Assignment 1b: Functions and Computation

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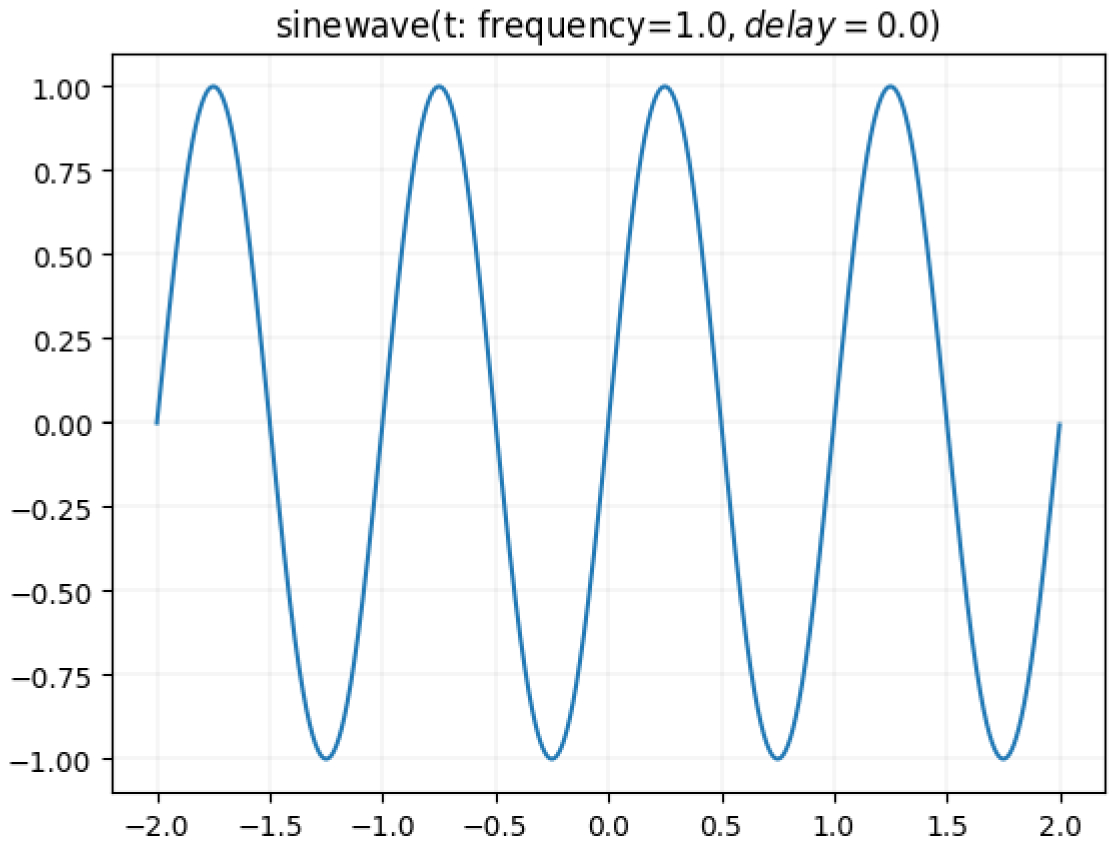
1. Markdown and LaTeX

1a. Sinewave

In [2]:
```
import math
import matplotlib.pyplot as plt
import numpy as np

def sinewave(t, f = 1.0, d = 0.0):
    return np.sin(2 * math.pi * f * (t + d))


def plot_sinewave(t, f = 1.0, d = 0.0):
    y = sinewave(t, f, d)
    plt.plot(t, y)

    plt.title(f'sinewave(t: frequency=${f}, delay=${d})')
    plt.grid(color='gray', linestyle='-', linewidth=0.1)
    # plt.legend()
    plt.show()


t = np.arange(-2, 2, 0.001)
plot_sinewave(t)

print(sinewave(0.0, f=5, d=0.05))
```




```
1.0
```

1) a time in seconds to a sample index, using f_s as the sampling frequency and i as the sample index (zero-based)

For this equation we know that the sampling frequency times time is equal to the index. Converting this to its unit value we see that this works because:

$$f_s * t = i \tag{1}$$

$$\frac{sample}{sec} * sec = sample \tag{2}$$

$$sample = sample \tag{3}$$

Therefore we know that this works because index = sample.

