Imperial College London

DE2 Electronics 2

Tutorial 3

Selected Questions from Problem sheets 1 & 2

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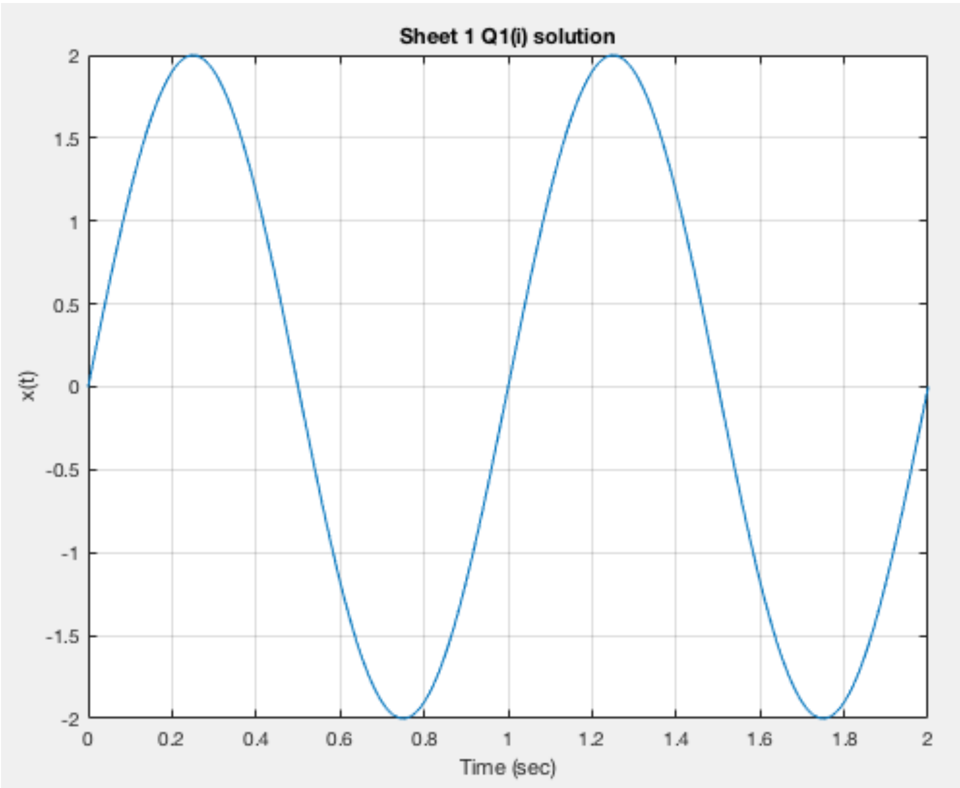
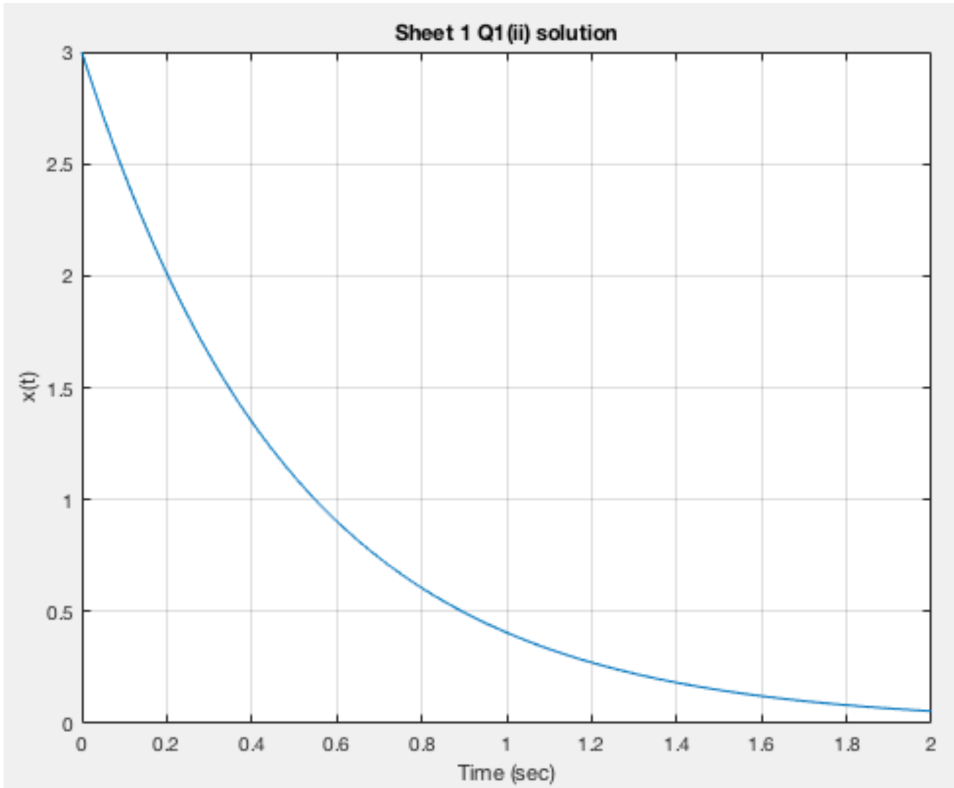
Sheet 1 Q1 – Test yourself

