Sana'a University
Faculty of Engineering
Electrical Engineering Department
B.Sc. of Computer and Control Engineering

35. Course Specification of Data Structures and Algorithms

I. Course Identification and General Information:

1.	Course Title:	Data Structures and Algorithms				
2.	Course Code & Number:	CCE246				
3.	Credit hours:	C.H				Total
		Th.	Tu.	Pr.	Tr.	
		2	-	2	-	3
4.	Study level/ semester at which this course is offered:	3rd Year – 2nd Semester				
5.	Pre-requisite (if any):	Programming Language 2 (C/C++), Programming Language 3 (Java)				
6.	Co-requisite (if any):	None.				
7.	Program(s) in which the course is offered:	Computer Engineering and Control				
8.	Language of teaching the course:	English				
9.	Location of teaching the course:	Electrical Engineering Department, Faculty of Engineering				
10.	Prepared By:	Asst. Prof. Dr. Sami AL-Maqtari				
11.	Date of Approval:					

II. Course Description:

This course aims to provide students with principles and concepts in data structures organization & programming as well as algorithms generalization & evaluations. Data Structures and Algorithms have different important applications in computer programming, software development, optimized resources reservation & allocation and variant hardware's

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processes scheduling. This course covers the following topics: Abstract Data Types (ADTs), Algorithm Complexity Analysis, Big-O Notations, Recursion, Stacks, Queues, Linked Lists, Binary and Multiway Trees, Graphs, Sorting Algorithms, and Hashing. Throughout computer lab work, students will develop their skills in implementing different data structures techniques, evaluating and analyzing software algorithms complexity.

	III. Course Intended learning outcomes (CILOs) of the course	**Referenced PILOs**
a1	Define a core group of basic data structures and algorithms.	A1
a2	Explain the tradeoffs between different studied data structures and algorithms.	A2, A3
b1	Improve the acquired knowledge in programming with standard data structures techniques and algorithms.	B1, B3
b2	Solve software development requirements related to data structures algorithms & techniques using object-oriented programming paradigm.	B2, B4
c1	Apply knowledge of various data structure and algorithms for solving and analyzing different issues and applications in computer science.	C1, C3
c2	Carry-out performance analysis in data structures and their algorithms for asymptotic behavior.	C2, C4
d1	Gain basics in data structures and algorithms for applying them in solving of different engineering problems.	D1, D4
d2	Conduct searches on new data structures and algorithm solutions to engineering problems and be able to communicate them with others.	D3, D4

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(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a1. Define a core group of basic data structures and algorithms.	▪ Active Lectures. ▪ Homework	▪ Written Exams. ▪ Quizzes. ▪ Assignments
a2. Explain the tradeoffs between different studied data structures and algorithms.	▪ Active Lectures. ▪ Homework ▪ Laboratory Work	▪ Written Exams. ▪ Quizzes. ▪ Lab Reports

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1- Improve the acquired knowledge in programming with standard data structures techniques and algorithms.	▪ Active Lectures. ▪ Laboratory Work. ▪ Homework	▪ Written Exam. ▪ Quizzes. ▪ Lab Report
b2- Solve software development requirements related to data structures algorithms & techniques using object- oriented programming paradigm.	▪ Active Lectures. ▪ Laboratory Work ▪ Project ▪ Search	▪ Quizzes. ▪ Lab Reports ▪ Presentation

(C) Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
c1- Apply knowledge of various data structure and algorithms for solving and analyzing different issues and applications in computer science.	▪ Active Lectures. ▪ Homework ▪ Laboratory Work ▪ Project	▪ Written Exam. ▪ Quizzes. ▪ Lab Reports ▪ Lab Exam

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(C) Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
c2- Carry-out performance analysis in data structures and their algorithms for asymptotic behavior.	▪ Active Lectures. ▪ Laboratory Work ▪ Project	▪ Written Exam. ▪ Quizzes. ▪ Lab Reports ▪ Lab Exam ▪ Presentation

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1. Gain basics in data structures and algorithms for applying them in solving of different engineering problems.	▪ Active Lectures ▪ Homework ▪ Project ▪ Laboratory Work	▪ Lab & Project Reports ▪ Presentations
d2. Conduct searches on new data structures and algorithm solutions to engineering problems and be able to communicate them with others.	▪ Search ▪ Project	▪ Project Reports ▪ Presentations

