

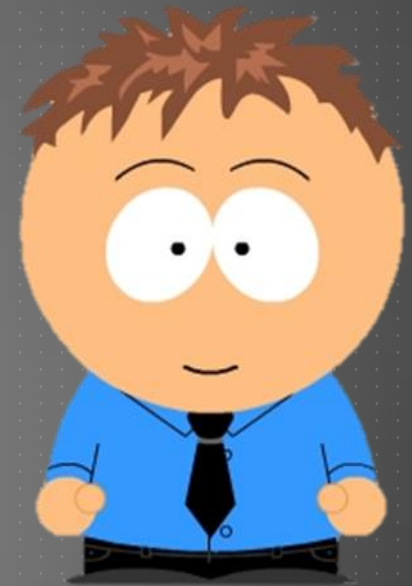
DIFFERENTIATION AND INTEGRATION PART I

Mr C's IB Standard Notes

In this PDF you can find the following:

1. [Notation](#)
2. [Keywords](#)
3. [Basic Methods](#)
4. [Standard Derivatives and Integrals](#)

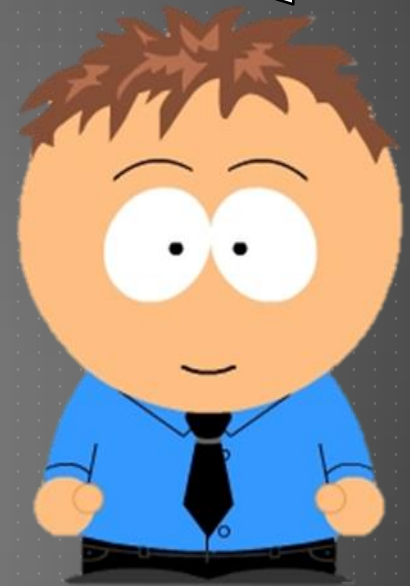
Make sure you read through everything and then try examples for yourself before looking at the solutions



NOTATION

Writing derivatives and integrals

Functions are typically written
two different ways

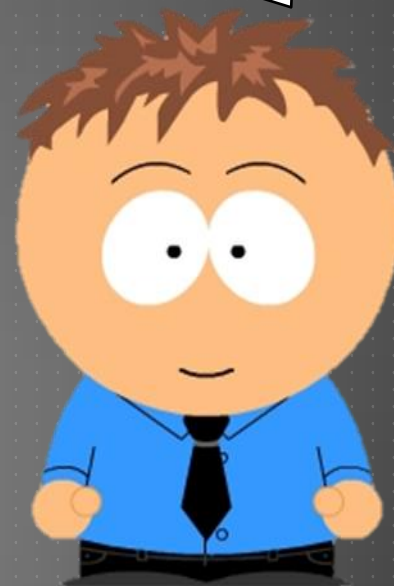


NOTATION

Writing derivatives and integrals

$$y = e^x + \sin(2x) + \dots$$

$y = \dots$

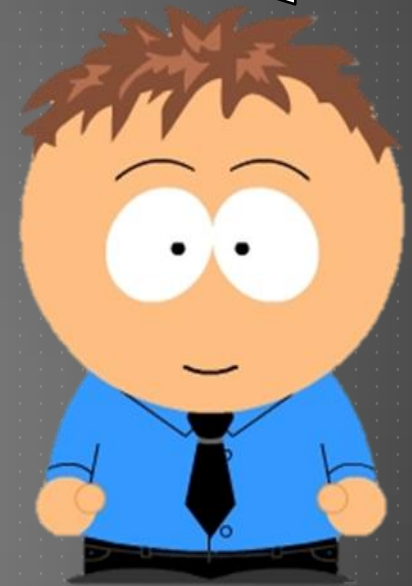


NOTATION

Writing derivatives and integrals

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

Or $f(x) = \dots$



NOTATION

Writing derivatives and integrals

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

We have different ways to write derivatives

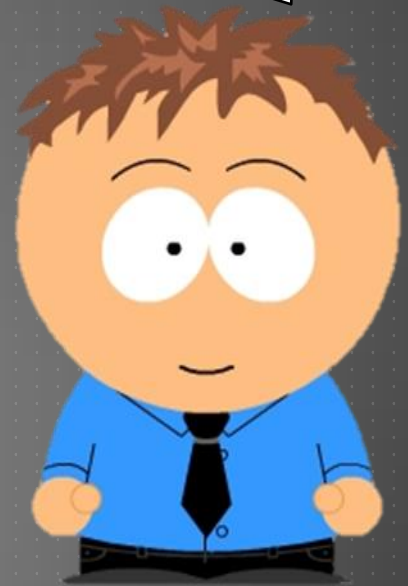


NOTATION

Writing derivatives and integrals

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

1st Derivative



NOTATION

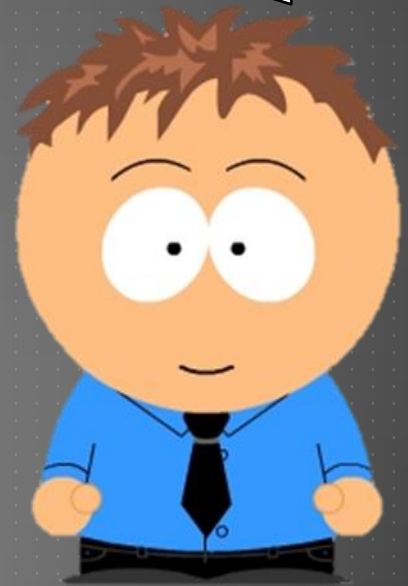
Writing derivatives and integrals

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

$$\frac{dy}{dx} = \dots$$

$$f'(x) = \dots$$

1st Derivative



NOTATION

Writing derivatives and integrals

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

$$\frac{dy}{dx} = \dots$$

$$f'(x) = \dots$$

2nd Derivative
(differentiate again)



NOTATION

Writing derivatives and integrals

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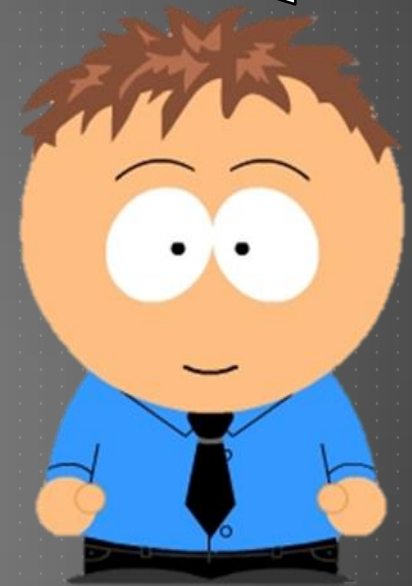
$$\frac{dy}{dx} = \dots$$

$$f'(x) = \dots$$

$$\frac{d^2y}{dx^2} = \dots$$

$$f''(x) = \dots$$

2nd Derivative
(differentiate again)



NOTATION

Writing derivatives and integrals

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

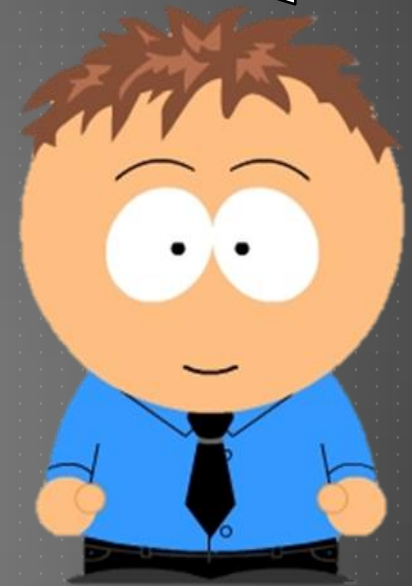
$$\frac{dy}{dx} = \dots$$

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3rd Derivative
(and again)



NOTATION

Writing derivatives and integrals

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

$$\frac{dy}{dx} = \dots$$

$$f'(x) = \dots$$

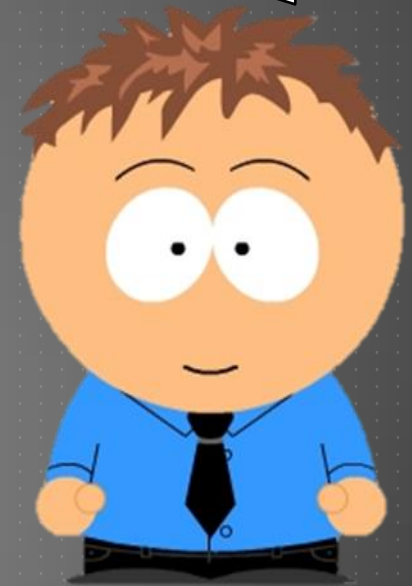
$$\frac{d^2y}{dx^2} = \dots$$

$$f''(x) = \dots$$

$$\frac{d^3y}{dx^3} = \dots$$

$$f^{(3)}(x) = \dots$$

3rd Derivative
(and again)



NOTATION

Writing derivatives and integrals

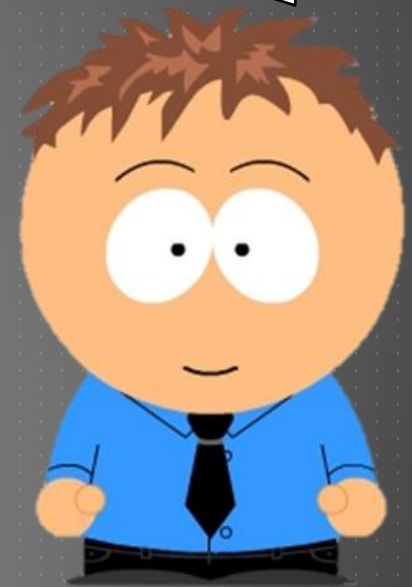
$$y = e^x + \sin(2x) + \dots \quad f(x) = e^x + \sin(2x) + \dots$$

$$\frac{dy}{dx} = \dots \quad f'(x) = \dots$$

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

$$\frac{d^3y}{dx^3} = \dots \quad f^{(3)}(x) = \dots$$

4th Derivative
(yet again)



NOTATION

Writing derivatives and integrals

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

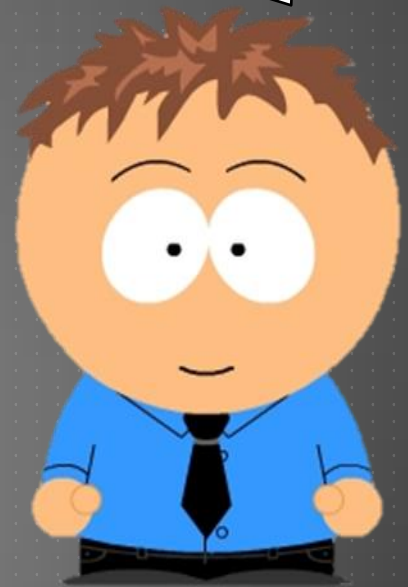
$$\frac{dy}{dx} = \dots \quad f'(x) = \dots$$

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

$$\frac{d^3y}{dx^3} = \dots \quad f^{(3)}(x) = \dots$$

$$\frac{d^4y}{dx^4} = \dots \quad f^{(4)}(x) = \dots$$

4th Derivative
(yet again)



NOTATION

Writing derivatives and integrals

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

$$\frac{dy}{dx} = \dots$$

$$f'(x) = \dots$$

$$\frac{d^2y}{dx^2} = \dots$$

$$f''(x) = \dots$$

$$\frac{d^3y}{dx^3} = \dots$$

$$f^{(3)}(x) = \dots$$

$$\frac{d^4y}{dx^4} = \dots$$

$$f^{(4)}(x) = \dots$$

And so on...



