of the bearing capacity analysis of shallow foundations; and methods of subsoil exploration. Prerequisite(s): 560.305 Soil Mechanics or equivalent. 560.305 is offered on-site through the full-time Civil Engineering Department. Course Note(s): This course is a requirement for the general Civil Engineering program.	EP
EN.565.619 Advanced Structural Analysis	https://e-catalogue.jhu.edu/search/?P=EN.565.619	The course will focus on matrix implementations of the stiffness method for the analysis of statically indeterminate structures such as plane/space trusses and plane/space frames. Computational aspects of the stiffness method will be discussed with connections made to commercial software. Linear elastic analysis will be the primary focus, but topics in nonlinear analysis will also be introduced.This course may be used to satisfy the structural analysis requirement for the Structural Engineering focus area.	Homewood
EN.560.619 Advanced Structural Analysis	https://e-catalogue.jhu.edu/course-descriptions/civil_engineering/	Matrix methods for the analysis of statistically indeterminate structures such as beams, plane and space trusses, and plane and space frames. Stiffness and flexibility methods. Linear elastic analysis and introduction to nonlinear analysis. Area: Engineering	
EN.565.616 Advanced Finite Element Methods	https://e-catalogue.jhu.edu/search/?P=EN.565.616	This course will introduce finite element methods for the analysis of solids and structures. The following topics will be considered: procedure for defining a mechanics problem (governing equations, constitutive equations, boundary and initial value problems); theory and implementation of the finite element method for static analysis using linear elasticity; and the verification/validation of results using finite element analysis software.	EP
EN.560.770 Advanced Finite Elements Methods and Multi-Scale Methods	https://e-catalogue.jhu.edu/course-descriptions/civil_engineering/	Addresses advanced topics in various areas of the finite element methodology. Covers a range of topics, viz. element stability and hourglass control, adaptive methods for linear and nonlinear problems, mixed and hybrid element technology, eigen-value problems, multi-scale modeling for composites and polycrystalline materials. Recommended Course Background: EN.530.730 or EN.560.730	Homewood
EN.565.628 Preservation Engineering 1: Theory and Practice	https://e-catalogue.jhu.edu/search/?P=EN.565.628	The renovation of existing buildings often holds many advantages over new construction, including greater economy, improved sustainability, and the maintenance of engineering heritage and architectural character in our built environment. Yet, the renovation of existing structures presents many challenges to structural engineers. These challenges include structural materials that are no longer in widespread use (e.g., unreinforced masonry arches and vaults, cast iron, and wrought iron) as well as structural materials for which analysis and design practices have changed significantly over the last half-century (e.g., wood, steel, and reinforced concrete). This first course in the theory and practice of preservation engineering will include a review of the building code requirements related to work on existing buildings and a discussion of the load paths (both vertical and horizontal) through such structures. Further, this course will begin its review of structural materials with those that were available prior to the Industrial Revolutionnamely masonry and timber. The course will conclude with an overview of the response of wood structures to wind and seismic loads. Wood deterioration mechanisms and structural repair strategies for wood will also be presented.	EP
EN.560.629 Preservation Engineering 1: Theory and Practice	https://e-catalogue.jhu.edu/course-descriptions/civil_engineering/	The renovation of existing buildings often holds many advantages over new construction, including greater economy, improved sustainability, and the maintenance of engineering heritage and architectural character in our built environment. Yet, the renovation of existing structures presents many challenges to structural engineers. These challenges include structural materials that are no longer in widespread use (e.g., unreinforced masonry arches and vaults, cast iron, and wrought iron) as well as structural materials for which analysis and design practices have changed significantly over the last half-century (e.g., wood, steel, and reinforced concrete). This course will examine structures made of a wide variety of materials and instruct the student how to evaluate their condition,	Homewood

Course Name	Link	Descriptiopn	EP/Homewood
		determine their existing capacity, and design repairs and/or reinforcement. The investigation and analysis procedures learned from this course may then be applied to create economical and durable structural alterations that allow for the reuse of older buildings. Site visits near Homewood campus will supplement lectures. This course is co-listed with EN.565.628. Area: Engineering	
EN.565.636 Lateral Forces: Analysis and Design of Building Structures	https://e-catalogue.jhu.edu/search/?P=EN.565.636	From earthquakes to wind events, lateral forces constitute some of the most extreme loading conditions for which new and existing building structures must be analyzed and designed to resist. This course provides a fundamental yet practical introduction to the development and application of earthquake and wind loadings on building structures, the dynamic response and behavior of structures to lateral forces, and the bases and requirements for ductile design and detailing of steel, concrete, wood, and masonry lateral force resisting elements. The course will build on these analysis and design fundamentals to examine the technical considerations and methodologies for evaluating the lateral force resisting systems of existing, oftentimes monumental, building structures, and for designing and implementing repairs and retrofits to these lateral systems, including the application of Performance Based Design. This course is co-listed with 560.615.	EP
EN.560.636 Lateral Forces: Analysis and Design of Building Structures		From earthquakes to wind events, lateral forces constitute some of the most extreme loading conditions for which new and existing building structures must be analyzed and designed to resist. This course provides a fundamental yet practical introduction to the development and application of earthquake and wind loadings on building structures, the dynamic response and behavior of structures to lateral forces, and the bases and requirements for ductile design and detailing of steel, concrete, wood, and masonry lateral force resisting elements. The course will build on these analysis and design fundamentals to examine the technical considerations and methodologies for evaluating the lateral force resisting systems of existing, oftentimes monumental, building structures, and for designing and implementing repairs and retrofits to these lateral systems, including the application of Performance Based Design. This course is co-listed with EN.565.636. Area: Engineering	Homewood
EN.565.633 Investigations, Diagnosis, and Rehabilitation	https://e-catalogue.jhu.edu/search/?P=EN.565.633	Why do buildings deteriorate? And how do we investigate and diagnose the causes, as well as design and implement appropriate solutions? This course examines the deterioration of building materials and systems caused by both humans and nature. Through weekly lectures and one weekend workshop, students will learn how to plan and execute an investigation, identify the symptoms, determine what tests are needed, diagnose the causes, and design and administer necessary repairs to address deterioration and system deficiencies. Weekly lectures will use a combination of Virtual Live and online formats; a weekend workshop in Baltimore (date TBD) will include hands-on activities and a field trip to a local project site.	EP
EN.560.633 Investigations, Diagnosis, and Rehabilitation		Why do buildings deteriorate, and how do we address this problem? This course examines the deterioration (by human and nature) of building materials and systems. Through lectures and a field trip, students will learn how to set up and execute an investigation, study the symptoms, diagnose the problems, determine what kinds of tests are needed, design the necessary repairs, and maintain existing systems. This course is co-listed with Engineering for Professionals EN.565.633. Area: Engineering	Homewood
EN.575.604 Principles of Environmental Engineering	https://e-catalogue.jhu.edu/search/?P=EN.575.604	This course addresses the wide range of environmental engineering fundamentals with quantitative analyses where applicable. Topics include mass and energy transfer and balances; environmental chemistry; mathematics of growth and decay; risk assessment and management; surface water pollutants, biological and chemical oxygen demands; eutrophication; water supply systems and drinking water standards; wastewater treatment systems and effluent standards; groundwater flow, contaminant transport, and remediation technologies; hazardous waste and pollution prevention; remedial and corrective actions at contaminated sites; air pollution sources, control technologies, and atmospheric stability; ambient air quality standards and indoor air quality; global temperature, greenhouse effect and warming potential; global energy balance, carbon emission, and stratospheric ozone depletion; solid waste management, landfill disposal, combustion, composting, and recycling; medical waste; and environmental law, ethics, and justice. Field trips are integrated into the classes. Course Note(s): This course is required of all degree students studying environmental engineering, science, and management who do not possess an undergraduate degree in environmental engineering.	EP
EN.575.658 Natural Disaster Risk Modeling	https://e-catalogue.jhu.edu/search/?P=EN.575.658	Natural hazards such as floods, earthquakes, and hurricanes exert a heavy toll of victims and economic losses every year. Yet, concentrations of population in hazard-prone-areas, the growth of infrastructure and climate change are aggravating the risk of future losses. Consequently, adequate interventions must be implemented to mitigate the damaging effects of natural hazards. To do this, public agencies, non-profits, and companies	EP

