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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	TRANSFORM CIRCUIT
COURSE CODE	:	BEV 20203
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTIONS 2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.** 3.STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

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Q1 (a) Determine the convolution of the pairs of signals $x(t)$ and $h(t)$ in **Figure Q1(a).**

(10 marks)

(b) The Laplace transform of a function $f(t)$ is given $F(s)$, where:

$$\mathcal{L}[f(t)] = F(s) = \int_{0}^{\infty} f(t)e^{-s}\, dt$$

Considering the above equation, determine the Laplace transformation of the following functions. You may refer the Laplace Transform Pairs and properties in **Table 1** and **Table 2**, respectively.

(i) $f(t) = \delta(t) + 2u(t) - 3e^{-2t}u(t)$

(2 marks)

(ii) $f(t) = sin\omega t\, u(t)$

(4 marks)

(iii) $j(t) = (4 + 3e^{-2t})u(t)$

(1 mark)

(c) Determine the Inverse Laplace transformation of the following functions.

(i) $H(s) = \frac{s+4}{s(s+4)}$

(2 marks)

(ii) $F(s) = \frac{s^2+12}{s(s+2)(s+3)}$

(3 marks)

(ii) $D(s) = \frac{10s}{(s^2+1)(s^2+4)}$

(3 marks)

Q2 (a) **Figure Q2(a)** shows the time domain RC circuit with $V_S = 20$ V.

(i) Draw the equivalent circuit in frequency domain.

(2 marks)

(ii) Determine the current, i(t) and the voltage, $v(t)$ of the circuit when $t > 0$.

(4 marks)

(iii) When the V_S increases to 50V, determine the current, i(t) and the voltage, $v(t)$ of the circuit.

(4 marks)

(b) **Figure Q2(b)** shows the RLC circuit with $V_s(t) = 10u(t)$ V. Assume that at t=0, -1 A current flows through the inductor and +5V voltage drop is appear across the capacitor. Determine the value of capacitor voltage using the superposition method.

(15 marks)

Q3 (a) **Figure Q3(a)** shows the time domain and frequency domain of RC circuit.

(i) Express the transfer function Vo/Vs for frequency domain RC circuit.

(5 marks)

(ii) Sketch the amplitude and the phase response of the results in Q3(a)(i).

(4 marks)

(b) A new system with a transfer function is cascaded to the existing system to get the new transfer function as below:

$$H(s) = \frac{s+10}{s(s+5)^2}$$

Analyse its characteristics by illustrating its magnitude and phase response in Bode plot.

(16 marks)

Q4 (a) Draw **one (1)** odd symmetry periodic function and **one (1)** even symmetry periodic function.

(4 marks)

(b) A voltage source, $v_s(t)$ is given in Fourier series equation as below. Determine the first three AC terms of the voltage source. Provide answers in polar form ($A\angle\theta$).

$$v_s(t) = \frac{1}{2} + \frac{2}{\pi}\sum_{k=1}^{\infty}\frac{1}{n}\sin(n\pi t)\ V, \quad n = 2k-1$$

(5 marks)

(c) An output voltage, $v_o(t)$ is given in Fourier series equation as below. Sketch the amplitude and phase spectrums of the output voltage.

$$v_o(t) = 0.5\cos(\pi t - 52°) + 0.2\cos(3\pi t - 75°) + 0.13\cos(5\pi t - 81°) + \cdots V$$

(6 marks)

(d) Compute the first three AC terms of the current *i*(*t*) given in **Figure Q4(d)**. The input voltage is given below. Provide answers in polar form ($A\angle\theta$).

$$v(t) = 3 - \frac{6}{\pi}\sum_{n=1}^{\infty}\frac{1}{n}sin(2\pi nt)\ V$$

(10 marks)

– END OF QUESTIONS –

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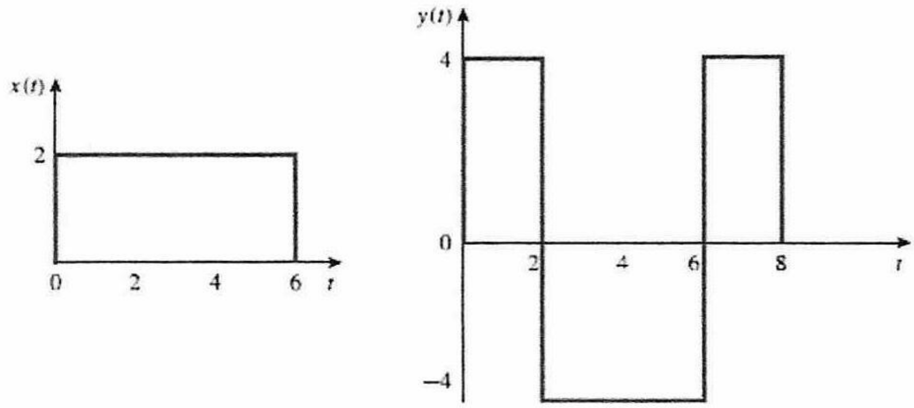

Figure Q1(a)

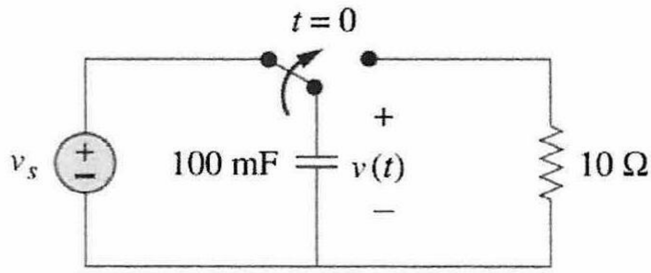

Figure Q2(a)

