

Differentiation Rules: math practice, College – download the PDF

22 problems graded by difficulty (★ easy, ★★ medium, ★★★ hard). Try first, without looking at the solutions!

1 Product rule on polynomials

★ ★ ★

Let $f(x) = (x^2 + 1)(x^3 - 2x)$. Use the product rule to find $f'(x)$, then check your answer by expanding first.

2 A first quotient

★ ★ ★

Let $g(x) = \frac{x}{x+3}$. Find $g'(x)$ and compute $g'(1)$.

3 Power of a linear function

★ ★ ★

Differentiate $h(x) = (4x - 7)^5$ and evaluate $h'(2)$.

4 Trigonometric sum

★ ★ ★

Let $y = 3 \sin x - 2 \cos x + \tan x$. Find y' and evaluate it at $x = 0$.

5 Exponentials and logarithms



Differentiate $f(x) = 5e^x - 4\ln x + 2^x$ for $x > 0$, and give $f'(1)$ as an exact value and to two decimal places.

6 Successive derivatives



For $f(x) = x^4 - 3x^3 + 2x$, find $f'(x)$, $f''(x)$, $f^{(3)}(x)$ and $f^{(4)}(x)$, then compute $f''(2)$.

7 Velocity and acceleration of a cart



A cart on a track has position $s(t) = t^3 - 6t^2 + 9t$ feet after t seconds. Find its velocity and acceleration at $t = 4$, and the times when it is momentarily at rest.

8 Product with a sine



Let $f(x) = x^2 \sin x$. Find $f'(x)$ and the exact value of $f'(\pi)$.

9 Where is the tangent horizontal?



Let $y = \frac{e^x}{x^2 + 1}$. Show that $y' = \frac{e^x(x-1)^2}{(x^2+1)^2}$ and find every point where the tangent line is horizontal.

10 Cosine of a quadratic



Differentiate $y = \cos(3x^2 + 1)$. Evaluate y' at $x = 0$ and at $x = 1$ (calculator, radians, two decimals).

11 Logarithm of a quadratic



Let $y = \ln(x^2 + 4x + 5)$. Explain why the function is defined for every real x , then find y' and the value of x where $y' = 0$.

12 Tangent line to an exponential product



Let $f(x) = x e^{-2x}$. (a) Find the equation of the tangent line at $x = 0$. (b) Find the point where the tangent line is horizontal.

13 Implicit slope of a tilted curve



The point $(2, 1)$ lies on the curve $x^2 + xy + y^2 = 7$. Verify this, then find $\frac{dy}{dx}$ and the tangent line at that point.

14 Derivatives of $x \ln x$



For $x > 0$ let $f(x) = x \ln x$. Find f' , f'' and $f^{(3)}$, then compute $f''(4)$ and $f^{(3)}(2)$.

15 Find the mistakes



A student wrote: (i) $\frac{d}{dx}(x^2 e^x) = 2x e^x$; (ii) $\frac{d}{dx} \sin(4x) = \cos(4x)$. Explain each error and give the correct derivatives.

16 A variable exponent



For $x > 0$ let $y = x^{\sin x}$. Use logarithmic differentiation to find y' , then compute $y'\left(\frac{\pi}{2}\right)$.

17 A long product and quotient

★★★

Let $y = \frac{(x^2 + 1)^3(2x - 1)^4}{(x + 5)^2}$ for $x > \frac{1}{2}$. Use logarithmic differentiation to write $\frac{y'}{y}$, then compute $y'(1)$.

18 Three layers

★★★

Let $y = \sqrt{\sin(x^2)}$. Find y' , and evaluate it at $x = \sqrt{\pi/6}$.

19 Second derivative of a circle

★★★

For the circle $x^2 + y^2 = 25$, we know $y' = -\frac{x}{y}$. Differentiate again to show that $y'' = -\frac{25}{y^3}$, then evaluate at $(3, 4)$ and say what it tells you about the concavity.

20 Inflating balloon

★★★

A spherical balloon has volume $V = \frac{4}{3}\pi r^3$ cubic inches. Its radius grows at **0.5** inch per second. How fast is the volume growing when $r = 6$ inches? (One inch is 2.54 cm.)

21 Proving the tangent rule

★★★

Use the quotient rule on $\tan x = \frac{\sin x}{\cos x}$ to prove that $\frac{d}{dx} \tan x = \sec^2 x$.

22 Product of three functions

★★★

Let $y = x e^x \sin x$. Extend the product rule to three factors, find y' , and evaluate it at $x = \frac{\pi}{2}$.



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