UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: August 2018

Module Number: EE3205 **Module Name: Signals and Systems**

[Three Hours]

[Answer **all questions**, each question carries 10 marks]

- **All symbols have their usual meanings.**
- **Use the properties of the Laplace transform and the unilateral Laplace transforms in Table 1 and Table 2 for Question 4.**

Q1 a) i) For an energy signal $f(t)$ with energy E_f, show that the energy of any of the signals $-f(t)$, $f(-t)$ and $f(t-T)$ is E_f.

ii) Show that the energy of $f(at)$ as well as $f(at-b)$ is $\frac{E_f}{a}$.

iii) What conclusions can be made for the energy of time-inverted, time-shifted, time-compressed and time-expanded signals respectively based on the findings in part i) and part ii) ?

[4.0 Marks]

b) Determine whether the system described by $(2+\sin t)\,x(t)$ is

i) linear.
ii) memoryless.
iii) time invariant.
iv) stable.

[4.0 Marks]

c) i) What is meant by the correlation between two signals?

ii) Explain how the correlation property can be used for object detection in radar communications.

[2.0 Marks]

Q2 a) i) Derive the exponential Fourier series of a time delayed periodic signal $v(t-t_0)$ in terms of the exponential Fourier series coefficients of $v(t)$.

ii) Hence, show that the amplitude spectra of the two signals are the same.

[3.0 Marks]

b) Consider the half-wave rectified sine signal shown in Figure Q2.

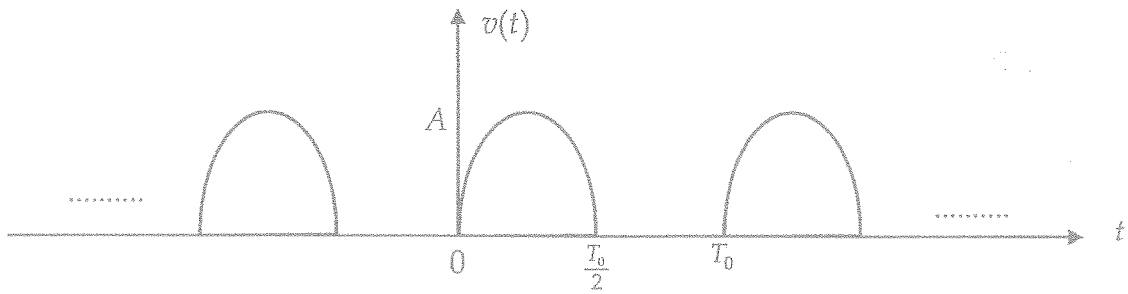

Figure Q2

i) Determine the exponential Fourier series of the half-wave rectified sine signal in Figure Q2.
ii) Sketch the amplitude spectrum of the half-wave rectified sine signal.

[5.0 Marks]

c) Using the result in part b) or otherwise, obtain an expression for the Fourier series coefficients of a full-wave rectified signal of the same frequency.

[2.0 Marks]

Q3 a) Consider the causal periodic function

$$v_T(t) = \sum_{m=0}^{\infty} v(t - mT)$$

where $v(t)$ is an energy signal which is zero outside the interval $0 \le t \le T$. Determine $V_T(f)$, the Fourier transform of $v_T(t)$ in terms of $V(f)$, the Fourier transform of $v(t)$.

[3.0 Marks]

b) Consider the decaying exponential signal $v(t) = Ae^{-at}\,u(t)$ shown in Figure Q3.

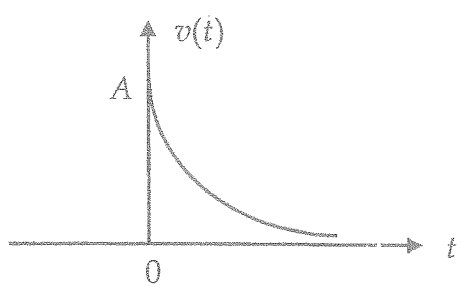

Figure Q3

i) Determine the Fourier transform of the signal.
ii) Sketch the amplitude and phase spectra of the signal.

[7.0 Marks]

Q4 a) Using the definition of the Laplace transform, determine the Laplace transform of $f(t)$ shown in Figure Q4.

