Sana'a University
Faculty of Engineering
Department: Electrical Engineering
Title of the Program: Power Engineering and Electrical Machines

Course Specification of Electrical Power Quality

I. Course Identification and General Information:

1.	Course Title:	Electrical Power Quality				
2.	Course Code & Number:	PME447				
3.	Credit hours:	C.H				Total
		Th.	Tu.	Pr.	Tr.	
		2	2		-	3
4.	Study level/ semester at which this course is offered:	Fifth Year/First Semester				
5.	Pre –requisite (if any):	Power Electronics (PME244) Renewable Energy Technologies (PME222).				
6.	Co –requisite (if any):	None.				
7.	Program (s) in which the course is offered:	Power Engineering and Electrical Machines				
8.	Language of teaching the course:	English				
9.	Location of teaching the course:	Electrical Engineering Department/Faculty of Engineering				
10.	Prepared By:	Prof. Dr. Eng. Omar H. Al-Sakaf				
11.	Date of Approval					

II. Course Description:

This course provides an introduction to power quality and harmonics phenomena in electric power systems. It includes characteristics and definitions, voltage sags, electrical transients, harmonics, mitigation techniques, and standards of power quality and harmonics. Students will acquire advanced theoretical knowledge, critical analytical and practical skills which can be applied to investigation and resolution of complex problem-solving scenarios. The subject of power quality is very broad by nature.

Prepared by	Head of Department	Quality Assurance Unit	Dean of the Faculty	Academic Development Center & Quality Assurance
Prof. Dr. Eng. Omar H. Al-Sakaf	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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It covers all aspects of power system engineering from transmission and distribution level analyses to end-user problems. Therefore, electric power quality has become the concern of utilities, end users, architects and civil engineers as well as manufacturers. The increased use of power electronic components within the distribution system and the reliance on renewable energy sources which have converters as interface between the source and the power system lead to power quality problems for the operation of machines, transformers, capacitors and power systems. Power quality of power systems affects all connected electrical and electronic equipment, and is a measure of deviations in voltage, current, frequency, temperature, force, and torque of particular supply systems and their components.

III. Course Intended Learning Outcomes (CILOs) of the Course		**Referenced PILOs**
a1	Acquire knowledge on power quality phenomena, classifications, measuring and monitoring methods and mitigation techniques.	A1, A2
a2	Define the broad issues and effects of power quality in modern power systems in the supply and demand side.	A3, A4
b1	Design parameters of the equipment needed to diagnose power in order to determine quality and the presence of harmonics.	B1, B2
b2	Analyze the power quality characteristics to select the suitable components for a better power quality.	B3, B4
c1	Apply specialist technical knowledge to determine power quality and harmonics in a variety of contexts.	C1, C2, C3, C4
c2	Apply specialist practices to ensure efficiency in both transmission and distribution of quality power.	C1, C2, C3
d1	Create systematic and methodical approaches when dealing with new and advancing power quality improving technologies.	D3, D5

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d2	Acquire problem solving and design skills and use computer applications and internet to extract information related to power quality and to prepare and present design reports.	D2, 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 on power quality phenomena, classifications, measuring and monitoring methods and mitigation techniques.	▪ Lectures, ▪ Demonstrations, ▪ Interactive class discussion, Tutorials, Case study Report (data collection, internet search, and reporting)	▪ Assignments, ▪ Oral Presentations, ▪ Quizzes, ▪ Tests, ▪ Written Exams
a2	Define the broad issues and effects of power quality in modern power systems in the supply and demand side.		

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

Course Intended Learning Outcomes		Teaching strategies	Assessment Strategies
b1	Design and implement parameters of the equipment needed to diagnose power in order to determine quality and the presence of harmonics.	▪ Lectures, ▪ Demonstrations, ▪ Interactive class discussion	▪ Assignments, ▪ Oral Presentations, Quizzes, ▪ Tests, ▪ Exams
b2	Analyze, and determine the power quality characteristics to select the suitable components for a better power quality.		

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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
c1	Apply specialist technical knowledge to determine power quality and harmonics in a variety of contexts.	▪ Lectures, ▪ Demonstrations, ▪ Interactive class discussion.	▪ Assignments, ▪ Oral Presentations, ▪ Quizzes, ▪ Tests, ▪ Written Exams.
c2	Apply specialist practices to ensure efficiency in both transmission and distribution of quality power.		

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:			
Course Intended Learning Outcomes		Teaching strategies	Assessment Strategies
d1	Create systematic and methodic approaches when dealing with new and advancing power quality improving technologies.	▪ Demonstrations, ▪ Interactive class discussion.	▪ Assignments, ▪ Oral Presentations.
d2	Acquire problem solving and design skills and use computer applications and internet to extract information related to power quality and to prepare and present design reports.		

