Sana'a University
Faculty of Engineering
Mechanical Engineering Department
Mechanical Engineering Program

52. Course Specification of Turbomachines

I. Course Identification and General Information:

1.	Course Title:	Turbomachines.				
2.	Course Code & Number:	ME343.				
3.	Credit Hours:	C.H				TOTAL CR. HRS.
		Th.	Seminar/Tu	Pr	Tr.	
		2	2	-	-	3
4.	Study level/ semester at which this course is offered:	Fourth Year-Second Semester.				
5.	Pre –requisite (if any):	Fluid Mechanics – II (ME242) and Thermodynamics – II (ME252).				
6.	Co –requisite (if any):	None.				
7.	Program (s) in which the course is offered:	Mechanical Engineering Program.				
8.	Language of teaching the course:	English Language.				
9.	Location of teaching the course:	Mechanical Engineering Department.				
10.	Prepared By:	Assoc. Prof. Dr. Abdul-Malik Momin.				
11.	Date of Approval:					

II. Course Description:

The course aims at giving an overview of different types of turbomachinery used for energy transformation, such as pumps, compressors, as well as hydraulic, steam and gas turbines. This course provides the detailed application on the power generation. Some Renewable energy topics will also be included. The skills developed from this course will allow the students to have a vast knowledge in the power generation. This course introduces the topic of turbomachinery to undergraduate students. In particular, the course allows for a smooth transition from the study of thermodynamics, fluid dynamics, and heat transfer to the subject of turbomachinery. At the end of this course, the students should have acquired the necessary background and the principles for the analysis and design methods for turbomachines.

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III. Alignments of the Course Intended learning outcomes (CILOs)		Referenced PILOs
a1	Characterize the knowledge of basic sciences subjects related to turbomachines.	A1
a2	Describe the principles of different types of turbomachines.	A3
b1	Explore different ideas related to the applications of turbomachines reaching to innovative solutions.	B1
b2	Analyze different processes related to the applications of turbomachines.	B2
c1	Implement different techniques for the enhancement.	C1
c2	Perform different analytical work related to the use of turbomachines.	C2
d1	Assess to life -long learning regarding the new innovations for the applications.	D3
d2	Cooperate effectively within the team in presenting the technical reports.	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- Characterize the knowledge of basic sciences subjects related to turbomachines	• Active Lectures. • Tutorials.	• Written Exam. • Homework.
a2- Describe the principles of different types of turbomachines.		

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies

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b1- Explore different ideas related to the applications of turbomachines reaching to innovative solutions.	• Active Lectures. • Seminars. • Projects.	• Examination. • Homework. • Project Reports.
b2- Analyze different processes related to the applications of turbomachines.		

© 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 different techniques for the enhancement.	• Computer Laboratory Based Session. • Active Lectures. • Seminars. • Projects. • Problem Based Learning.	• Examination. • Homework. • Project Reports. • Presentations.
c2- Perform different analytical work related to the use of turbomachines.		

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1- Assess to life -long learning regarding the new innovations for the applications.	• Team Work. • Directed Self – Study.	• Individual and Group Projects Reports. • Presentations
d2- Cooperate effectively within the team in presenting the technical reports.		

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub -Topics List	Number of Weeks	Contact Hours
1.	Introduction and Types of Turbomachines.	a1, d1, d2.	• Definition. • Power Generating Turbomachines.	2	4

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			• Power Absorbing Turbomachines. • Power Generation and Transmission. • Types of Plants. • Main Components of each Plant. • Performance and Calculations.		
2.	Thermodynamics Cycles.	b2, c1, c2.	• Main Power Cycles. • PV and TS Diagrams.	1	2
3.	Steam Turbines.	a1, a2, b1, b2,c1, c2, d1, d2.	• Types of Steam Turbines. • Vector Diagrams. • Performance and Losses.	2	4
4.	Gas Turbine Power Plant and Power Cycles. Methods of Enhancement.	a1, a2, b1, b2,c1, c2, d1, d2.	• Main Cycles. • Performance and Losses. • Effect of Operating Variables. • Comparison with Steam Power Plant. • Combined Steam and Gas Power Plants.	2	4
5.	Mid-Term Exam.	a1, a2, b1, b2,c1, c2.	• The First 4 Chapters.	1	2
6.	Nozzles and Diffusers.	a1, a2, b1, b2,c1, c2, d1, d2.	• Types of Nozzles. • Performance and Losses. • Diffusers.	1	2
7.	Centrifugal Pumps.	a1, a2, b1, b2,c1, c2, d1, d2.	• Introduction. • Classification of a Centrifugal Pump. • Basic Elements of a Centrifugal Pump. • Head and Pump Efficiency.	2	4

