DESK No.

FAMILY NAME:

GIVEN NAMES:

SIGNATURE:

STUDENT NUMBER:

SEMESTER 2, 2020 EXAMINATIONS

ENSC3015

Engineering

Signals and Systems

Electrical, Electronic and Computer Engineering

This paper contains: **5+12** Pages **(including title page)**

Time Allowed: **2:00** hours

INSTRUCTIONS:

TOTAL MARKS: 84 marks

All 11 questions are to be completed in the answer booklet provided.

Please show all working to arrive at your final answer(s).

APPROVED CALCULATORS ALLOWED.

THIS IS A OPEN BOOK EXAMINATION

SUPPLIED STATIONERY	**ALLOWABLE ITEMS**
1 x Answer Booklet 18 Pages	**UWA Approved Calculator with Sticker** **Open Book with Student Notes**

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Question 1 (8 marks)

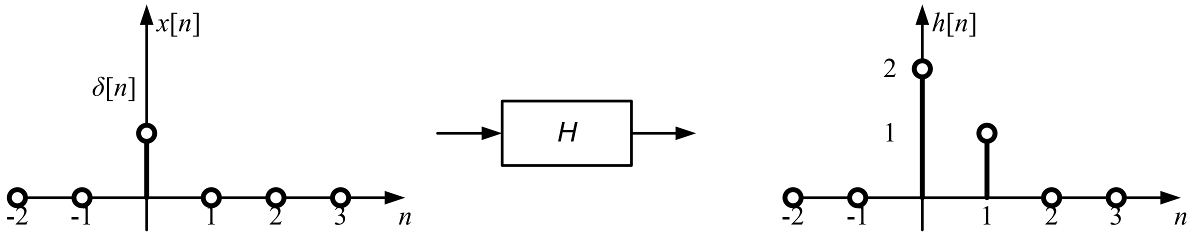
Determine the <u>total energy</u> of the signal:

$$x(t) = \begin{cases} 1 - \dfrac{|t|}{2} & |t| < 2 \\ 0 & otherwise \end{cases}$$

HINT: Split the integral to handle the $|t|$.

Question 2 (6 marks)

A linear, time-invariant system has the impulse response, $h[n]$, shown below (when input $x[n] = \delta[n]$):



Sketch the response of the system to the input when it is:

$$x[n] = \delta[n+1] - \delta[n-2]$$

You must label and scale all axes.

Question 3 (8 marks)

Determine the response, $y(t)$, given an LTI system described by:

$$\frac{d^2y(t)}{dt^2} + 6\frac{dy(t)}{dt} + 8y(t) = 2x(t)$$

with input $x(t) = 0$ and initial conditions $y(0^-) = 1$ and $\dot{y}(0^-) = 2$.
Do NOT use the Laplace transform for this.

Question 4 (6 marks)

Determine the <u>Laplace transform</u> of $x(t) = tu(t-1)$ using the table of Laplace transforms pairs and properties. **HINT**: Use the fact that $(t-1)u(t-1) = tu(t-1) - u(t-1)$, the time-shift property and the pair (for $k = 0, 1$ and 2):

$$\frac{1}{k!}t^k u(t) \leftrightarrow \frac{1}{s^{k+1}}$$

Question 5 (6 marks)

The transfer function of a causal continuous-time LTI system is given below:

$$H(s) = \frac{s+5}{s^2+4s+3}$$

(i) State with reason if the system is stable and minimum phase.
(ii) Describe the differential equation relating the input $x(t)$ and the output $y(t)$.

Question 6 (4 marks)

Consider the discrete-time LTI system with difference equation:

$$y[n] = x[n] - \frac{1}{2}x[n-1] - \frac{3}{4}y[n-1]$$

What is the difference equation of the inverse system?

Question 7 (10 marks)

A discrete system is described by the following transfer function:

$$H(z) = \frac{(1-0.5z^{-1})}{(1+0.5z^{-1})(1-z^{-1})}$$

(i) Find the system output response, $y[n]$, to input $x[n] = 2^{-n}u[n]$ if all initial conditions are zero.
(ii) Write the difference equation relating the output $y[n]$ to input $x[n]$ for this system.

