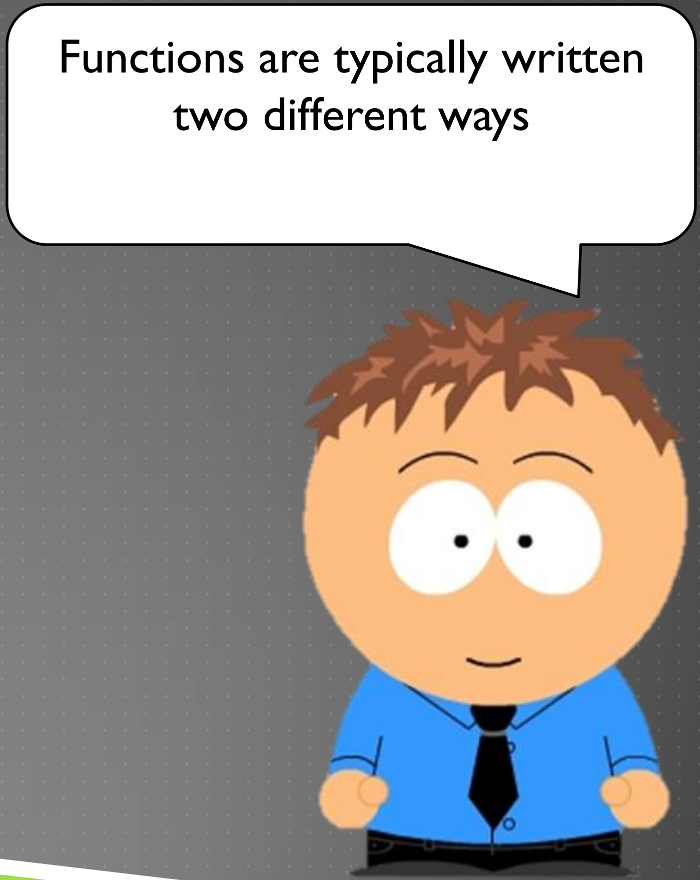
DIFFERENTIATION AND INTEGRATION PART 1

Mr C’s IB Standard Notes

In this PDF you can find the following:

NOTATION

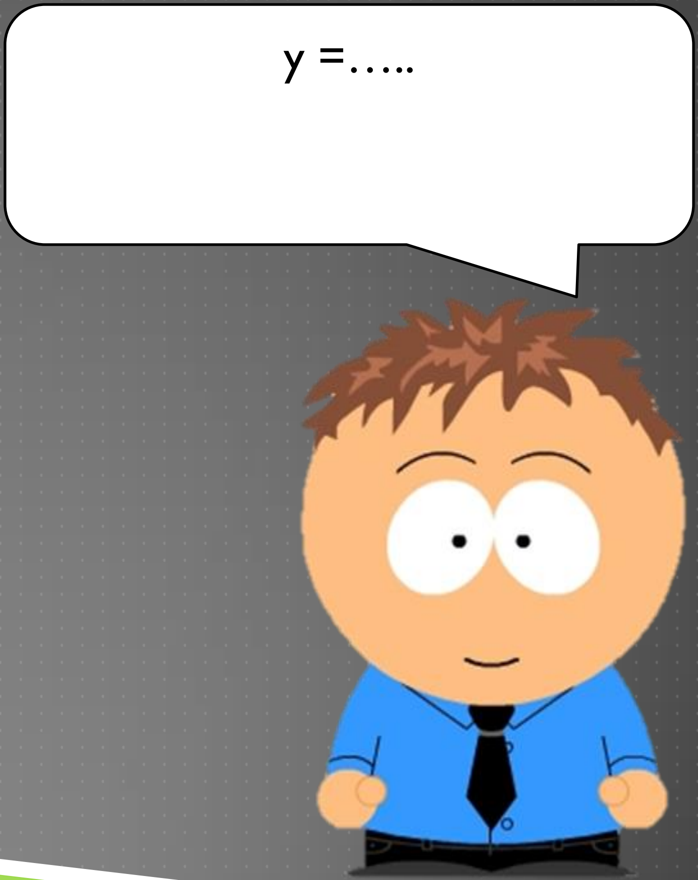
Writing derivatives and integrals



NOTATION

<u>Writing derivatives and integrals</u>

$y = e^{x} + \sin(2x) + \cdots$



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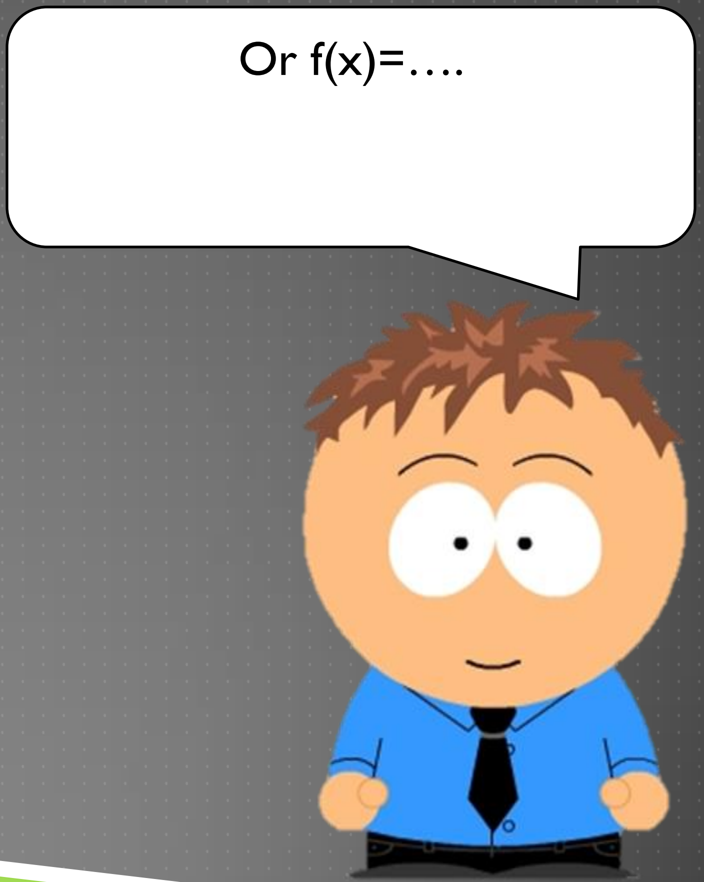
$y = e^x + \sin(2x) + \cdots$ $\quad$ $f(x) = e^x + \sin(2x) + \cdots$



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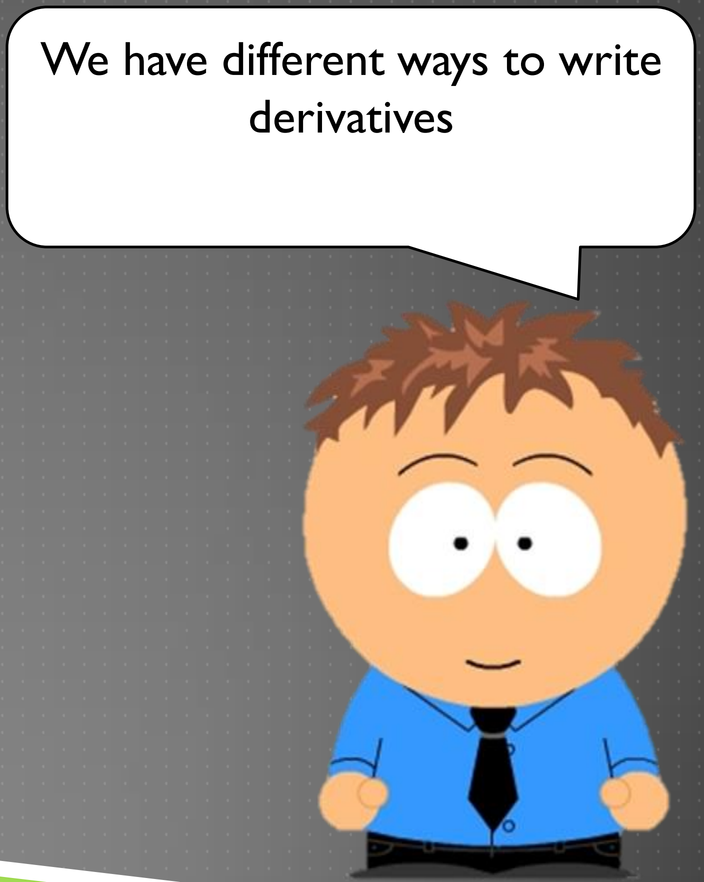

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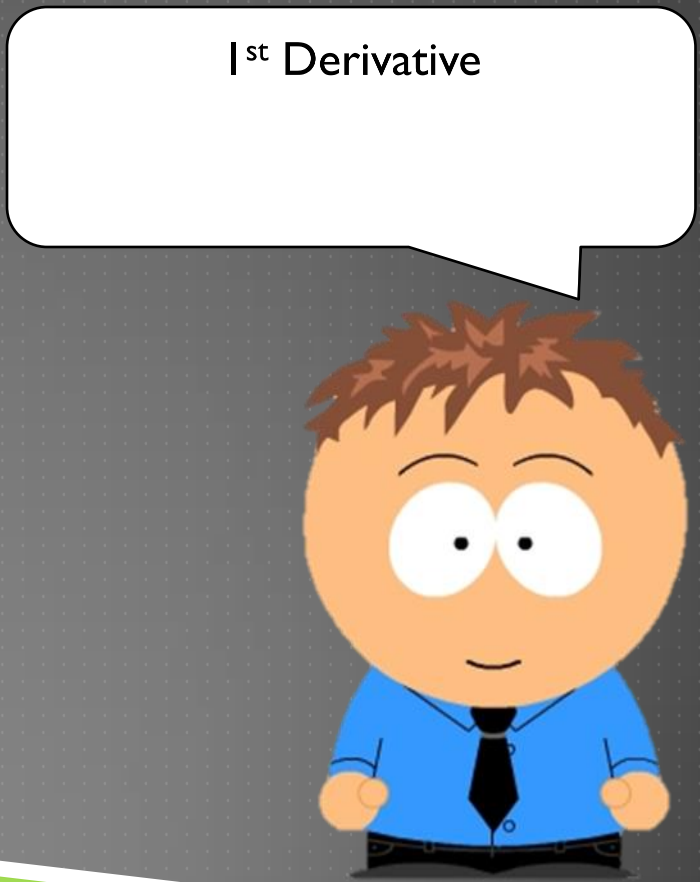

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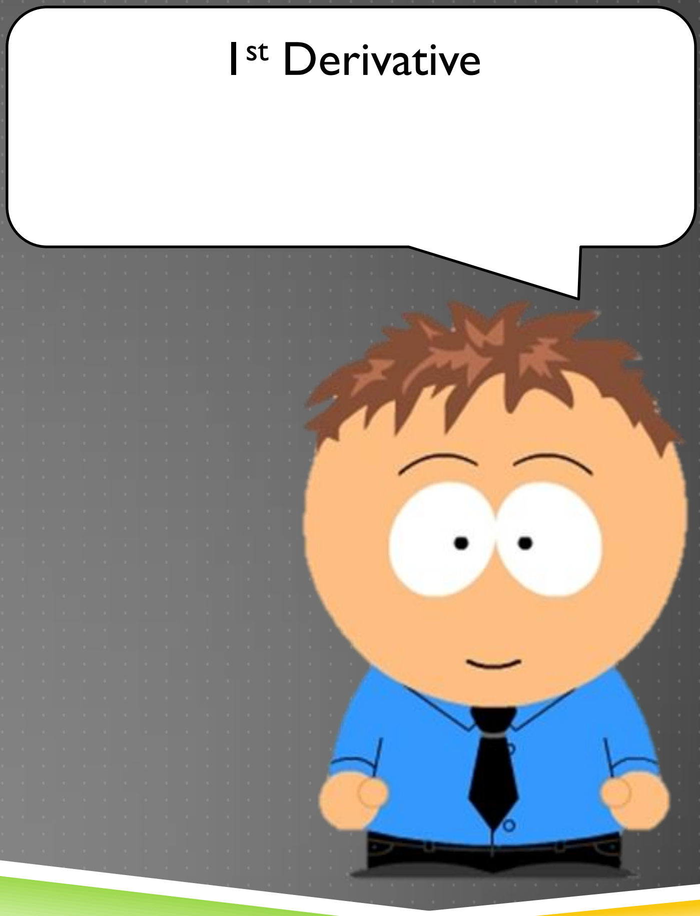
$$y = e^x + \sin(2x) + \cdots \qquad f(x) = e^x + \sin(2x) + \cdots$$

$$\frac{dy}{dx} = \cdots \qquad f'(x) = \cdots$$



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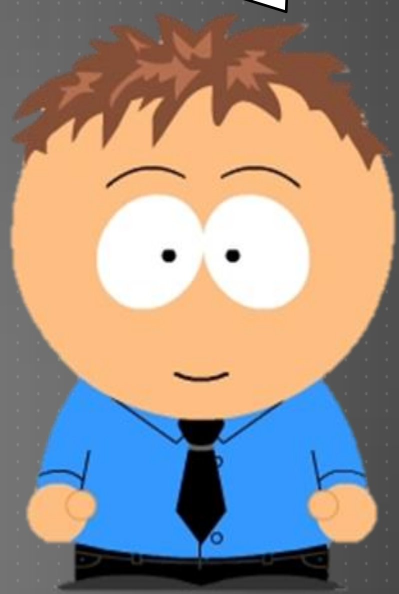
2nd Derivative
(differentiate again)



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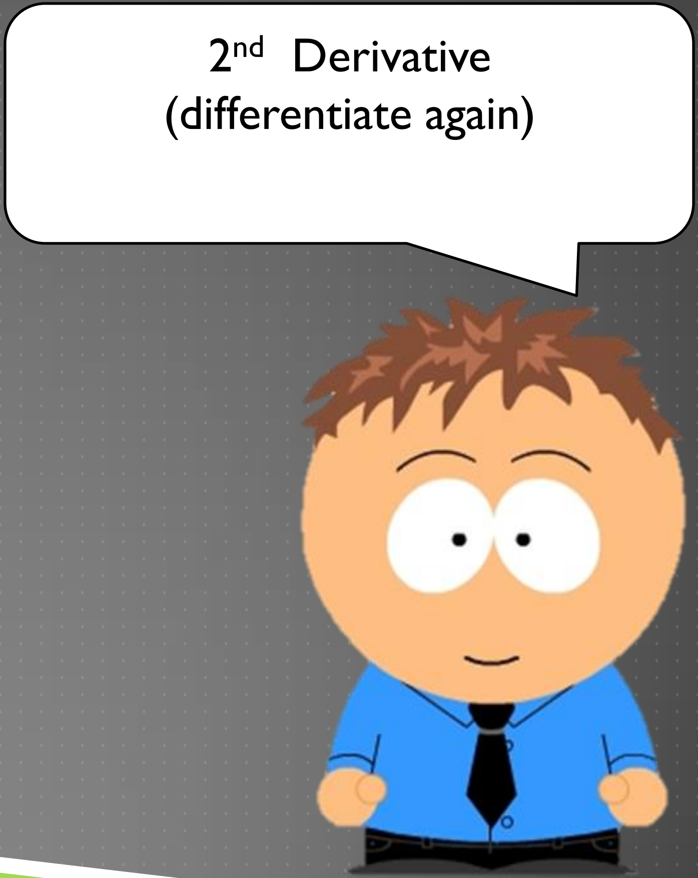
$\frac{d^2y}{dx^2} = \cdots$ $\quad$ $f''(x) = \cdots$



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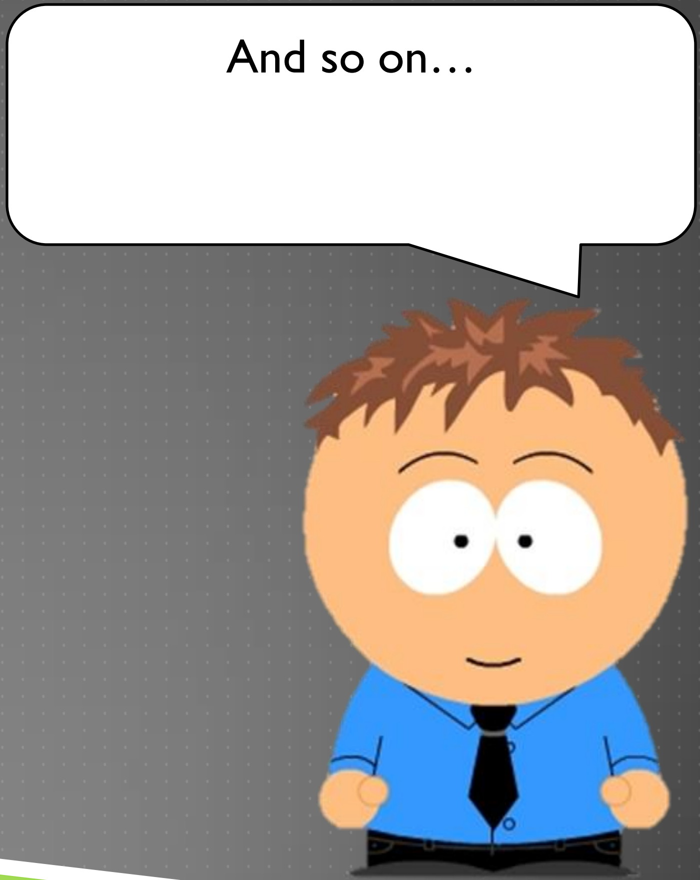