NOTATION

Writing derivatives and integrals

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

$$\frac{dy}{dx} = \dots$$

$$f'(x) = \dots$$

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$$\frac{d^3y}{dx^3} = \dots$$

$$f^{(3)}(x) = \dots$$

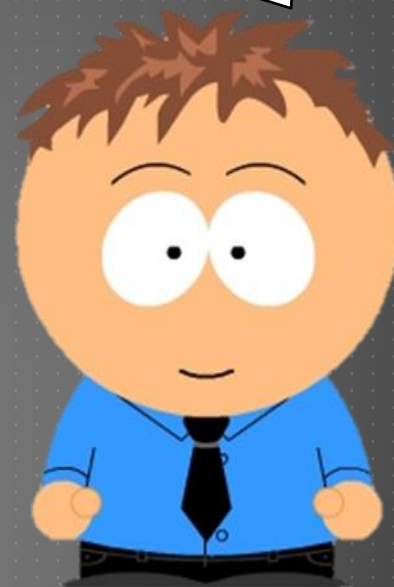
$$\frac{d^4y}{dx^4} = \dots$$

$$f^{(4)}(x) = \dots$$

$$\frac{d^ny}{dx^n} = \dots$$

$$f^{(n)}(x) = \dots$$

And so on...

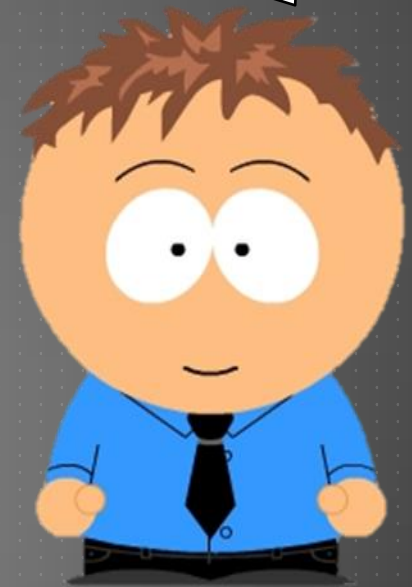


NOTATION

Writing derivatives and integrals

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

When we integrate we always
write it the same way



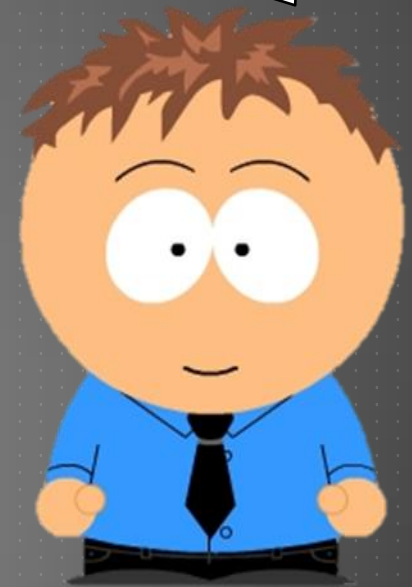
NOTATION

Writing derivatives and integrals

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

$$\int y \, dx = \dots \quad \int f(x) \, dx = \dots$$

When we integrate we always
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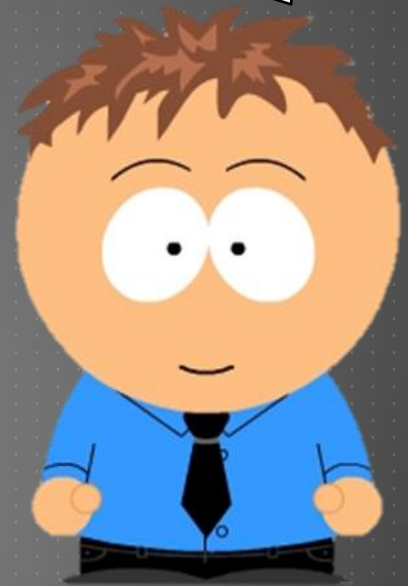
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$$\int y \, dx = \dots \quad \int f(x) \, dx = \dots$$

Make sure to include the variable you are integrating with respect to



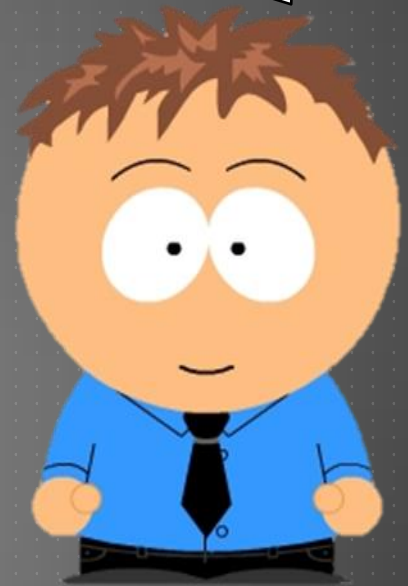
NOTATION

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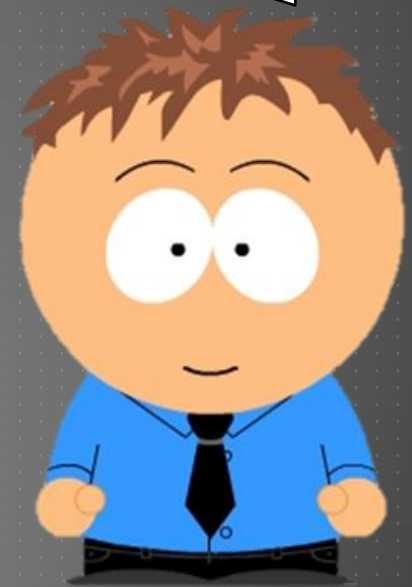
NOTATION

Writing derivatives and integrals

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$$\int y \, \underline{dx} = \dots \quad \int f(x) \, \underline{dx} = \dots$$

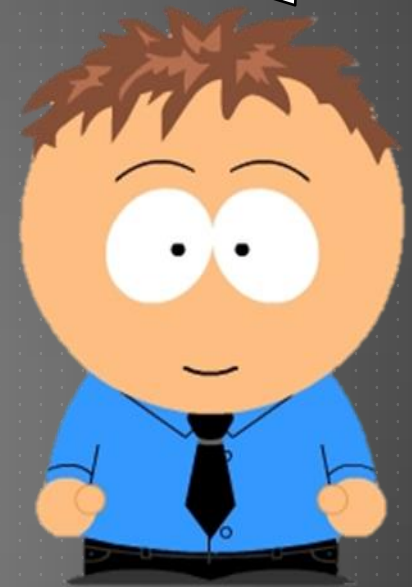
This is the same as the variable
in the equation (in our case x)



NOTATION

Writing derivatives and integrals

Sometimes the question may use different lettered variables

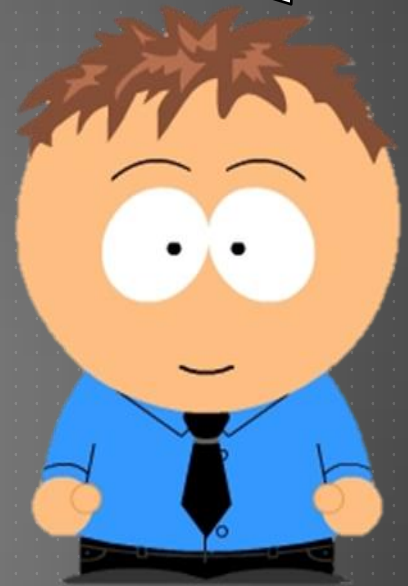


NOTATION

Writing derivatives and integrals

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

Sometimes the question may use different lettered variables



NOTATION

Writing derivatives and integrals

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

Just make sure to write the
correct derivative or integral



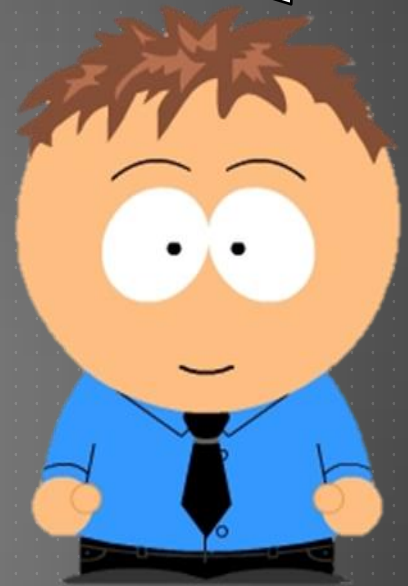
NOTATION

Writing derivatives and integrals

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

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

Just make sure to write the correct derivative or integral



NOTATION

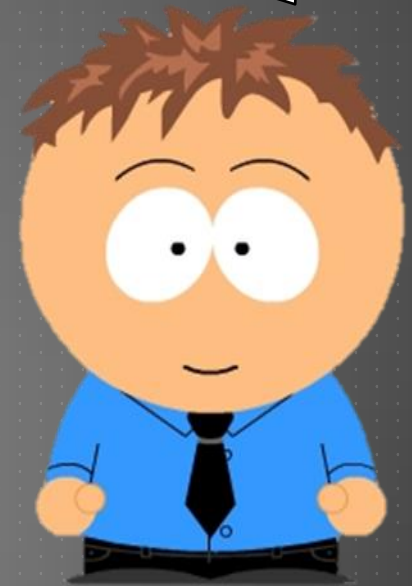
Writing derivatives and integrals

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

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

$$\int A dt = \dots$$

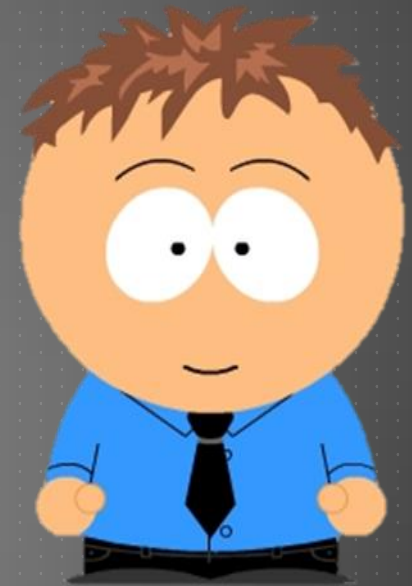
Just make sure to write the correct derivative or integral



KEYWORDS

When do I **differentiate**?

