Plotting with Matplotlib

Pacchetto `matplotlib`

The main plotting package in Python is matplotlib

It can be used to build all sorts of scientific plot

- `matplotlib` is an extensive package
- ...And we'll use just a small part of its capabilities

If you are interested, the online documentation is very well done

Plots are built in `matplotlib` by calling functions

- A function is used to construct an (empty) figure
- ...Then other functions populate the figure with graphical elements
- ...And yet other functions can modify the figure properties

We'll see how to use a few key functions step by step

Preparing Plot

First, we need to import the `pyplot` module

```
In [1]: from matplotlib import pyplot as plt
```

- The alias `plt` is usually employed for `pyplot` when importing

Then, we build a new figure using `figure`

```
In [2]: plt.figure(figsize=(20, 3))

Out[2]: <Figure size 2000x300 with 0 Axes>

        <Figure size 2000x300 with 0 Axes>
```

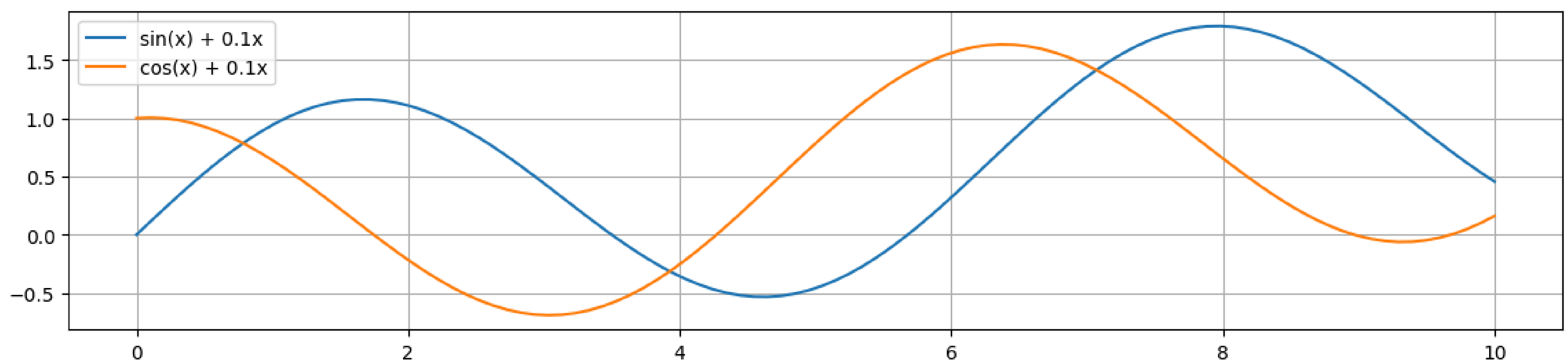
- We can specify the size witht the (optional) `figsize` parameter
- Size is specify as a tuple in the `(width, height)` form

In [3]:

```python
from matplotlib import pyplot as plt
import numpy as np

x = np.linspace(0, 10, 100)
y = np.sin(x) + 0.1 * x
y2 = np.cos(x) + 0.1 * x

plt.figure(figsize=(14, 3))
plt.plot(x, y, label='sin(x) + 0.1x')
plt.plot(x, y2, label='cos(x) + 0.1x')
plt.grid()
plt.legend()
plt.show()
```



The `plot` Function

We can draw curves using the `plot` function

In this example, we'll use it to draw the function: $f(x) = \sin(x) + 0.1x$

- First, we build arrays with the x and y coordinates of points on the curve

```
In [4]: import numpy as np

        x = np.linspace(0, 10, 12)
        y = np.sin(x) + 0.1 * x
        n = 4
        print(f'First {n} elements of x: {x[:n]}')
        print(f'First {n} elements of y: {y[:n]}')
```

```
First 4 elements of x: [0.         0.90909091 1.81818182 2.72727273]
First 4 elements of y: [0.         0.87985455 1.15137413 0.67529476]
```

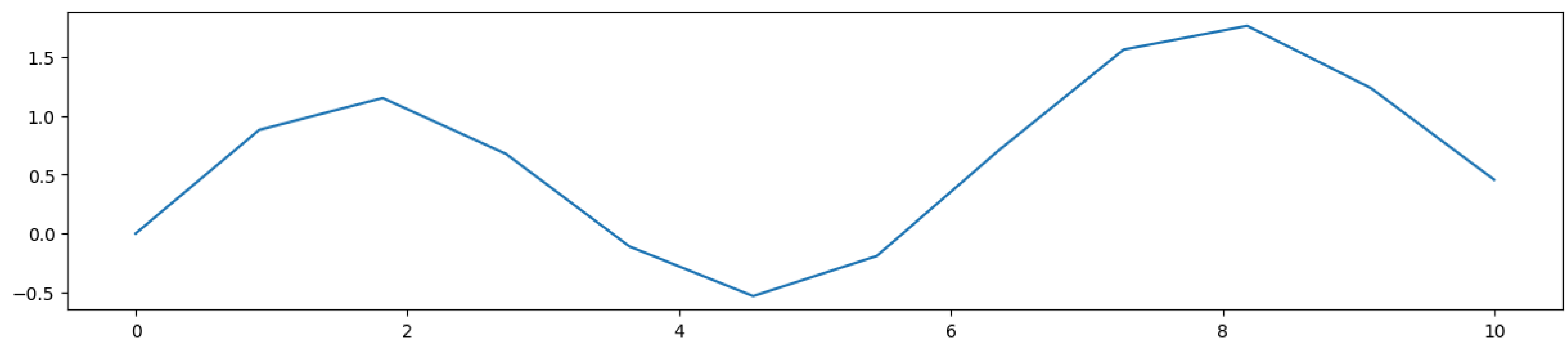
- We use `linspace` to define a sequence of x values
- ...Then we use `numpy` operations to evaluate the function for those points

