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*Indian Institute of Engineering Science and Technology, Shibpur*  
*B. Tech (CST) 4<sup>th</sup> Semester Endsem Examination, 2023*  
*Programming Paradigms (CS 2203)*

*Full Marks: 50*

*Time: 3 Hours*

*Answer Q.1, Q.2 and any two from the rest*

1. Choose the correct alternative.
  - a) Identify the correct extension of the user-defined header file in C++.  
(i) .cpp (ii) .h (iii).c (iv) .txt
  - b) Which constructor in C++ is not possible?  
(i) Parameterized (ii) Default (iii) Friend (iv) Copy
  - c) Identify the correct example for a pre-increment operator.  
(i) n+ (ii) ++n (iii) n++ (iv)+n+
  - d) Choose the correct option which is mandatory in a function.  
(i) return type and parameter (ii) function name and parameter  
(iii) function name, parameter and return type (iv)none
  - e) What is the output? (i) 9 (ii) 9.5 (iii) 9.0 (iv) 10  
main () {  
 int a, b = 10;  
 a = 95 / 10;  
 cout << a << endl;  
}
  - f) Package is a collection of (i) editing tool (ii) classes (iii) classes and source code (iv) source code
  - g) Identify the keyword among the following that makes a variable belong to a class, rather than being defined for each instance of the class. (i) static (ii) final (iii) import (iv) abstract
  - h) What is the output? (i) 101 (ii) Compiler error (iii) 100 (iv) 102  
int ++a = 100;  
System.out.println(++a);
  - i) Where does the system store parameters and local variables whenever a method is invoked.  
(i) Heap segment (ii) Stack segment (iii) Code segment (iv) Data segment
  - j) Which of the following exception is thrown when divided by zero statement is executed?  
(i) NullPointerException (ii) NumberFormatException (iii) ArithmeticException (iv) None

*(1x10=10)*

2. Write briefly on  
a) Scope resolution operator b) Call by reference c) Call by address  
d) Void pointer e) 2GL f) Abstract class g) 'super' keyword  
h) 'final' keyword i) Labelled 'break' j) lambda (in Scheme) (2x10=20)
3. Is it possible to achieve dynamic linking in both C++ and Java? If yes then discuss with appropriate and complete programs. (10)
4. Discuss virtual function in C++ and abstract class in Java with appropriate and complete programs. (10)
5. Prove that a) 'Exponent' is a primitive recursive function b) ' $3+3=6$ ' using  $\lambda$ -Calculus (5+5)

# B.Tech. 4th Semester (CST) End Semester Examination 2023

Indian Institute of Engineering Science and Technology, Shibpur.

## Theory of Computation CS 2204

Time: 3 hrs

Full Marks: 50

Answer question no 1 and any four from the rest. It is advised to answer all parts of a question together.  
Credit will be given to precise answer.

1. Justify the truth and falsity of the following statements (any 5)

- (a) Pumping property is the characteristic of regular languages.
- (b) Deterministic and non deterministic Push Down Automata are equal in power.
- (c) Every grammar in Chomsky Normal Form (CNF) is regular.
- (d) Deterministic Context free grammars are always unambiguous.
- (e) If  $L$  is a regular language, then  $L$  is generated by some right-linear grammar.
- (f) There are algorithms to test emptiness of a CFL.
- (g) CFLs are closed under intersection.

[5 × 2]

2. (a) Design DFA machine for the following languages (any one)

- (i)  $L_1 = \{w \in (a, b)^* | w \text{ has exactly 2 } a's \text{ and at least 2 } b's\}$
- (ii)  $L_2 = \{w \in (a, b)^* | w \text{ has even number } a's \text{ and each } a \text{ is followed by at least one } b\}$

- (b) Write down the language described by the regular expression  $(1 + 01)^*(0 + \epsilon)$

- (c) Prove whether the language  $L = \{1^r \mid r \geq 0 \text{ and } r! \text{ is a factorial of } r\}$  is regular or not. [4+2+4]

3. (a) Design a PDA that accepts the language  $L = \{a^m b^{3m} \mid m \geq 1\}$ .

- (b) Prove whether following two languages are CFL or not.