2) the delay in seconds to phase in radians.

$$\phi = sec * \frac{cycles}{sec} * \frac{radians}{cycles} \tag{4}$$

This is equivalent to:

$$\phi = -d * f * 2\pi \tag{5}$$

Here the seconds is negative because it is a delay. And so if we substitute this into the sin equation:

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

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

And we can factor out the $2f\pi$ to get

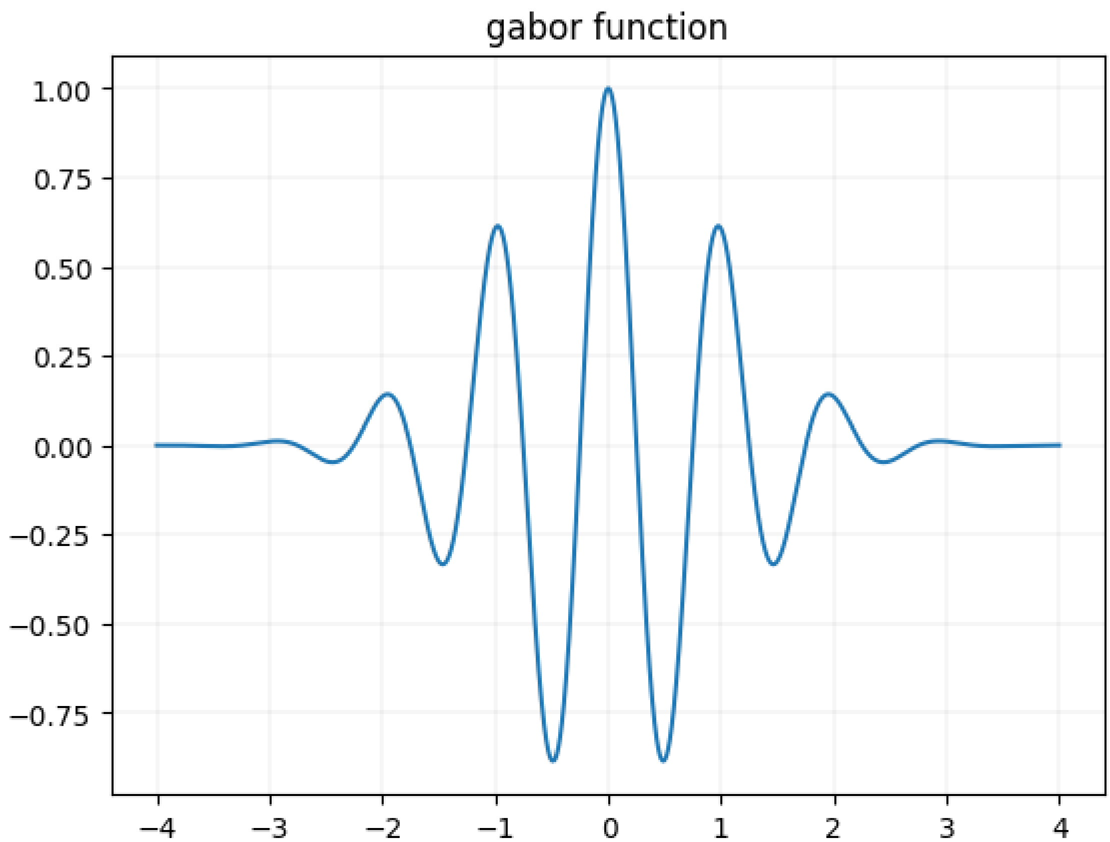
$$\sin(2\pi f(t + d))$$

1b. Gabor

In [10]:

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

def gabor(t, a = 1, f = 1, sigma = 1, phi = 0):
    vector = np.vectorize(np.float_)
    t = vector(t)
    return a * np.exp(- (t ** 2) / (2 * sigma ** 2)) * np.cos(2 * np.pi * f * t + p

def plot_gabor(t, a = 1, f = 1, sigma = 1, phase = 0, type="gabor"):
    if type == "gabor":
        y = gabor(t, a, f, sigma, phase)
    elif type == "gabore" or type == "even":
        y = gabore(t, a, f, sigma)
    else:
        y = gaboro(t, a, f, sigma)
    plt.plot(t, y)
    plt.title(f'gabor function')
    plt.grid(color='gray', linestyle='-', linewidth=0.1)
    # plt.legend()
    plt.show()

def gabore(t, a = 1, f = 1, sigma = 1):
    phi = 0
    return gabor(t, a, f, sigma, phi)

def gaboro(t, a = 1, f = 1, sigma = 1):
    phi = np.pi / 2
    return gabor(t, a, f, sigma, phi)

def gabor_norm(f = 1, sigma = 1, phi = 0, fs = 100):

    t = np.arange(-8*sigma, 8*sigma, 1/fs)
    a = 1
    gab = gabor(t, a, f, sigma, phi)
    return np.linalg.norm(gab)

def gabore_norm(f = 1, sigma = 1, fs = 100):
    phi = 0
    return gabor_norm(f, sigma, phi, fs)

def gaboro_norm(f = 1, sigma = 1, fs = 100):
    phi = np.pi / 2
    return gabor_norm(f, sigma, phi, fs)
```

```
t = np.arange(-4, 4, 0.001)
plot_gabor(t)

print('#4', gaboro(-3, f=0.0625, sigma=8))
print('#5', gabor_norm(f=100, sigma=0.01, fs=10000))
a = gaboro_norm(f=100, sigma = 0.01, fs = 10000)
print('#6', gaboro(0.003, a=a, f=100, sigma=0.01))
```



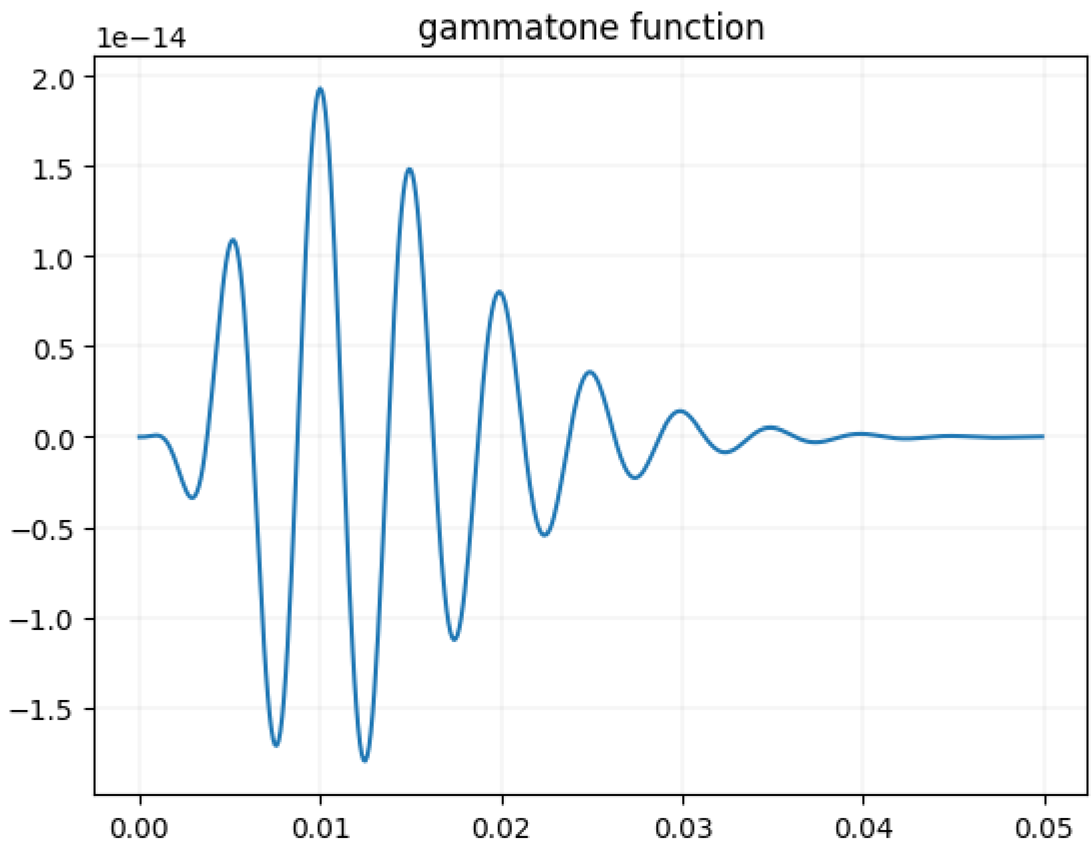

```
#4 0.8611504148937256
#5 9.413962637767014
#6 -8.559246702653548
```

1c. Gammatone

In [10]:

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


def erb(f):
    return 24.7 * ((4.37 * f) / 1000 + 1)

def get_b(f):
    return (1.019 * erb(f))

def gammatone_norm(t, n = 4, f = 200, phi = 0):
    b = get_b(f)
    gamma = t ** (n - 1) * np.exp(-2 * np.pi * b * t) * np.cos(2 * np.pi * f * t +
    return np.linalg.norm(gamma)

def gammatone(t, n = 4, f = 200, phi = 0):
```

```
    b = get_b(f)
    a = gammatone_norm(t, n, f, phi)

    return a * (t ** (n - 1)) * np.exp(-2 * np.pi * b * t) * np.cos(2 * np.pi * f *


def plot_gammatone(t, n = 4, f = 200, phi = 0):
    y = gammatone(t, n, f, phi)
    plt.plot(t, y)

    plt.title(f'gammatone function')
    plt.grid(color='gray', linestyle='-', linewidth=0.1)
    # plt.legend()
    plt.show()


t = np.arange(0, 0.05, 0.0001)
plot_gammatone(t)
```



2. Simple Computation

2a. Local Maxima

In [12]:
```
def localmaxima(arr):
    local_maxes = []
    i = 1
    while i < len(arr) - 1:
        if arr[i - 1] < arr[i] and arr[i + 1] < arr[i]:
```

```
            local_maxes.append(i)
        i += 1
    return local_maxes

test_arr = [1, 2, 3, 4, 1, 2, 3, -1, -5, -7, 0, -1]
print(localmaxima(test_arr))

t2 = [1, 3, 2, -2, 2, 4, 8, 6]
print(localmaxima(t2))
```

```
[3, 6, 10]
[1, 6]
```

2b. Crossings

In [15]:

```
# a function to compute the indicies of where a function first equals or crosses a
def crossings(arr, threshold, direction = 'both'):
    crosses = []
    i = 1
    while i < len(arr):
        if arr[i] == threshold and arr[i - 1] != threshold:
            crosses.append(i)
        elif arr[i] > threshold and arr[i - 1] < threshold and (direction == 'both'
            crosses.append(i)
        elif arr[i] < threshold and arr[i - 1] > threshold and (direction == 'both'
            crosses.append(i)
        i += 1
    return crosses



test_arr = [1, 2, 3, 4, 1, 2, 3, -1, -5, -7, 0, -1, 1]
exp = [4, 7, 12]
print(crossings(test_arr, 1))


crossings([-1, 0, 1, 2, 0, -2], threshold=1, direction="both")
```

```
[4, 7, 12]
```