[4.0 Marks]

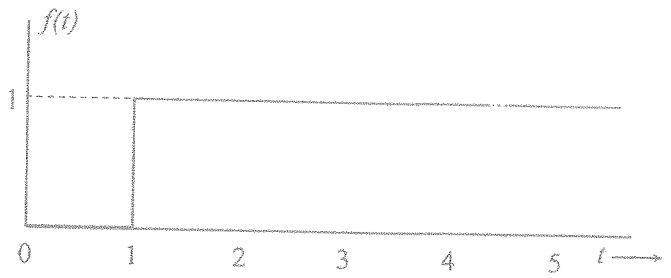

Figure Q4

b) A system is described by the following differential equation.

$$\frac{d^2y(t)}{dt^2} + 3\frac{dy(t)}{dt} + 2y(t) = f(t)$$

Determine the response of the system $y(t)$, if the initial conditions are $y(0)=0$, $\frac{dy(0)}{dt} = 1$ and the input $f(t)$ is given by Figure Q4.

[6.0 Marks]

Q5 a) Spectral folding or aliasing is a fundamental practical difficulty that occurs when reconstructing a signal from its samples.

i) Why does spectral folding or aliasing occur when reconstructing a signal from its samples?

ii) How can this difficulty be eliminated?

[4.0 Marks]

b) Consider two signals $f_1[n]$ and $f_2[n]$ shown in Figure Q5.

i) Using the definition of z-transform, determine the z-transforms of $f_1[n]$ and $f_2[n]$.

ii) Using the results in part i), determine the z-transform of $f_1[n] * f_2[n]$.

[6.0 Marks]

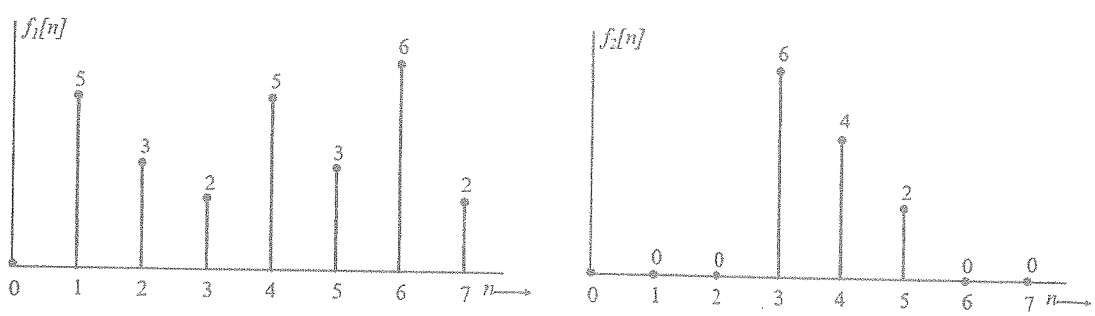

Figure Q5

Table 1: Properties of the Laplace transform

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	$f_1(t) * f_2(t)$	$F_1(s)F_2(s)$

Table 2: A short table of unilateral Laplace transforms

	$f(t)$	$F(s)$
1	$\delta(t)$	1
2	$u(t)$	$\frac{1}{s}$
3	$tu(t)$	$\frac{1}{s^2}$
4	$t^n u(t)$	$\frac{n!}{s^{n+1}}$
5	$e^{\lambda t} u(t)$	$\frac{1}{s-\lambda}$
6	$te^{\lambda t} u(t)$	$\frac{1}{(s-\lambda)^2}$
7	$t^n e^{\lambda t} u(t)$	$\frac{n!}{(s-\lambda)^{n+1}}$
8a	$\cos bt\, u(t)$	$\frac{s}{s^2+b^2}$
8b	$\sin bt\, u(t)$	$\frac{b}{s^2+b^2}$
9a	$e^{-at} \cos bt\, u(t)$	$\frac{s+a}{(s+a)^2+b^2}$
9b	$e^{-at} \sin bt\, u(t)$	$\frac{b}{(s+a)^2+b^2}$
10a	$re^{-at} \cos(bt+\theta)\, u(t)$	$\frac{(r\cos\theta)s + (ar\cos\theta - br\sin\theta)}{s^2+2as+(a^2+b^2)}$
10b	$re^{-at} \cos(bt+\theta)\, u(t)$	$\frac{0.5re^{j\theta}}{s+a-jb} + \frac{0.5re^{-j\theta}}{s+a+jb}$

