ECE 3210 Midterm 1

Week of: September 27, 2022

Student's name: ______________________________

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You have 2 hours for 5 problems.

- Show enough (neat) work in the clear spaces on this exam to convince us that you derived, not guessed, your answers.
- Put your final answers in the boxes at the bottom of the page.

You may use one US letter-style size page of notes, front and back.

Problem	Score	Possible Points
1		20
2		20
3		20
4		20
5		20
Total score		100

1 Short answer

(a) What is the verb form of "convolution"?

(b) Given the following system differential equations or impulse response functions, determine if each system is stable, marginally stable, or unstable. Show work if needed.

(i) $(D^3 + 6D^2 + 9D)y(t) = (D - 1)f(t)$

(ii) $h(t) = t^{-2}u(t)$

(iii) $(D^2 + 4D + 4)y(t) = (D + 1)f(t)$

(i) (ii) (iii)

(c) Consider the Fourier transform pair $f(t) \Longleftrightarrow F(\omega)$ which has the Fourier transform defined as

$$F(\omega) = \omega(u(\omega + 10) - u(\omega - 10)).$$

Is $f(t)$ real or complex valued? (No need to explicitly determine $f(t)$, consider symmetry.)

Circle one:	real	complex

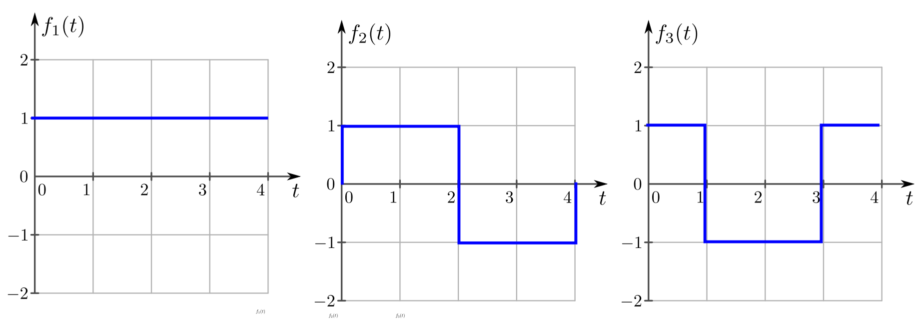
(d) Consider the Fourier transform pair $f(t) \Longleftrightarrow F(\omega)$ which has the Fourier transform defined as

$$F(\omega) = \mathrm{sinc}(\omega)e^{-j\omega^2}.$$

Is $f(t)$ real or complex valued? (No need to explicitly determine $f(t)$, consider symmetry.)

Circle one:	real	complex

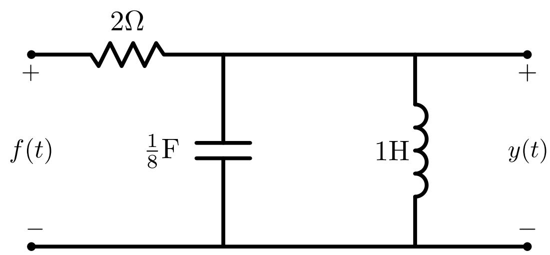
(e) A special type of basis functions called the Walsh functions are depicted below. Are they mutually orthogonal?



Circle one:	orthogonal	not orthogonal

2 Circuit analysis

Using the circuit below, please answer the following questions.



(a) Derive a differential equation relating the input $f(t)$ and the output $y(t)$. In your final answer, don't worry about including the units, just write the ODE in the form we have seen in class.

(b) Determine the zero-input response (we'll call it $y_2(t)$ for this system). Assume $y'(0) = 1$ and $y(0) = 0$.

$y_2(t) =$

(c) Determine the impulse response $h(t)$ for this system.

$h(t) =$

Left intentionally blank.

3 Convolution

Using direct integration or graphical (i.e., "flip-and-drag") methods, solve for $y(t)$ by performing the following convolutions.

