<u>Content beyond the syllabus</u>

The use of Numerical Methods in solving practical technical problems using scientific and Mathematical tools when available, and using experience and intuition otherwise, Mathematical models provide a priori estimates of performance— very desirable when prototypes or experiments are costly. Engineering problems frequently arise in which exact analytical solutions are not available. Approximate solutions are normally sufficient for engineering applications, allowing the use of approximate numerical methods.

Analysis:

Predicting the response of a system given a fixed system design and operating conditions. mph acceleration time of a vehicle (Mechanical Engineering),Power output of an electric motor (Electrical/Mechanical Engineering),Gain of an electromagnetic antenna (Electrical Engineering), Maximum load a bridge can support (Civil Engineering), Reaction time of a chemical process (Chemical Engineering), Drag force of an airplane (Aerospace Engineering), Expected return of a product portfolio (Industrial and Operations Engineering), Determining an ideal system design such that a desired response is achieved. Maximizing a vehicle's fuel economy while maintaining adequate performance levels,by varying vehicle design parameters. Minimizing the weight of a mountain bike while ensuring it will not fail structurally by varying frame shape and thickness

Design:

Maximize performance criteria subject to failure constraints: Minimize bicycle frame weight subject to structural failure constraints by varying frame shape and thickness. Minimize cost subject to performance and failure constraints. Minimize vehicle cost subject to acceleration, top speed, handling, comfort, and safety constraints by varying vehicle design variables. Regression: technique for approximating an unknown response surface (function). Sample several points experimentally. Fit an approximating function to the data points, minimizing the error between the approximating function and the actual data points. Gravitational, Potential Energy. Objects seek position of minimum gravitational potential energy, Bubbles, Energy associated with surface area. Bubbles seek to minimize surface area, spherical shape. Many small bubble coalesce to form fewer large bubbles. Atomic Spacing, Atoms seek positions that minimize 'elastic' potential energy. At large separation distances attractive forces pull atoms together (depends on bonding type).At small separation distances repulsive forces due to positively charged nuclei push atoms apart. The net force results in energy well. The steepness of this well determines material properties such as thermal expansion determining position from discrete set of acceleration values (robotics), Determine stress within a loaded object to predict failure

Numerical solutions to differential equations – Finite Difference Method Computational Fluid Dynamics (Navier–Stokes Equations) Dynamics (Newton-Euler &Lagrange's equations, finite Element Method Solid Mechanics (Elasticity equations) Heat Transfer (Heat equation) Kinematics Simulation, and Complex System Optimization