Course Name	Link	Descriptiopn	EP/Homewood
		formulate mitigation actions such as emergency preparedness plans and building retrofits. Catastrophe models are tools to inform all these efforts, which simulate the socioeconomic risk resulting from the interaction of geophysical events and the spatial distribution of infrastructure.	
EN.560.658 Natural Disaster Risk Modelling	https://e-catalogue.jhu.edu/search/?P=EN.575.6588	This course will: • Introduce the student to disaster risk modeling process, including: - Structure of catastrophe models. Uses in loss estimation and mitigation. - Study and modeling of hazards (esp. hurricanes and earthquakes; also flood, landslide, and volcanic) - Vulnerability assessment: simulation of building damage, and estimation of post-disaster injuries and casualties. - Exposure modeling (building typology distribution). • Introduction to disaster economic loss modeling: - Interpretation of risk metrics (return periods, PML, AAL, VaR, TVaR), their uncertainty, and applicability to management and financial decision making process. - Elements of present and future risk: climate and exposure changes. - Student will gain introductory experience in the use of GIS and simulation with Matlab. This course is co-listed with EN.560.458. Area: Engineering	Homewood
EN.575.735 Energy Policy and Planning Modeling	https://e-catalogue.jhu.edu/search/?P=EN.575.735	This course provides students with comprehensive knowledge on methods for optimizing operation and design of energy systems and methods for analyzing market impacts of energy and environmental policies with emphasis on both theory and solution of actual models. The course also covers linear and nonlinear programming and complementarity methods for market simulation. Prerequisite(s): Microeconomics or optimization methods (linear programming).	EP
EN.570.607 Energy Policy and Planning Modeling	https://e-catalogue.jhu.edu/course-descriptions/environmental_health_and_engineering/	Methods for optimizing operation and design of energy systems and for analyzing market impacts of energy and environmental policies are reviewed, emphasizing both theory and solution of actual models. Review of linear and nonlinear programming and complementarity methods for market simulation. Recommended Course Background: EN.570.493 and EN.570.495 or equivalent.	Homewood
EN.575.714 Water Resource Management	https://e-catalogue.jhu.edu/search/?P=EN.575.714	This multidisciplinary course examines the scientific, institutional, and analytical aspects of managing water quantity and quality. Students are provided a historical context that is useful for assessing current policy. The water cycle and basic hydrology are reviewed. The course surveys the laws and regulatory instruments for managing water quantity and quality, which operate across federal, state, and local levels of government. Funding issues associated with water resources management include operating and capital budgets, debt financing, the challenges of pricing, and the role of privatization. The course addresses the management of water supply and demand in the United States by economic sector and by in-stream and off-stream uses. This includes trends in water supply and demand, as well as modeling methods for water supply management. Fundamentals of flood and drought management are covered, with attention given to the context of global climate change and extreme events. The critical role of the general public in water resource management decision making is addressed in the context of structured techniques involving economic analyses, multiobjective analyses, and collaborative decision making. Water quality-based management under the federal Clean Water Act includes the topics of water quality standards, water quality assessments, total maximum daily loads (TMDLs), and ensuing permit requirements. Regional ecological water resources management is addressed for the Susquehanna River and by contrasting the Chesapeake Bay case with other largescale cases.	Ep
EN.570.631 Collaborative Modelling for Resolving Water Resources Disputes	https://e-catalogue.jhu.edu/course-descriptions/environmental_health_and_engineering/	Overview of collaborative modeling in water resources, Economic issues in water resources disputes, Legal issues in water resources disputes, Biological/Environmental issues in water resources disputes, Water management in the Delaware Basin, Understanding and using the Delaware River Basin Commission's water management tool (an OASIS based model of the Delaware, Multi-objective water management, Understanding management trade-offs, Collaborative processes, Reality based negotiation skills, and Consensus building. Recommended Course Background: A strong interest in utilizing scientific tools to help resolve real-world disputes A background in general science – with at least two of the following disciplines: Biology, chemistry, physics, earth science, economics. Area: Engineering, Quantitative and Mathematical Sciences	Homewood
EN.575.745 Physical and Chemical Processes for Water and Wastewater Treatment	https://e-catalogue.jhu.edu/search/?P=EN.575.745	In this course, mass and momentum transport, aquatic chemistry, and chemical reaction engineering are applied to physical and chemical processes used for water and wastewater treatment. Students also learn the theory and practice of various unit processes including disinfection, oxidation, coagulation, sedimentation, filtration, adsorption, gas transfer, and membrane filtration. The goal is to provide a theoretical understanding of various chemical and physical unit operations, with direct application of these operations to the design and operation of water and wastewater treatment systems. Students will use the concepts learned in this class to better understand the design and	EP

