國立中山大學113學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：通訊理論【電機系碩士班戊組選考、通訊所碩士班甲組、乙組選考、電波聯合碩士班選考】

—作答注意事項—

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答。
- 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶書籍、紙張（應考證不得做計算紙書寫）、具有通訊、記憶、傳輸或收發等功能之相關電子產品或其他有礙試場安寧、考試公平之各類器材入場。
- **試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。**
- **試題採雙面列印，考生應注意試題頁數確實作答。**
- **違規者依本校招生考試試場規則及違規處理辦法處理。**

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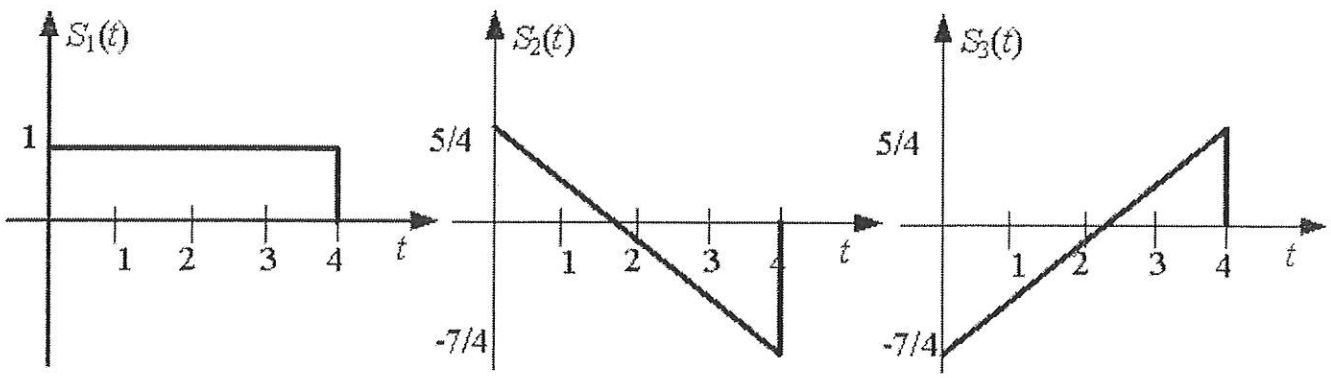
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　

1. (20%) We are given the complex baseband signal $x_z(t) = \text{sinc}(t-1) + j2\text{sinc}(t)$.
   (A) (5%) Calculate the real and imaginary parts of the Fourier transform $X_z(f)$. To express the transforms, please use the function $\text{rect}(t)$, which is defined as a rectangle of unit height and spanning the interval [-1/2,1/2].
   (B) (5%) Plot the real and imaginary parts of $X_z(f)$.
   (C) (10%) Plot the real and imaginary parts of the Fourier transform of the bandpass signal obtained by upconverting $x_z(t)$ to the carrier frequency of 10 Hz.

2. (20%) Let $x(t) = m(t) + \cos(\omega_c t)$. Let W be the bandwidth of $m(t)$. Assume that the average value of $m(t)$ is zero and that the maximum value of $|m(t)|$ is M. Also assume that the square-law device is defined by $y(t) = 4x(t) + 2x^2(t)$.
   (A) (5%) Write the equation for $y(t)$.
   (B) (10%) Describe the filter with input signal $y(t)$ that produces an AM signal for $g(t)$, where $g(t)$ represents the output of the filter.
   (C) (5%) Specify the requirement of M to ensure no distortion when using envelope demodulation.

3. (10%) A transmitter uses a carrier frequency of 1000 Hz, with the unmodulated carrier represented as $A_c \cos(2\pi f_c t)$. Determine both the phase and frequency deviation for each of the following transmitter outputs:
   (A) (5%) $x_c(t) = \cos[2\pi(1000)t + 40\sin(5t^2)]$
   (B) (5%) $x_c(t) = \cos[2\pi(600)t]$

4. (10%) Consider the following three signals:



   (A) (6%) Use Gram-Schmidt procedure to find the set of basis functions from the three signals and determine the dimensionality of the set.