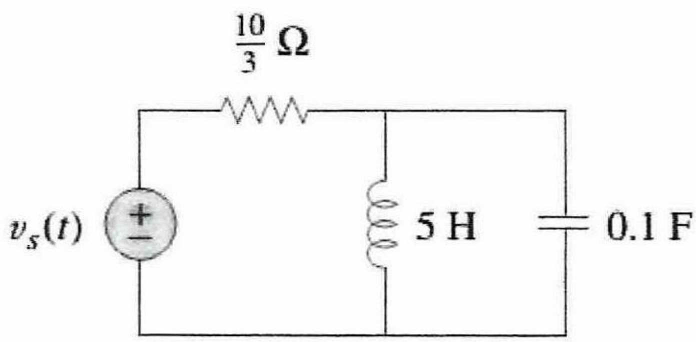

Figure Q2(b)

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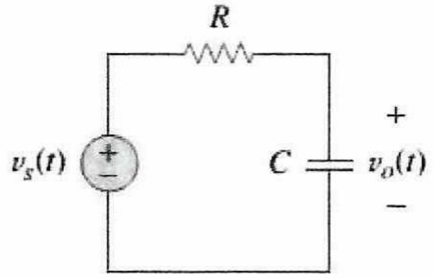

Figure Q3(a)

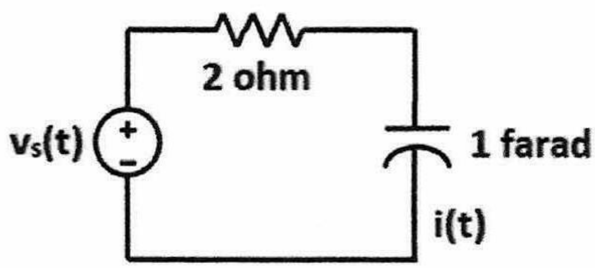

Figure Q4(d)

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$$A_n \angle \phi_n = a_n - jb_n$$

$$A_n = \sqrt{a_n^2 + b_n^2}, \qquad \phi_n = -\tan^{-1}\frac{b_n}{a_n}$$

$$f(t) = a_0 + \sum_{n=1}^{\infty} (a_n \cos n\omega_0 t + b_n \sin n\omega_0 t)$$

$$f(t) = a_0 + \sum_{n=1}^{\infty} A_n \cos(n\omega_0 t + \phi_n)$$

Table 1: Laplace Transform Pairs and Euler Formula

$f(t)$	$F(s)$	$f(t)$	$F(s)$
$\delta(t)$	1		
$u(t)$	$\frac{1}{s}$	$\cos\omega t$	$\frac{s}{s^2+\omega^2}$
e^{-at}	$\frac{1}{s+a}$	$\sin(\omega t+\theta)$	$\frac{s\sin\theta+\omega\cos\theta}{s^2+\omega^2}$
t	$\frac{1}{s^2}$	$\cos(\omega t+\theta)$	$\frac{s\cos\theta-\omega\sin\theta}{s^2+\omega^2}$
t^n	$\frac{n!}{s^{n+1}}$	$e^{-at}\sin\omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
te^{-at}	$\frac{1}{(s+a)^2}$	$e^{-at}\cos\omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$
$t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$		
$\sin\omega t$	$\frac{\omega}{s^2+\omega^2}$		

*Defined for $t \geq 0$; $f(t) = 0$, for $t < 0$.

Euler's formula

a. $\cos\theta = \frac{1}{2}\left(e^{j\theta} + e^{-j\theta}\right)$ b. $\sin\theta = \frac{1}{2j}\left(e^{j\theta} - e^{-j\theta}\right)$

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Table 2: Laplace Transform Properties

Property	$f(t)$	$F(s)$
Linearity	$a_1 f_1(t) + a_2 f_2(t)$	$a_1 F_1(s) + a_2 F_2(s)$
Scaling	$f(at)$	$\frac{1}{a} F\left(\frac{s}{a}\right)$
Time shift	$f(t-a)u(t-a)$	$e^{-as} F(s)$
Frequency shift	$e^{-at} f(t)$	$F(s+a)$
Time differentiation	$\frac{df}{dt}$	$sF(s) - f(0^-)$
	$\frac{d^2 f}{dt^2}$	$s^2 F(s) - sf(0^-) - f'(0^-)$
	$\frac{d^3 f}{dt^3}$	$s^3 F(s) - s^2 f(0^-) - sf'(0^-) - f''(0^-)$
	$\frac{d^n f}{dt^n}$	$s^n F(s) - s^{n-1} f(0^-) - s^{n-2} f'(0^-) - \cdots - f^{(n-1)}(0^-)$
Time integration	$\int_0^t f(x)\,dx$	$\frac{1}{s} F(s)$
Frequency differentiation	$tf(t)$	$-\frac{d}{ds} F(s)$
Frequency integration	$\frac{f(t)}{t}$	$\int_s^\infty F(s)\,ds$
Time periodicity	$f(t) = f(t + nT)$	$\frac{F_1(s)}{1 - e^{-sT}}$
Initial value	$f(0)$	$\lim_{s \to \infty} sF(s)$
Final value	$f(\infty)$	$\lim_{s \to 0} sF(s)$
Convolution	$f_1(t) * f_2(t)$	$F_1(s) F_2(s)$