Course Name	Link	Descriptiopn	EP/Homewood
		operation of engineered and natural aquatic systems. Prerequisite(s): EN.575.605 Principles of Water and Wastewater Treatment.	
EN.570.644 Physical and Chemical Processes	https://e-catalogue.jhu.edu/course-descriptions/environmental_health_and_engineering/	The application of basic physical and chemical concepts to the analysis of environmental engineering problems. Principles of chemical equilibrium and reaction, reaction engineering, interphase mass transfer, and adsorption are presented in the context of process design for unit operations in common use for water and wastewater treatment. Topics addressed include mass balances, hydraulic characteristics of reactors, reaction kinetics and reactor design, gas transfer processes (including both fundamentals of mass transfer and design analysis), and adsorption processes (including both fundamentals of adsorption and design analysis). Area: Engineering	Homewood
EN.575.715 Subsurface Fate and Contaminant Transport	https://e-catalogue.jhu.edu/search/?P=EN.575.715	This course provides an introduction to the concepts relating to the nature and sources of environmental contaminants in the subsurface, the role of groundwater and soil water in mobilizing and spreading contamination, the processes that control distribution and fate of subsurface contamination, the accepted methods of investigating and analyzing contamination, and the analytical techniques that can be employed to model contaminant fate and transport in the subsurface. The course also considers surface water contamination caused by contamination in the groundwater. Computer laboratories of groundwater model simulations and solute transport solutions are used.	EP
EN.570.651 Environmental Transport and Dispersion	https://e-catalogue.jhu.edu/course-descriptions/environmental_health_and_engineering/	The course will provide an overview of the basic foundations of transport and dispersion phenomena in the environment (surface water, groundwater, ocean and atmosphere). The emphasis will be on mathematical formulation of transport equations, analytical solutions, physical insights, methods of analysis of concentration data. The course will cover classical advection-diffusion concepts, shear dispersion phenomena, and transport in random velocity fields with applications to turbulent diffusion and macrodispersion in groundwater. Although numerical modeling is not the primary objective of the course, we will build a simple computational toolbox using random-walk particle tracking to visualize and quantify transport processes. Computation of analytical solutions will require MATLAB or python (or equivalent programming, although EXCEL may also suffice with macros). If time permits, we will touch upon reactive transport and non-Fickian transport formulations. Recommended course background in EN.553.291 Linear Algebra and Differential Equations and EN.570.351 Fluid Mechanics. Area: Engineering, Quantitative and Mathematical Sciences	Homewood
EN.575.721 Air Quality Control Technologies	https://e-catalogue.jhu.edu/search/?P=EN.575.721	This is a multidisciplinary course that involves the applications of chemistry, thermodynamics, and fluid mechanics in the selection and design of air pollution control equipment. Topics include the estimation of potential pollutants, chemical characterization of gas streams to be controlled, theory and practice of air pollution control, and design and costing of control technologies. The course emphasizes the design of systems to reduce particulate matter emissions, volatile organic compound (VOC) emissions, nitrogen oxide emissions, and sulfur dioxide emissions. Prerequisite(s): EN.575.601 Fluid Mechanics or an equivalent course in fluid flow; an undergraduate course in thermodynamics.	EP
EN.570.657 Air Pollution	https://e-catalogue.jhu.edu/course-descriptions/environmental_health_and_engineering/	The course consists of an introduction to the fundamental concepts of air pollution. Major topics of concern are aspects of atmospheric motion near the earth's surface; basic thermodynamics of the atmosphere; atomospheric stability and turbulence; equations of mean motion in turbulent flow, mean flow in the surface boundary layer; mean flow, turbulence in the friction layer; diffusion in the atmosphere; statistical theory of turbulence; plume rise. Emphasis is place upon the role and utility of such topics in a systems analysis context, e.g., development of large and mesoscale air pollution abatement strategies. Comparisons of the fundamental concepts common to both air and water pollution are discussed. Area: Engineering, Quantitative and Mathematical Sciences	Homewood
EN.575.620 Solid Waste Engineering and Management	https://e-catalogue.jhu.edu/search/?P=EN.575.620	This course covers engineering and scientific concepts and principles applied to the management of municipal solid waste (MSW) to protect human health and the environment and the conservation of limited resources through resource recovery and recycling of waste material. Topics include regulatory aspects and hierarchy of integrated solid waste management; characterization and properties of MSW; municipal wastewater sludge utilization; hazardous waste found in MSW; collection, transfer, and transport of solid waste; separation, processing, combustion, composting, and recycling of waste material; and the landfill method of solid waste disposal, which encompasses guidelines for design, construction, operation, siting, monitoring, remedial actions, and closure of landfills. Permitting and public participation processes, current issues, and innovative approaches are also addressed.	EP
EN.570.690 Solid Waste Engineering and Management	https://e-catalogue.jhu.edu/course-descriptions/envir	This course covers advanced engineering and scientific concepts and principles applied to the management of municipal solid waste (MSW) to protect human health and the environment and the conservation of limited resources through resource recovery and	Homewood

