いろいろな関数の微分

2023.06.26

復習

導関数の定義式

a における微分係数

$$f'(a) = \lim_{z o a} rac{f(z)-f(a)}{z-a}$$

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a を x で置き換える

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aをxで置き換える

$$f'(x) = \lim_{z o x} rac{f(z)-f(x)}{z-x}$$

$$ullet f'(x) = \lim_{z o x} rac{f(z)-f(x)}{z-x}$$

$$\bullet \ f'(x) = \lim_{z \to x} \frac{f(z) - f(x)}{z - x}$$

- $\bullet z x = \Delta x$ とおく(x の変化量でデルタx と読む)
- ullet $f(z)-f(x)=\Delta y$ とおく(y の変化量)
- $z \rightarrow x \,$ \$\tag{5} \quad \Delta x \rightarrow 0

$$ullet f'(x) = \lim_{z o x} rac{f(z)-f(x)}{z-x} = \lim_{\Delta x o 0} rac{\Delta y}{\Delta x}$$

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- $z \rightarrow x \, \ \ \ \ \ \Delta x \rightarrow 0$

$$oldsymbol{\circ} z = x + \Delta x$$
 より $f'(x) = \lim_{\Delta x o 0} rac{f(x + \Delta x) - f(x)}{\Delta x}$ (教科書)

x^3 の微分

$$\bullet \ f(x) = x^3$$

$$ullet f(x) = x^3 \ ullet f'(x) = \lim_{z o x} rac{z^3-x^3}{z-x}$$

(1)

x^3 の微分

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$$z^3 - x^3 = (z - x)(z^2 + zx + x^2)$$

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x^3 の微分

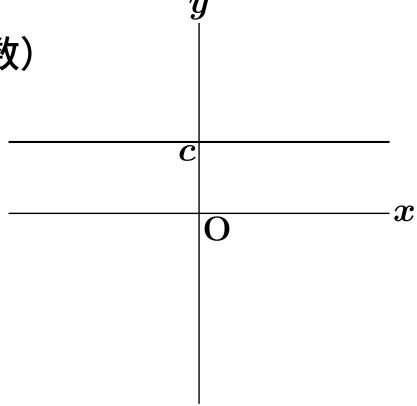
$$ullet f(x) = x^3$$

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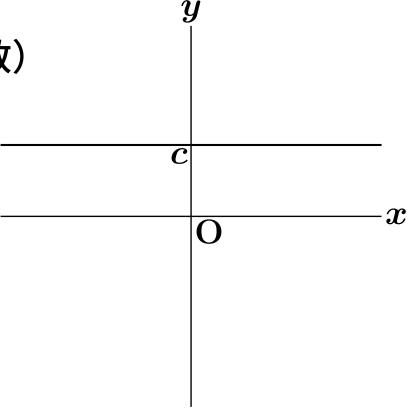
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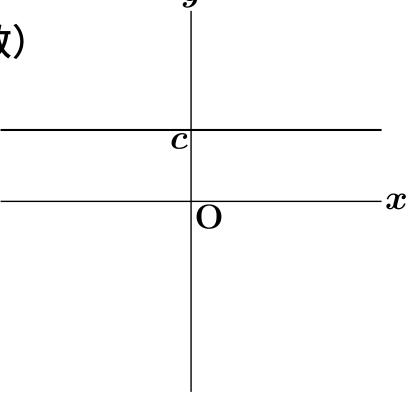
• 定数関数f(x)=c(cは定数)(c)'=0



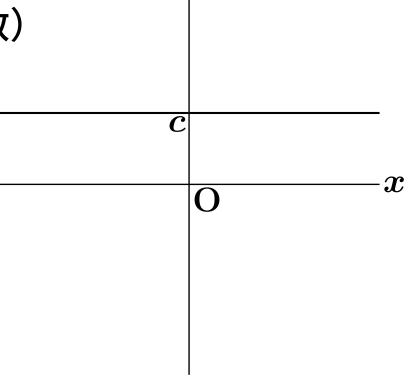
- 定数関数 f(x) = c (cは定数) (c)' = 0
- ullet f(x) = x $(x)' = \lim_{z o x} rac{z-x}{z-x} = 1$



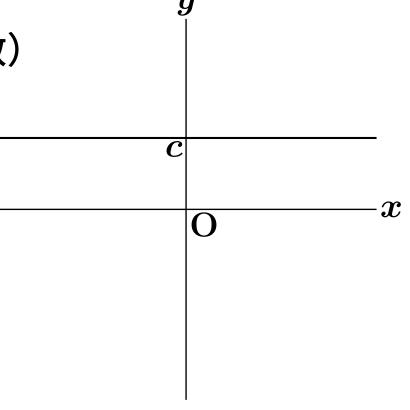
- 定数関数 f(x) = c (cは定数) (c)' = 0
- $ullet f(x) = x \ (x)' = \lim_{z o x} rac{z-x}{z-x} = 1$
- $\bullet \ (x^2)' = 2x$



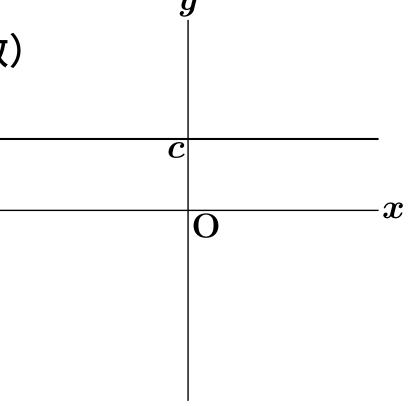
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微分の性質 (和と定数倍)

f(x), g(x) と定数 c について

$$\bullet (f+g)' = f'+g', (f-g)' = f'-g'$$

$$\bullet \ (cf)' = cf'$$

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例)
$$(x^2+3x+4)'=(x^2)'+(3x)'+(4)'=2x+3$$

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例)
$$(x^2+3x+4)'=(x^2)'+(3x)'+(4)'=2x+3$$

課題 0626-1 微分せよ

[1]
$$y = 2x^2 - 3x + 2$$

[2]
$$y = \frac{1}{3}x^3 - \frac{1}{2}x^2 + 2x + 1$$

• 関数 y=f(x) を変数 x で微分する $y',\ f'(x),\ f',\ \left(f(x)\right)'$ (ラグランジュ)

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例) $y = f(x) = x^3$

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例)
$$y=f(x)=x^3$$
 $y'=f'(x)=f'=\left(x^3\right)'=3x^2$ $rac{dy}{dx}=rac{df}{dx}=rac{d}{dx}f(x)=rac{d}{dx}(x^3)=3x^2$

積と商の微分・記法

$$ullet$$
 $|(fg)'=f'g+fg'|$ 積の微分公式

● | (fg)' = f'g + fg' | 積の微分公式

$$\left(f(x)g(x)
ight)' = \lim_{z o x} rac{f(z)g(z) - f(x)g(x)}{z-x}$$

$$ullet$$
 $(fg)'=f'g+fg'$ 積の微分公式

$$egin{aligned} ig(f(x)g(x)ig)' &= \lim_{z o x} rac{f(z)g(z)-f(x)g(x)}{z-x} \ &= \lim_{z o x} rac{ig(f(z)-f(x)ig)g(z)+f(x)ig(g(z)-g(x)ig)}{z-x} \ &= \lim_{z o x} igg(rac{f(z)-f(x)}{z-x}g(z)+f(x)rac{g(z)-g(x)}{z-x}igg) \end{aligned}$$

$$egin{aligned} ig(f(x)g(x)ig)' &= \lim_{z o x} rac{f(z)g(z) - f(x)g(x)}{z - x} \ &= \lim_{z o x} rac{ig(f(z) - f(x)ig)g(z) + f(x)ig(g(z) - g(x)ig)}{z - x} \ &= \lim_{z o x} igg(rac{f(z) - f(x)}{z - x}g(z) + f(x)rac{g(z) - g(x)}{z - x}igg) \ &= f'(x)g(x) + f(x)g'(x) \end{aligned}$$

例
$$y' = \left((x+1)(x^2+2x+3)\right)'$$

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= $(x+1)'(x^2+2x+3)+(x+1)(x^2+2x+3)'$

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 $= (x^2+2x+3)+(x+1)(2x+2)$
 $= 3x^2+6x+5$

積の微分の例

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課題 0626-2 積の微分公式で微分せよ.

