

COLLEGE ALGEBRA COLLEGE ALGEBRA MATH TANGENT

NAVIGATING THE TANGENT IN COLLEGE ALGEBRA: A COMPREHENSIVE EXPLORATION

COLLEGE ALGEBRA COLLEGE ALGEBRA MATH TANGENT INTRODUCES A CONCEPT FUNDAMENTAL TO UNDERSTANDING CURVES, SLOPES, AND RATES OF CHANGE WITHIN THE BROADER LANDSCAPE OF MATHEMATICS. THIS ARTICLE DELVES DEEP INTO THE MEANING, CALCULATION, AND SIGNIFICANCE OF TANGENT LINES AS ENCOUNTERED IN COLLEGE ALGEBRA COURSES. WE WILL EXPLORE ITS RELATIONSHIP WITH DERIVATIVES, ITS GEOMETRIC INTERPRETATIONS, AND ITS PRACTICAL APPLICATIONS, PROVIDING A THOROUGH AND ACCESSIBLE GUIDE FOR STUDENTS AND ENTHUSIASTS ALIKE. FROM DEFINING THE TANGENT LINE TO UNDERSTANDING ITS CRITICAL ROLE IN CALCULUS, THIS EXPLORATION AIMS TO DEMYSTIFY THIS ESSENTIAL MATHEMATICAL TOOL.

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UNDERSTANDING THE TANGENT LINE IN COLLEGE ALGEBRA

IN THE REALM OF COLLEGE ALGEBRA, THE TANGENT LINE REPRESENTS A STRAIGHT LINE THAT "JUST TOUCHES" A CURVE AT A SINGLE POINT. THIS POINT IS KNOWN AS THE POINT OF TANGENCY. IT'S CRUCIAL TO DISTINGUISH THIS FROM A SECANT LINE, WHICH INTERSECTS A CURVE AT TWO OR MORE DISTINCT POINTS. THE ESSENCE OF A TANGENT LINE LIES IN ITS LOCAL APPROXIMATION OF A CURVE'S BEHAVIOR. AT THE POINT OF TANGENCY, THE TANGENT LINE SHARES THE SAME DIRECTION AS THE CURVE. THIS FUNDAMENTAL CONCEPT LAYS THE GROUNDWORK FOR UNDERSTANDING MORE COMPLEX CALCULUS PRINCIPLES.

THE ALGEBRAIC DEFINITION OF A TANGENT LINE INVOLVES FINDING THE LIMIT OF SECANT LINES. IMAGINE DRAWING A SERIES OF SECANT LINES THROUGH A POINT ON A CURVE AND ANOTHER POINT THAT IS PROGRESSIVELY CLOSER TO THE FIRST. AS THE SECOND POINT APPROACHES THE FIRST, THE SLOPE OF THESE SECANT LINES CONVERGES TO A SPECIFIC VALUE. THIS LIMITING VALUE IS PRECISELY THE SLOPE OF THE TANGENT LINE AT THAT POINT. THIS ITERATIVE PROCESS HIGHLIGHTS THE ALGEBRAIC MANIPULATION AND CONCEPTUAL UNDERSTANDING REQUIRED IN COLLEGE ALGEBRA WHEN DEALING WITH CURVES AND THEIR INSTANTANEOUS RATES OF CHANGE.

DEFINING THE TANGENT LINE CONCEPTUALLY

CONCEPTUALLY, A TANGENT LINE CAN BE VISUALIZED AS THE "BEST LINEAR APPROXIMATION" OF A FUNCTION AT A GIVEN POINT. IF YOU ZOOM IN INFINITELY CLOSE TO A POINT ON A SMOOTH CURVE, THE CURVE BEGINS TO RESEMBLE A STRAIGHT LINE. THIS IMAGINARY STRAIGHT LINE IS THE TANGENT LINE. IT CAPTURES THE IMMEDIATE DIRECTION AND STEEPNESS OF THE CURVE AT THAT EXACT LOCATION. THIS INTUITIVE UNDERSTANDING IS VITAL FOR GRASPING WHY TANGENT LINES ARE SO IMPORTANT IN DESCRIBING LOCAL BEHAVIOR.

