Sympy Tutorial

- *sp.init_printing()* is specifically for SymPy mathematical expressions and sets a global display format used to print/display expressions in nice math like format
- *display()* is similar but more versatile and can handle multiple types of objects, but needs to be called explicitly each time (called as *from IPython.display import display*)
- *sympy.symbols()*: core way to create symbolic objects . accepts string containing the names of the symbols you want, separated by spaces or commas. returns the Symbol objects, which you typically assign to Python variables.
- *sympy.var()* :Shortcut for symbols() with automatic assignment, It automatically creates the Symbol objects and assigns them to Python variables with the same names.

In [1]:
```
import sympy as sp
import numpy as np
```

In [2]:
```
# Define  symbolic variables x and y
x,y = sp.symbols('x y')
#  printed as y+4 and not any value as its treated a symbolic variable
y+4
# to enable symolic printing similar to latex ,
# #use sympy.init_printing() with display() function
sp.init_printing()
y+4
```

Out[2]: $y + 4$

In [3]:
```
print(x**y)
```

```
x**y
```

In [4]:
```
from IPython.display import display
display(x**y)
display(np.sqrt(2))
display(sp.sqrt(2))
```

x^y

1.4142135623731

$\sqrt{2}$

In [5]:
```
x,y = sp.symbols('x y')
display(y*x**2)
```

```
# symbols also works with greek letters
mu,sigma = sp.symbols('mu sigma')
y_guass = 1/(sigma*sp.sqrt(2*sp.pi))*sp.exp(-(x-mu)**2/(2*sigma**2))
display(y_guass)
```

x^2y

$$\frac{\sqrt{2}e^{-\frac{(-\mu+x)^2}{2\sigma^2}}}{2\sqrt{\pi}\sigma}$$

- using *sym.subs()*

subs() is a method used to substitute values or expressions into symbolic expressions, thus evaluating symbolic expression at that value

subs(x,2) -> replace x with 2

expr.subs(old, new) - replaces old with new

expr.subs({old1: new1, old2: new2}) - multiple substitutions

In [6]:
```
# Define symbolic variables
x, y = sp.symbols('x y')

# Create an expression
expr = x**2 + 2*x + y
display(expr)
# Basic substitution - replace x with 2
#  # Returns: 4 + 2*2 + y = 8 + y
display(expr.subs(x, 2) )

# Multiple substitutions using a dictionary
# this is 3^2 + 2*3 + 1 = 9 + 6 + 1 = 16
display(expr.subs({x: 3, y: 1}))

# Substitute expressions
display(expr.subs(x,y))
```

$x^2 + 2x + y$

$y + 8$

16

$y^2 + 3y$

Why Latex

display(sp.sqrt(4)*x) # gives 2x and not desired $ sqrt(4) * x

without using sp.init_printing
display(sp.sqrt(x)*sp.sqrt(x)) # gives x and not desired sqrt(x) * sqrt(x) $

So, we can use latex for this using sym.latex for printing and evaluating The *sympy.latex* function in SymPy is used to convert symbolic expressions into LaTeX strings, which can be rendered nicely in Jupyter Notebooks or other environments that support LaTeX rendering.

In [7]:
```
# Define symbolic variables
x, y = sp.symbols('x y')
# Create an expression
expr = x**2 + 2*x + y
display(expr) # prints x^{2} + 2 x + y
# display(sp.latex()) dont give correct view)
display(sp.latex(expr)) # prints string 'x^{2} + 2 x + y'
#method 2
from IPython.display import display, Math
# Display the LaTeX string using Math and display : display(Math(sp.latex()))
display(Math(sp.latex(expr)))

# suppose want to print latex string 3/4

print('3/4') # prints   3/4
display('3/4') # prints  '3/4'
display(sp.latex('3/4')) # prints \\mathtt{\\text{3/4}}'
display(Math(sp.latex('3/4'))) # prints 3/4
# use sp.sympify(expr) to convert the string to a sympy expression

display(Math(sp.latex(sp.sympify('3/4')))) # prints correctly
```