[1]
$$y = (x+1)(x+3)$$
 [2] $y = x^2(x+2)$

$$ullet \left(rac{f}{g}
ight)' = rac{f'g - fg'}{g^2}$$
 商の微分公式

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例
$$(1)$$
 $\left(\frac{2x+1}{3x+1}\right)'$

$$ullet \left(rac{f}{g}
ight)' = rac{f'\,g - f\,g'}{g^2}$$
 商の微分公式

例
$$(1)$$
 $\left(\frac{2x+1}{3x+1}\right)' = \frac{(2x+1)'(3x+1) - (2x+1)(3x+1)'}{(3x+1)^2}$

$$ullet$$
 $\left(rac{f}{g}
ight)' = rac{f'\,g - f\,g'}{g^2}$ 商の微分公式

例
$$(1)$$
 $\left(\frac{2x+1}{3x+1}\right)' = \frac{(2x+1)'(3x+1) - (2x+1)(3x+1)'}{(3x+1)^2}$ $= \frac{2(3x+1) - 3(2x+1)}{(3x+1)^2}$

$$ullet$$
 $\left|\left(rac{f}{g}
ight)' = rac{f'\,g - f\,g'}{g^2}
ight|$ 商の微分公式

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 $\left(\frac{2x+1}{3x+1}\right)' = \frac{(2x+1)'(3x+1) - (2x+1)(3x+1)'}{(3x+1)^2}$ $= \frac{2(3x+1) - 3(2x+1)}{(3x+1)^2} = \frac{-1}{(3x+1)^2}$

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 $\left(rac{f}{g}
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例 (1)
$$\left(\frac{2x+1}{3x+1}\right)' = \frac{(2x+1)'(3x+1) - (2x+1)(3x+1)'}{(3x+1)^2}$$

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例
$$(2)$$
 $\left(\frac{1}{x}\right)'$

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 $\left(rac{f}{g}
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例
$$(2)$$
 $\left(\frac{1}{x}\right)' = \frac{(1)'(x) - 1(x)'}{x^2}$

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 $\left(rac{f}{g}
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例
$$(2)$$
 $\left(\frac{1}{x}\right)' = \frac{(1)'(x) - 1(x)'}{x^2} = \frac{0-1}{x^2}$

$$ullet$$
 $\left(rac{f}{g}
ight)' = rac{f'\,g - f\,g'}{g^2}$ 商の微分公式

例 (1)
$$\left(\frac{2x+1}{3x+1}\right)' = \frac{(2x+1)'(3x+1) - (2x+1)(3x+1)'}{(3x+1)^2}$$

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The (1) $\frac{(1)'(x) - 1(x)'}{(3x+1)^2} = \frac{1}{(3x+1)^2}$

例
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課題 0626-3 次を微分せよ.

[1]
$$y = \frac{x}{x+1}$$
 [2] $y = \frac{1}{x^2}$

• 関数 y = f(x) を変数 x で微分する y', f'(x)(ラグランジュ)

• 関数 y = f(x) を変数 x で微分する y', f'(x)(ラグランジュ) $\frac{dy}{dx}$ (ライプニッツ)

• 関数 y = f(x) を変数 x で微分する $y', \ f'(x)$ (ラグランジュ) $\lim_{z \to x} \frac{f(z) - f(x)}{z - x}$

• 関数 y = f(x) を変数 x で微分する $y', \ f'(x)$ (ラグランジュ) $\frac{dy}{dx}$ (ライプニッツ) $\frac{\lim_{z \to x} \frac{f(z) - f(x)}{z - x}}{-\frac{\Delta y}{z - x}}$

 $z
ightharpoonup \bar{x}$ Δx

• 関数 y=f(x) を変数 x で微分する $y',\ f'(x)$ (ラグランジュ) $\lim_{z\to x} \frac{f(z)-f(x)}{z-x}$ 例) $y=f(x)=x^3$ $=\lim_{z\to x} \frac{\Delta y}{\Delta x}$

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ullet 関数 y=f(x) を変数 x で微分する y', f'(x) (ラグランジュ) $rac{dy}{dx}$ (ライプニッツ) $\lim_{z o x}rac{f(z)-f(x)}{z-x}$ 例) $y = f(x) = x^3$ $y' = f'(x) = f' = (x^3)' = 3x^2$ $rac{dy}{dx} = rac{df}{dx} = rac{d}{dx}f(x) = rac{d}{dx}(x^3) = 3x^2$