Question 8 (8 marks)

Use Euler's relation and the fact that $x(t) = \sum_{k=-\infty}^{\infty} X[k]e^{jk\omega_0 t}$ to derive the Fourier series, $X[k] = |X[k]|e^{j\angle x[k]}$, for the following periodic signal:

$$x(t) = \cos t + 0.5\cos(4t + \pi/3)$$

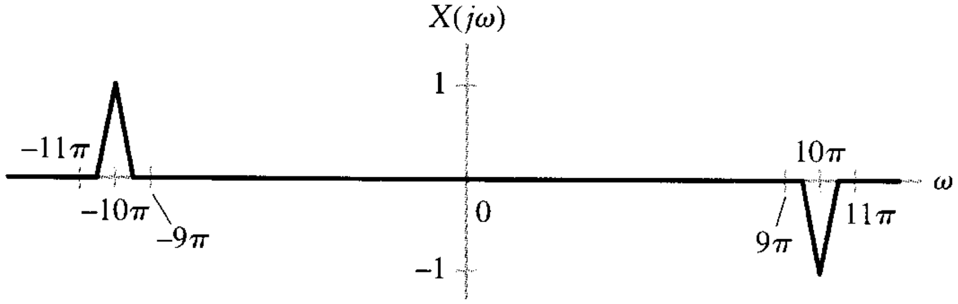
Question 9 (8 marks)

Calculate the Fourier Transform by direct integration using the defining equations of the following time-domain signal (where $u(t)$ is the unit step function):

$$x(t) = e^{1+t}u(-t+2)$$

Question 10 (12 marks)

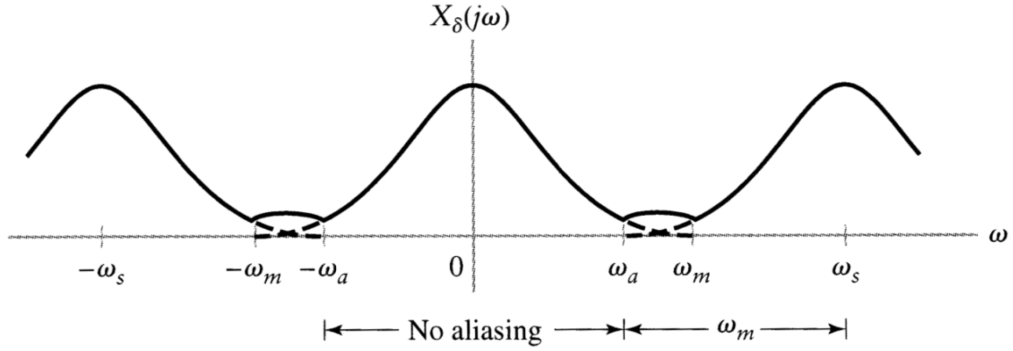
(a) The continuous-time signal $x(t)$ with Fourier Transform as depicted below is sampled:



Sketch the Fourier Transform of the sampled signal for the following sampling periods, T_s, and identify whether aliasing occurs:

(i) $T_s = 1/14$
(ii) $T_s = 1/7$
(iii) $T_s = 1/5$

(b) We sample a continuous-time signal with Fourier spectra $X(j\omega)$ and want to ensure that we can reconstruct $X(j\omega)$ over the interval $-\omega_a < \omega < \omega_a$ given that the signal is band-limited with maximum frequency ω_m but where $\omega_m \geq \omega_a$. This is depicted in the figure below:



What is the maximum sampling period, T_s, we can use?

Question 11 (8 marks)

Use the defining equation, $x[n] = \frac{1}{2\pi}\int_{-\pi}^{\pi} X(e^{j\Omega})e^{j\Omega n}d\Omega$, to determine the time-domain signal, $x[n]$, that has the following DTFT: