Ph.D. Qualify Examination 2019
Theory of Computation

- This examination is closed books.
- Please turn off your cell phones.
- Remember that there are 2 pages of the qualify examination.
- Answer all questions as possible. You may have a partial score if you answer the correct direction.

1. Deterministic Finite Acceptor (DFA) (10 pts)

   Find a dfa for the following language on $\Sigma = \{0, 1\}$:
   All the strings with exactly two 0's and more than two 1's.

2. Nondeterministic Finite Acceptor (NFA) (10 pts)

   Find an nfa with no more than five states for the set
   $\{1010^n : n \geq 0\} \cup \{101^n : n \geq 0\}$ on $\Sigma = \{0, 1\}$.

3. Convert the following nfa into an equivalent dfa. (10 pts)

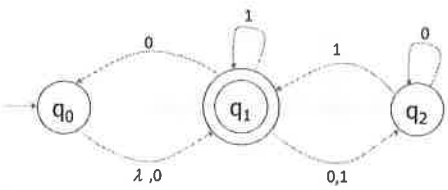


Figure 1: NFA diagram.

4. Determine whether or not the following language is regular: (10 pts)
   $L = \{a^n b^k c^n : n \geq 0, k \geq n\}$.

5. Construct a dfa that accepts the language generated by the following grammar: (10pts)

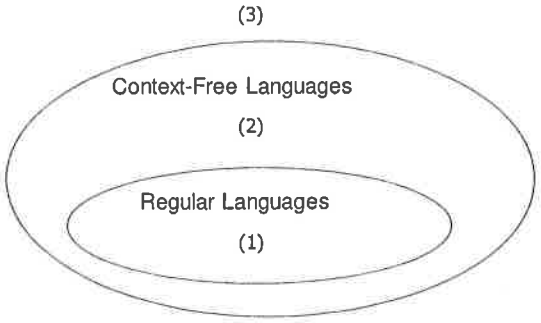
$$S \rightarrow abA,$$
$$A \rightarrow baB,$$
$$B \rightarrow aA|bb.$$

6. Show that the following grammar is ambiguous. (10 pts)
   $S \to aSb|SS|\lambda$.

7. Construct a nondeterministic pushdown automata for the language: (10 pts)
   $L = \{w \in \{a,b\}^* : n_a(w) = n_b(w)\}$.

8. Convert the grammar $S \to aSb|Sab|ab$ into Chomsky normal form. (10 pts)

9. Fill the following languages into the language hierarchy (If L_i is a regular language and also a context-free language, please fill L_i in the set of regular languages): (20 pts)
   $L_1 = \{a^n b^j : n \leq j^3\}$,
   $L_2 = \{ab, ad, ac, bc, cd\}$,
   $L_3 = \{a^2 b^n c^n : n >= 0\}$,
   $L_4 = \{a^n b^k c^n d^k : n \geq 0, k > n\}$,
   $L_5 = \{a^n b^m c^{n+m} : n \geq 0, m \geq 0\}$,
   $L_6 = \{ww : w \in \{a,b\}^*\}$,
   $L_7 = \{a^n b^n c^n : n \geq 0\}$,
   $L_8 = \{a^n$: n is a prime number$\}$,
   $L_9 = \{a^{n!} : n \geq 0\}$,
   $L_{10} = \{a^n b^i c^j d^k : n + k \leq i + j\}$.



Ph.D. Qualification Exam (Fall 2019)
Compiler Construction

1. During the development of Java programs, there are several tools/technologies are involved. (20pt)

   a) Please describe the functionality/meaning of the involved tools/technologies: Lexer, Parser, Semantic Analyzer and Runtime. (10pt)

   b) It is common that some situations/errors may occur during the program development. Please answer which tool/technology mentioned above is related to each of the listed errors below. (10pt)

   #. An undefined keyword.

   #. A method/function invocation, where the number of actual parameters is less than that of the formal parameters.

   #. A method/function being called on an object without proper definition.

2. Code optimizations are done by compilers automatically to transfer an input program into a more efficient version of code. Please perform the code optimizations on the following code segment repeatedly until there is no optimization technique can be applied on the code, leading to the shortest length of the code. (20pt)

```
int x = 30;
int y = 9 - (x/5);
int z;

z = y * 4;

if (z > 10) {
    z = z - 10;
}

return z * (60/x);
```

3. Consider the following function code. Please draw the control-flow graph for the code. (12pt)

```
int sum(int i)
{
   int sum = 0;
   while (i <= 10) {
       if (i/2 == 0)
           sum = sum + i;
       i++;
   }
   return sum;
}
```

4. Consider the following context-free grammar, *G*, and answer the following questions. (24pt)

   a) Can LL(0) be used to handle *G*? Why? (8pt)

   b) Construct the LR(0) parse table for *G*. (8pt)

   c) Show the parsing steps for the string **cbcac$**. (8pt)

Context-free grammar, G.

$E' \rightarrow E$

$E \rightarrow E\ a\ T \mid T$

$T \rightarrow T\ F \mid F$

$F \rightarrow F\ b \mid c$

Example of the parse steps.