- (i)  $L_1 = \{a^n b^m \mid n \neq m\}$
- (ii)  $L_2 = \{w \in \{a, b, c\}^* \mid w \text{ has equal numbers } a's, b's \text{ and } c's\}$

[4 + (3 × 2)]

4. (a) What do you mean by useless symbols in a grammar. How are they identified and removed?

- (b) Why do we need grammar to be in CNF form? Convert the following grammar into CNF form

$$S \rightarrow abAB$$

$$A \rightarrow bAB \mid \lambda$$

$$B \rightarrow BAa \mid A \mid \lambda$$

- (c) Prove that to derive a string  $w$  of length  $n$  from a CNF grammar, the number of derivation steps required is always  $2n - 1$ . [3+4+3]

5. (a) What do you mean by decidable and undecidable language?

- (b) Write down what do you understand by polynomial time reducibility and hence prove that the statement "If  $A$  is Turing recognizable and  $A \leq_p \bar{A}$  then  $A$  is decidable" holds true.

- (c) The Diagonalization Language  $L_d$  is defined as follows:

$L_d = \{w_i \mid w_i \notin L(M_i)\}$ , i.e., the language of all strings whose corresponding machine does not accept itself (i.e., its own code). Prove that  $L_d$  is not recursively enumerable. [3+3+4]

6. (a) Is it possible to write a general program to estimate the running time of any other program given as input.

- (b)\* Design a Turing machine that takes as input strings of the form  $0^m 1 0^n 1$  and produce  $0^{m+n} 1$ .
- (c) Consider the language  $L = \{a^n b^n | n \geq 0\}$ . Now, write down a grammar  $G$  such that  $L(G) = \overline{L}$ .  
[3+4+3]

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**Indian Institute of Engineering Science and Technology, Shibpur**  
**BTech (CST) 4<sup>th</sup> Semester Mid Semester Examination, February 2023**

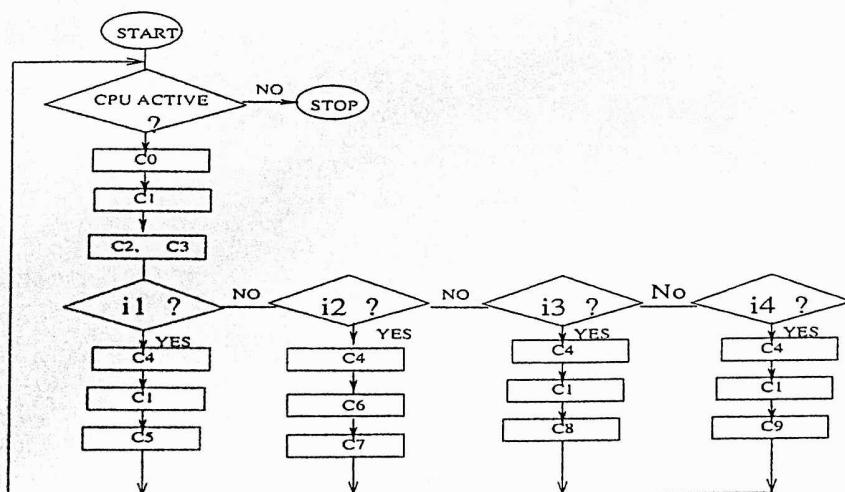
Subject: Computer Architecture and Organization I (CS-2202)

Full marks: 30

Time: 2 hours

Answer all

1. Answer in short 1+1+1+2+1
- a) Find the number of address and data lines of a 4GX32 memory.
- b) The 16-bit registers R1 and R2 store decimal +127 and -127 respectively in 2's complement. Show the content of R1 and R2.
- c) Consider a hypothetical CPU having 32-bit address bus and 16-bit data bus. What is the size of program counter (PC) and address register (AR) of this CPU?
- d) Write programs to compute  $Y = (w-x) * (a+b)$  in 2-addressed and 1-addressed m/c. Use any number of temporary registers so that operands are not overwritten.
- e) Explain memory operations done by the following two micro-operations.
- i)  $R \leftarrow M(AR)$ , ii)  $M(AR) \leftarrow R$
2. An instruction I in a program occupies memory location L and L+1. The location L+1 contains the operand address A. However, the operand is in location  $A_{eff}$ . Find  $A_{eff}$  if the addressing mode for I is (i) Direct, (ii) Indirect, (iii) Relative. 4
3. State Booth's algorithm. Show the computation of  $p = y * x$  following Booth's, where  $y = 0110$  (multiplicand) and  $x = 1011$  (multiplier) in 2's complement. If  $Y = 00000000 00000110$  and  $X = 11111111 11111011$ , then what is the product  $P = Y*X$ . 8
4. The following diagram describes the function (partial) of a processor control unit (CU). Show the hardwired realization of the CU in delay element method. 6



5. Describe in brief the opcode extension scheme with example. 6

# B.Tech. 4th Semester (CST) Mid Term Examination 2023

Indian Institute of Engineering Science and Technology, Shibpur.

