UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF INDUSTRIAL TECHNOLOGY

FINAL EXAMINATION
JANUARY 2016 SEMESTER

COURSE CODE	:	JCB 20303
COURSE TITLE	:	SIGNAL AND SYSTEM
PROGRAMME LEVEL	:	BACHELOR
DATE	:	18 MAY 2016
TIME	:	2.30 PM – 5.30 PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question paper consists of ONE (1) section.
4. Answer FOUR (4) questions in Section A.
5. Please write your answers on the answer booklet provided.
6. Table and formula are enclosed as reference.
7. Please answer all questions in English only.

THERE ARE 5 PAGES OF QUESTIONS EXCLUDING THIS PAGE.

SECTION A (Total: 100 marks)

INSTRUCTION: Answer FOUR (4) questions ONLY.
Please use the answer booklet provided.

Question 1

(a) Identify the following system is causal or non-causal system.

$$y(t) = x^2(t) + x(t-3)$$

(2 marks)

(b) Obtain the amplitude spectrums for following function up to 5^{th} harmonic.

$$x(t) = \frac{A}{2} + \frac{4A}{\pi^2}\cos\omega_0 t + \frac{4A}{9\pi^2}\cos 3\omega_0 t + \frac{4A}{25\pi^2}\cos 5\omega_0 t$$

(6 marks)

(c) The input and the impulse response of the system are given by;

$$x(t) = u(t+2)$$
$$h(t) = u(t-3)$$

Examine the output of the system graphically using convolution method.

(9 marks)

(d) Determine the frequency response, $H(\omega)$ and the impulse response $h(t)$ of circuit in Figure 1 below;

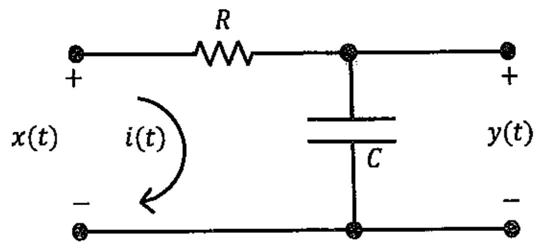

Figure 1

(8 marks)

Question 2

(a) Define the following terms;

i. Time Invariant System

ii. Memoryless System

(2 marks)

(b) For below continuous time signal;

$$x(t) = \begin{cases} 4\ ;\ \text{for } t=0 \\ 4-t\ ;\ \text{for } 0 \le t \le 4 \\ 0\ ;\ \text{otherwise} \end{cases}$$

i. Sketch the waveform $x(t)$.

ii. Then, sketch the function $3x(2t-2)$.

(6 marks)

(c) For signal $x(t)$ below;

$$x(t) = e^{-2t}u(-t) + e^{-3t}u(-t)$$

i. Determine the Laplace Transform of $x(t)$.

(3 marks)

ii. Determine its Region of Convergence (ROC).

(2 marks)

(d) Based on Figure 2,

i. Determine the Fourier Series Coefficient.

ii. Then, describe the following signal in Fourier Series up to 5th harmonic.

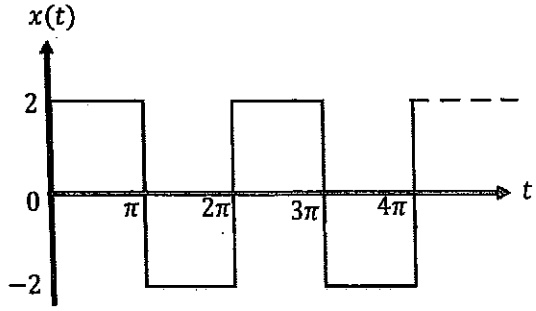

Figure 2: Continuous time signal, $x(t)$

(12 marks)

Question 3

(a) Identify the High Pass Filter transfer function from the given magnitude characteristic in Figure 3. Assume $\xi < 0.7017$.