(a) $y(t) = e^{-t}u(t) * (u(t-1) - u(t-3))$

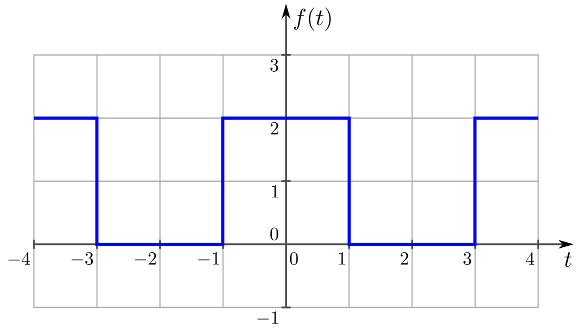
$y(t) =$

(b) $y(t) = (u(t-1) - u(t-3)) * \cos(\pi t)$

$y(t) =$

4 Fourier series

(a) Determine the period and fundamental frequency ω_0 for the function $f(t)$ seen below.

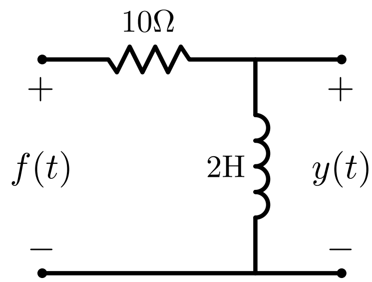


$T =$ ω_0

(b) Derive the *complex exponential* Fourier series for $f(t)$.

$f(t) =$

(c) Derive the transfer function $H(s)$ for the circuit seen below.



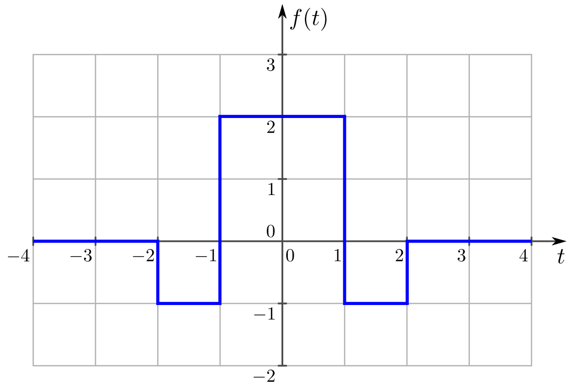
$H(s) =$

(d) Given the input $f(t)$ used in parts (a) and (b) for the circuit in part (c), what is the output $y(t)$?

$y(t) =$

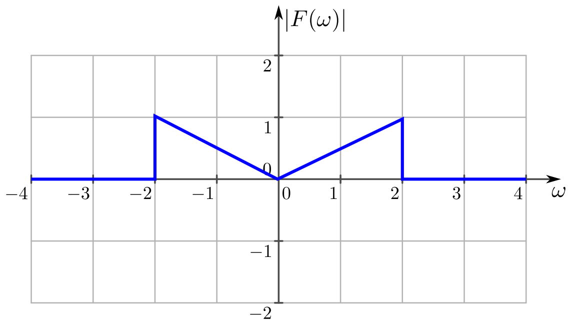
5 Fourier transforms

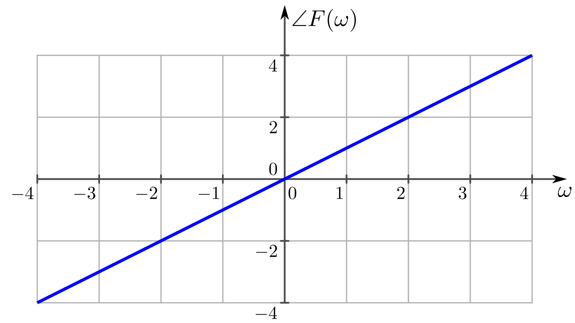
(a) Find the Fourier transform for $f(t)$ which is defined on the plot below.



$F(\omega) =$

(b) Find the inverse transform $f(t)$ if $|F(\omega)|$ and $\angle F(\omega)$ are given below. Note the phase $\angle F(\omega)$ extends linearly for all ω.





$f(t) =$