Out[15]:

```
[2, 4]
```

2c. Envelope

In [18]:

```
# function to downsample data and get the lower, upper, and block indicies of each

def envelope(y, nblocks = 10):
    ylower = []
    yupper = []
    blockindices = []

    size_block = int(len(y) / nblocks)

    remainders = len(y) % nblocks
    # if we have remainders the first few blocks need to take an extra element
    if remainders > 0:
```

```
        size_block += 1

    index = 0
    iteration_num = 0
    while index < len(y):
        # here we are setting the size of the block back to the original number aft
        if iteration_num == remainders and remainders != 0:
            size_block -= 1
        else: size_block
        if index + size_block < len(y):
            upper = index + size_block
        else:
            upper = len(y)
        arr = y[index: upper]
        ylower.append(min(arr))
        yupper.append(max(arr))
        blockindices.append(index)
        index = upper
        iteration_num += 1
    return ylower, yupper, blockindices

test_arr = [1, 2, 3, 4, 1, 2, 3, -1, -5, -7, 0, -1, 1, ]
yl, yu, bi = envelope(test_arr)
print("ylower: ", yl)
print("yupper: ", yu)
print("blockindicies: ", bi)


y = [5, 5, 2, 3, 4, 3, -6, -9, 0, -3, 9, -7]
ylower, yupper, blockindices = envelope(y, nblocks=3)
print(blockindices)
```

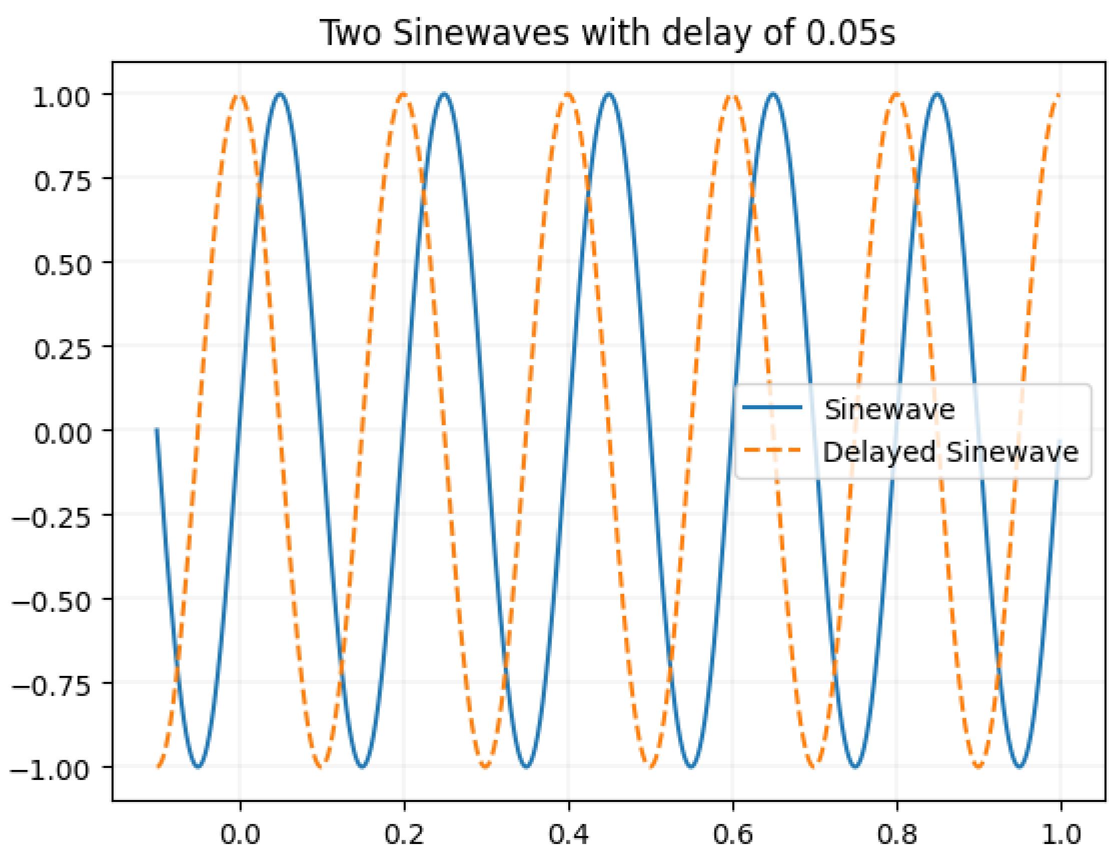
```
ylower:  [1, 3, 1, 3, -1, -5, -7, 0, -1, 1]
yupper:  [2, 4, 2, 3, -1, -5, -7, 0, -1, 1]
blockindicies:  [0, 2, 4, 6, 7, 8, 9, 10, 11, 12]
[0, 4, 8]
```

