MACHAKOS UNIVERSITY

University Examinations 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

SPH 322: SIGNAL PROCESSING

DATE: 18/8/2021 **TIME: 2.00-4.00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections
- Section **A** is **compulsory** (30 marks)
- Answer any **two** questions from section **B** (each 20 marks)

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

a) i Define a signal (1 mark)

ii Draw a typical communication system citing the main elements of the system (2 marks)

b) The one sided exponential function $f(t) = e^{-\alpha t}u(t)$ has Fourier transform $F(\omega) = \dfrac{1}{\alpha + i\omega}$.

Find the real and imaginary parts of $F(\omega)$ (2 marks)

c) i Write the Fourier and Laplace transform equations (2 marks)

ii Show that the bilateral Laplace transform of signal $f(t)$ is the Fourier transform of the product of the signal and exponential function $e^{-\sigma t}$ (2 marks)

iii Define the linearity property hence find the Laplace transform of the function $5 - 3t + 8\cos(2t)$ (3 marks)

d) State the difference between auto and cross correlation in signal processing (1 mark)

e) A ramp signal has neither power nor energy whereas a unit step signal which is not periodic has finite power. Explain this fact. (2 marks)

f) Distinguish between recursive and non-recursive discrete time processors (1 mark)

g) i Explain the following operation in signal processing (2 marks)

I. Time shifting

II. Time scaling

ii For the signal $x(-t)$ in Figure 1 sketch and describe mathematically signal $x(t)$ which is time reversed $x(-t)$.

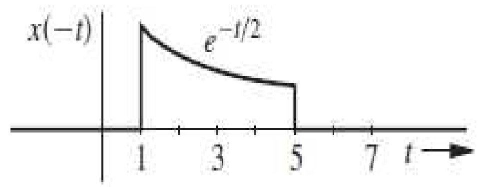

Figure 1

h) Define convolution in signal processing (1 mark)

i. State the relationship between the following functions (2 marks)

ii. Impulse and unit functions

iii. Unit and ramp functions

i) State the Paserval's theorem in signal processing (1 mark)

j) Test and classify the following systems as time varying or time invariant (2 marks)

i. $y(t) = sx(t)$

ii. $y(t) = 2e^{\alpha t}x(t)$

k) State why a system specified by equation $y(t) = x(t-2) + x(t+2)$ is non-casual and show how its output can be realized in real time (2 marks)

l) Test the inevitability property of the systems describe the equations below (2 marks)

i. $y[n] = 3cx[n]$

ii. $y[n] = \left(x[n]\right)^4$

m) Derive an expression to show the zero input response and zero state response in a RC circuit (2 marks)

SECTION B (ANSWER ANY TWO QUESTIONS)

QUESTION TWO (20 MARKS)

a) Figure 2 (a) and (b) show two types of signals. Classify them as power or energy signal then calculate the measures in each of them (6 marks)

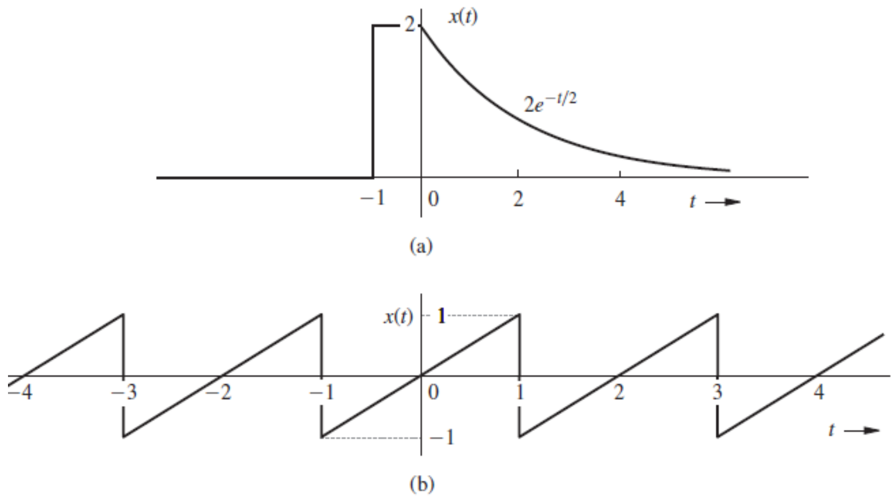

Figure 2

b) Deduce $\mathrm{Re}(F(\omega))$ and $\mathrm{Im}(F(\omega))$ if

i. f(t) is real and even (3 marks)

