**UT Math 1920-1930 Submission for OTM Calculus I&II sequence – TMM 017**

**Learning Outcomes from Calc I:**

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|   | Learning Outcome Description | Describe how the Courses or Programs address each outcome |
| 1  | \* Determine the existence of, estimate numerically and graphically and find algebraically the limits of functions. Recognize and determine infinite limits and limits at infinity and interpret them with respect to asymptotic behavior. | Students examine tables of sequential values and graphs of functions to analyze limiting behavior of functional values, including infinite limits and limits at infinity. Students determine whether limits exist and evaluate those limits by manipulating the algebraic expressions of functions. |
| 2  | \* Determine the continuity of functions at a point or on intervals and distinguish between the types of discontinuities at a point. | Students identify removable and jump discontinuities and asymptotes from graphs and evaluate left- and right-hand limits from piecewise algebraic definitions. |
| 3  | \* Determine the derivative of a function using the limit definition and derivative theorems. Interpret the derivative as the slope of a tangent line to a graph, the slope of a graph at a point, and the rate of change of a dependent variable with respect to an independent variable. | Students apply the limit concept to the secants through a given point on the graph of a function to define the tangent line and interpret the derivative as its slope. Students employ this technique to the motion of a point along a line or other physical phenomena to interpret derivative as velocity or rate of change. |
| 4  | \* Determine the derivative and higher order derivatives of a function explicitly and implicitly and solve related rates problems. | Students combine the interpretation of derivative as slope and rate of change to study the second derivative as both a measure of concavity of the graph and of the acceleration of a physical quantity, such as a particle in motion. The student will apply Chain Rule and other rules of differentiation to implicitly defined quantities, including those involving geometric and physical relationships, to determine their relative rates of change and higher derivatives. |
| 5  | \* Determine absolute extrema on a closed interval for continuous functions and use the first and second derivatives to analyze and sketch the graph of a function, including determining intervals on which the graph is increasing, decreasing, constant, concave up or concave down and finding any relative extrema or inflection points. Appropriately use these techniques to solve optimization problems. | Students will apply all of the concepts and techniques above to determine intervals of monotonicity, intervals of concavity, and interpret the transition points as local extrema or inflection points. Students will apply this method to sketch accurate graphs of functions, exhibiting all critical behavior; and to solve optimization problems, including those given in verbal form. |
| 6  | Determine when the Mean Value Theorem can be applied and use it in proofs of other theorems such as L’Hopital’s rule. | Students will apply L’Hospital’s rule to evaluate limits of quantities expressed in “indeterminate form”. |
| 7  | Use differentials and linear approximations to analyze applied problems. | Usually covered in class and midterms but not a course objective and hence not required for the final exam. |
| 8  | \* Determine antiderivatives, indefinite and definite integrals, use definite integrals to find areas of planar regions, use the Fundamental Theorems of Calculus, and integrate by substitution. | Students will analyze the areas of geometric figures using the method of exhaustion. Students will apply this concept to determine the areas of regions bounded by the graphs of functions, leading to the formal expression of the definite integral as the limit of Riemann sums. Students will study the inverse process of differentiation to develop the concept of antiderivative. In particular students will use the Chain Rule in conjunction with this process to develop the method of substitution. Students will link the concepts of Riemann integral and antiderivative through the Fundamental Theorem of Calculus, and apply it to determine the areas of planar regions analytically. |

**Learning Outcomes from Calc II:**

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|   | Learning Outcome Description | Describe how the Courses or Programs address each outcome |
| 1 | \*Use antiderivatives to evaluate definite integrals and apply definite integrals in a variety of applications to model physical, biological or economic situations. Whatever applications (e.g. determining area, volume of solids of revolution, arc length, area of surfaces of revolution, centroids, work, and fluid forces) are chosen, the emphasis should be on setting up an approximating Riemann sum and representing its limit as a definite integral. | Students will use definite integrals to find volumes of rotation, arc lengths, centroids, work, and fluid forces. To solve for the desired quantity in these application problems, students will identify a pertinent interval of the independent variable and divide that interval into subintervals of equal width. Students will construct a formula which estimates the value of the desired quantity within each subinterval. Students will recognize the summation of subinterval estimates as a Riemann sum and an estimate of the desired quantity over the whole interval. Students will find the exact value of the desired quantity by using a definite integral to find the limit of the Riemann sum as the number of subintervals increases to infinity.  |
| 2 | Approximate a definite integral by the Trapezoidal Rule and Simpson¿s Rule. | Not addressed. |
| 3 | \*Employ a variety of integration techniques to evaluate special types of integrals, including substitution, integration by parts, trigonometric substitution, and partial fraction decomposition. | Students will continue the analysis of the inverse process of differentiation, from Calc I, to develop further techniques of integration including integration by parts from the product rule. Students will develop further integration techniques by combining trigonometric identities with the method of substitution to obtain the technique of trigonometric substation; and by reversing the process of adding rational expressions by means of common denominators to obtain the technique of partial fractions. |
| 4 | \*Evaluate limits that result in indeterminate forms, including the application of L’Hôpital’s Rule. | This is addressed primarily in Calc I. In this semester the student will further apply this technique to transcendental functions and in convergence criteria for series. |
| 5 | \*Evaluate improper integrals, including integrals over infinite intervals, as well as integrals in which the integrand becomes infinite on the interval of integration. | Students will apply the integration techniques above together with the limit concept from Calc I to evaluate improper integrals, including both those over infinite intervals and those with finite singularities. |
| 6 | Find, graph, and apply the equations of conics, including conics where the principal axes are not parallel to the coordinate axes. | These topics are addressed at the discretion of the instructor. |
| 7 | \*Determine the existence of, estimate numerically and graphically, and find algebraically the limits of sequences. Determine whether a series converges by using appropriate tests, including the comparison, ratio, root, integral and alternating series tests. | Students will review the concept of sequential limit from Calc I and then use this to begin a study of infinite series. Students will study the geometric series and obtain a closed form for its partial sums then evaluate the infinite sum by computing the limit of its partial sums. In particular students will learn the conditions which imply convergence or divergence. Students will study further explicit examples, including the harmonic series, and use these to distinguish between absolute and conditional convergence. Students will apply the explicit analysis of geometric series together with the comparison test to develop and apply further tests for convergence, including the ratio and root tests. Students will combine the comparison tests together with the concept of Riemann sum and the techniques of indefinite integral to derive the integral test for convergence of a series. |
| 8 | \*Find the nth Taylor polynomial at a specified center for a function and estimate the error term. Use appropriate techniques to differentiate, integrate and find the radius of convergence for the power series of various functions. | Students will study the expression of a function as an infinite power series, again beginning with the example of the geometric series. Students will use term-wise operations to derive the Taylor, Maclaurin, and binomial formulas; and to develop power series representations of familiar functions such as logarithmic and inverse trigonometric functions Students will employ the concepts and techniques for general series (above) determine intervals of convergence. |
| 9 | \*Analyze curves given parametrically and in polar form and find the areas of regions defined by such curves. | Students will study parametric curves through the analysis of the motion of a particle in the plane. Students will employ the chain rule to derive expressions for the slope and concavity and use these to graph the curves. Students will review the definition of polar coordinates and then combine the parametric techniques with trigonometric identities to develop and evaluate integrals for the areas enclosed by polar graphs. |
| 10 | Perform and apply vector operations, including the dot and cross product of vectors, in the plane and space. | Students will study three-dimensional coordinate systems, with a focus on linear equations in 2 or more variables, including parametric equations. Students will interpret linear equations as dot products in a vector representation. Students will study the geometry of the dot and cross products using trigonometry and then will apply the geometry of these operations in physical situations, including force and velocity. |
| 11 | Solve separable differential equations. Understand the relationship between slope fields and solution curves for differential equations. Use Euler’s method to find numerical solutions to differential equations. | Not addressed. |