DISTINGUISHING TANGENT FROM SECANT LINES

THE DISTINCTION BETWEEN TANGENT AND SECANT LINES IS FUNDAMENTAL. A SECANT LINE CUTS THROUGH A CURVE AT TWO OR MORE POINTS, PROVIDING AN AVERAGE RATE OF CHANGE BETWEEN THOSE POINTS. FOR EXAMPLE, IF WE HAVE A FUNCTION $f(x)$ AND TWO POINTS $(a, f(a))$ AND $(b, f(b))$ ON ITS GRAPH, THE SECANT LINE CONNECTING THEM HAS A SLOPE OF $(f(b) - f(a)) / (b - a)$. A TANGENT LINE, ON THE OTHER HAND, TOUCHES THE CURVE AT A SINGLE POINT, REPRESENTING THE INSTANTANEOUS RATE OF CHANGE AT THAT SPECIFIC POINT. THIS DIFFERENCE IS CENTRAL TO THE DEVELOPMENT OF CALCULUS FROM ALGEBRA.

THE GEOMETRIC INTERPRETATION OF TANGENT LINES

GEOMETRICALLY, THE TANGENT LINE OFFERS A POWERFUL VISUAL REPRESENTATION OF A CURVE'S BEHAVIOR. IT ILLUSTRATES THE INSTANTANEOUS DIRECTION OF THE CURVE AT A PARTICULAR POINT. THINK OF DRIVING A CAR: IF YOU WERE TO ABRUPTLY STOP PRESSING THE ACCELERATOR AND TURN THE STEERING WHEEL IN A SPECIFIC DIRECTION, THE TANGENT LINE REPRESENTS THE PATH YOUR CAR WOULD TAKE AT THAT PRECISE MOMENT IF IT CONTINUED IN A STRAIGHT LINE WITHOUT FURTHER STEERING OR ACCELERATION. THIS GEOMETRIC INTERPRETATION MAKES THE ABSTRACT CONCEPT OF SLOPE MORE TANGIBLE.

FOR CIRCLES, THE TANGENT LINE HAS A SPECIFIC GEOMETRIC PROPERTY: IT IS ALWAYS PERPENDICULAR TO THE RADIUS DRAWN TO THE POINT OF TANGENCY. THIS PROPERTY, OFTEN EXPLORED IN GEOMETRY BEFORE COLLEGE ALGEBRA, IS A SPECIAL CASE THAT HINTS AT THE BROADER SIGNIFICANCE OF TANGENTS IN CURVE ANALYSIS. WHILE COLLEGE ALGEBRA FOCUSES ON THE ALGEBRAIC AND CALCULUS-BASED APPROACHES, REMEMBERING THIS GEOMETRIC AXIOM CAN AID IN CONCEPTUALIZING THE "TOUCHING" ASPECT OF TANGENCY.

VISUALIZING TANGENCY ON A GRAPH

WHEN GRAPHING FUNCTIONS IN COLLEGE ALGEBRA, UNDERSTANDING THE VISUAL ASPECT OF A TANGENT LINE IS KEY. FOR A SMOOTH FUNCTION, THE TANGENT LINE AT A POINT SHOULD APPEAR TO "HUG" THE CURVE CLOSELY IN THE IMMEDIATE VICINITY OF THAT POINT. IF THE LINE CUTS THROUGH THE CURVE NEAR THE POINT OF TANGENCY, IT IS LIKELY NOT THE TRUE TANGENT. VISUAL INSPECTION, THOUGH NOT A RIGOROUS PROOF, CAN BE A HELPFUL INITIAL STEP IN IDENTIFYING OR SKETCHING TANGENT LINES.

TANGENT LINES AND CURVE PROPERTIES

TANGENT LINES PROVIDE INSIGHTS INTO VARIOUS CURVE PROPERTIES. FOR INSTANCE, WHERE THE TANGENT LINE IS HORIZONTAL (HAS A SLOPE OF ZERO), THE FUNCTION IS MOMENTARILY NEITHER INCREASING NOR DECREASING. THIS OFTEN CORRESPONDS TO LOCAL MAXIMUM OR MINIMUM POINTS ON THE GRAPH, A CONCEPT CRUCIAL FOR OPTIMIZATION PROBLEMS INTRODUCED IN COLLEGE ALGEBRA AND FURTHER DEVELOPED IN CALCULUS. THE SIGN OF THE SLOPE OF THE TANGENT LINE ALSO INDICATES WHETHER THE FUNCTION IS INCREASING (POSITIVE SLOPE) OR DECREASING (NEGATIVE SLOPE) AT THAT POINT.