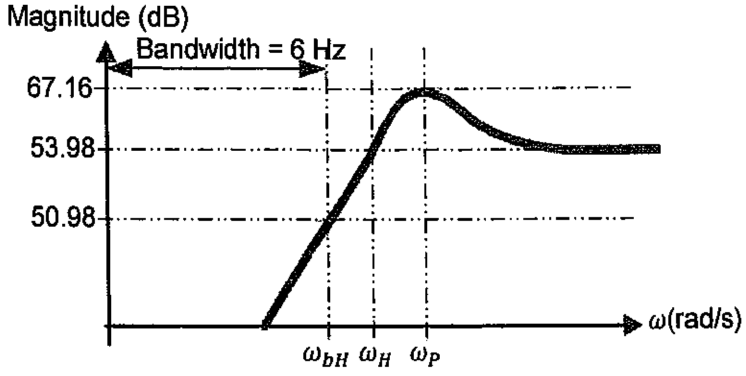

Figure 3: Magnitude characteristic of High Pass Filter

(8 marks)

Formula:

$$H_{HPF}(s) = \frac{K\omega_H s^2}{s^2 + 2\xi\omega_H s + \omega_H{}^2} \qquad M_{p.w} = \frac{1}{2|\xi|\sqrt{1-2\xi^2}}$$

$$\omega_H = \omega_{BH}\sqrt{(1-2\xi^2) + \sqrt{4\xi^4 - 4\xi^2 + 2}}$$

(b) The input, $x(t)$ and the output, $y(t)$ of a causal LTI system are described by the differential equation;

$$\frac{\partial^2 y(t)}{\partial t^2} + \frac{3dy(t)}{dx} + 2y(t) = x(t)$$

i. Determine the frequency response of the system.

(3 marks)

ii. Determine the impulse response of the system.

(5 marks)

iii. Based on the answer in (ii), examine the output of the system if the input, $x(t) = te^{-t}u(t)$.

(9 marks)

Question 4

(a) Find the inverse Fourier Transform of the following function by using partial fraction expansion.

$$X(\omega) = \frac{4(j\omega)+6}{(j\omega)^2+6(j\omega)+8}$$

(4 marks)

(b) Design the Low Pass Filter by obtaining their transfer function for the following band pass filter characteristic.

i. Gain, 20dB
ii. Bandwidth 3dB = 3000Hz
iii. $\xi = 0.707$

Formula:

$$H_{LPF}(s) = \frac{K\omega_n^{\,2}}{s^2+2\xi\omega_n s+\omega_n^{\,2}} \qquad \omega_n = \frac{\omega_{bn}}{\sqrt{(1-2\xi^2)+\sqrt{4\xi^4-4\xi^2+2}}}$$

(4 marks)

(c) Sketch the Bode plot for following function.

$$H(j\omega) = \frac{1100j\omega}{(j\omega+100)(j\omega+1000)}$$

(7 marks)

(d) Examine the corresponding exponential form of Fourier series for periodic waveform in Figure 4.

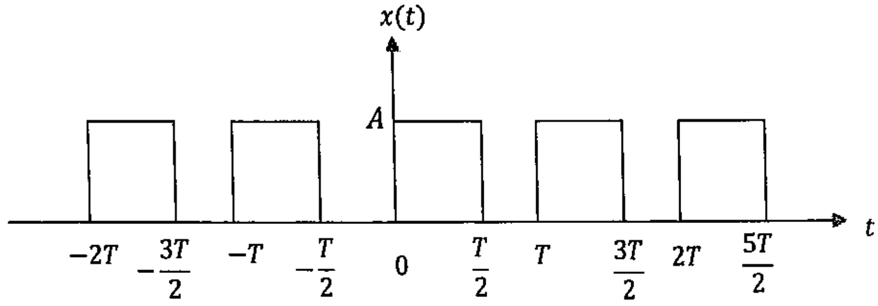

Figure 4: Periodic waveform, $x(t)$

(10 marks)

Question 5

(a) Find the Fourier transform of the signal below.

$$x(t) = \begin{cases} e^{|t|} \text{ ; for } -4 \le t \le 4 \\ 0 \text{ ; otherwise} \end{cases}$$

(4 marks)

(b) Obtain the time domain of following function using the Laplace Transform pairs and table of properties;

$$X(s) = \frac{s+4}{s^2+5s+6}$$

(4 marks)

(c) Examine the output of the causal LTI system for an input $x(t) = 3e^{-t}u(t)$ with impulse response $h(t) = e^{-4t}u(t)$.