$x^2 + 2x + y$

```
'x^{2} + 2 x + y'
```

$x^2 + 2x + y$

```
3/4
'3/4'
'\\mathtt{\\text{3/4}}'
```

3/4

$\frac{3}{4}$

Latex tutorial

display(Math()) is used to display a mathematical expression formatted using LaTeX syntax within a notebook cell, allowing you to present complex equations with proper formatting

- for using latex in python code , use \ , first \ is used to escape the second \

which specifies following latex code, as compared with \ used in markdown which specifies latex code directly

In [ ]:
```
# use sp.latex with display and Math
display(Math('\\sigma = \\mu \\times \\sqrt{5}' ))
```

- using ***sp.symbols**, **sp.eq*** and ***sp.latex***

In [ ]:
```
# method 2
# create symbols
sigma, mu = sp.symbols('sigma mu')
# Create the equation using sp.Eq
expr = sp.Eq(sigma, mu * sp.sqrt(5))
# use sp.latex with display and Math
display(Math(sp.latex(expr, order='old')) )
# display sqrtx * sqrt x
display(Math('\\sqrt(x) \\times \\sqrt(x)  {or}  \\sqrt{x} \\sqrt{x}'))
# display fractions: \\frac{numerator}{denominator}
display(Math('\\frac{3}{4}'))
# markdown in latex: use \\text{markdown}
display(Math('\\text{The answer is } \\frac{1}{2} \\text{.}'))
```

- Note :In following expression, The symbols ***x, y, m, n, k, +, -***,

subscripts (*_), and superscripts (**^***) are all directly understood by LaTeX without needing a backslash., so there is no need of \

In [ ]:
```
# display subscript: use _tobeSubscripted
display(Math('x_mm'))
# display more chars in subscript: _{tobeSubscripted}
display(Math('x_{mm}'))
# display superscript : ^{tobeSuperscripted}
display(Math('x_{mm} + y^{n+2k-15}'))
```

- write text as is in latex:

The ***\text{}*** command tells LaTeX to treat the content inside the curly braces as normal text.

In [21]:
```
display(Math(r'\text{The area of a circle is } A = \pi r^2'))
```

The area of a circle is $A = \pi r^2$

- Latex in markdown cell: here, we dont use \ for latex but single quote and dollar sign

so, we write
dollar \sigma = \mu \times \sqrt{5} dollar

$\sigma = \mu \times \sqrt{5}$

some common latex commands

Math	LaTeX	Example	Output
Fraction	\frac{}{}	P(A)=\frac{n(A)}{n(U)}	$P(A) = \frac{n(A)}{n(U)}$
Square root	\sqrt()	\sqrt{x+y}	$\sqrt{x+y}$
Superscript	u^n	u_n=u_1r^{n-1}	$u_n = u_1 r^{n-1}$
Subscript	u_n	u_n=u_1+(n-1)d	$u_n = u_1 + (n-1)d$
Greek letters	\alpha	\alpha \beta \pi \Gamma	$\alpha\beta\pi\Gamma$
Text	\text{}	A=\pi r^2\text{ ,where r is the radius}	$A = \pi r^2 \text{ ,where r is the radius}$
Sigma	\sum	n=\sum \limits _{i=1} ^{\infty} f_i	$n = \sum\limits_{i=1}^{\infty} f_i$
Limit	\lim	\lim\limits_{x\to\infty}	$\lim\limits_{x\to\infty}$
Integration	\int	\int\limits_{a}^{b} x^2 dx	$\int\limits_{a}^{b} x^2 dx$
Trig	\sin	\sin()	$\sin(x+y)$
Comparison	\leq	\leq \geq \approx \neq	$\leq\geq\approx\neq$
Overline	\overline{}	\overline{x}	$\overline{x}$
Tilde ~	\sim	X\sim N(\mu, \sigma^2)	$X \sim N(\mu, \sigma^2)$
Number sets	\mathbb{}	\mathbb{I, R, Q, N, Z}	$\mathbb{I}, \mathbb{R}, \mathbb{Q}, \mathbb{N}, \mathbb{Z}$

write command to display the following

$$\text{With } x=-2, \quad x^2+4 \quad \Rightarrow \quad -2^2+4=8$$

$$\text{With } x=-1, \quad x^2+4 \quad \Rightarrow \quad -1^2+4=5$$

$$\text{With } x=0, \quad x^2+4 \quad \Rightarrow \quad 0^2+4=4$$

$$\text{With } x=1, \quad x^2+4 \quad \Rightarrow \quad 1^2+4=5$$

$$\text{With } x=2, \quad x^2+4 \quad \Rightarrow \quad 2^2+4=8$$

```
second way  to display
```

$$\text{With } x=-2, \quad x^2+4 \quad \Rightarrow \quad -2^2+4=8$$

$$\text{With } x=-1, \quad x^2+4 \quad \Rightarrow \quad -1^2+4=5$$

$$\text{With } x=0, \quad x^2+4 \quad \Rightarrow \quad 0^2+4=4$$

$$\text{With } x=1, \quad x^2+4 \quad \Rightarrow \quad 1^2+4=5$$

$$\text{With } x=2, \quad x^2+4 \quad \Rightarrow \quad 2^2+4=8$$

In [22]:

```
expr = x**2 + 4
for i in range(-2, 3):
    display(Math('\\text{With } x=%g, \\quad x^2+4 \\quad \\Rightarrow \\quad %
 # breakdown

# Constructs a formatted string using
# # Math('\\text{With } x=%g, \\quad x^2+4 \\quad \\Rightarrow \\quad %g^2+4 =
# #This string uses LaTeX notation to create a
# nicely formatted mathematical expression. The %g placeholders are replaced wi

# The \text{} command tells LaTeX to treat the content inside the curly braces
# x=%g, when combined with the first i in % (i, i, expr.subs(x,i)) part,  gives
# %g^2+4 , when combined with the second i in % (i, i, expr.subs(x,i)) part,  g
# %g , when combined with the expr.subs(x,i) in % (i, i, expr.subs(x,i)) part,
# with #expr.subs(x, i)  calculating  the result of the expression with x repla
print("second way  to display")
for i in range(-2, 3):
    ans = (x**2 + 4).subs(x, i)
    display(Math('\\text{With } x=%g, \\quad x^2+4 \\quad \\Rightarrow \\quad %
```

$$\text{With } x=-2, \quad x^2+4 \quad \Rightarrow \quad -2^2+4=8$$

With $x = -1, \quad x^2 + 4 \quad \Rightarrow \quad -1^2 + 4 = 5$

With $x = 0, \quad x^2 + 4 \quad \Rightarrow \quad 0^2 + 4 = 4$

With $x = 1, \quad x^2 + 4 \quad \Rightarrow \quad 1^2 + 4 = 5$

With $x = 2, \quad x^2 + 4 \quad \Rightarrow \quad 2^2 + 4 = 8$

```
second way  to display
```

With $x = -2, \quad x^2 + 4 \quad \Rightarrow \quad -2^2 + 4 = 8$

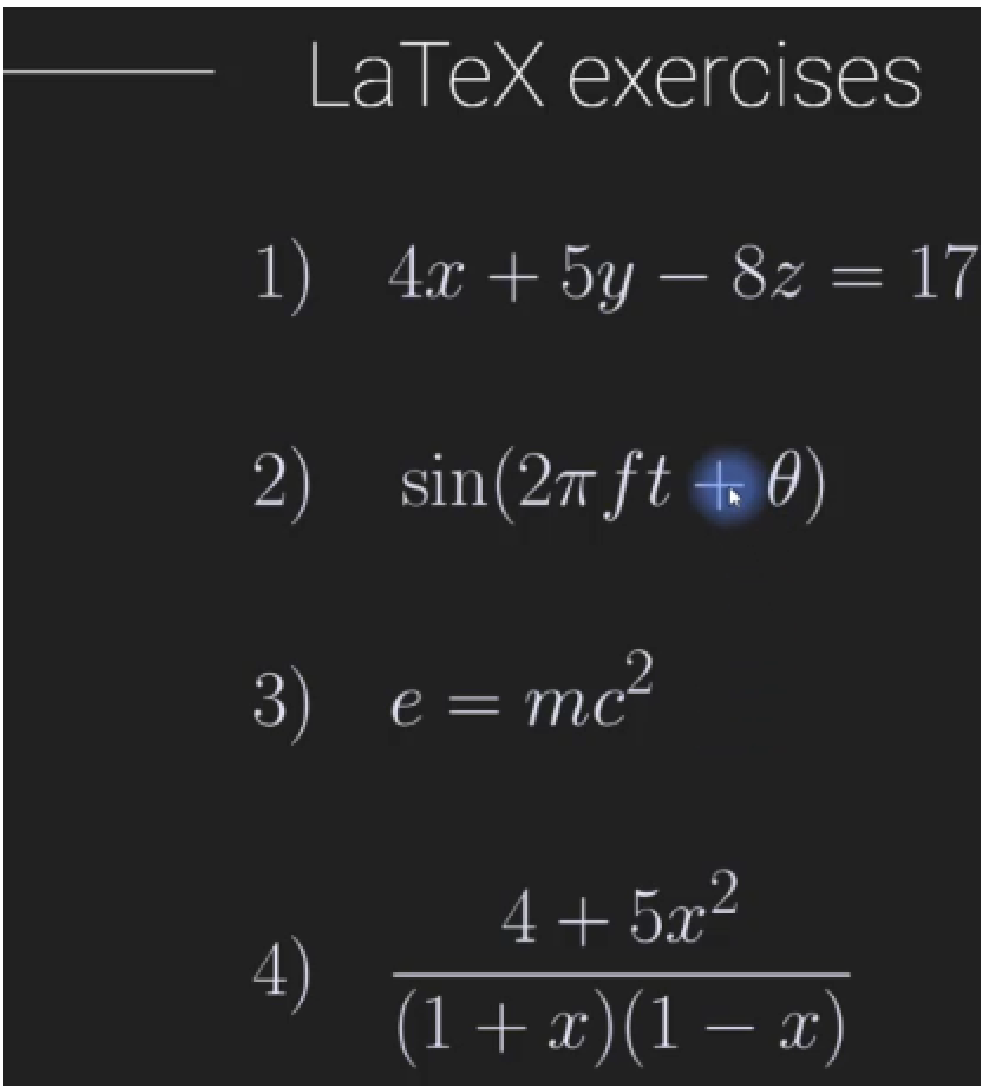
With $x = -1, \quad x^2 + 4 \quad \Rightarrow \quad -1^2 + 4 = 5$

With $x = 0, \quad x^2 + 4 \quad \Rightarrow \quad 0^2 + 4 = 4$

With $x = 1, \quad x^2 + 4 \quad \Rightarrow \quad 1^2 + 4 = 5$

With $x = 2, \quad x^2 + 4 \quad \Rightarrow \quad 2^2 + 4 = 8$

- solve these exercises



In [35]:
```
display(Math('4*x + 5*y -8*z = 17'))
display(Math('\\sin(2\\pi f t + \\theta)'))
```

```
display(Math('e=mc^2'))
display(Math('\\frac{4+5x^2}{(1+x)(1-x)}'))
```

$$4 * x + 5 * y - 8 * z = 17$$

$$\sin(2\pi ft + \theta)$$

$$e = mc^2$$

$$\frac{4+5x^2}{(1+x)(1-x)}$$