L-2/T-2/CSE Date: 19/10/2023

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2021-2022

Sub: **CSE 207** (Data Structures and Algorithms II)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** Questions.

1. (a) Define and distinguish the two basic properties of the greedy algorithm. **(8)**

   (b) Prove (i) the optimal sub-structure property and (ii) the greedy choice property of the Minimum Spanning Tree (MST) problem. **(12)**

   (c) Develop a solution of the MST problem using disjoint set / union-find data structure. Use the array implementation to maintain union-find data structure. **(15)**

2. (a) What are the splay-step operations to make a binary search tree a balanced one. **(8)**

   (b) Suppose you are inserting a node in an AVL tree, and x is the lowest node violating AVL and x is left-heavy. Demonstrate the balancing procedure using figures. **(12)**

   (c) What are the properties of a red-black tree? Derive that if a tree with n keys follows the red-black properties, its height h can be bounded as $h <= 2\lg(n + 1)$. **(15)**

3. The Bangladesh government is deeply concerned about addressing the severe traffic congestion issues in Dhaka. Despite numerous attempts to alleviate the problem, it remains a persistent challenge. Recognizing the need for fresh perspectives and innovative solutions, the government has turned to experts like you in the field of computer science, seeking guidance on a novel approach.

   Your proposed solution is straightforward: the construction of new roads. However, the key challenge lies in ensuring the effective utilization of these newly built roads. This can only be achieved by reducing travel costs along specific routes. By doing so, the traffic will naturally redistribute throughout the network, alleviating congestion in critical areas.

   In this problem, a map of Dhaka is represented as an undirected graph, where each node represents a station and each edge represents a road between two stations. These nodes are depicted as simple 2-D geometric points, and the cost of traveling along a road is directly proportional to the Euclidean distance between two nodes.

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CSE 207
Contd... Q. No. 3

The proposed strategy involves temporarily constructing a single road, with a specific criterion for selecting the two nodes between which this new road will be built. To make the decision, whether a new road will be built between node u and node v, the following formula is employed: Cuv = Sum($PreCost_{ij}$ - $CurCost_{ij}$). Here $CurCost_{ij}$ represents the shortest path cost from any node i to any node j if a road is built between node u and node v. On the other hand, $PreCost_{ij}$ represents the shortest path cost before the road between u and v is constructed. The pair (u,v) with the highest Cuv value is selected as the optimal choice.

In essence, this approach aims to identify the pair of nodes where the construction of a new road will result in the most significant improvement in the overall transportation network, effectively reducing travel costs and mitigating traffic congestion in Dhaka. From the above problem description, answer the following:

(a) Define the input and output of the program. **(8)**

(b) Sketch the pseudo-code of the solution. **(12)**

(c) Develop the most efficient solution of the underlying algorithm that serves as the backbone of the solution. **(15)**

4. (a) Define the Max-flow problem. **(8)**

(b) Consider a car parking problem scenario, where you need to match each of the cars with a parking spot. The cars and the available parking spots are located at different parts of the city and can only accessible through a road network graph, G. Let A be the set of cars and B be the set of parking slots. The cost of a car, a in A to reach to a parking slot, b in B is the shortest distance (on the graph G) between a and b. If the spot is unreachable by a car, we can assign it an infinite cost.

(i) Formulate the above problem using Max-flow/min-cut problem. **(12)**

(ii) Develop an efficient solution of the above problem to find a match for every car so that the overall cost is minimized. **(15)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. Suppose there are two priority queues named pq1 and pq2. The pq1 is a max priority queue and pq2 is a min priority queue. Both the priority queues are implemented using the binomial heap data structure. The priority queue pq1 was initially empty, but then the following numbers were inserted in this order: 210, 201, 220, 202, 221, 205, and 209. The internal heap representation of the priority queue pq2 is show in figure 1. Now answer the following questions:

CSE 207

Contd... Q. No. 5

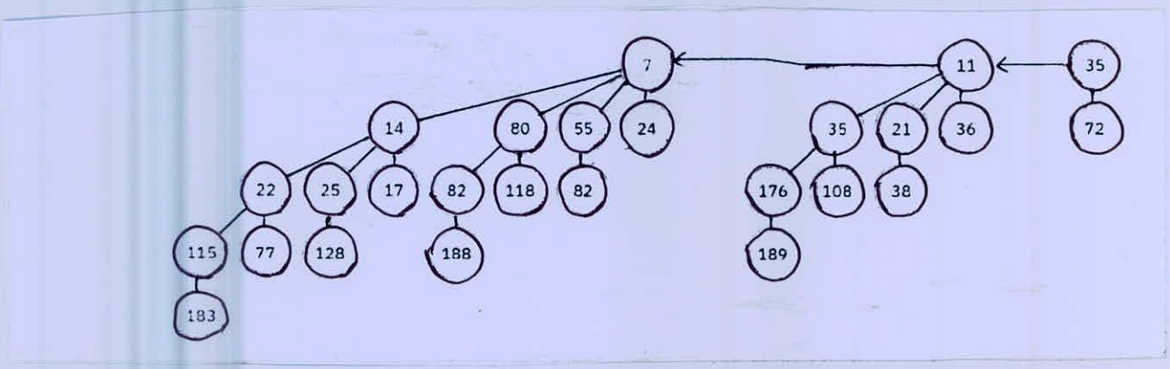

Figure 1: Internal heap representation of pq2

(a) Formulate an algorithm or pseudocode that will convert a min priority queue to a max priority queue. The amortized running time of the algorithm has to be O(n) where n is the total length of the min priority queue. Note that the priority queues are implemented using the binomial heap data structure. Also, analyze the amortized running time of your proposed algorithm using the potential method. **(15)**

(b) Apply your proposed algorithm on pq2 to convert it to a max priority queue. **(5)**

(c) Apply the meld operation on pq1and pq2 and store it to a new priority queue pq3. Show the internal heap representation of pq3. Note that you have to work with updated pq2. **(5)**

(d) Determine the internal heap representation of pq3 after executing extract-max operation three times on pq3. **(5)**

(e) Evaluate the total actual cost in credits of the extract-max operations you did in the previous question. Assume that unlinking a node from its children takes one credit, a node addition operation takes one credit, an insertion of a node takes one credit, and a comparison takes one credit. **(5)**