3. Extra plots from check

In [3]:

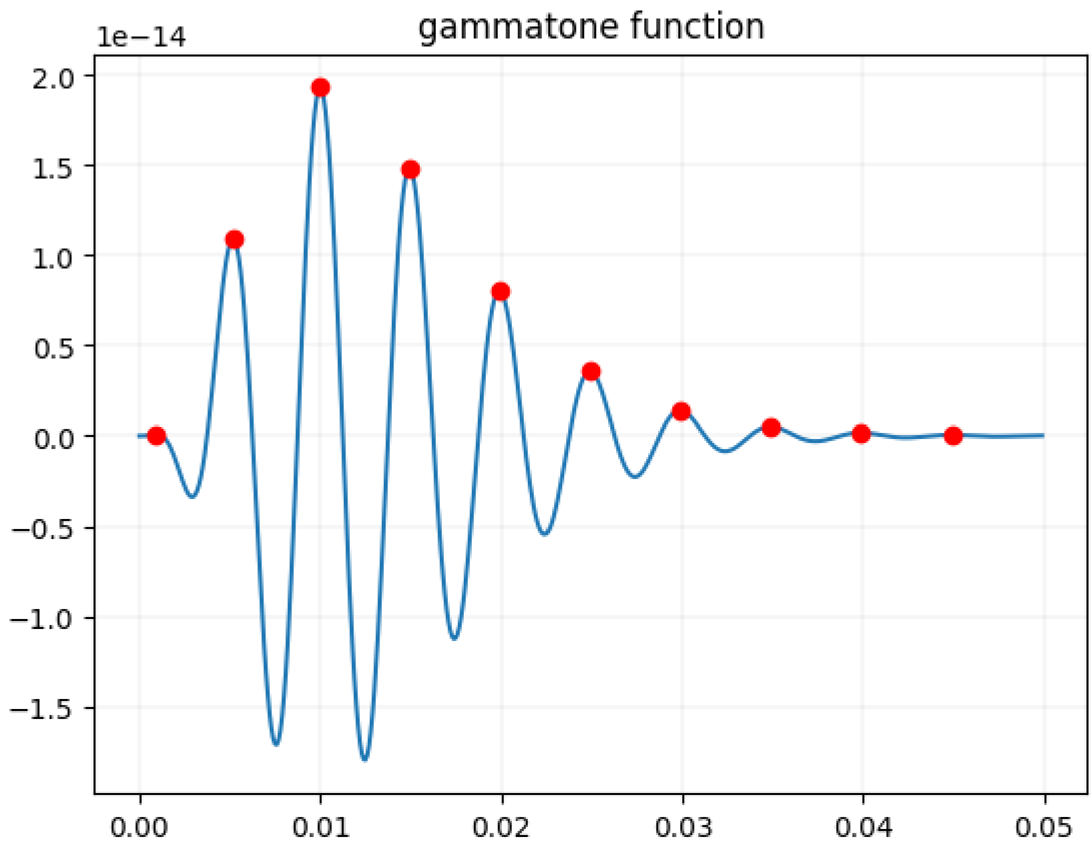
```
# q11
import math
import matplotlib.pyplot as plt
import numpy as np

def sinewave(t, f = 1.0, d = 0.0):
    return np.sin(2 * math.pi * f * (t + d))


def plot_sinewave(t, f = 1.0, d = 0.0):
    y = sinewave(t, f, d)
    plt.plot(t, y)

    plt.title(f'sinewave(t: frequency=${f}, delay=${d})')
    plt.grid(color='gray', linestyle='-', linewidth=0.1)
    # plt.legend()
```

```
    plt.show()


def plot_twowaves():
    t = np.arange(-0.1, 1.0, 0.001)
    f = 5
    delay = 0.05

    y_solid = sinewave(t, f)
    y_dashed = sinewave(t, f, delay)

    plt.plot(t, y_solid, "-", label="Sinewave")
    plt.plot(t, y_dashed, "--", label="Delayed Sinewave")
    plt.grid(color='gray', linestyle='-', linewidth=0.1)
    plt.title(f'Two Sinewaves with delay of 0.05s')
    plt.legend()
    plt.show()

plot_twowaves()
```