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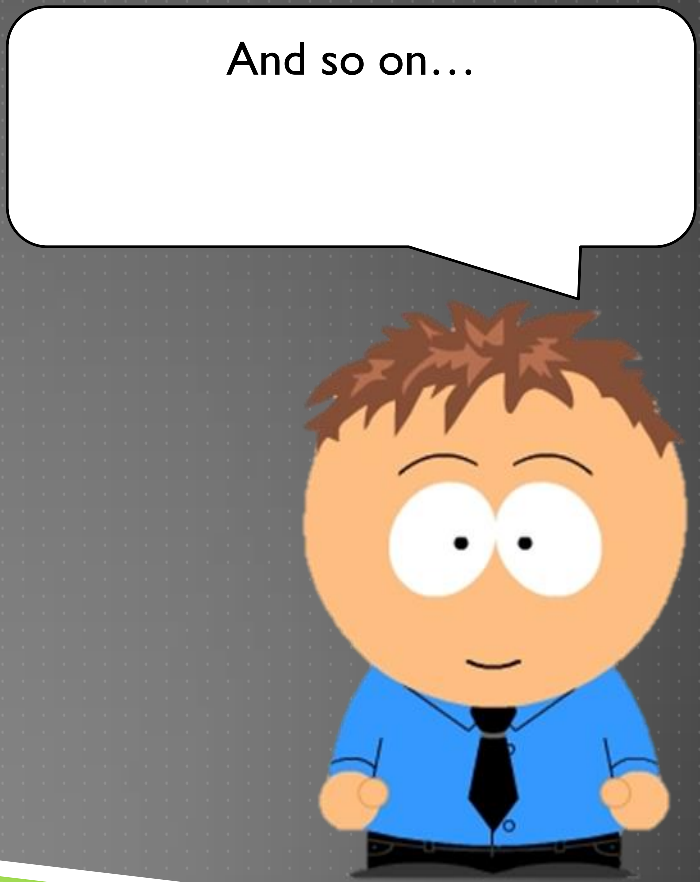
$$\boldsymbol{\frac{d^ny}{dx^n}} = \cdots \qquad \boldsymbol{f^{(n)}(x)} = \cdots$$



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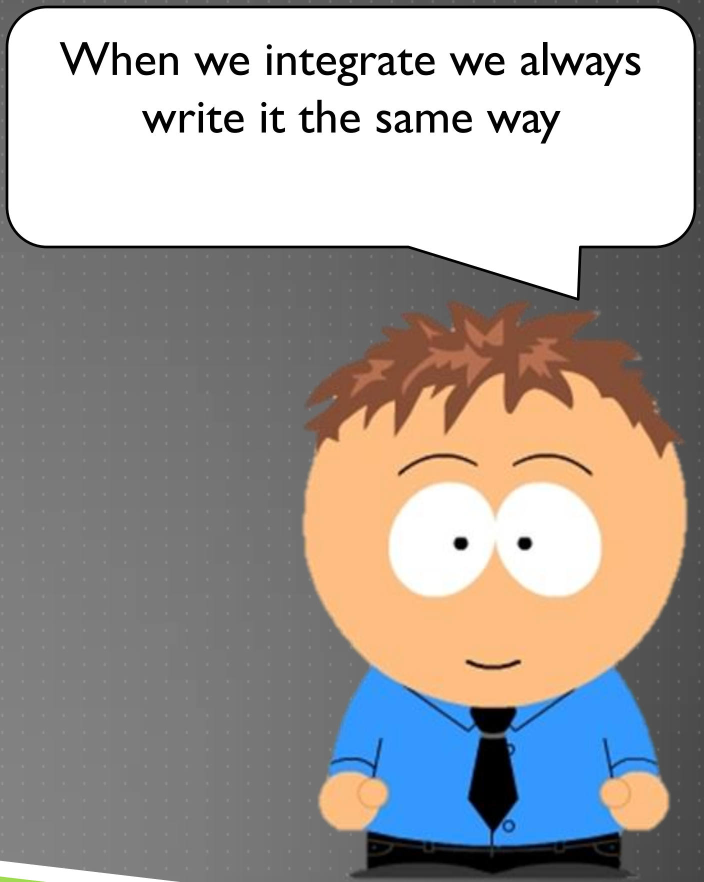

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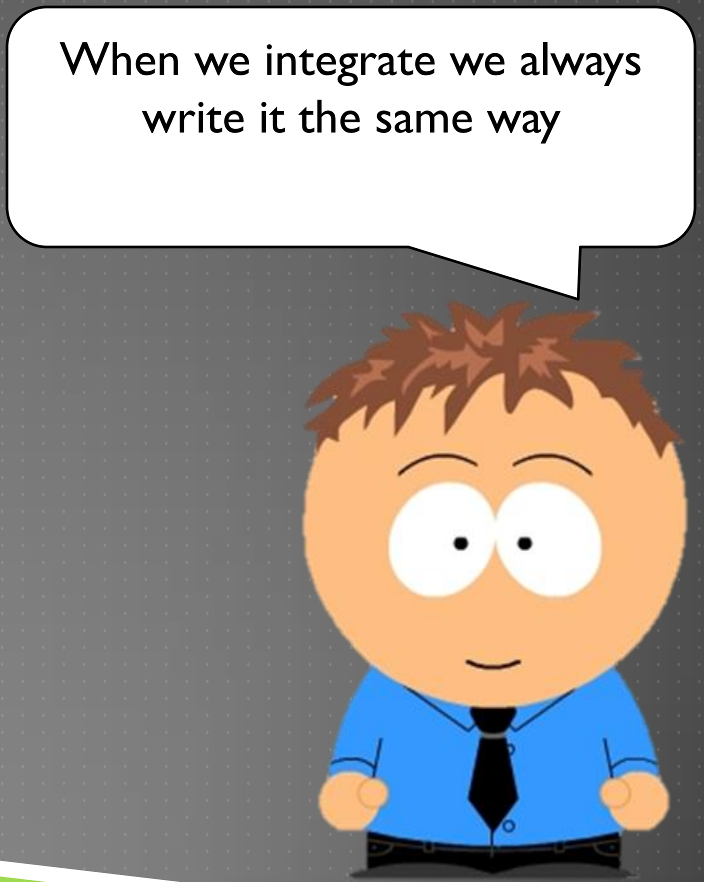
$\int \boldsymbol{y\,dx} = \cdots$ $\int f(x)\,dx = \cdots$



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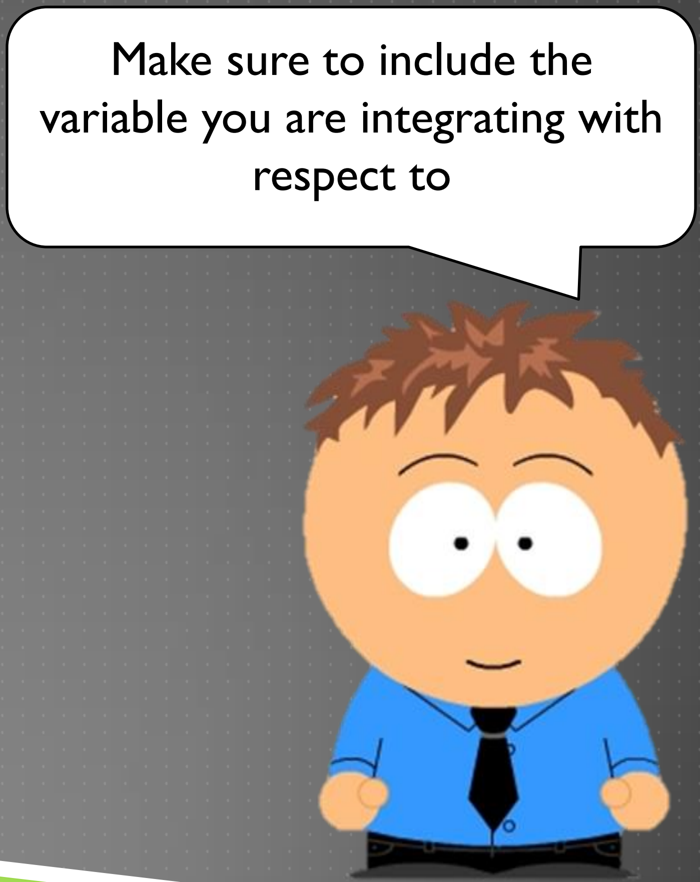

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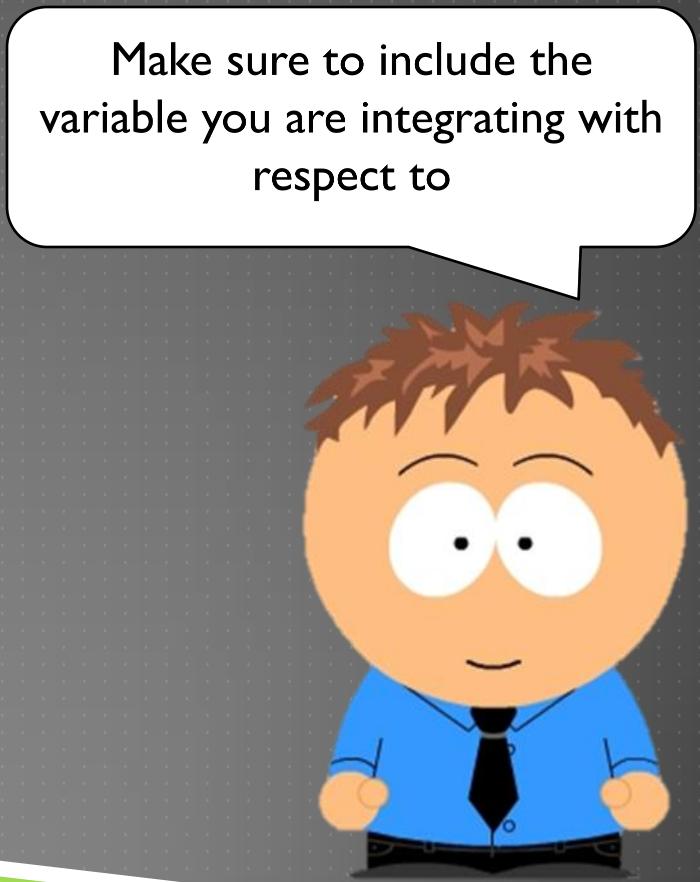

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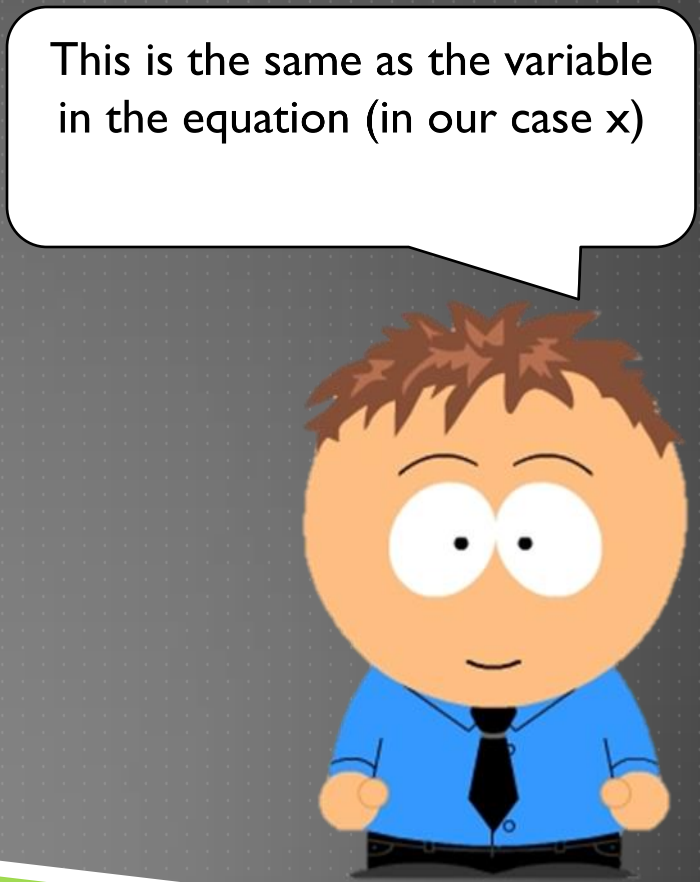

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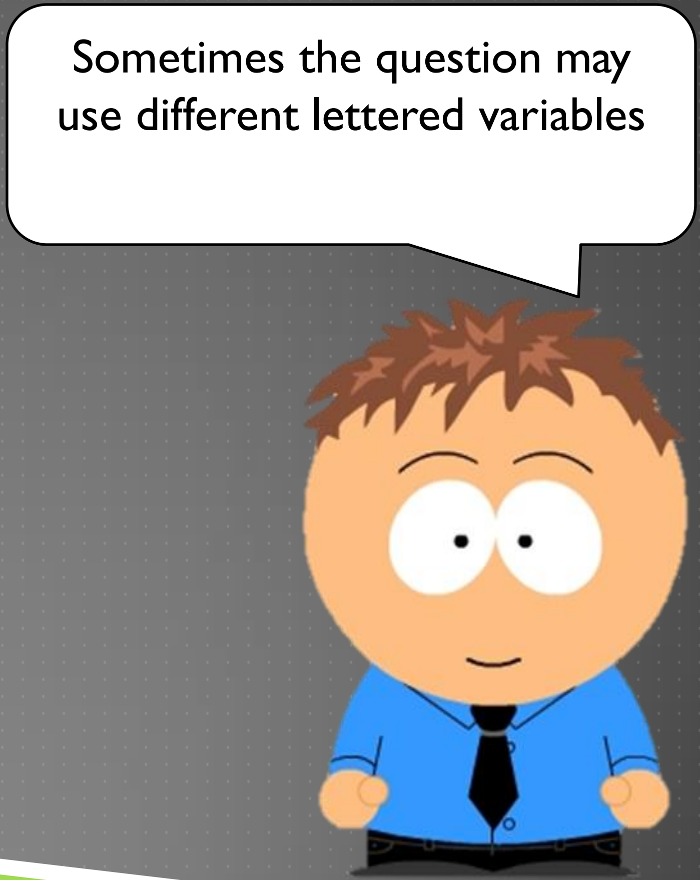
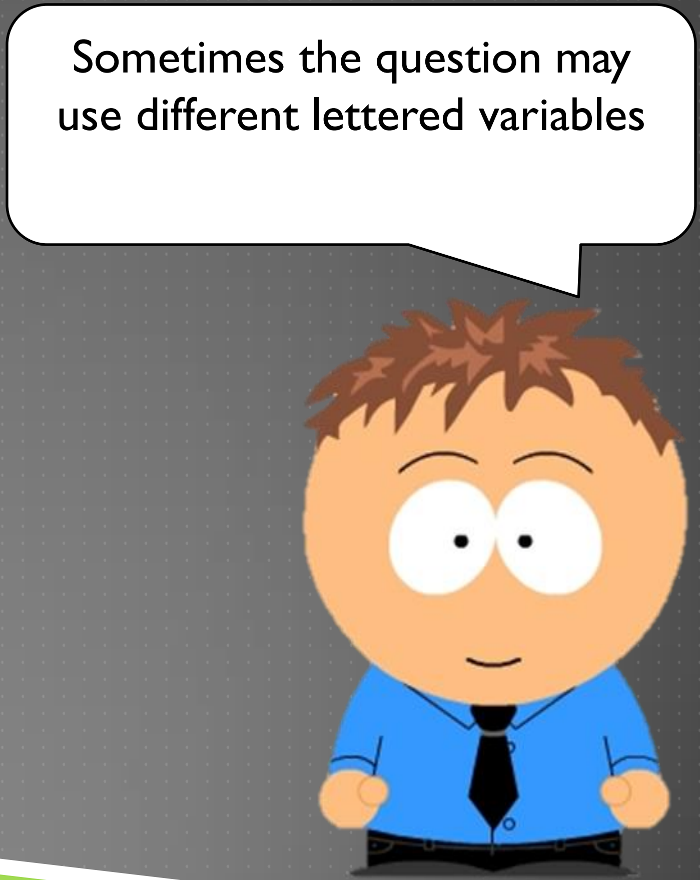