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

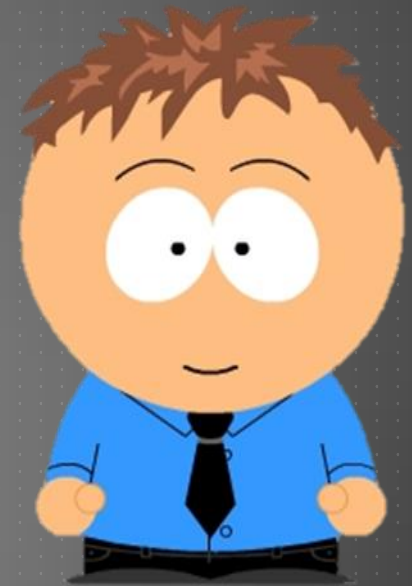


KEYWORDS

When do I differentiate?

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

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



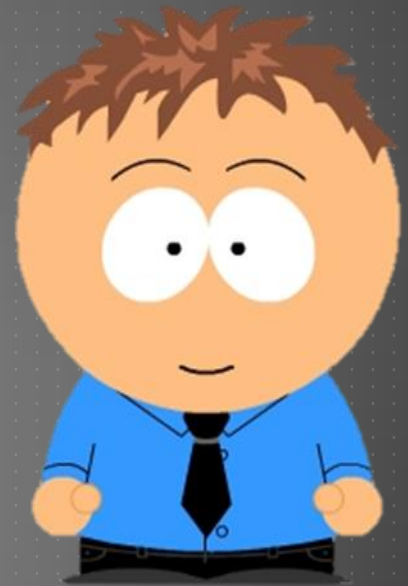
KEYWORDS

When do I differentiate?

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

Gradient

You might need to find the gradient of a function for a particular value of x



KEYWORDS

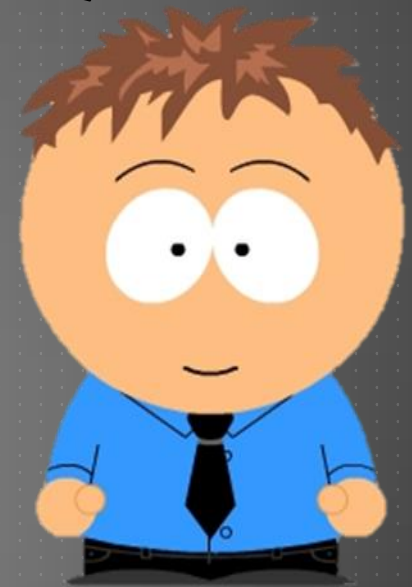
When do I differentiate?

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

Gradient

Equation of Tangent or Normal

If you want to work out normals,
you must first find the gradient
and then take the negative
reciprocal ($3 \rightarrow -\frac{1}{3}$)



KEYWORDS

When do I differentiate?

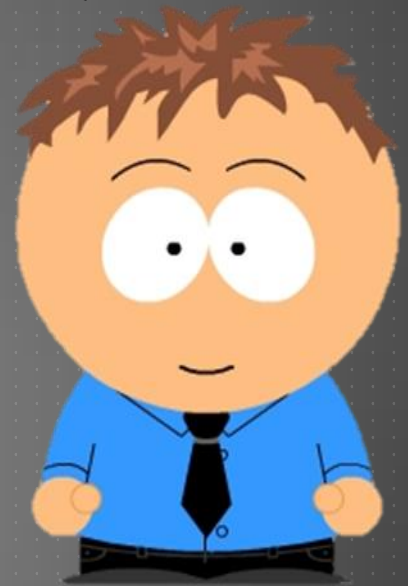
Find derivative, dy/dx , $f'(x)$

Gradient

Equation of Tangent or Normal

Rate of Change

Differentiation tells you how one variable changes with respect to another, e.g. differentiate speed w/r to time and get acceleration



KEYWORDS

When do I differentiate?

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

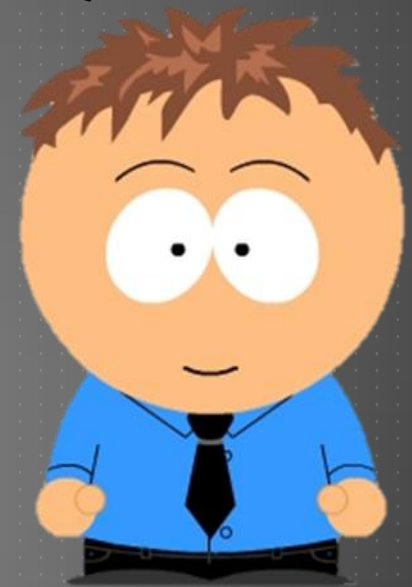
Gradient

Equation of Tangent or Normal

Rate of Change

Stationary points (max/min)

You might need to find
stationary or turning points of a
curve (where gradient = 0)



KEYWORDS

When do I differentiate?

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

Gradient

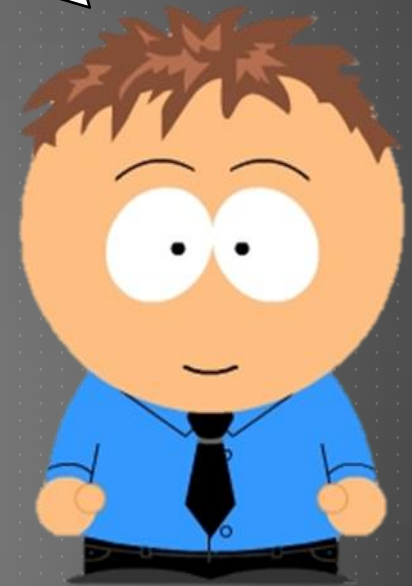
Equation of Tangent or Normal

Rate of Change

Stationary points (max/min)

Finding Optimum Solutions
(best, largest, etc.)

Finding the maximum or minimum value for a function is its 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

Stationary points (max/min)

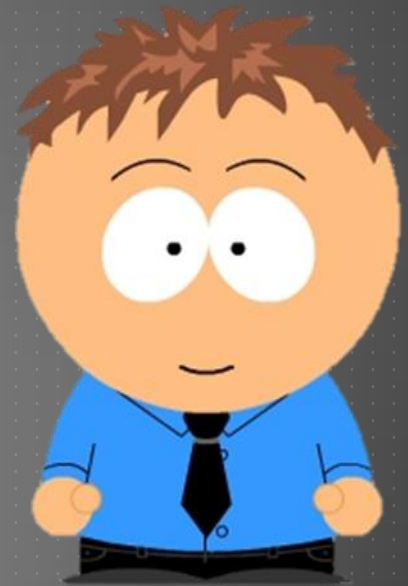
Finding Optimum Solutions
(best, largest, etc.)



KEYWORDS

When do I **integrate**?

There are fewer examples of
keywords to look for when
integrating

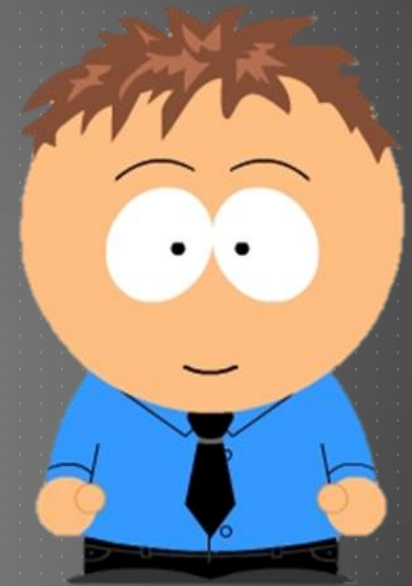


KEYWORDS

When do I **integrate**?

Find integral, $\int \dots$

Quite often you will simply be told to integrate, or given the integration symbol



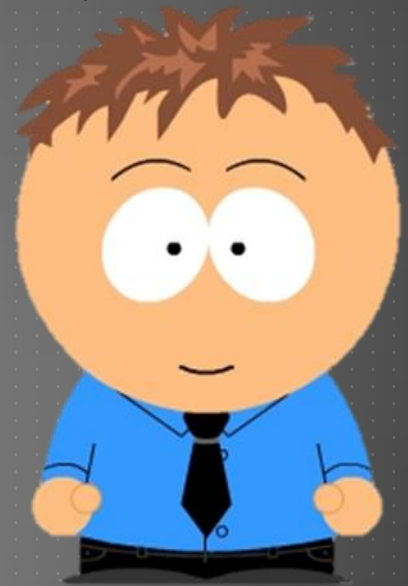
KEYWORDS

When do I **integrate**?

Find integral, $\int \dots$

Find the **Area**...

You may be asked to find a particular area (e.g. beneath a curve, bounded between two curves, etc.)



KEYWORDS

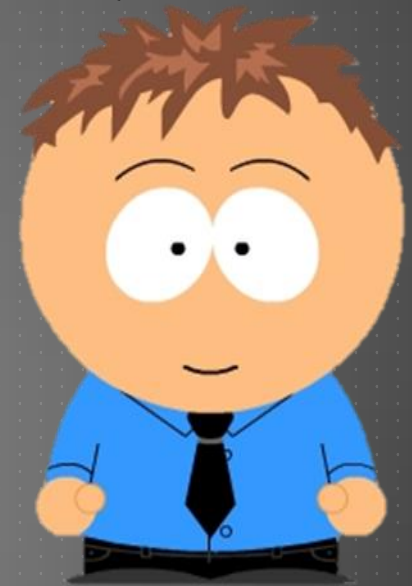
When do I **integrate**?

Find integral, $\int \dots$

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



KEYWORDS

When do I **integrate**?

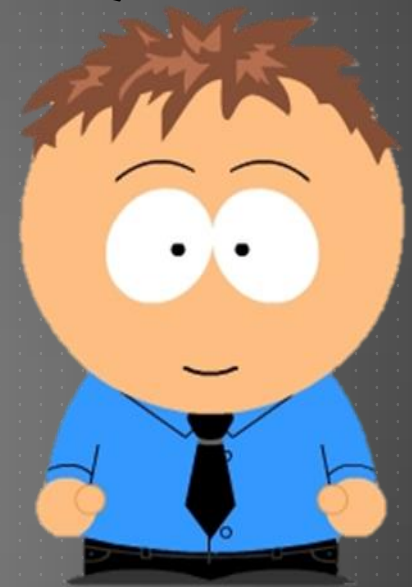
Find integral, $\int \dots$

Find the **Area**...

Volumes of Revolution

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

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.



KEYWORDS

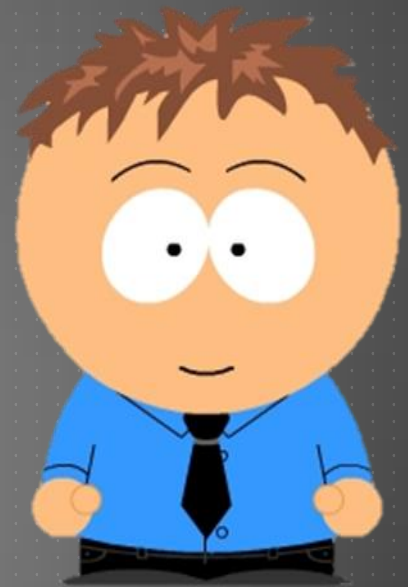
When do I **integrate**?

Find integral, $\int \dots$

Find the **Area**...

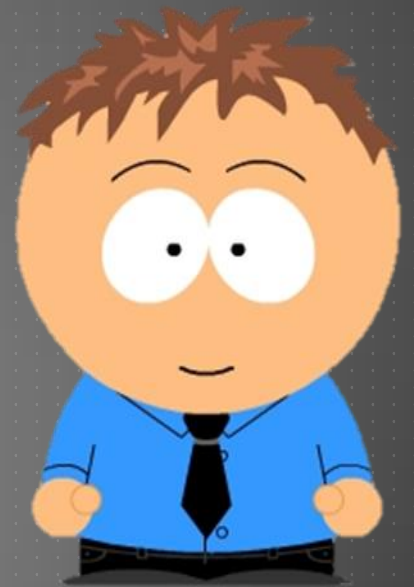
Volumes of Revolution

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



DIFFERENTIATION TECHNIQUES

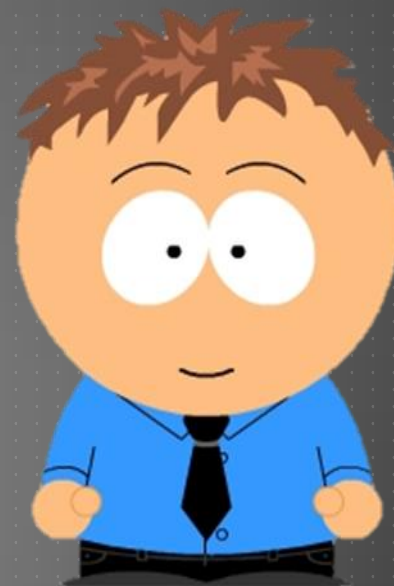
Powers of x



DIFFERENTIATION TECHNIQUES

Powers of x

Any expression consisting of terms using x^n can be differentiated the same way

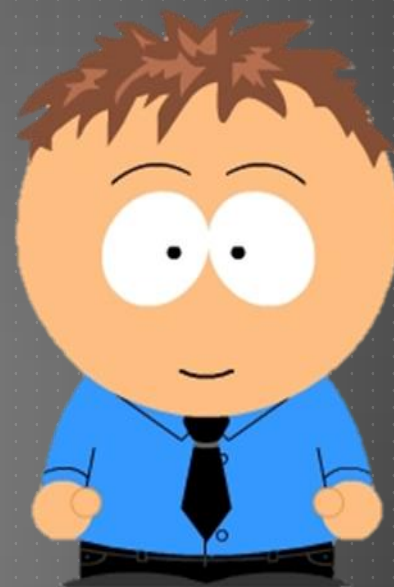


DIFFERENTIATION TECHNIQUES

Powers of x

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

Any expression consisting of terms using x^n can be differentiated the same way

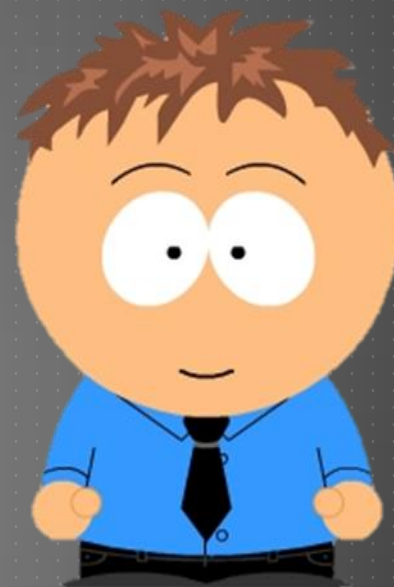


DIFFERENTIATION TECHNIQUES

Powers of x

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

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



DIFFERENTIATION TECHNIQUES

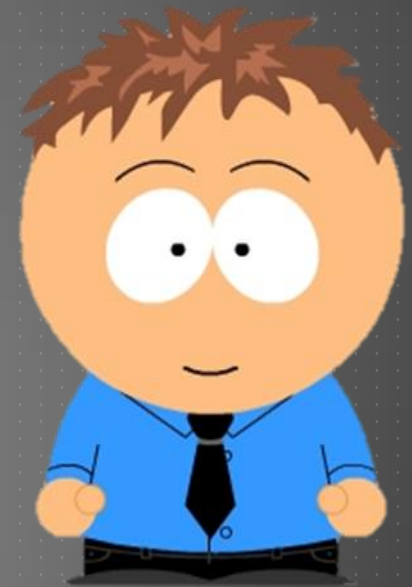
Powers of x

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

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

Multiply by the power
Subtract one from the power

$f'(x) = 4x$



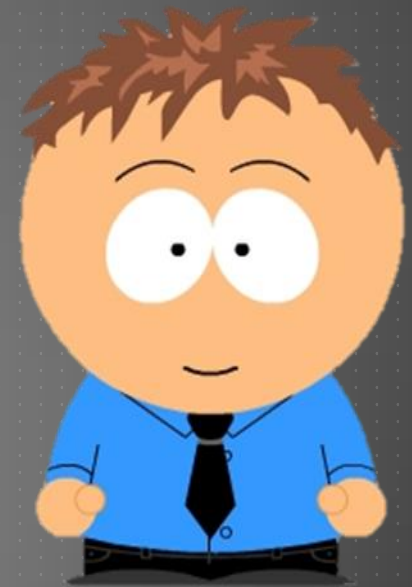
DIFFERENTIATION TECHNIQUES

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

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

Sometimes you might have to
rewrite using powers and rules
of indices



$$f'(x) = 4x$$

DIFFERENTIATION TECHNIQUES

Powers of x

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

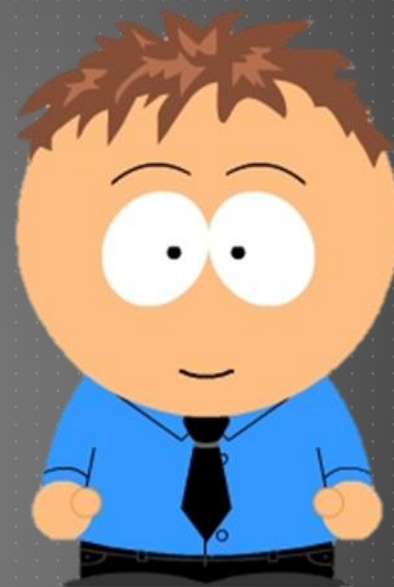
$$f(x) = x^n \Rightarrow f'(x) = nx^{n-1}$$

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



$$f'(x) = 4x$$

Sometimes you might have to
rewrite using powers and rules
of indices



DIFFERENTIATION TECHNIQUES

Powers of x

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

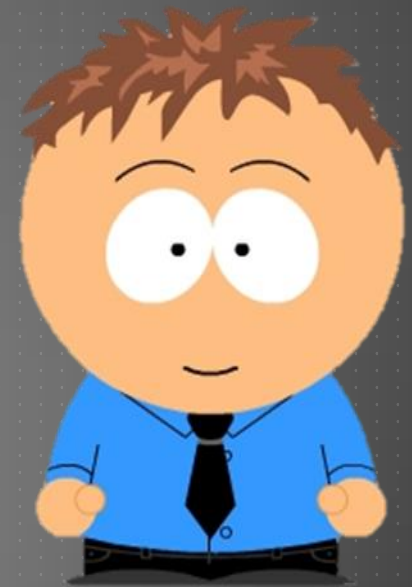
$$f(x) = x^n \Rightarrow f'(x) = nx^{n-1}$$

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

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

$$f'(x) = 4x$$

And then finally differentiate



DIFFERENTIATION TECHNIQUES

Powers of x

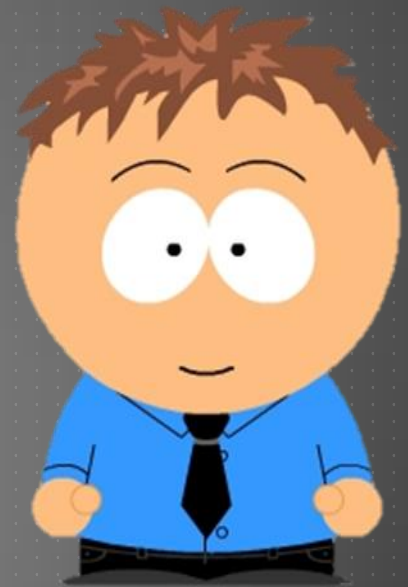
e.g. $2x^2 + \frac{\sqrt{x}}{x} - \frac{2x+1}{x^3} + 7$

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

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

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

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



DIFFERENTIATION TECHNIQUES

Powers of x

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

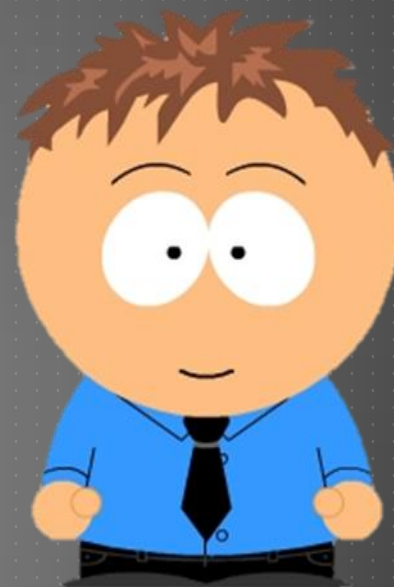
$$f(x) = x^n \Rightarrow f'(x) = nx^{n-1}$$

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

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

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

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



DIFFERENTIATION TECHNIQUES

Powers of x

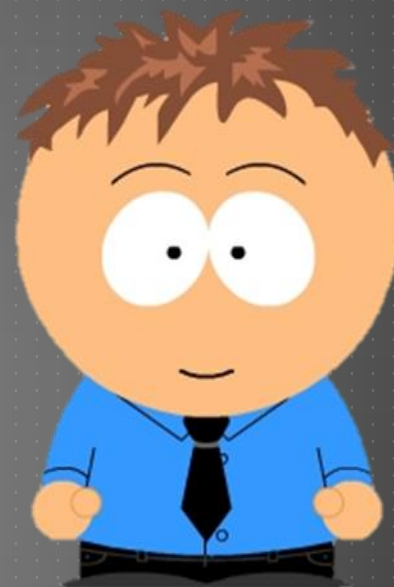
e.g. $2x^2 + \frac{\sqrt{x}}{x} - \frac{2x+1}{x^3} + 7$

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

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

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

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



DIFFERENTIATION TECHNIQUES

Powers of x

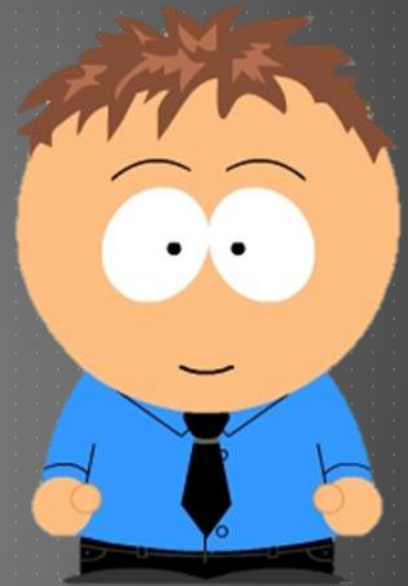
e.g. $2x^2 + \frac{\sqrt{x}}{x} - \frac{2x+1}{x^3} + 7$

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

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

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

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



DIFFERENTIATION TECHNIQUES

Powers of x

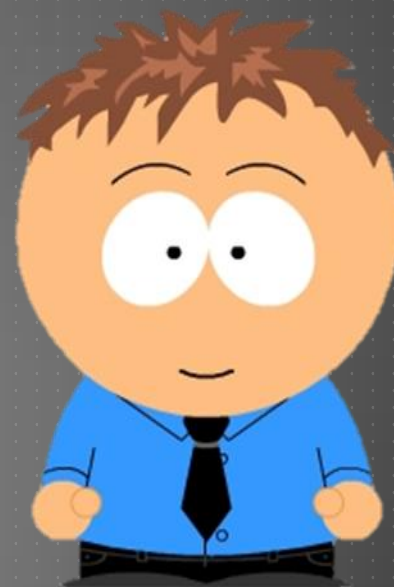
e.g. $2x^2 + \frac{\sqrt{x}}{x} - \frac{2x+1}{x^3} + 7$

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

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

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

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



DIFFERENTIATION TECHNIQUES

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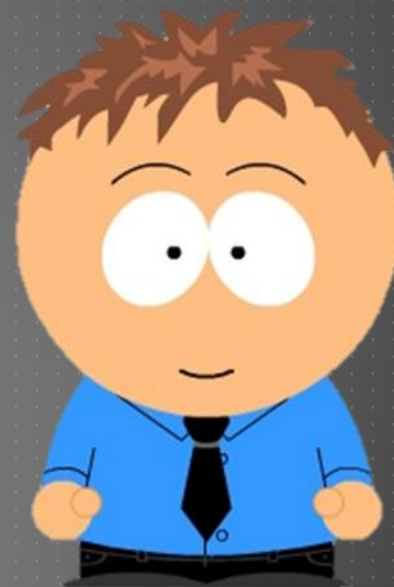
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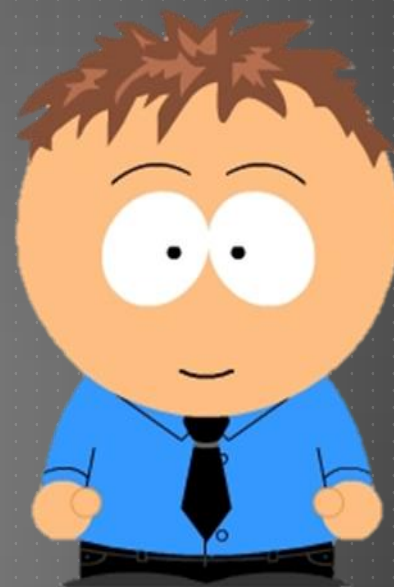
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$$f'(x) = 4x - \frac{1}{2}x^{-\frac{3}{2}} + 4x^{-3} - 3x^{-4} + 0$$

When you differentiate a constant it disappears (7 is $7x^0$), multiplying by 0 makes it all 0



DIFFERENTIATION TECHNIQUES

Powers of x

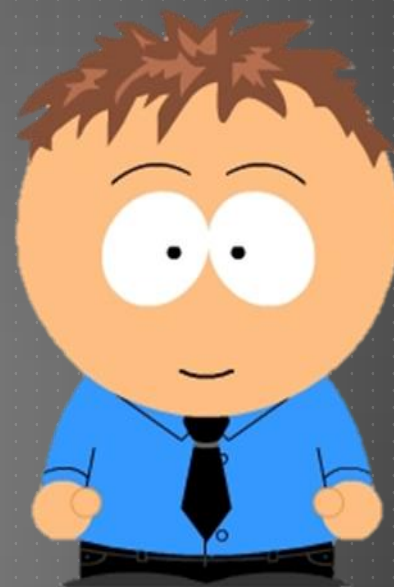
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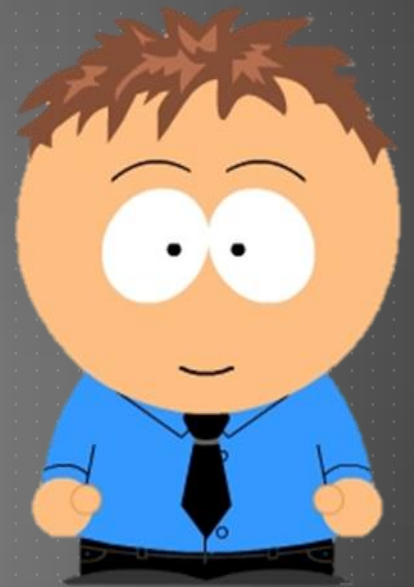
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INTEGRATION TECHNIQUES

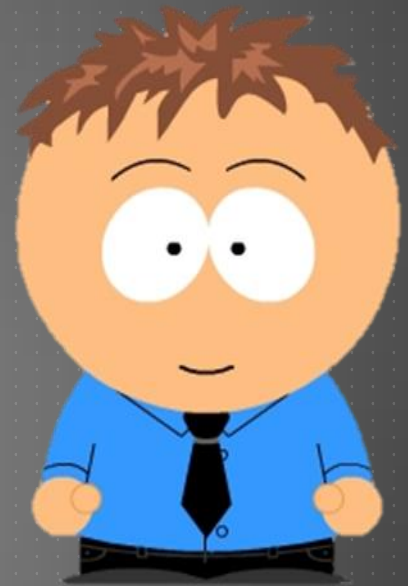
Powers of x



INTEGRATION TECHNIQUES

Powers of x

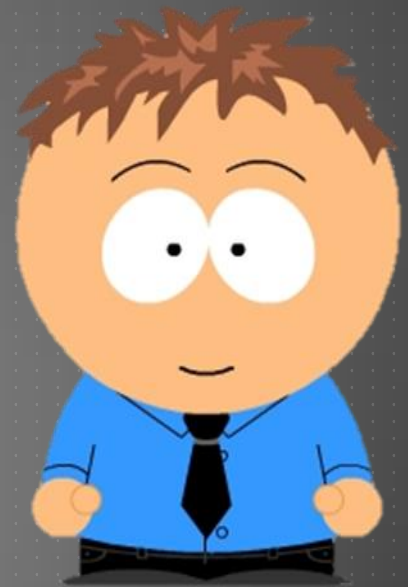
Integration is the reverse of
differentiation



INTEGRATION TECHNIQUES

Powers of x

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



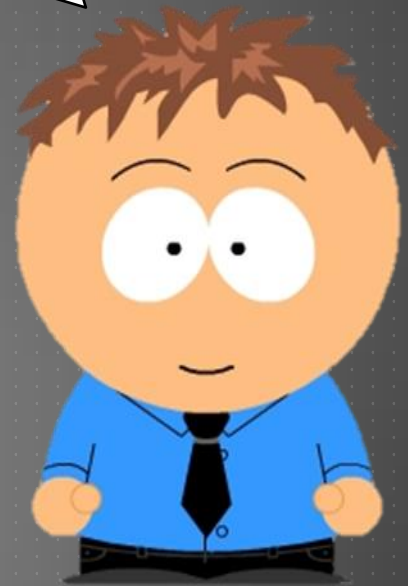
INTEGRATION TECHNIQUES

Powers of x

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

To differentiate you:
x power, -1 from power

Therefore to integrate you:
+1 to power, \div power



INTEGRATION TECHNIQUES

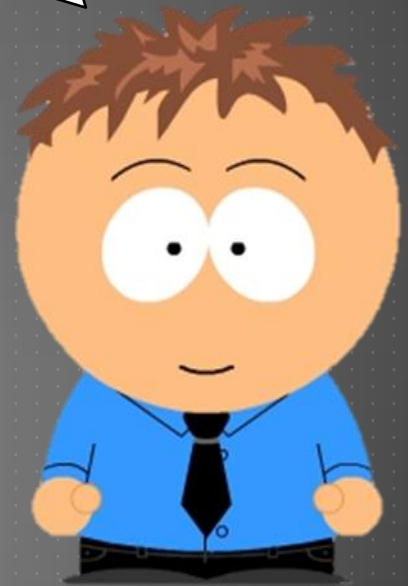
Powers of x

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

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

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INTEGRATION TECHNIQUES

Powers of x

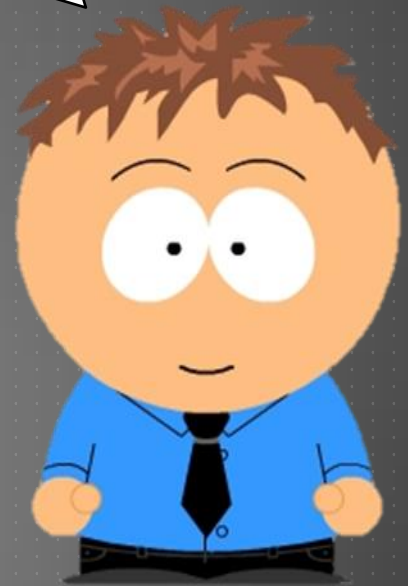
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$$\frac{5}{4}x^4$$

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INTEGRATION TECHNIQUES

Powers of x

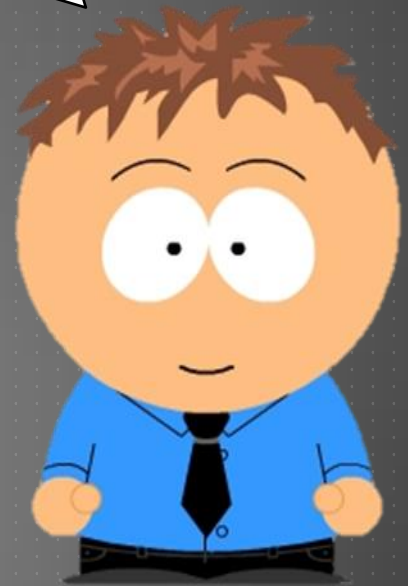
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$$\frac{5}{4}x^4$$

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

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



INTEGRATION TECHNIQUES

Powers of x

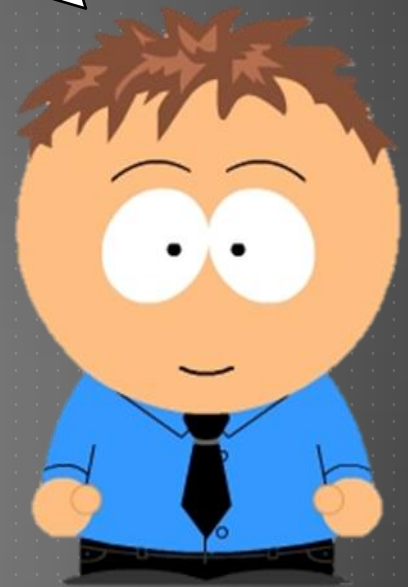
e.g. $\int 5x^3 + 4 \, dx$

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

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

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

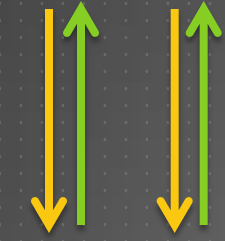
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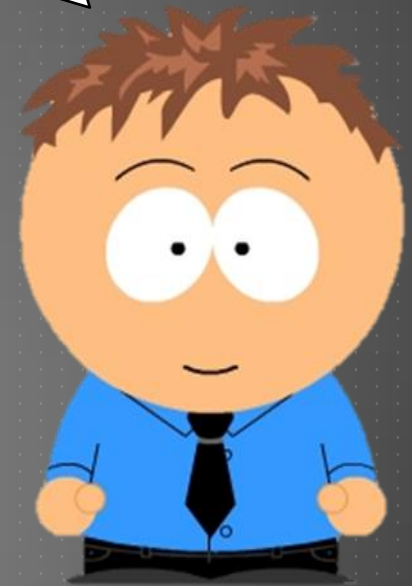
INTEGRATION TECHNIQUES

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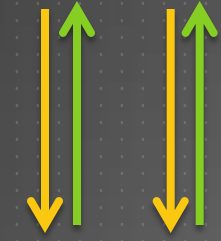
At this point it looks as though we are correct. The integral we have can be differentiated and give the original expression



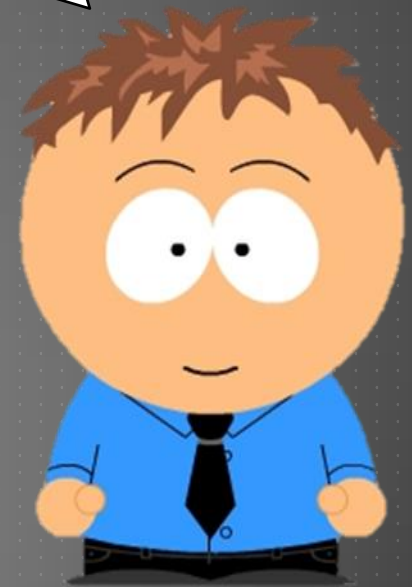
INTEGRATION TECHNIQUES

Powers of x

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


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

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

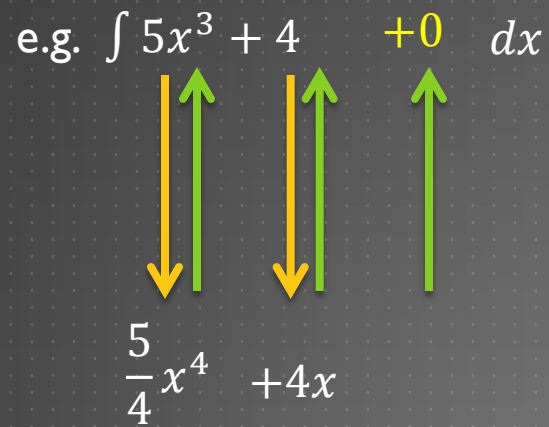


INTEGRATION TECHNIQUES

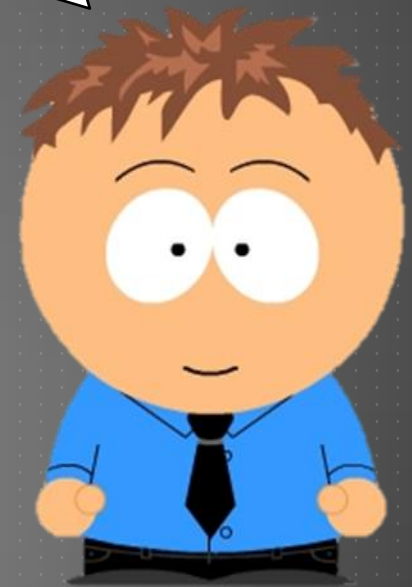
Powers of x

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

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



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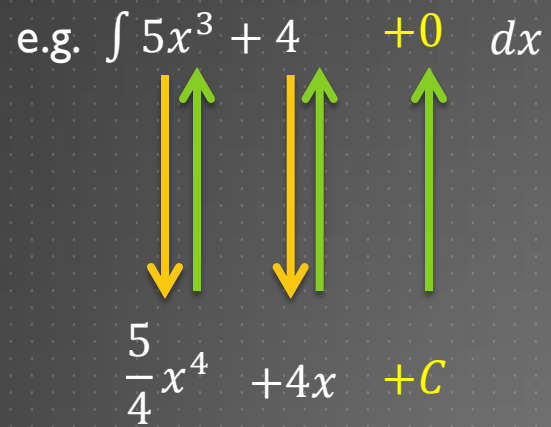


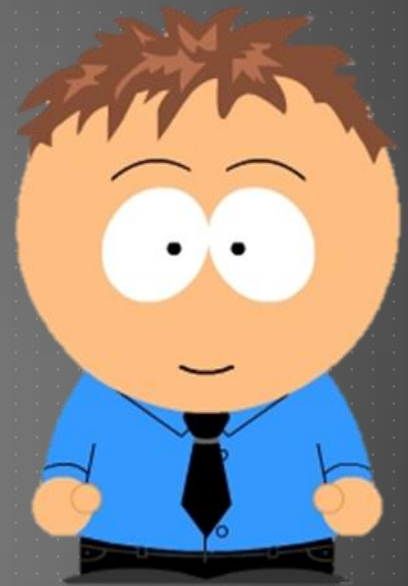
INTEGRATION TECHNIQUES

Powers of x

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

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



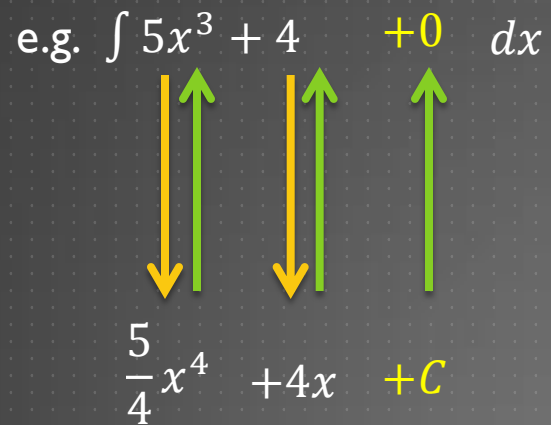


INTEGRATION TECHNIQUES

Powers of x

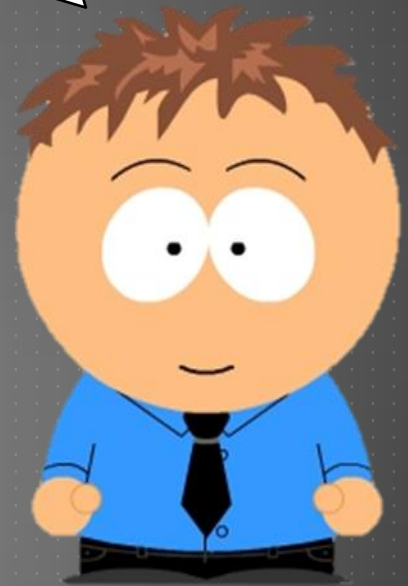
e.g. $\int 5x^3 + 4 + 0 \, dx$

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This is our *constant of integration, C*

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



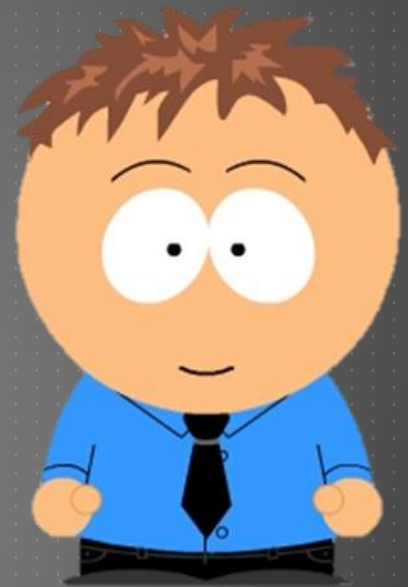
INTEGRATION TECHNIQUES

Powers of x

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

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

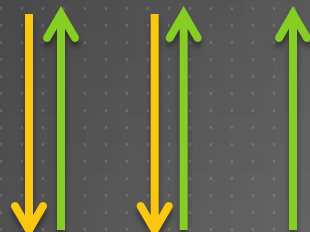
Including limits



INTEGRATION TECHNIQUES

Powers of x

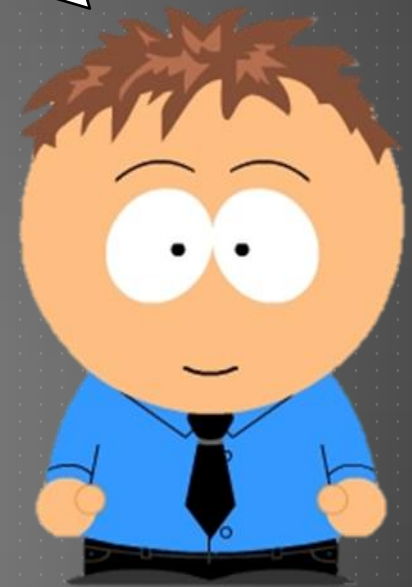
e.g. $\int 5x^3 + 4 \quad dx$



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

The one time you do not need to include C, is when you are evaluating the integral (known as a *definite integral*)

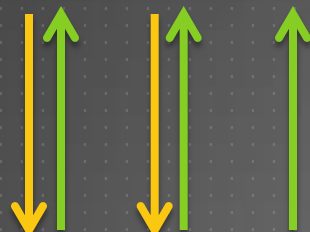
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INTEGRATION TECHNIQUES

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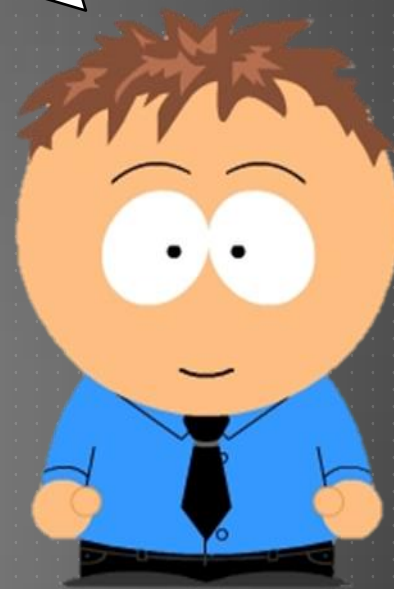


$\frac{5}{4}x^4 + 4x + C$

The limits tell you numbers to substitute into your final expression as x.

Including limits

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

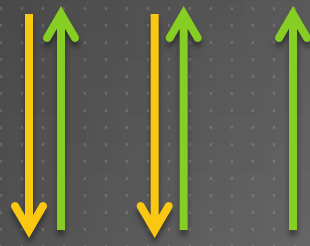


INTEGRATION TECHNIQUES

Powers of x

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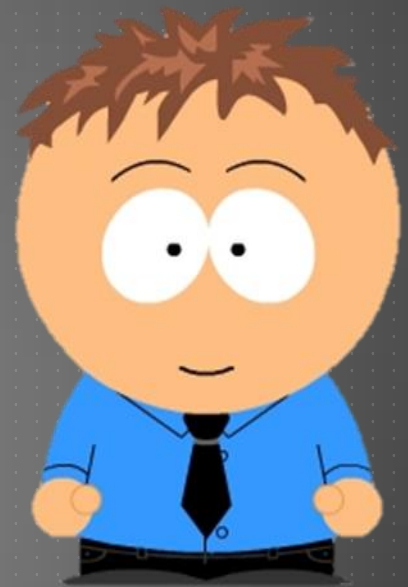
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Including limits

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

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

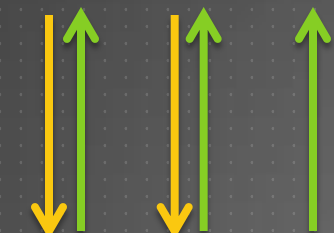


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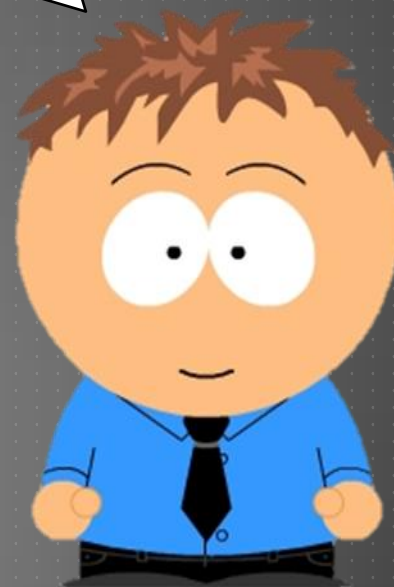


You first evaluate by
substituting the top number for
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Including limits

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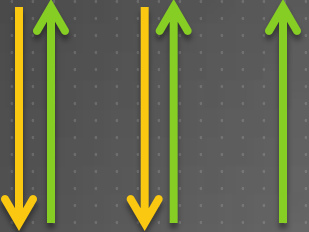


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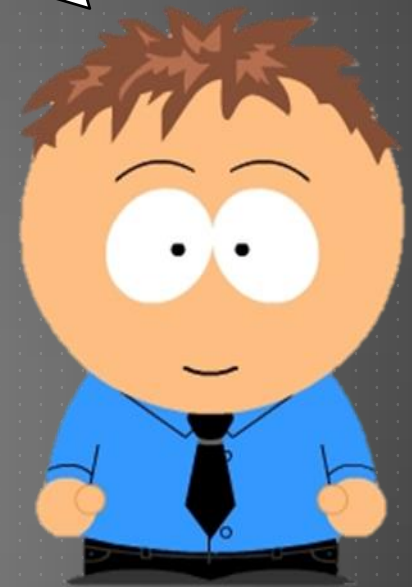


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e.g. $\int_{-1}^2 5x^3 + 4 \, dx$

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

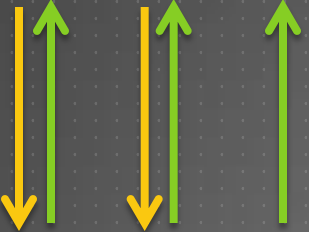


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You first evaluate by
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Including limits

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

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

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

$= 28 - \left[\frac{5}{4} - 4 \right]$

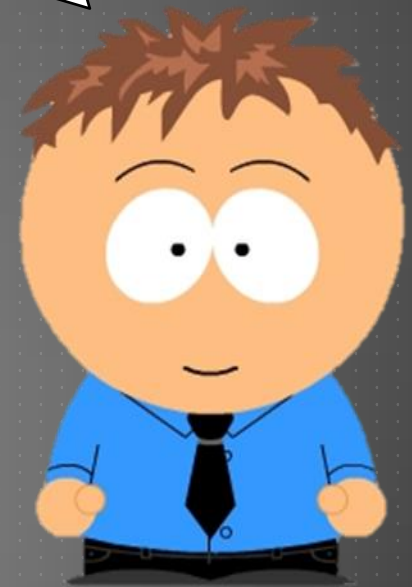
$= 28 - \left[\frac{5}{4} - \frac{16}{4} \right]$

$= 28 - \left[-\frac{11}{4} \right]$

$= 28 + \frac{11}{4}$

$= \frac{112}{4} + \frac{11}{4}$

$= \frac{123}{4}$

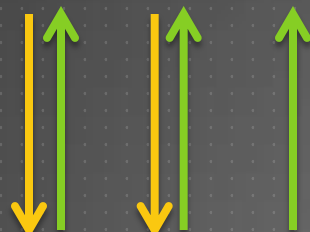


INTEGRATION TECHNIQUES

Powers of x

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

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



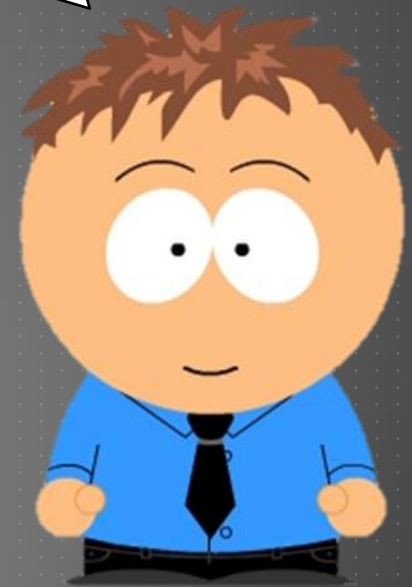
And then the bottom number

Including limits

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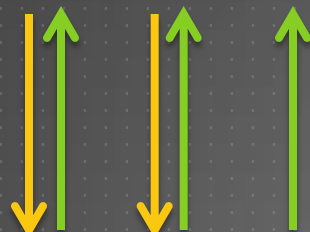


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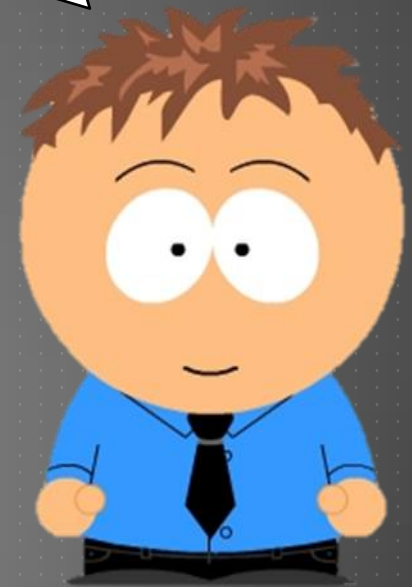
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28

