OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

SEMESTER I EXAMINATIONS 2001/2002

THIRD YEAR ELECTRONIC ENGINEERING
THIRD YEAR ELECTRONIC AND COMPUTER ENGINEERING

EE308 SIGNALS AND COMMUNICATIONS

Professor H.W. Whittington
Professor D.J. Wilcox
Mr. J. Breslin

Duration of Examination: **TWO** hours
Instructions: Answer **THREE** questions

1.

(a) Explain the following terms: (i) orthogonality **[2 marks]**, (ii) Gibbs' effect **[2 marks]**. Also, explain why complex exponential functions are a good choice of basis function for Fourier analysis **[3 marks]**.

(b) Obtain the exponential Fourier series representation of the decaying exponential waveform given by the following equation:

$$x(t) = e^{-t} \qquad 0 \le t \le 0.5$$

which repeats with a frequency of twice per second **[8 marks]**. Derive expressions for the magnitude and phase spectra, and sketch these as functions of frequency, ω **[5 marks]**.

2.

(a) Obtain the trigonometric Fourier series representation of the periodic waveform in Fig. 1 **[9 marks]**. Note that $\int x\sin(ax)dx = \frac{1}{a^2}\left[\sin(ax) - ax\cos(ax)\right]$. Sketch the spectrum of the signal **[3 marks]**.

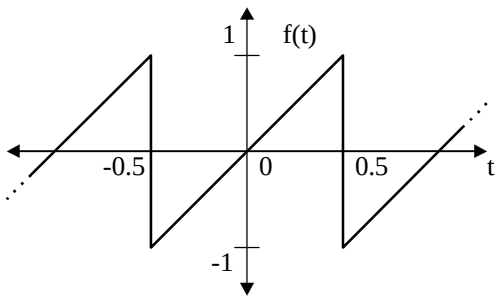

Fig. 1.

(b) Define odd and even signals, and explain how the trigonometric Fourier series can be simplified for each type **[8 marks]**.

[cont'd]

3.

(a) Find the Fourier transform of the signal f(t) shown in Fig. 2 **[8 marks]**.

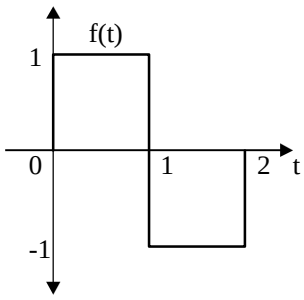

Fig. 2.

(b) Name and prove both of the following properties of the Fourier transform:

(i) $\Im\{s(\alpha t)\} = \frac{1}{|\alpha|} S\left(\frac{\omega}{\alpha}\right)$ **[3 marks]**.

(ii) $\Im\{f(t - t_0)\} = F(\omega)e^{-j\omega t_0}$ **[3 marks]**.

(c) State and prove Parseval's theorem for finite energy signals **[6 marks]**.

4.

(a) Consider the system shown in Fig. 3.

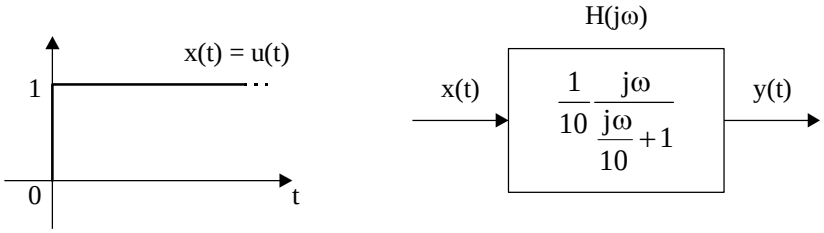

Fig. 3.

(i) Calculate and sketch the magnitude of H(jω) **[5 marks]**.

(ii) If this system is a filter, what type is it **[2 marks]**?

(iii) Find the output signal y(t) and sketch it **[5 marks]**. Note the Fourier transform pairs: $\frac{1}{j\omega + a} \Leftrightarrow e^{-at}u(t)$ and $\pi\delta(\omega) + \frac{1}{j\omega} \Leftrightarrow u(t)$.

(b) Sketch the circuit diagram for a Sallen-Key second-order low-pass active filter **[3 marks]**. Such a filter is designed to give a Butterworth-type response with f_0 = 7 kHz. If the value of R = 1 kΩ, calculate suitable values for C and k **[5 marks]**.

5.

(a) Describe the following physical sources of noise: (i) thermal noise, and (ii) shot noise. In both cases, give an approximate expression for the power spectral density **[6 marks]**.

(b) Sketch the PSD and autocorrelation functions for both ideal and bandwidth-limited white noise **[4 marks]**.

(c) Define the four average quantities used to describe random signals **[10 marks]**.