MSE 3025: Statistics and Numerical Methods

Credit hours and contact hours: 3-0-0-3

Instructor: Seung Soon Jang

Textbook: Steven C. Chapra, and Raymond P. Canale, *Numerical Methods for Engineers*, 7th Edition, McGraw-Hill, 2014.

Specific course information

Catalog description: Concepts of computational modeling and statistics, with examples based on materials science and engineering applications.

Prerequisites: MSE 2001 - Principles and Applications of Engineering Materials and CS 1371 - Introduction to Computing
Corequisite: MATH 2403 Differential Equations

Course: Required

Specific goals for the course

Outcomes of instruction:

1. Ability to flowchart and pseudocode logic for problem solving
2. Solve root-finding problems using several methods
3. Solve systems of linear algebraic equations using Gauss elimination and LU decomposition
4. Perform regression and interpolation on datasets
5. Numerically differentiate and integrate equations and datasets
6. Numerically integrate ODEs for initial value problems
7. Numerically integrate PDEs for initial-boundary value problems
8. Describe essential aspects of statistical sampling and analysis of experimental data
9. Describe estimation of parameters and hypothesis testing
10. Describe concepts of probability and conditional probability and apply to atomic jumps and diffusion problems
11. Describe discrete and continuous statistical distributions and concepts of mean, variance and skewness
12. Describe multivariate distributions and statistics of relevance in materials science

Student Outcomes:

(1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
(3) An ability to communicate effectively with a range of audiences.

(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

Topics covered:

1. Introduction to mathematical modeling and numerical solution of engineering problems.
2. Problem Solving – Approximations, Accuracy, Precision, Round-Off Errors, and Truncation Errors.
3. Root of Equation – Bracketing Methods and Open Methods.
4. Linear Algebraic Equations – Gaussian Elimination and LU-Decomposition.
5. Curve fitting – Least-Squares Regression Methods and Interpolation
6. Numerical Integration – The trapezoidal Rule and Simpson's Rules.
7. Numerical Differentiation – Forward, Backward and Centered Finite Difference Methods, and Richardson Extrapolation
8. Ordinary Differential Equations – Euler's Method, Heun's Method, Mid-point Method, and Runge-Kutta Methods.
9. Basic Concepts of Probabilities – Random Experiments, Concept of Probability, Conditional Probability
10. Statistical Distribution Functions – Random Variables, Discrete and Continuous Distributions, Mean, Variance, Skewness, Binomial, Poisson, Normal, and Log-Normal Distributions, Bose-Einstein, Fermi-Dirac Distributions, Multivariate Distributions
11. Statistical Analysis of Experimental Data – Statistical Sampling, Errors, Central Limit Theorem, Estimation
12. Estimation of Parameters and Hypothesis Testing – Estimation of Parameters, Testing of Hypothesis, Fitting of Straight Lines, Regression Analysis

Correlation between Outcomes of Instruction and Student Outcomes:

Outcomes of Instruction	**Student Outcomes**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1. Ability to flowchart and pseudocode logic for problem solving	X		X				
2. Solve root finding problems using several methods	X		X				
3. Solve systems of linear algebraic equations using Gauss elimination and LU decomposition	X		X				
4. Perform regression and interpolation on datasets	X		X			X	
5. Numerically differentiate and integrate equations and datasets	X		X			X	
6. Numerically integrate ODEs for initial value problems	X		X			X	
7. Numerically integrate PDEs for initial-boundary value problems	X		X				
8. Describe essential aspects of statistical sampling and analysis of experimental data	X					X	

9. Describe estimation of parameters and hypothesis testing	X					X	
10. Describe concepts of probability and conditional probability and apply to atomic jumps and diffusion problems	X						
11. Describe discrete and continuous statistical distributions and concepts of mean, variance and skewness	X					X	
12. Describe multivariate distributions and statistics of relevance in materials science	X					X	

School of Materials Science and Engineering Student Outcomes:

(1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
(2) An ability to apply engineering design to produce solutions that meet specified needs with consideration for public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
(3) An ability to communicate effectively with a range of audiences.
(4) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
(5) An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
(7) An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.