CALCULATING TANGENT LINES: ALGEBRAIC APPROACHES

CALCULATING THE EQUATION OF A TANGENT LINE IN COLLEGE ALGEBRA TYPICALLY INVOLVES FINDING THE SLOPE OF THE TANGENT AT A SPECIFIC POINT AND THEN USING THE POINT-SLOPE FORM OF A LINEAR EQUATION. THE CHALLENGE LIES IN DETERMINING THAT SLOPE ALGEBRAICALLY, ESPECIALLY FOR CURVES THAT ARE NOT SIMPLE LINEAR FUNCTIONS. THIS OFTEN REQUIRES PRE-CALCULUS TECHNIQUES OR AN INTRODUCTION TO THE CONCEPT OF LIMITS.

TO FIND THE SLOPE OF THE TANGENT AT A POINT (x_0, y_0) ON THE CURVE $y = f(x)$, WE CAN UTILIZE THE DIFFERENCE QUOTIENT. THIS INVOLVES CALCULATING THE SLOPE OF A SECANT LINE BETWEEN $(x_0, f(x_0))$ AND A NEARBY POINT $(x_0 + h, f(x_0 + h))$. THE DIFFERENCE QUOTIENT IS GIVEN BY $[f(x_0 + h) - f(x_0)] / h$. THE SLOPE OF THE TANGENT IS THEN FOUND BY TAKING THE LIMIT OF THIS EXPRESSION AS h APPROACHES ZERO. THIS ALGEBRAIC PROCESS IS THE PRECURSOR TO FORMAL DIFFERENTIATION.

USING THE DIFFERENCE QUOTIENT

THE DIFFERENCE QUOTIENT IS A CORNERSTONE FOR ALGEBRAICALLY APPROACHING TANGENT LINE SLOPES. FOR A FUNCTION $f(x)$, THE SLOPE OF THE SECANT LINE BETWEEN x AND $x + h$ IS GIVEN BY:

- $[f(x + h) - f(x)] / h$

THIS EXPRESSION REPRESENTS THE AVERAGE RATE OF CHANGE OVER THE INTERVAL OF WIDTH h . TO FIND THE INSTANTANEOUS RATE OF CHANGE, WHICH IS THE SLOPE OF THE TANGENT, WE MUST EVALUATE THE LIMIT OF THIS QUOTIENT AS h APPROACHES ZERO.

FINDING THE EQUATION OF THE TANGENT LINE

ONCE THE SLOPE OF THE TANGENT LINE, LET'S CALL IT ' m ', AT A POINT (x_0, y_0) IS DETERMINED, THE EQUATION OF THE TANGENT LINE CAN BE FOUND USING THE POINT-SLOPE FORM: $y - y_0 = m(x - x_0)$. THIS FORMULA IS A STANDARD TOOL IN ALGEBRA FOR CONSTRUCTING THE EQUATION OF A LINE WHEN A POINT AND ITS SLOPE ARE KNOWN. THE PRIMARY ALGEBRAIC TASK IN FINDING A TANGENT LINE THUS BECOMES THE COMPUTATION OF ' m '.

THE TANGENT LINE AND THE DERIVATIVE: A CRUCIAL CONNECTION

THE MOST PROFOUND CONNECTION FOR COLLEGE ALGEBRA STUDENTS REGARDING TANGENT LINES IS THEIR DIRECT RELATIONSHIP WITH THE DERIVATIVE OF A FUNCTION. IN CALCULUS, THE DERIVATIVE OF A FUNCTION $f(x)$ AT A POINT x_0 , DENOTED $f'(x_0)$, IS PRECISELY THE SLOPE OF THE TANGENT LINE TO THE GRAPH OF $f(x)$ AT THAT POINT. THIS UNIFICATION OF ALGEBRAIC AND CALCULUS CONCEPTS IS A MAJOR LEAP IN MATHEMATICAL UNDERSTANDING.