Course Name	Link	Descriptiopn	EP/Homewood
	onmental_health_and_engineering/	recycling of waste material. Area: Engineering	
EN.575.742 Hazardous Waste Engineering and Management	https://e-catalogue.jhu.edu/search/?P=EN.575.742	The course addresses traditional and innovative technologies, concepts, and principles applied to the management of hazardous waste and contaminated sites to protect human health and the environment. Topics include regulatory requirements; hazardous waste generators and transporters; permitting and enforcement of hazardous waste facilities; closure and financial assurance requirements; RCRA Corrective Action and CERCLA/Superfund/Brownfields site remediation processes; groundwater flow and fate and transport of contaminants; physical, chemical, and biological treatment; land disposal restrictions; guidelines for design, construction and closure of hazardous waste landfills; environmental monitoring systems; management of medical waste and treatment options; management of underground and aboveground storage tanks; toxicology and risk assessment; and pollution prevention and waste minimization.	EP
EN.570.691 Hazardous Waste Engineering and Management	https://e-catalogue.jhu.edu/course-descriptions/environmental_health_and_engineering/	This course addresses traditional and innovative technologies, concepts, and principles applied to the management of hazardous waste and site remediation to protect human health and the environment. Area: Engineering	Homewood

Appendix C

Global Innovation and Leadership through Engineering Faculty

Name	Title	Email	Full Time?	Area of Expertise
Amanda Hilliard	Lecturer	ahillia5@jhu.edu	Yes	Professional Writing and Oral Communications
Andrew Ross	Senior Lecturer, Associate Director of the Professional Communications Program	aross55@jhu.edu	Yes	Professional Writing and Oral Communications
Annette Leps	Associate Teaching Professor, Director, W.P. Carey Program in Entrepreneurship & Management, Accounting & Financial Management Minor, and Business Minor	aleps@jhu.edu	Yes	Accounting and Financal Management
Alissa Burkholder Murphy	Senior Lecturer, Director Multi-disciplinary Design	alissa@jhu.edu	Yes	Multi-disciplinary Engineering Design
Eric Rice	Associate Teaching Professor, Director of Non-Degree Graduate Programs	ericmrice@gmail.com	Yes	Management and Innovation Strategies
