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Calculus 2 (Quick Study Academic)

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Calculus 2

Integration

Riemann Sum

The primary application of integration is to determine the area between a function and the x-axis. A **Riemann sum** is an approximation of this area that is found using rectangles.

A **Riemann sum** of a function f defined on the interval $[a, b]$ is determined by a partition, which is a division of $[a, b]$ into subintervals. The interval is typically expressed by $a = x_0 < x_1 < x_2 < \dots < x_n = b$ and a sampling of points with one point from each subinterval, for example, c_i from $[x_i, x_{i+1}]$. The associated Riemann sum is $\sum f(c_i)(x_{i+1} - x_i)$.

A **regular partition** has subintervals of the same length: $\Delta x = \frac{b-a}{n}$ and $x_i = a + i\Delta x$. A partition's **width** is its maximum subinterval length. A **left sum** takes the left endpoint, $c_i = x_i$, of each subinterval, whereas a **right sum** takes the right endpoint.

Ex: The sum of the areas of the rectangles (left graph) represents a left Riemann sum of $f(x)$ on the interval $[0, 10]$ using positions that are 2 units wide.

Ex: The sum of the areas of the rectangles (right graph) represents a right Riemann sum of $f(x)$ on the interval $[0, 10]$ using positions that are 2 units wide. An upper sum of a continuous function, f , takes a point c_i in each subinterval where the maximum value of f is achieved. A lower sum takes the minimum value of f in each subinterval.

Definite Integral

As the partitions of a Riemann sum get smaller and smaller, the area approximation gets closer and closer to the actual area under the curve. The **definite integral** of f on the interval $[a, b]$ is defined as $\int f(x)dx = \lim_{n \rightarrow \infty} \sum f(c_i)\Delta x$.

The expression to be integrated, $f(x)$, is called the **integrand**. The definite integral gives the **area** under f on the interval $[a, b]$. Thus the function is said to be **integrable**.

Antiderivative

An **antiderivative** of a function f is a function F whose derivative is f : $F'(x) = f(x)$ for all x in some domain (usually an interval). Any two antiderivatives of a function on an interval differ by a constant.

Ex: $\int \cos(x)dx = \sin(x) + C$ ($C = \sin(0) = 0$)

Fundamental Theorem of Calculus

There are two parts to the fundamental theorem of calculus.

- First Part (Evaluating Integrals):** If f is a continuous function on $[a, b]$, and $F(x)$ is an antiderivative of f on that interval, then $\int f(x)dx = F(x)|_a^b = F(b) - F(a)$.
- Ex:** Evaluate $\int (x^2 + 5)dx$, given that $\int (x^2 + 5)dx = x^3 + 5x + C$

$$\begin{aligned} & \int (x^2 + 5)dx = F(x) \\ & = \frac{x^3}{3} + 5x + C \\ & = \frac{1}{3}x^3 + 5x \end{aligned}$$

The area of the shaded region between $f(x)$ and the x-axis on $[2, 8]$ is 314 square units.

- Second Part (Determining Antiderivatives):** If f is a continuous function on $[a, b]$, then the function $F(x) = \int f(x)dx$ is an antiderivative of f on $[a, b]$ and $F'(x) = f(x)$.
- Ex:** $\int \cos(x)dx = \sin(x) + C$ ($C = \sin(0) = 0$)

Interpretation of Integrals

Area Under a Curve

If f is nonnegative and continuous on $[a, b]$, then $F(x) = \int f(x)dx$ gives the area between the graph of the function and the x-axis.

The area Function: $A(x) = \int_a^x f(t)dt$ gives the accumulated area on the interval from a up to x . If f is negative, the integral is the opposite of the area.

Average Value

The average value of f over an interval $[a, b]$ is defined by the expression

$$\text{average value} = \frac{1}{b-a} \int_a^b f(x)dx$$

Ex: Find the average value of $f(x) = \sin(x)$ on the interval $[0, \pi]$.

$$\begin{aligned} \text{average value} &= \frac{1}{\pi-0} \int_0^\pi \sin(x)dx \\ &= \frac{1}{\pi} \left[-\cos(x) \right]_0^\pi \\ &= \frac{1}{\pi} [\cos(0) - \cos(\pi)] = \frac{2}{\pi} \end{aligned}$$

The average value of $A(x)$ on the interval $[b, a]$ is $\frac{1}{a-b} \int_b^a A(t)dt$.

A rough estimate of an integral may be made by estimating the average value of a function (by inspection) and multiplying it by the length of the interval.

Accumulated Change

The integral of a rate of change of a quantity over a time interval gives the total change in the quantity over the time interval.

Ex: Let $s(t)$ represent the position of an object as a function of time. Then $s'(t) = v(t)$ represents the velocity (the rate of change of position) of the object. Furthermore, $v(t)$ represents the instantaneous velocity at time t .

Adding the displacements for all time increments gives the approximate change in position over the entire time interval. In the limit of small time increments, the exact total displacement (or movement) is found: $\int s'(t)dt = s(t) - s(0)$



Synopsis

Calculus 2, focusing on integral calculus, is the gateway to higher level mathematics of which the best degrees and careers are built upon. The core essentials can be used along with your text and lectures, as a review before testing, or as a memory companion that keeps key answers always at your fingertips. Suggested uses: - Quick Reference - instead of digging into the textbook to find a core answer you need while studying, use the guide to reinforce quickly and repeatedly - Memory - refreshing your memory repeatedly is a foundation of studying, have the core answers handy so you can focus on understanding the concepts - Test Prep - no student should be cramming, but if you are, there is no better tool for that final review

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Just as described, purchased for my son the engineering student. It makes my stomach lurch when I look at it, though. I am math averse. Perhaps if I had this helper in my formative years I would not have a visceral, physical revulsion of numbers and equations? How would my life have been improved , and by what magnitude, by obtaining this miraculous helper in my youth? the world will never know. Parents, caregivers, anyone who cares about today's youth --- buy these products and save the youth of tomorrow.

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