6. (a) Suppose you implemented a hashtable ADT that supports constant time insertion, deletion, and search. You used the hash function h1. On the contrary, your friend suggested using the hash function h2. The h1 hashes the keys 100, 130, 110, 150, 160, 200, 700, 800, 300 into 0, 3, 2, 0, 3, 1, 2, 5, and 8, respectively. The h2 hashes the same keys into 1, 4, 7, 10, 13, 4, 7, 10, 13. You made the hashtable size 15 but your friend suggested making it 17. You used the quadratic probing function $f(i) = 3*i^2 + 5$ for collision resolution. Your friend suggested using the double-hashing technique. The second hash function is $h_2(x) = 11 - (x\%17)$. You inserted all the keys in the order mentioned before to the hashtable. Then you deleted the key 110 and then searched for the key 700. But your hashtable implementation was showing "key 700 not found". Now, answer the following questions:

i. Compare your decisions with your friend's suggestions by analyzing the total unsuccessful probes during insertion in both cases. **(15)**

CSE 207

Contd... Q. No. 6(a)

ii. Comment on your friend's suggestion on the hashtable size. **(5)**

iii. Identify the possible core reason for not finding the key 700 during the search and provide a solution. **(5)**

(b) Analyze the running time of a chaining hashtable in both successful search and unsuccessful search cases. **(10)**

7. (a) Suppose you are a developer of a social media platform. The platform wants to add a feature in the admin section. The feature is to identify the minimal subset of users who can reach out to all other users of the platform through their (selected subset users') connections. Now you have to formulate an algorithm to develop the feature. Your colleague commented that the problem can be mapped to a popular np-complete problem.

i. Map the problem to the np-complete problem that your colleague suggested. **(5)**

ii. Prove that the problem is np-complete. You have to use the 3-SAT problem in the proof. **(10)**

(b) There are 6 places in your village. You want to visit all the places and return to the first place that you will visit. Also, you don't want to visit the same place twice other than the starting place. You want to finish the visits with minimum cost. The cost of the roads between these places are given below: **(20)**

From/To	1	2	3	4	5	6
1	0	10	15	20	25	30
2	5	0	12	18	24	29
3	8	9	0	17	22	28
4	11	14	16	0	21	27
5	13	19	23	26	0	31
6	28	27	25	24	22	0

Find the optimal tour using branch and bound, and pruning techniques combinedly.

8. Suppose you want to fill up your luggage with the required items for your upcoming tour. But the luggage has a capacity of 600 kg. The items have different values and weights which are given below:

Contd P/5

CSE 207

Contd... Q. No. 8

Item	Value	Weight
1	1200	150
2	1100	100
3	950	250
4	1350	350
5	800	200
6	1500	300

You want to fill up your luggage so that the total values of the items are maximized. So you plan to use an approximation algorithm that you learned from your teacher to solve the problem. The approximation algorithm scales down the high values by $\epsilon V_{max}/2n$ (ϵ = precision parameter, V_{max} = largest value and n = total items) and utilizes a dynamic programing technique. The dynamic programing technique uses the subproblem $OPT(i.v)$ (the minimum weight of the luggage for which we can obtain a solution of value at least v using a subset of items 1 to i), instead of using $OPT(i, w)$ (the max value subset of items 1 to i with weight limit w).

(a) Why does the approximation algorithm mentioned above use the $OPT(i, v)$ subproblem instead of $OPT(i, w)$? **(5)**

(b) Apply the approximation algorithm to solve your luggage problem. Use $\epsilon = 0.1$. **(15)**

(c) prove that for any $\epsilon > 0$, the approximation algorithm computes a feasible solution whose value is within a $(1 + \epsilon)$ factor of the optimum in $O(n^3/\epsilon)$. **(15)**

L-2/T-2/CSE **Date: 3/10/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2021-2022

Sub: **CSE 211** (Theory of Computation)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section.
Answer Question No. 1 and any **TWO** from the rest. Questions No. 1 is **COMPULSORY**.

1. **[COMPULSORY]**

(a) In the password-protected login system of a computer, which of the three traditionally central areas of the Theory of Computation has been applied? Explain clearly. **(4)**

(b) Design a deterministic finite automaton (DFA) with not more than five states for the alphabet $\Sigma = \{a, b\}$, which accepts the strings that begin with a but does not contain the substring aab. Showing only the state diagram for this DFA should suffice. **(10)**

(c) If M is a deterministic finite automaton (DFA) that recognizes the language C, swapping the accepting and non-accepting states in M yields a DFA that recognizes $\overline{C}$. Explain why this technique works. Does this method work for non-deterministic finite automatons (NFA) as well? Why? Give examples. **(6+3=9)**

(d) Comment on the acceptability of the following arguments by B L Perfunctory (BLP) related to the pumping lemma for regular languages: **(9)**

(i) Consider the set of palindromes over {0, 1}. BLP supposed that the set of palindromes is regular. Let p be the pumping length. Consider the string $w = 00011000$. Clearly w is a palindrome. By the pumping lemma, there must exist strings x, y, and z satisfying the constraints of the pumping lemma. xy is entirely contained in the 0^p at the start of w. So x and y consist entirely of zeros.

Now, consider xz. By the pumping lemma, xz must be in the language. But xz can't be a palindrome. This means that the set of palindromes doesn't satisfy the pumping lemma and, thus, the set of palindromes cannot be regular.

(ii) Consider the language $\{w|w$ has an equal number of 0s and 1s$\}$. BLP supposed that the language is regular. If p is the pumping length, let w be the string $0^{\underline{p}}1^{\underline{p}}0^{\underline{p}}1^{\underline{p}}, w = xyz$, where for any $i \geq 0$ the string xy^iz is in the language. y will be entirely contained in the first 0s. For any length of y in the permissible range, xy^iz will have an unequal number of 0s and 1s and hence not in the given language. Thus BLP concluded that the given language cannot be regular.

Contd P/2

CSE 211

Contd... Q. No. 1(d)

(iii) Consider the language $\{0^{2n} | n \geq 0\}$. BLP supposed that the language is regular. If p is the pumping length, let w be the string $w = 0^{2p}$, $w = xyz$, where for any $i \geq 0$, the string xy^iz is in the language. If $x = \epsilon$, $y = 0$, $z = 0^{2p-1}$, taking $i = 0$, we get $xy^iz = 0^{2p-1}$, which isn't in the language because its length is odd. So, the language isn't regular after all.