ii. f(t) is Real and odd (3 marks)

c) Determine the linearity of the systems given in the equations below (6 marks)

i. $\dfrac{dy}{dt} + 5y(t) = x(t)$

ii. $y(t)\dfrac{dy}{dt} + 8y(t) = x(t)$

QUESTION THREE (20 MARKS)

a) Discuss the following classes of signals (8 marks)

i. Periodic and aperiodic

ii. Deterministic and probabilistic

iii. Casual and non-casual

iv. Analog and digital

b) Convolute two sequences $x[n] = \{2,3,4,6\}$ and $h[n] = \{-1,1,2,3\}$ using circular convolution (6 marks)

c) Figure 3 shows a sketch of exponential function $x(t) = e^{-2t}$. Sketch and mathematically describe the output signals when the signal is:

i. Delayed by 1 second (3 marks)

ii. Advanced by 2 seconds (3 marks)

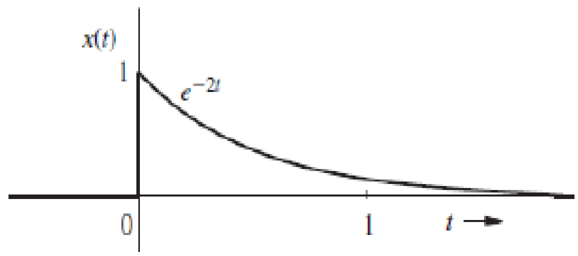

Figure 3

QUESTION FOUR (20 MARKS)

a) Calculate the energies of signals (a), (b), (c) and (d) in Figure 4 (8 marks)

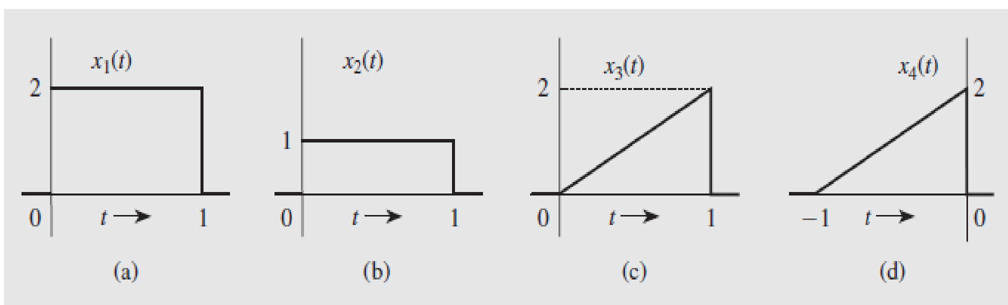

Figure 4

b) By use of block diagrams describe serial and parallel system interconnection and show the relationship between inputs and outputs in the two system interconnections. (6 marks)

c) Find the Laplace transform of the following functions $f(t) = e^{\alpha t}\sin(\omega t)$ hence demonstrate the shifting property using $f(t) = e^{3t}\sin(5t)$ (6 marks)

QUESTION FIVE (20 MARKS)

a) Briefly describe the following function in both continuous and discrete signal spectrum

i. Sampling function

ii. Impulse function

iii. Signum function

iv. Exponential function (8 marks)

b) Figure 5 shows a function $x(t)$ sketch and mathematically describe the function when:

i. Compressed by a factor of 3 (3 marks)

ii. Expanded by a factor of 2 (3marks)

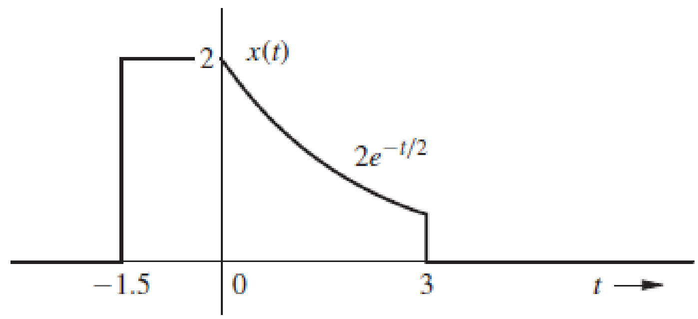

Figure 5

c) By use of block diagrams show how the processors described by the following equations can be implemented hence classify them as recursive or non-recursive systems. (6 marks)

i. y[n] = x[n] + x[n-1] + x[n-2]

ii. y[n] = y[n-1] + x[n]

iii. y[n] = 1.8y[n-1] –0.9y[n-2] + x[n] –1.9x[n-1] + x[n-2]