MSE 3025: Statistics and Numerical Methods (required)

Catalog Description: (3-0-3)
Prerequisites: MSE 2001 Principles and Applications of Engineering Materials; CS 1371 Introduction to Computing;
Corequisite: MATH 2403 Differential Equations
Concepts of computational modeling and statistics, with examples based on materials science and engineering applications.

Textbook: Steven C. Chapra, and Raymond P. Canale, *Numerical Methods for Engineers*, 6th Edition, McGraw-Hill, 2009

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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

Course Outcomes:

The student will develop a working knowledge of several numerical methods and their analytical basis.

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

Correlation between Course Outcomes and Student Outcomes:

Course Outcomes	**Student Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Course Outcome 1	X			X	X		X		X	X	X
Course Outcome 2	X			X	X		X				X
Course Outcome 3	X			X	X		X				X
Course Outcome 4	X	X			X		X		X		X
Course Outcome 5	X	X			X		X				X
Course Outcome 6	X	X			X		X		X	X	X
Course Outcome 7	X				X		X		X		X
Course Outcome 8	X	X					X		X		X
Course Outcome 9	X	X					X				X
Course Outcome 10	X										X
Course Outcome 11	X	X					X		X		X
Course Outcome 12	X	X					X		X		X
Entire Course	**2**	**2**	**0**	**1**	**2**	**0**	**3**	**0**	**3**	**1**	**3**
0 = None or insignificant; 1 = Some; 2 = Moderate; 3 = Strong											

School of Materials Science and Engineering Student Outcomes:

(a) an ability to apply knowledge of mathematics, science and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice