Derivative

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VT23

derivative

$$f(x) = 3x^2 + 4x + 5$$

$$f'(x) = 6x + 4$$

representation

How do we represent an expression?

- numbers : 2, 2.34, ...
- variables : x, y ...
- constants : π, ...
- operations : $2 + x$, $2 * y$, x^2 ...

The representation should be easy to work with.

How hard can it be?

$3x^2 + 2x + \pi$

```
"3x^2 + 2x + pi"
```

We need an Abstract Syntax Tree (AST).

AST: literals

- numbers: `{:num, 124}`, `{:num, 12.4}` ...
- variables: `{:var, :x}`, ...
- constants: `{:var, :pi}`, ...

```
@type literal() :: {:num, number()}
                 | {:var, atom()}
```


AST: expressions

- addition: `{:add, {:num, 124}, {:var, :pi}}`, ...
- multiplication: `{:mul, {:num, 2}, {:var, :x}}`, ...

```
@type expr() :: {:add, expr(), expr()}
              | {:mul, expr(), expr()}
              | literal()
```


parsing

```
"2 * x + 3"
```

```
{:add, {:mul, {:num, 2}, {:var, :x}}, {:num, 3}}
```

Building the AST is the job of the parser - not out problem.

the rules

These are the rules that we will use:

- $\frac{d}{dx}x \equiv 1$
- $\frac{d}{dx}c \equiv 0$ for any literal different from x
- $\frac{d}{dx}f + g \equiv \frac{d}{dx}f + \frac{d}{dx}g$
- $\frac{d}{dx}f \cdot g \equiv \frac{d}{dx}f \cdot g + f \cdot \frac{d}{dx}g$

let's do some coding

```
def deriv({:num, _}, _), do: ...

def deriv({:var, v}, v), do: ...

def deriv({:var, y}, _), do: ...

def deriv({:mul, e1, e2}, v), do: ...

def deriv({:add, e1, e2}, v), do: ...
```