NOTATION

Writing derivatives and integrals

$A(t) = e^t + 2t^2$



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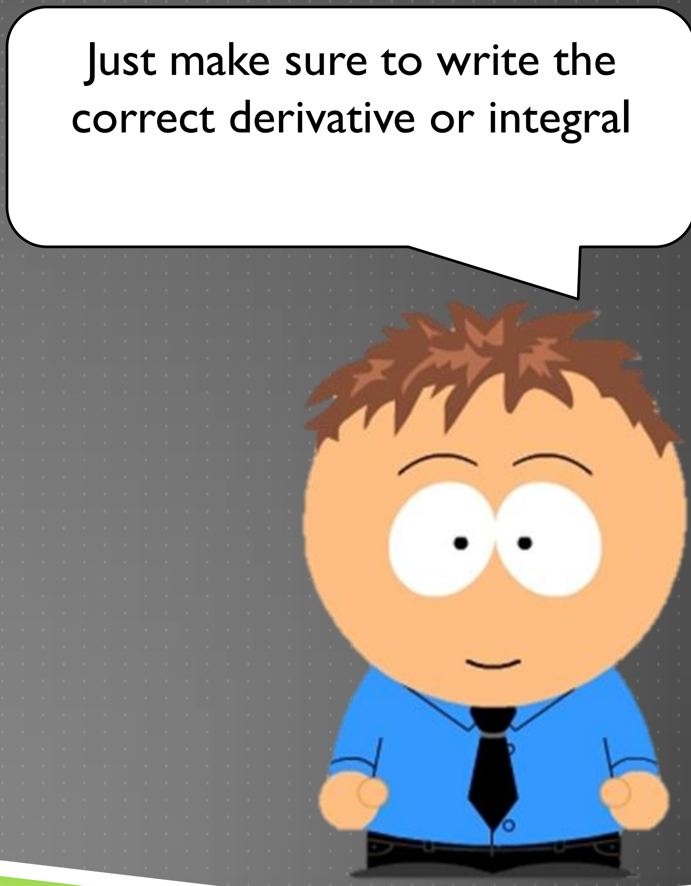

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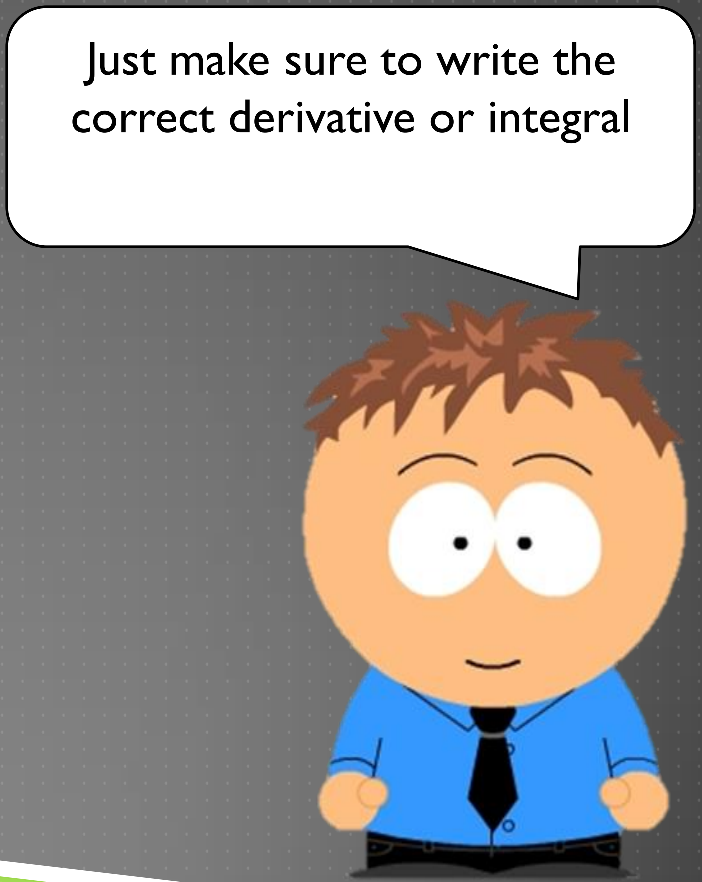
$A(t) = e^t + 2t^2$

$\frac{dA}{dt} = \cdots$

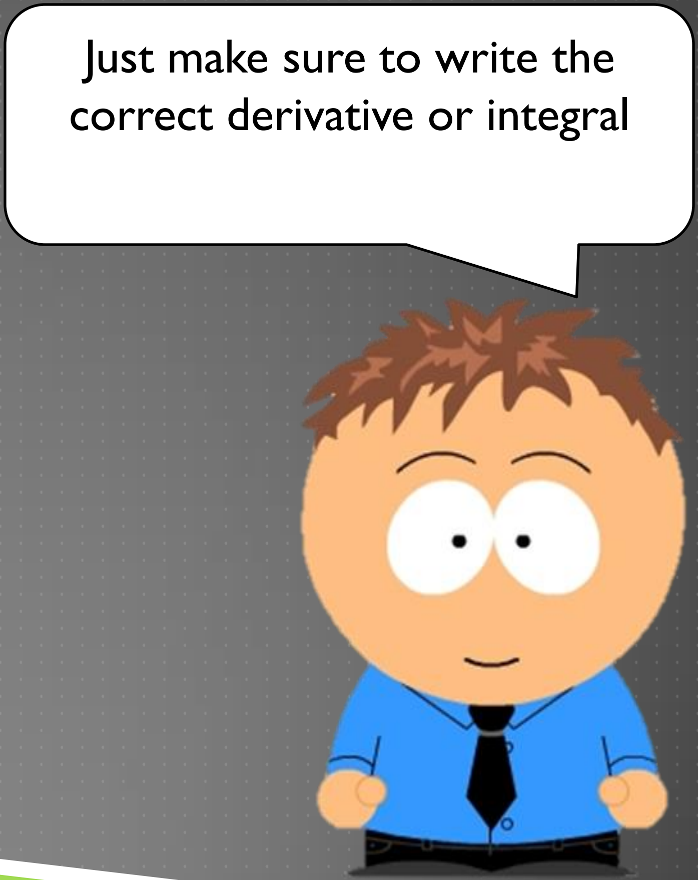


NOTATION

<u>Writing derivatives and integrals</u>

$$A(t) = e^t + 2t^2$$

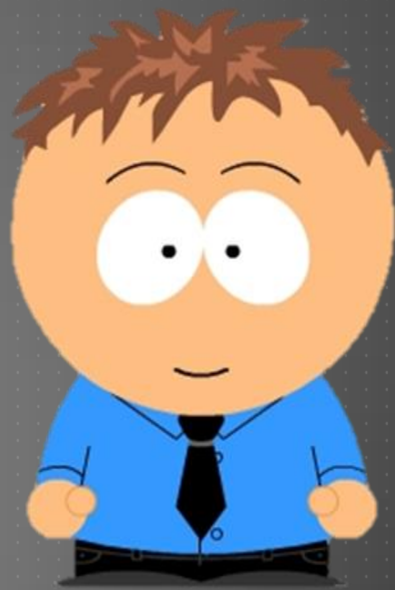
$$\frac{dA}{dt} = \cdots \qquad \int A\,dt = \cdots$$



KEYWORDS

When do I differentiate?

Make sure to look out for certain keywords which will let you know to differentiate

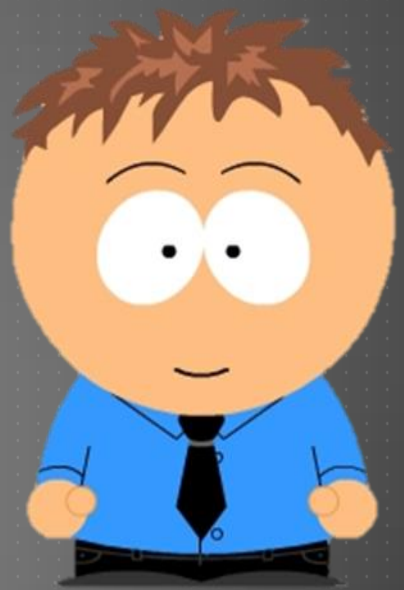


KEYWORDS

When do I differentiate?

Find derivative, dy/dx, f’(x)

You might be explicitly told to differentiate....that’s pretty straight forward

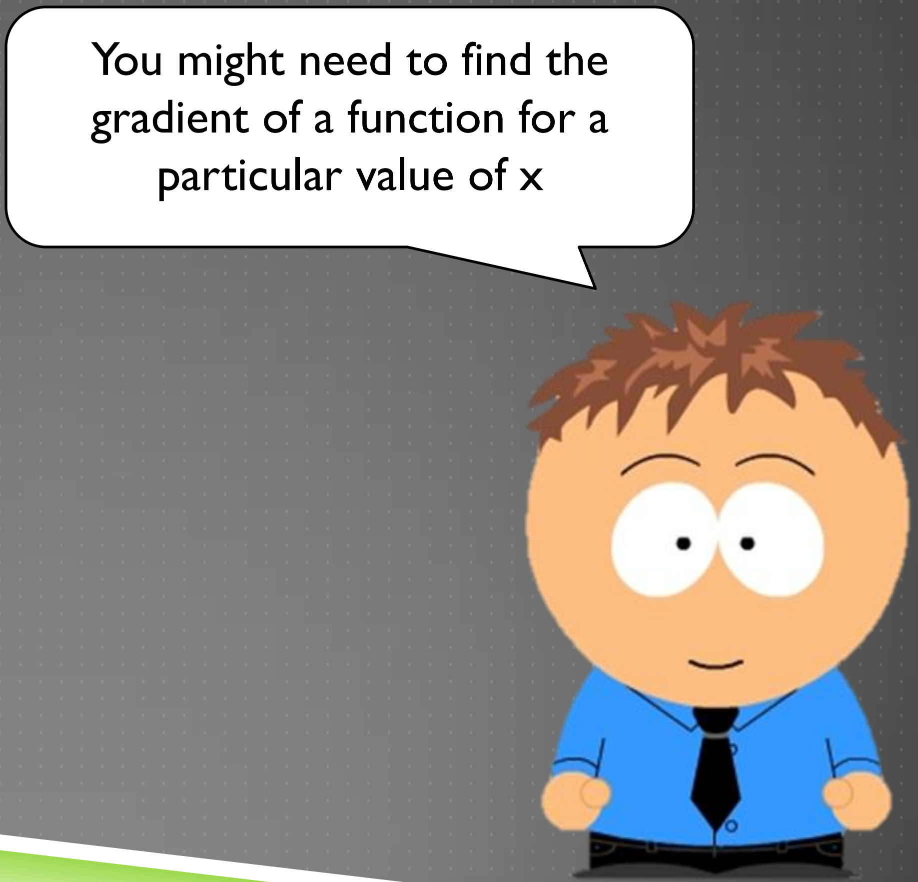


KEYWORDS

When do I differentiate?

Find derivative, dy/dx, f'(x)

Gradient



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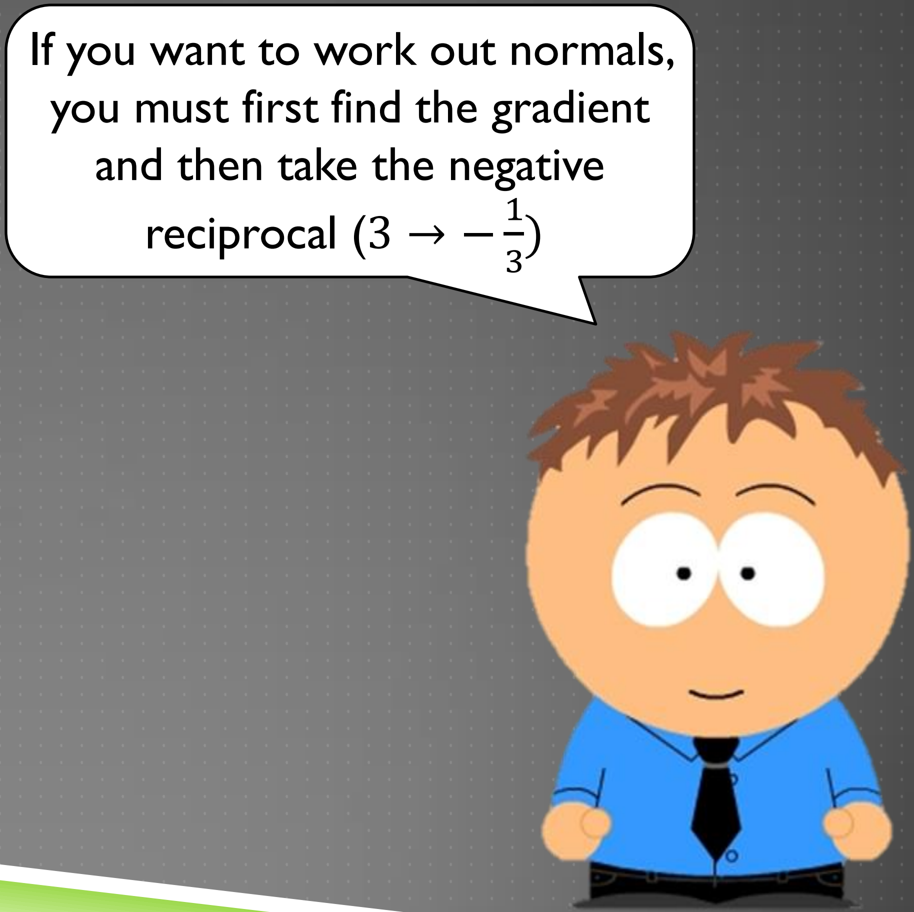
Find derivative, dy/dx, f'(x)

Gradient

Equation of Tangent or Normal



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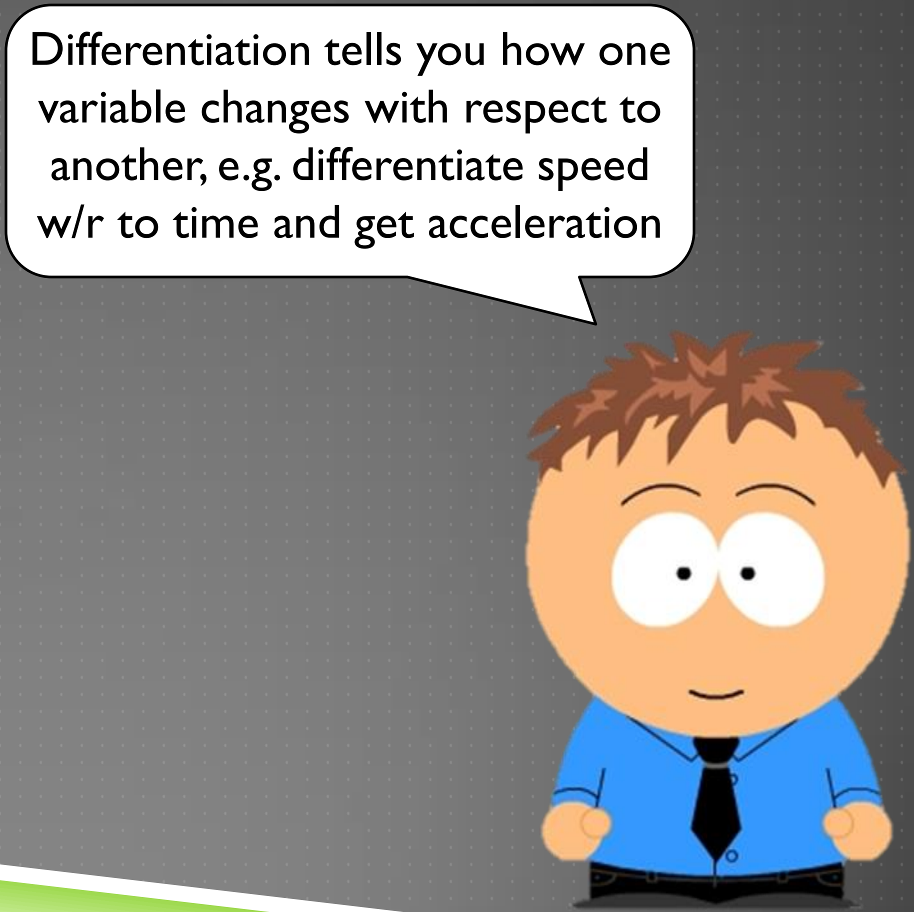
Equation of Tangent or Normal

Rate of Change



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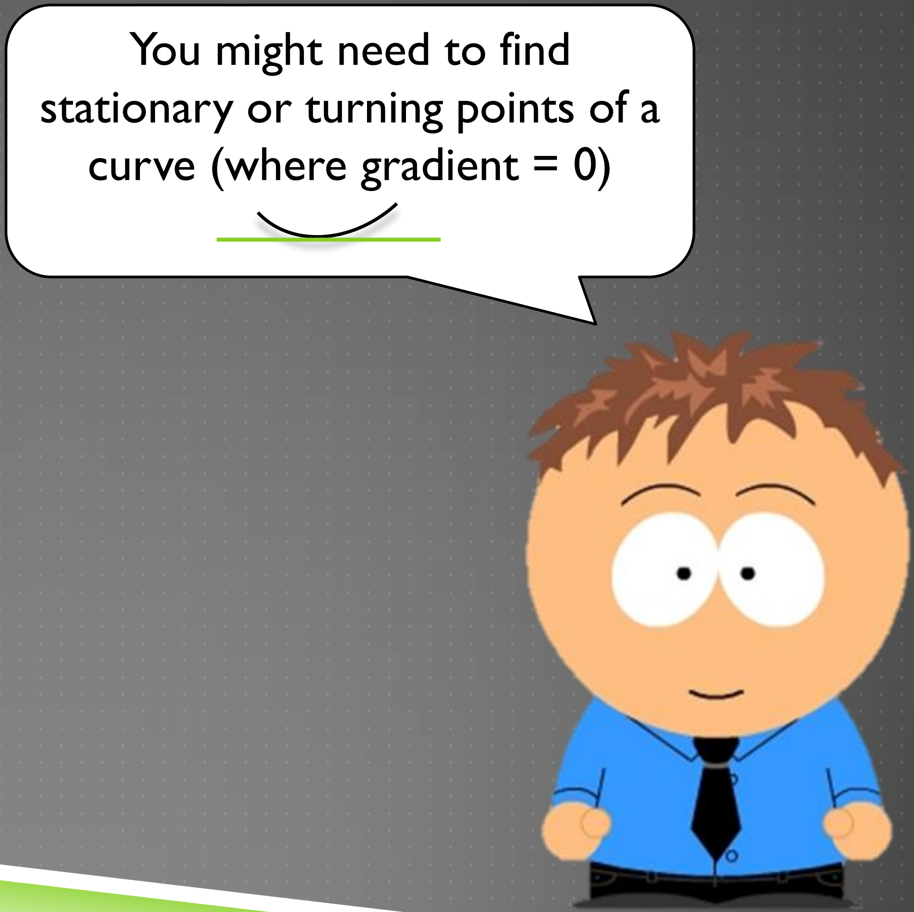
Equation of Tangent or Normal

Rate of Change

Stationary points (max/min)



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When do I differentiate?