(B) (2%) Find the signal-space representation of the three signals based on the basis functions obtained in (a). (Represent the signals in terms of vectors)

(C) (2%) Determine the minimum distance between any pair of waveforms.

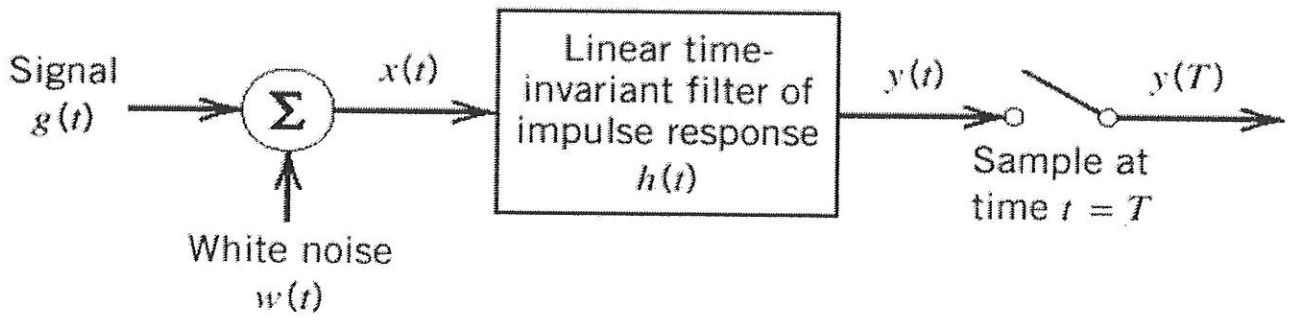
5. (20%) Let $x(t)$ denote a real valued WSS random process with an autocorrelation function $R_x(\tau)$ and $y(t) = x(t)\cos(2\pi f_c t + \theta), \theta \sim U(0,2\pi)$.

(A) (5%) Find $R_y(\tau)$.

(B) (5%) $y(t)$ is passed through a low-pass filter with a frequency-domain response $H(f) = \begin{cases} 1, & |f| < f_c \\ 0, & |f| > f_c \end{cases}$ and $\tilde{y}(t)$ denotes the filter output. Find $E[y(t)^2]$.

(C) (10%) If we let $\theta = \frac{\pi}{4}$ and $r(t) = s(t)\cos(2\pi f_c t) + y(t)$, please show how to demodulate $s(t)$ based on $r(t)$ in detail.

6. (10%) Let $x(t) = g(t) + w(t),\ 0 \le t \le T$, be the received noisy signal, where $g(t)$ denotes the transmitted pulse that represents a binary symbol 0 or 1 and $w(t)$ denotes an additive white noise process with zero mean and power spectral density (PSD) $\frac{N_0}{2}$. Since the filter is linear, the result output can be express as $y(t) = g_o(t) + n(t)$, where $g_o(t)$ denotes the response to $g(t)$ and $n(t)$ denotes the response to $w(t)$. We know that the peak pulse signal to noise ratio of the match filter is $\eta = \frac{|g_0(T)|^2}{E[n^2(t)]}$. Please show that $\eta \le \frac{2}{N_0}\int_{-\infty}^{\infty} |G(f)|^2\, df$.



7. (10%) Consider two discrete random variables X and Y with the joint distribution:

$P(x,y)$	$X=-1$	$X=0$	$X=1$
$Y=2$	0.1	0.15	0.15
$Y=4$	0.05	0.2	0.15
$Y=6$	0.05	0.05	0.1

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(A) (2%) Find the entropy $H(X,Y)$.

(B) (2%) Find the entropy $H(X)$.

(C) (4%) Find the entropy $H(X|Y)$.

(D) (2%) Find the mutual information $I(X;Y)$.