The `plot` Function

Now we can call `plot(x, y, ...)` to draw the curve

- The `x` and `y` parameters are iterables with x and y coordinates
- The function draws a curve by connecting adjacent points

In [5]:
```
plt.figure(figsize=(15, 3))
plt.plot(x, y)
plt.show()
```

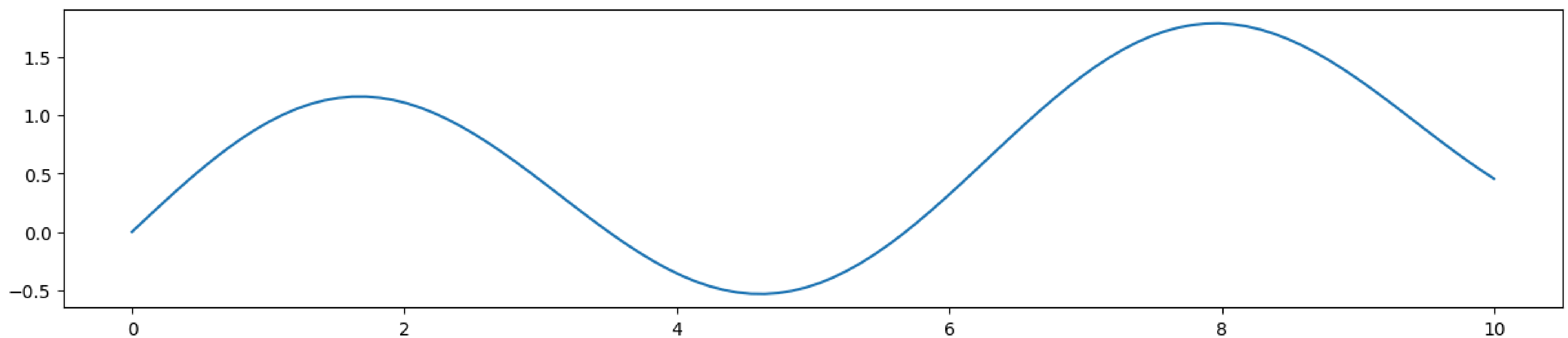


The `plot` Function

We can improve the plot quality by just using more points

In [6]:
```
x = np.linspace(0, 10, 100)
y = np.sin(x) + 0.1 * x

plt.figure(figsize=(15, 3))
plt.plot(x, y)
plt.show()
```

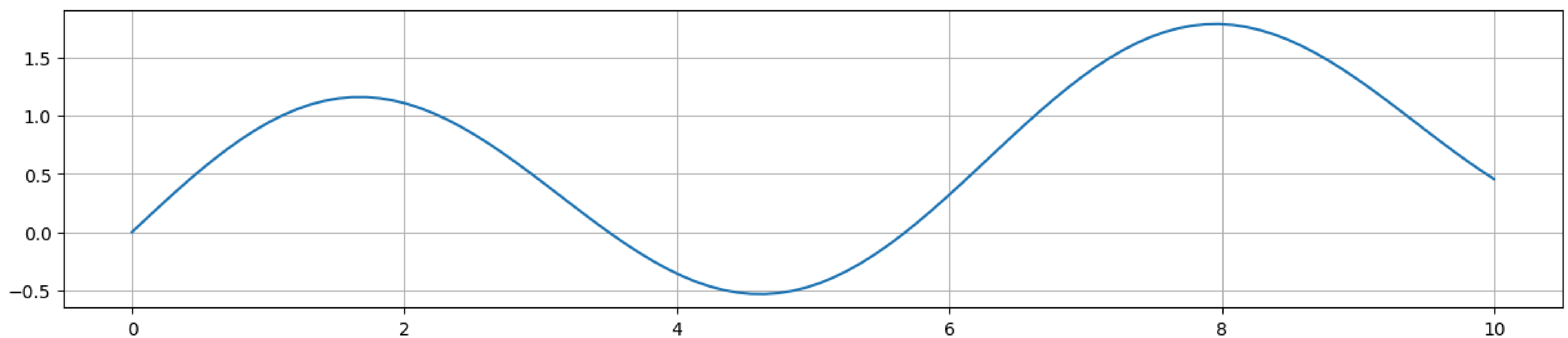


The `plot` Function

We can add a reference grid by calling `grid`

In [7]:
```
x = np.linspace(0, 10, 100)
y = np.sin(x) + 0.1 * x

plt.figure(figsize=(15, 3))
plt.plot(x, y)
plt.grid()
plt.show()
```