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			• Cavitation of a Pump. • Pump Performance. • Main Categories of a Pump.		
8.	Axial Flow Compressors.	a1, a2, b1, b2,c1, c2, d1, d2.	• Types of Compressors. • Performance and Losses.	1	2
9	Hydraulic Turbines.	a1, a2, b1, b2,c1, c2, d1, d2.	• Principles of Hydraulics. • Hydraulic Pressure and Force. • Pipe Flow Systems. • Hydraulic Turbine and its Classifications.	1	2
10.	Wind Turbines.	a1, a2, b1, b2,c1, c2, d1, d2.	• Types of Turbines. • Wind Energy Applications. • Performance and Losses.	1	2
11.	Jet Engines.	a1, a2, b1, b2,c1, c2, d1, d2.	Types of Jet Engines.	1	2
12.	Final Exam.	a1, a2, b1, b2,c1, c2.	All the Chapters.	1	2
Number of Weeks /and Units Per Semester				**16**	**32**

B – Tutorial Aspect:

Order	Units/Topics List	Learning Outcomes	Sub -Topics List	Number of Weeks	Contact Hours
1.	Introduction and Types of Turbomachines.	a1, d1, d2.	• Definition. • Power Generating Turbomachines. • Power Absorbing Turbomachines.	2	4

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			• Power Generation and Transmission. • Types of Plants. • Main Components of each Plant. • Performance and Calculations.		
2.	Thermodynamics Cycles.	b2, c1, c2.	• Main Power Cycles. • PV and TS Diagrams.	1	2
3.	Steam Turbines.	a1, a2, b1, b2,c1, c2, d1, d2.	• Types of Steam Turbines. • Vector Diagrams. • Performance and Losses.	2	4
4.	Gas Turbine Power Plant and Power Cycles. Methods of Enhancement.	a1, a2, b1, b2,c1, c2, d1, d2.	• Main Cycles. • Performance and Losses. • Effect of Operating Variables. • Comparison with Steam Power Plant. • Combined Steam and Gas Power Plants.	2	4
5.	Nozzles and Diffusers.	a1, a2, b1, b2,c1, c2, d1, d2.	• Types of Nozzles. • Performance and Losses. • Diffusers.	1	2
6.	Centrifugal Pumps.	a1, a2, b1, b2,c1, c2, d1, d2.	• Introduction. • Classification of a Centrifugal Pump. • Basic Elements of a Centrifugal Pump. • Head and Pump Efficiency. • Cavitation of a Pump. • Pump Performance. • Main Categories of a Pump.	2	4

7.	Axial Flow Compressors.	a1, a2, b1, b2,c1, c2, d1, d2.	• Types of Compressors. • Performance and Losses.	1	2
8.	Hydraulic Turbines.	a1, a2, b1, b2,c1, c2, d1, d2.	• Principles of Hydraulics. • Hydraulic Pressure and Force. • Pipe Flow Systems. • Hydraulic Turbine and its Classifications.	1	2
9.	Wind Turbines.	a1, a2, b1, b2,c1, c2, d1, d2.	• Types of Turbines. • Wind Energy Applications. • Performance and Losses.	1	2
10.	Jet Engines.	a1, a2, b1, b2,c1, c2, d1, d2.	Types of Jet Engines.	1	2
Number of Weeks /and Units Per Semester				**14**	**28**

V. Teaching Strategies of the Course:

- Active Lectures.
- Tutorials.
- Seminars.
- Projects.
- Computer Laboratory Based Session.
- Problem Based Learning.
- Team Work.
- Directed Self –Study.

VI. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1.	Assignment 1	a1, a2, b1, b2,c1, c2, d1, d2.	1st	1
2.	Assignment 2	a1, a2, b1, b2,c1, c2, d1, d2.	2nd	1

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Academic Development Center & Quality Assurance
Assoc. Prof. Dr. Huda Al-Emad

