University of Sana'a
Faculty of Engineering
Department of Electrical Engineering
Title of the Program: Computer and Control Section

Course Specification of Compiler Theory & Design

I. Course Identification and General Information:

1.	Course Title:	Compiler Theory & Design				
2.	Course Code & Number:	CCE347				
3.	Credit hours:	C.H				TOTAL
		Th.	Tu.	Pr.	Tr.	
		2	-	2	-	3
4.	Study level/ semester at which this course is offered:	4^{th} Year – 1^{st} semester				
5.	Pre-requisite (if any):	Programming Language 2 (C/C++) (CCE143) & Introduction to Computation Theory (CCE142)				
6.	Co-requisite (if any):	None.				
7.	Program(s) in which the course is offered:	Electrical Engineering – Computer and Control section				
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 the principles and practices for the design and the implementation of compilers and interpreters. Topics covered by this course include: introduction to compilers & interpreter -based languages and their differences, Compiler software phases, lexical analysis, parsing theory, symbol tables, type systems, scope, semantic analysis, intermediate representations, runtime environments, and code generation. Throughout computer-based & term-project works, students will able to develop the software development skills by applying their gained knowledge in programming & computation skills to the design and the implementation of simple compiler software.

Prepared by	Head of Department	Quality Assurance Unit	Dean of the Faculty	Academic Development Center & Quality Assurance
Asst. Prof. Dr. Sami AL-Maqtari	Asst. Prof. Dr. Adel Ahmed Al-Shakiri	Assoc. Prof. Dr. Mohammad Algorafi	Prof. Dr. Mohammed AL-Bukhaiti	Assoc. Prof. Dr. Huda Al-Emad

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III. Course Intended learning outcomes (CILOs) of the course		Referenced PILOs
a1	Acquire knowledge of the principles and practices for designing and implementation of compilers and interpreters.	A1, A2
a2	Define the underlying structure of programming languages and their computers execution.	A2, A3
b1	Explore the logic of computer languages and their building.	B2
b2	Formalize solutions for complex engineering problem.	B1
c1	Implement simple programming languages in order to generalize problem solving techniques beyond the initial usage.	C1, C2
c2	Develop a larger project which needs more than simple graphic interfacing for API interaction.	C2, C4
d1	Apply problem-solving techniques & Skills in solving different engineering problems related to compiler theory & Design.	D2, D3
d2	Search Web and other information resources for modern solutions applied in software development.	D5

(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- Acquire knowledge of the principles and practices for designing and implementation of compilers and interpreters.	• Active Lectures. • Laboratory Works. • Home Works & Assignments. • Use of IT Tools.	• Written Exams. • Quizzes. • Lab & Projects Reports.
a2- Define the underlying structure of programming languages and their computers execution.	• Active Lectures. • Home Works & Assignments. • Laboratory Works.	• Written Exams. • Quizzes. • Lab & Projects Reports.

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(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1- Explore the logic of computer languages and their building.	• Active Lectures. • Laboratory Works. • Home Works & Assignments. • Projects	• Written Exam. • Quizzes. • Lab & Projects Reports. • Short Reports
b2- Formalize solutions for complex engineering problem.	• Active Lectures. • Laboratory Works. • Home Works & Assignments. • Projects • Use of IT Tools.	• Written Exams. • Quizzes. • Lab & Projects Reports. • Short Reports

(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- Implement simple programming languages in order to generalize problem solving techniques beyond the initial usage.	• Active Lectures, • Laboratory Works. • Home Works & Assignments. • Projects • Use of IT Tools.	• Lab Assessments. • Quizzes. • Lab & Projects Reports.
c2- Develop a larger project which needs more than simple graphic interfacing for API interaction.	• Projects • Use of IT Tools.	• Lab & Projects Reports. • Short Reports.

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(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:			
	Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1-	Apply problem-solving techniques & Skills in solving different engineering problems related to compiler theory & Design.	• Project • Home Works & Assignments.	• Lab & Project reports. • Short Reports
d2-	Search Web and other information resources for modern solutions applied in software development.	• Project • Home Works & Assignments.	• Lab & Project reports. • Short Reports

IV. Course Content:

A. Theoretical Aspect

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact hours
1.	**Chapter 1:** Introduction to Compilers Theory & Interpreters	a1, a2, b1	• Introduction to Compiler Theory, • Compilers & Interpreters, theory and differences • Language processors. • The structure of a compiler. • The evolution of programming languages. • The science of building a compiler. • Applications of compiler technology. • Programming language basics.	1	2

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2.	**Chapter 2:** A Simple Syntax-Directed Translator	a1, a2, b1, b2	• Introduction. • Syntax definition. • Syntax-directed translation. • Parsing. • A translator for simple expressions. • Lexical analysis. • Symbol tables. • Intermediate code generation.	2	4
3.	**Chapter 3:** Lexical Analysis	a1, a2, b1, b2	• the role of the lexical analyzer. • input buffering. • specification of tokens. • recognition of tokens. • the lexical-analyzer generator Lex. • finite automata. • from regular expressions to automata. • design of a lexical-analyzer generator. • optimization of DFA-based pattern matchers.	2	4
4.	**Chapter 4:** Syntax Analysis	a1, a2, b1, b2	• Introduction. • Context-free grammars. • Writing a grammar. • Top-down parsing. • Bottom-up parsing. • Introduction to LR parsing: simple LR. • More powerful LR parsers. • Using ambiguous grammars. • Parser generators.	2	4

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5.	**Chapter 5:** Syntax-Directed Translation	a1, a2, b1, b2	• Syntax-directed definitions. • Evaluation orders for SDD's. • Applications of syntax-directed translation. • Syntax-directed translation schemes. • Implementing l-attributed SDD's.	1	2
6.	**Chapter 6:** Intermediate-Code Generation	a1, a2, b1, b2	• Variants of syntax trees. • Three-address code. • Types and declarations. • Translation of expressions. • Type checking. • Control flow. • Backpatching. • Switch-statements. • Intermediate code for procedures.	2	4
7.	**Chapter 7:** Run-Time Environments	a1, a2, b1, b2	• Storage organization. • Stack allocation of space. • Access to nonlocal data on the stack. • Heap management. • Introduction to garbage collection. • Introduction to trace-based collection. • Short-pause garbage collection. • Advanced topics in garbage collection.	1	2

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8.	**Chapter 8:** Code Generation	a1, a2, b1, b2	• Issues in the Design of a Code Generator. • The Target Language. • Addresses in the Target Code. • Basic Blocks and Flow Graphs. • Optimization of Basic Blocks. • A Simple Code Generator. • Peephole Optimization. • Register Allocation and Assignment. • Instruction Selection by Tree Rewriting. • Optimal Code Generation for Expressions. • Dynamic Programming Code-Generation.	2	4
9.	Interpreters	a1, a2, b1, b2	• Interpreter work theory, • Interpreter structure and operation.	1	2
Number of Weeks /and Units Per Semester				**14**	**28**

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B. Practical Aspect:				
Order	**Tasks/ Experiments**	**Number of Weeks**	**Contact hours**	**Learning Outcomes**
1.	• Demonstration & Installing of a Computer-based tool for simulation & construction Compilers or any Modern Programming Language	1	2	a1
2.	• Building, Implementation using programming language and/or simulating Finite Automata (DFA & NDA), Context-free Grammars (CFGs) and Pushdown Automata (PDA) to simple language and Regular Expressions. • Distribute Students into groups of 2 or 3 members and assign the required project to be performed for design, simulation and implementation of large Projects based on lecturer suggestions.	3	6	a1, a2, b2, c1, d1, d2
3.	• Use Programming Language or Simulation Tools to Work with Compiler's phases: ▪ Lexical Analysis, ▪ Syntax Analysis, ▪ Intermediate Code Generations, ▪ Run-Time environment management, ▪ Target Code Optimization & Generation.	5	10	a1, a2, b1, b2, c1, d1
4.	• Use Programming Language or Simulation Tools to implement Simple programming language's Compiler.	3	6	a1, a2, b1, b2, c1, c2, d1, d2
5.	• Review	1	2	a1, a2, b1, b2, c1, c2, d1, d2
6.	• Project Presentation	1	2	a1, a2, b1, b2, c1, c2, d1, d2
Number of Weeks /and Units Per Semester		**14**	**28**	

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V. Teaching strategies of the course:

- Active Lectures,
- Laboratory Works (Computer-based),
- Home Works & Assignments,
- Projects & Presentations,
- Use of IT Tools.

VI. Assignments & Reports:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1.	Lexical and Syntax Analysis	a1, a2, b1, b2, d1	3rd to 6th	2
2.	Intermediate Code and Final code Optimization & Generations	a1, a2, b1, b2, d1	9th to 12th	2
3.	Short Reports based on Lecturer Suggestions on language & Compile Construction and implementations	a2, b1, b2, c2, d1, d2	5th, 10th & 14th	4
4.	Lab Reports	a1, a2, b1, b2, c1, d1	3rd to 12th	7
	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 14th	15	10%	a1, a2, b1, b2, c2, d1, d2
2.	Quizzes	5th, 10th & 14th	10	6.67%	a1, a2, b1, b2
3.	Midterm Exam (Theory)	8th	20	13.33%	a1, a2, b1, b2
4.	Final Lab. Exam (including Course Project Evaluation)	14th & 15th	30	20%	a1, a2, b1, b2, c1, c2, d1, d2
5.	Final Exam (Theory)	16th	75	50%	a1, a2, b1, b2
	Total		**150**	**100%**	

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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- Alfred V. Aho & Ravi Sethi & Jeffrey D. Ullman, 2006, "Compilers: Principles, Techniques, & Tools", 2nd Edition, Addison Wesley. ISBN-13: 978-0321486813
2- Douglas Thain, 2019, "Introduction to Compilers and Language Design", lulu.com. ISBN-13: 978-0359138043

2- Essential References.