Theory of Computation  
CS 2204

Time: 2hrs

Full Marks: 30

Answer question no 1 and any two from the rest. It is advised to answer all parts of a question together.  
Credit will be given to precise answer.

1. Justify the truth or falsity of the following statements (any 5).
  - (a) Any finite subset of an infinite set (regular/non-regular) is regular.
  - (b) There always exist a unique minimum DFA to recognise a given regular language.
  - (c) The class of regular languages, the class of context free languages, and the class of turing decidable languages are equal in size.
  - (d) For a given alphabet  $\Sigma$ , the number of languages over  $\Sigma$  is uncountable.
  - (e) The set containing encoding of all those DFA's that does not accept themselves is not regular.
  - (f) If a DFA accepts anything, it must accept a string of length less than  $n$ , where  $n$  is the number of states in the DFA. [5 × 2]
2. (a) Define a language over an alphabet  $\Sigma$  and hence define what is it meant by a language to be regular.
- (b) Design a DFA to accept all those strings over  $\{0, 1\}$  that does not contain  $11010$  as a substring.
- (c) Write down few statements that convinces you of existence of non-regular languages. [3+4+3]
3. (a) State and prove pumping lemma for regular languages.
- (b) Prove whether following two languages are regular or not.
  - (i)  $L_1 = \{1^r \mid r \text{ is not a perfect cube}\}$
  - (ii)  $L_2 = \{x \in (a, b)^* \mid x \text{ contains exactly twice as many } a's \text{ as } b's\}$  [3 + (3.5 × 2)]
4. (a) You are supplied with three languages, namely  $L_1, L_2$ , and  $L_3$  of which  $L_1$  is regular but  $L_2$  and  $L_3$  are not regular. What can you say (i.e. whether they are regular or not) about the following languages. (i)  $L_1 \cup L_2$  (ii)  $L_1 \cap L_2$  (iii)  $(L_1 \cup L_2) \cap L_3$  (iv)  $(L_2 \cup L_3) \cdot L_3$
- (b) What is the complement of the language accepted by the NFA  $M$  shown Fig.1? Assume  $\Sigma = \{a\}$  and  $\epsilon$  is the empty string.

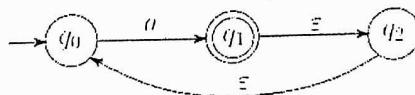


Figure 1: NFA M

- (c) State how Myhill-Nerode theorem can be used to obtain minimized DFA to accept a regular language. [4+2+4]

CST Fourth Semester Midterm Examination, March 2023  
**Analysis and Design of Algorithms (CS-2201)**

Answer any four questions.

Time 120 minutes

Full Marks 30

Marks distribution for each question is  $2.5+2.5+2.5=7.5$ .

- Let the rightmost digit of your registration number be  $x$  and last but one digit be  $y$ . In any problem, reference to this variable name is to be interpreted accordingly.

- State and prove are the matroid properties for a graph with set of nodes and edge weights. Explain how greedy algorithm can be applied to the minimum spanning tree problem. Find the minimum spanning tree for the following graph with five vertices and edge weights indicated in the adjacency table:

Vertex	A	B	C	D	E
A	-	$x+1$	3	2	5
B		-	4	3	6
C			-	$x+4$	5
D				-	7
E					-

- What is the advantage of taking median of medians as the pivotal element? Derive the time complexity of selection of the middlemost element in an array by the median of medians method with five elements per group. Find the median of medians for the ordering of the following twentyfive elements:  
 $23, 71, 42, 37, 10x + y + 11; 59, 67, 35, 29, 10x + 7; 17, 26, 34, 82, 10y + x + 13; 12, 43, 61, 28, 10y + 5; 25, 40, 51, 93, 10x + 17.$
- How are Polygon triangulation problem and matrix chain multiplication problem connected? Describe an algorithm for solving the polygon triangulation problem to optimize the total perimeter of the triangles. Consider a pentagon with vertices at  $(0, 0); (0, 4); (3, 0); (7, 3); (4, 7)$ . Find the optimal triangulation.
- Suppose in a quick sort algorithm, the pivotal element always divides the array in the size ratio of  $2 : 1$ . What will be the time complexity? Show that there is a bound that sorting algorithms cannot beat unless some assumptions are made about the dataset. Describe a sorting algorithm that is somehow able to beat this bound using certain assumptions.
- Write short notes on the following:
  - Greedy choice properties of knapsack problem
  - Optimality of data compression algorithms
  - Catalan number and their usage

*Indian Institute of Engineering Science and Technology, Shibpur*

*B. Tech (CST) 4<sup>th</sup> Semester Midterm Examinations, 2023*

*Programming Paradigms (CS 2203)*

*Full Marks: 30*

*Time: 2 Hours*

*Answer any three*

1. a) What are the different styles of programming? Discuss with example.

b) Give examples of some programming languages and categorize them.

(8+2)

2. a) Develop a procedure  $f(x, y) = \frac{20}{\frac{x^2 + 6e^{x(10x-107)}}{\log_y(\cos x)} + 1}$  using the Scheme Lisp  
 $\log_y(\cos x) + \frac{1}{7}$

Step by step approach is preferred over writing the entire expression simultaneously.

b) Discuss higher-order procedures in Scheme Lisp. (8+2)

3. a) Discuss function overloading in C++ with an application program of your choice.

b) State the use of the scope resolution operator in C++.

(8+2)

4. Write a short note on the following. To illustrate use C++ code.

a) Virtual function.

b) Private constructor.

(5+5)

B.Tech 4th Semester Midterm Examination, 2023

Subject: Introduction to Data Science

Code: CS2205

Full Marks- 30

Time: 2hrs

Answer any three questions

1. (a) What is over-fitting problem?

(b) What are the different methods to deal with overfitting problem and how? Give explanation for each cases.

2+3+5

2. (a)

Home Owner	Marital Status	Annual Income	Defaulted Borrower
Y	Single	125	N
N	Married	100	N
N	Single	70	N
Y	Married	120	N
N	Divorced	95	Y
N	Married	60	N
Y	Divorced	220	N
N	Single	85	Y
N	Married	75	N
N	Single	90	Y

construct the decision tree using this dataset. Apply any method suitable to you.

(c) Why decision tree algorithm is called Greedy Algorithm?

7+3

3. (a) What is box plot?

(b) Why do you measure correlation and covariance of variables in a dataset.

(c) What is the purpose of p-value test?

2+2.5+2.5+3

4.(a) Describe the Gradient Descent Algorithm used to minimize the Mean Square Error Loss function of a linear regression model.

(b) What is Template Matching?

8+2

CST Fourth Semester Final Examination, March 2023  
Analysis and Design of Algorithms (CS-2201)

**Answer  
Full Marks 50**

Time 3 hours

1. Answer any four of the following: For each question, clearly mention the algorithm used and the steps of calculation to get full marks. [4 X 4.5 = 18]

  - Consider a matrix chain with the dimensions  $(3 \times 2) \times (2 \times 5) \times (5 \times 4) \times (4 \times 2) \times (2 \times 3)$ . Find the optimal multiplication sequence and the resulting number of operations for multiplying the matrices in that sequence.
  - Implement Shannon Fano code and Huffman code for these 5 symbols and

Symbol	A	B	C	D	E
Probability	0.475	0.125	0.25	0.1	0.05

compare the average length of the codewords for the two codes

- (c) Consider a 3CNF satisfiability problem  $(\bar{x} \vee y \vee z) \wedge (x \vee \bar{y} \vee z) \wedge (x \vee y \vee z)$ . Construct the graph  $G$  which reduces the above formula to a clique in P-time.

(d) For the tasks tabulated, find the schedule that minimizes the penalty.