べき関数の微分

ullet n が正の整数のとき $|(x^n)'=nx^{n-1}|$

$$(x^n)' = nx^{n-1}$$

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• 分数乗

$$(x^{\frac{1}{2}})'=(\sqrt{x})'$$

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• 分数乗

$$(x^{rac{1}{2}})'=(\sqrt{x})'=\lim_{z o x}rac{\sqrt{z}-\sqrt{x}}{z-x}$$
 $\sqrt{z}=w,\sqrt{x}=u$ とおくと $z=w^2,x=u^2$

ullet n が正の整数のとき $|(x^n)' = nx^{n-1}|$

$$(x^n)' = nx^{n-1}$$

$$(x^{rac{1}{2}})' = (\sqrt{x})' = \lim_{z o x} rac{\sqrt{z} - \sqrt{x}}{z - x} = \lim_{w o u} rac{w - u}{w^2 - u^2}$$
 $\sqrt{z} = w, \sqrt{x} = u$ とおくと $z = w^2, x = u^2$

x^p の微分 |

ullet n が正の整数のとき $|(x^n)' = nx^{n-1}|$

$$\left|(x^n)'=nx^{n-1}
ight|$$

$$(x^{\frac{1}{2}})' = (\sqrt{x})' = \lim_{z \to x} \frac{\sqrt{z} - \sqrt{x}}{z - x} = \lim_{w \to u} \frac{w - u}{w^2 - u^2}$$
 $\sqrt{z} = w, \sqrt{x} = u$ とおくと $z = w^2, x = u^2$
 $= \lim_{w \to u} \frac{1}{w + u}$

ullet n が正の整数のとき $|(x^n)' = nx^{n-1}|$

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 $\sqrt{z} = w, \sqrt{x} = u$ とおくと $z = w^2, x = u^2$ $= \lim_{w o u} rac{1}{w + u} = rac{1}{2u}$

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ullet n が正の整数のとき $|(x^n)' = nx^{n-1}|$

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otag \ z = w^2, x = u^2 \ = \lim_{w o u} rac{1}{w + u} = rac{1}{2u} = rac{1}{2\sqrt{x}} = rac{1}{2}x^{-rac{1}{2}}$$

ullet n が正の整数のとき $|(x^n)' = nx^{n-1}|$

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分数乗

$$(x^{rac{1}{2}})' = (\sqrt{x})' = \lim_{z o x} rac{\sqrt{z} - \sqrt{x}}{z - x} = \lim_{w o u} rac{w - u}{w^2 - u^2} \ orall_{z = w, \sqrt{x} = u} ag{5} < z = v^2, x = u^2 \ = \lim_{w o u} rac{1}{w + u} = rac{1}{2u} = rac{1}{2\sqrt{x}} = rac{1}{2}x^{-rac{1}{2}}$$

課題 0626-4 $y=x^{rac{3}{2}}=x\sqrt{x}$ を微分せよ.

$$ullet$$
 $(x^p)'=$

$$ullet (x^p)' = ig| px^{p-1}$$

- $ullet (x^p)' = px^{p-1}$
- マイナス乗も同じ $(\frac{1}{x})'$

- $ullet (x^p)' = \boxed{px^{p-1}}$
- マイナス乗も同じ $(rac{1}{x})'=(x^{-1})'$

- $ullet (x^p)' = \boxed{px^{p-1}}$
- ullet マイナス乗も同じ $(rac{1}{x})' = (x^{-1})' = -x^{-2}$

$$ullet (x^p)' = \boxed{px^{p-1}}$$

• マイナス乗も同じ $(\frac{1}{x})' = (x^{-1})' = -x^{-2} = -\frac{1}{x^2}$

$$ullet (x^p)' = igg| px^{p-1}$$

• マイナス乗も同じ

$$(\frac{1}{x})' = (x^{-1})' = -x^{-2} = -\frac{1}{x^2}$$

課題 0626-5 次の関数を微分せよ.