Stack		Input
0	Initial Configuration	cbcac$

5. Consider the following context-free grammar, *S*, and answer the following questions. (24pt)

   a) Is *S* an ambiguous grammar when the input string is **4*5+6$**? Why? (8pt)

   b) Is the priority of the multiply "*" operation lower than that of the addition "+" operation? Why? (8pt)

   c) Is *S* an ambiguous grammar when the input string is **4+5+6$**? (8pt)

   Context-free grammar, S.

   X => X + X | Y

   Y => Y * Y | number

Discrete-Time Signal Processing 資格考

November 2019

1. **(20%)** A causal and stable LTI system S has its input $x[n]$ and output $y[n]$ related by the linear constant-coefficient difference equation

$$y[n]+\sum_{k=1}^{10}\alpha_k y[n-k]=x[n]+\beta x[n-1],$$

Let the impulse response of S be the sequence $h[n]$

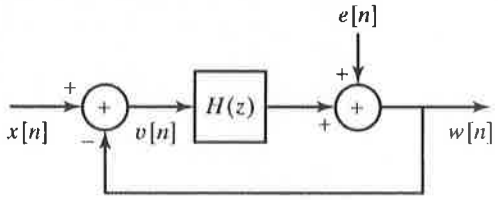
(a) Show that α_1 can be determined from the knowledge of $h[0]$ and $h[1]$.

(b) If $h[n]=(0.9)^n\cos(\pi n/4)$ for $0\le n\le 10$, sketch the pole-zero plot for the system function of S, and indicate the region of convergence.

2. **(20%)** In the following figure, H(z) is the system function of a causal LTI system. As shown in the figure, $W(z)$ can be expressed in the form

$$W(z)=H_1(z)X(z)+H_2(z)E(z)$$

For the case $H(z)=\dfrac{z^{-1}}{(1-z^{-1})}$, determine $H_1(z)$ and $H_2(z)$.

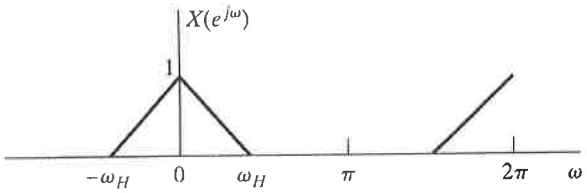


3. **(20%)** Consider the sequence x[n] whose Fourier transform $X(e^{j\omega})$ is shown in the following figure.

Define

$$x_s[n]=\begin{cases}x[n], & n=Mk,\ k=0,\pm1,\pm2,\ldots\\ 0, & \text{Otherwise}\end{cases}$$

and $\quad x_d[n]=x_s[Mn]=x[Mn]$



(a) Sketch $X_d(e^{j\omega})$ for M=3 and for $\omega_H=\dfrac{\pi}{2}$.

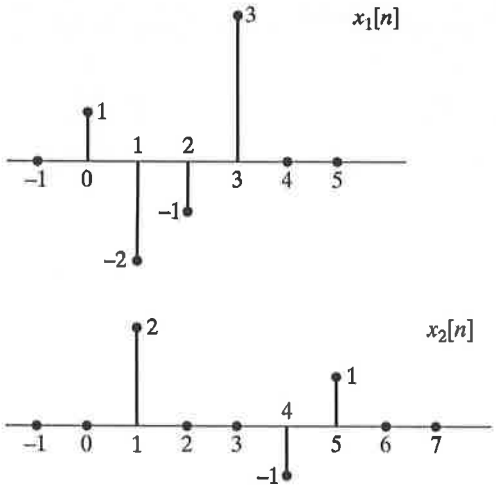
(b) What is the minimum value of ω_H that will avoid aliasing when M=3?

4. **(20%)** Let $X(e^{j\omega})$ denote the Fourier transform of the sequence $x[n]=(\frac{1}{2})^n u[n]$.

Let $y[n]$ denote a finite-duration sequence of length 10; i.e., $y[n]=0$, $n<0$, and $y[n]=0$, $n\ge 10$. The 10-point DFT of $y[n]$, denoted by $Y[k]$,

corresponds to 10 equally spaced samples of $X(e^{j\omega})$; i.e., $Y[k] = X(e^{j2\pi k/10})$. Determine $y[n]$.

5. (20%) The following figure shows two finite-length sequences $x_1[n]$ and $x_2[n]$. What is the smallest N such that the N-point circular convolution of $x_1[n]$ and $x_2[n]$ are equal to the linear convolution of these sequences, i.e., such that $x_1[n] \textcircled{N} x_2[n] = x_1[n]*x_2[n]$?



