

# Extra 5

The famous example of a function that is continuous everywhere and differentiable nowhere is the **Weierstrass function**

$$W(x) = \sum_{n=0}^{\infty} a^n \cos(b^n \pi x)$$

The graph of the Weierstrass function exhibits a fractal-like behavior, with self-similar oscillations at all scales. It is a continuous, yet extremely irregular and jagged curve that fills up the entire real number line. The graph never becomes smooth, and no matter how closely you examine it, you'll always find more fine-scale oscillations.

```
import numpy as np
import matplotlib.pyplot as plt

def weierstrass_funtion(x, a, b, n = 100):
    # f(x)=Σ a^n * cos(b^n*πx)
    result = 0
    for k in range(n):
        result += a ** k * np.cos(b ** k * np.pi * x)
    return result

"""
a and b have to be chosen to satisfy specific conditions for the function to be
0 < a < 1
b = 2k + 1, b > 1
The function is continuous since it is a sum of continuous functions
"""

if __name__ == "__main__":
    a = 0.5
    b = 3

    x = np.linspace(-1, 1, 1000)

    y = weierstrass_funtion(x, a, b)

    plt.plot(x, y)
    plt.title("Weierstrass function")
    plt.xlabel('x')
    plt.ylabel('f(x)')
    plt.show()
```



