1. (5 pt.) Define the Von Neumann Model.

2. (15 pt.) Represent -3 using the following 8-bit representation (a) signed binary magnitude (b) 1's complement binary number (c) 2's complement binary number.

3. (10 pt.) Suppose that one program runs in 80 seconds on computer A, which has a 4 GHz clock. A computer designer is trying to build a new machine B, which will run this program in 50 seconds. The designer can use new technology to substantially increase the clock rate, but this increase will affect the rest of the CPU design, causing machine B to require 1.4 times as many clock cycles as machine A for the same program. What clock rate should the designer target?

4. (10 pt.) Use Amdahl's Law to calculate the overall speedup if we make 90% of a program run 10 times faster.

5. (10 pt.) What is "data hazard"? What are three typical ways to remedy this problem?

6. During Chinese New Year 2011, 100 new sets of winning lottery numbers were added in Taiwan Lotto 6/49, each with a prize of NT$1 million, which means 100 additional people have the chance of becoming millionaires overnight.

(a) (10pt.) Write a C program to output 100 sets of six random numbers chosen from one to forty-nine. For example,

```
Set#001: 34 23 19 21 05 49
Set#002: 04 01 45 48 49 22
Set#003: 22 12 19 35 34 45
.....
Set#100: 08 12 03 43 07 38
```

(b) (10pt.) Write a C program to output 100 sets of sorted numbers above in ascending order. For example,

```
Set#001: 05 19 21 23 34 49
Set#002: 01 04 22 45 48 49
Set#003: 12 19 22 34 35 45
.....
Set#100: 03 07 08 12 38 43
```

(c) (10pt.) Write a C program to sort 100 sets of above lottery numbers in ascending order. For example,

```
Set#002: 01 04 22 45 48 49
Set#100: 03 07 08 12 38 43
Set#001: 05 19 21 23 34 49
Set#003: 12 19 22 34 35 45
.....
```

(d) (10pt.) Write a C helper program to help users to check whether they become millionaires with this additional chance by inputting their lottery numbers.

(e) (10pt.) Explain data structures used in all of your programs above and your reason for such design.

1. (15%) Please explain the following terms:
   (a). CSMA/CA
   (b). CSMA/CD
   (c). Exponential Backoff
   (d). Multiple Access (list at least 4 Multiple Access Techniques)
   (e). PAN, LAN, WAN (list at least one standard for each network)
2. (10%) The following five descriptions are about IP Addressing. For each description, use O (or X) to indicate that it is correct (or wrong).
   (a). Virtual, hardware independent value
   (b). IPv6 has 120-bit IP address
   (c). Prefix identifies network; suffix identifies host
   (d). Network systems use address mask to specify boundary between prefix and suffix
   (e). 64-bit Internet address is assigned to each computer
3. (15%) Describe the OSI model and TCP/IP model respectively. Compare the differences between the OSI and TCP/IP reference models.
4. (10%) Please answer how to update the values of congestion window (***cwnd***) and slow start threshold (***ssthresh***) in Fast retransmit/Fast recovery mechanism of the **TCP Reno**. If the TCP state is in slow start or in congestion avoidance state, when the third duplicate ACK in a row is received, set ___(a)___ to one-half the current ***cwnd***. Retransmit the missing segment. Then set ***cwnd*** to ___(b)_____. In Fast recovery state, each time when another ___(c)___ arrives, increment ***cwnd*** by one. This inflates the congestion window for the additional segment that has left the network. If timeout occurs, set ___(d)___ to one-half the current ***cwnd*** and then reset ___(e)___ to one.
5. (10%) Cyclic redundancy check (CRC) is used in many data communication protocols. Consider the generator G=10011.
   (a). How long will the CRC check bits be?
   (b). What is the value of the CRC check bits R for the data D=10010110?

6. (12%) You are asked to configure a wireless router at home. This would allow PCs to access the Internet by using the wireless LAN interface. In configuring the wireless router, you are asked to specify SSID and choose between DHCP and PPPoE.

   (a). Explain what these three terms (SSID, DHCP, PPPoE) mean.

   (b). The wireless router is usually configured by connecting a PC to the LAN port of the wireless router and by accessing the url http://192.168.1.1 . Explain what is special about 192.168.1.1 .

7. (12%) Consider the Go-Back-N protocol with a sequence number space of size 32 (i.e., 0, 1, 2, 3, … , 31). Suppose that at time t, the next in-order packet that the receiver is expecting has a sequence number of 27. Assume that the medium does not reorder packets.