國立成功大學資訊工程系一０八學年度第一學期博士班資格考命題紙

科目名稱：生醫超音波訊號與成像技術　　**考試時間：**一０八年十一月十五日

本試題共 1 張，本張為第 1 張

1. Ultrasound signals and images have been applied to nondestructive testing for various materials. (a). Design an ultrasound system capable of ex situ 3D scanning defects in a 5(L)x5(W)x2(H) cm stainless steel block (assuming sound velocity=6000 m/s and density=8 g/cm^3) using a 5 MHz round shape (5 mm in diameter) and non-focus single element transducer. Plot the whole system with a block diagram and then provide functions of each components. (15%); (b). If the transducer was immersed in water (assuming sound velocity=1500 m/s), estimate the corresponding wavelength, focal length, and the divergence angle. (9%); (c). What is the pressure refection and transmission coefficients for the ultrasound wave propagating from water into stainless steel? (6%); (d). The sound velocity of the stainless steel may vary if there are a fraction of pores or flaws in the material. Design and describe an arrangement for measuring the sound velocity of this stainless steel (10%); What are the possible factors to affect the accuracy of velocity measurement (5%); (e). The ultrasound attenuation would affect the depth of image penetration. Design and describe an arrangement for measuring the attenuation coefficient of this stainless steel (10%)

2. The transducer is an essential device for ultrasound wave generation and reception. (a). Plot with a diagram for detailing the internal structure and functions of a single element transducer. (10%); (b). What are the difference, in terms of design and implementation, between linear and phased array transducers. (8%); (c). Describe feasible methods/modalities to measure acoustic field of an ultrasound transducer. (7%)

3. Design an ultrasound nondestructive testing system capable of in situ measuring the porosity of a stainless steel part which is manufactured using a laser selective manufacturing machine. Provide functions and considerations for your design in details. (20%)

「模糊邏輯」資格考

1. Answer the following questions (每小題 3 分)
   (1) Explain the difference between ambiguity and vagueness, and classify different types of ambiguity.
   (2) Explain the form of *L-R* fuzzy set to represent fuzzy numbers.
   (3) Explain the concept and characteristics of proximity relation.
   (4) Explain the concept of strong homomorphism between two fuzzy relations.
   (5) Explain the design procedure for a fuzzy logic controller
   (6) Explain the τ -degree connected fuzzy graph
   (7) Explain the consonant body of evidence
   (8) Explain Bezdek's fuzzy c-means clustering algorithm

2. (10 分) Let A, B and C be fuzzy sets defined on the universal set $X = Z$(integers) whose membership functions are given by
   $A(x) = .5/(-1) + .8/0 + .7/1$
   $B(x) = .5/1 + .3/2 + .7/3$
   $C(x) = .9/(-1) + .1/0$
   Let a function $f: X \times X \times X \to X$ be defined for all $x_1, x_2, x_3 \in X$ by
   $f(x_1, x_2, x_3) = x_1 \cdot x_2 + 2x_3$
   Calculate $f(A, B, C)$.

3. (12 分) Solve the following fuzzy relation equation for the max-min composition:

$$\mathrm{P} \circ \begin{bmatrix} .9 & .6 & 1 \\ .8 & .8 & .5 \\ .6 & .4 & .6 \end{bmatrix} = \begin{bmatrix} .6 & .7 & .5 \end{bmatrix}$$

4. (a)(3 分)請提出使 OWA operation 等於 min 及 max operations 的 weighting vectors。
   (b)(7 分)請利用 standard fuzzy complement 及 Hamming distance，計算下列 fuzzy set 的 fuzziness:

$$\begin{bmatrix} .9 & .6 & 1 \\ .8 & .8 & .5 \\ .6 & .4 & .6 \end{bmatrix}$$

5. (10 分) Consider the *if-then* rules
   If X is A_1,then Y is B_1,
   If X is A_2,then Y is B_2,

where $A_j \in \mathcal{F}(X)$, $B_i \in \mathcal{F}(Y)$ $(j = 1, 2)$ are fuzzy sets

$A_1 = .9/x_1 + .1/x_2 + .5/x_3$; $A_2 = .4/x_1 + 1/x_2 + .7/x_3$;

$B_1 = 1/y_1 + .2/y_2$; $B_2 = .9/y_1 + .3/y_2$

Given the fact X is A', where $A' = .1/x_1 + .8/x_2 + .5/x_3$, use the method of interpolation to calculate the conclusion B'.

6. (10 分) Let A, B be two fuzzy numbers whose membership functions are given by

$$A(x) = \begin{cases} (x+2)/2 & for\ -2 < x \le 0 \\ (2-x)/2 & for\ 0 < x < 2 \\ 0 & otherwise \end{cases}$$

$$B(x) = \begin{cases} (x-2)/2 & for\ 2 < x \le 4 \\ (6-x)/2 & for\ 4 < x \le 6 \\ 0 & otherwise \end{cases}$$

Calculate the fuzzy number $A+B$.

7. (12 分) Consider the following fuzzy automaton.

$$R = \begin{array}{c|ccc} & y_1 & y_2 & y_3 \\ z_1 & 1 & .4 & 0 \\ z_2 & 0 & 1 & .1 \\ z_3 & 0 & 0 & 1 \\ z_4 & .5 & 1 & .3 \end{array}$$

$$S = \left[\begin{array}{c|ccccc} x_1 & z_1 & z_2 & z_3 & z_4 \\ z_1 & 0 & .4 & .2 & 1 \\ z_2 & .3 & 1 & 0 & .2 \\ z_3 & .5 & 0 & .3 & 1 \\ z_4 & 0 & .6 & 0 & 1 \end{array} \middle| \begin{array}{c|ccccc} x_2 & z_1 & z_2 & z_3 & z_4 \\ z_1 & 0 & 0 & 1 & 0 \\ z_2 & .2 & 0 & .4 & 1 \\ z_3 & 0 & .5 & 0 & 1 \\ z_4 & 1 & .3 & 0 & .6 \end{array}\right]$$

Generate sequences of three fuzzy internal and output states under the following condition: the initial fuzzy state is C^1=[1 .8 0 .4], the input fuzzy states are A^1=[.8 .3], A^2=[.5 1].

