**P01 Engineering Mathematics – Learning Outcomes**

After you complete this course you will you have demonstrated a range of skills and abilities in calculus and computational proficiency in MATLAB.

Specifically you will be able to:

**In Single Variable Differential Calculus:**

LO1. Express and use the tangent/slope and rate of change meanings of the derivative. [PLO 1]

LO2. Construct application models from word problems and use derivatives to investigate properties of the models.

**In Single Variable Integral Calculus:**

LO3. Express and use the relationship between integration and the area under a curve/rate graph.

LO4. Construct application models from word problems and use integrals and/or derivatives to investigate properties of the models.

**In Mathematical Modelling**

LO5. Construct mathematical models from word problems.

LO6. Select and apply appropriate differential or integral techniques to investigate properties of the models.

**In Differential Equations**

LO7. Construct differential equations and interpret their meaning.

LO8. Be able to identify different types of differential equations and use the correct technique to solve them.

**In Linear Algebra**

LO9. Create and solve linear systems that model real-world situations

L10. Use linear algebra techniques to gain deep understanding of engineering problems and solutions.

Week 1: By the end of this week, learners should be able to:

* + - Interpret the derivative, and be able to discuss the difference between the secant line and the derivative (LO1, LO2)
    - Compute the derivative of polynomial, exponential, logarithmic, powers, trigonometric functions and their combinations, with the correct application of the product and quotient rules, and the chain rule (LO2)
    - Report the graphs, domain and range of the **inverse** trigonometric functions arcsin, arccos and arctan. (LO1)
    - Apply the derivative rules for arcsin, arccos and arctan. (LO2)

Week 2: By the end of this week, learners should be able to:

* + - Understand the meaning and value of linearization (LO2, LO3)
    - Apply the technique of linearization to solve a variety of nonlinear equations (LO3)
    - Use Newton’s Method as a technique to solve a class of root-finding problems (LO3)
    - Use MATLAB to graph and compare functions with their linearizations (LO2)
    - Use MATLAB to implement Newton’s method. (LO3)
    - Calculate and interpret the first and second derivatives, as well as higher order derivatives (LO2)

Week 3: By the end of this week, learners should be able to:

* + - Use the first and second derivatives to identify properties of a given function (LO2, LO3)
    - Calculate a Taylor Polynomial and apply them to a variety of problems (LO2, LO3)
    - Use MATLAB to graph and compare functions with their Taylor polynomial approximations (LO2, LO3)
    - Find the critical points of a function using derivatives (LO2, LO3)
    - Distinguish between global and local optimization (LO2, LO3)
    - Use the techniques of optimization to solve a variety of applied problems. (LO2, LO3)
    - Use MATLAB single-variable optimizers to identify optimal values for functions. (LO2, LO3)
    - Use MATLAB single-variable equation solvers to identify critical points given the derivative function (LO2, LO3)
    - Use MATLAB to graph and compare functions with their linearizations (LO2, LO3)

Week 4: By the end of this week, learners should be able to:

* + - Use the definite integral to model and find a solution to a posed area- or accumulation-related problem (LO4, LO5)
    - Scale and add definite integrals, understand the meaning of integral bounds and how to apply them (LO4, LO5)
    - Recognize an anti-derivative of a function, (LO4, LO5)
    - Apply the theory of the Fundamental Theorem of Calculus to evaluate simple integrals (LO4, LO5)
    - Distinguish between definite and indefinite integrals and their meaning (LO4, LO5)
    - Use MATLAB single-variable integration tools to evaluate definite integrals (LO4, LO5)

Week 5: By the end of this week, learners should be able to:

* + - Recognize the family of functions that can be solved with the technique of integration by substitution (LO4)
    - Solve integration problems using the technique of substitution (LO4)
    - Recognize the family of functions that can be solved with the technique of integration by parts (LO4)
    - Solve integration problems using the technique of integration by parts (L04)

Week 6: By the end of this week, learners should be able to:

* + - Use MATLAB to solve a variety of integration problems (LO4, LO5)
    - Use integration to find the average value of a function (LO4, LO5)
    - Use MATLAB to find the average value of a function (LO4, LO5)
    - Use MATLAB to find the average value of a sequence of data. (LO4, LO5)

Week 7: By the end of this week, learners should be able to:

* + - Understand and express real world situations in terms of first order differential equations (LO8)
    - Tell the difference between linear and nonlinear differential equations (LO9)
    - Solve basic first order separable and linear differential equations (LO9)
    - Use MATLAB to solve nonlinear first order differential equations (LO9)

Week 8: By the end of this week, learners should be able to:

* + - Understand and express real world situations in terms of second order linear differential equations (LO8)
    - Understand the difference between homogeneous and nonhomogeneous second order linear differential equations (LO8)
    - Use MATLAB to solve linear and nonlinear second order differential equations, both homogeneous and nonhomogeneous. (LO9)

Week 9: By the end of this week, learners should be able to:

* + - Take problems that can be modeled by differential equations, both first and second order, and give solutions both by hand and MATLAB (LO5, LO8)
    - Examine case studies of differential equations applied to engineering problems and reproduce those solutions.

Week 10: By the end of this week, learners should be able to:

* + - express vectors, linear combinations, and compute dot products (LO9)
    - Write information in matrix form in the context of engineering applications (LO9)
    - Understand the definition of the transpose, and use MATLAB to compute it (LO9)
    - Use MATLAB to compute the inverse of a matrix (LO9)

Week 11: By the end of this week, learners should be able to:

* + - Use MATLAB to solve linear system and interpret the answer the program provides (LO9)
    - Write the nullspace of A by solving Ax = 0 (LO9)
    - Compute the rank and find row-reduced echelon form (LO9)
    - Explain the notions of linear independence and bases (LO10)

Week 12: By the end of this week, learners should be able to:

* + - Describe the properties of the matrix determinant (LO10)
    - Explain the concept of bases and orthogonal bases (LO10)
    - Diagonalize a matrix and use the result to interpret the behavior of a linear system. (L)10)