THE UNIVERSITY OF ADELAIDE

EXAMINATION FOR THE DEGREE OF B.E.

NOVEMBER 1999

ADVANCED COMMUNICATION THEORY (9334)

Time : ONE and a HALF hours

(In addition, candidates are allowed ten minutes before the examination begins to read the paper.)

The use of calculators is permitted; this equipment is to be supplied by the candidate. No pre-recorded material nor calculator instruction book is permitted, and calculators with remote communication links will be barred from the examination room.

Attempt **ALL 3** questions.

All questions carry equal marks; part marks are given in brackets where appropriate.

ANSWERS TO QUESTIONS SHOULD BE EXPRESSED CLEARLY AND WRITTEN LEGIBLY. THESE ASPECTS OF PRESENTATION WILL BE TAKEN INTO ACCOUNT IN ASSESSMENT.

Question 1 follows on page 2

1. Consider the random process $x(t) = A \cos(\omega_c t + \theta)$, where A and ω_c are constants, and θ is a random variable with probability density function (pdf)

$$f(\theta) = 4/\pi \ , \ -\pi/8 \leq \theta \leq \pi/8 \ .$$

a) Find the statistical mean of x(t) by computing $E\{x(t)\}$.

b) Find the Autocorrelation Function of x(t) by computing $R(t,\tau) = E\{x(t)\ x(t + \tau)\}$

c) From your answer in part (b) what is the variance of x(t)?

d) What is the time average mean and time average variance of x(t)?

e) Is x(t) a stationary process? Why or why not?

(20 marks, 4 marks per part)

2. Consider the pulse signal $s(t) = e^{-t}[u(t) - u(t - T)]$, where T is the pulse width.

a) Sketch the impulse response, h(t), of the matched filter for detecting the presence of s(t) in additive noise.

b) Find the shape of the output pulse when s(t) is passed through filter h(t).

c) If white noise with Power Spectral Density $S_n(f) = N_0/2$ Watts/Hz is added to s(t), then passed through the matched filter, h(t), find the maximum Signal-to-Noise Ratio (SNR).

d) Does the matched filter you found in this problem preserve the shape of s(t)?

(20 marks, 5 marks per part)

3. Let a random signal, s(t), be added to noise to form the random process $x(t) = s(t) + n(t)$. Given x(t), we desire a Minimum Mean Squared Error (MMSE) estimate of s(t) by passing x(t) through a linear filter with impulse response, h(t). Assume s(t) and n(t) are uncorrelated. The filter defined by h(t) may be non-causal.

a) Given that s(t) is characterised by a Power Spectral Density (PSD) of

$$S_s(f) = 3 / (1 + 2\omega^2 + \omega^4)$$

and that the noise is characterised by its PSD

$$S_n(f) = 3 / (1 + \omega^2)$$

find the transfer function, H(f), for the MMSE linear filter to estimate s(t).

(15 marks)

b) Find the Minimum Squared Error for this filter. (5 marks)