

Calculus Learning Objectives

Program Learning Goals

- Gain a firm understanding of the concepts of function, slope, and limits, which provide the backdrop for calculus.
 - Learn the definition of the derivative & be able to relate it to algebraic, numerical, graphical, or verbal descriptions and data.
 - Learn to calculate derivatives using a variety of standard techniques.
 - Learn to use derivatives in applied problems, particularly in the context of the physical sciences.
0. I: Be able to work in and switch between verbal, numerical/tabular, graphical, and algebraic/symbolic representations. II: Interpret and solve increasingly complicated questions involving derivatives. III: Connect and apply concepts and methods of calculus to other disciplines, particularly physics and chemistry.
 1. Define, determine, and interpret the average rate of change of a function over an interval numerically & algebraically (using the difference quotient), and graphically (using the slope of the secant line).
 2. Use the idea of limits to explain that: the instantaneous rate of change of a function at a point is the limit of the average rate of change of the function over an interval including the point, as the interval approaches zero; and the tangent line to the graph of a function at a point is the limit of the secant line between two points on the graph as the points approach each other.
 3. Define the derivative at a point as the instantaneous rate of change of a function at that point, and connect that to the slope of the tangent line to the graph of the function. Use the limit definition of the derivative to determine and interpret the derivative numerically & algebraically, and graphically (as the slope of the tangent line).
 4. Generalize the derivative at a point to the derivative as a function.
 5. Interpret and apply the derivative graphically, including being able to estimate the graph of the derivative from the graph of the function, determine the equation of the tangent line to a function at a point, and use the sign of the derivative on an interval to determine whether the graph of the function is increasing, decreasing, constant, or changing direction.
 6. Use the power rule to determine the derivative of power functions.
 7. Use and interpret various derivative notations, and connect with using units.
 8. Interpret and apply meanings of derivatives in various scenarios.
 9. Given graphs of functions, sketch first and higher order derivatives. Given information about derivatives, tell whether the function is increasing, decreasing, or neither and whether it is concave up, down, or neither.
 10. State and use the connection between differentiability and continuity.
 11. Use the derivative of a constant multiple rule, the derivative of a sum and difference rule, and the power rule to find derivatives of power and polynomial functions.
 12. Find derivatives of the exponential functions e^x and a^x .
 13. Use the product rule and the quotient rule to find derivatives of functions multiplied together or divided together.
 14. Identify “inner” functions and “outer” functions of composite functions. Identify functions and corresponding inverse functions.
 15. Differentiate composite functions and inverse functions using the chain rule.
 16. Find derivatives of $\sin x$, $\cos x$, and $\tan x$ along with other trig functions. Find derivatives of compositions and inverses involving trig functions.
 17. Find derivatives of the natural logarithm function $\ln x$. Use the natural logarithm formula along with the change of base formula to find derivatives of $\log_b x$. Find derivatives of compositions and inverses involving logarithmic functions.
 18. Perform implicit differentiation, i.e. use various differentiation short-cuts to find derivatives of implicit functions.
 19. State and use the Mean Value Theorem.
 20. Given a function (its equation or graph), use first and second derivatives to determine where the function is increasing or decreasing, concave up or concave down, along with the values for critical points, inflection points, and local and global maxima and minima.
 21. Construct a mathematical model for a given scenario looking for maximum or minimum values, and solve the corresponding optimization problem.
 22. Identify rates of change with appropriate derivatives.
 23. Construct a mathematical model for a given scenario concerning *related rates*, and use the chain rule to solve such related rate problems.
 24. Apply l’Hôpital’s Rule to find limits of the $0/0$ or ∞/∞ form. Where possible, transform limits of the form $0 \cdot \infty$, $\infty - \infty$, 1^∞ , 0^0 , and ∞^0 into either the $0/0$ or ∞/∞ form, and apply l’Hôpital’s Rule.
 25. Use limits to determine which of two functions is dominant as $x \rightarrow \infty$.