

ME 23900
INTRODUCTION TO DATA SCIENCE FOR MECHANICAL ENGINEERS

Course Outcomes

1. Represent mathematically uncertainty in engineering models and assess quantitatively its effect on quantities of interest. [1]
2. Demonstrate the data-driven calibration of engineering models. [1]
3. Introduce the basics of constructing, calibrating, and evaluating data-driven models for common supervised learning tasks. [1]
4. Demonstrate how engineering knowledge and data to make decisions under uncertainty. [1, 2]
5. Improve Python programming and data visualization skills. [3]

Introduction (1 week)

1. What is data science?
2. Examples of supervised and unsupervised learning tasks.
3. The unique data-related challenges of engineering problems.
4. Big data vs small data.
5. The machine learning view vs the probabilistic view.



**Python Basics via Data Analysis Examples
(3 wks)**

1. Introduction to Python programming (running Jupyter notebooks, Python types, Python as a calculator, if statements, for and while loops, lists, functions).
3. Manipulating data in python (reading/writing CSV files, binary file formats, the Python data analysis library, time-stamped data).
4. Sampling average, variance, standard deviation, correlation.



Data Visualization in Python (2 wks)

1. The Matplotlib Python library.
2. Plotting 1D functions.
3. Plotting timeseries.
4. Style basics (font sizes, linewidths, symbols).
6. Scatter plots.
7. Histograms.
8. Visualization of basics statistics (average, variance, standard deviation, correlations).



**Basics of Parameter Estimation
(4 wks)**

1. Maximum likelihood parameter estimation.
2. Linear regression.
3. Least squares estimators.
4. The generalized linear model.
5. Probabilistic interpretation of least squares.
6. Logistic regression.



Basic Probability Theory (6 wks)

1. Interpretation of probability.
2. Basic rules of probability.
3. Random variables.
4. Probability density function.
5. Cumulative distribution function.
6. Expectation, variance, correlation.
7. Independent random variables.
8. The law of large numbers.
9. Monte Carlo sampling.
10. Uncertainty propagation through engineering models

COURSE NUMBER: ME 23900		COURSE TITLE: Introduction to Data Science for Mechanical Engineers	
REQUIRED COURSE OR ELECTIVE COURSE: ELECTIVE COURSE		TERMS OFFERED: Spring, Fall	
TEXTBOOK/REQUIRED MATERIAL: None		PRE-REQUISITES: CS 159, MA 261, MA 262 (or permission by the instructor)	
COORDINATING FACULTY: I. Bilonis		COURSE OUTCOMES: 1. Represent mathematically uncertainty in engineering models and assess quantitatively its effect on quantities of interest. [1] 2. Demonstrate the data-driven calibration of engineering models. [1] 3. Introduce the basics of constructing, calibrating, and evaluating data-driven models for common supervised and unsupervised learning tasks. [1] 4. Demonstrate how engineering knowledge and data can be combined to make decisions under uncertainty. [1, 2] 5. Improve Python programming and data visualization skills. [3] RELATED ME PROGRAM OUTCOMES: 1. Engineering fundamentals 2. Engineering design 3. Communication skills	
COURSE DESCRIPTION: Introduction to the fundamentals of data science for mechanical engineers. The fundamentals taught in this course are relevant to many modern Mechanical Engineering applications including: <ul style="list-style-type: none">Autonomous systems (e.g., vehicles, robots, buildings)Fault detection, diagnosis, and prognosis (e.g., gears, motors, HVAC systems, human biological organs such as the heart or lungs)Human machine interaction (e.g., VR, haptics, robot-human collaboration)			
ASSESSMENTS TOOLS: 1. Class participation. 2. Weekly homework. 3. Project reports (initial, midterm, and final).			
PROFESSIONAL COMPONENT: None			
NATURE OF DESIGN CONTENT: The students will be able to use data analysis to (i) estimate the parameters of engineering models which can be used to predict the performance of new designs with quantified uncertainties; (ii) build data analysis techniques in engineered artifacts to give them more capabilities.			
COMPUTER USAGE: All class activities, homework, and the project require students to write Python code in the form of Jupyter notebooks			
COURSE STRUCTURE/SCHEDULE: Lecture – 1 day per week at 50 minutes			
PREPARED BY: I. Bilonis		REVISION DATE: 5 / 19 / 2025	