IV. Course Content:

A. Theoretical Aspect

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact hours
1.	Introduction to Data Structures	a1, a2, b1, c2	▪ Course Orientations, aims & Objective	2	4

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	and Algorithms Complexity		▪ Review on Abstract Data Types (ADTs). ▪ Algorithm Complexity Analysis. ▪ Big-O Notation. ▪ Best, Worst, and Average Case. ▪ Performance Measurement. ▪ Examples.		
2.	Recursion	a1, a2, b1	▪ Recursive Definitions. ▪ Function Calls and Recursion Implementation. ▪ Anatomy of a Recursive Call. ▪ Tail Recursion. ▪ Nontail Recursion. ▪ Indirect Recursion. ▪ Nested Recursion. ▪ Excessive Recursion. ▪ Backtracking.	1	2
3.	Stacks and Queues	a1, a2, b1, b2, c1, c2	▪ Stacks. ▪ Queues. ▪ Priority Queues. ▪ Applications of Stack, Infix, Prefix and Postfix expressions	2	4
4.	Linked Lists	a1, a2, b1, b2, c1, c2	▪ Singly Linked Lists. ▪ Doubly Linked Lists. ▪ Circular Lists. ▪ Skip Lists. ▪ Self-Organizing Lists. ▪ Sparse Tables.	2	4

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5.	Binary Trees	a1, a2, b1, c1, c2	▪ Trees, Binary Trees, and Binary Search Trees. ▪ Implementing Binary Trees. ▪ Searching a Binary Search Tree. ▪ Tree Traversal. ▪ Insertion. ▪ Deletion. ▪ Balancing a Tree. ▪ Self-Adjusting Trees. ▪ Heaps. ▪ Treaps. ▪ k-d Trees. ▪ Polish Notation and Expression Trees.	2	4
6.	Multiway Trees	a1, a2, b1, b2, c1, c2	▪ The Family of B-Trees. ▪ Tries.	1	2
7.	Graphs	a1, a2, b1, b2, c1, c2	▪ Graph Representation. ▪ Graph Traversals. ▪ Shortest Paths. ▪ Cycle Detection. ▪ Spanning Trees. ▪ Connectivity. ▪ Topological Sort. ▪ Networks. ▪ Matching. ▪ Eulerian and Hamiltonian Graphs. ▪ Graph Coloring. ▪ NP-Complete Problems in Graph Theory.	2	4

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8.	Sorting	a1, a2, b1, b2, c1, c2	▪ Elementary Sorting Algorithms: Insertion Sort, Selection Sort, Bubble Sort, Comb Sort. ▪ Decision Trees. ▪ Efficient Sorting Algorithms: Shell Sort, Heap Sort, Quicksort, Mergesort, Radix Sort, Counting Sort.	1	2
9.	Hashing	a1, a2, b1, b2, c1, c2	▪ Hash Functions ▪ Collision Resolution. ▪ Deletion. ▪ Perfect Hash Functions. ▪ Rehashing. ▪ Hash Functions for Extendible Files	1	2
Number of Weeks /and Units Per Semester				**14**	**28**

B. Practical Aspect:

Order	Tasks/ Experiments	Number of Weeks	Contact hours	Learning Outcomes
1.	▪ ADT & Recursion ▪ Stacks in the Standard Template Library. ▪ Applications of Stack, Infix, Prefix and Postfix expressions ▪ Queues in the Standard Template Library. ▪ Priority Queues in the Standard Template Library. ▪ Deques in the Standard Template Library.	4	8	a1, a2, b1, b2, c1, c2, d1

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B. Practical Aspect:				
Order	**Tasks/ Experiments**	**Number of Weeks**	**Contact hours**	**Learning Outcomes**
2.	▪ Linked Lists in the Standard Template Library.	3	6	a2, b1, b2, c1, c2, d1
3.	▪ Binary and Multiway Trees implementation using OOP.	3	6	b1, b2, c1, c2, d1
4.	▪ Sorting in the Standard Template Library.	2	4	a2, b1, b2, c1, c2, d1
5.	▪ Course Project Presentation & Evaluations	1	2	a1, a2, b1, b2, c1, c2, d1, d2
6.	▪ Final Lab Exam	1	2	a1, a2, b1, b2, c1, c2, d1
Number of Weeks /and Units Per Semester		**14**	**28**	