(e) Why are context free grammars called "context free"? **(3)**

2. (a) "Deterministic and nondeterministic finite automata recognize the same class of languages. Such equivalence is both surprising and useful". Why is this equivalence both surprising and useful? **(4)**

(b) Using the basic principles convert the regular expression $(((00)^*(11)) \cup 01)^*$ into a nondeterministic finite automata (NFA). **(10)**

(c) Consider the languages given below for an alphabet $\{a, b\}$, **(6)**

$L_1 = \{ a, aa, aaa \}$,

$L_2 = \{ a, ab, aab, aabb \}$,

$L_3 = \{$ Number of b's is a multiple of 3 $\}$

Now, comment on the size (finite/infinite) for each of the following languages. You must state the reason in each case.

i. $L_1^* \circ L_2^*$

ii. $L_1 \circ (L_1 \cup L_2)$

iii. $L_2 \circ L_3$

(d) Design a context free grammar for the language **(15)**

$\{a^i b^j c^k \mid i \neq j + k$, where $i, j, k \geq 0\}$. Merely putting forth the production rules shall not suffice. You need to explain your design idea first for your answer to be acceptable.

3. (a) Why is the Kleene star of a null set an empty sting? **(4)**

(b) Design a nondeterministic finite automaton (NFA) which accepts binary numbers which contains at least two 0s, or exactly two 1s. Showing only the state diagram for this NFA should suffice. **(10)**

(c) Convert the following non-deterministic finite automaton (NFA) into an equivalent deterministic finite automaton (DFA). You don't need to show the calculations. Showing only the state diagram for the DFA should be sufficient. **(9)**

Contd P/3

CSE 211

Contd... Q. No. 3(c)

	a	b	ε
q_1	$\{q_3\}$	ϕ	$\{q_2\}$
q_2	$\{q_1\}$	ϕ	ϕ
q_3	$\{q_2\}$	$\{q_2, q_3\}$	ϕ

(d) Which one of the following regular expressions represents the language: the set of *all* binary strings having two consecutive 0s as well as two consecutive 1s? You need to provide the necessary explanation regarding why your choice is correct while the others are not. Your answer will not be accepted without proper explanations. **(12)**

A. (0 + 1) *0011 (0 + 1)* + (0 + 1) *1100 (0 + 1) *

B. (0 + 1) * (00 (0 + 1) *11 + 11 (0 + 1) *00) (0 + 1) *

C. (0 + 1) *00 (0 + 1) * + (0 + 1) *11 (0 + 1) *

D. 00 (0 + 1) *11 + 11 (0 + 1) *00

4. (a) Why is it said that the pumping lemma for regular languages is useful for "negative proofs" only? **(4)**

(b) Let $N_1 = (Q_1, \Sigma, \delta_1, q_1, F_1)$ recognizes L_1, and $N_2 = (Q_2, \Sigma, \delta_2, q_2, F_2)$ recognizes L_2. We want to construct $N = (Q, \Sigma, \delta, q_0, F)$ to recognize $L_1 \cup L_2$. Now answer clearly the following with detailed explanations (must include the reason behind an action): **(12)**

i. How do we get the start state for N?

ii. How do we get the set of accept states for N?

iii. When we are considering the transitions originating from the start state of N, what are the cases that need to be considered? Why? What are the possible destination states in each case?

(c) To design a context free grammar (CFG) for the language, **(3+6=9)**

$\{a^i b^j c^k \mid i = j$, or, $j = k$, where $i, j, k \geq 0\}$,

A B Sloppy produced the following solutions:

i. $S \rightarrow aSb \mid bSc \mid aS \mid Sc \mid \varepsilon$

ii.

$S_0 \rightarrow S_1 \mid S_3$

$S_1 \rightarrow aS_1bS_2c \mid \varepsilon$

$S_2 \rightarrow S_2c \mid \varepsilon$

$S_3 \rightarrow aS_4bS_3c \mid \varepsilon$

$S_4 \rightarrow aS_4 \mid \varepsilon$

Do you find any flaw in the above solutions? Explain clearly.

Contd P/4

CSE 211

Contd... Q. No. 4

(d) We have a certain grammar for an infinite language. For a string s in that language, comment with reasons on the ambiguity of s and the grammar for each of the following scenarios. **(10)**

i. The grammar generates only one parse tree for s but generates more than one parse trees for other strings in the language.

ii. The grammar generates only one parse tree for s as well for other strings in the language.

iii. The grammar generates more than one leftmost derivations for s.

SECTION – B

There are **NINE** questions in this section. Answer any **SEVEN**.

5. Convert the following context-free grammar into an equivalent grammar in *Chomsky normal form (CNF)*. Show the steps of your conversion. **(15)**

$S \rightarrow A1A|B$

$A \rightarrow 0A|1A|\varepsilon$

$D \rightarrow 1$

6. What is an ambiguous grammar and an inherently ambiguous language? Determine whether the following grammar is ambiguous or not: **(6+9=15)**

$S \rightarrow AB \mid C$

$A \rightarrow aAb \mid ab$

$B \rightarrow cB \mid c$

$C \rightarrow aCc \mid aDc$

$D \rightarrow bD \mid b$

7. Let $\Sigma = \{a, +, *, (,)\}$ and consider the language ARITH = $\{w \in \Sigma^* \mid w$ is a legal arithmetic expression$\}$. Construct a pushdown automaton (PDA) that recognizes the language ARITH. Show its transition diagram. For example: $a+a*a$ and $((a+a)*(a+a))+(a)$ are legal expressions whereas $aa*a$ (two consecutive variables without an operator), $a++a$ (two consecutive operators), $+a$ (starts with an operator) and $(a+a))$ (imbalanced parentheses) are not. **(15)**

Contd P/5

CSE 211

8. Provide an example of a language that is not *context-free*. Illustrate that the language you provided is not context-free using the pumping lemma for context-free languages. **(5+10=15)**

9. Construct a Turing machine that takes as input a number w in *signed magnitude* form and computes the 2's *complement* of the number. Initially the tape contains a number in binary, MSB being the leftmost bit. If the MSB is 0, the number will remain the same. However, if the MSB is 1, w needs to be converted to its two's complement. Recall that you can convert a number to its two's complement by working from the least significant bit (LSB) towards the most significant bit (MSB), copying all the zeros until the first 1 is reached; then copy that 1, and flipping all the remaining bits (leave the MSB as 1). Your TM should terminate with only the two's complement of the number on the tape. (You can use multiple tracks, storages in the state if you wish). **(15)**

10. Justify whether the following statements are true or false: **(7+8=15)**

    i) A one-tape Turing machine with multiple tracks can simulate a Multi-tape Turing machine.

    ii) A conventional computer can simulate n moves of a non-deterministic Turing machine in $P(n)$ moves, where $P(n)$ is some polynomial in n.