8. (12 分)

Let basic probability assignments m_1 and m_2 on X={a, b, c, d}, which are obtained from two independent sources, be defined as follows: $m_1(\{a,b\}) = .2$, $m_1(\{b,c\}) = .2$, $m_1(\{b,c,d\}) = .6$, $m_2(\{a,d\}) = .2$, $m_2(\{b,c\}) = .7$, $m_2(\{a,b,c,d\}) = .1$. Calculate the combined basic probability assignment $m_{1,2}$ and $Bel_{1,2}$ by using the Dempster rule of combination.

108. 11. 15 VLSI 姓名:_____ (題目卷請交回)

1. Explain the following terms in detail: (60%)

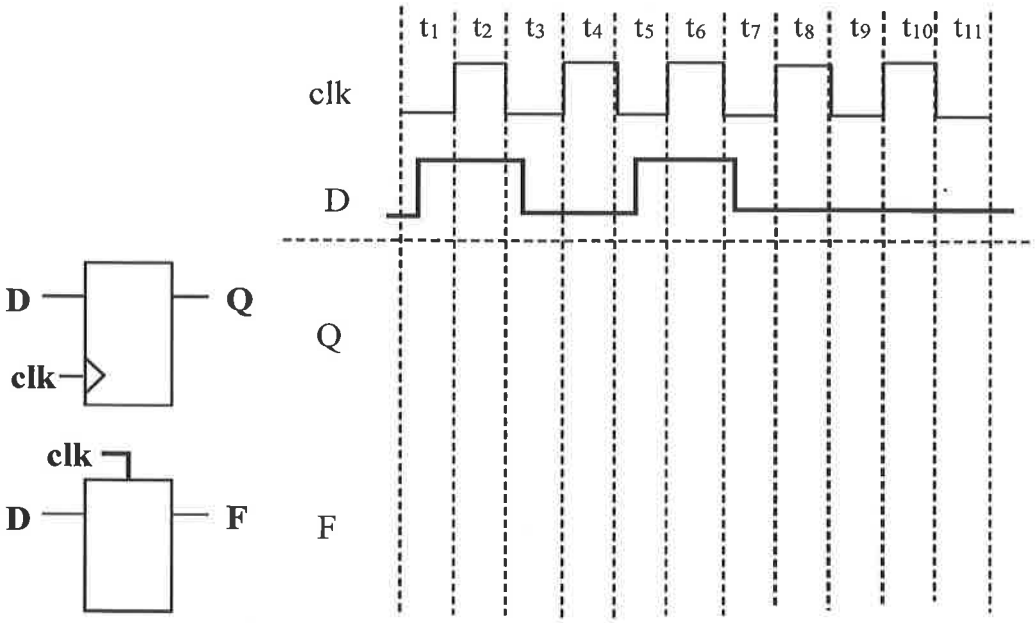
(a) critical path **(b) setup time**
(c) power dissipation **(d) clock skew**
(e) RTL **(f) hard IP**

2. Describe the difference between full custom and Cell-based design flow. (15%)

3. What is the difference between "a front-end designer" and "a back-end designer" ? (10%)

4. Explain the difference of the following two graphic symbols (5%) and draw their timing outputs Q and F (gate delay is ignored) for the input sequence (10%).

本題答案寫在題目卷並交回



計算機組織資格考題（Fall 2019）

1. (30%) Explain the following synchronization primitives: atomic exchange, test-and-set, and fetch-and-increment. Also, explain the following pair of instructions, load linked (LL) and store conditional (SC) and how this pair of instructions can be used to implement atomic exchange and fetch-and-increment.

2. (20%) With dynamic hardware prediction for reducing branch costs, what is the disadvantage of a simple 1-bit branch-prediction buffer for a branch that is almost always taken? Explain why the 2-bit prediction scheme can remedy this disadvantage. Also, explain what correlated predictors are by illustrating an example.

3. (20%) Describe what the RAW, WAW, and WAR hazards are and give an example for each hazard.

4. (30%) For the following cache optimization, explain (1) what can be improved? miss rate, miss penalty, or hit time? (2) explain why
   a. Larger Block Size.
   b. Larger Caches.
   c. Higher Associativity.
   d. Multilevel Caches.
   e. Giving Priority to Read Misses over Writes.
   f. Avoiding Address Translation during indexing of the cache:

2019 Ph.D. Program Qualify Examination – Information Retrieval

1. (25%) Please explain how to construct *query expansion* for indexing scheme.

2. (25%) Please explain the concept of "Word Frequency *vs*. Resolving Power" for an information retrieval system in terms of word frequency and word rank.

3. (25%) Please describe the detailed procedure of how to obtain the 11-point *precision* and *recall rates* curve. Given you have a test data set consists of n documents for the purpose of information retrieval, and you can illustrate how to draw the curve from the retrieving results.