Find derivative, dy/dx, f’(x)

Gradient

Equation of Tangent or Normal

Rate of Change

Stationary points (max/min)

Finding Optimum Solutions
(best, largest, etc.)

Finding the maximum or minimum value for a function is it’s optimal solution. You often see questions like this with population models.

KEYWORDS

When do I differentiate?

Find derivative, dy/dx, f'(x)

Gradient

Equation of Tangent or Normal

Rate of Change

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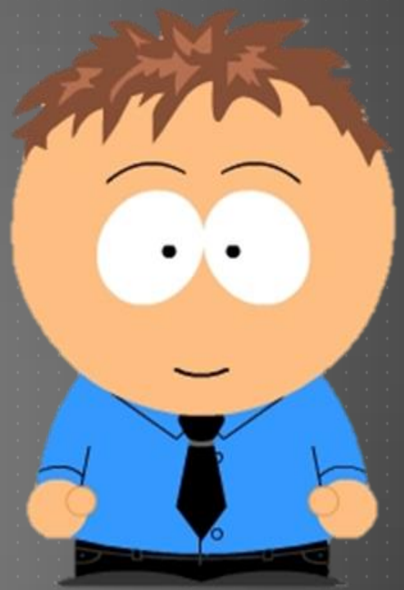
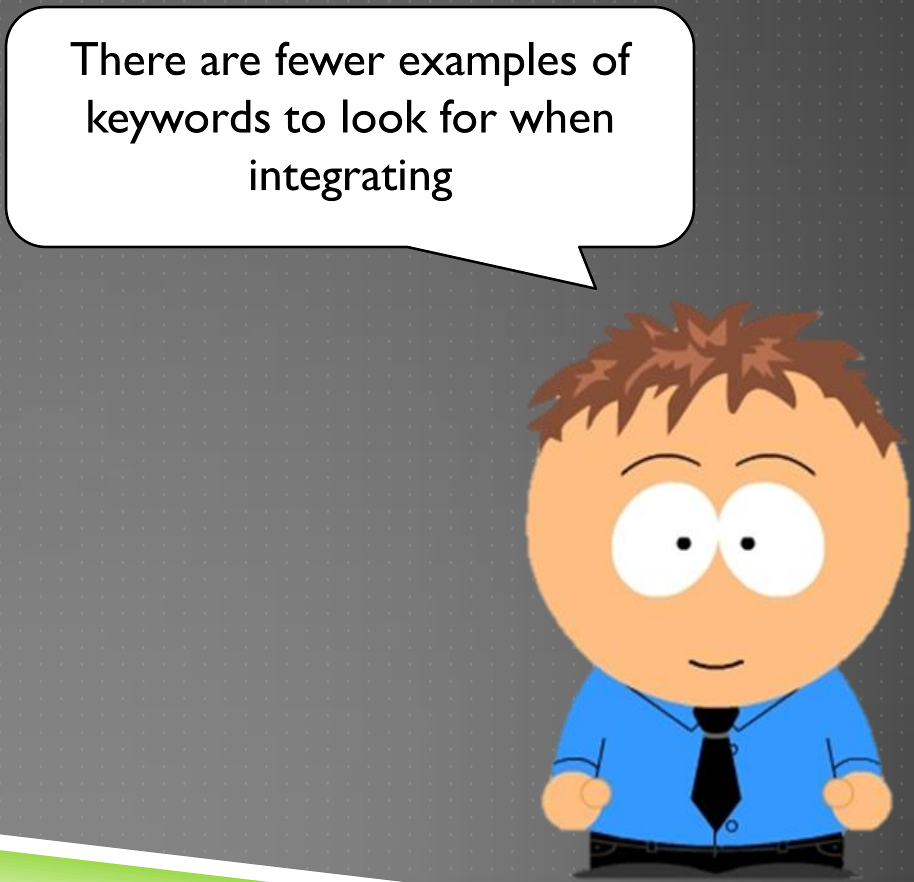


KEYWORDS

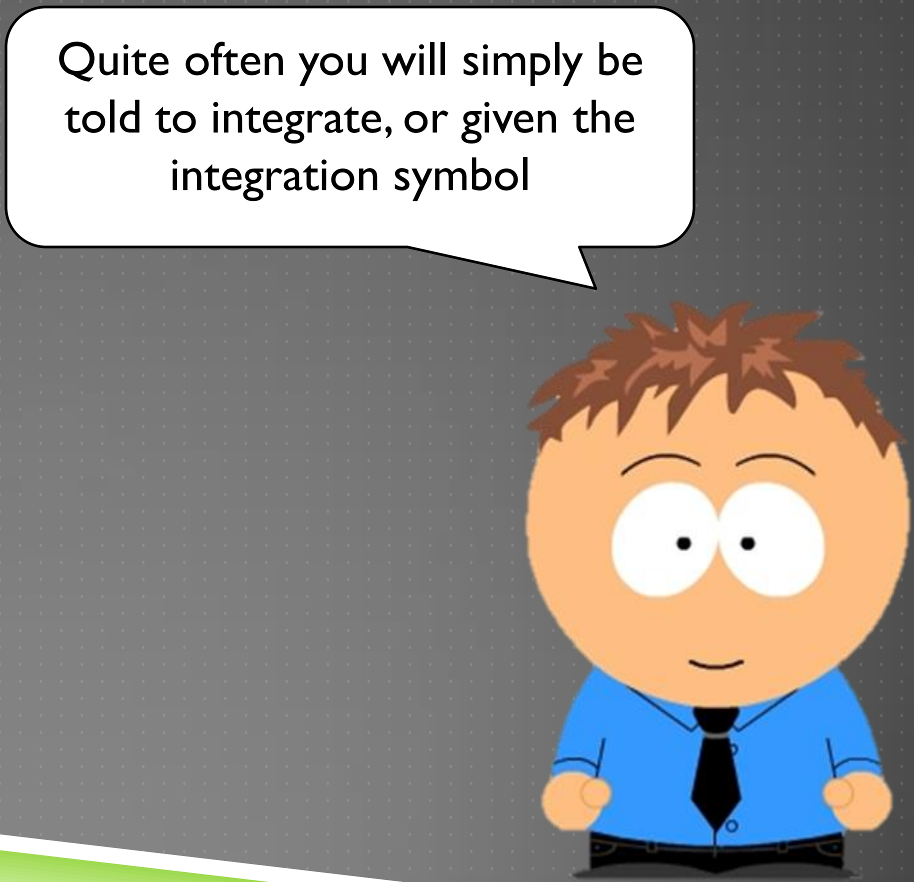
When do I integrate?



KEYWORDS

When do I integrate?

Find integral, $\int$ ...

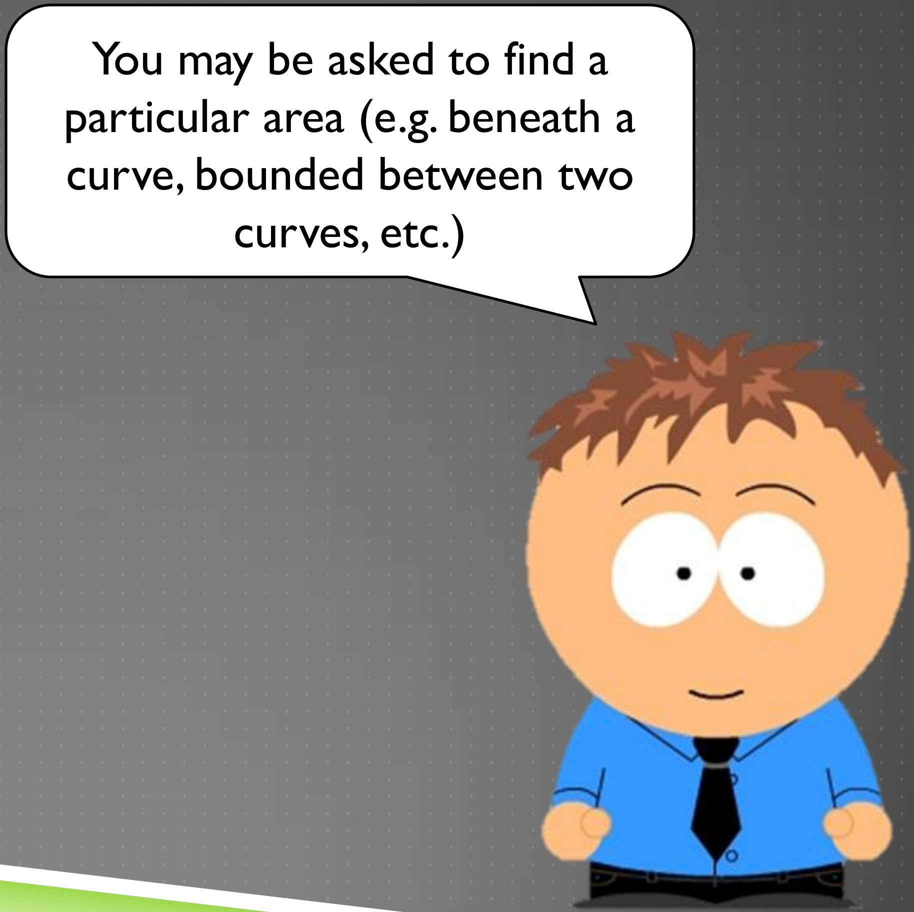


KEYWORDS

When do I integrate?

Find integral, $\int$...

Find the Area…



KEYWORDS

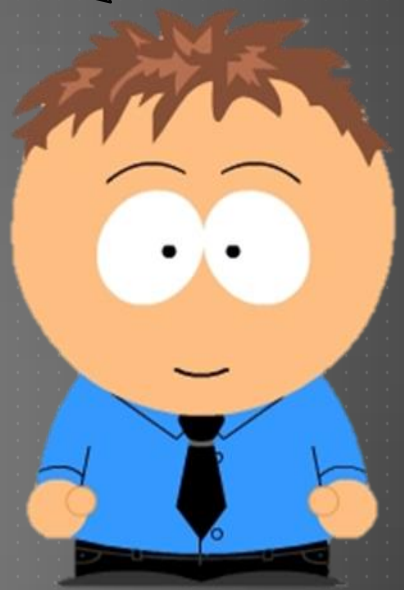
<u>When do I integrate?</u>

Find integral, $\int$ ...

Find the Area…

Volumes of Revolution

And don't forget there is a formula for integrating to find the volume produced when a shape is rotated around the x-axis



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Find the Area…

Volumes of Revolution

$$V = \int_a^b \pi y^2 \, \mathrm{d}x$$

Don't forget to square the function first. You can multiply by π either at the beginning or end, it doesn't make a difference.

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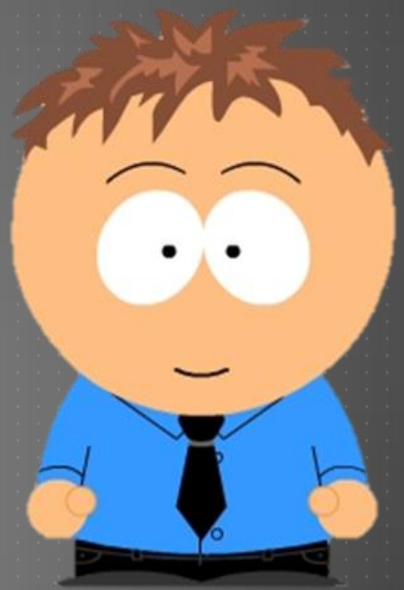
When do I integrate?

Find integral, $\int$ ...

Find the Area…

Volumes of Revolution

$$V = \int_a^b \pi y^2 \, dx$$



DIFFERENTIATION TECHNIQUES

Powers of x

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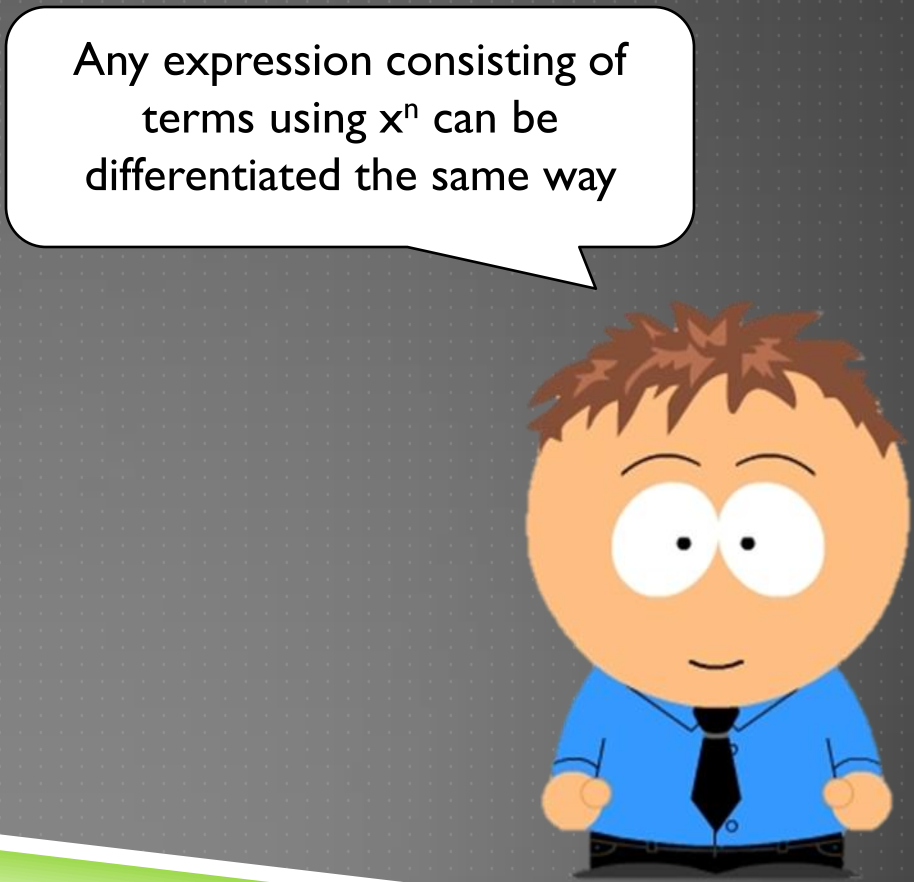
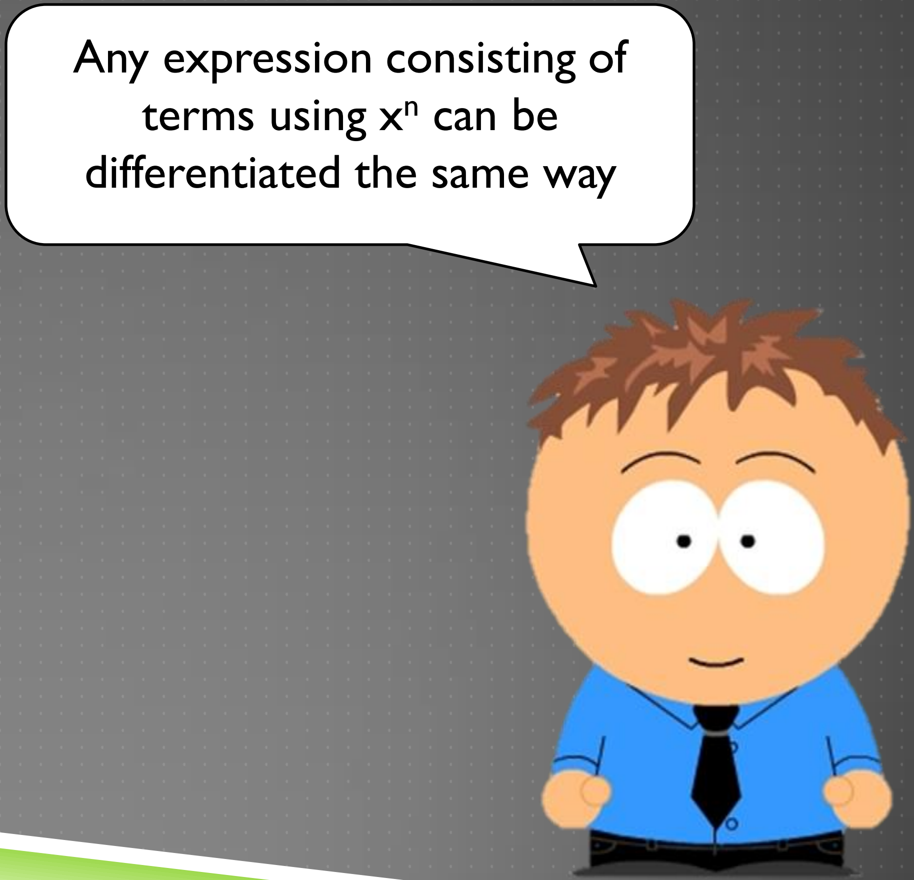