Rector of Sana'a University
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3.	Assignment 3	a1, a2, b1, b2,c1, c2, d1, d2.	3rd	1
4.	Assignment 4	a1, a2, b1, b2,c1, c2, d1, d2.	4th	1
5.	Assignment 5	a1, a2, b1, b2,c1, c2, d1, d2.	5th	1
6.	Assignment 6	a1, a2, b1, b2,c1, c2, d1, d2.	6th	1
7.	Assignment 7	a1, a2, b1, b2,c1, c2, d1, d2.	7th	1
8.	Assignment 8	a1, a2, b1, b2,c1, c2, d1, d2.	8th	1
9.	Assignment 9	a1, a2, b1, b2,c1, c2, d1, d2.	9th	1
10.	Assignment 10	a1, a2, b1, b2,c1, c2, d1, d2.	10th	1
Total				**10**

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.	Assignment for Each Chapter.	Weekly	15	10 %	a1, a2, b1, b2, c1, c2, d1, d2.
2.	Mid-Term Exam.	8 th	25	16.7 %	a1, a2, b1, b2, c1, c2.
3.	Course File.	15 th	20	13.3 %	a1, a2, b1, b2, c1, c2, d1, d2.
4.	Final Exam.	16 th	90	60 %	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. Erik Dick, 2015, Fundamentals of Turbomachines, Springer.
2. Grant Ingram, 2009," Basic Concepts in Turbomachinery, Ventus Publishing A

2- Essential References.

1. M. P. Boyce, 2002, "Gas Turbine Engineering Hand Book", Second Edition, Gulf Professional Publishing, TX, U.S.A.
2. Royce N. Brown, 1997, "Compressors Selection and Sizing", Second Edition, Gulf Professional Publishing, U.S.A.

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	3. B. H. Khan, 2006, "Non-Conventional Energy Resources", Tata McGraw Hill Publishing Company Limited, India. 4. P.C. Sharma, 2000, "Power Plant Engineering", S.K. Kataria and Sons. India.
3- Electronic Materials and Web Sites *etc*.	
	1. www.turbomachinerymag.com. 2. www.turbomachine.com. 3. Turbomachinery.man-es.com.

I. Course Policies:

1	**Class Attendance:** - The student should be attending not less than 75% of total contact hours of the subject, otherwise he will not able to take exam and be considerd as an exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic.
2	**Tardy:** - For lateness in attending the class, the student will be initially notified. If he repeates late in attending class he will be considered absent.
3	**Exam Attendance/Punctuality:** - The student should attend the exam on time. He is permitted to attend the exam half one hour from exam beginning, after that he/she will not be permitted to take exam and he/she is considered absent in the exam.
4	**Assignments & Projects:** - In general one assignment is given after each chapter of a course. The student should submit the assignment on time, mostly one week after giving the assignment
5	**Cheating**: - For cheating in exam, the student is considered as failure. In case the cheating is repeated three times during study the student will be disengaged from the Faculty
6	**Plagiarism**: Plagiarism is the attending of the student the exam of a course instead of other 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 Affair Council of the university.
7	**Other policies:** - The mobile phone is not allowable to be used during class lecture. It must be switched off, otherwise the student will be ordered to leave the lecture room. - The mobile phone is not allowed to be taken during the examination time. - Lecture notes and assignments may be given directly to students using soft or hard copy.

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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. Eng. Hamoud A. Al-Nahari**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed** **Asst. Prof. Dr. Munasar Alsubri**

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52. Template for Course Plan of Turbomachines

I. Information about Faculty Member Responsible for the Course:

		Office Hours					
Name of Faculty Member	Assoc. Prof. Dr. Abdul-Malik Momin						
Location& Telephone No.	Mechanical Engineering Department- 777943334	**SAT**	**SUN**	**MON**	**TUE**	**WED**	**THU**
E-mail	dramalikmomin@yahoo.com						

II. Course Identification and General Information:

1.	Course Title:	Turbomachines.				
2.	Course Number & Code:	ME343.				
3.	Credit Hours:	C.H				Total Cr. Hrs.
		Th.	Seminar/Tu.	Pr.	Tr.	
		2	2	-	-	3
4.	Study level/year at which this course is offered:	Fourth Year-Second Semester.				
5.	Pre –requisite (if any):	Fluid Mechanics – II (ME242) and Thermodynamics – II (ME252)..				
6.	Co –requisite (if any):	None.				
7.	Program (s) in which the course is offered	Mechanical Engineering Program.				
8.	Language of teaching the course:	English Language.				
9.	System of Study:	Semesters.				
10.	Mode of delivery:	Lectures and Tutorials.				
11.	Location of teaching the course:	Mechanical Engineering Department.				