4. (25%) What is the TFIDF weighting scheme? Please give at least 3 variant TFIDF functions and explain the difference.

無線通訊網路　資格考

1. Please explain the below terms in details. [20%]
   A. Poisson Distribution
   B. Delay Spread
   C. Inter Symbol Interference
   D. Reuse Distance
   E. Doppler Shift

2. Consider a cruise boat with two passengers. Each passenger will make 3 calls per hour with each call of 5-minute duration. There is only one telephone set on the boat. Please calculate the probability of the phone being occupied by one person while the other person wishes to make a call. (Namely, please calculate the blocking probability.) (In your answer, please provide the drawing of Markov Chain as well.) [20%]

3. Please describe the following protocol in Pseudo code. [20%]
   A. Aloha
   B. *p*-persistent CSMA
   C. CSMA/CD
   D. CSMA/CA

4. Please derive the throughput of Aloha and slotted Aloha by showing the maximum value of offered load. Assume the arrival rate is λ and packet transmission time is $1/\mu$. [10%]

5. Please explain the following terms in details. [20%]
   A. System architecture of GSM
   B. TDMA/FDMA/CDMA
   C. Backoff mechanism of IEEE 802.11
   D. Hidden terminal problem

6. Define the first-meter path loss as the received signal strength (in dB) when the receiver stands one meter away from the transmitter. Now, consider the case when the first-meter path loss is -20dB . Please calculate the free-space path loss for a receiver if the distance between the transmitter and receiver is [10%]
   A. 10 meters,
   B. 100 meters,
   C. 1 KM.

演算法資格考 201911

1. **(40pts) Answer "True" or "False" for the following statements. You don't have to explain your answer.**
   - **(a) (10pt) We can use dynamic programing to solve the activities selection problem**
   - **(b) (10pt) Dynamic programming is an algorithm instead of a technique.**
   - **(c) (10pt) We can use dynamic programing to solve Longest simple path problem.**
   - **(d) (10pt) The idea of greedy algorithm is making the locally optimal choice at each stage with the intent of finding a global optimum.**

2. **(20pt) Given a set of activities and the starting & finishing time of each activity,**

   (10pt) Find out the maximum number of activities that can be performed by a single person assuming that a person can only work on a single activity at a time.

   (10pt)Also, give a set of activities that match the optimal solution.

i	1	2	3	4	5	6
s_i	0	3	1	5	5	8
f_i	6	4	2	9	7	9

3. (10pt) Ture or False, $2n=O(n)$.
4. (20%) Please give the lower bound for sorting.
5. (10%) Ture or False, $2n=\Omega(n)$.

2019/11 博士班資格考: 機率與統計

1. (30%) On stationary random process.
   (a) Give the definitions of Strict Sense Stationary(SSS) and Wide Sense Stationary (WSS).
   (b) A system g is called memoryless if $y(t)=g[x(t)]$ with $y(t)$ and $x(t)$ as the output process and the input process. Show that if $x(t)$ is a SSS process, then $y(t)$ is also a SSS process.
   (c) If x(t) is a W.S.S. stochastic process, show that $E\{[x(t+T)-x(t)]^2\}=2\{R(0)-R(T)\}$.

2. (20%) A random sample of 20 students obtained a mean of 75 and a variance of 15 on a college placement test in math. Assume the scores to be normally distributed, construct the 98% confidence interval for σ^2.

3. (20%) Let X be a random variable of $N(0,2)$. Let $y=2x^2$. Find the *pdf* of Random variable Y.

4. (20%)
   Let x and y are two RVs.
   (a) Define the joint moment of x and y for m_{xy}.
   (b) Define the joint characteristic functions of x and y.
   (c) Please show how to use the result of (b) to find the result of (a).

5. (10%) Let $x_1, x_2, ..., x_n, ...$ be a sequence of i.i.d. random variables with uniform distributed pdf in the interval [-1, 1]. Let $z=x_1+x_2$, find the *pdf* of z.

OS 資格考題 (108 學年度第一學期)

1. [15%] Please describe *asynchronous* thread cancellation and *deferred* thread cancellation.

2. [20%] List 2 advantages and 2 disadvantages of using small memory pages. Please explain your answer.

3. [15%] Please describe the clock page replacement algorithm (i.e., the second-chance algorithm). Which kind of hardware support is required in this algorithm?

4. [15%] Why does the shortest-job-first (SJF) scheduling algorithm need to *estimate* the CPU burst lengths for each process? Why not just *measure* them? Moreover, please describe the estimation method.

5. [20%] Please write the pseudocode of a multi-threaded web server. You may need to use the following APIs.

   Socket API: socket(), connect(), accept()…

   Pthread API: pthread_create(), pthread_join()…

   File system API: read(), write()…

6. [15%] Briefly describe the *processor affinity* in SMP systems.

Computer Vision: From Theory to Application

Total 3 pages,

Ph.D. Qualify Exam

2019

1. (**20%**, Camera Model)

   (a) If the camera sensor size is 1/3 inch with resolution $w*h$=800*600 pixels, based on 1.0X lens magnification (i.e., image resolution is 800*600 pixels) please find the pixel size = _____ *um* * _____*um*? **(10%)** (Hint: Please check Figure 1.)