V. Teaching strategies of the course:

- Active Lectures.
- Laboratory Work
- Homework
- Project
- Search

VI. Assignments & Reports:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1.	▪ Report on Algorithm Complexity Analysis Techniques	a2, b2, d2	3rd	1

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VI. Assignments & Reports:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
2.	▪ Assignments on Recursion, Stack & Queues Applications ▪ Short Reports on Stack & Queue Applications	a1, a2, b1, b2, c1, c2, d1, d2	5th	2
3.	▪ Assignment on Linked List ▪ Report on Linked List Applications	a2, b1, b2, c1, c2, d1, d2	7th	2
4.	▪ Reports on Trees, Graph and Sorting Techniques Programming & Applications	a1, a2, b1, b2, c1, c2, d1, d2	9th to 13th	2
5.	▪ Lab Reports	a2, b1, b2, c1, c2, d1	3rd to 12ve	8
Total				**15**

VII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1.	Assignments & Reports	3rd to 13th	15	10%	a1, a2, b1, b2, c1, c2, d1, d2
2.	Quizzes	5th, 10th & 14th	7.5	5%	a1, a2, b1, b2, c1, c2
3.	Midterm Exam (theoretical)	8th	22.5	15%	a1, a2, b1, b2, c1, c2
4.	Final Lab Exam (including Course Project Evaluation)	13th & 14th	30	20%	a1, a2, b1, b2, c1, c2, d1, d2

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5.	Final Exam (theoretical)	15th week	75	50%	a1, a2, b1, b2, c1, c2
Total			**150**	**100**	

VIII. Learning Resources:

Written in the following order: (Author - Year of publication – Title – Edition – Place of publication – Publisher).

1- Required Textbook(s) (maximum two).

1. Adam Drozdek, 2012, "Data Structures and Algorithms in C++", 4th Edition, Cengage Learning. ISBN-13: 978-1133608424
2. Greg W. Scragg and Orit Hazzan, 2004, "Algorithms and Data Structures: The Science of Computing", Cengage Learning. ISBN-13: 978-1584502500

2- Essential References.

1. Harsh Bhasin, 2018, "Algorithms: Design and Analysis", Oxford Univ Press. ISBN-13: 978-0199456666
2. Allen Downey, 2018, "Think Data Structures: Algorithms and Information Retrieval in Java", O'Reilly Media. ISBN-13: 978-1491972397

3- Electronic Materials and Web Sites *etc*.

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IX. Course Policies:

1.	**Class Attendance:** A student should attend not less than 75 % of total hours of the subject; otherwise he will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic
2.	**Tardy:** For late in attending the class, the student will be initially notified. If he repeated lateness in attending class he will be considered as absent.
3.	**Exam Attendance/Punctuality:**

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	A student should attend the exam on time. He is Permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam-
4.	**Assignments & Projects:** The assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time-
5.	**Cheating:** For cheating in exam, a student will be considered as failure. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty-
6.	**Plagiarism:** Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proved a plagiarism of a student, he will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university.
7.	**Other policies:** - Mobile phones are not allowed to use during a class lecture. It must be closed, otherwise the student will be asked to leave the lecture room - Mobile phones are not allowed in class during the examination. Lecture notes and assignments my given directly to students using soft or hard copy

Reviewed By	**Vice Dean for Academic Affairs and Post Graduate Studies: Asst. Prof. Dr. Tarek A. Barakat** **President of Quality Assurance Unit: Assoc. Prof. Dr. Mohammed Algorafi** **Name of Reviewer from the Department: Asst. Prof. Dr. Adel Ahmed Al-Shakiri**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed** **Asst. Prof. Dr. Munasar Alsubri**

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35. Course Plan of Data Structures and Algorithms

I. Information about Faculty Member Responsible for the Course:

Name of Faculty Member	Dr. Sami AL-MAQTARI	Office Hours					
Location& Telephone No.	771010885	SAT	SUN	MON	TUE	WED	THU
E-mail	dr.samiaziz@gmail.com			10-12			