   (a). What is the maximum sender window size allowed?

   (b). Suppose the sender window size is chosen to be 12. If the Acknowledgements on the way back at time t are 25 and 26, what are the sequence numbers inside the sender's window at time t?

   (c). Suppose the sender window size is chosen to be 8. What are the possible sets of sequence numbers inside the sender's window at time t? Justify your answer.

8. (16%) Suppose two hosts, A and B, are separated by 8,000 kilometers and are connected by a direct link of rate R=10 Mbps. The propagation speed over the link is $2*10^8$ meters/sec. A 20 Mbit MP3 file is sent from host A to host B.

   (a). Suppose that the entire MP3 file is sent as one packet. What is the end-to-end delay (transmission delay plus propagation delay)?

   (b). How many bits will the source have transmitted when the first bit arrives at the destination B?

   (c). Now suppose there are two links between source and destination, with one router connecting the two links. Each link is 4,000 km long. Again suppose the MP3 file is sent as one packet. Assume that there is no congestion, so that the packet is transmitted onto the second link as soon as the router receives the entire packet. What is the end-to-end delay?

   (d). Continue with two links between source and destination. Now suppose that the MP3 file is broken into 4 packets, each of 5 Mbits. Ignore headers that may be added to these packets. Also ignore router processing delays. Assuming store and forward packet switching at the router, what is the total delay in transmitting the MP3 file?

國立中正大學100學年度碩士班招生考試試題

系所別：電機工程學系-信號與媒體通訊組
通訊工程學系-通訊系統組
通訊工程學系-網路通訊甲組、乙組

科目：線性代數與機率

第 2 節

機率部份 50 分

1. (20%) The probability density function (*p.d.f.*) of a Chi-square random variable, X with $2n$ degrees of freedom is given by

$$f_X(x) = \begin{cases} \frac{1}{(n-1)!}x^{n-1}e^{-x} & , x \geq 0 \\ 0 & , \text{otherwise.} \end{cases}$$

where n is a positive integer.

   (a) (10%) Find the expected value $\mathrm{E}\{e^{-\frac{X}{4}}\}$.
   Hint: Use the fact that $\int_0^\infty t^{n-1}e^{-t}dt = (n-1)!$ for any positive integer n.

   (b) (10%) Let Y be a Chi-square random variable with 2 degrees of freedom, and Y is independent of X. Find the probability $\mathrm{P}(Y \leq \frac{X}{4})$.

2. (5%) Two cards are randomly chosen without replacement from an ordinary deck of 52 cards. Let B be the event that both cards are aces; let A be the event that at least one ace is chosen. Find the conditional probability $\mathrm{P}(B|A)$.

3. (15%) The lifetime a light bulb is an exponential random variable X with parameter λ i.e., the *p.d.f.* of the random X is defined as $f_X(x) = \lambda e^{-\lambda x}$, $x \geq 0$
   (1). (10%) Describe and prove the memoryless property of the random variable X.
   (2). (5%) Suppose 100 new light bulbs are installed at time t=0. Find the probability that all light bulbs are still working at time t=10. (Hint: Use the parameter λ to express the answer.)

4. (10%) Suppose that random variables X and Y are jointly Gaussian.
   (1). (5%) Write down the joint *p.d.f.* of the random variables X and Y. (Hint: Use the mean, variances and correlation coefficient of X and Y i.e., $m_X, m_Y, \sigma_X, \sigma_Y, \rho_{XY}$ to express the joint *p.d.f.*)
   (2). (5%) If X and Y are uncorrelated, are they independent? Prove your answer mathematically. (Hint: No credit will be given if there is no proof.)

線性代數部份 50 分

5. (10%) Find a matrix S such that $S^2 = A$, if $A = \begin{bmatrix} 1 & 3 & 1 \\ 0 & 4 & 5 \\ 0 & 0 & 9 \end{bmatrix}$.

6. (10%) Find the least squares solution of the linear system given by

$$\begin{aligned} x_1 \quad\quad - x_3 &= 6 \\ 2x_1 + x_2 - 2x_3 &= 0 \\ x_1 + x_2 &= 9 \\ x_1 + x_2 - x_3 &= 3 \end{aligned}$$

7. (10%) What conditions must b_1, b_2, and b_3 satisfy in order for the following system of equations to be consistent?

$$\begin{aligned} x_1 + 2x_2 + 3x_3 &= b_1 \\ 2x_1 + 5x_2 + 3x_3 &= b_2 \\ x_1 \quad\quad + 8x_3 &= b_3 \end{aligned}$$

8. (10%) Let **u** and **v** be nonzero vectors in 2- or 3-space, and let $k = \|\mathbf{u}\|$ and $l = |\mathbf{v}|$. Show that the vector $\mathbf{w} = l\mathbf{u} + k\mathbf{v}$ bisects the angle between **u** and **v** (i.e., the angles between **u** and **w** and between **v** and **w** are equal).