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IV. Course Content:

A – Theoretical Aspects:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact Hours
1.	Power Quality Terms, Definitions and Standards.	a1, a2	▪ General classes of power quality problems, ▪ Transients, ▪ Long duration voltage variations, ▪ Short-duration voltage variations, ▪ Voltage imbalance, ▪ Waveform distortion, ▪ Voltage fluctuations, ▪ Power frequency variations, ▪ Power quality standards and terms.	1	2
2.	Voltage Sags and Interruptions.	a1, a2, b1	▪ Sources of Sags and Interruptions, ▪ Estimating Voltage Sag Performance, ▪ Fundamental Principles of Protection, ▪ Solutions at the End-User Level, ▪ Evaluating the Economics of Different Ride-Through Alternatives, ▪ Motor Starting Sags, ▪ Utility System Fault-Clearing Issues.	2	4

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IV. Course Content:

A – Theoretical Aspects:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact Hours
3.	Transient Overvoltages.	a1, a2, b1, b2	▪ Sources of Transient Overvoltage, ▪ Principle of Overvoltage Protection, ▪ Devices for Overvoltage Protection, ▪ Utility Capacitor-Switching Transients, ▪ Utility System Lightning Protection, ▪ Managing Ferro-resonance, ▪ Switching Transient Problems with Loads, ▪ Computer Tools for Transient Analysis.	2	4
4.	Fundamentals of Harmonics.	a1, a2, b1, b2, c1, c2, d1	▪ Harmonic Distortion, ▪ Voltage Versus Current Distortion, ▪ Harmonics Versus Transients, ▪ Power System Quantities under Non-Sinusoidal Conditions, ▪ Harmonic Indices, ▪ Harmonic Sources from Commercial Loads, ▪ Locating Harmonic Sources,	1	2

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IV. Course Content:

A – Theoretical Aspects:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact Hours
			▪ System Response Characteristics, ▪ Effects of Harmonic Distortion, ▪ Inter-harmonics.		
5.	Long Duration Voltage Variations.	a1, a2, b1, b2, , c1, c2, d1, d.2	▪ Principles of Regulating the Voltage, ▪ Devices for Voltage Regulation, ▪ Utility Voltage Regulator Application, ▪ Capacitors for Voltage Regulation, End-User Capacitor Application, ▪ Regulating Utility Voltage with Distributed Resources, ▪ Flicker.	4	8
6.	Power Quality Monitoring.	a1, a2, b1, b2, , c1, c2, d1, d.2	▪ Monitoring Considerations, ▪ Historical Perspective of Power Quality Measuring Instruments, ▪ Power Quality Measurement Equipment, Assessment of Power Quality Measurement Data, ▪ Application of Intelligent Systems, ▪ Power Quality Monitoring Standards.	4	8
Number of Weeks /and Units Per Semester				**14**	**28**

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B -Tutorial				
Order	**Tasks/ Experiments**	**Number of Weeks**	**Contact Hours**	**Learning Outcomes**
1.	Discussion of power quality terminology and standards.	1	2	a1, a2, d1, d.2
2.	Problems on power system analysis using simulation software to demonstrate power quality issues.	3	6	b1, b2, c1, c2, d1, d.2
3.	Brainstorming on methods of analysis, prediction, and mitigation of voltage sags and interruptions.	2	4	b1, b2, c1, c2, d1, d.2
4.	Problems on economic analysis of voltage sags and interruptions impacts and mitigation measures.	2	4	b1, b2, c1, c2, d1, d.2
5.	Analysis of power system transients using simulation software and tools.	3	6	b1, b2, c1, c2, d1, d.2
6.	Power quality monitoring considerations – Case study.	3	6	b1, b2, c1, c2, d1, d.2
Number of Weeks /and Units Per Semester		**14**	**28**	

V. Teaching Strategies of the Course:

- Lectures
- Interactive class discussion
- Demonstration – Simulation Software
- Tutorials

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VI. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1.	Homework.	a1,a2,b1, b2,	2,5,8,12	5
2.	Solve power quality problems and analyze results independently using simulation software.	b1, b2, c1, c2	3,6,9	5
3.	Presentations.	b1, b2, d1,d2	13	5
4.	Mini Projects - Scientific Research Work.	c1, c2,d1,d2	15	5
	Total			**20**

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.	2^{nd} -15^{th}	20	13.3%	a1,a2,b1,b2,c1,c1,d1,d2
2.	Mid-Term Exam.	7^{th}	20	13.3%	a1,a2,b1,b2
3.	Practical Final Exam	15^{th}	20	13.3%	b1,b2,c1,c1
4.	Final Exam (theoretical).	16^{th}	90	60%	a1,a2,b1,b2
Total			**150**	**100%**	

VIII. Learning Resources:

1- Required Textbook(s)

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1. Dugan Roger C, McGranaghan M F, Santoso S and Beaty H Wayne, Electrical Power Systems Quality, 3rd edition, McGraw-Hill, 2012.
2- Essential References.
1. Alexander Kusko, Marc T. Thompson, Power Quality in Electrical Systems, McGraw-Hill, 2007. 2. Barry W. Kennedy, Power Quality Primer, McGraw-Hill, 2000.
3- Electronic Materials and Websites *etc*.
1. Course Power Point. 2. Video clips. 3. Links to information resources.