DIFFERENTIATION TECHNIQUES

Powers of x

e.g. $2x^2 + \frac{\sqrt{x}}{x} - \frac{2x+1}{x^3} + 7$



DIFFERENTIATION TECHNIQUES

<u>Powers of x</u>

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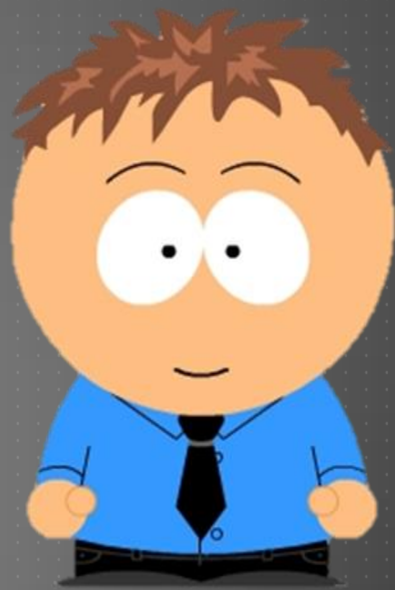
You can differentiate terms one at a time, and they all follow the same rule



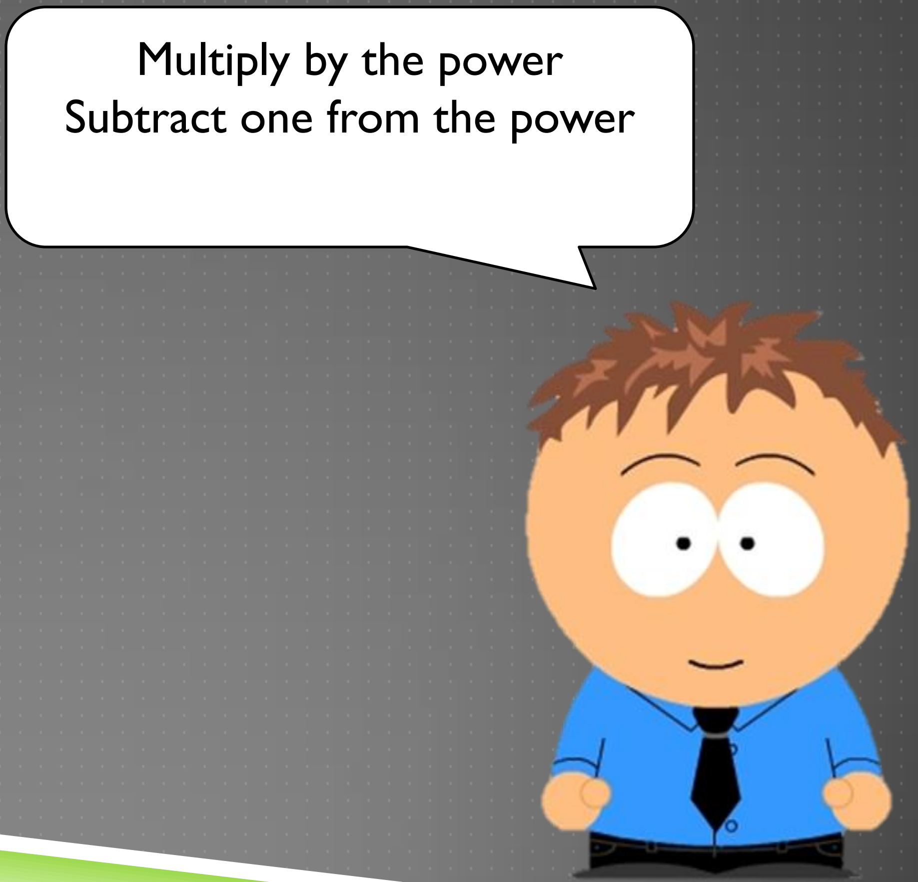
DIFFERENTIATION TECHNIQUES

Powers of x

e.g. $2x^2 + \frac{\sqrt{x}}{x} - \frac{2x+1}{x^3} + 7$

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

f’(x)= $4x$



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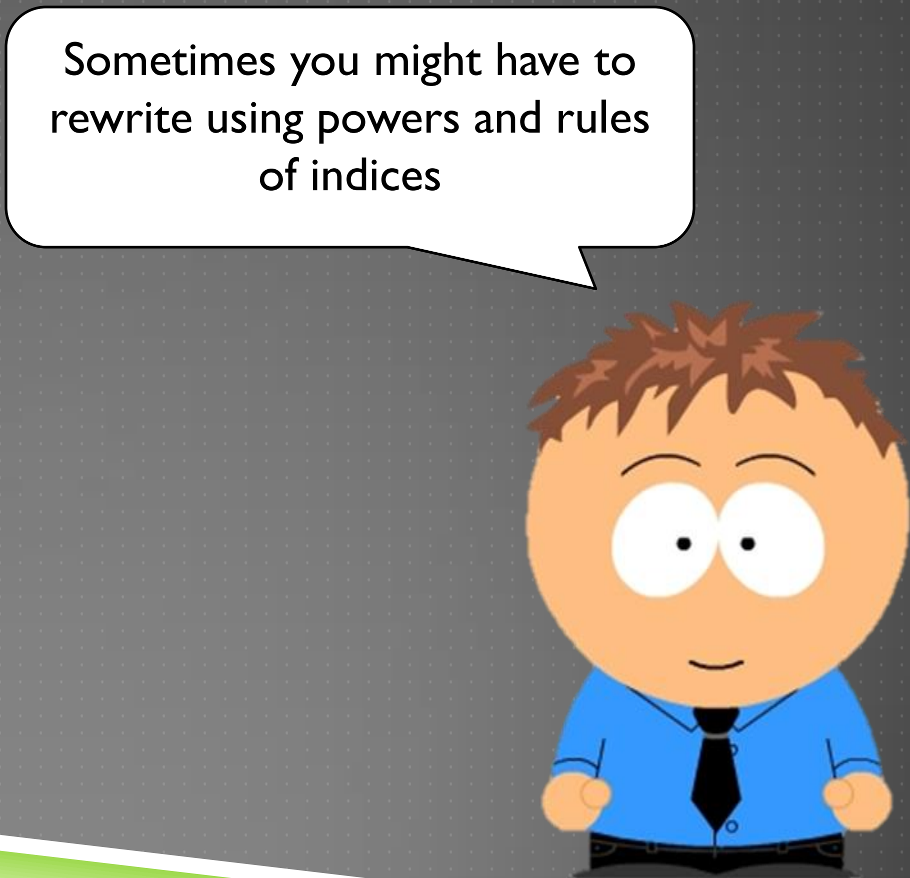

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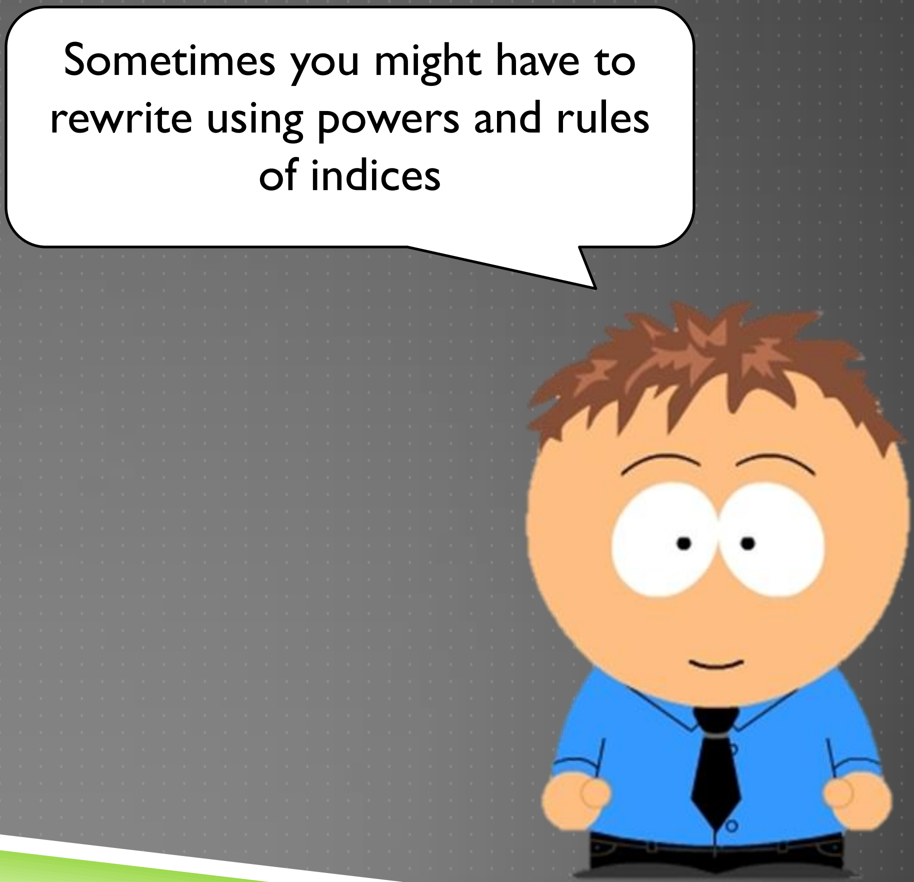
$$= \frac{x^{\frac{1}{2}}}{x}$$

f'(x)= $4x$



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$$= x^{-\frac{1}{2}}$$

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

$$= \frac{x^{\frac{1}{2}}}{x}$$

$$= x^{-\frac{1}{2}}$$

f'(x)= $4x - \frac{1}{2}x^{-\frac{3}{2}}$

DIFFERENTIATION TECHNIQUES

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e.g. $2x^2 + \frac{\sqrt{x}}{x} - \frac{2x+1}{x^3} + 7$

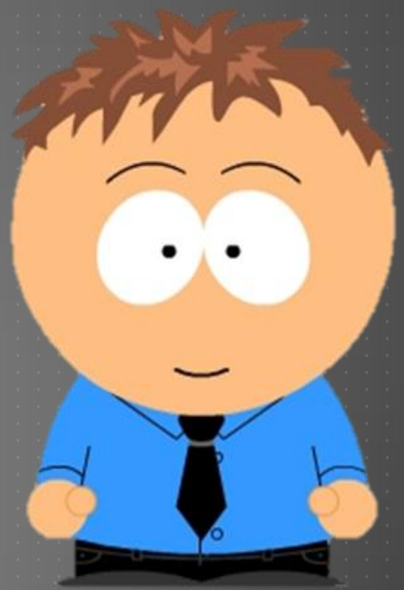
$$f(x) = x^n \quad \Rightarrow \quad f'(x) = nx^{n-1}$$

$$\frac{x^{\frac{1}{2}}}{x}$$

$$x^{-\frac{1}{2}}$$

f'(x)= $4x \; - \frac{1}{2}x^{-\frac{3}{2}}$

You can also split up fractions to make life easier
(all terms on top divide by **everything** on the bottom)



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e.g. $2x^2 + \frac{\sqrt{x}}{x} - \frac{2x+1}{x^3} + 7$

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

$$\frac{x^{\frac{1}{2}}}{x} - \frac{2x}{x^3} + \frac{1}{x^3}$$

$$x^{-\frac{1}{2}}$$

f'(x)= $4x - \frac{1}{2}x^{-\frac{3}{2}}$

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$$\frac{x^{\frac{1}{2}}}{x} - \frac{2x}{x^3} + \frac{1}{x^3}$$

$$x^{-\frac{1}{2}} - 2x^{-2} + x^{-3}$$

f'(x)= $4x - \frac{1}{2}x^{-\frac{3}{2}}$

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$$\frac{x^{\frac{1}{2}}}{x} - \frac{2x}{x^3} + \frac{1}{x^3}$$

$$x^{-\frac{1}{2}} - 2x^{-2} + x^{-3}$$

f'(x)= $4x - \frac{1}{2}x^{-\frac{3}{2}} + 4x^{-3} - 3x^{-4}$

DIFFERENTIATION TECHNIQUES

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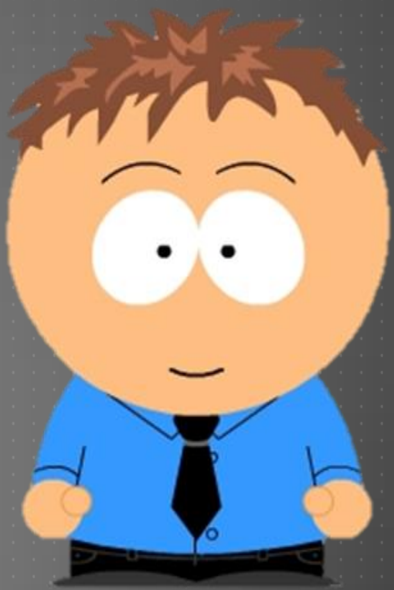
$$\frac{x^{\frac{1}{2}}}{x} - \frac{2x}{x^3} + \frac{1}{x^3}$$

$$x^{-\frac{1}{2}} - 2x^{-2} + x^{-3}$$

f'(x)= $4x - \frac{1}{2}x^{-\frac{3}{2}} + 4x^{-3} - 3x^{-4}$



DIFFERENTIATION TECHNIQUES

Powers of x

e.g. $2x^2 + \frac{\sqrt{x}}{x} - \frac{2x+1}{x^3} + 7$

$$f(x) = x^n \quad \Rightarrow \quad f'(x) = nx^{n-1}$$

$$\frac{x^{\frac{1}{2}}}{x} - \frac{2x}{x^3} + \frac{1}{x^3}$$

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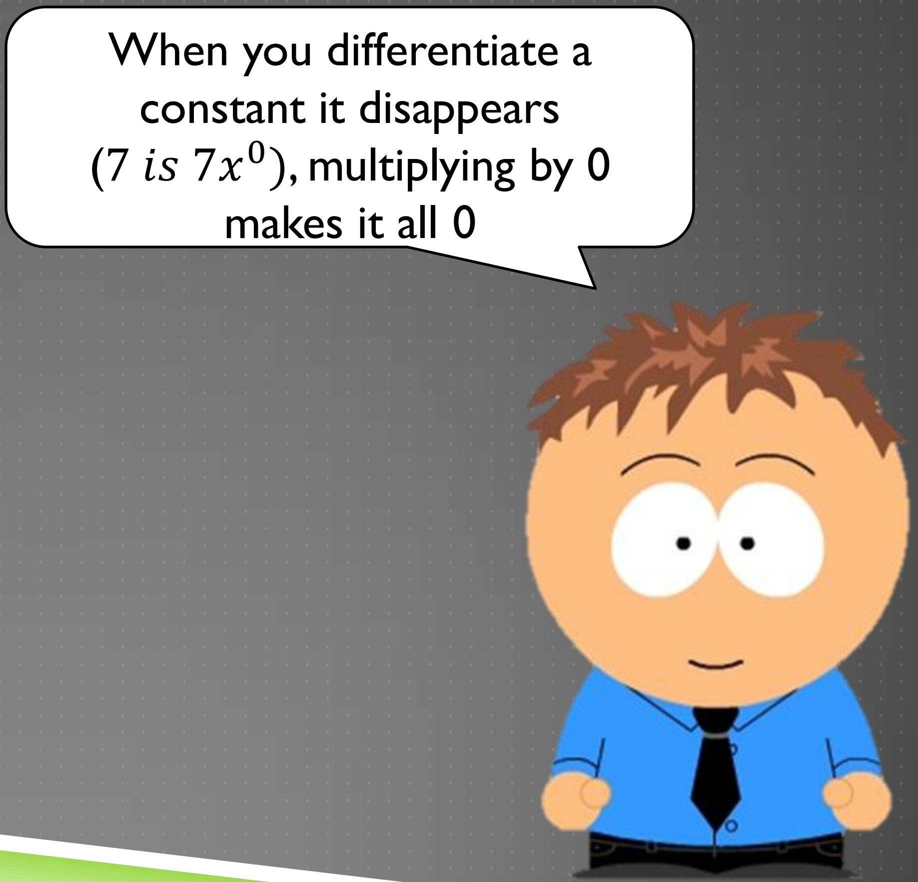
f'(x)= $4x - \frac{1}{2}x^{-\frac{3}{2}} + 4x^{-3} - 3x^{-4} + 0$