9. (10%) Find the coordinate vector of **v** relative to the basis $S = \{\mathbf{v}_1, \mathbf{v}_2, \mathbf{v}_3\}$, where

$$\mathbf{v} = (2,-1,3),\ \mathbf{v}_1 = (1,0,0),\ \mathbf{v}_2 = (2,2,0),\ \mathbf{v}_3 = (3,3,3)$$

一、單選題(共 30 分)：每題有五個選項，其中只有一個最適當的答案，每題答對得 5 分；未作答、答錯或答多於一個選項者，該題以 0 分計算。

1. Consider the discrete-time complex exponential $x[n]=e^{j2\pi n/N}$, N is a positive integer. Which of the following statements about $x[n]$ is false ?
   (a) Its fundamental period is N.
   (b) It is orthogonal to $e^{j2\pi\cdot 2n/N}$.
   (c) It is orthogonal to $e^{j2\pi\cdot 3n/N}$.
   (d) Its discrete-time Fourier transform is $X(j\omega)=2\pi\,\delta(\omega-\frac{2\pi}{N})$.
   (e) Its discrete-time Fourier transform is a periodic function.

2. Suppose that continuous-time $x(t)$ is a periodic signal with period T, and, its associated Fourier series coefficients are $a_k=\frac{1}{T}\int_0^T x(t)\,e^{-j2\pi kt/T}\,dt, \forall k$. Which of the following statements about $x(t)$ is false ?
   (a) It can be written as $\sum_{k=-\infty}^{\infty} a_k e^{j2\pi kt/T}$.
   (b) Its spectrum can be expressed as $\sum_{k=-\infty}^{\infty} 2\pi\, a_k\,\delta\left(\omega-\frac{2\pi}{T}k\right)$.
   (c) Its autocorrelation is defined by $R_x(\tau)=\lim_{x\to\infty}\int_{t=-\infty}^{\infty} x(t)x^*(t-\tau)\,dt$.
   (d) Its autocorrelation is equal to $R_x(\tau)=\sum_{k=-\infty}^{\infty}|a_k|^2 e^{j2\pi k\tau/T}$.
   (e) Its time-averaged power is equal to $\sum_{k=-\infty}^{\infty}|a_k|^2$.

3. Suppose that $x(t)=x_c(t)\cos(2\pi f_0 t)-x_s(t)\sin(2\pi f_0 t)$ is a real-valued bandpass signal at center (or carrier) frequency f_0. Which of the following statements about $x(t)$ is false ?
   (a) Its lowpass equivalent signal is $x_c(t)+j\,x_s(t)$.
   (b) Its corresponding analytic signal $x(t)+j\,\hat{x}(t)$, where $\hat{x}(t)$ denotes the Hilbert transform of $x(t)$.

(c) Its lowpass equivalent signal can be obtained by

$x_l(t) = LP\{2x(t)\cos(2\pi f_0 t)\} - j\,LP\{2x(t)\sin(2\pi f_0 t)\}$, where $LP\{\cdot\}$ denotes the lowpass filtering.

(d) It is related to its analytic signal $z(t)$ by $x(t) = \frac{1}{2}\left[z(t) + z^*(t)\right]$.

(e) Its Hilbert transform produces $\hat{x}(t) = x_c(t)\sin(2\pi f_0 t) - x_s(t)\cos(2\pi f_0 t)$.

4. An *i.i.d.* discrete time random process X_n has mean m and variance σ^2.

Which of the following statements is true ?

(a) The random variable X_n is Gaussian distributed.

(b) The mean of random variable $Y = \sum_{n=1}^{N} X_n$ is m.

(c) The variance of random variable $Y = \frac{1}{N}\sum_{n=1}^{N} X_n$ is σ^2

(d) The process X_n is wide-sense stationary.

(e) The process $Z_n = X_n - X_{n-1}$ is also an *i.i.d.* discrete time random process.