THE DERIVATIVE IS FORMALLY DEFINED AS THE LIMIT OF THE DIFFERENCE QUOTIENT AS h APPROACHES ZERO: $f'(x) = \lim_{h \rightarrow 0} \frac{f(x + h) - f(x)}{h}$. THIS DEFINITION EXPLICITLY SHOWS THAT THE DERIVATIVE IS THE INSTANTANEOUS RATE OF CHANGE, WHICH, GEOMETRICALLY, IS THE SLOPE OF THE TANGENT LINE. UNDERSTANDING THIS RELATIONSHIP TRANSFORMS THE GEOMETRIC CONCEPT OF A TANGENT LINE INTO A POWERFUL ANALYTICAL TOOL FOR UNDERSTANDING FUNCTION BEHAVIOR.

THE DERIVATIVE AS THE SLOPE OF THE TANGENT

THE FORMAL DEFINITION OF THE DERIVATIVE ENCAPSULATES THE CONCEPT OF THE TANGENT LINE'S SLOPE. WHEN WE LEARN ABOUT DERIVATIVES IN COLLEGE ALGEBRA OR INTRODUCTORY CALCULUS, WE ARE ESSENTIALLY LEARNING A SYSTEMATIC WAY TO FIND THE SLOPE OF THE TANGENT LINE FOR ANY DIFFERENTIABLE FUNCTION AT ANY GIVEN POINT. THIS ABILITY UNLOCKS THE DOOR TO ANALYZING RATES OF CHANGE ACROSS VARIOUS DISCIPLINES.

APPLICATIONS IN RATES OF CHANGE

THE DERIVATIVE, AND BY EXTENSION THE TANGENT LINE'S SLOPE, IS FUNDAMENTAL TO UNDERSTANDING RATES OF CHANGE IN THE REAL WORLD. WHETHER IT'S THE VELOCITY OF AN OBJECT (THE RATE OF CHANGE OF ITS POSITION), THE RATE OF GROWTH OF A POPULATION, OR THE RATE AT WHICH A COMPANY'S PROFIT CHANGES, THE DERIVATIVE PROVIDES THE PRECISE INSTANTANEOUS RATE. THE TANGENT LINE'S SLOPE AT A SPECIFIC MOMENT GIVES THE VALUE OF THIS RATE.

REAL-WORLD APPLICATIONS OF TANGENT LINES IN COLLEGE ALGEBRA

WHILE COLLEGE ALGEBRA MIGHT PRESENT TANGENT LINES IN A MORE THEORETICAL CONTEXT, THEIR APPLICATIONS EXTEND FAR BEYOND THE CLASSROOM. UNDERSTANDING TANGENT LINES IS FOUNDATIONAL FOR FIELDS THAT RELY ON ANALYZING DYNAMIC SYSTEMS AND INSTANTANEOUS CHANGES. THESE APPLICATIONS HIGHLIGHT THE PRACTICAL UTILITY OF MASTERING THIS ALGEBRAIC CONCEPT.

IN PHYSICS, THE SLOPE OF THE TANGENT LINE TO A POSITION-TIME GRAPH AT ANY GIVEN MOMENT REPRESENTS THE INSTANTANEOUS VELOCITY OF AN OBJECT. SIMILARLY, THE TANGENT TO A VELOCITY-TIME GRAPH GIVES THE INSTANTANEOUS ACCELERATION. IN ECONOMICS, TANGENT LINES CAN APPROXIMATE MARGINAL COST OR MARGINAL REVENUE AT A SPECIFIC PRODUCTION LEVEL, INDICATING THE IMMEDIATE IMPACT OF PRODUCING ONE MORE UNIT. ENGINEERING DISCIPLINES ALSO HEAVILY RELY ON TANGENT LINE ANALYSIS FOR UNDERSTANDING STRESS, STRAIN, AND MATERIAL BEHAVIOR.

PHYSICS AND VELOCITY CALCULATIONS

IN PHYSICS, THE POSITION OF AN OBJECT IS OFTEN DESCRIBED BY A FUNCTION OF TIME, $s(t)$. THE INSTANTANEOUS VELOCITY AT TIME t_0 IS THE SLOPE OF THE TANGENT LINE TO THE POSITION-TIME GRAPH AT t_0 . THIS CONCEPT IS CRUCIAL FOR UNDERSTANDING MOTION, FROM PROJECTILE TRAJECTORIES TO THE DYNAMICS OF CELESTIAL BODIES. COLLEGE ALGEBRA STUDENTS BEGIN TO GRASP THIS BY UNDERSTANDING THAT THE TANGENT LINE CAPTURES THE "SPEED AND DIRECTION" AT AN INSTANT.