Illysa Izenberg	Associate Teaching Professor	ibizenberg@gmail.com	Yes	Engineering Management
Jenna Frye	Senior Lecturer	jenna@jennafrye.com	Yes	Multi-disciplinary Engineering Design
Joseph Forte	Lecturer	jforte8@jhu.edu	Yes	Professional Writing and Oral Communications
Julie Reiser	Associate Teaching Professor, Director, Marketing & Communications Minor	julie.reiser@gmail.com	Yes	Professional Writing and Oral Communications
Lawrence Aronhime	Associate Teaching Professor & Director, International Programs	aronhime@jhu.edu	Yes	Innovation, Engineering Design and Entrepreneurship
Leslie Kendrick	Senior Lecturer	kendrick@jhu.edu	Yes	Marketing
Mary Clare Coghlan	Senior Lecturer	mcoghla2@jhu.edu	Yes	Leadership Theory
Mia Russell	Lecturer	mrusse29@jhu.edu	Yes	Finance, Engineering Management and Leadership
Nusaybah Abu-Mulaweh	Lecturer	nabumula@purdue.edu	Yes	Multi-disciplinary Engineering Design
Pamela Sheff	Associate Teaching Professor, Director, Center for Leadership Education and Master of Science in Engineering Management Program	psheff@jhu.edu	Yes	Engineering Management, Innovation Strategies
Robert Murray	Senior Lecturer, Associate Director of Master in Global Innovation and Leadership through Engineering	robjamesmurray@mac.com	Yes	Global Innovation and Strategies
Sarah Harrison Smith	Senior Lecturer, Associate Director of Master in Global Innovation and Leadership through Engineering	ssmit263@jhu.edu	Yes	Professional Writing and Oral Communications
Shadi Esnaashari	Lecturer	Shadi.esnaashari10@gmail.com	Yes	Decision Analytics
Trevor Mackesey	Senior Lecturer, Associate Director of Master of Science in Engineering Management	tmackes1@jhu.edu	Yes	Engineering Management, Innovation Strategies
William Smedick	Associate Teaching Professor, Director of Leadership Programs	smedick@jhu.edu	Yes	Leadership Studies
Andrew Kulanko	Senior Lecturer	akulanko@aol.com	No	Oral Presentations
Bryan Rakes	Lecturer	wbrakes@venable.com	No	Business Law
David Long	Lectruer	dlong@tuscanyassociates.com	No	Business and Marketing
Denise Link-Farajali	Lectrurer	farajali@comcast.net	No	Professional Writing and Oral Communications
Doug Sandhaus	Senior Lectrurer	doug@sandhauslaw.com	No	Professional Writing (Law)
Herman Goodyear	Lectrurer	hgoodye1@jhu.edu	No	Product Management
JJ Rorie	Lecturer	JJrorie@greatproductmanagement.com	No	Product Management