5. Which of the following statements about bandwidth efficiency is true ?

(a) The bandwidth efficiency of the double sideband suppressed carrier (DSB-SC) AM is higher than that of conventional AM

(b) The bandwidth efficiency of the conventional AM is higher than that of FM

(c) The bandwidth efficiency of the single sideband AM is the same as that of the conventional AM.

(d) The bandwidth efficiency of binary PSK is higher than that of binary ASK

(e) The bandwidth efficiency of binary PSK is the same as that of quaternary PSK

6. Let $N(t)$ be a zero-mean white Gaussian noise with power spectral density $N_0/2$. Which of the following statements is true ?

(a) $\int_0^1 N(t)\,dt = 0$.

(b) The power of $N(t)$ is finite.

(c) The power spectral density of $N(t)$ is $\frac{N_0}{2}\delta(t)$ for some N_0.

(d) If $N(t)$ is passed through an LTI system, the output of the LTI system is

also a white Gaussian random process.

(e) If $N(t)$ is sampled at t_1 and t_2, then $N(t_1)$ and $N(t_2)$ are independent Gaussian random variables

二、計算題(共 40 分)：

1. (10 分) Consider the three waveforms $\psi_n(t)$ shown in Fig. 1.

(a) Show that the waveforms are orthogonal.

(b) Express the waveform $y(t)$ as a weighted linear combination of $\psi_1(t)$, $\psi_2(t)$, and $\psi_3(t)$, if

$$y(t)=\begin{cases}-1, & 0\le t\le 1\\ 1, & 1\le t\le 3\\ -1, & 3\le t\le 4\end{cases}$$

and determine the weighting coefficients.

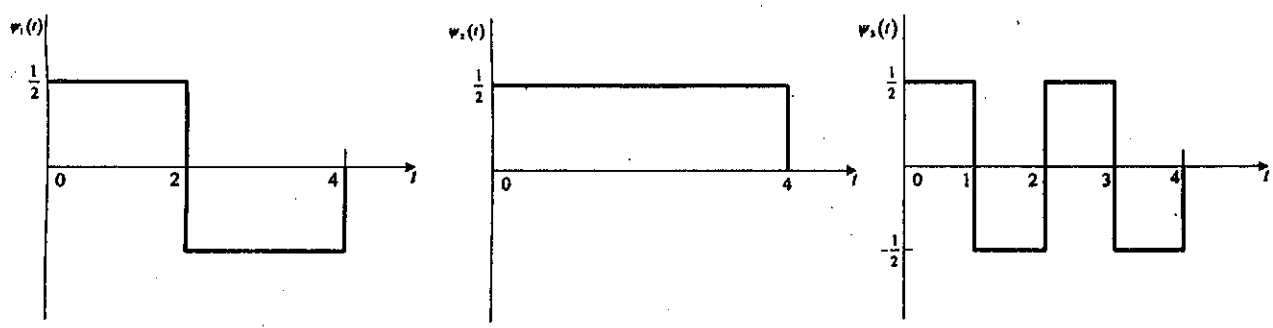

Figure 1: Three waveforms

2. (10 分) Consider the signal detector with an input

$$r=\pm A+n$$

where $+A$ and $-A$ occur with equal probability and the noise n is random with the Laplacian probability density function

$$p(n)=\frac{1}{\sqrt{2\sigma}}e^{-|n|\sqrt{2}/\sigma}.$$

Determine the probability of error as a function of parameters A and σ.

3. (10 分) The message signal $m(t) = 10\,\mathrm{sinc}(500t)$ frequency modulates the carrier $c(t) = 100\cos(2\pi f_c t)$. The modulation index is 5.
   (a) Write an expression for the modulated signal.
   (b) What is the maximum frequency deviation of the modulated signal ?
   (c) What is the power content of the modulated signal ?
   (d) Find the bandwidth of the modulated signal ?

4. (10 分) The random process $X(t)$ is defined by $X(t) = X\cos(2\pi f_0 t)$ where X is a zero-mean standard Gaussian random variable.
   (a) Find the time and ensemble average of $X(t)$
   (b) Find the autocorrelation function $R_X(t+\tau, t)$ of $X(t)$. Is $X(t)$ stationary ? Is it cyclostationary ?
   (c) Find the power-spectral density of $X(t)$.

三、名詞解釋(共 30 分)：請利用數學符號、數學式、圖表或其他專業術語寫兩段短文(每段至多 500 字)，分別解釋下列兩個名詞。

1. (15 分) Optimal Detection of BPSK Signals
2. (15 分) Sampling Theory