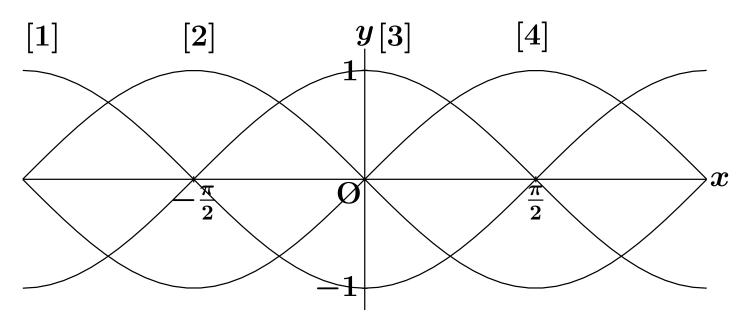
$$[1] \,\,\, y \,\,=\,\, x^{rac{1}{4}}$$

$$[2] y = x^{-2}$$

$$[1] \,\, y \, = \, x^{rac{1}{4}} \qquad \qquad [2] \,\, y \, = \, x^{-2} \qquad \qquad [3] \,\, y \, = \, x^{-rac{1}{2}} \, .$$

三角関数の微分

三角関数のグラフ



課題 0626-6 上の図は

 $y=\sin x, y=\cos x, y=-\sin x, y=-\cos x$ のグラフである. [1]-[4] の関数を答えよ.

$\sin x,\cos x$ の微分

課題 0626-7 「導関数の意味」を用いて導関数を求めよ.

$$[1] \,\, y = \sin x$$

$$[1] y = \sin x \qquad [2] y = \cos x$$

$\sin x,\cos x$ の微分

課題 0626-7 「導関数の意味」を用いて導関数を求めよ.

$$[1] y = \sin x$$

$$[2] y = \cos x$$

• 微分公式

$$(\sin x)' = \cos x, \ (\cos x)' = -\sin x$$

$\sin x,\cos x$ の微分

課題 0626-7 「導関数の意味」を用いて導関数を求めよ.

$$[1] y = \sin x$$

$$[2] y = \cos x$$

• 微分公式

$$(\sin x)' = \cos x, \ (\cos x)' = -\sin x$$

課題 0626-8 次の問いに答えよ

[1] $y = \sin x$ の (0, 0) における接線の傾きを求めよ

$$[2]$$
 $y=2\sin x-3\cos x$ を微分せよ

tan x の微分

$$\bullet \left| (\tan x)' = \frac{1}{\cos^2 x} \right|$$

$$\tan x = \frac{\sin x}{\cos x}$$
$$\cos^2 x = (\cos x)^2$$

tan x の微分

$$\bullet \left| (\tan x)' = \frac{1}{\cos^2 x} \right|$$

$$(\tan x)' = (\frac{\sin x}{\cos x})'$$

$$\tan x = \frac{\sin x}{\cos x}$$

$$\cos^2 x = (\cos x)^2$$

an x の微分

$$\begin{array}{ll}
\bullet & \left| (\tan x)' = \frac{1}{\cos^2 x} \right| & \tan x = \frac{\sin x}{\cos x} \\
(\tan x)' = \left(\frac{\sin x}{\cos x} \right)' & \cos^2 x = (\cos x)^2 \\
& = \frac{(\sin x)'(\cos x) - (\sin x)(\cos x)'}{\cos^2 x}
\end{array}$$

tan x の微分

$$\begin{aligned}
\bullet & (\tan x)' = \frac{1}{\cos^2 x} & \tan x = \frac{\sin x}{\cos x} \\
(\tan x)' &= (\frac{\sin x}{\cos x})' \\
&= \frac{(\sin x)'(\cos x) - (\sin x)(\cos x)'}{\cos^2 x} \\
&= \frac{(\cos x \cos x) - \sin x(-\sin x)'}{\cos^2 x} \end{aligned}$$

tan x の微分

$$\bullet \left[(\tan x)' = \frac{1}{\cos^2 x} \right] \quad \tan x = \frac{\sin x}{\cos x}
(\tan x)' = \left(\frac{\sin x}{\cos x} \right)'
= \frac{(\sin x)'(\cos x) - (\sin x)(\cos x)'}{\cos^2 x}
= \frac{(\cos x \cos x) - \sin x(-\sin x)'}{\cos^2 x}
= \frac{\cos^2 x + \sin^2 x}{\cos^2 x} = \frac{1}{\cos^2 x}$$

課題

課題 0626-9 次の関数を微分せよ

- $[1] y = \sin x \cos x$
- $[2] y = \sin^2 x (= \sin x \sin x)$
- $[3] y = x \tan x$
- $[4] y = \tan x x$

$$y'=(\sin(ax+b))'=\lim_{z o x}rac{\sin(az+b)-\sin(ax+b)}{z-x}$$

$$y' = (\sin(ax+b))' = \lim_{z \to x} \frac{\sin(az+b) - \sin(ax+b)}{z - x}$$
 $ax + b = u, \ az + b = w$ とおくと
 $w - u = a(z - x), \ w \to u$