1- Torben Mogensen, 2009, "Basics of Compiler Design", lulu.com. ISBN-13: 978-1260440232
2- Andrew W. Appel & Jens Palsberg, 2002, "Modern Compiler Implementation in Java", 2nd Edition, Cambridge University Press. ISBN-13: 978-0521820608

3- Electronic Materials and Web Sites *etc*.

1-

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 a proof 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.
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.

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6.	**Plagiarism**: Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proofed 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: Assoc. Prof. Dr. Farouk Al-Fuhaidy**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed** **Asst. Prof. Dr. Munasar Alsubri**

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University of Sana'a
Faculty of Engineering
Department of Electrical Engineering
Title of the Program: Computer and Control Section

Course Plan of Compiler Theory & Design

I. Information about Faculty Member Responsible for the Course:							
Name of Faculty Member	Asst. Prof. 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:	Compiler Theory & Design				
2.	Course Code & Number:	CCE347				
3.	Credit hours:	C.H				TOTAL
		Th.	Tu.	Pr.	Tr.	
		2	-	2	-	3
4.	Study level/ semester at which this course is offered:	4^{th} Year – 1^{st} semester				
5.	Pre-requisite (if any):	Programming Language 2 (C/C++) (CCE143) & Introduction to Computation Theory (CCE142)				
6.	Co-requisite (if any):	None.				
7.	Program(s) in which the course is offered:	Electrical Engineering – Computer and Control section				
8.	Language of teaching the course:	English				
9.	System of Study:	Semester				
10.	Mode of delivery:	Collective and individual learning				
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 the principles and practices for the design and the implementation of compilers and interpreters. Topics covered by this course include: introduction to compilers & interpreter -based languages and their differences, Compiler software phases, lexical analysis, parsing theory, symbol tables, type systems, scope, semantic analysis, intermediate representations, runtime environments, and code generation. Throughout computer-based & term-project works, students will able to develop the software development skills by applying their gained knowledge in programming & computation skills to the design and the implementation of simple compiler software.

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

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

1- Acquire knowledge of the principles and practices for designing and implementation of compilers and interpreters.
2- Define the underlying structure of programming languages and their computers execution.
3- Explore the logic of computer languages and their building.
4- Formalize solutions for complex engineering problem.
5- Implement simple programming languages in order to generalize problem solving techniques beyond the initial usage.
6- Develop a larger project which needs more than simple graphic interfacing for API interaction.
7- Apply problem-solving techniques & Skills in solving different engineering problems related to compiler theory & Design.
8- Search Web and other information resources for modern solutions applied in software development.

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V. Course Content:

Distribution of Semester Weekly Plan of Course Topics/Items and Activities.

A. Theoretical Aspect:

Order	Topics List	Sub Topics List	Week Due	Contact Hours
1.	- **Chapter 1:** Introduction to Compilers Theory & Interpreters	• Introduction to Compiler Theory, • Compilers & Interpreters, theory and differences • Language processors. • The structure of a compiler. • The evolution of programming languages. • The science of building a compiler. • Applications of compiler technology. • Programming language basics.	1st	2
2.	- **Chapter 2:** A Simple Syntax-Directed Translator	• Introduction. • Syntax definition. • Syntax-directed translation. • Parsing. • A translator for simple expressions. • Lexical analysis. • Symbol tables. • Intermediate code generation.	2nd, 3rd	4
3.	- **Chapter 3:** Lexical Analysis	• the role of the lexical analyzer. • input buffering. • specification of tokens. • recognition of tokens. • the lexical-analyzer generator Lex. • finite automata. • from regular expressions to automata. • design of a lexical-analyzer generator. • optimization of DFA-based pattern matchers.	4th, 5th	4