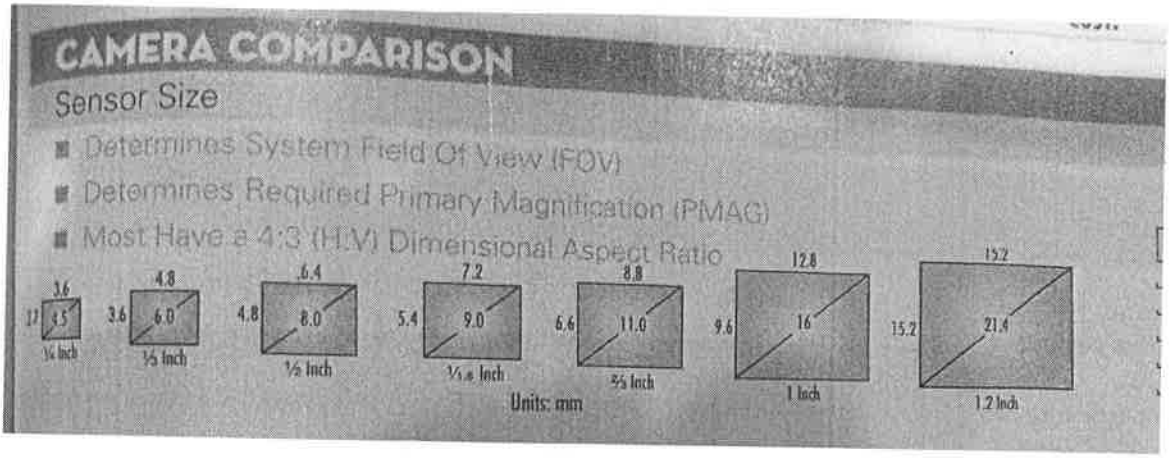


Figure 1

   (b) As shown in Figure 2, please find focal length f =function of (w, θ)? **(5%)** = ? *mm* **(5%)**

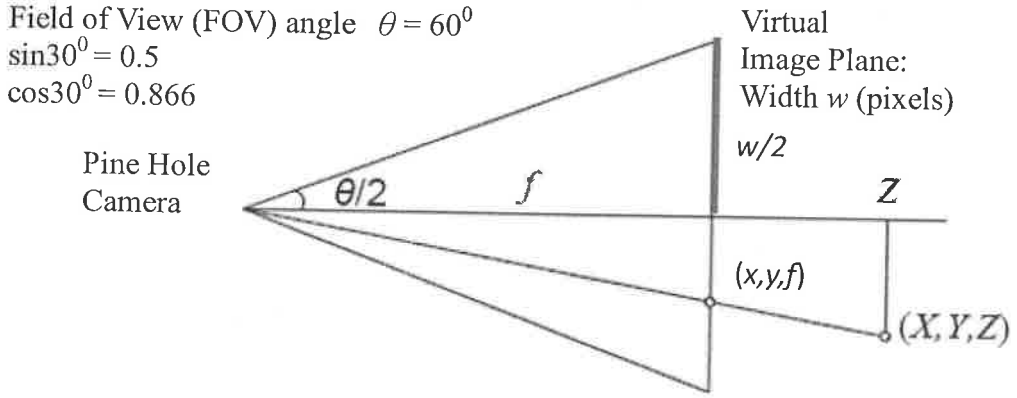


Figure 2

2. (**20%**, PCA) For principal component analysis (PCA) computation, first the covariance matrix C is created. Second, the Singular Value Decomposition (SVD) is applied to C (i.e., $C = UDV^T$) to obtain eigenvalue matrix D with corresponding eigenvector matrix U. Here, there are five data samples $x=\{x_1, x_2, x_3, x_4, x_5\}$ as shown in table 1 and corresponding low-dimensional (projected) data is represented by $y=\{y_1, y_2, y_3, y_4, y_5\}$. Suppose the unsorted eigenvalues and corresponding eigenvectors of covariance matrix are shown in the table 2. If we want to reduce the dimension of data vector x from 5 to 2.

   (a) What is the projection matrix w? **(4%)**

   (b) What is the projection data (weight) vector $\{y_2, y_3\}$? (Please show all calculations) **(4%+4%)**

   (c) PCA belongs to _____ model. (Hint: Gaussian, non-Gaussian, or Markov) **(4%)**

   (d) PCA belongs to _____ learning. (Hint: Supervised, semi-supervised, or unsupervised, reinforcement) **(4%)**

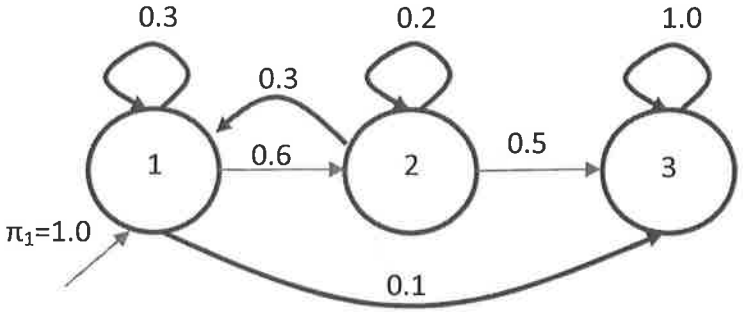
Table1

x_1	$[1, 2, -7, 5, 3]^T$
x_2	$[4, -2, 6, 0, 3]^T$
x_3	$[-7, 5, -1, -2, 1]^T$
x_4	$[3, -3, 4, -2, -5]^T$
x_5	$[-1, -2, -2, -1, -2]^T$

Table2

eigenvalues	eigenvectors
1	(4, 3, 6, -2, 0)
9	(-3, 5, 0, 0 7)
4	(1, 8, -4, 5, 6)
7	(2, -1, 0, 4, 1)
3	(5, 5, 9, -1, 2)

3. **(20%,** HMM) A HMM topology and parameters are as following graph.