DIFFERENTIATION TECHNIQUES

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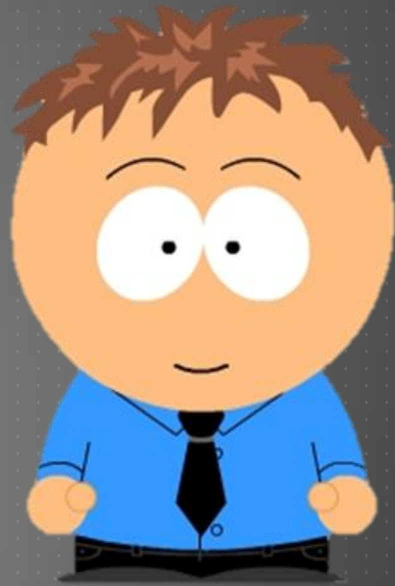
INTEGRATION TECHNIQUES

Powers of x

INTEGRATION TECHNIQUES

Powers of x

Integration is the reverse of differentiation



INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \; dx$

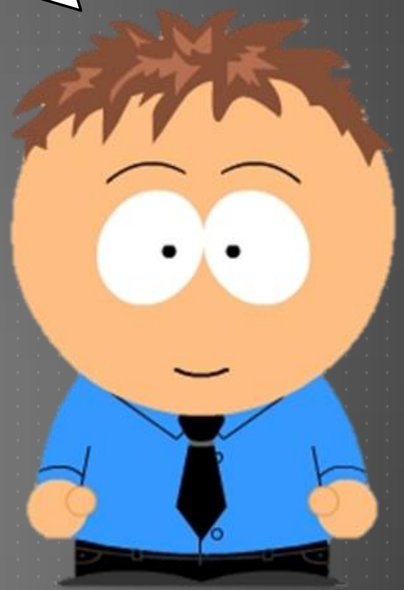
INTEGRATION TECHNIQUES

<u>Powers of x</u>

e.g. $\int 5x^3 + 4 \ dx$

To differentiate you:
x power, -1 from power

Therefore to integrate you:
+1 to power, ÷power



INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \ dx$

$$\int x^n \, dx = \frac{x^{n+1}}{n+1} + C, \quad n \neq -1$$

To differentiate you:
x power, -1 from power

Therefore to integrate you:
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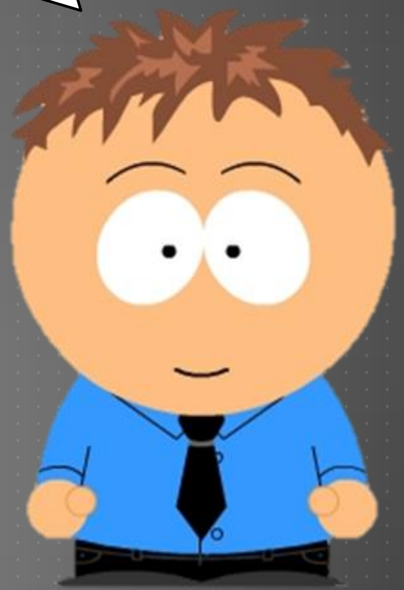

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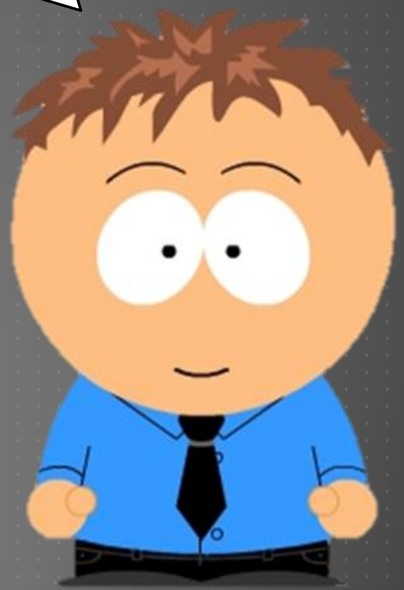


INTEGRATION TECHNIQUES

Powers of x

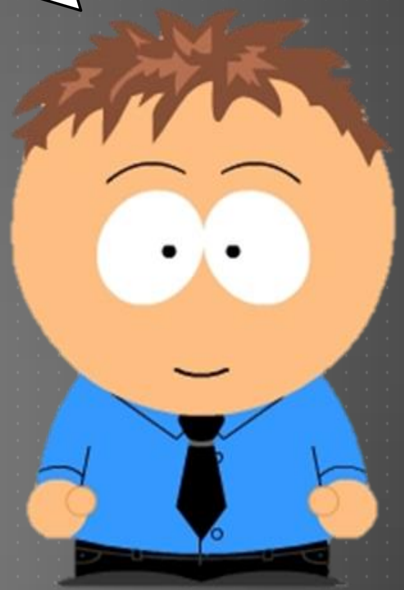
e.g. $\int 5x^3 + 4 \;\; dx$

e.g. $\int 5x^3 + 4$

$\frac{5}{4}x^4$

To differentiate you:
x power, -1 from power

Therefore to integrate you:
+1 to power, ÷power



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Powers of x

e.g. $\int 5x^3 + 4 \ dx$

$$\int x^n \, dx = \frac{x^{n+1}}{n+1} + C, \quad n \neq -1$$

$$\frac{5}{4}x^4$$

Integrating a constant just puts an 'x' on the end of it

4 is $4x^0 \rightarrow \frac{4}{1}x^1$

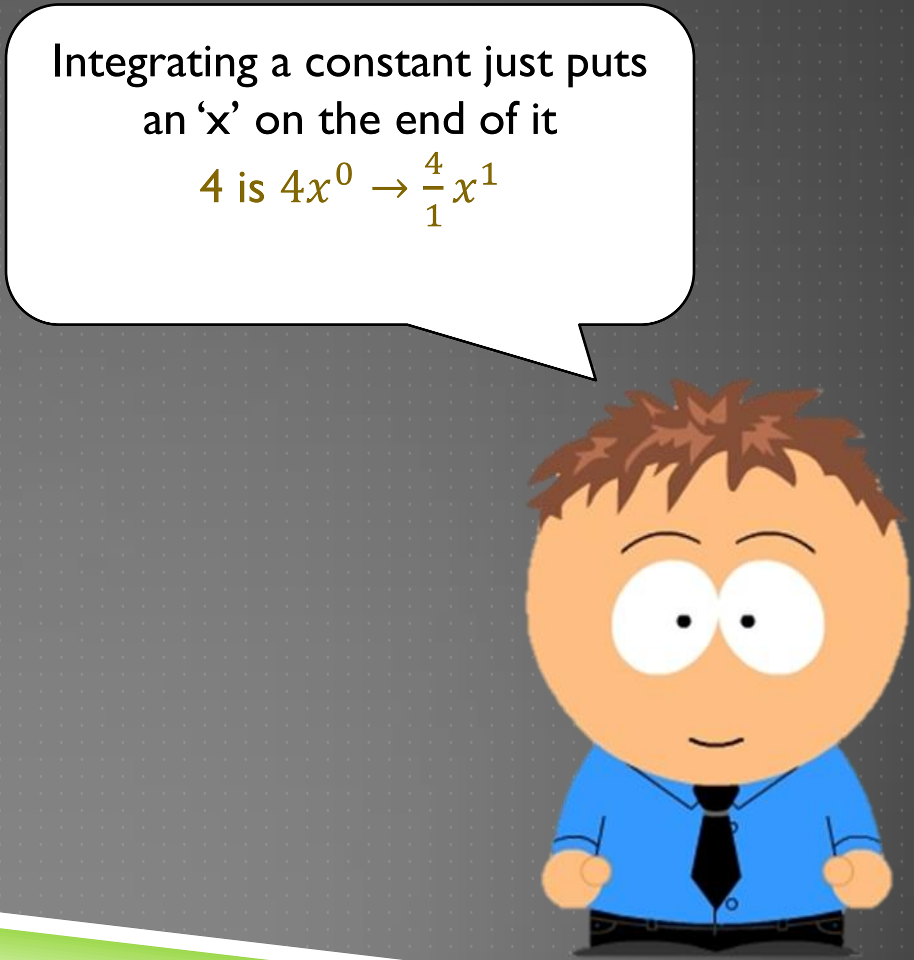
INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \ dx$

$$\int x^n \, dx = \frac{x^{n+1}}{n+1} + C, \quad n \neq -1$$

$\frac{5}{4}x^4 \quad +4x$



INTEGRATION TECHNIQUES

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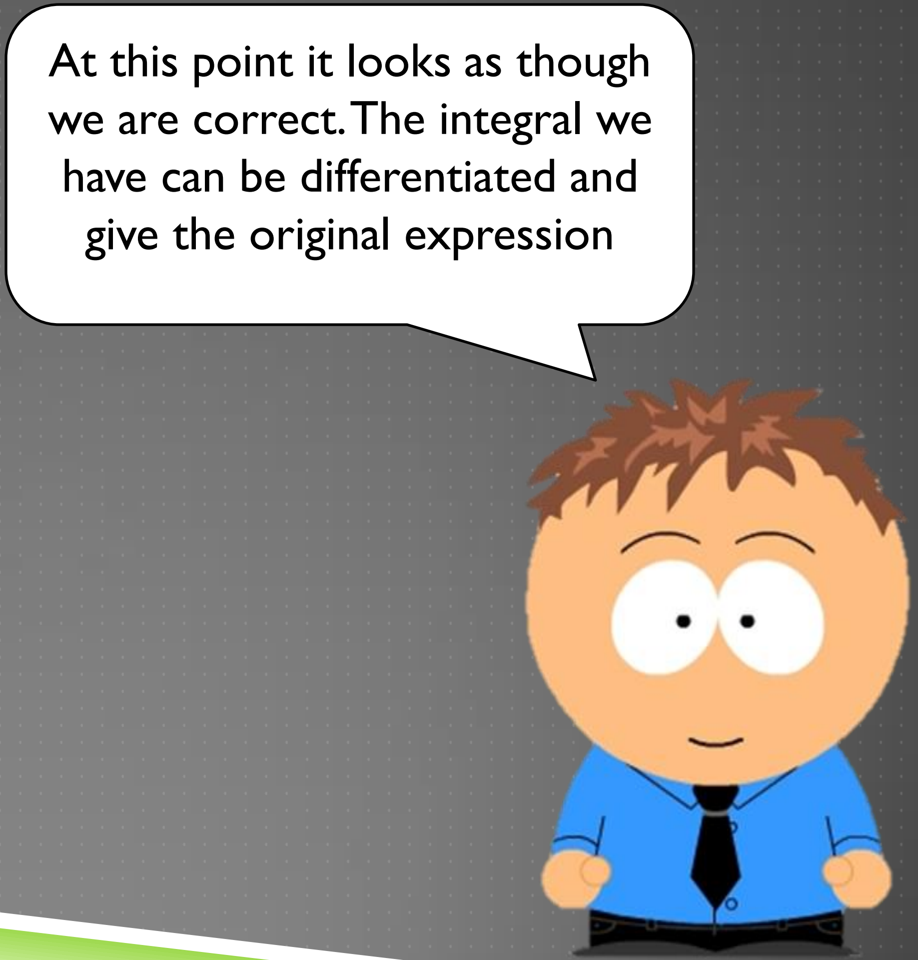


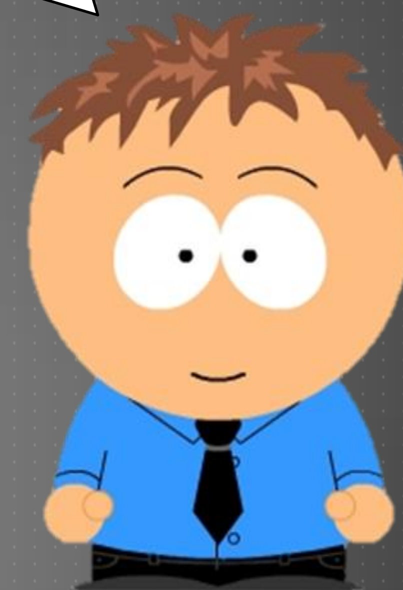
INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \; dx$

$\frac{5}{4}x^4 \quad +4x$

However we also must include a constant term that might have differentiated to 0.



INTEGRATION TECHNIQUES

Powers of x

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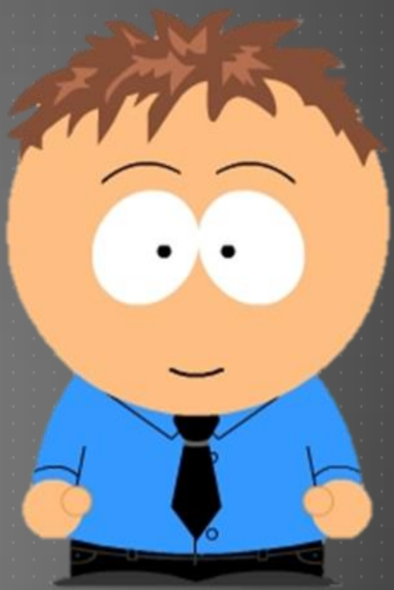
INTEGRATION TECHNIQUES

<u>Powers of x</u>

e.g. $\int 5x^3 + 4 \quad +0 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$



INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \quad +0 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

This is our *constant of integration, C*

Always remember to write it at the end of an indefinite integral

INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \qquad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