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4.	- **Chapter 4:** Syntax Analysis	• Introduction. • Context-free grammars. • Writing a grammar. • Top-down parsing. • Bottom-up parsing. • Introduction to LR parsing: simple LR. • More powerful LR parsers. • Using ambiguous grammars. • Parser generators.	6^{th}, 7^{th}	4
5.	- Mid Term Exam	• ALL Previous Topics	8^{th}	2
6.	- **Chapter 5:** Syntax-Directed Translation	• Syntax-directed definitions. • Evaluation orders for SDD's. • Applications of syntax-directed translation. • Syntax-directed translation schemes. • Implementing l-attributed SDD's.	9^{th}	2
7.	- **Chapter 6:** Intermediate-Code Generation	• Variants of syntax trees. • Three-address code. • Types and declarations. • Translation of expressions. • Type checking. • Control flow. • Backpatching. • Switch-statements. • Intermediate code for procedures.	10^{th}, 11^{th}	4
8.	- **Chapter 7:** Run-Time Environments	• Storage organization. • Stack allocation of space. • Access to nonlocal data on the stack. • Heap management. • Introduction to garbage collection. • Introduction to trace-based collection. • Short-pause garbage collection. • Advanced topics in garbage collection.	12^{th}	2

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9.	- **Chapter 8:** Code Generation	• Issues in the Design of a Code Generator. • The Target Language. • Addresses in the Target Code. • Basic Blocks and Flow Graphs. • Optimization of Basic Blocks. • A Simple Code Generator. • Peephole Optimization. • Register Allocation and Assignment. • Instruction Selection by Tree Rewriting. • Optimal Code Generation for Expressions. • Dynamic Programming Code-Generation.	13th, 14th	4
10.	- Interpreters	• Interpreter work theory, • Interpreter structure and operation.	15th	2
11.	- Final Exam	• ALL Topics	16th	2
Number of Weeks/Units Per Semester			**16**	**32**

A. Practical Aspect:

Order	Tasks/ Experiments	Number of Weeks	Contact hours
1.	• Demonstration & Installing of a Computer-based tool for simulation & construction Compilers or any Modern Programming Language	1st	2
2.	• Building, Implementation using programming language and/or simulating Finite Automata (DFA & NDA), Context-free Grammars (CFGs) and Pushdown Automata (PDA) to simple language and Regular Expressions. • Distribute Students into groups of 2 or 3 members and assign the required project to be performed for design, simulation and implementation of large Projects based on lecturer suggestions.	2nd ,3rd ,4th	6

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3.	• Use Programming Language or Simulation Tools to Work with Compiler's phases: ▪ Lexical Analysis, ▪ Syntax Analysis, ▪ Intermediate Code Generations, ▪ Run-Time environment management, ▪ Target Code Optimization & Generation.	5^{th} ,6^{th} ,7^{th} ,8^{th} ,9^{th}	10
4.	• Use Programming Language or Simulation Tools to implement Simple programming language's Compiler.	10^{th} ,11^{th} ,12^{th}	6
5.	• Review	13^{th}	2
6.	• Project Presentation	14^{th}	2
7.	• Final exam	15^{th}	2
Number of Weeks /and Units Per Semester		**15**	**30**

VI. Teaching strategies of the course:

- Active Lectures,
- Laboratory Works (Computer-based),
- Home Works & Assignments,
- Projects & Presentations,
- Use of IT Tools.

VII. Assignments & Reports:

No	Assignments	Week Due	Mark
1.	Lexical and Syntax Analysis	3^{rd} to 6^{th}	2
2.	Intermediate Code and Final code Optimization & Generations	9^{th} to 12^{th}	2
3.	Short Reports based on Lecturer Suggestions on language & Compile Construction and implementations	5^{th}, 10^{th} & 14^{th}	4
4.	Lab Reports	3^{rd} to 12^{th}	7
	Total		**15**

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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 14th	15	10%
2.	Quizzes	5th, 10th & 14th	10	6.67%
3.	Midterm Exam (Theory)	8th	20	13.33%
4.	Final Lab. Exam (including Course Project Evaluation)	14th & 15th	30	20%
5.	Final Exam (Theory)	16th	75	50%
	Total		**150**	**100%**

IX. Learning Resources:

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

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

1- Alfred V. Aho & Ravi Sethi & Jeffrey D. Ullman, 2006, "Compilers: Principles, Techniques, & Tools", 2nd Edition, Addison Wesley. ISBN-13: 978-0321486813
2- Douglas Thain, 2019, "Introduction to Compilers and Language Design", lulu.com. ISBN-13: 978-0359138043

2- Essential References.

1- Torben Mogensen, 2009, "Basics of Compiler Design", lulu.com. ISBN-13: 978-1260440232
2- Andrew W. Appel & Jens Palsberg, 2002, "Modern Compiler Implementation in Java", 2nd Edition, Cambridge University Press. ISBN-13: 978-0521820608

3- Electronic Materials and Web Sites *etc*.

1-

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 a proof statement from university Clinic

2. **Tardy:**

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Rector of Sana'a University
Prof. Dr. Al-Qassim Mohammed Abbas

	- 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.
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 proofed 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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