1.* Sketch each of the following continuous-time signals. For each case, specify if the signal is causal/non-causal, periodic/non-periodic, odd/even. If the signal is periodic specify its period.

(i) $x(t) = 2\sin(2\pi t)$

(ii) $x(t) = \begin{cases} 3e^{-2t}, & t \geq 0 \\ 0, & t < 0 \end{cases}$





Sheet 1 Q4 (i) – Test yourself

4.* Sketch the spectrum of the time domain signal.

(i) $$x(t) = \sin(2\pi \times 350t) + 0.35 \times \sin(6283t) + 0.1$$

$$x(t) = \sin(2199t) + 0.35(2\pi \times 1000t) + 0.1$$

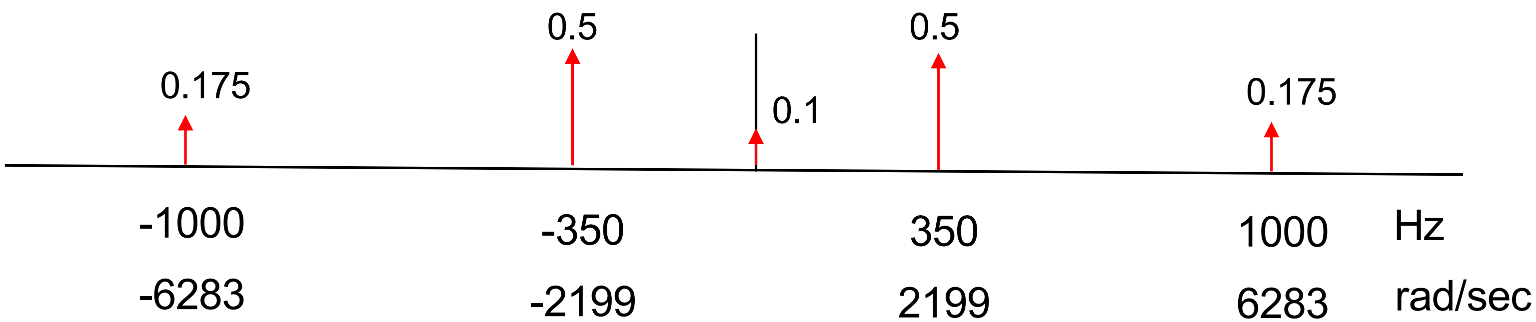
f_1 in radian/sec

f_2 in Hz

DC

We will only consider the magnitude of spectrum here.

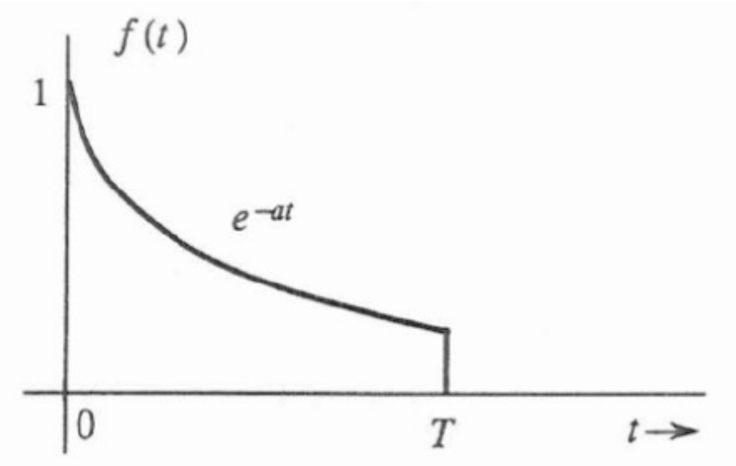
Lecture 3 slide 2: $\sin(\omega t) = \dfrac{e^{j\omega t} - e^{-j\omega t}}{2j}$ Therefore, $|\sin(\omega t)| = \dfrac{1}{2}\left|e^{j\omega t}\right| + \dfrac{1}{2}\left|e^{-j\omega t}\right|$



Sheet 2 Q1 a) – Test yourself

1.* Derive from first principle the Fourier transform of the signals *f(t)* shown in Fig. Q1 (a)

Solution: The purpose of this question is to get you to be familiar with the basic definition of Fourier Transform. You need to know calculus and integration reasonably well into to tackle this problem.