Task	$T_1$	$T_2$	$T_3$	$T_4$	$T_5$	$T_6$	$T_7$
Deadline	4	5	3	2	2	5	3
Execution time	1	1	1	1	1	1	1
Penalty	70	60	50	40	30	20	10

- (e) Compare the median of medians taking 3 elements per group, 5 elements per group with the actual median for the given sequence of elements (last digit of your roll number is  $x$  and last but one is  $y$ .) and comment on complexity of quick sort using such pivot:  $59, 67, 42, 37, 10x+y+11, 40, 51, 35, 29, 10x+17, 17, 26, 23, 71, 10y+x+13, 12, 34, 82, 28, 10y+5, 25, 43, 61, 93, 10x+17$ .

2. Explain whether solution of CSAT in polynomial time leads to  $P = NP$ . Show that travelling salesman problem (TSP) is NP Complete. Does it really mean that TSP cannot be solved at all?  $[3+3+2=8]$

3. How does modular exponentiation algorithm work? Use it to show that 341 is a modulo-2 pseudoprime. Explain the algorithm how the multiplicative inverse of some  $n$  can be found modulo- $p$  and give a small example.  $[2+2+4=8]$

4. Describe data structure that results in improved time complexity for:  $[4+4=8]$   
(a) Disjoint set operations; (b) Polynomial representation

5. Analyze the time complexity of the following operation / algorithm :  $[4+4=8]$   
(a) Searching in open addressing scheme; (b) Average case quick sort

6. Write short notes on any two the following:  $[4+4=8]$   
(a) RSA Public key cryptosystems  
(b) FFT algorithm to find frequencies in time series data  
(c) Hash functions for disjoint set operations

7. Point out the differences between the following:  $[4+4=8]$   
(a) Kruskal algorithm and Prim algorithm  
(b) Fractional knapsack and 0-1 knapsack problem

Indian Institute of Engineering Science and Technology, Shibpur  
BTech (CST) 4<sup>th</sup> Semester Examinations, 2023

Computer Architecture and Organization I (CS-2202)

Full marks: 50

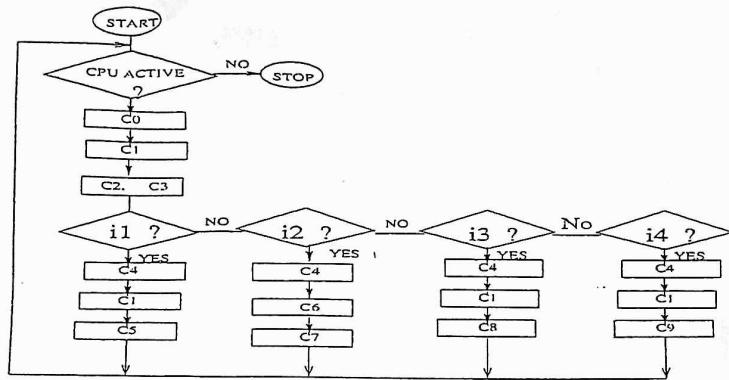
Time: 3 hours

Answer any four

- 1 a) Find the speedup of CPU1 having an average CPI and clock period of 2 and 120 ns compared to the CPU2 having CPI and clock period of 5 and 100 ns respectively. 3
- b) Show the organization of RAID 1 in a storage system with 4 disks, each of 128 GB. 2
- c) In a 2-way set-associative cache, a main memory address is viewed as consisting of three fields - define the fields. If in the 2-way set-associative cache of 4Kbytes there are cache lines (frames), each of 16 bytes, and the main memory (byte addressable) is of 16Mbyte, then show the format of main memory addresses. 4
- d) Show addition of six 8-bit numbers using Carry Save Adders. 3.5
- 2a) There are four registers R1, R2, R3 and R4 in a CPU. Realize the implementation of data movement instruction MOV *destreg*, *sourcereg*, where *destreg* and *sourcereg* can be from the set {R1, R2, R3, R4}. Mention the assumptions taken. 6.5
- ~~b) Design a logic circuit that implements the NAND ( $R3 = \overline{R1} \cdot \overline{R2}$ ), XOR ( $R3 = R1 \oplus R2$ ), OR ( $R3 = R1 + R2$ ) and NOT ( $R3 = \overline{R1}$ ) operations. Show the detail logic diagram.~~ 6
- ~~3a) A CPU is having 24 address lines, 16-bit data bus, RD, WR, and other normal signal lines. In addition to that, there is a signal line  $IO/\bar{M}$  to define the memory ( $IO/\bar{M} = 0$ ) and IO ( $IO/\bar{M} = 1$ ) address on the address bus. Show the interfacing logic (block diagram only) of two 1Mx16 RAM chips and one 256Kx16 ROM chip with the CPU in complete decoding. Specify memory address space occupied by each chip.~~ 6.5
- b) Construct 8Kx8, 4Kx16 and 8Kx16 ROM with the available 4Kx8 ROMs. Show only the external connections. 6
- ~~4a) Define memory direct and memory indirect operand addressing schemes (with diagram). An instruction I at address 7800H of an one-addressed m/c is set for memory indirect operand addressing and contains opcode for OR operation and operand as F800H. The content of memory location F800H is F820H. Further, F850H is stored in F820H and the content of AC is 7810H. Determine the contents of PC, AR, DR, AC at the end of execution of I. Also determine the content of AC if I follows direct addressing.~~ 6.5
- ~~b) Define opcode extension and frequency dependent opcode encoding schemes. Find Hoffman encoding of instructions (in frequency dependent opcode selection scheme) for a hypothetical CPU with five type of instructions - Data movement, Logical, Arithmetic, Branch and Debug in its instruction set with probable occurrence (frequencies) of 34%, 22%, 18%, 21% and 5% respectively.~~ 6

