ECE 3210 Midterm 1

Week of: September 28, 2021

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) $h(t) = tu(t)$

(ii) $(D^2 + 9)y(t) = (D + 3)f(t)$

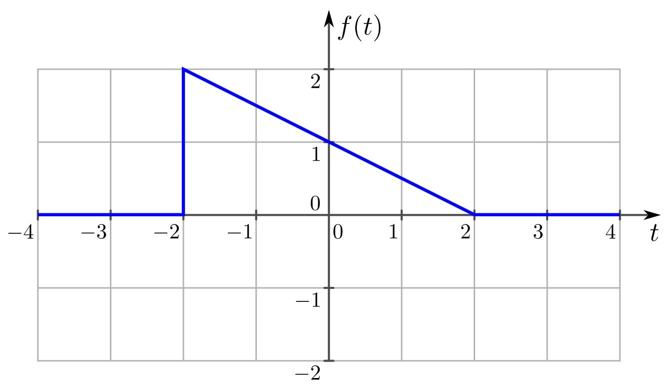
(iii) $(D^3 + 2D^2 + D)y(t) = f(t)$

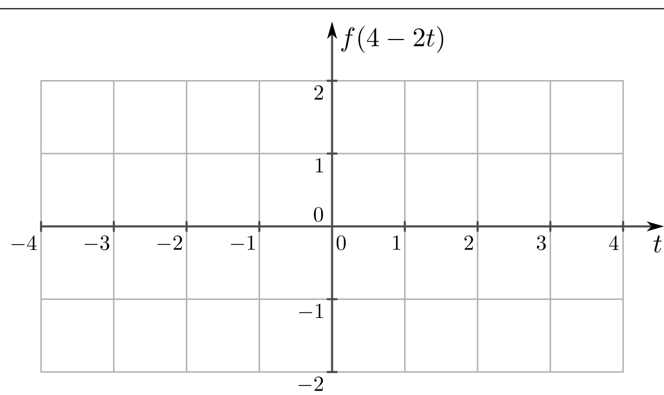
(i) (ii) (iii)

(c) True are false: are the functions $f_1(t) = t\cos(t)$ and $f_2(t) = t\sin(t)$ orthogonal on the interval $t \in [0,\, 2\pi]$?

True or False:

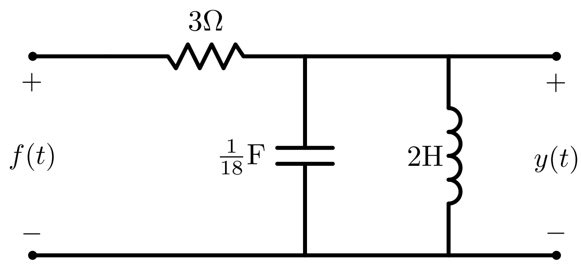
(d) Given $f(t)$ below, plot $f(2t + 2)$.





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.

$h(t) =$

3 Convolution

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

(a) $y(t) = \sin(t)(u(t) - u(t - 2\pi)) * u(t)$

$y(t) =$

(b) $y(t) = u(t) * t(u(t+1) - u(t-2))$

$y(t) =$

4 Fourier series

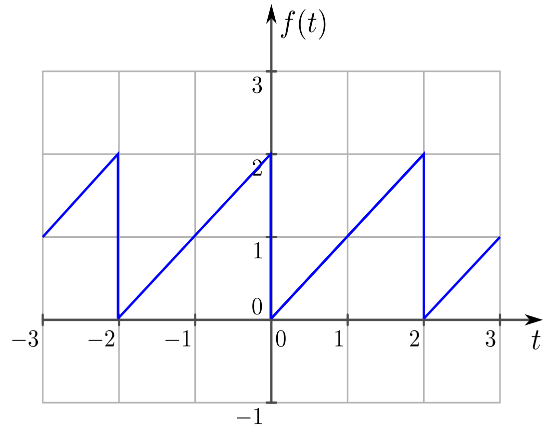
(a) Consider the function

$$f(t) = 0.5 + 5\sin(0.75t) + 2\cos(t) + 7\cos(-0.5t) + \sin(-0.25t).$$

Determine if this function is periodic. If it is, find the first five terms of the trigonometric Fourier series. (*Hint:* if you are using integrals here, you are doing it wrong...)

$a_0 =$				
$a_1 =$	$a_2 =$	$a_3 =$	$a_4 =$	$a_5 =$
$b_1 =$	$b_2 =$	$b_3 =$	$b_4 =$	$b_5 =$

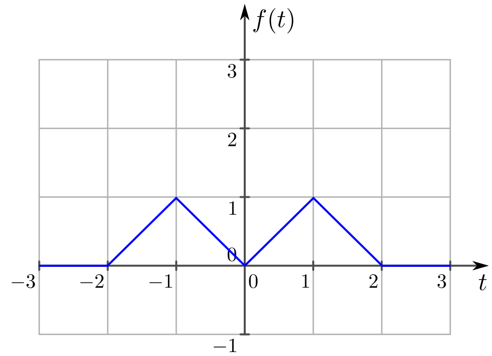
(b) Derive the *complex exponential* Fourier series for $f(t)$ which is periodic and is shown below.



$f(t) =$

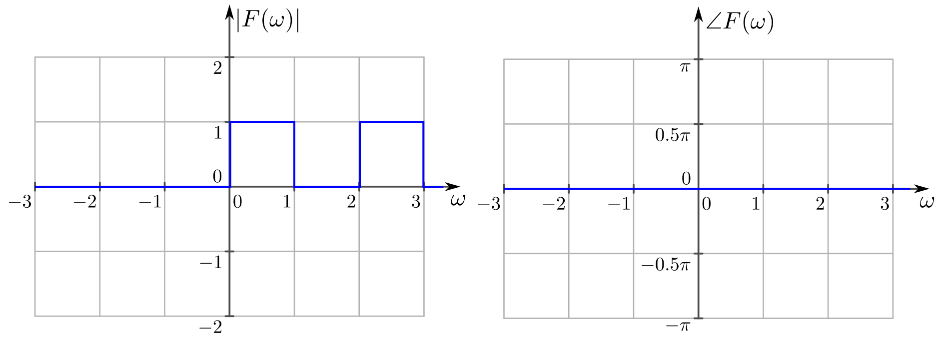
5 Fourier transforms

(a) Find the Fourier transform for $f(t)$ which is defined in 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.

$f(t) =$