UNIVERSITY OF RUHUNA

Faculty of Engineering

Semester 3 Examination in Engineering: August 2018

Module Number: CE3203 **Module Name: Engineering Surveying**

[Three Hours]

[Answer all questions. Each question carries **TWELVE** marks]
All Standard Notations denote their regular meanings

Q1 a) Consider a parameter A given by the division by of a by b (i.e A = (a/b)). Where a and b have standard errors of σ_a and σ_b. Find the error in A.

[4.0 Marks]

b) a, b, c, and d form a round of angle at a station so that their sum is equal to 360°. The observed values of these angles are;

a = 103° 27′ 20″
b = 91° 14′ 15″
c = 94° 23′ 50″
d = 70° 54′ 45″

The angle (b+c) was also measured separately twice and found to average 185° 38′ 10″. Find the most probable values of the four angles if all the measurements of individual angles are of the same accuracy.

[8.0 Marks]

Q2 a) Consider a closed clockwise traverse ABCD, whose stations have co-ordinates (E_1, N_1), (E_2, N_2), (E_3, N_3), and (E_4, N_4) relative to two axes with origin 'O'. Calculate the area enclosed by ABCD.

[4.0 Marks]

b) It is proposed to widen a highway by increasing the gradient of the side slope from 1 in 1.5 to 1 in 2.0 by keeping the top of the cut (Point B) at the same point (See Figure Q2-1). The difference in level between the bottom and top of the cut at a critical section was measured as 15.0 m. The length of the embankment along the side slope was measured as 29.872 m using a steel tape under a pull of 151 N at a temperature of 27°C. Determine the additional road width which will be available with the new slope.

The tape was standardized on the flat at 18°C under a pull of 47 N. The cross-sectional area of the tape is 6.5 mm^2, E = 20.8 × 10^4 MN/m^2 and $\alpha = 1.1 \times 10^{-5}$ per °C.

[8.0 Marks]

Q3 a) How do you level a theodolite or total station which has four foot-screws in the levelling head?

[3.0 Marks]

b) A link traverse (Figure Q3-1) commences from known stations, A and B, and connects to known stations C and D. Stations A, B, C and D are usually fixed to a higher order of accuracy. Co-ordinates of points B and C are (3,854.28 mE, 9,372.98 mN) and (7,575.56 mE, 8,503.21 mN), respectively. The WCB of AB and CD lines are 151° 27′ 38″ and 347° 37′4 1″ respectively. The Table Q3-1 indicates the lines, observed angles, and lengths of the legs of the link traverse. Calculate the final coordinates of all traverse points and find the accuracy of the traverse.

[9.0 Marks]

Q4 a) Derive a formula for the cross-sectional area of the level section as show in Figure Q4-1 in terms of formation width b, side slope given by 1: m and central line height h.

[2.0 Marks]

b) A road embankment is 8 m wide with side slope 1:2.5. The top (made) surface of a straight portion of this road embankment rises at a gradient of 1:120 along its center line in the longitudinal direction. At the start of this straight section, the reduced level of the center of the top (made) surface is 210.00 m above the datum. The reduced levels of the natural ground along the center line of the road embankment are given in Table Q4-1. Assume that the natural ground is level in the direction transverse to the center line. Calculate the volume of the earth-work (cutting and filling volume) contained in a length of 560 m.

[5.0 Marks]

c) The areas within the contour lines of a reservoir is measured with a planimeter from a plan drawn to a scale 1:1000 and show in Table Q4-2. If the lowest raw-off level is 56m and the maximum water level is 68m, estimate the full storage capacity of the reservoir and find the water level when reservoir is 50% capacity.

[5.0 Marks]

Q5 a) Explain the meaning of the following terms connected to levelling:

i. Datum
ii. Temporary Bench Mark
iii. Hight of Collimation
iv. Rise and Fall method

[4.0 Marks]