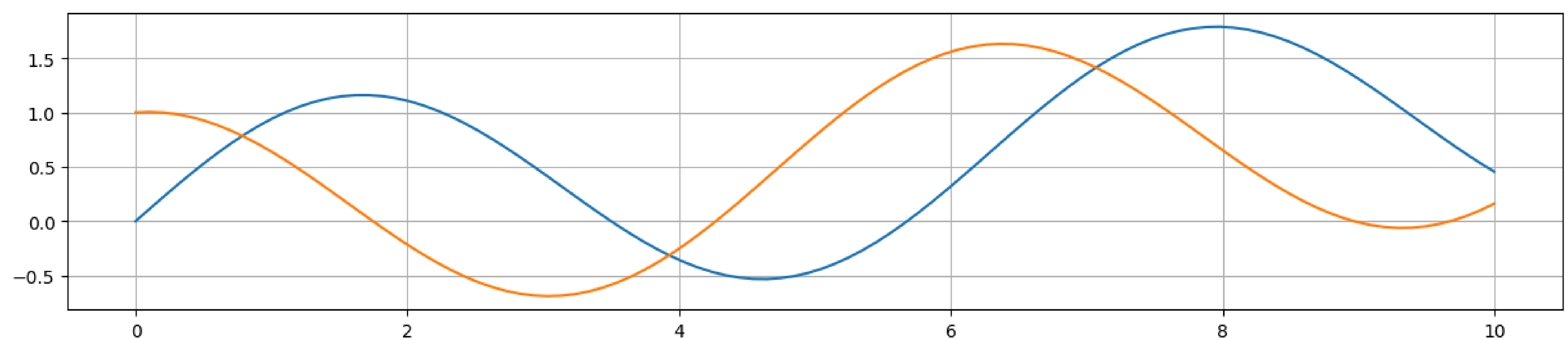


The `plot` Function

We can also draw multiple curves on the same plot

In [8]:
```
x = np.linspace(0, 10, 100)
y = np.sin(x) + 0.1 * x
y2 = np.cos(x) + 0.1 * x

plt.figure(figsize=(15, 3))
plt.plot(x, y)
plt.plot(x, y2) # Disegno la seconda curva
plt.grid()
plt.show()
```

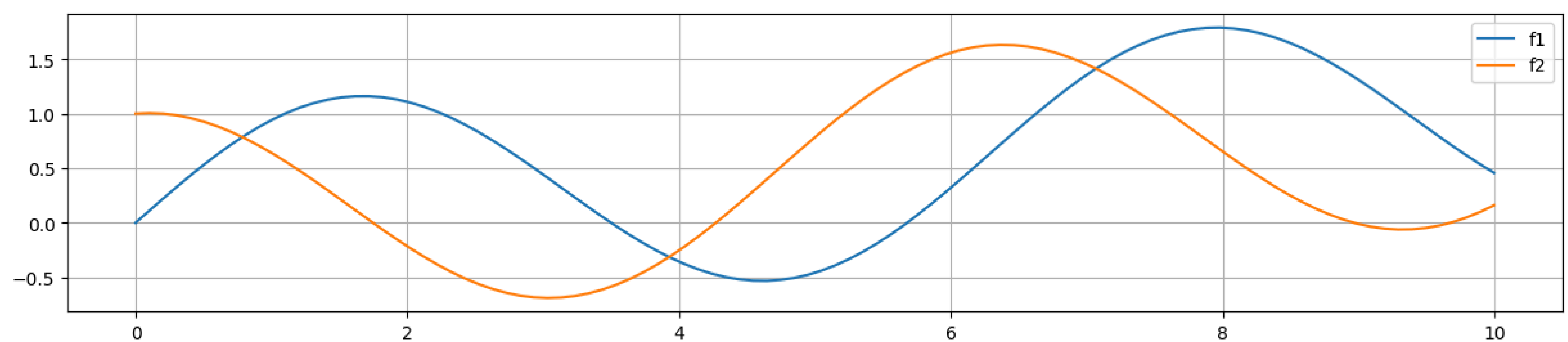


The `plot` Function

We can assign a label to each curve, the call draw a legend with `legend`

In [9]:
```
x = np.linspace(0, 10, 100)
y = np.sin(x) + 0.1 * x
y2 = np.cos(x) + 0.1 * x

plt.figure(figsize=(15, 3))
plt.plot(x, y, label='f1')
plt.plot(x, y2, label='f2')
plt.grid()
plt.legend()
plt.show()
```



Exercise

Consider the function $1.5x^3 - 1.5x^2 - x - 0.4$

- Draw it on the interval $[-1, 1.5]$, by using a different number of points

In [ ]:

Exercise

Compare on the $[0, 10]$ interval

...The functions x^4 and $e^x - 1$

```
In [ ]:
```

Exercise

Visualli determione for which x values the following function is 0

$$\sin(x) - \frac{1}{2}(e^x - 1)$$

- Proceed by drawing the curve and checking where it crosses the $x - axis$

```
In [ ]:
```