$b_1(O_0)=0.6$	$b_2(O_0)=0.1$	$b_3(O_0)=0.3$
$b_1(O_1)=0.1$	$b_2(O_1)=0.15$	$b_3(O_1)=0.1$
$b_1(O_2)=0.2$	$b_2(O_2)=0.05$	$b_3(O_2)=0.4$
$b_1(O_3)=0.1$	$b_2(O_3)=0.7$	$b_3(O_3)=0.2$

Please write its corresponding 1 parameter vector and 2 parameter matrixes, π (1x3 vector) **(6%),** A (3x3 matrix) **(7%),** and B (4x3 matrix) **(7%),** with values?

4. **(20%,** VQ) Please set the sort order for the procedure of Vector Quantization algorithm:

Step : Codebook Updating - Update the codeword (symbol) o^i of each cluster C^i by computing new cluster centers $c^i(l+1)$ where $i = 0,1,...,M-1$ at the $l+1$th iteration.

$$c^i(l+1) = \frac{1}{N}\sum_{n=1}^{N} x_n^i \quad \text{where } x^i \in C^i(l+1)$$

N is the number of feature vectors in cluster $C^i(l+1)$ at the $l+1$th iteration.
And

$$q(x) = o^i \quad \text{where } 0 \le o^i \le M-1$$

where $q(.)$ is the quantization operator.

Step : Termination 1 - If the difference between the current overall distortion $D(l+1)$ and that of the previous iteration $D(l)$ is below a selected threshold,

$$\begin{cases} \text{if } |D(l+1) - D(l)| < \textit{threshold, then Goes to Step } \underline{?1} \\ \text{if } |D(l+1) - D(l)| \ge \textit{threshold, then Goes to Step } \underline{?2} \end{cases}$$

(where *threshold* is 0.0001 in our study.)

Step : Termination 2 -

Is the codebook size M equal to the VQ codebook size required ?

$$\begin{cases} \textit{if Yes, then } \underline{?3} \\ \textit{if No, then Goes to Step } \underline{?4} \end{cases}$$

Step : Classification - At the lth iteration, according to following equation, classify each k-dimensional sample x of training feature vectors into one of the clusters C^i.

$$x \in C^i(l) \quad \text{if } \|x - c^i(l)\| < \|x - c^j(l)\| \text{ where } i \ne j,\ i, j = 0,1,...,M-1$$

Step : Initialization - Assume all N k-dimensional training vectors to be one cluster C^0, *i.e.*, codebook size $M = 1$ and codeword $o^0 = 0$, and find its k-dimensional cluster centroid $c^0(1)$ where 1 is the initial iteration.

$$c^0(1) = \frac{1}{N}\sum_{n=1}^{N} x_n^0$$

where x is one sample of all N k-dimensional feature vectors at cluster C^0.

Step : Splitting - Double the size M of the codebook by splitting each cluster into two. The current codebook size M is split into $2M$. Set $M = 2M$ by

$$\begin{cases} c_+^i(l) = c^i(l) + \varepsilon \\ c_-^i(l) = c^i(l) - \varepsilon \end{cases} \quad where \;\; 0 \le i \le M-1$$

c^i is the centroid of the ith cluster C^i, M is the size of current codebook, ε is a k-dimensional splitting parameter vector and is value 0.0001 for each dimension in our study. 1 is the initial iteration.

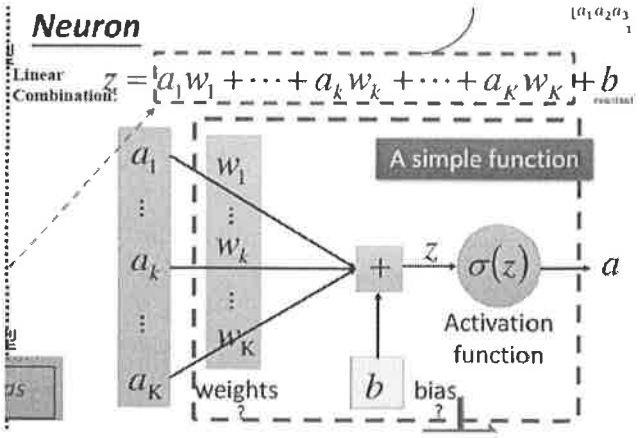
(a) Set the sort order above 6 steps? **(12%)**

(b) Which step includes the nearest neighbor rule? **(4%)**

(c) Vector quantization belongs to _____ learning. (Hint: Supervised, semi-supervised, or unsupervised, reinforcement) **(4%)**