11. What is (i) the Diagonalization language, and (ii) the Universal language? Show that the Halting problem is *not recursive*. **(6+9=15)**

12. i) Briefly explain how Cook's theorem shows that all problems in NP are reducible to the *satisfiability* problem in polynomial time. **(8+7=15)**

    ii) Explain how finding a polynomial time algorithm for any NP-complete problem implies P = NP.

13. For each of the following pairs of classes of languages, what is the widely believed relationship between the classes (whether they are equal or which one is a subset of the other)? Briefly justify your answer. **(15)**

    i) P and NP

    ii) P and PSPACE

    iii) PSPACE and NPSPACE

L-2/T-2/CSE **Date: 14/10/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2021-2022

Sub: **CSE 215** (Database)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** Questions.

Please read carefully, some questions might have additional restrictions.

1. (a) Consider the Toys database of a retail store. It has the following database schema: **(25)**

Toys (id, name, color, min_age, weight, number_available)

Client (id, name, age, address, city)

Request (client id, toy id)

The underlined attributes are keys for each relation. The tables contain the following information:

- *Toys* records information about all of the toys in the store. Each Toy has a unique integer *id*. Attributes *name* and *color* are strings that describe the toy; *min_age, weight,* and *number_available* are integers giving the minimum age a child should be to use the toy, the weight of the toy in pounds, and how many are currently available in the store.
- *Client* stores information about each of the clients. Each client has a unique integer *id,* strings with the client's *name*, *address*, and *city*, and an integer *age*.
- *Request* has a pair of integers indicating that a particular client has requested a particular toy.

You should assume that all entries in all of the tables are not null. Answer the followings:

i. Give the name of the clients who do not have any request at the moment for any toys.

ii. List the name of the tows that has weight more than the average weight of the toys with the same color.

iii. List the name of the requesting clients who have to wait because the toys are currently unavailable at the store.

iv. List all of the requests where *age* of the client is less than the *min-age* listed for the Toy. The answer should include the client id, client name, and the toy id. The results should be sorted by client name.

v. Give the id and name of the "most popular" toy. The most popular toy is the one that has more requests than all others. If there is a tie so there is more than one toy with the maximum number of requests, give the id's and names of all of these toys. They do not need to be in any particular order.

Contd P/2

CSE 215
Contd... Q. No. 1

(b) Consider the following relational database schema: **(10)**

Product (maker, model, type)

PC(model, speed, ram, hd, price)

Laptop(model, speed, ram, hd, screen, price)

Write SQL queries as part of DML to update the above tables to reflect the following facts:

(i) Insert the fact that for every PC there is a laptop with the same manufacturer, speed, ram, and hard disk, a 17-inch screen, a model number 1100 greater and a price $400 more with respect to the PC.

(ii) Delete all laptops made by manufacturer that does not make PCs.

2. (a) Suppose you are given the following requirements for a simple database for the Bangladesh premier League (BPL) in as season: **(10)**

- The BPL has many teams.
- Each team has a name, a city, a coach, a captain, and a set of players.
- Each player belongs to only one team; a player may not be hired by any team.
- Each player has a name, a position during fielding (such as slip, mid-wicket, long on, long off etc), a ranking and a set of injury records.
- A team captain is also a player.
- Injury records must have an id, period (start and end), and a short description.
- A game is played between two teams (referred to as host_team and guest_team) and has a data (such as May 11th, 2023) and scores (winning and losing team scores such as 143/10 and 148/6).

Construct a clean and concise E/R diagram for the BPL database using the notation as in your textbook. List your assumptions and clearly indicate the cardinality mappings as well as any role indicators in your E/R diagram.

(b) Consider the following descriptions of an organization having many EMPLOYEES. **(10+10=20)**

(i) An EMPLOYEE has a name, nid number, data of birth, and address.

(ii) Based on the EMPLOYEE's Job, EMPLOYEE may be further grouped into:

SECRETARY, ENGINEER, TECHNICIAN, and MANAGER

(iii) Based on the EMPLOYEE's method of pay, EMPLOYEE may also be grouped into:

SALARIED_ EMPLOYEE, and HOURLY_ EMPLOYEE

(iv) A salaried employee who is also an engineer belongs to the two subclasses: ENGINEER, and SALARIED_EMPLOYEE

Contd P/3

CSE 215
Contd... Q. No. 2(b)

(v) A salaried employee who is also an engineering manager belongs to the three subclasses:
MANAGER, ENGINEER, and SALARIED_EMPLOYEE.

(vi) We want to record typing speed of each SECRETARY.

(vii) Each technician has a technical grade (a number) which depends on his skill level

(viii) Each Engineer has a type (ME, CSE, EEE, etc ...)

(ix) Each MANAGER manages at least one project, each project has a project id, title, and a project value.

(x) Each HOURLY_EMPLOYEE is a member of some TRADE_UNION which has a name and member count.

- Construct an E/R diagram with the above description; clearly indicate the cardinality mappings as well as any role indicators in your E/R diagram.
- Convert the E/R diagram into a set of relational database schema. You should avoid keeping null values in attributes.

(c) Convert the E/R diagram of Figure 2(c) into a relational database schema. **(5)**

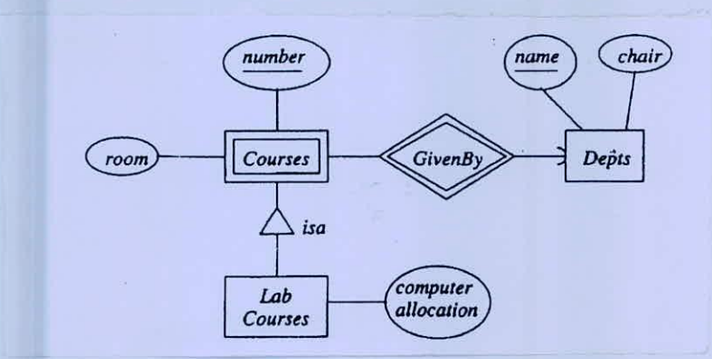

Figure 2(c): E/R Diagram

3. (a) Show SQL command to create a duplicate copy of table named Student. What the command will be if we just want to copy the schema not the data of Student table? **(5)**

(b) Consider a relation with schema R(A, B, C, D, E) and FD's $A \rightarrow B$, $B \rightarrow C$, $C \rightarrow D$, and $D \rightarrow A$. **(10)**

(i) What are all the nontrivial FD's that follow from the given FD's? You should restrict yourself to FD's with single attributes on the right sides.

(ii) What are all the keys of R?

(iii) What are all the super-keys that are not keys?

Contd P/4

CSE 215
Contd... Q. No. 3

(c) Consider a relation with schema R(A, B, C, D, E) and FD's AB → C, DE → C, and B → D. **(20)**

Decompose the relations, as necessary, into collections of relations that are in BCNF. Show your work, and the final normalized schema including all keys.