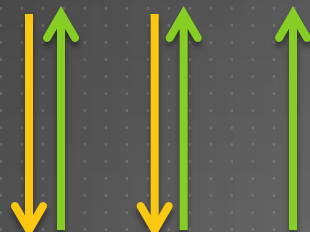


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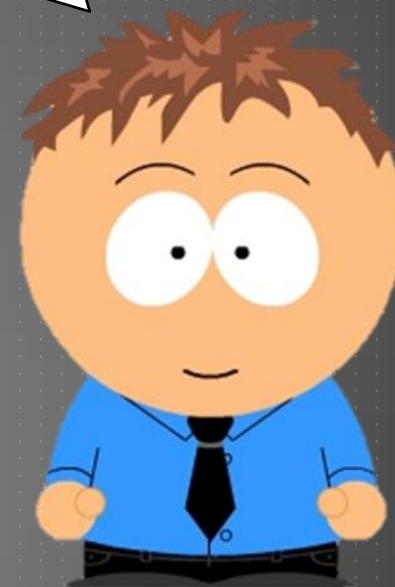
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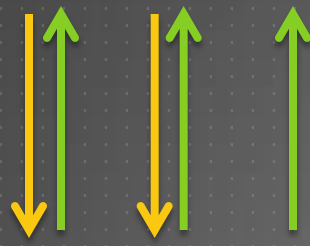


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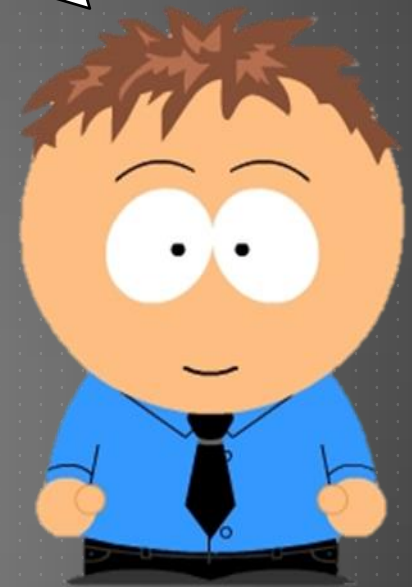


And subtract the result

Including limits

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

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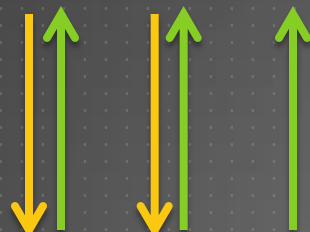


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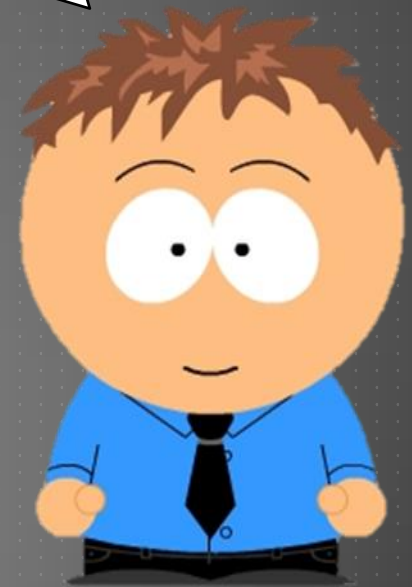


And subtract the result

Including limits

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

$$= \left[\frac{5}{4}x^4 + 4x \right]_{-1}^2$$
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$$= 28 - 2\frac{3}{4}$$

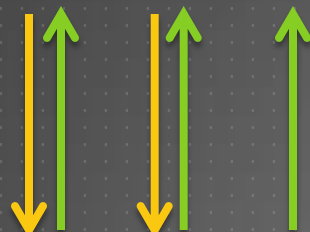


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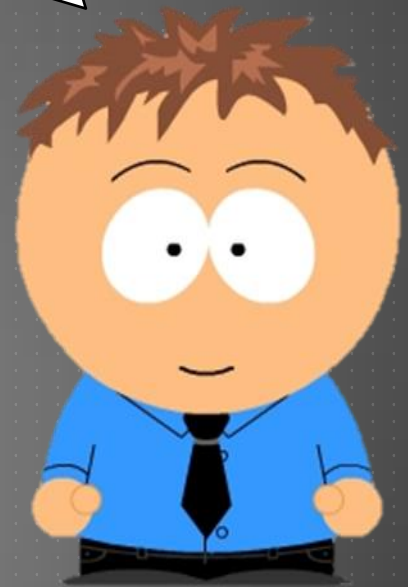


And subtract the result

Including limits

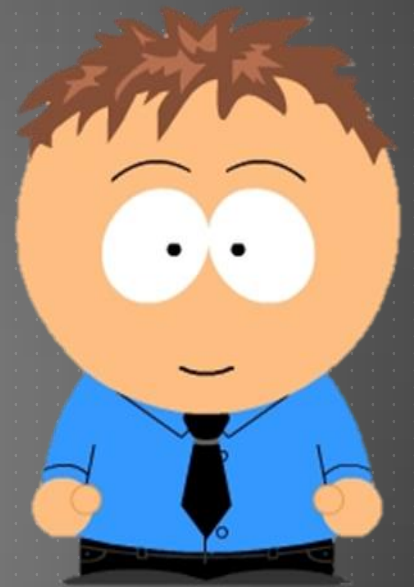
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$$= \left[\frac{5}{4}x^4 + 4x \right]_{-1}^2$$
$$= \left[\frac{5}{4}(2)^4 + 4(2) \right] - \left[\frac{5}{4}(1)^4 + 4(1) \right]$$
$$= 28 - 2\frac{3}{4}$$
$$= 30\frac{3}{4}$$



STANDARD DERIVATIVES AND INTEGRALS

Trigonometric and Exponential Functions



STANDARD DERIVATIVES AND INTEGRALS

Trigonometric and Exponential Functions

Common functions which you may have to differentiate or integrate are given to you in the formula booklet



STANDARD DERIVATIVES AND INTEGRALS

Trigonometric and Exponential Functions

Derivatives

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

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

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

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

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

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

Integrals

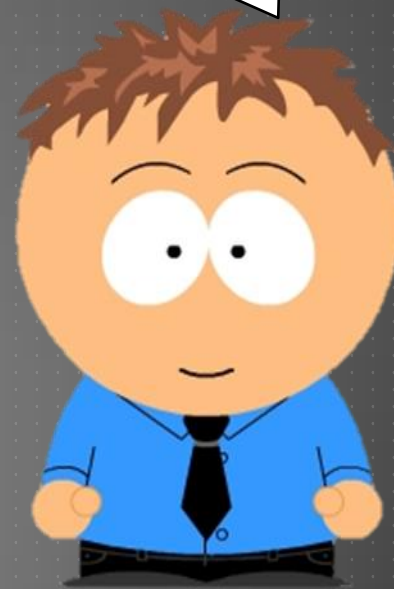
$$\int \frac{1}{x} dx = \ln x + C, x > 0$$

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

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

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

Common functions which you may have to differentiate or integrate are given to you in the formula booklet



STANDARD DERIVATIVES AND INTEGRALS

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

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

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Integrals

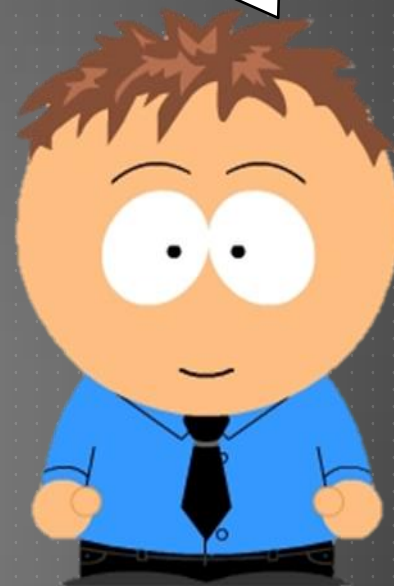
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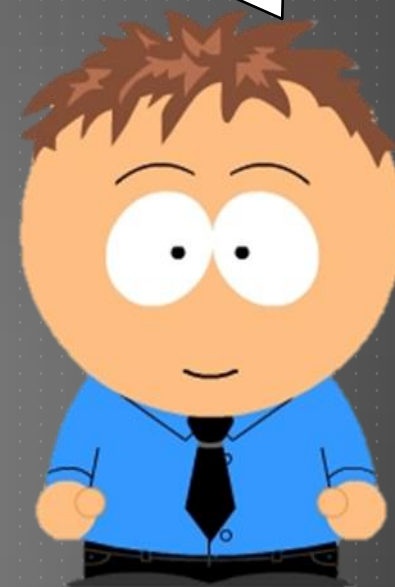
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$\sin(x)$

$\cos(x)$

$-\cos(x)$

$-\sin(x)$



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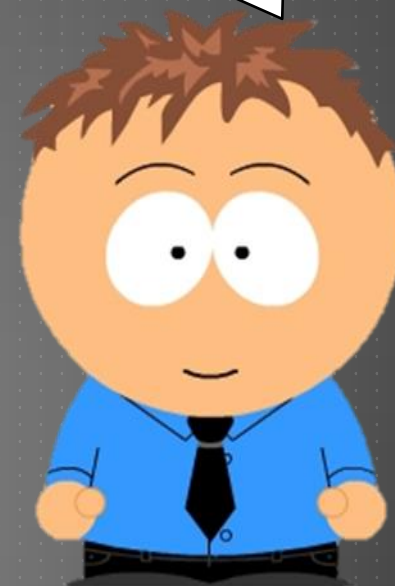
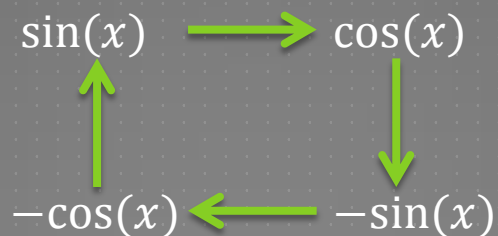
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Differentiating...



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And integrating...