ECONOMICS AND MARGINAL ANALYSIS

IN ECONOMICS, UNDERSTANDING MARGINAL CHANGES IS VITAL. FOR A COST FUNCTION $C(x)$, WHERE x IS THE NUMBER OF UNITS PRODUCED, THE MARGINAL COST AT x_0 IS THE SLOPE OF THE TANGENT LINE TO THE COST CURVE AT x_0 . THIS REPRESENTS THE APPROXIMATE COST OF PRODUCING ONE ADDITIONAL UNIT. COLLEGE ALGEBRA INTRODUCES THE ALGEBRAIC TOOLS TO APPROXIMATE THESE CONCEPTS, PAVING THE WAY FOR MORE SOPHISTICATED ECONOMIC MODELING.

ADVANCED CONCEPTS AND FURTHER EXPLORATION

AS STUDENTS PROGRESS BEYOND INTRODUCTORY COLLEGE ALGEBRA, THE CONCEPT OF THE TANGENT LINE BECOMES EVEN MORE NUANCED AND POWERFUL. UNDERSTANDING DIFFERENT TYPES OF CURVES, INCLUDING THOSE WITH SHARP CORNERS OR VERTICAL TANGENTS, INTRODUCES FURTHER COMPLEXITIES AND DEEPER MATHEMATICAL INSIGHTS. THE ABILITY TO WORK WITH THESE MORE CHALLENGING SCENARIOS BUILDS A ROBUST MATHEMATICAL FOUNDATION.

FOR CURVES THAT ARE NOT "SMOOTH" EVERYWHERE, THE TANGENT LINE MIGHT NOT BE WELL-DEFINED AT CERTAIN POINTS. FOR INSTANCE, AT A SHARP CORNER, A UNIQUE TANGENT LINE DOES NOT EXIST. SIMILARLY, AT POINTS WHERE THE CURVE BECOMES INFINITELY STEEP, WE ENCOUNTER VERTICAL TANGENT LINES, WHICH HAVE UNDEFINED SLOPES IN THE TRADITIONAL SENSE. EXPLORING THESE EXCEPTIONS FURTHER SOLIDIFIES THE UNDERSTANDING OF DIFFERENTIABILITY AND ITS RELATIONSHIP TO THE EXISTENCE OF A UNIQUE TANGENT LINE.

VERTICAL TANGENT LINES

A VERTICAL TANGENT LINE OCCURS WHEN THE SLOPE APPROACHES INFINITY AS h APPROACHES ZERO. THIS MEANS THE SECANT LINES ARE BECOMING INCREASINGLY STEEP. ALGEBRAICALLY, THIS OFTEN HAPPENS WHEN THE DENOMINATOR OF THE DIFFERENCE QUOTIENT APPROACHES ZERO FASTER THAN THE NUMERATOR. GEOMETRICALLY, IT INDICATES THAT THE CURVE IS MOMENTARILY GOING STRAIGHT UP OR DOWN AT THAT POINT. UNDERSTANDING THESE SITUATIONS REQUIRES CAREFUL ALGEBRAIC MANIPULATION AND AN APPRECIATION FOR LIMITS.

NON-DIFFERENTIABLE POINTS

NOT ALL FUNCTIONS ARE DIFFERENTIABLE AT EVERY POINT. POINTS WHERE A FUNCTION HAS A SHARP CORNER, A CUSP, OR A VERTICAL TANGENT ARE POINTS OF NON-DIFFERENTIABILITY. AT THESE POINTS, A UNIQUE TANGENT LINE DOES NOT EXIST.

COLLEGE ALGEBRA COURSES OFTEN INTRODUCE EXAMPLES OF SUCH FUNCTIONS TO ILLUSTRATE THE CONDITIONS UNDER WHICH A TANGENT LINE CAN BE UNIQUELY DEFINED, LINKING BACK TO THE FORMAL DEFINITIONS OF DERIVATIVES.

FAQ ABOUT COLLEGE ALGEBRA COLLEGE ALGEBRA MATH TANGENT

Q: WHAT IS THE PRIMARY DIFFERENCE BETWEEN A TANGENT LINE AND A SECANT LINE IN COLLEGE ALGEBRA?