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III. Course Description:

The course aims at giving an overview of different types of turbomachinery used for energy transformation, such as pumps, compressors, as well as hydraulic, steam and gas turbines. This course provides the detailed application on the power generation. Some Renewable energy topics will also be included. The skills developed from this course will allow the students to have a vast knowledge in the power generation. This course introduces the topic of turbomachinery to undergraduate students. In particular, the course allows for a smooth transition from the study of thermodynamics, fluid dynamics, and heat transfer to the subject of turbomachinery. At the end of this course, the students should have acquired the necessary background and the principles for the analysis and design methods for turbomachines.

IV. Course Intended learning outcomes (CILOs) of the course

1.	Characterize the knowledge of basic sciences subjects related to turbomachines.
2.	Describe the principles of different types of turbomachines.
3.	Explore different ideas related to the applications of turbomachines reaching to innovative solutions.
4.	Analyze different processes related to the applications of turbomachines.
5.	Implement different techniques for the enhancement.
6.	Perform different analytical work related to the use of turbomachines.
7.	Assess to life -long learning regarding the new innovations for the applications.
8.	Cooperate effectively within the team in presenting the technical reports.

V. Course Content:

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

A – Theoretical Aspect:

Order	Units/Topics List	Sub -Topics List	Week Due	Contact Hours
1.	Introduction and Types of Turbomachines.	• Definition. • Power Generating Turbomachines. • Power Absorbing Turbomachines. • Power Generation and Transmission. • Types of Plants. • Main Components of each Plant. • Performance and Calculations.	1st, 2nd	4
2.	Thermodynamics Cycles.	• Main Power Cycles. • PV and TS Diagrams.	3rd	2
3.	Steam Turbines.	• Types of Steam Turbines. • Vector Diagrams. • Performance and Losses.	4th, 5th	4
4.	Gas Turbine Power Plant and Power Cycles. Methods of Enhancement.	• Main Cycles. • Performance and Losses. • Effect of Operating Variables. • Comparison with Steam Power Plant. • Combined Steam and Gas Power Plants.	6th, 7th	4
5.	Mid-Term Exam.	• The First 4 Chapters.	8th	2
6.	Nozzles and Diffusers.	• Types of Nozzles. • Performance and Losses. • Diffusers.	9th	2
7.	Centrifugal Pumps.	• Introduction. • Classification of a Centrifugal Pump. • Basic Elements of a Centrifugal Pump. • Head and Pump Efficiency. • Cavitation of a Pump.	10th, 11th	4

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		• Pump Performance. • Main Categories of a Pump.		
8.	Axial Flow Compressors.	• Types of Compressors. • Performance and Losses.	12th	2
9	Hydraulic Turbines.	• Principles of Hydraulics. • Hydraulic Pressure and Force. • Pipe Flow Systems. • Hydraulic Turbine and its Classifications.	13th	2
10.	Wind Turbines.	• Types of Turbines. • Wind Energy Applications. • Performance and Losses.	14th	2
11.	Jet Engines.	Types of Jet Engines.	15th	2
12.	Final Exam.	All the Chapters.	16th	2
Number of Weeks /and Units Per Semester			**16**	**32**

C – Tutorial Aspect:

Order	Units/Topics List	Sub -Topics List	Week Due	Contact Hours
1.	Introduction and Types of Turbomachines.	• Definition. • Power Generating Turbomachines. • Power Absorbing Turbomachines. • Power Generation and Transmission. • Types of Plants. • Main Components of each Plant. • Performance and Calculations.	1st, 2nd	4
2.	Thermodynamics Cycles.	• Main Power Cycles. • PV and TS Diagrams.	3rd	2
3.	Steam Turbines.	• Types of Steam Turbines. • Vector Diagrams. • Performance and Losses.	4th, 5th	4
4.	Gas Turbine Power Plant and Power Cycles.	• Main Cycles. • Performance and Losses. • Effect of Operating Variables.	6th, 7th	4

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	Methods of Enhancement.	• Comparison with Steam Power Plant. • Combined Steam and Gas Power Plants.		
5.	Nozzles and Diffusers.	• Types of Nozzles. • Performance and Losses. • Diffusers.	8th	2
6.	Centrifugal Pumps.	• Introduction. • Classification of a Centrifugal Pump. • Basic Elements of a Centrifugal Pump. • Head and Pump Efficiency. • Cavitation of a Pump. • Pump Performance. • Main Categories of a Pump.	9th, 10th	4
7.	Axial Flow Compressors.	• Types of Compressors. • Performance and Losses.	11th	2
8.	Hydraulic Turbines.	• Principles of Hydraulics. • Hydraulic Pressure and Force. • Pipe Flow Systems. • Hydraulic Turbine and its Classifications.	12th	2
9.	Wind Turbines.	• Types of Turbines. • Wind Energy Applications. • Performance and Losses.	13th	2
10.	Jet Engines.	Types of Jet Engines.	14th	2
Number of Weeks /and Units Per Semester			**14**	**28**

VI. Teaching strategies of the course:

- Active Lectures.
- Tutorials.
- Seminars.
- Projects.
- Computer Laboratory Based Session.
- Problem Based Learning.
- Team Work.
- Directed Self –Study.