(7 marks)

(d) Based on Figure 5, determine $i(t)$ when switch S is closed at $t \ge 0$.
Assume $i(0) = 5[A]$.

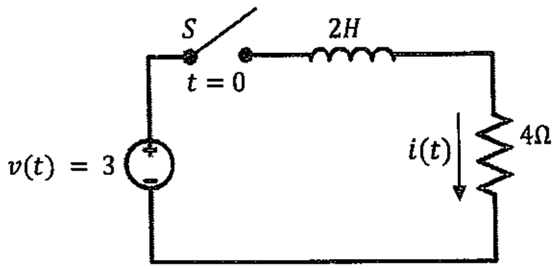

Figure 5

(10 marks)

END OF EXAMINATION PAPER

APPENDIX A

Table 1 Fourier Transform Pairs

S. No	Function $x(t)$	Fourier Transform $X(\omega)$
1	$\delta(t)$	1
2	$\delta(t-t_0)$	$e^{-j\omega t_0}$
3	1	$2\pi\delta(\omega)$
4	$u(t)$	$\pi\delta(\omega)+\frac{1}{j\omega}$
5	$\sum_{n=-\infty}^{\infty}\delta(t-nT)$	$\omega_0\sum_{n=-\infty}^{\infty}\delta(\omega-n\omega_0),\ \omega_0=\frac{2\pi}{T}$
6	$sgn(t)$	$\frac{2}{j\omega}$
7	$e^{j\omega_0 t}$	$2\pi\delta(\omega-\omega_0)$
8	$cos\ \omega_0 t$	$\pi[\delta(\omega-\omega_0)+\delta(\omega+\omega_0)]$
9	$sin\ \omega_0 t$	$-j\pi[\delta(\omega-\omega_0)-\delta(\omega+\omega_0)]$
10	$e^{-at}u(t), a>0$	$\frac{1}{j\omega+a}$
11	$te^{-at}u(t), a>0$	$\frac{1}{(j\omega+a)^2}$
12	$e^{-a\|t\|}, a>0$	$\frac{2a}{a^2+\omega^2}$
13	$e^{-\|t\|}$	$\frac{2}{1+\omega^2}$
14	$\frac{1}{\pi t}$	$-j\ sgn(\omega)$
15	$\frac{1}{a^2+t^2}$	$\frac{\pi}{a}e^{-a\|\omega\|}$
16	$\Pi\left(\frac{t}{\tau}\right)$	$\tau\ sinc\frac{\omega\tau}{2}$
17	$\Delta\left(\frac{t}{\tau}\right)$	$\frac{\tau}{2}sinc^2\left(\frac{\omega\tau}{4}\right)$
18	$\frac{\sin at}{\pi t}$	$P_a(\omega)=\begin{matrix}1, & \|\omega\|<a \\ 0, & \|\omega\|>a\end{matrix}$
19	$\cos\ \omega_0 t\, u(t)$	$\frac{\pi}{2}[\delta(\omega-\omega_0)+\delta(\omega+\omega_0)]+\frac{j\omega}{(j\omega)^2+{\omega_0}^2}$
20	$\sin\ \omega_0 t\, u(t)$	$-j\frac{\pi}{2}[\delta(\omega-\omega_0)-\delta(\omega+\omega_0)]+\frac{\omega_0}{(j\omega)^2+{\omega_0}^2}$