4. (a) What is the difference between UNIQUE key and Primary key? **(3)**

(b) Consider the following relational database schema: **(24)**

Product (maker, model, type)

PC(model, speed, ram, hd, price)

Laptop(model, speed, ram, hd, screen, price)

Printer (model, color, type, price)

The *Product* relation gives the manufacturer, model number and type (PC, laptop, or printer) of various products. model numbers are unique over all manufacturers and product types. The *PC* relation gives for each model number that is a PC the speed (of the processor, in gigahertz), the amount of RAM (in megabytes), the size of the hard disk (in gigabytes), and the price. The *Laptop* relation is similar, except that the screen size (in inches) is also included. The *Printer* relation records for each printer model whether the printer produces color output ('T', if so; 'F' otherwise), the process type (laser or ink-jet, typically), and the price.

Write necessary constraints to implement the followings (answer each independently):

(i) speed, ram, hd, screen and price cannot be negative.

(ii) A model of a product must also be the model of a PC, a laptop, or a printer

(iii) A laptop with a screen size less than 15 inches must have at least a 40 GB hard disk or sell for less than $1000

(iv) No manufacturer of PCs may also make laptops

(v) If a laptop has a large main memory than a PC, then the laptop must also has a higher price than the PC

(vi) A manufacturer of a PC also make a laptop with at least as great a processor speed

(c) Suppose we have two relations A and B with same set of attributes, Relation A has *na* tuples and relation B has *nb* tuples. For each of the following relational algebra expressions, give the minimum and maximum number of tuples that can appear in the result. Assume that the produced results are the bags, not the sets. **(8)**

a. $A \cap B$
b. $\sigma_c(A) - B$
c. $A \cup B$
d. $A \propto B$, *where* $\propto$ *is the left outer join*

Contd P/5

CSE 215

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Consider the relations r1(A, B, C), r2(C, D, E), and r3(E, F). Assume that there are no primary keys. Let V (C, r1) be 900, V (C, r2) be 1100, V(E, r2) be 50, and V(E, r3) be 100. Assume that r1 has 1000 tuples, r2 has 1500 tuples, and r3 has 750 tuples. Compute the size r1 ⋈ r2 ⋈ r3. **(15)**

(b) With necessary figures and examples, explain how Two-Phase Lock is implemented using Lock Table. **(10)**

(c) Consider a relational database table containing a few records shown in **Figure: 5(c)** which is stored in a database file using fixed length records and a free list. **(10)**

i) Show the structure of the file after deleting Record 2 (Mohammad Naim) and inserting a new row (Tamim Iqbal, Batter, 34).

ii) Discuss how the table would be stored in a slotted page structure with high-level block diagram showing only the records. You do not have to show the attributes of the records.

Header	Player Name	Role	Age	Free List
Record 0	Shakib Al Hasan	Allrounder	36	-
Record 1				
Record 2	Mohammad Naim	Batter	24	
Record 3	Taskin Ahmed	Bowler	28	
Record 4				
Record 5	Mushfiqur Rahim	Batter	36	
Record 6				
Record 7	Litton Das	Batter	28	
Record 8	Mustafizur Rahman	Bowler	28	

Figure: 5(c)

6. (a) Suppose that extendable hashing is being used on a database file that contains records with the following search key values: 2, 3, 5, 7, 11, 17, 19, and 23. Construct the extendable hash structure for this file if the hash function is $h(x) = x \ mod \ 7$ and each bucket can hold at most three records. **(15)**

(b) Briefly describe the differences between RAID-5 and RAID-6. **(5)**

(c) The SQL standard defines three weak isolation levels: dirty reads, read committed, and repeatable reads. Compare these three levels with illustrative examples. **(15)**

Contd P/6

CSE 215

7. (a) "Without bitmap index scan strategy, secondary index scan can sometimes perform worse than linear file scan." - Justify or criticize this statement with proper explanation. **(15)**

(b) Suppose, BIIS has a large number of records in its Course Registration table, accumulated over last 20 years. Explain how table partitioning can be done on this table, and what benefits and drawbacks it could offer. **(10)**

(c) For the following schedule, containing four concurrent transactions shown in chronological order, sketch the precedence graph and determine whether the schedule is conflict serializable. If so, write down the equivalent serial schedule(s) **(10)**

R1(A), W2(B), R3(C), W3(A), R1(D), R4(B), W4(D), W2(C)

8. (a) Describe how aggregation and set operations of SQL query are processed and whether pipelining can improve their performance. **(10)**

(b) Observe the Schema and SQL query shown in **Figure: 8(b)**. Construct an optimized query plan for the query using the equivalence rules of **Figure: 8(b).** You have to draw the query plan using expression tree and justify the plan with explanations. **(15)**

Schema:
Student (sid, name, major)
Enroll (sid, course, section, term, grade)
Class (course, section, term, instructor, room, time)

Query

```
SELECT S.name, C.instructor, C.term
FROM Student S, Enroll E, Class C
WHERE S.sid = E.sid AND E.course = C.course
AND E.section = C.section AND E.term = C.term
AND C.instructor = 'Hinon' AND S.major = 'ML';
```

Equivalence Rules (The notations carry usual meaning)

1. $\sigma_{\theta}(E_1 \times E_2) \equiv E_1 \bowtie_{\theta} E_2$
2. $\sigma_{\theta 0}(E_1 \bowtie_{\theta} E_2) \equiv (\sigma_{\theta 0}(E_1)) \bowtie_{\theta} E_2$
3. $\sigma_{\theta 1 \wedge \theta 2}(E_1 \bowtie_{\theta} E_2) \equiv (\sigma_{\theta 1}(E_1)) \bowtie_{\theta} (\sigma_{\theta 2}(E_2))$
4. $\prod_{L1 \cup L2}(E_1 \bowtie_{\theta} E_2) \equiv \prod_{L1}(E_1) \bowtie_{\theta} \prod_{L2}(E_2)$
5. $\prod_{L1 \cup L2}(E_1 \bowtie_{\theta} E_2) \equiv \prod_{L1 \cup L2}(\prod_{L1 \cup L3}(E_1) \bowtie_{\theta} \prod_{L2 \cup L4}(E_2))$

Figure: 8(b)

(c) Suppose A Megatron 800 Disk has the following pending disk requests (listed by track number). If the head is currently at track 71 and moving towards the higher track number, calculate average disk seek times for both the SCAN and C-SCAN algorithms. **(10)**

Disk Requests: 21, 98, 12, 80, 85 and 10

L-2/T-2/CSE **Date: 8/10/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2021-2022

Sub: **MATH 247** (Linear Algebra, Laplace Transformation and Fourier Analysis)

Full Marks: 280 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

Symbols have their usual meanings.