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VII. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1.	Assignment 1	a1, a2, b1, b2,c1, c2, d1, d2.	1st	1.5
2.	Assignment	a1, a2, b1, b2,c1, c2, d1, d2.	2nd	1.5
3.	Assignment	a1, a2, b1, b2,c1, c2, d1, d2.	3rd	1.5
4.	Assignment	a1, a2, b1, b2,c1, c2, d1, d2.	4th	1.5
5.	Assignment	a1, a2, b1, b2,c1, c2, d1, d2.	5th	1.5
6.	Assignment	a1, a2, b1, b2,c1, c2, d1, d2.	6th	1.5
7.	Assignment	a1, a2, b1, b2,c1, c2, d1, d2.	7th	1.5
8.	Assignment	a1, a2, b1, b2,c1, c2, d1, d2.	8th	1.5
9.	Assignment	a1, a2, b1, b2,c1, c2, d1, d2.	9th	1.5
10.	Assignment 10	a1, a2, b1, b2,c1, c2, d1, d2.	10th	1.5
Total				**15**

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

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment
1.	Assignment for Each Chapter.	Weekly	15	10 %
2.	Mid-Term Exam.	8th	25	16.7 %
3.	Course File.	15th	20	13.3 %
4.	Final Exam.	16th	90	60 %
	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. Erik Dick, 2015, Fundamentals of Turbomachines, Springer.
2. Grant Ingram, 2009," Basic Concepts in Turbomachinery, Ventus Publishing Aps.

2- Essential References.

Head of Department	Quality Assurance Unit	Dean of the Faculty	Academic Development Center & Quality Assurance	Rector of Sana'a University
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	1. M. P. Boyce, 2002, "Gas Turbine Engineering Hand Book", Second Edition, Gulf Professional Publishing, TX, U.S.A. 2. Royce N. Brown, 1997, "Compressors Selection and Sizing", Second Edition, Gulf Professional Publishing, U.S.A. 3. B. H. Khan, 2006, "Non-Conventional Energy Resources", Tata McGraw Hill Publishing Company Limited, India. 4. P.C. Sharma, 2000, "Power Plant Engineering", S.K. Kataria and Sons. India.
3- Electronic Materials and Web Sites *etc*.	
	1. www.turbomachinerymag.com. 2. www.turbomachine.com. 3. Turbomachinery.man-es.com.

II. Course Policies:

1	**Class Attendance:** - The student should be attending not less than 75% of total contact hours of the subject, otherwise he will not able to take exam and be considerd as an exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic.
2	**Tardy:** - For lateness in attending the class, the student will be initially notified. If he repeates late in attending class he will be considered absent.
3	**Exam Attendance/Punctuality:** - The student should attend the exam on time. He is permitted to attend the exam half one hour from exam beginning, after that he/she will not be permitted to take exam and he/she is considered absent in the exam.
4	**Assignments & Projects:** - In general one assignment is given after each chapter of a course. The student should submit the assignment on time, mostly one week after giving the assignment
5	**Cheating**: - For cheating in exam, the student is considered as failure. In case the cheating is repeated three times during study the student will be disengaged from the Faculty
6	**Plagiarism**: Plagiarism is the attending of the student the exam of a course instead of other 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 Affair Council of the university.

Head of Department Asst. Prof. Dr. Adel Ahmed Al-Shakiri	Quality Assurance Unit Assoc. Prof. Dr. Mohammad Algorafi	Dean of the Faculty Prof. Dr. Mohammed AL-Bukhaiti	Academic Development Center & Quality Assurance Assoc. Prof. Dr. Huda Al-Emad	Rector of Sana'a University Prof. Dr. Al-Qassim Mohammed Abbas

7	**Other policies:** - The mobile phone is not allowable to be used during class lecture. It must be switched off, otherwise the student will be ordered to leave the lecture room. - The mobile phone is not allowed to be taken during the examination time. - Lecture notes and assignments may be given directly to students using soft or hard copy.