Table 2 Fourier Transform Properties

Property	$x(t)$	$X(\omega)$
Direct transform	$x(t)$	$\int_{-\infty}^{\infty} x(t)\, e^{-j\omega t}\, dt$
Inverse transform	$\frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)\, e^{j\omega t}\, d\omega$	$X(\omega)$
Linearity	$ax_1(t) + bx_2(t)$	$aX_1(\omega) + bX_2(\omega)$
Time shifting	$x(t \pm t_0)$	$e^{\pm j\omega t_0}X(\omega)$
Frequency shifting	$e^{\pm j\omega_0 t}\, x(t)$	$X(\omega \mp \omega_0)$
Time reversal	$x(-t)$	$X(-\omega)$
Time scaling	$x(at)$	$\frac{1}{\lvert a\rvert}X\left(\frac{\omega}{a}\right)$
Differentiation in time domain	$\frac{d}{dt}x(t)$	$j\omega X(\omega)$
Differentiation in frequency domain	$tx(t)$	$j\frac{d}{d\omega}X(\omega)$
Time integration	$\int_{-\infty}^{t} x(\tau)\, d\tau$	$\frac{1}{j\omega}X(j\omega)$
Convolution	$x_1(t) * x_2(t)$	$X_1(\omega)X_2(\omega)$
Multiplication	$x_1(t)x_2(t)$	$\frac{1}{2\pi}[X_1(\omega) * X_2(\omega)]$
Duality	$X(t)$	$2\pi x(-\omega)$
Modulation	$x(t)\cos\omega_c t$	$\frac{1}{2}[X(\omega - \omega_c) + X(\omega + \omega_c)]$
	$x(t)\sin\omega_c t$	$\frac{1}{2j}[X(\omega - \omega_c) - X(\omega + \omega_c)]$
Conjugation	$x^*(t)$	$X^*(-\omega)$
Auto correlation	$R(\tau)$	$\lvert X(\omega)\rvert^2$
Parseval's theorem	$\int_{-\infty}^{\infty} x_1(t)\, x_2^*(t)dt$	$\frac{1}{2\pi}\int_{-\infty}^{\infty} X_1(\omega)X_2^*(\omega)\, d\omega$
	$E = \int_{-\infty}^{\infty} \lvert x(t)\rvert^2\, dt$	$\frac{1}{2\pi}\int_{-\infty}^{\infty} \lvert X(\omega)\rvert^2\, d\omega$
Area under the curve	$\int_{-\infty}^{\infty} x(t)\, dt$	$\frac{1}{2\pi}X(0)$

Table 3 Laplace Transform Pairs

Function $x(t)$	Laplace transform $X(s)$
$\delta(t)$	1
$\delta(t-a)$	e^{-as}
$u(t)$	$\frac{1}{s}$
$u(t-a)$	$\frac{e^{-as}}{s}$
$u(-t)$	$-\frac{1}{s}$
$tu(t)$	$\frac{1}{s^2}$
$t^2u(t)$	$\frac{2!}{s^3}$
$t^nu(t)$	$\frac{n!}{s^{n+1}}$
$e^{-at}u(t)$	$\frac{1}{(s+a)}$
$e^{at}u(t)$	$\frac{1}{(s-a)}$
$te^{-at}u(t)$	$\frac{1}{(s+a)^2}$
$t^ne^{-at}u(t)$	$\frac{n!}{(s+a)^{n+1}}$
$\sin\omega t\, u(t)$	$\frac{\omega}{s^2+\omega^2}$
$\cos\omega t\, u(t)$	$\frac{s}{s^2+\omega^2}$
$e^{-at}\sin\omega t\, u(t)$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at}\cos\omega t\, u(t)$	$\frac{s+a}{(s+a)^2+\omega^2}$
$\sin(\omega t+\theta)$	$\frac{s\, sin\theta+\omega\, cos\theta}{s^2+\omega^2}$
$\cos(\omega t+\theta)$	$\frac{s\, cos\theta+\omega\, sin\theta}{s^2+\omega^2}$
$t\, sin\omega t\, u(t)$	$\frac{2\omega s}{(s^2+\omega^2)^2}$
$t\, cos\omega t\, u(t)$	$\frac{s^2-\omega^2}{(s^2+\omega^2)^2}$