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** Questions.

1. (a) Solve the following system of linear equations by Gauss-Jordan elimination method: **(20)**

$$x_1 - x_2 + 2x_3 - x_4 = -1$$
$$2x_1 + x_2 - 2x_3 - 2x_4 = -2$$
$$-x_1 + 2x_2 - 4x_3 + x_4 = 1$$
$$3x_1 \qquad\qquad - 3x_4 = -3$$

(b) Let $A = \begin{bmatrix} 4 & 1 & -1 \\ 2 & 5 & -2 \\ 1 & 1 & 2 \end{bmatrix}$. **$(26\frac{2}{3})$**

(i) Find all eigenvalues of the matrix A.

(ii) Find a maximum set S of linearly independent eigenvectors of A.

(iii) Is A diagonalizable? If yes, find P such that $D = P^{-1}AP$ is diagonal.

(iv) Find A^6.

2. (a) Determine whether the following polynomials are linearly independent or dependent: **(12)**

$$\boldsymbol{P}_1 = 2 - x + 4x^2, \boldsymbol{P}_2 = 3 + 6x + 2x^2, \boldsymbol{P}_3 = 2 + 10x - 4x^2.$$

(b) Let T be the linear operator on $\mathbf{R}^3$ defined by $T(x, y, z) = (x\text{-}y, x+z, x+y+2z)$. **$(14\frac{2}{3})$**

Determine whether T is invertible; if so, find $T^{-1}(x,y,z)$

(c) Given $A = \begin{bmatrix} 1 & 2 & 1 & 3 & 1 \\ 2 & 5 & 5 & 6 & 4 \\ 3 & 7 & 6 & 11 & 6 \\ 1 & 5 & 10 & 8 & 9 \end{bmatrix}$ **(20)**

Find the bases for the row space and column space of A. Hence verify the dimension theorem for A.

Contd P/2

MATH 247

3. (a) Consider the basis S = $\{\mathbf{v}_1, \mathbf{v}_2, \mathbf{v}_3\}$ for $\mathbf{R}^3$, where $\mathbf{v}_1 = (1, 2, 1)$, $\mathbf{v}_2 = (2, 9, 0)$ and $\mathbf{v}_3 = (3, 3, 4)$. Let T: $\mathbf{R}^3 \rightarrow \mathbf{R}^2$ be the linear transformation such that $T(\mathbf{v}_1) = (1, 0)$, $T(\mathbf{v}_2) = (-1, 1)$ and $T(\mathbf{v}_3) = (0, 1)$. Find a formula for $T(x, y, z)$ and use that formula to find $T(7, 13, 7)$. **(20)**

(b) Let $\mathbf{R}^3$ have the inner product **(26 2/3)**

$$\langle \mathbf{u}, \mathbf{v} \rangle = u_1v_1 + 2u_2v_2 + 3u_3v_3$$

Use the Gram-Schmidt process to transform the basis vectors $\mathbf{u}_1 = (0, 1, 2)$, $\mathbf{u}_2 = (-1, 0, 1)$, and $\mathbf{u}_3 = (-1, 1, 3)$ into an orthogonal basis $\{\mathbf{v}_1, \mathbf{v}_2, \mathbf{v}_3\}$; then normalize the orthogonal basis vectors to obtain the orthonormal basis $\{\boldsymbol{q}_1, \boldsymbol{q}_2, \boldsymbol{q}_3\}$.

4. (a) Let, $F(t) = \begin{cases} \sin t & ; \quad 0 < t < \pi \\ 0 & ; \quad \pi < t < 2\pi \end{cases}$, where $F(t)$ has period 2π. Then find $L\{F(t)\}$. **(15)**

(b) Find the Laplace transform of $\{t^2(\sin 3t + e^{5t})\}$. **(15)**

(c) Find $L\left\{\dfrac{\cos at - \cos bt}{t}\right\}$. **(16 2/3)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Find $L\left\{\int_0^t \dfrac{\sin u}{u}\,du\right\}$ and hence evaluate $\int_0^\infty e^{-t}\int_0^t \dfrac{\sin u}{u}\,du\,dt$. **(15)**

(b) Find $L^{-1}\left\{\dfrac{8}{(s^2+1)^3}\right\}$ using convolution theorem. **(15)**

(c) Use Laplace transform to solve the following integral equation: **(16 2/3)**

$$f(t) + \int_0^t (t - \tau) f(\tau) d\tau = t.$$

6. (a) Solve the following differential equation using Laplace transform: **(20)**

$$y'' + 2y' + 5y = e^{-t} \sin t,\ y(0) = 0,\ y'(0) = 1.$$

(b) Use finite Laplace transform to solve the following boundary value problem **(26 2/3)**

$$\frac{\partial T}{\partial t} = 2\frac{\partial^2 T}{\partial x^2}, \qquad 0 < x < 5, \qquad t > 0$$

given that $T(0, t) = 0$, $T(5, t) = 0$, $T(x, 0) = 10 \sin 4\pi x$.

Contd P/3

MATH 247

7. (a) Expand $f(x) = x$, $0 < x < 2$ in a half-range Fourier cosine series. **(15)**

Hence write Parseval's identy corresponding to the series.

(b) Derive the Fourier integral from the Fourier series. **(15)**

(c) Compute the Fourier sine integral of the following function **($16\frac{2}{3}$)**

$$f(x)=\begin{cases} e^{2x} & if \quad 0< \quad x<1 \\ 0 & if \qquad\quad x>1 \end{cases}$$

8. (a) Find the Fourier transform of $f(x) = \begin{cases} 1 & |x| < a \\ 0 & |x| > a \end{cases}$. graph $f(x)$ and its **($26\frac{2}{3}$)**

Fourier transform for $a = 3$. Hence evaluate $\int_{-\infty}^{\infty} \frac{\sin \alpha a \cos \alpha x}{\alpha} d\alpha$.

(b) Use the method of Fourier Transform to determine the displacement $y(x, t)$ of an infinite string, given that the string is initially at rest and that the initial displacement is $f(x)$, $-\infty < x < \infty$. Also show that the solution can be put in the form $y(x, t) = \frac{1}{2}[f(x+ct)+f(x-ct)]$ **(20)**

L-2/T-2/CSE **Date: 30/10/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2021-2022

Sub: **EEE 269** (Electrical Drives and Instrumentation)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer to Question **No. 1** is **COMPULSORY**. Answer any **TWO** Questions from Question 2-4. The corresponding Course Outcomes (COs) of each part of Question 1 are mentioned on the right most column below the marks. The COs of the Course are mentioned at the end of the question paper.

