**Review Sheet – Final ChE 310 Spring 2019**

**NOTE:** The final is cumulative; however, the emphasis will be on the last unit. These problems will require you to remember past skills in addition to the new techniques.

**Unit III**

* Design of Experiments
  + What is it? Why do we care?
  + Types of DoE
    - Screening design
    - Fractional factorial, full factorial
    - Response surface design
      * bbdesign
      * ccdesign
  + Fitting results of response surface design
    - Dropping parameters
    - Optimization
* Numerical Differentiation
  + Types of numerical differentiation methods (table)
  + Richardson extrapolation
  + Derivatives from noisy experimental data
  + Partial derivatives
  + **diff** and **gradient**
* Numerical Integration
  + Tabulated data
    - Trapezoidal rule
    - Simpson’s rules (1/3, 3/8)
    - **trapz**, **cumtrapz**, **polyint**
  + Integrals from functions
    - Romberg integration w/ Richardson extrapolation
    - Gauss quadrature
    - **integral**, **integral2**, **integral3**
* Ordinary Differential Equations
  + Initial Value Problems
    - First order and second order
    - Euler
    - 2nd order methods
      * Huen (not iterative)
      * Midpoint
    - 4th order Runge Kutta
      * **rk4sys**
    - Solving problems that are systems of ODEs
  + Adaptive Methods
    - Step halving
    - Embedded or Fehlberg methods (**ode23**, **ode45**)
  + Stiff Problems
    - What are they?
    - **ode15s** and **ode23s**
  + Boundary Value Problems
    - What are they?
    - Types of boundaries
      * Constant (Dirichlet)
      * Rates (Neumann)
    - Shooting Method
      * Linear equations with interpolation (not important)
      * All equations with root finding (important!)
    - Finite Difference
      * Convert ODE to algebraic expression
      * Coefficient matrix, solve as system of equations
      * SLOW, if given option use shooting method

**Unit II**

* Root finding
  + Graphical
  + Bracketed methods
    - Bisection
    - False position
  + Open methods
    - Fixed point iteration (successive substitution)
    - Newton Raphson method
    - Secant method
  + Matlab tools
    - fzero
    - roots
  + Excel solver
* Optimization (root finding)
  + Global vs. local
  + Golden search
  + fminbnd
  + fminsearch
  + fmincon
* Systems of linear equations and matrix math
  + Setting up system of equations from conservation type problems
  + Condition and determinant
  + Gauss elimination
  + Partial pivoting
  + LU factorization
  + \ command
  + Gauss seidel method
  + Sparse (banded) matrix
    - Setting up from finite element problems
    - tridiag function
* Matrix inverse and other matrix measures
  + Calculating the inverse
  + Stimulus response problems
  + Norm of matrix
  + Condition number
* Systems of Non-linear Equations
  + Graphical
  + Multidimensional Newton Raphson
  + newtmult algorithm with Jacobian
  + fsolve
* Curve Fitting: Basic linear regression
  + Regression vs. interpolation – when to use each method
  + Residual
  + Sum of squares of residuals
  + Quantification of error
    - Coefficient of determination
      * What does it mean?
  + polyfit
  + fit
  + plotting with confidence intervals
* Curve Fitting: Non-linear regression
  + How linear least squares problems are reduced to a system of linear equations using ‘normal’ equations (15.1-15.2)
  + General linear least squares (15.3)
  + polyfit
  + fit
  + Curve Fitting Toolbox (cftool)
  + Automating fits
    - Extracting goodness of fit measures
    - Extracting coefficients
    - Extracting confidence intervals

**Unit I**

* MATLAB basics
  + Use of basic built-in functions (e.g. sin, exp, round, abs)
  + M-files: scripts vs. functions, concept of scope
  + Anonymous functions/function handles
  + Accessing and assigning array variables
  + Colon notation, linspace/logspace functions
  + Boolean expressions: relational and logical operators
  + If… ElseIf… Else structures
  + For loops
  + While loops, error estimation, and stopping criteria
  + Nesting of loops
  + Data import/export (to screen as well as to file)
  + Plotting: plot/semilog/loglog functions, fplot function, subplots
* Statistics and measurement
  + Accuracy and precision
  + Types and sources of error
  + True error, relative error, defining error tolerance
  + Built-in MATLAB statistical functions
    - mean, median, mode, std, iqr
    - Plotting: box, histogram
  + Probability density functions, cumulative density functions, MATLAB tools for fitting distributions and generating data according to those distributions
* Interpolation
  + *Order* of polynomials and relationship to size of data set
  + Newton/LaGrange methods for creating interpolating polynomials
  + MATLAB polynomial syntax
  + Built-in functions for finding and using interpolating polynomials: polyfit, polyval
  + Multi-dimensional interpolation
  + Piecewise interpolation and built-in functions (interp1, interp2)
  + Splines: common types, implementation in MATLAB
* Differentiation
  + Forward, backward, central difference formulas
  + truncation error notation
  + Differentiation of discrete data sets
  + Differentiation of functions
  + Differentiation strategies for unevenly spaced data