Graduate Course Requirements for
MS Track in "Data Science + Civil and Environmental Engineering"

Students shall take 9 courses (36 credits) in this non-thesis Master's track in CEE. All students must take the 3 required core courses in the Data Science track. For the remaining 6 courses, the students shall follow the recommended coursework from one of the CEE Technical Areas or Interdisciplinary Programs. A minimum of three 5XX courses (12 hours) is required.

1. Core Courses for Data Science in CEE (All three courses required):

- **CEE 492**   **Data Science for CEE**
  Course description: Students will learn to leverage data to study CEE problems, identify patterns and make actionable insights. The course includes training in digital and computer tools (such as data processing, exploratory data analysis, spatial data, data visualization, distributed computing, and statistical modeling) with their applications to CEE issues.

- **CEE 498MLC**   **Machine Learning for CEE**
  Course description: Students will learn the fundamentals behind advanced machine learning and learn how to use machine learning tools to solve CEE problems. Topics include regression, Bayesian inference, deep neural networks, scientific deep learning, and Gaussian Processes.

- **CEE 498ISL or CEE 598DL**

  CEE 498ISL: CE Measurement and Experiments
  Course description: Students will learn basic strategies for experimental design, and gain experience working with a variety of CEE sensing techniques; with components in experimental design and approaches to terrestrial, field, and laboratory-based measurements and experiential learning to explore sensor types and technologies. The course will have modules on 4 sensing applications: (1) mechanics and materials, (2) water and environment, (3) transportation, and (4) construction.

  CEE 598DL: Deep Learning for CEE
  Deep Learning for CEE Sensing, Simulation, & Prediction. This course focuses on deep learning within the civil and environmental engineering domain. In addition to examining the basics of deep learning, students will investigate practical applications in remote sensing, sensor data processing, information extraction, surrogate modeling, and predictive analytics. Topics of interest include deep convolutional networks, recurrent neural networks, and generative adversarial learning. Students will learn to identify, understand, and compare different deep learning techniques and formulate civil engineering problems using appropriate techniques.

2. Recommended Core Courses from *one* of the CEE technical areas (see Appendix A):

1. Construction Engineering and Management
2. Construction Materials
3. EES
4. EWES
5. Geotechnical Engineering
6. Structures
7. Transportation
8. WRES
9. SRIS
10. SRHM

Appendix A. Recommended coursework in each CEE Technical Areas or Interdisciplinary Program

A.1. Construction Engineering and Management (CEM)

Course number	Course name	No of credit hours
CEE420	Construction Productivity	4
CEE421	Construction Planning	4
CEE422	Construction Cost Analysis	4
CEE5xx	Pick from CEM 500-level course list	4
CEE5xx	Pick from CEM 500-level course list	4
5xx	Free technical elective course	4

CEM 500-level course list:

CEE524	Construction Law
CEE525	Construction Case Studies
CEE526	Construction Optimization
CEE528	Construction Data Modeling
CEE598VSO	Visual Sensing in Civil Infrastructure
CEE598BIM	Building Information Modeling
CEE595	AI in Construction Seminar

A.2. Construction Materials (CM)

Course number	Course name	No of credit hours
CEE401	Concrete Materials	4
CEE405	Asphalt Materials	4
CEE504	Infrastructure NDE Methods	4
CEE5xx	Pick from CM 500-level course list	4
5xx	Pick from data-driven engineering courses (Appendix B)	4
4xx or 5xx	Free Technical elective course	4

CM 500-level course list:

CEE501	Construction Materials Characterization
CEE502	Advanced Cement Chemistry
CEE503	Construction Materials Deterioration

A.3. EES

Course number	Course name	No of credit hours
CEE442	Env Eng Principles, Physical	4

CEE443 or 447	Env Eng Principles, Chemical / Atmos. Chemistry	4
CEE444 or 445	Env Eng Principles, Biological / Air Quality Modeling	4
CEE537	Water Quality Control Proc, I	4
CEE538	Water Quality Control Proc, II	4
5xx	Pick from data-driven engineering courses (Appendix B)	4

A.4. EWES

Course number	Course name	No of credit hours
CEE 493	CEE 493 Sustainable Design of Engineering Technologies	4
ENG 571	ENG 571 Theory of Energy & Sustainable Engineering	4
CEE592	Sustainable Urban Systems	4
5xx	Pick from data-driven engineering courses (Appendix B)	4
4xx or 5xx	Free Technical elective course	4
4xx or 5xx	Free Technical elective course	4

A.5. Geotechnical Engineering

Course number	Course name	No of credit hours
CEE483	Soil Mechanics and Behavior	4
CEE484	Applied Soil Mechanics	4
CEE5XX	Pick from Geotech 500-level course list	4
CEE5XX	Pick from Geotech 500-level course list	4
5XX	Pick from data-driven engineering courses (Appendix B)	4
4xx or 5xx	Free Technical elective course	4

Geotech 500-level course list:

CEE580	Excavation and Support Systems
CEE581	Dams, Embankments, and Slopes
CEE582	Consolidation of Clays
CEE585	Deep Foundations
CEE586	Rock Mechanics and Behavior
CEE587	Applied Rock Mechanics
CEE588	Geotechnical Earthquake Engineering
CEE589	Computational Geomechanics
CEE590	Geotechnical field measurements
CEE593	Tunneling

