GENERAL

application of derivatives problems with answers

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Application of Derivatives Problems with Answers

Derivatives lie at the heart of calculus, turning abstract mathematical concepts into powerful tools for solving real world challenges. Whether you're a student preparing for exams, an engineer designing a bridge, or a business analyst forecasting profits, understanding how to apply derivatives is essential. This guide delivers a wealth of practice problems paired with step by step solutions, covering the most common application areas. By working through these examples, you'll strengthen your intuition, master problem solving techniques, and build confidence for any calculus based task.

Why Focus on Application Problems?

Purely theoretical calculus can feel detached from everyday life. Application problems bridge that gap, demonstrating how derivatives model motion, growth, optimization, and change. They also sharpen analytical skills: you learn to translate a real world scenario into a mathematical expression, identify the relevant derivative, and interpret the result in context. Mastery of application problems is a key indicator of calculus proficiency and a prerequisite for advanced studies in physics, engineering, economics, and beyond.

Key Topics Covered in This Guide

- Optimization – finding maximum or minimum values for real world situations
- Related Rates – linking changing quantities in dynamic systems
- Curve Sketching – using first and second derivatives to describe graph shape
- Motion and Velocity – applying derivatives to describe speed, acceleration, and distance
- Economics and Profit – modeling revenue, cost, and profit functions
- Advanced Applications – exponential growth, logarithmic relationships, and more

Problem 1: Optimizing a Rectangle's Area

1. Problem Statement: A farmer wants to fence a rectangular field using 200 /m of fencing. What dimensions will maximize the area of the field?
2. Solution Steps:\\n \\n Let the length be L and width W.
3. The perimeter constraint: 2L + 2W = 200 !' W = 100 – L.
4. Area: A = L·W = L(100 – L) = 100L – L2.
5. Differentiate: A'' = 100 – 2L.
6. Set derivative to zero: 100 – 2L = 0 !' L = 50 /m.
7. Find width: W = 100 – 50 = 50 /m.
8. Second derivative: A'''' = –2 , confirming a maximum.

Problem 2: Related Rates – A Balloon Rising

1. Problem Statement: A helium balloon rises vertically at a rate of 3 /m/s. A 2 /m tall person watches the balloon from a distance of 10 /m away. How fast is the angle of elevation changing when the balloon is 15 /m above the ground?

2. Solution Steps:\\n \\n Let ;, &R F†R ævÆR öb VÆPvation, h the balloon’s height.
3. Using right triangle geometry: tan /;, Ò , ò à
4. Differentiate implicitly: sec2 /;‹vC¸/dt = (1/10)·dh/dt.
5. Plug in values: dh/dt = 3 /m/s, h = 15 /m !’ sec2 /;, Ò ² F ã" ó¸ = 1 + (15/10)2 = 1 + 2.25 = 3.25.
6. Compute d;,öGB Ò ƒ ó ›s2 ò 2ã#R Ò ã2 ò 2ã#R $, ã “#2 ÷ ad/s.

Problem 3: Curve Sketching – Analyzing a Cubic Function

1. Problem Statement: Sketch the graph of f(x) = x3 – 3x2 + 2, labeling intercepts, critical points, and inflection point.
2. Solution Steps:\\n \\n Intercepts: Set f(x)=0 !’ (x – 1)(x – 2)(x + 1) = 0 !’ x = –1, 1, 2. y intercept: f(0) = 2.
3. First derivative: f''(x) = 3x2 – 6x = 3x(x – 2). Critical points at x = 0 and x = 2.
4. Second derivative: f""(x) = 6x – 6 = 6(x – 1). Inflection point where f""(x)=0 !’ x = 1.
5. Classify critical points: f""(0) = –6 0 !’ local minimum at (2, 0).
6. Plot points and sketch the curve accordingly.

Problem 4: Motion – Projectile Trajectory

1. Problem Statement: A ball is thrown upward with an initial velocity of 20 /m/s from the top of a 50 /m high cliff. What is the maximum height above the ground the ball reaches, and how long does it take to hit the ground?
2. Solution Steps:\\n \\n Position function: s(t) = –5t2 + 20t + 50 (using g = 10 /m/s² for simplicity).
3. Velocity: v(t) = s''(t) = –10t + 20.
4. Set v(t) = 0 for maximum height: –10t + 20 = 0 !’ t = 2 /s.
5. Compute height: s(2) = –5(4) + 20(2) + 50 = –20 + 40 + 50 = 70 /m.
6. Time to hit ground: solve s(t) = 0 !’ –5t2 + 20t + 50 = 0 !’ t = 2 /s or t = 5 /s. The ball reaches the ground at t = 5 /s.

Problem 5: Economics – Maximizing Profit

1. Problem Statement: A company sells a product at a price of P(x) = 50 – 0.5x, where x is the quantity sold. The cost function is C(x) = 10x + 200. Find the quantity that maximizes profit and determine the maximum profit.
2. Solution Steps:\\n \\n Revenue: R(x) = P(x)·x = (50 – 0.5x)·x = 50x – 0.5x2.
3. Profit: < ‡,’ Ò "‡,’ b 2‡,’ Ò ƒS , b ãWƒ"' b ƒ , ² # ’ Ò C , b ãWƒ" b # à
4. First derivative: < rr‡,’ Ò C b ,à
5. Set to zero: 40 – x = 0 !’ x = 40 units.
6. Second derivative: < rrrr‡,’ Ò c
7. Compute maximum profit: < ƒC ’ Ò C ƒC ’ b ãRƒC “" b # Ò Ãc b ƒ b # Ò c à

Problem 6: Optimization – Minimizing Material for a Cylinder

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