5. **(20%,** DL) Based on the deep learning lecture:

(a) For each neuron as following, if a_i is the given (known) input image pixel, w_i is the weight parameter of neural network, b is the bias parameter, and z is it output result. Please write its ***AX=B*** format? Here ***A*** is unknown parameter vector, ***X*** is the known input pixel vector and ***B*** is the output result. **(7%)** After activation function, the output of $\sigma(z)$ is the _____ result **(3%)** (Hint: Linear Discrimination, Non-Linear Discrimination)



(b) Each of following answers for physical meaning has only one answer selection:

(b.1) Deep learning, which is the same as AdaBoost, has the property of _____? **(2%)**

(b.2) Deep learning, which is the same as Supported Vector Machine, has the property of _____? **(2%)**

(b.3) Convolution process has the property of _____? **(2%)**

(b.4) Max Pooling has the property of _____? **(2%)**

(b.5) Softmax function has the property of _____? **(2%)**

(Hint: Non-linear discrimination, subsampling, feature extraction, cascade, output normalization)

DBMS Qualify Exam

1. (30%) Consider the following schema for a suppliers-and-parts database:

SUPPLIER(SupNo, SName, Status, City)

PART(PartNo, Color, Weight, City)

PROJECT(ProjNo, PName, City)

SHIPMENT(SupNo, PartNo, ProjNo, Qty)

Answer the following queries in SQL.

(a) Get the total weight for the parts that have a "red" color.

(b) Get the total quantity for the red parts that are supplied by all suppliers.

(c) Get the suppliers that supply a project in which all the supplied parts are red parts.

2.(30%) Answer the above queries in relational algebra.

3. (15%) A relation, R(A, B, C, D, E, F, G), whose attributes satisfy the functional dependencies: (BC → A, D, E, F, G), (C → E), (D → F, G), (D→B)

Normalize the above relation to make it satisfy

(a) 2NF

(b) 3NF

(c) BCNF

Note: Don't make unnecessary normalization unless it is required.

4.(15%)

(a) Serializability.

(b) What is two-phase locking protocol?

(c) Is two-phase locking a necessary or sufficient condition for serializability? Explain why.

5. (10%) In performing an update operation, the record to be updated must be locked (as indicated in concurrency control protocols). Then, can a query access these locked records during query processing? If no, how can a query result be accurate with these records being locked and inaccessible? If yes, then will the access to these locked items violate the concurrency control protocol (because the lock on the records is broken)? How does a DBMS manage this problem?

Qualify Exam – Data Mining, 2019

1. (15 points) Please briefly describe the following terminologies. (1) large itemset (2) ROC curve (3) Apriori property (in Apriori Algorithm)

2. (15 points) What is "overfitting" and "underfitting" problem in classification modeling? Please also explain how to reduce their effects when you are training models in DNN.

3. (10 points) Please compare K-means and K-medoids algorithms and list their advantages and disadvantages.

4. (20 points) Please apply FP-growth algorithm to find large itemsets in the following transaction data, if mini_support=3.

TID	Items bought
100	{a, c, d, f, g, i, m, p}
200	{a, b, c, f, i, m, o}
300	{b, f, h, j, o}
400	{b, c, k, s, p}
500	{a, c, e, f, l, n, p}

5. (15 points) A simple labeled data with 4 attributes shown in the right table. Please use **naïve Bayes** method to calculate the class probability of a test instance with "Give Birth"=yes, "Can Fly"=no, "Live in Water"=yes, and "Have Legs"=no.

Name	Give Birth	Can Fly	Live in Water	Have Legs	Class
human	yes	no	no	yes	mammals
python	no	no	no	no	non-mammals
salmon	no	no	yes	no	non-mammals
whale	yes	no	yes	no	mammals
frog	no	no	sometimes	yes	non-mammals
komodo	no	no	no	yes	non-mammals
bat	yes	yes	no	yes	mammals
pigeon	no	yes	no	yes	non-mammals
cat	yes	no	no	yes	mammals
leopard shark	yes	no	yes	no	non-mammals
turtle	no	no	sometimes	yes	non-mammals
penguin	no	no	sometimes	yes	non-mammals
porcupine	yes	no	no	yes	mammals
eel	no	no	yes	no	non-mammals
salamander	no	no	sometimes	yes	non-mammals
gila monster	no	no	no	yes	non-mammals
platypus	no	no	no	yes	mammals
owl	no	yes	no	yes	non-mammals
dolphin	yes	no	yes	no	mammals
eagle	no	yes	no	yes	non-mammals

6. (25 points) You want to design a classification system on a data set with 10 testing samples (5 positive and 5 negative cases). Now, you have two scoring approaches (M1 and M2) to generate the ranking for these testing samples. Please answer the following questions.
   (1). Draw the ROC curves for these two scoring approaches and answer their AUC respectively.
   (2). What are the R-precision values of M1 and M2 respectively?
   (3). Which approach is better? And why? How to improve these two approaches?

Scoring results	Ranking Result (M1)	Ranking Result (M2)
P: positive, N: negative	PPNNP NNNPP	NPPPN PNNNP