(a)

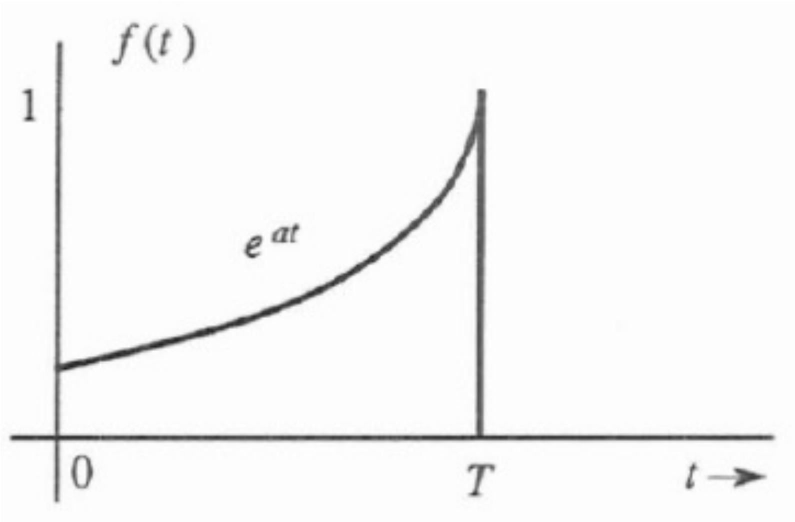
$$F(\omega) = \int_0^T e^{-at} e^{-j\omega t} dt$$

$$= \int_0^T e^{-(a+j\omega)t} \, dt$$

$$= \frac{1 - e^{-(a+j\omega)T}}{a + j\omega}$$

Sheet 2 Q1 b) – Test yourself

Derive from first principle the Fourier transform of the signals *f(t)* shown in Fig. Q1 (a) and (b).



$$F(\omega) = \int_0^T e^{at} e^{-j\omega t} dt$$

$$= \int_0^T e^{-(-a+j\omega)t} \; dt$$

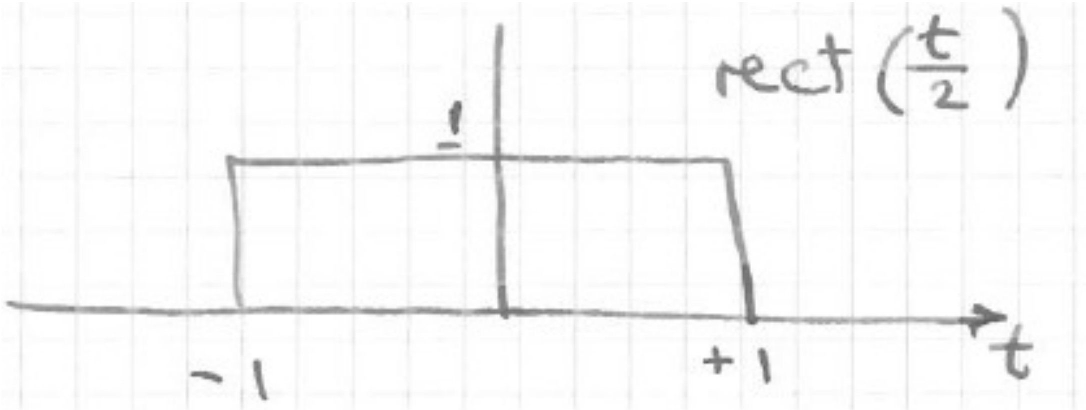
$$= \frac{1 - e^{-(-a+j\omega)T}}{-a + j\omega}$$

Easy way – substitute –a for a to previous solution.

Sheet 2 Q3 a) – Test yourself

Sketch the following functions:

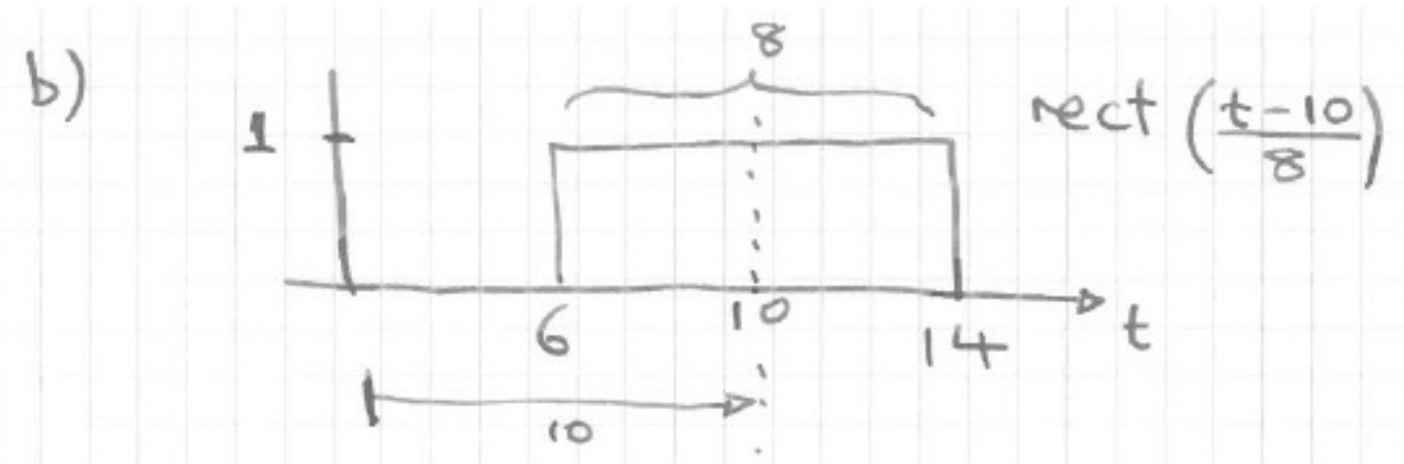
a) $rect(\frac{t}{2})$



Sheet 2 Q3 b) – Test yourself

Sketch the following functions:

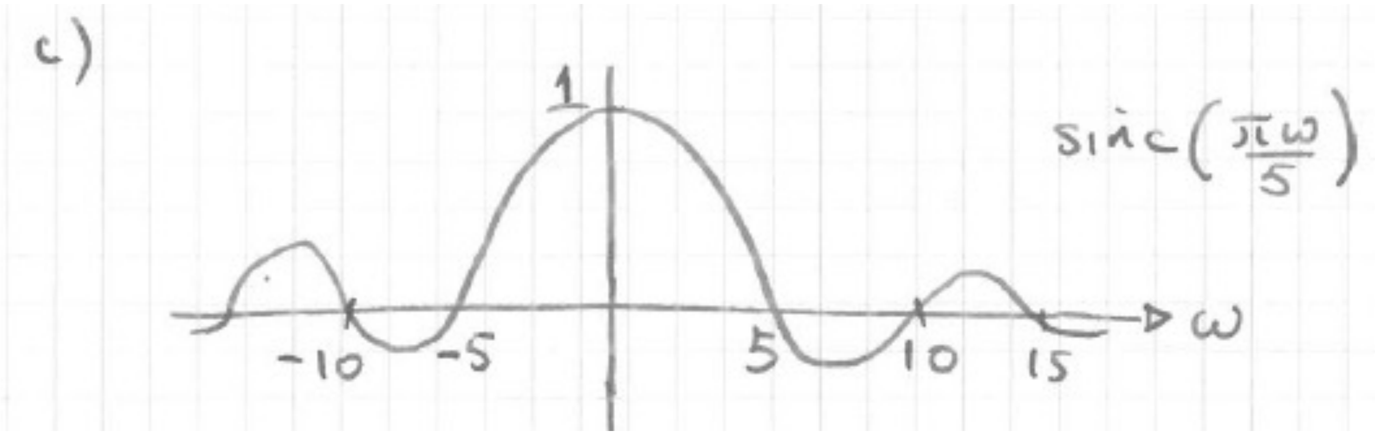
b) $rect(\frac{t-10}{8})$



Sheet 2 Q3 c) – Test yourself

Sketch the following functions:

c) $\text{sinc}(\frac{\pi\omega}{5})$



Sheet 2 Q5 (1) – Explain it

For a signal $f(t)$ that is time-limited to 10 ms and has an essential bandwidth of 10 kHz, determine N_0, the number of signal samples necessary to compute its DFT with a frequency resolution f_0 of 50 Hz.

Given that the signal bandwidth of f(t) is 10 kHz, sampling frequency fs ≥ 20kHz. Let us assume fs = 20kHz for minimum samples.

We require a frequency resolution f_0 of our DFT to be 50Hz. This determines the width of the time window Tw we need to extract the segment of signal to form the periodic signal, before we perform the DFT.

Therefore, $T_w = \frac{1}{50}$ = 20ms

If fs = 20 kHz, $N_0 \geq \frac{\frac{1}{f_s}}{T_w} \geq 400.$

However, we only have 10ms with signal and we need 20ms. What can be done?