In [35]:
```
import matplotlib.pyplot as plt
import numpy as np


def localmaxima(arr):
    local_maxes = []
    i = 1
    while i < len(arr) - 1:
        if arr[i - 1] < arr[i] and arr[i + 1] < arr[i]:
            local_maxes.append(i)
```

```
        i += 1
    return local_maxes


def erb(f):
    return 24.7 * ((4.37 * f) / 1000 + 1)

def get_b(f):
    return (1.019 * erb(f))

def gammatone_norm(t, n = 4, f = 200, phi = 0):
    b = get_b(f)
    gamma = t ** (n - 1) * np.exp(-2 * np.pi * b * t) * np.cos(2 * np.pi * f * t +
    return np.linalg.norm(gamma)

def gammatone(t, n = 4, f = 200, phi = 0):
    b = get_b(f)
    a = gammatone_norm(t, n, f, phi)

    return a * (t ** (n - 1)) * np.exp(-2 * np.pi * b * t) * np.cos(2 * np.pi * f *


def plot_gammatone(t, n = 4, f = 200, phi = 0):
    y = gammatone(t, n, f, phi)
    plt.plot(t, y)

    maxes = localmaxima(y)
    for i in maxes:
        plt.plot(t[i], y[i], 'ro', label="local maxima")

    plt.title(f'gammatone function')
    plt.grid(color='gray', linestyle='-', linewidth=0.1)
    plt.show()


t = np.arange(0, 0.05, 0.0001)
plot_gammatone(t)
```



In [43]:

```
# q17

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

# a function to compute the indicies of where a function first equals or crosses a
def crossings(arr, threshold, direction = 'both'):
    crosses = []
    i = 1
    while i < len(arr):
        if arr[i] == threshold and arr[i - 1] != threshold:
            crosses.append(i)
        elif arr[i] > threshold and arr[i - 1] < threshold and (direction == 'both'
            crosses.append(i)
        elif arr[i] < threshold and arr[i - 1] > threshold and (direction == 'both'
            crosses.append(i)
        i += 1
    return crosses


def sinewave(t, f = 1.0, d = 0.0):
    return np.sin(2 * math.pi * f * (t - d))


def plot_sinewave(t, f = 1.0, d = 0.0):
    y = sinewave(t, f, d)
    plt.plot(t, y)
    plt.axhline(y = 0.5, color = 'r', linestyle = '-', label="threshold")
```

```
    plt.title(f'sinewave(t: frequency=${f}, delay=${d})')
    plt.grid(color='gray', linestyle='-', linewidth=0.1)
    c = crossings(y, 0.5)
    for i in c:
        plt.plot(t[i], y[i], 'ro', label="local maxima")
    # plt.legend()
    plt.show()


t = np.arange(0, 0.5, 1/200)
plot_sinewave(t, f=5)
```