1. (a) Explain Time Division Multiplexing (TDM) and Frequency Division Multiplexing (FDM) technique in data acquisition system with necessary diagram. **(10)** (CO1)

(b) Selecting an appropriate transducer, design an op-Amp based trigger circuit for automatic switching of street light and discuss its operation. **(10)** **(CO4)**

(c) A barium titanate pickup has the dimensions of 5 mm *x* 5 mm *x* 1.25 mm. The force acting on it is 5 N. The charge sensitivity of barium titanate is 150 pC/N and its permittivity is 12.5×10^{-9} F/m. If the modulus of elasticity of barium titanate is 12×10^{6} N/m^2, applying the theory of piezoelectric transducer, calculate the strain and Capacitance. **(15)** **(CO2)**

2. (a) What is the purpose of multiplexing while interfacing multiple 7 segment display? Draw a complete circuit diagram to interface four-unit 7 segment display with microprocessor including multiplexing technique and describe its operation. **(15)**

(b) With necessary diagram and equation, describe the problems and corresponding solution technique in direct recording method of magnetic tape recording. How these problems are dealt with in FM recording method? **(20)**

3. (a) Comment on the property of ideal differential amplifier in the context of CMRR, input impedance, and output impedance parameters. If an op amp based differential amplifier has CMRR of 10^{-3} and differential gain (A_d) measured as 1000, what is the output voltage if the input voltages in two terminals are 3V and 4V? **(15)**

(b) Derive the expression of total gain, $G = \frac{V_{out}}{V_{in}}$ as a function of $\boldsymbol{R_{gain}}$ and $\boldsymbol{R}$ of the following Op-amp based differential amplifier shown in Fig. 3(b). What is the maximum achievable gain in this configuration? **(20)**

Contd P/2

EEE 269

Contd... Q. No. 3(b)

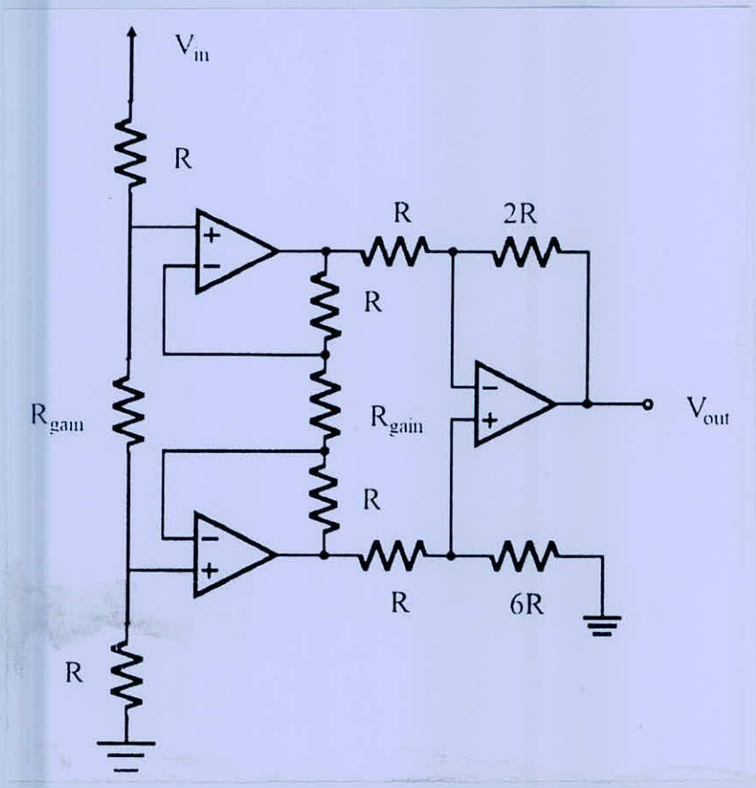

Fig. for Q. 3(b)

4. (a) Why 3 phase is most prevalent among all polyphase systems? The circuit in Fig. for Q. 4(a) is excited by a balanced three-phase source. If $V_p = 200V, Z_\Delta = 24-30j, Z_y = 12+5j$ *and* $Z_l = 1+1j$, determine the magnitude of the line current I_{Bb} of the combined loads and total real power supply from the 3 phase source. **(20)**

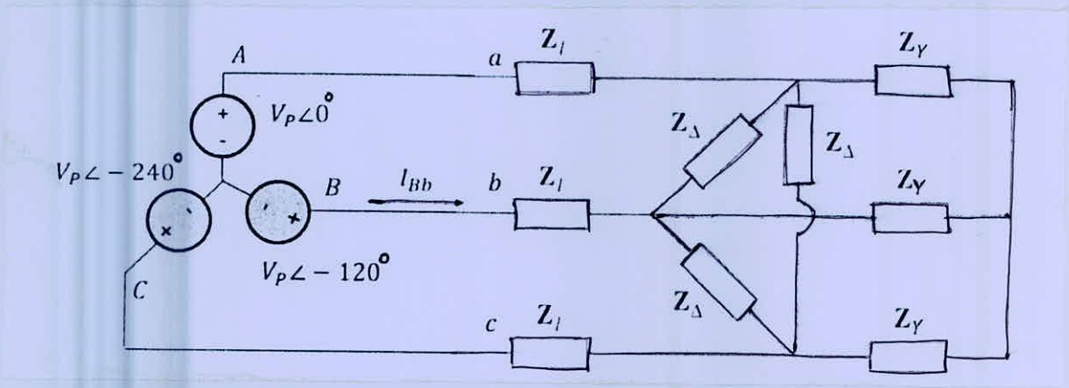

Fig. for Q. 4(a)

(b) What is bipolar and unipolar stepper motor driver? Draw the circuit diagram and explain working mechanism of interfacing stepper motor in full step mode with bipolar motor driver. **(15)**

EEE 269

SECTION – B

There are **FOUR** questions in this section. Answer to Question **No. 5** is **COMPULSORY**. Answer any **TWO** Questions from Question 6-8. The corresponding Course Outcomes (COs) of each part of Question 5 are mentioned on the right most column below the marks. The COs of the Course are mentioned at the end of the question paper.