II. Course Identification and General Information:

1.	Course Title:	Data Structures and Algorithms				
2.	Course Code & Number:	CCE246				
3.	Credit hours:	C.H				Total
		Th.	Tu.	Pr.	Tr.	
		2	-	2	-	3
4.	Study level/ semester at which this course is offered:	3rd Year – 2nd Semester				
5.	Pre-requisite (if any):	Programming Language 2 (C/C++), Programming Language 3 (Java)				
6.	Co-requisite (if any):	None.				
7.	Program(s) in which the course is offered:	Computer Engineering and Control				
8.	Language of teaching the course:	English				
9.	System of Study:	Regular				
10.	Mode of delivery:	Face-to-face with Lab. Work				
11.	Location of teaching the course:	Electrical Engineering Department, Faculty of Engineering				

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III. Course Description:

This course aims to provide students with principles and concepts in data structures organization & programming as well as algorithms generalization & evaluations. Data Structures and Algorithms have different important applications in computer programming, software development, optimized resources reservation & allocation and variant hardware's processes scheduling. This course covers the following topics: Abstract Data Types (ADTs), Algorithm Complexity Analysis, Big-O Notations, Recursion, Stacks, Queues, Linked Lists, Binary and Multiway Trees, Graphs, Sorting Algorithms, and Hashing. Throughout computer lab work, students will develop their skills in implementing different data structures techniques, evaluating and analyzing software algorithms complexity.

IV. Intended learning outcomes (ILOs) of the course:

- Brief summary of the knowledge or skill the course is intended to develop**:**

1. Define a core group of basic data structures and algorithms.
2. Explain the tradeoffs between different studied data structures and algorithms.
3. Improve the acquired knowledge in programming with standard data structures techniques and algorithms.
4. Solve software development requirements related to data structures algorithms & techniques using object-oriented programming paradigm.
5. Apply knowledge of various data structure and algorithms for solving and analyzing different issues and applications in computer science.
6. Carry-out performance analysis in data structures and their algorithms for asymptotic behavior.
7. Gain basics in data structures and algorithms for applying them in solving of different engineering problems.
8. Conduct searches on new data structures and algorithm solutions to engineering problems and be able to communicate them with others.

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V. Course Content:

A. Theoretical Aspect

Order	Units/Topics List	Sub Topics List	Number of Weeks	Contact hours
1.	Introduction to Data Structures and Algorithms Complexity	▪ Course Orientations, aims & Objective ▪ Review on Abstract Data Types (ADTs). ▪ Algorithm Complexity Analysis. ▪ Big-O Notation. ▪ Best, Worst, and Average Case. ▪ Performance Measurement. ▪ Examples.	1st ,2nd	4
2.	Recursion	▪ Recursive Definitions. ▪ Function Calls and Recursion Implementation. ▪ Anatomy of a Recursive Call. ▪ Tail Recursion. ▪ Nontail Recursion. ▪ Indirect Recursion. ▪ Nested Recursion. ▪ Excessive Recursion. ▪ Backtracking.	3rd	2
3.	Stacks and Queues	▪ Stacks. ▪ Queues. ▪ Priority Queues. ▪ Applications of Stack, Infix, Prefix and Postfix expressions	4th ,5th	4

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4.	Linked Lists	▪ Singly Linked Lists. ▪ Doubly Linked Lists. ▪ Circular Lists. ▪ Skip Lists. ▪ Self-Organizing Lists. ▪ Sparse Tables.	6^{th} ,7^{th}	4
5.	Midterm Exam	▪ ALL Previous Topics	8^{th}	2
5.	Binary Trees	▪ Trees, Binary Trees, and Binary Search Trees. ▪ Implementing Binary Trees. ▪ Searching a Binary Search Tree. ▪ Tree Traversal. ▪ Insertion. ▪ Deletion. ▪ Balancing a Tree. ▪ Self-Adjusting Trees. ▪ Heaps. ▪ Treaps. ▪ k-d Trees. ▪ Polish Notation and Expression Trees.	9^{th} ,10^{th}	4
7.	Multiway Trees	▪ The Family of B-Trees. ▪ Tries.	11^{th}	2

