國立雲林科技大學
96學年度碩士班入學招生考試試題

系所：通訊所
科目：機率學

1. (20%) A random variable X is uniformly distributed on the interval (-5,15). Another random variable $Y = e^{-X/5}$ is formed. Find E[Y].

2. (30%) A joint probability density function is given as follows.

$$f_{X,Y}(x,y) = \begin{cases} c \cdot e^{-x} e^{-y}, & 0 \le y \le x < \infty \\ 0, & elsewhere \end{cases}$$

Where c is a constant.

(i) (5%) Find the value of c.

(ii) (10%) Find the marginal pdfs $f_X(x)$ and $f_Y(y)$, are X and Y independent?

(iii) (15%) $P[X+Y \le 1] = ?$

3. (20%)在一次伯努力試驗(Bernoulli trial)中，假設成功的機率爲 p，失敗的機率爲 q=1-p。令 $p_n(k) = P[k \text{ successes in } n \text{ trials}] = \binom{n}{k} p^k q^{n-k}$。

(i) (5%) 請問 n 次試驗中，平均成功的次數爲何?

(ii) (10%) 請問 $p_n(k)$ 的最大值發生在 k=? (注意：k 爲整數，並以 n, p 表達之)

(iii) (5%) 請問以上兩個子問題的答案之間，有何關連?

4. (20%) Suppose that we have five symbols s_1, s_2, s_3, s_4 and s_5 with probabilities $p_1 = 0.4, p_2 = 0.2, p_3 = 0.2, p_4 = 0.1$, and $p_5 = 0.1$.

Compare the following two encoding rules:

Encoding rule 1	Encoding rule 2
$s_1 \to 1$	$s_1 \to 00$
$s_2 \to 01$	$s_2 \to 10$
$s_3 \to 000$	$s_3 \to 11$
$s_4 \to 0010$	$s_4 \to 010$
$s_5 \to 0011$	$s_5 \to 011$

(i) (8%) Find the individual average code length for both encoding rules.

(ii) (12%) Compute the variances in the two cases. Which encoding rule has less variability in use on finite-length messages?

5. (10%) 某旅館有三間客房各可住 4，3，3 人，今恰有 10 人想要入住，請問

(i) (5%) 甲、乙、丙三人各住一間的機率爲多少?

(ii) (5%) 甲、乙同住一房間的機率爲多少?

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系所：通訊所
科目：通信系統

1. (20%) The message signal $m(t) = A[\cos(2\pi 2000t) + 2\cos(2\pi 6000t)]$ is input to an AM transmitter with $k_a = 2$ volt^{-1}. Assume the carrier is $c(t) = \cos(2\pi 10^6 t)$.

   (a) (5%) Determine the maximum value of $|m(t)|$.
   (b) (8%) To avoid overmodulation, find the maximum allowable value of A.
   (c) (7%) Draw the spectrum of the modulated signal.

2. (20%) It is known that, when additive noise is passed through an FM receiver (frequency discriminator), the power spectral density of the output is $S_{N_o}(f) = N_0 f^2 / A_c^2$, for $|f| \le W$.

   (a) (12%) Draw the block diagram of an FM system using pre-emphasis and de-emphasis filters. Then explain how these filters can be used to improve system performance.
   (b) (4%) What is the relationship between the two filters?
   (c) (4%) If the frequency response of a filer is $H(f) = (1 + jf / f_0)^{-1}$, should we use it as a pre-emphasis or a de-emphasis filter?

3. (20%) Assume a frequency modulated signal is transmitted through a nonlinear channel which has input-output relationship as

$$v_o(t) = v_i(t) + 0.4v_i^2(t) + 0.4v_i^3(t).$$

   Describe how the receiver can remove the nonlinearity caused by the channel.
   {*useful identities*: $2\cos^2 x = 1 + \cos(2x)$; $4\cos^3 x = 3\cos x + \cos(3x)$.}

4. (20%) In an ASK system, the signals representing 1 and 0, respectively, are

$$s_1(t) = A\cos(2\pi f_c t)$$
$$s_2(t) = 0$$

   where $0 \le t \le T_b$, and A is a constant.

   (a) (8%) Assume the transmitted symbols are equiprobable. Determine the average transmission energy of the ASK system in terms of A.
   (b) (12%) Compare the error performance of coherent reception for binary ASK and PSK systems. (that is, please find: by how many dBs is PSK superior to ASK?)

5. (20%) Consider a discrete memoryless source with source alphabet $S = \{ s_1, s_2, s_3, s_4, s_5, s_6 \}$ with respective probabilities { 0.3, 0.2, 0.2, 0.1, 0.1, 0.1 }.

   (a) (6%) Calculate the entropy of the source.
   (b) (10%) Assuming it is required that the variance of the codeword length be as small as possible, construct the Huffman code for this source. Then evaluate the average codeword length and the efficiency of the code.
   (c) (4%) Calculate the entropy of the second-order extension of the source.