Calculus | Differential and Integral Calculus

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Calculus was founded by **Newton** and **Leibniz.** Calculus is a branch of mathematics that helps us **study change**. It is used to understand how things change over time or how quantities grow, shrink, or accumulate. There are two main parts of calculus:

- **Differential Calculus**: It helps us calculate the rate of change of one quantity concerning another. This rate of change is called the **derivative**.
    - **Example:** Finding how fast a balloon inflates as you pump air into it.
    - Calculating the slope of a hill (steepness).

- **Integral Calculus**: helps us calculate the total accumulation of change. This accumulation is called the **integral**.
    - Example: Calculating the area under a curve (e.g., finding the distance traveled by a car when you know its speed at every moment).
    - Determining the total rainfall collected in a reservoir.

Note: The process of finding the value of a derivative is called **differentiation**, and the process of finding the value of an integral is called **integration**.

Basic of Calculus

This section covers the basics of calculus, including functions, limits, and continuity. You will learn key techniques for finding limits and understanding discontinuities in functions.

- **Functions**
  - Domain and Range of a Function
- **Limits**
- **Formal Definition of Limits**
  - One-Sided Limits
  - Infinite Limits
  - Limits at Infinity
- **Techniques for Finding Limits**
  - Limits by Rationalization
  - Limits using Algebraic Manipulation
  - Estimating Limits from Graphs
  - Estimating Limits from Tables
  - Squeeze Theorem
  - Limits of Trigonometric Functions
- **Properties of Limits**
- **Continuity of Functions**
  - Continuity at a Point
  - Intermediate Value Theorem
  - Extreme Value Theorem
- **Discontinuity**
  - Types of Discontinuity

Differential Calculus

power, product, quotient, and chain rules, along with real-life applications such as rate of change, extrema, and curve sketching.

- **Differentiability**
  - Mean Value Theorem: Cauchy's Mean Value Theorem
  - Rolle's Mean Value Theorem
- **Derivative**
  - Derivative by First Principle
  - Algebra of Derivative of Functions
- **Rules for Differentiation**
  - Power Rule
  - Product Rule
  - Quotient Rule
  - Chain rule
- **Formulas for Differentiation**
  - Implicit Differentiation
  - Logarithmic Differentiation
  - Parametric Differentiation
- **Examples of Derivatives**
  - Derivatives of Polynomial Functions
  - Derivatives of Trigonometric Functions
  - Derivatives of Exponential Functions
  - Derivatives of Logarithmic Functions
  - Derivatives of Inverse Trigonometric Functions
  - Derivatives of Inverse Functions
  - Derivatives of Composite Functions
- **Application of Derivatives**
  - Critical Points
  - Rate Change of Quantities
  - Increasing Function
  - Decreasing Function
  - Approximation

- Tangent and Normal

- **Concavity and Points of Inflection**
- **Curve Sketching**
- **Partial Derivatives**
- **Higher Order Derivatives**
- **Antiderivatives**
- **Real-Life Application of Differentiation**

Integral Calculus

This section covers the fundamentals of integral calculus, exploring the concept of integration and its relationship to differentiation. You will learn various methods of integration, such as substitution and integration by parts, and apply these techniques to solve real-world problems involving areas, volumes, and surfaces.

- Introduction to Integration
    - Antiderivative: Integration as an Inverse Process of Differentiation
    - Fundamental Theorem of Calculus
- Types of Integrals
    - Definite Integrals
        - Definite Integral as the Limit of a Riemann Sum
        - Properties of Definite Integrals
        - Evaluation of Definite Integrals
    - Indefinite Integrals
    - Improper Integrals
- **Riemann Sum**
    - Riemann Sums in Summation Notation
- **Functions defined by Integrals**
- **Integration Formulas**
- **Methods of Integration**

- Integration by Partial Fraction

- **Application of Integration**
  - Area Under a Curve
  - Area Between Curves
  - Area Between Polar Curves
  - Volume of Solids of Revolution
  - Arc Length of Curves
  - Surface Area of Revolution
- **Line Integral**
- **Surface Integral**
- **Double Integration**
- **Triple Integral**

Differential Equations

This section introduces differential equations, covering their types, including ordinary and partial differential equations, and methods for solving them. You will explore key concepts such as order, degree, and techniques like exact and separable equations, with a focus on first and second-order differential equations.

- **Introduction to Differential Equations**
  - Order and Degree of Differential Equations
  - to Differential Equations
- **Types of Differential Equations**
  - Exact Differential Equations
  - Separable Differential Equations
  - Ordinary Differential Equations
  - Partial Differential Equations
  - Linear Differential Equations
  - Homogeneous Differential Equations
  - First Order Differential Equation
  - Second Order Differential Equation

Practice for Calculus

This section provides a series of practice quizzes and questions to reinforce your understanding of key calculus concepts. You'll test your knowledge on limits, continuity, maxima and minima, and integration through interactive exercises.

- Limits - Quiz
- Continuity of Function - Quiz
- Maxima and Minima - Quiz
- Integration - Quiz
- Practice Questions on Calculus

Programs for Calculus

This section offers practical programming solutions for implementing calculus operations. You'll learn how to write efficient code in Python and MATLAB, enhancing your skills in applying mathematical concepts through programming.

- Calculus with Python
- Program to Differentiate Given Polynomial
- Program to Calculate Double Integration
- Calculus in MATLAB
- Diffrentiation in MATLAB

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Limits in Calculus

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Integrals are an integral part of calculus. They represent summation, for functions which are not as straightforward as standard functions, integra...

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In engineering mathematics, calculus is one of the important branches of mathematics from which questions are asked in the GATE exam, includin...

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