A: IN COLLEGE ALGEBRA, A TANGENT LINE TOUCHES A CURVE AT A SINGLE POINT AND REPRESENTS THE INSTANTANEOUS RATE OF CHANGE AT THAT POINT. A SECANT LINE INTERSECTS A CURVE AT TWO OR MORE POINTS AND REPRESENTS THE AVERAGE RATE OF CHANGE BETWEEN THOSE POINTS.

Q: HOW DO YOU ALGEBRAICALLY FIND THE SLOPE OF A TANGENT LINE IN COLLEGE ALGEBRA?

A: ALGEBRAICALLY, THE SLOPE OF A TANGENT LINE IS FOUND BY TAKING THE LIMIT OF THE DIFFERENCE QUOTIENT AS THE INTERVAL BETWEEN TWO POINTS ON THE CURVE SHRINKS TO ZERO. THIS LIMIT IS THE FORMAL DEFINITION OF THE DERIVATIVE.

Q: WHAT IS THE POINT-SLOPE FORM OF A LINEAR EQUATION USED FOR IN FINDING TANGENT LINES?

A: THE POINT-SLOPE FORM, $y - y_0 = m(x - x_0)$, IS USED TO FIND THE EQUATION OF THE TANGENT LINE ONCE ITS SLOPE (m) AND THE POINT OF TANGENCY (x_0, y_0) ARE KNOWN. IT ALLOWS US TO CONSTRUCT THE LINE'S EQUATION USING THESE TWO PIECES OF INFORMATION.

Q: CAN A TANGENT LINE INTERSECT A CURVE AT MORE THAN ONE POINT?

A: WHILE A TANGENT LINE, BY DEFINITION, TOUCHES A CURVE AT A SINGLE POINT OF TANGENCY, IT IS POSSIBLE FOR THE TANGENT LINE TO INTERSECT THE CURVE AT OTHER POINTS FURTHER AWAY FROM THE POINT OF TANGENCY. HOWEVER, AT THE POINT OF TANGENCY ITSELF, IT TYPICALLY INTERSECTS AT ONLY ONE POINT.

Q: WHAT IS THE ROLE OF LIMITS IN UNDERSTANDING TANGENT LINES IN COLLEGE ALGEBRA?

A: LIMITS ARE FUNDAMENTAL TO UNDERSTANDING TANGENT LINES. THE SLOPE OF A TANGENT LINE IS DEFINED AS THE LIMIT OF THE SLOPES OF SECANT LINES AS THE TWO POINTS DEFINING THE SECANT LINE APPROACH EACH OTHER INFINITELY CLOSELY. THIS LIMIT PROCESS IS WHAT GIVES US THE INSTANTANEOUS RATE OF CHANGE.

Q: HOW DOES THE TANGENT LINE RELATE TO THE DERIVATIVE OF A FUNCTION?

A: THE DERIVATIVE OF A FUNCTION AT A SPECIFIC POINT IS PRECISELY THE SLOPE OF THE TANGENT LINE TO THE FUNCTION'S GRAPH AT THAT POINT. THIS RELATIONSHIP IS A CORE CONCEPT BRIDGING ALGEBRA AND CALCULUS.

Q: ARE THERE CASES IN COLLEGE ALGEBRA WHERE A TANGENT LINE DOES NOT EXIST?

A: YES, TANGENT LINES DO NOT EXIST AT POINTS WHERE A FUNCTION IS NOT DIFFERENTIABLE. THIS INCLUDES SHARP CORNERS, CUSPS, AND POINTS WHERE THE FUNCTION HAS A VERTICAL TANGENT, AS A UNIQUE INSTANTANEOUS RATE OF CHANGE CANNOT BE DETERMINED.

Q: HOW IS THE CONCEPT OF A TANGENT LINE APPLIED IN REAL-WORLD SCENARIOS DISCUSSED IN COLLEGE ALGEBRA?

A: IN COLLEGE ALGEBRA, TANGENT LINE CONCEPTS ARE OFTEN LINKED TO REAL-WORLD APPLICATIONS LIKE CALCULATING INSTANTANEOUS VELOCITY IN PHYSICS (THE SLOPE OF A POSITION-TIME GRAPH) OR APPROXIMATING MARGINAL COST IN ECONOMICS (THE SLOPE OF A COST FUNCTION).

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