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8.	Graphs	▪ Graph Representation. ▪ Graph Traversals. ▪ Shortest Paths. ▪ Cycle Detection. ▪ Spanning Trees. ▪ Connectivity. ▪ Topological Sort. ▪ Networks. ▪ Matching. ▪ Eulerian and Hamiltonian Graphs. ▪ Graph Coloring. ▪ NP-Complete Problems in Graph Theory.	12^{th} ,13^{th}	4
9.	Sorting	▪ Elementary Sorting Algorithms: Insertion Sort, Selection Sort, Bubble Sort, Comb Sort. ▪ Decision Trees. ▪ Efficient Sorting Algorithms: Shell Sort, Heap Sort, Quicksort, Mergesort, Radix Sort, Counting Sort.	14^{th}	2
10.	Hashing	▪ Hash Functions ▪ Collision Resolution. ▪ Deletion. ▪ Perfect Hash Functions. ▪ Rehashing. ▪ Hash Functions for Extendible Files	15^{th}	2
11.	Final Exam	▪ ALL Topics	16^{th}	2
Number of Weeks /and Units Per Semester			**16**	**32**

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B. Practical Aspect:			
Order	**Tasks/ Experiments**	**Number of Weeks**	**Contact hours**
1.	▪ ADT & Recursion ▪ Stacks in the Standard Template Library. ▪ Applications of Stack, Infix, Prefix and Postfix expressions ▪ Queues in the Standard Template Library. ▪ Priority Queues in the Standard Template Library. ▪ Deques in the Standard Template Library.	1st ,2nd ,3rd ,4th	8
2.	▪ Linked Lists in the Standard Template Library.	5th ,6th ,7th	6
3.	▪ Binary and Multiway Trees implementation using OOP.	8th ,9th ,10th	6
4.	▪ Sorting in the Standard Template Library.	11th ,12th	4
5.	▪ Course Project Presentation & Evaluations	13th	2
6.	▪ Final Lab Exam	14th	2
Number of Weeks /and Units Per Semester		**14**	**28**

VI. Teaching strategies of the course:

- Active Lectures.
- Laboratory Work
- Homework
- Project
- Search

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VII. Assignments & Reports:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1.	▪ Report on Algorithm Complexity Analysis Techniques	a2, b2, d2	3rd	1
2.	▪ Assignments on Recursion, Stack & Queues Applications ▪ Short Reports on Stack & Queue Applications	a1, a2, b1, b2, c1, c2, d1, d2	5th	2
3.	▪ Assignment on Linked List ▪ Report on Linked List Applications	a2, b1, b2, c1, c2, d1, d2	7th	2
4.	▪ Reports on Trees, Graph and Sorting Techniques Programming & Applications	a1, a2, b1, b2, c1, c2, d1, d2	9th to 13th	2
5.	▪ Lab Reports	a2, b1, b2, c1, c2, d1	3rd to 12ve	8
Total				**15**

VIII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment
1.	Assignments & Reports	3rd to 13th	15	10%
2.	Quizzes	5th, 10th & 14th	7.5	5%
3.	Midterm Exam (theoretical)	8th	22.5	15%
4.	Final Lab Exam (including Course Project Evaluation)	13th & 14th	30	20%
5.	Final Exam (theoretical)	15th week	75	50%
Total			**150**	**100**

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Written in the following order: (Author - Year of publication – Title – Edition – Place of publication – Publisher).

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2. Greg W. Scragg and Orit Hazzan, 2004, "Algorithms and Data Structures: The Science of Computing", Cengage Learning. ISBN-13: 978-1584502500

2- Essential References.

1. Harsh Bhasin, 2018, "Algorithms: Design and Analysis", Oxford Univ Press. ISBN-13: 978-0199456666
2. Allen Downey, 2018, "Think Data Structures: Algorithms and Information Retrieval in Java", O'Reilly Media. ISBN-13: 978-1491972397

3- Electronic Materials and Web Sites *etc*.

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X. Course Policies:

1.	**Class Attendance:** A student should attend not less than 75 % of total hours of the subject; otherwise he will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic
2.	**Tardy:** For late in attending the class, the student will be initially notified. If he repeated lateness in attending class he will be considered as absent.
3.	**Exam Attendance/Punctuality:** A student should attend the exam on time. He is Permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam-

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4.	**Assignments & Projects:** The assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time-
5.	**Cheating:** For cheating in exam, a student will be considered as fail. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty-
6.	**Plagiarism:** Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proved a plagiarism of a student, he will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university.
7.	**Other policies:** - Mobile phones are not allowed to use during a class lecture. It must be closed, otherwise the student will be asked to leave the lecture room - Mobile phones are not allowed in class during the examination. Lecture notes and assignments my given directly to students using soft or hard copy

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