5. (a) Draw the per phase equivalent circuit of a 3-phase induction motor. **(12)**

Explain that, the induced torque becomes maximum when **(CO1)**

$$s_{max} = \frac{R_2}{\sqrt{R_{TH}^{\ 2} + (X_{TH} + X_2)^2}}$$

Derive the expression of maximum torque

$$\tau_{ind} = \frac{3V_{TH}^{\ 2}}{2\omega_{sync}\left[R_{TH} + \sqrt{R_{TH}^{\ 2} + (X_{TH} + X_2)^2}\right]}$$

(b) The torque speed characteristic curve of a 208V, Y connected, 50 Hz, three-phase induction motor is shown in Figure 5(a). **(5+10=15)** **(CO3+CO2)**

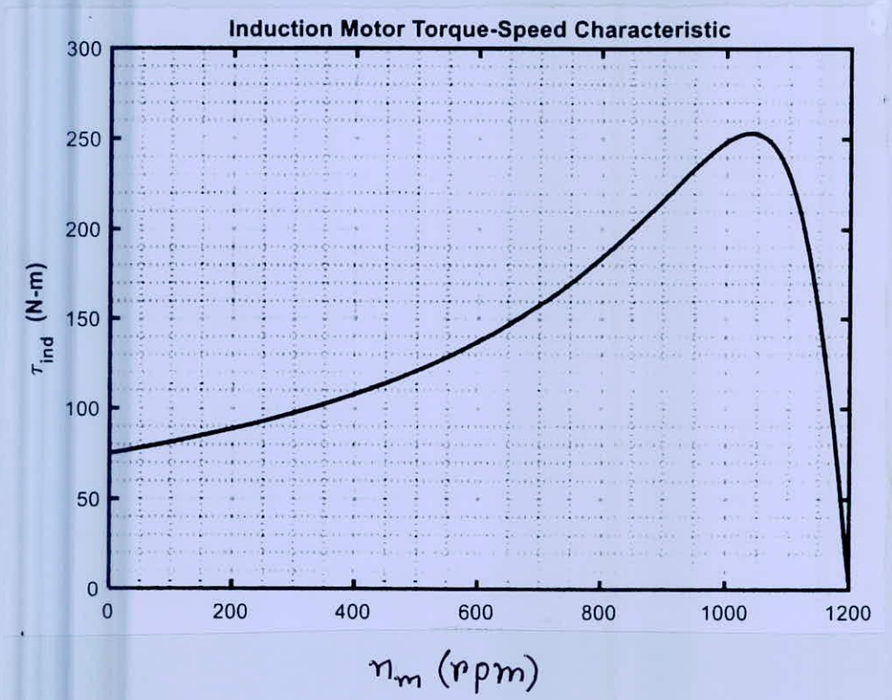

Figure 5(a)

Analyze the curve and explain its nature.

Ignoring all the mechanical power losses, find the following from the curve by applying the induction motor theory:

i) Synchronous speed

ii) Number of poles in the machine

iii) Maximum torque and starting torque

Contd P/4

EEE 269

Contd... Q. No. 5(b)

iv) Air gap power when the induced torque in the motor is 80% of maximum torque.

v) Rotor copper loss at n_m = 800 rpm

c) Apply the equations derived in Q5(a) to find the rotor resistance of the induction motor of Q5(b). Given that V_{Th} = 115.42 V and R_{Th} = 0.0970Ω **(8)** **(CO2)**

6. (a) The internal generated voltage of a 4 pole, 50Hz, Y connected three phase synchronous generator is 14.4kV and the terminal voltage is 12.8kV. The synchronous reactance of this machine is 4Ω and armature resistance can be ignored. This generator has friction and windage losses of 15kW and core losses of 20kW. **(4×5+5=25)**

i) If the torque angle of the generator is 18° how much power is being supplied by this generator at the current time?

ii) What is the power factor of the generator at this time?

iii) What is the voltage regulation?

iv) Find the efficiency of this generator

v) What torque must be applied to its shaft by its prime mover at this condition?

vi) What happens to terminal voltage if another load with same power factor is connected to this generator? Justify your answer by sketching the before and after phasor diagram.

(b) Explain, using phasor diagrams, what happens to a synchronous motor as its field current is varied. Derive a synchronous motor V curve from the phasor diagram. **(10)**

7. (a) The following test data are obtained from open-circuit and short-circuit tests of 20k VA, 8000-240V, 50 Hz step-down transformer: **(3×10=30)**

Open circuit Test (High Side)	**Short circuit Test (High Side)**
V_{oc} = 8000 V	V_{sc} = 480 V
I_{oc} = 0.22 A	I_{sc} = 2.5 A
P_{oc} = 410 W	P_{sc} = 240 W

Determine

i) All the transformer model parameters (R_{eq}, X_{eq}, R_{fe} and X_M) referred to the low side and draw the equivalent circuit.

ii) Voltage regulation if the transformer operates at rated load and 75% power factor lagging.

iii) Efficiency if it operates at one-half of rated load and 80% power factor leading.

Contd P/5

EEE 269

Contd... Q. No. 7

(b) What is eddy current loss? How eddy current loss is reduced in transformer? **(5)**

8. (a) Derive the torque-speed relationship of a series DC motor. **(15)**

(b) A 10-hp 120-V 1000 r/min shunt dc motor has a full-load armature current of 70 A when operating at rated conditions. The armature resistance of the motor is 0.12Ω, and the field resistance is 40Ω. The adjustable resistance R_{adj} in the field circuit may be varied over the range from 0 to 200Ω and is currently set to 100 Ω. Armature reaction may be ignored in this machine. The magnetization curve for this motor, taken at a speed of 1000 r/min, is given in tabular form below: **(20)**

E_A(V)	5	78	95	112	118	126
I_F(A)	0	0.80	1.00	1.28	1.44	2.88

i) What is the speed of this motor when it is running at rated conditions specified above?

ii) If the motor is now unloaded with no changes in terminal voltage or R_{adj}, what is the no load speed of the motor?

iii) What range of no-load speed is possible in this motor, given the range of field resistance adjustments available with R_{adj}

iv) What is the efficiency of this motor?

Course Outcomes of EEE 269

CO s	CO Statement
CO1	**Explain** the operation and working principles of electrical machineries, and measurement system, standards, elements of a generalized instrumentation system
CO2	**Apply** knowledge to solve problems relevant to the operation of electrical machineries, different analogue types of instruments and techniques and techniques of measurement of electrical quantities
CO3	**Analyze** the operation of electrical machineries, different analog types of instruments and techniques for measurement of electrical quantities
CO4	**Design** control circuits for electrical machines such that specified performance characteristics are attained, select the appropriate transducer/sensor for measurement the non-electrical quantities