Pg. 1 of 2

5. The following figure describes the function (partial) of a processor control unit (CU). Duration of control signal  $C_1$  is  $2t$  and that is for other control signals of the figure is  $t$ . Show design of CU following (a) Delay element method, and (b) Sequence counter method. 12.5



- 6a) Consider the following reservation table for a 3-stage ( $S_1, S_2, S_3$ ) non-linear function  $X$  -

	1	2	3	4	5	6
$S_1$	X			X		X
$S_2$			X			
$S_3$				X		

time step →

- i) Identify forbidden latencies.
  - ii) Find collision vector and draw the state diagram.
  - iii) Identify simple cycles, greedy cycles and compute MAL.
  - iv) Find lower bound of MAL.
  - v) Give the block diagram for the non-linear pipeline architecture. 6.5
- b) Describe the steps in bulk DMA data transfer from an Input device to the Main Memory. 6

Fig 2.7.2

B.Tech (4<sup>th</sup> semester) Final Examination, 2023

Introduction to Data Science (CS2205)

Full Marks 50

Time 3hrs.

Answer mandatory Question no. 4 and any two from the rest

1. ~~(a)~~ What are the benefits of using recommender systems in different business houses? 3  
~~(b)~~ What are the different approaches of recommending an item? 2  
~~(c)~~ How much data do you need to measure effectiveness of a recommender system? 5  
~~(d)~~ What is the "cold start" phenomenon? 5  
~~(e)~~ How collaborative filtering recommends items to the users? 5
2. (a) A matrix  $A$  ( $m \times n$ ) is associated with a vector  $v$  ( $R^n$ ), describe a linear transformation from  $R^n$  into  $R^m$  5  
(b) Why Eigenvectors are important? Justify your answer considering the matrix 5

$$A = \begin{bmatrix} .8 & .3 \\ .2 & .7 \end{bmatrix}$$

(c)

$$A = [u_1 \ u_2 \ \dots \ u_n] \begin{bmatrix} \lambda_1 & 0 & \dots & 0 \\ 0 & \lambda_2 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \lambda_n \end{bmatrix} [u_1 \ u_2 \ \dots \ u_n]^T$$

Describe each part of matrix  $A$  obtained by Eigen decomposition method. 7

3

(d) Define Singular values of the matrix  $A$ . 3

7

3. ~~(a)~~ Why K-NN classifier is called **lazy learner algorithm**? 5  
~~(b)~~ How to select the value of K in the K-NN Algorithm? 4  
~~(c)~~ What is the basic characteristic of probabilistic classifiers? 4  
~~(d)~~ Explain role of Bayes rule to describe the *naïve Bayes classification model* 7

4

4

7

4. ~~(i)~~ What is the difference between multi-class and multi-label classification? 2.5  
~~(ii)~~ How many non-zero singular values of a matrix  $A$  is considered and why? 3.5  
~~(iii)~~ When do you use the linear regression, and logistic regression classifiers? 4

2.5

3.5

4