A.6. Structures

Course number	Course name	No of credit hours
CEE470	Structural Analysis	(Typically taken in undergrad)
CEE471	Structural Mechanics	4
CEE462*	Steel Structures, II	Total of 8
CEE463*	Reinforced Concrete II	
CEE472*	Structural Dynamics I	
CEE570	Finite Element Methods	4
CEE5XX	Pick from Structures 500-level course list	4
5XX	Pick from data-driven engineering courses (Appendix B)	4

take 2 out of 3 of these courses in consultation with advisor

Structures 500-level course list:

CEE562	Highway Bridge Design
CEE571	Computational Plates and Shells
CEE572	Earthquake Engineering
CEE573	Structural Dynamics II
CEE574	Probabilistic Loads and Design
CEE576	Nonlinear Finite Elements
CEE577	Computational Inelasticity

A.7. Transportation

Course number	Course name	No of credit hours
CEE4xx or 5xx	Pick from a TE Subgroup course list	4
CEE4xx or 5xx	Pick from a TE Subgroup course list	4
CEE5xx	Pick from a TE Subgroup course list	4
CEE5xx	Pick from a TE Subgroup course list	4
5xx	Pick from data-driven engineering courses (Appendix B)	4
4xx or 5xx	Free technical elective	4

TE Subgroup Course Lists:

Pavement and Facilities

CEE405	Asphalt Materials I
CEE406	Pavement Design I
CEE415	Geometric Design of Roads

CEE505	Transportation Soil Stabilization
CEE506	Pavement Design II
CEE508	Pavement Evaluation & Rehabilitation
CEE509	Transportation Soils

Systems

CEE416	Traffic Capacity Analysis
CEE418	Public Transportation Systems
CEE498TE	Transportation Economics
CEE512	Logistic Systems Analysis
CEE515	Traffic Flow Theory
CEE517	Traffic Signal Systems
CEE598UTM	Urban Transportation Models

Railroad

CEE408	Railroad Transportation Engr
CEE409	Railroad Track Engineering
CEE410	Railway Signaling and Control
CEE411	RR Project Design & Constr
CEE412	High-Speed Rail Engineering
CEE598RTD	Railway Terminal Design & Oper
CEE509	Transportation Soils
CEE598SS	Transportation Soil Stabilization

A.8. WRES

Course number	Course name	No of credit hours
CEE4xx	Pick from WRES course list	4
CEE4xx	Pick from WRES course list	4
CEE4xx	Pick from WRES course list	4
CEE5xx	Pick from WRES course list	4
CEE5xx	Pick from WRES course list	4
5xx	Pick from data-driven engineering courses (Appendix B)	4

WRES Course list

CEE434	Environmental Systems I
CEE450	Surface Hydrology

CEE451	Environmental Fluid Mechanics
CEE457	Groundwater
CEE534	Surface Water Quality Modeling
CEE535	Environmental Systems II
CEE550	Hydroclimatology
CEE551	Open-Channel Hydraulics
CEE552	River Basin Management
CEE553	River Morphodynamics
CEE554	Hydrologic Variability
CEE555	Mixing in Environmental Flows
CEE557	Modeling of Groundwater Flow and Solute Transport
CEE559	Sediment Transport

A.9. SRIS

Course number	Course name	No of credit hours
CEE491	Decision and Risk Analysis	4
CEE493	Sustainable Design of Engineering Technologies	4
CEE592	Sustainable Urban Systems	4
5xx	Pick from data-driven engineering courses (Appendix B)	4
5xx	Free Technical elective course	4
4xx or 5xx	Free Technical elective course	4

A.10. SRHM

Student should take the 20-hr courses required by SRHM program plus one 500-level course from the data driven engineering course list (Appendix B).

Appendix B. List of Data-driven Engineering Courses

Data-driven courses in CEE

- CEE473   Wind Engineering
- CEE 491   Decision and Risk Analysis
- CEE498CM   Computer Methods
- CEE 498LM   Learning Methods for Civil Engineering
- CEE 528   Construction Data Modeling
- CEE 545   Aerosol Sampling and Analysis
- CEE 556   Hydrocomplexity
- CEE 590   Geotechnical field measurement
- CEE591   Reliability Analysis
- CEE 592   Sustainable Urban Systems
- CEE 598VSO   Visual Sensing in Civil Infrastructure
- CEE 598BIM   Building Information Modeling
- CEE598GW   Globalization of Water

Data-driven courses in other departments

- CS 412   Introduction to Data Mining
- CS 424   Real-Time Systems
- CS 440   Artificial Intelligence
- CS 446   Machine Learning
- CS 450   Numerical Analysis
- CS 512   Data Mining Principles
- CS 519   Scientific Visualization
- CS 543   Computer Vision
- CS 547   Deep Learning
- CS 598   Machine Learning for Signal Processing
- ECE 410   Digital Signal Processing
- ECE 486   Control Systems
- ECE 490   Introduction to Optimization
- ECE 515   Control System Theory & Design
- ECE 534   Random Processes
- IE 410   Stochastic Processes & Application
- IE 411   Optimization of Large Systems
- IE 510   Applied Nonlinear Programming
- IE 511   Integer Programming
- GEOG 517   Geospatial Visualization & Visual Analytics
- GEOG 527   Geospatial Artificial Intelligence and Machine Learning
- GEOG 570   Advanced Spatial Analysis
- STAT 420   Methods of Applied Statistics
- STAT 431   Applied Bayesian Analysis
- STAT 448   Advanced Data Analysis
- STAT 525   Computational Statistics
- STAT 542   Statistical Learning
- MATH 564   Applied Stochastic Process (STAT 555)
- ENG 498:   Interdisciplinary Methods in Research Computing