IX. Course Policies:

1.	• **Class Attendance** A student should attend not less than 75 % of total hours of the course; 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 being late in attending the class, the student will be initially notified. If he/she 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 an 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 and Projects** Assignments are given to the students after each chapter; students have to submit all 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 dismissed 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 dismissed from the Faculty. The final dismissal of the student from the Faculty should be confirmed by the Student Council Affairs 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 may be given directly to students using soft and/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. Radwan Al bouthigy**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed**

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Prof. Dr. Eng. Omar H. Al-Sakaf	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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	Asst. Prof. Dr. Munasar Alsubri

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Sana'a University
Faculty of Engineering
Department: Electrical Engineering
Title of the Program: Power Engineering and Electrical Machines

Course Plan of Electrical Power Quality

I. - Information about Faculty Member Responsible for the Course:							
Name of Faculty Member	Prepared by: Prof. Dr. Eng. Omar H. Al-Sakaf	**Office Hours**					
Location& Telephone No.	Faculty of Engineering Mobile: 733772328/773332328	SAT	SUN	MON	TUE	WED	THU
E-mail	oalsakaf@gmail.com oalsakaf@yahoo.com		08:00 - 12:00				

II. Course Identification and General Information:						
1-	Course Title:	Electrical Power Quality				
2-	Course Number & Code:	PME447				
3-	Credit hours:	C.H				Total
		Th.	Tu.	Pr.	Tr.	
		2	2	-	-	3
4-	Study level/year at which this course is offered:	Fifth year- First Semester				
5-	Pre –requisite:	Power Electronics (PME244) Renewable Energy Technologies (PME222).				
6-	Co –requisite (if any):	None				
7-	Program (s) in which the course is offered	Power Engineering & Electrical Machines				
8-	Language of teaching the course:	English				
9-	System of Study:	Regular				

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10-	Mode of delivery:	Semester
11-	Location of teaching the course:	Class& Lab

III. Course Description:

This course provides an introduction to power quality and harmonics phenomena in electric power systems. It includes characteristics and definitions, voltage sags, electrical transients, harmonics, mitigation techniques, and standards of power quality and harmonics. Students will acquire advanced theoretical knowledge, critical analytical and practical skills which can be applied to investigation and resolution of complex problem-solving scenarios. The subject of power quality is very broad by nature. It covers all aspects of power system engineering from transmission and distribution level analyses to end-user problems. Therefore, electric power quality has become the concern of utilities, end users, architects and civil engineers as well as manufacturers. The increased use of power electronic components within the distribution system and the reliance on renewable energy sources which have converters as interface between the source and the power system lead to power quality problems for the operation of machines, transformers, capacitors and power systems. Power quality of power systems affects all connected electrical and electronic equipment, and is a measure of deviations in voltage, current, frequency, temperature, force, and torque of particular supply systems and their components.

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IV. Intended Learning Outcomes (ILOs) of the Course:

1. Acquire knowledge on power quality phenomena, classifications, measuring and monitoring methods and mitigation techniques.
2. Define the broad issues and effects of power quality in modern power systems in the supply and demand side.
3. Design parameters of the equipment needed to diagnose power in order to determine quality and the presence of harmonics.
4. Analyze the power quality characteristics to select the suitable components for a better power quality.
5. Apply specialist technical knowledge to determine power quality and harmonics in a variety of contexts.
6. Apply specialist practices to ensure efficiency in both transmission and distribution of quality power.
7. Create systematic and methodical approaches when dealing with new and advancing power quality improving technologies.
8. Acquire problem solving and design skills and use computer applications and internet to extract information related to power quality and to prepare and present design reports.