Including limits

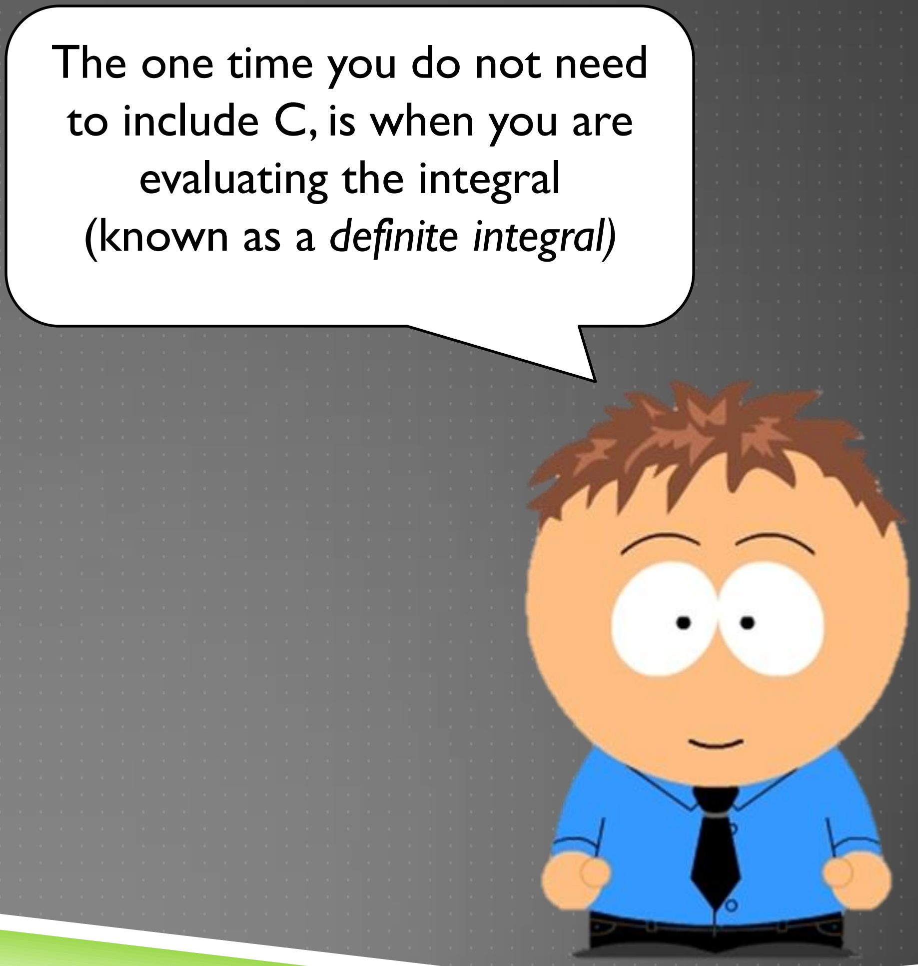
INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \quad dx$

$$\frac{5}{4}x^4 \quad +4x \quad +C$$

Including limits



INTEGRATION TECHNIQUES

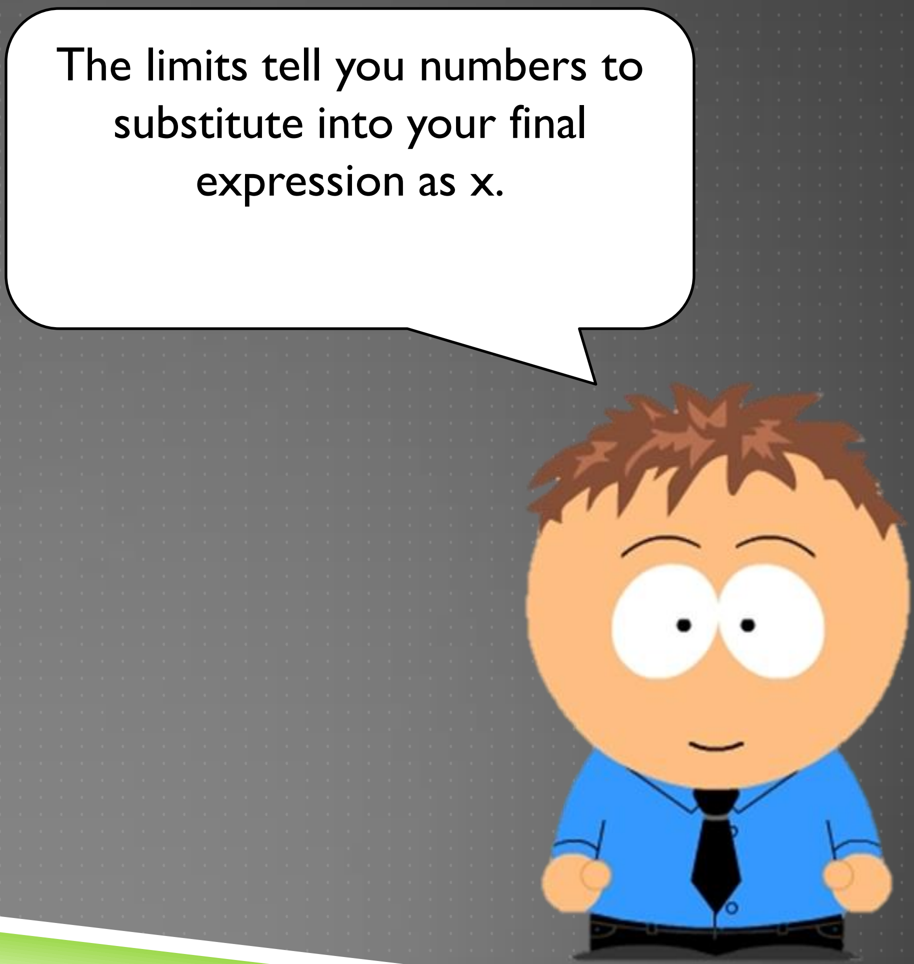
Powers of x

e.g. $\int 5x^3 + 4 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

Including limits

e.g. $\int_{-1}^{2} 5x^3 + 4 \; \mathrm{dx}$



INTEGRATION TECHNIQUES

Powers of x

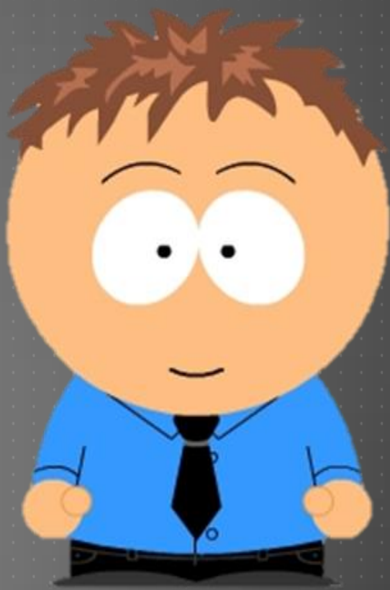
e.g. $\int 5x^3 + 4 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

Including limits

e.g. $\int_{-1}^{2} 5x^3 + 4 \ \mathrm{dx}$

$$= \left[\frac{5}{4}x^4 + 4x\right]_{-1}^{2}$$



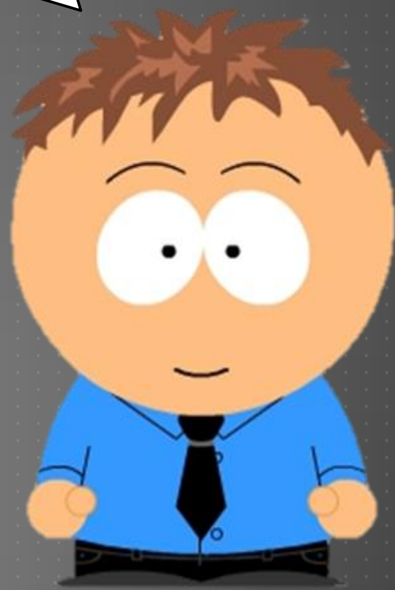
INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \quad dx$

$$\frac{5}{4}x^4 \quad +4x \quad +C$$

You first evaluate by substituting the top number for x



Including limits

e.g. $\int_{-1}^{2} 5x^3 + 4 \;\, \mathrm{dx}$

$$= \left[\frac{5}{4}x^4 + 4x\right]_{-1}^{2}$$

INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

Including limits

e.g. $\int_{-1}^{2} 5x^3 + 4 \;\, \mathrm{dx}$

$= \left[\frac{5}{4}x^4 + 4x\right]_{-1}^{2}$

$= \left[\frac{5}{4}(2)^4 + 4(2)\right]$

You first evaluate by substituting the top number for x

INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

Including limits

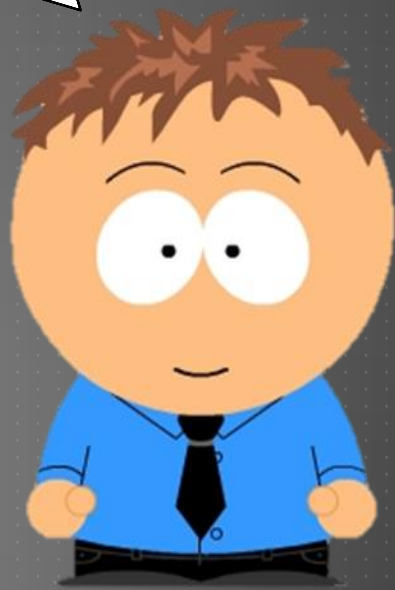
e.g. $\int_{-1}^{2} 5x^3 + 4 \ \mathrm{dx}$

$$= \left[\frac{5}{4}x^4 + 4x\right]_{-1}^{2}$$

$$= \left[\frac{5}{4}(2)^4 + 4(2)\right]$$

28

You first evaluate by substituting the top number for x



INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

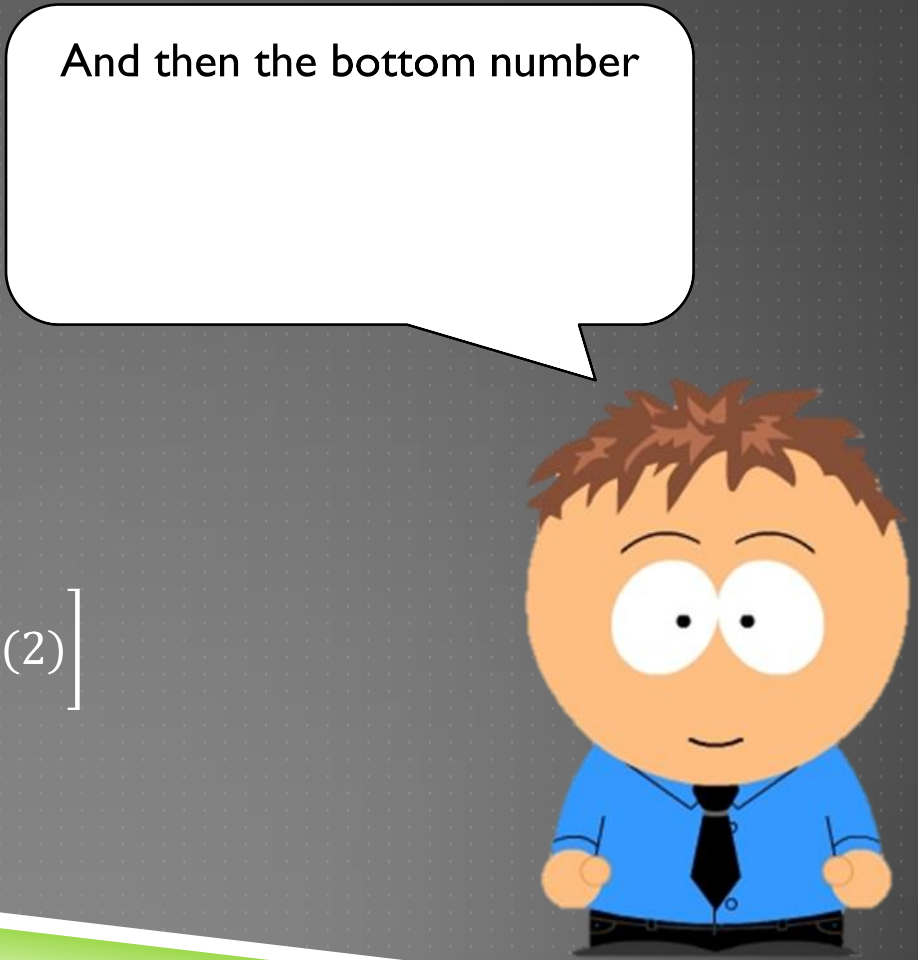
Including limits

e.g. $\int_{-1}^{2} 5x^3 + 4 \;\, \mathrm{dx}$

$$= \left[\frac{5}{4}x^4 + 4x\right]_{-1}^{2}$$

$$= \left[\frac{5}{4}(2)^4 + 4(2)\right]$$

$$28$$



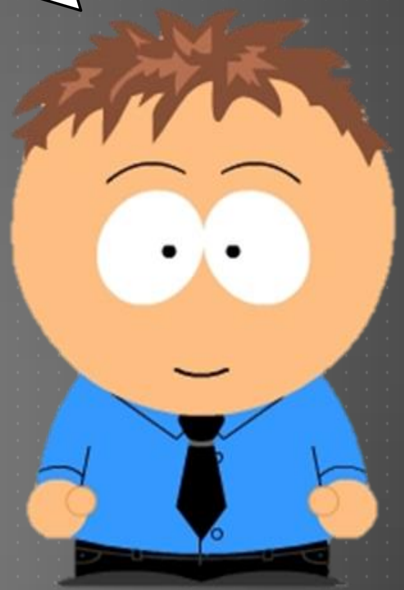
INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

And then the bottom number



Including limits

e.g. $\int_{-1}^{2} 5x^3 + 4 \ \ dx$

$= \left[\frac{5}{4}x^4 + 4x\right]_{-1}^{2}$

$= \left[\frac{5}{4}(2)^4 + 4(2)\right] \quad \left[\frac{5}{4}(1)^4 + 4(1)\right]$

28

INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

Including limits

e.g. $\int_{-1}^{2} 5x^3 + 4 \ \ dx$

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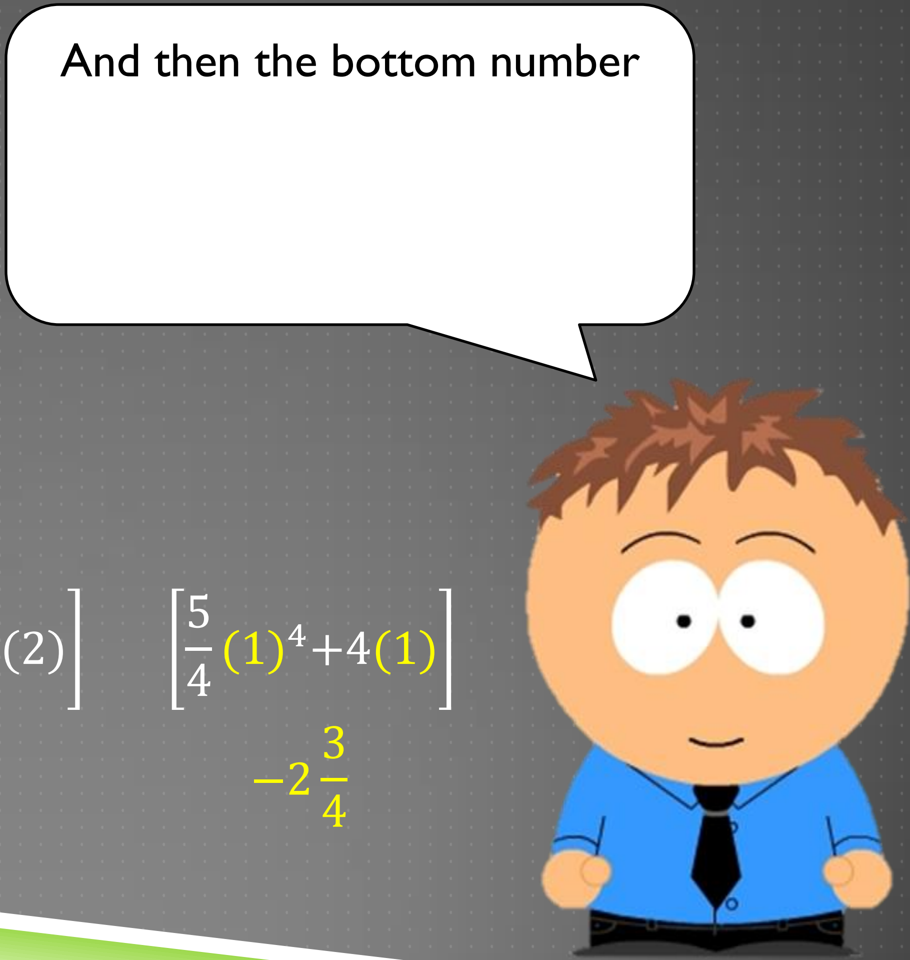
$= \left[\frac{5}{4}(2)^4 + 4(2)\right] \quad \left[\frac{5}{4}(1)^4 + 4(1)\right]$

$28 \quad -2\frac{3}{4}$



INTEGRATION TECHNIQUES

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e.g. $\int 5x^3 + 4 \quad dx$

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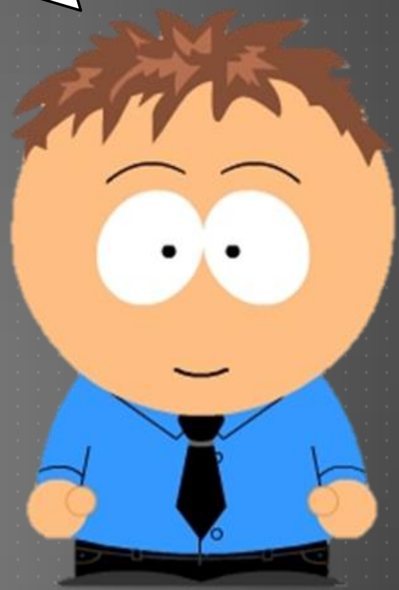


INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

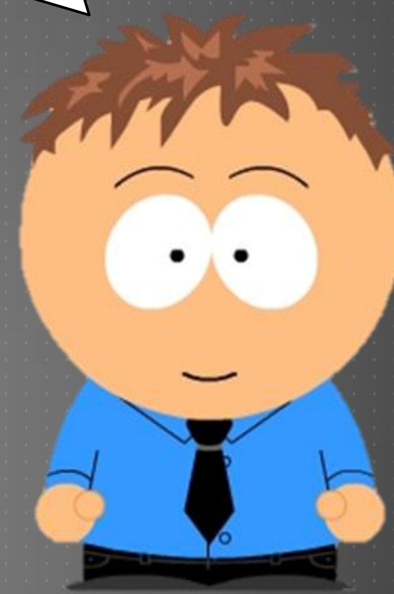
Including limits

e.g. $\int_{-1}^{2} 5x^3 + 4 \;\, \mathrm{dx}$

$$= \left[\frac{5}{4}x^4 + 4x\right]_{-1}^{2}$$

$$= \left[\frac{5}{4}(2)^4 + 4(2)\right] - \left[\frac{5}{4}(1)^4 + 4(1)\right]$$

$$28 \quad - \quad -2\frac{3}{4}$$



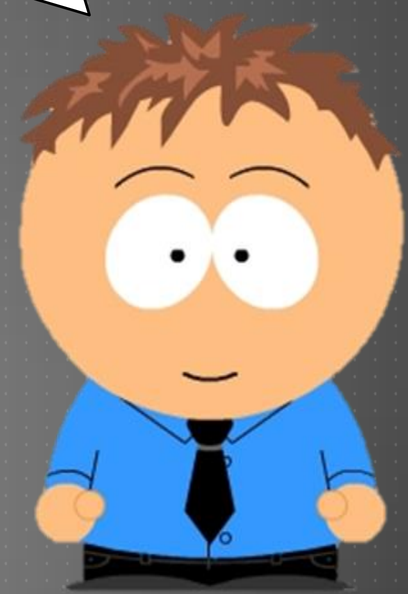
INTEGRATION TECHNIQUES

Powers of x

e.g. $\int 5x^3 + 4 \quad dx$

$\frac{5}{4}x^4 \quad +4x \quad +C$

And subtract the result



Including limits

e.g. $\int_{-1}^{2} 5x^3 + 4 \ \mathrm{dx}$

$= \left[\frac{5}{4}x^4 + 4x\right]_{-1}^{2}$

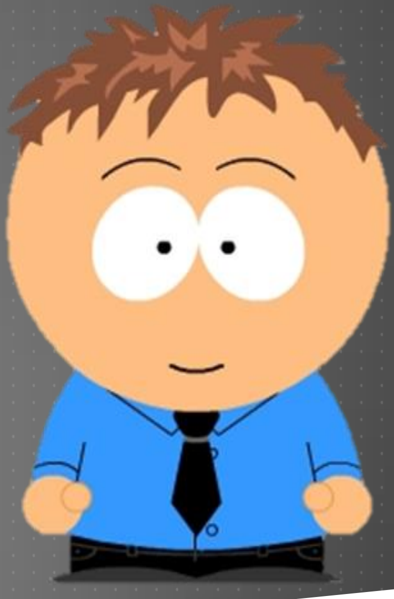
$= \left[\frac{5}{4}(2)^4 + 4(2)\right] - \left[\frac{5}{4}(1)^4 + 4(1)\right]$

$28 \quad - \quad -2\frac{3}{4}$

$= \mathbf{30\frac{3}{4}}$

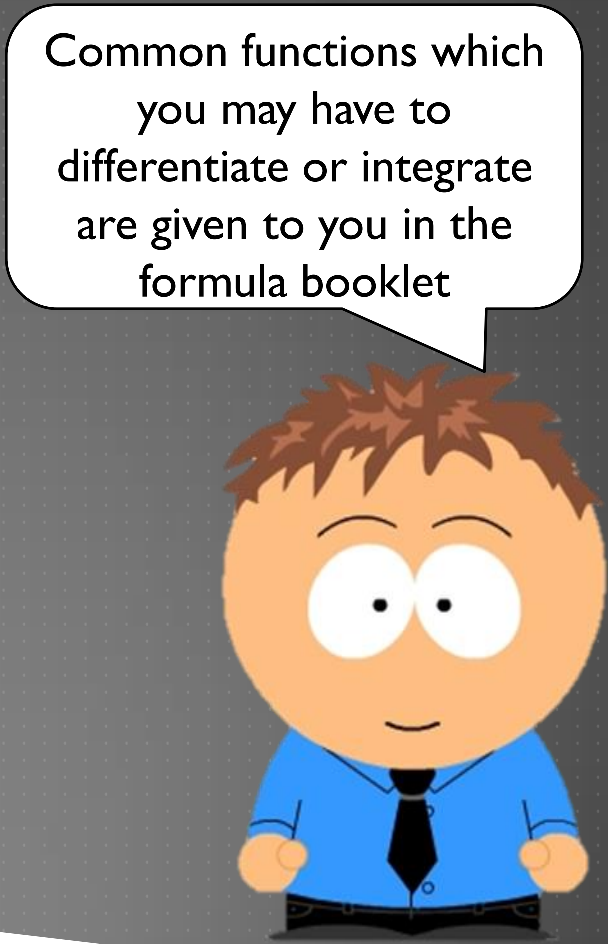
STANDARD DERIVATIVES AND INTEGRALS

Trigonometric and Exponential Functions



STANDARD DERIVATIVES AND INTEGRALS

Trigonometric and Exponential Functions



STANDARD DERIVATIVES AND INTEGRALS

Trigonometric and Exponential Functions

Derivatives

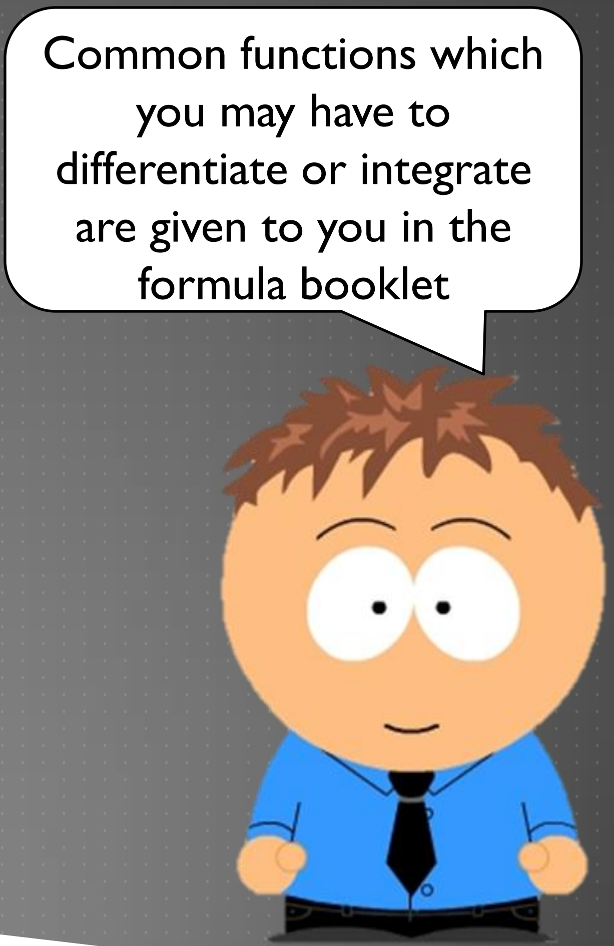
$$f(x) = \sin x \quad \Rightarrow \quad f'(x) = \cos x$$

$$f(x) = \cos x \quad \Rightarrow \quad f'(x) = -\sin x$$

$$f(x) = \tan x \quad \Rightarrow \quad f'(x) = \frac{1}{\cos^2 x}$$

$$f(x) = e^x \quad \Rightarrow \quad f'(x) = e^x$$

$$f(x) = \ln x \quad \Rightarrow \quad f'(x) = \frac{1}{x}$$



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$$f(x) = \ln x \quad \Rightarrow \quad f'(x) = \frac{1}{x}$$

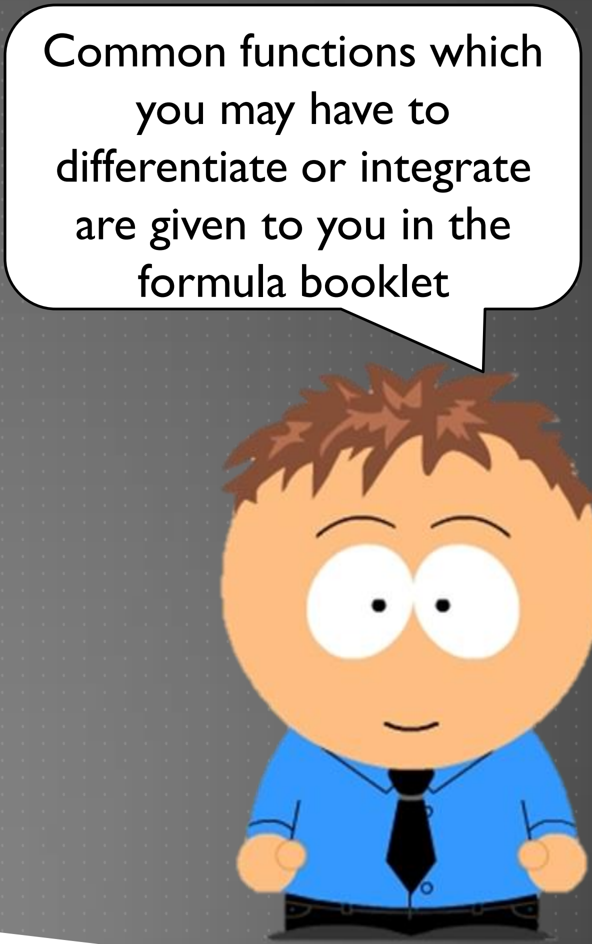
Integrals

$$\int \frac{1}{x}\,dx = \ln x + C, \;\; x > 0$$

$$\int \sin x\,dx = -\cos x + C$$

$$\int \cos x\,dx = \sin x + C$$

$$\int e^x\,dx = e^x + C$$



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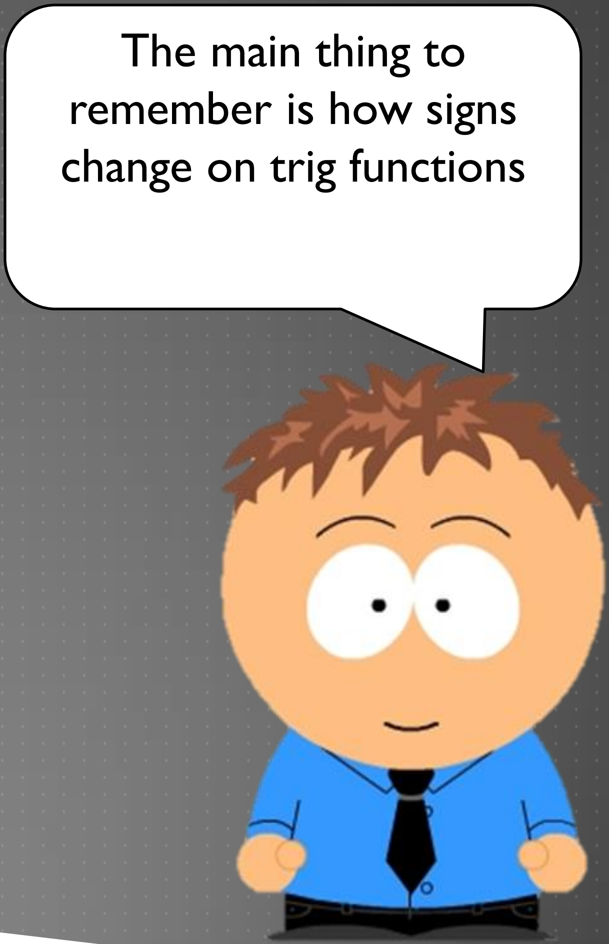

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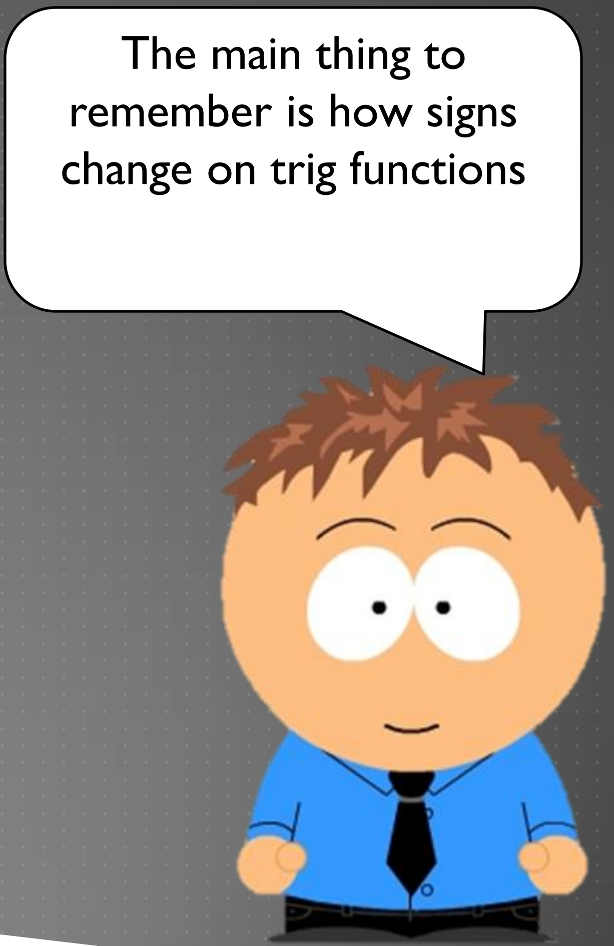

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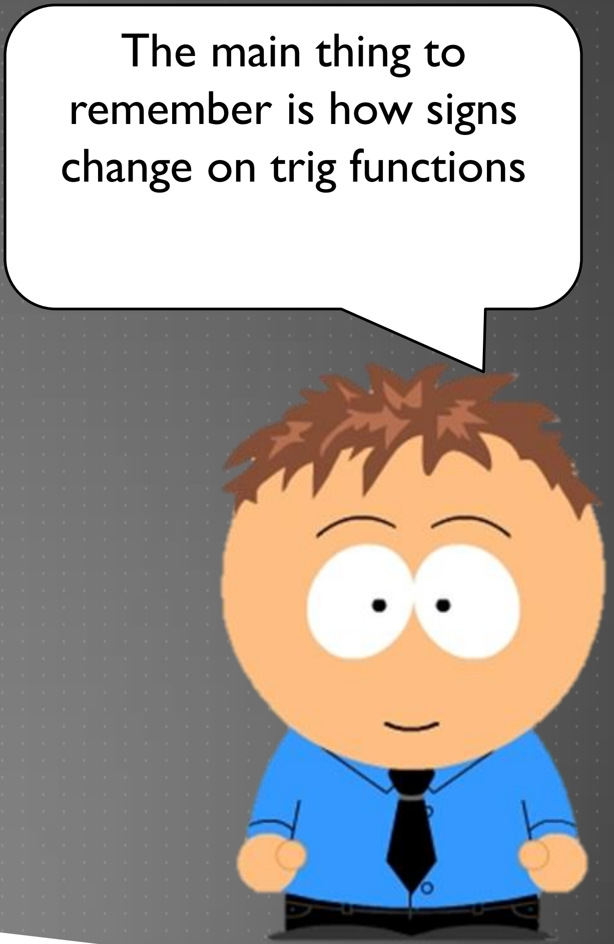
$$\int e^x\,dx = e^x + C$$

$\sin(x)$ $\cos(x)$

$-\cos(x)$ $-\sin(x)$



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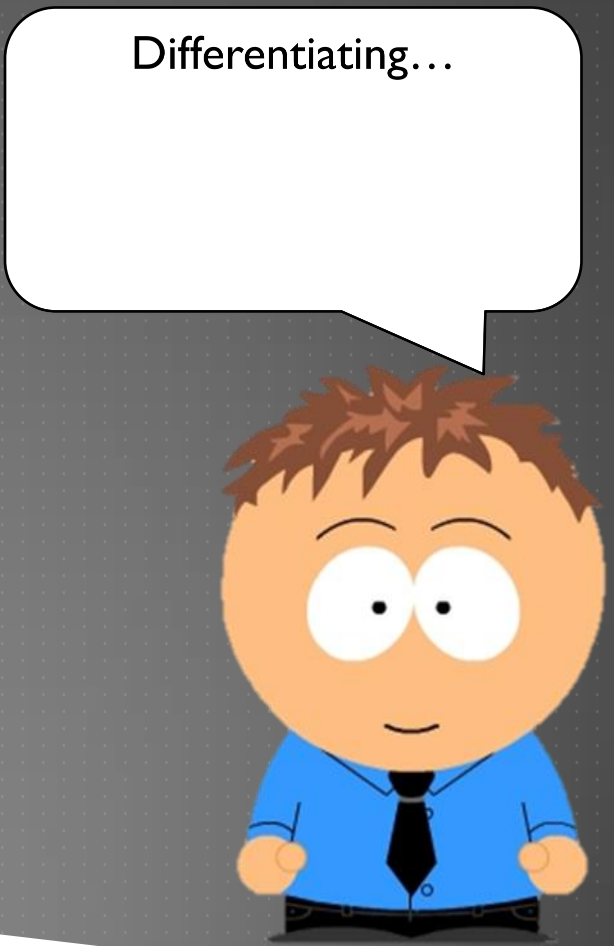
$$\int \cos x\,\mathrm{d}x = \sin x + C$$

$$\int \mathrm{e}^x\,\mathrm{d}x = \mathrm{e}^x + C$$

$$\begin{tikzcd}
\sin(x) \arrow[r] & \cos(x) \arrow[d] \\
-\cos(x) \arrow[u] & -\sin(x) \arrow[l]
\end{tikzcd}$$



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$$\int \mathrm{e}^x\,\mathrm{d}x = \mathrm{e}^x + C$$