CGR 2025 Lab 4: Convolution theorem

Duration: 1.5 hours (strict)
Tools: any programming language, any plotting tool

Important changes specific to this lab

1. *Programming assistants are not allowed for this lab*: This lab is the only assessed part of the course that prohibits the use of AI-powered coding assistants (Copilot, ChatGPT, Gemini, Claude, etc). You are allowed to use any library of your choice (e.g. to compute Fourier transforms, convolutions, plots, etc.).
2. *This lab will be 1.5h and not 2h:* The lab demonstrators will use the last 30 minutes to assess your results (everybody will be required to stop working once assessment begins). You may continue to discuss results while others are being assessed.

Objective

To empirically validate the convolution theorem. (Refer to lecture on 4th Nov)

Task: Plotting functions and their Fourier transforms

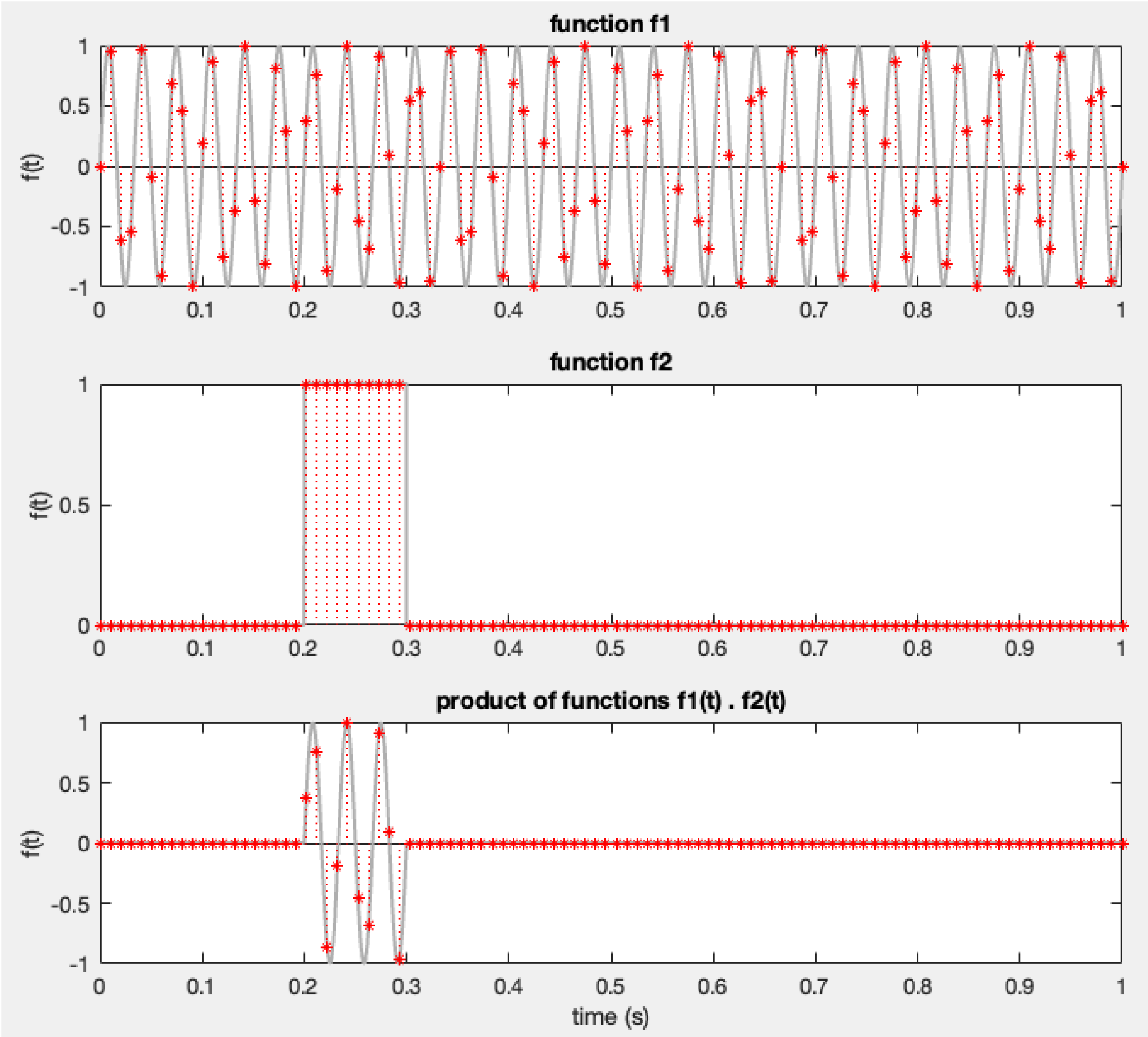
The notation below uses lower case (f) for functions in the time domain and upper case (F) for their Fourier transforms. A suffix 's' indicates that the function is sampled. Task 1 involves the following steps:

1. Choose two functions f1 and f2
2. Sample them regularly (Dirac comb) using N samples over a domain – say [0,1]. This yields the sampled functions f1s and f2s (both vectors of length N).
3. Plot the functions and their sampled versions
4. Calculate the Fourier transforms F1s and F2s of f1s and f2s respectively.
5. Plot the magnitudes ((they will be complex-valued) of F1s and F2s using appropriate axes and labels.
6. Calculate f3s as the element-wise product of f1s and f2s.
7. Calculate the Fourier transform F3s of f3s.
8. Compare the magnitude of F3s to the convolution of F1s and F2s.