V. Course Content:

A – Theoretical Aspects:

Order	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1.	Power Quality Terms, Definitions and Standards.	▪ General classes of power quality problems, ▪ Transients, ▪ Long duration voltage variations, ▪ Short-duration voltage variations,	1st	2

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V. Course Content:

A – Theoretical Aspects:

Order	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		▪ Voltage imbalance, ▪ Waveform distortion, ▪ Voltage fluctuations, ▪ Power frequency variations, ▪ Power quality standards and terms.		
2.	Voltage Sags and Interruptions.	▪ Sources of Sags and Interruptions, ▪ Estimating Voltage Sag Performance, ▪ Fundamental Principles of Protection, ▪ Solutions at the End-User Level, ▪ Evaluating the Economics of Different Ride-Through Alternatives, ▪ Motor Starting Sags, ▪ Utility System Fault-Clearing Issues.	2^{nd} ,3^{rd}	4
3.	Transient Overvoltages.	▪ Sources of Transient Overvoltage, ▪ Principle of Overvoltage Protection, ▪ Devices for Overvoltage Protection, ▪ Utility Capacitor-Switching Transients, ▪ Utility System Lightning Protection, ▪ Managing Ferro-resonance, ▪ Switching Transient Problems with Loads, ▪ Computer Tools for Transient Analysis.	4^{th} ,5^{th}	4

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V. Course Content:

A – Theoretical Aspects:

Order	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
4.	Fundamentals of Harmonics.	▪ Harmonic Distortion, ▪ Voltage Versus Current Distortion, ▪ Harmonics Versus Transients, ▪ Power System Quantities under Non-Sinusoidal Conditions, ▪ Harmonic Indices, ▪ Harmonic Sources from Commercial Loads, ▪ Locating Harmonic Sources, ▪ System Response Characteristics, ▪ Effects of Harmonic Distortion, ▪ Inter-harmonics.	6th	2
5.	Midterm Exam		7th	2
6.	Long Duration Voltage Variations.	▪ Principles of Regulating the Voltage, ▪ Devices for Voltage Regulation, ▪ Utility Voltage Regulator Application, ▪ Capacitors for Voltage Regulation, End-User Capacitor Application, ▪ Regulating Utility Voltage with Distributed Resources, ▪ Flicker.	8th ,9th ,10th ,11th	8
7.	Power Quality Monitoring.	▪ Monitoring Considerations, ▪ Historical Perspective of Power Quality Measuring Instruments,	12th ,13th ,14th 15th	8

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V. Course Content:

A – Theoretical Aspects:

Order	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		▪ Power Quality Measurement Equipment, Assessment of Power Quality Measurement Data, ▪ Application of Intelligent Systems, ▪ Power Quality Monitoring Standards.		
8.	Final Exam		16th	2
Number of Weeks /and Units Per Semester			**16**	**32**

B – Tutorial

Order	Tasks/ Experiments	Number of Weeks	Contact Hours
1.	Discussion of power quality terminology and standards.	1st	2
2.	Problems on power system analysis using simulation software to demonstrate power quality issues.	2nd ,3rd ,4th	6
3.	Brainstorming on methods of analysis, prediction, and mitigation of voltage sags and interruptions.	5th ,6th	4
4.	Problems on economic analysis of voltage sags and interruptions impacts and mitigation measures.	7th ,8th	4

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5.	Analysis of power system transients using simulation software and tools.	9th ,10th ,11th	6
6.	Power quality monitoring considerations – Case study.	12th ,13th ,14th	6
Number of Weeks /and Units Per Semester		**14**	**28**

VI. Teaching Strategies of the Course

- Lectures
- Interactive class discussion
- Demonstration – Simulation Software
- Tutorials

VII. Assignments:

No.	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1.	Homework	a1,a2,b1, b2,	2,5,8,12	5
2.	Assignments to solve power quality problems and analyze results independently using simulation software.	b1, b2, c1, c2	3,6,9	5
3.	Presentations	b1, b2, d1,d2	13	5
4.	Mini Projects - Scientific Research Work	c1, c2,d1,d2	15	5
	Total			**Total**

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

Assessment	Type of Assessment Tasks	Week Due	Mark	Proportion of Final Assessment
1.	Assignments.	2nd -15th	20	13.3%
2.	Mid-Term Exam.	7th	20	13.3%
3.	Practical Final Exam	15th	20	13.3%
4.	Final Exam (theoretical).	16th	90	60%
Total			**150**	**100%**

IX. Learning Resources:

1- Required Textbook(s)

1. Dugan Roger C, McGranaghan M F, Santoso S and Beaty H Wayne, Electrical Power Systems Quality, 3rd edition, McGraw-Hill, 2012.

2- Essential References

1. Alexander Kusko, Marc T. Thompson, Power Quality in Electrical Systems, McGraw-Hill, 2007.
2. Barry W. Kennedy, Power Quality Primer, McGraw-Hill, 2000.

3- Electronic Materials and Web Sites *etc*.

1. Course Power Point.
2. Video clips.
3. Links to information resources.

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

X. Course Policies:

1.	• **Class Attendance** A student should attend not less than 75 % of total hours of the course; 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 being late in attending the class, the student will be initially notified. If he/she 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 an 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 and Projects** Assignments are given to the students after each chapter; students have to submit all 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 dismissed 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 dismissed from the Faculty. The final dismissal of the student from the Faculty should be confirmed by the Student Council Affairs of the university.

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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 may be given directly to students using soft and/or hard copy**.**

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