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 $ax + b = u, \ az + b = w$ とおくと
 $w - u = a(z - x), \ w \to u$
 $y' = \lim_{w \to u} \frac{\sin(w) - \sin(u)}{\frac{w - u}{z}} = a \lim_{w \to u} \frac{\sin(w) - \sin(u)}{w - u}$

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 $ax + b = u, \ az + b = w$ とおくと
 $w - u = a(z - x), \ w \to u$
 $y' = \lim_{w \to u} \frac{\sin(w) - \sin(u)}{\frac{w - u}{a}} = a \lim_{w \to u} \frac{\sin(w) - \sin(u)}{w - u}$
 $(\sin x)' = \lim_{z \to x} \frac{\sin z - \sin x}{z - x}$

$$y' = (\sin(ax+b))' = \lim_{z \to x} \frac{\sin(az+b) - \sin(ax+b)}{z - x}$$
 $ax + b = u, \ az + b = w$ とおくと
 $w - u = a(z - x), \ w \to u$

$$y' = \lim_{w \to u} \frac{\sin(w) - \sin(u)}{\frac{w - u}{a}} = a \lim_{w \to u} \frac{\sin(w) - \sin(u)}{w - u}$$
 $(\sin x)' = \lim_{z \to x} \frac{\sin z - \sin x}{z - x}$
 $= a \cos u = a \cos(ax + b)$

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 $= a \cos u = a \cos(ax+b)$

$$\sin(ax+b)' = a \cos(ax+b)$$

$$y' = (\sin(ax+b))' = \lim_{z \to x} \frac{\sin(az+b) - \sin(ax+b)}{z - x}$$
 $ax + b = u, \ az + b = w$ とおくと
 $w - u = a(z - x), \ w \to u$
 $y' = \lim_{w \to u} \frac{\sin(w) - \sin(u)}{\frac{w - u}{a}} = a \lim_{w \to u} \frac{\sin(w) - \sin(u)}{w - u}$
 $(\sin x)' = \lim_{z \to x} \frac{\sin z - \sin x}{z - x}$
 $= a \cos u = a \cos(ax + b)$

$$f(ax+b)$$
の微分

 $ullet \left| f(ax+b)' = af'(ax+b)
ight|$

$$f(ax+b)$$
の微分

•
$$f(ax+b)'=of'(ax+b)$$
1つの変数とみて微分

•
$$f(ax+b)'=of'(ax+b)$$
 1つの変数とみて微分

 $\bullet (\cos(3x+1))'$

•
$$f(ax+b)'=of'(ax+b)$$
 1つの変数とみて微分

•
$$(\cos(3x+1))' = 3(-\sin(3x+1))$$

•
$$f(ax+b)'=of'(ax+b)$$
 1つの変数とみて微分

•
$$(\cos(3x+1))' = 3(-\sin(3x+1)) = -3\sin(3x+1)$$

•
$$f(ax+b)'=of'(ax+b)$$
 1つの変数とみて微分

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$$(\cos(3x+1))' = 3(-\sin(3x+1)) = -3\sin(3x+1)$$

•
$$((2x+3)^5)'$$

•
$$f(ax+b)'=of'(ax+b)$$
 1つの変数とみて微分

•
$$(\cos(3x+1))' = 3(-\sin(3x+1)) = -3\sin(3x+1)$$

$$\bullet \ \left((2x+3)^5 \right)' = 2 \cdot 5(2x+3)^4$$

•
$$f(ax+b)'=of'(ax+b)$$
 1つの変数とみて微分

•
$$(\cos(3x+1))' = 3(-\sin(3x+1)) = -3\sin(3x+1)$$

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$$((2x+3)^5)' = 2 \cdot 5(2x+3)^4 = 10(2x+3)^4$$

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$$f(ax+b)'=of'(ax+b)$$
 1つの変数とみて微分

•
$$(\cos(3x+1))' = 3(-\sin(3x+1)) = -3\sin(3x+1)$$

•
$$((2x+3)^5)' = 2 \cdot 5(2x+3)^4 = 10(2x+3)^4$$

課題 0626-10 微分せよ

[1]
$$y = \sin 3x$$
 [2] $y = (5x+1)^3$
[3] $y = \sqrt{2x+3}$ [4] $y = \tan(-x+1)$