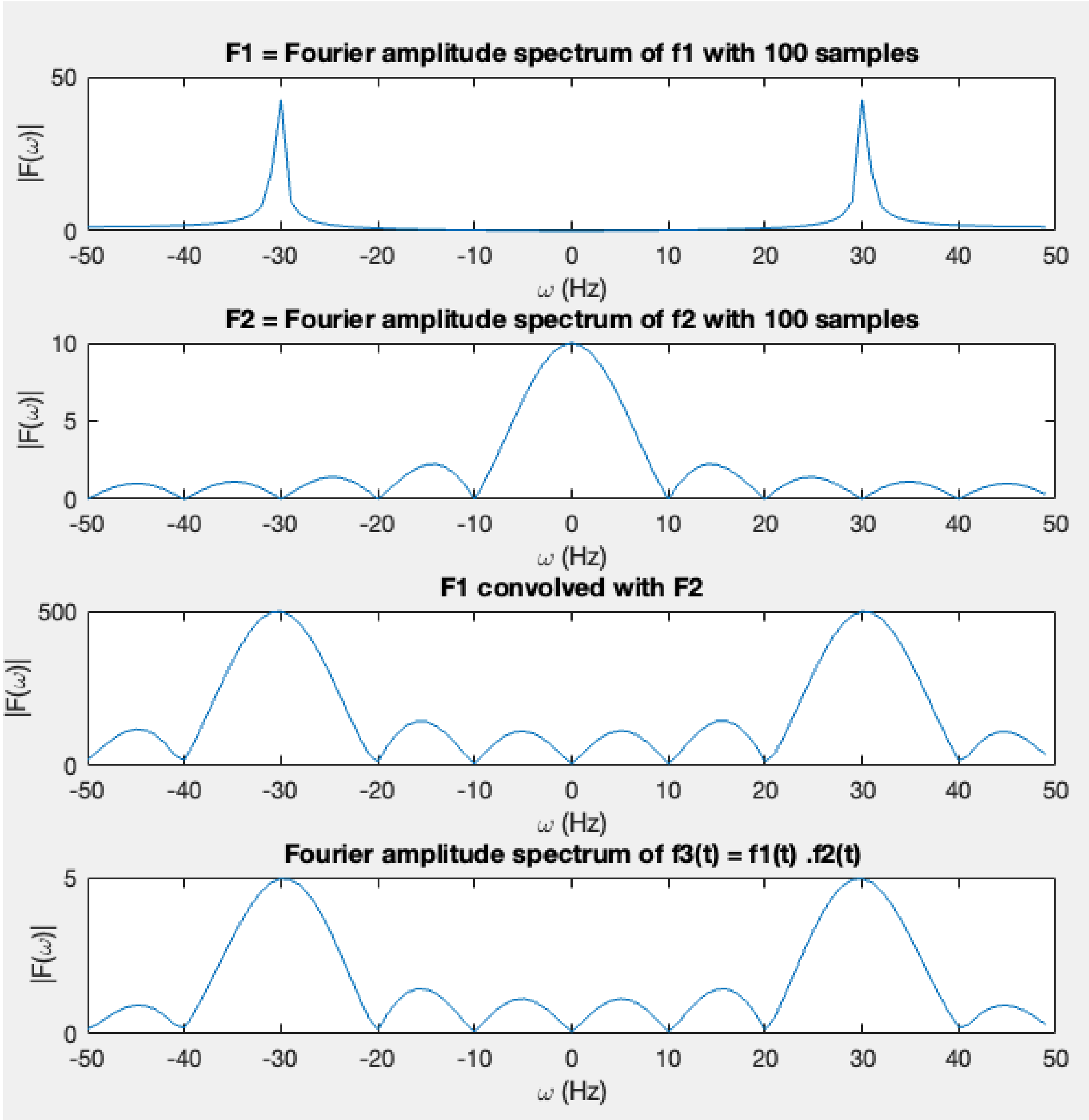
Example plots are shown at the end of this specification document.

Marking

1. Correct plots of f1s, f2s and f3s [1 mark]
2. Correct plots of F1s, F2s and F3s [1 mark]
3. Repeating all plots for a different choice of N [1 mark]
4. Explanation of your code and the result. [2 marks]
5. Bonus 1 mark: Demonstrating that the inverse Fourier transform of F3s matches f3s



function f1
f(t)
1
0.5
0
-0.5
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
function f2
f(t)
1
0.5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
product of functions f1(t) . f2(t)
f(t)
1
0.5
0
-0.5
-1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
time (s)



The last two plots are identical, proving that the convolution of Fourier spectra of f1 and f2 is equal to the Fourier spectrum of the product of f1 and f2.

Example questions for this plot: What do the peaks at -30 and 30 on the first plot (F1) signify?