Name	Title	Email	Full Time?	Area of Expertise
Jason Heiserman	Lecturer	jheiserman@jhu.edu	No	Oral Presentations
Jenny Bernstein	Lectrurer	jberns12@jhu.edu	No	Management, Oral Presentations
John Sunder	Lectrurer	JVSunder@Venable.com	No	Professional Writing (Law)
Joshua Reiter	Senior Lecturer	joshua.reiter@jhu.edu	No	Business Management
Kevin Dungey	Senior Lecturer	kdungey1@jhu.edu	No	Oral Presentations
Len Foxwell	Lectrurer	lenfoxwell@gmail.com	No	Professional Writing and Communications
Mark Franceschini	Lectrurer	markcf2@gmail.com	No	Professional Writing (Law)
Michael Hartwell	Lectrurer	mhartwe2@jhu.edu	No	Oral Communications
Mike Agronin	Lectrurer	magroni1@jhu.edu	No	Engineering Management and Leadership
Rachel (Brooke) Petty	Lectrurer	Brooke.petty31@gmail.com	No	Digital and Social Media Marketing
Reid Sczerba	Lectrurer	rsczerb1@jhu.edu	No	Data Storytelling
Alexander Cocron	Lectrurer	acocron@gmail.com	No	Innovation and Design
Sean Furlong	Lectrurer	sfurlong@gilman.edu	No	Financial and Managerial Accounting
Susan Conley	Lectrurer	sconley3@jhu.edu	No	Marketing, Decision Analytics
Tavish Forsyth	Lectrurer	tforsyt1@jhu.edu	No	Communications

Whiting School of Engineering Faculty: https://engineering.jhu.edu/faculty/

APPENDIX D

Table 1: Program Resources

Resource Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Reallocated Funds	0	0	0	0	0
2. Tuition/Fee Revenue (c + g below)					
a. Number of F/T Students	5	15	30	40	50
b. Annual Tuition/Fee Rate	58,720	60,480	62,290	64,160	66,080
c. Total F/T Revenue (a x b)	293,600	907,200	1,868,700	2,566,400	3,304,000
d. Number of P/T Students	0	0	0	0	0
e. Credit Hour Rate	1,957	2,016	2,076	2,139	2,203
f. Annual Credit Hour Rate	-	-	-	-	-
g. Total P/T Revenue (d x e x f)	-	-	-	-	-
3. Grants, Contracts & Other External Sources	0	0	0	0	0
4. Other Sources	0	0	0	0	0
TOTAL (Add 1 – 4)	293,600	907,200	1,868,700	2,566,400	3,304,000

Narrative: Table 1 addresses the program resources that will support the program and include the total revenue and associated tuition and fees, students, and other sources of income.

Table 2: Program Expenditures

Expenditures	Year 1	Year 2	Year 3	Year 4	Year 5
1. Faculty (b + c below)					
a. Number of FTE	1	2	3	3	3
b. Total Salary	75,000	150,000	225,000	225,000	225,000
c. Total Benefits	25,500	51,750	77,625	78,750	78,750
2. Admin. Staff (b + c below)					
a. Number of FTE	1	1	2	2	2
b. Total Salary	50,000	51,500	106,090	109,273	112,551
c. Total Benefits	17,000	17,768	36,601	38,245	39,393
3. Support Staff (b + c below)					
a. Number of FTE	0.5	0.5	1	1	1
b. Total Salary	22,000	22,000	45,000	46,350	47,741
c. Total Benefits	7,480	7,590	15,525	16,223	16,709
4. Technical Support and Equipment	0	0	0	0	0
5. Library	0	0	0	0	0
6. New or Renovated Space	0	0	0	0	0
7. Other Expenses	0	0	00		0
Student Internships	20,000	30,000	50,000	70,000	80,000
TOTAL (Add 1 – 7)	216,980	330,608	555,841	583,841	600,143

Narrative table 2: table 2 addresses the program's expenditures that the program's prosecution will incur. It includes total salary, benefits, and internship costs.