A) COURSE

Course Id:	Course
5674	Electrical Machines I

Class Hours per Week	Lab hours per week	Complementary practices	Credits	Total hour course
5	2	5	12	80

B) GENERAL COURSE INFORMATION:

	EE (IEA)	ME (IM)	MME (IMA)	EME (IME)	MTE (IMT)
Level:	VI				
Course Type (Required/Elective)	Required				
Prerequisite Course:	Electric Circuits II				
CACEI Classification:	IA				

C) COURSE OBJECTIVE

At the end of the course, the student will be capable of:
Desarrollar la teoría básica de ambas máquinas eléctricas y sus posibles aplicaciones.

D) TOPICS (CONTENTS AND METHODOLOGY)

1.- General classification of electrical machines.		1 hours
Specific Objective:	Develop basic theory of both electrical machines and its posible applications.	
Readings and other resources	**N A**	
Teaching Methodologies	Presentation.	
Learning Activities	**N A**	

2.- Basic principles of transformers		4 hours
Specific Objective:	Apply basic concepts of electromagnetism to the transformer.	
2.1.- Faraday law. 2.2.- Lenz law. 2.3.- Magnetic circuit. 2.4.- Transforming relations. 2.5.- Ideal Transformer.		

Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects
Learning Activities	Analysis of requirements, research, ideas organization, Developing of creativity to formulate solution options. Feasibility, creativity and logic Analysis to develop criteria of selection of solutions, preliminary elaboration of parts list, identification of critical components, cost estimation and delivery times, organization and purpose elaboration.

3.- Construction of transformers.	**4 hours**
Specific Objective:	Identify materials and construction forms of transformers.
3.1.- Materials: Iron, copper, aluminum, Isolation. 3.2.- One phase transformers: core type, Shell type. 3.3.- Polarity marks in one phase transformers. 3.4.- Three phase transformers of high power and distribution. 3.5.- Transformer accesories. 3.6.- Cooling transformer types.	
Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects
Learning Activities	Researching and information analysis, application of knowledge acquired during career, application of new knowledge during researching, proves elaboration and results analysis. Individual electronic Portfolio elaboration and weekly advances reporting (Taking care about orthography and redaction).

4. Real transformer	**10 hours**
Specific Objective:	Develop basic theory of real transformer.
4.1.- Winding resistance and dispersion reactance. 4.2.- Magnetizing current. 4.3.- Exact equivalent circuit. 4.4.- Simplified equivalent circuit. 4.5.- Phasor diagram. 4.6.- Voltage Regulation.	
Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.

5. Transformers connections	**4 hours**
Specific Objective:	Analyze the environment of transformers (one and three phase) according diverse connection types.

5.1.- Requirements to parallel transformer connection. 5.2.- Connection Y-Y. 5.3.- Connection Δ-Δ. 5.4.- Connection Y-Δ or Δ-Y. 5.5.- Phase displacement in Y-Δ or Δ-Y. 5.6.- Scott connection, Zig-Zag, T. 5.7.- Power converters connections.	
Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.

6. Autotransformer and special transformers.	**3 hours**
Specific Objective:	Identify particular applications of transformers.
6.1.- Transforming relation in autotransformer. 6.2.- Equivalent autotransformer circuit. 6.3.- Autotransformer impedance. 6.4.- Three windings transformers. 6.5.- Tap changer 6.6.- Transformers to power electronics. 6.7.- Isolation transformers. 6.8.- Measurement transformers. 6.9.- Transformers for arc furnaces.	
Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.

7. Efficiency and parameterization of the transformer	**5 hours**
Specific Objective:	Develop the theory of basic parameters of the transformer, as well as its efficiency for its diverse operation forms.
7.1.- Transformer loses. 7.2.- Transformer efficiency. 7.3.- Open circuit and short circuit tests. 7.4.- Per unit systems 7.5.- Overload and operating altitude.	
Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.

8. Transformers tests	**6 hours**
Specific Objective:	Identify and interpret tests to electrical power transformers.

8.1.- Transformers test classification: field, factory. 8.2.- Winding and isolation resistance test. 8.3.- Polarity and phase angle test. 8.4.- Transformation relation test. 8.5.- Temperature elevation test. 8.6.- Test oil and gas chromatography. 8.7.- Applied voltage and inducted voltage test. .8.- Impulse and partial discharges test.	
Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.

9. Dataplate: power and distribution	**1 hours**
Specific Objective:	Identify nominal data of a distribution and a power transformer.
Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.

10. Converting principles of electromagnetic energy.	**3 hours**
Specific Objective:	Apply and develop basic concepts of electromagnetism to the synchronous machine.
10.1.- Converting electrical to mechanical energy and vice versa. 10.2.- Induced voltage in a conductor in movement in a magnetic field. 10.3.- Rotary magnetic field theory. 10.4.- Magnetomotive forces and rotary magnetic field. 10.5.- Generating action	
Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.

11. Construction and classification of synchronous machine.	**3 hours**
Specific Objective:	Identify the elements that constitute the construction of the synchronous machine, as well as its classification.
11.1.- Armature windings: stator. 11.2.- Windings distribution 11.3.- Field windings: rotor. 11.4.-Damper windings. 11.5.- Damper windings. 11.6.- Excitement systems. 11.7.- Cooling system. 11.8.- Classification according primary motor .	
Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects

Learning Activities	Manual elaboration of operations and written final report. Oral exposing.

12. Smooth poles synchronous generator		**8 hours**
Specific Objective:	Desarrollar y analizar el circuito equivalente del generador de polos lisos, para interpretar su comportamiento en estado permanente.	
12.1.- Dispersion resistance and reactance. 12.2.- Magnetisement curve. 12.3.- Armor reaction. 12.4.- Three-phase circuit of the generator. 12.5.- Equivalent circuit of the generator. 12.6.- Phasor diagram of the generator. 12.7.- Voltage regulation 12.8.- Power and induced torque		
Readings and other resources	Internet, bibliography according needs of the Project.	
Teaching Methodologies	Learning oriented to projects	
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.	

13. Efficiency and parameterization		**2 hours**
Specific Objective:	Develop the necessary tests to obtain characteristic parameters, as well as its efficiency.	
13.1.- Generator loses diagram. 13.2.- Generator efficiency. 13.3.- Resistance tests in windings. 13.4.- Open circuit test 13.5.- Short circuit test.		
Readings and other resources	Internet, bibliography according needs of the Project.	
Teaching Methodologies	Learning oriented to projects	
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.	

14. Operation of the generator in the power system.		**9 hours**
Specific Objective:	Identify y analyze diverse operation forms of the generator.	
14.1.- Operation of an isolated generator. 14.2.- Voltage and frequency control. 14.3.- Parallel operation of two or more generators. 14.4.- Active and reactive power control. 14.5.- Operation of the generator with an electrical network.		
Readings and other resources	Internet, bibliography according needs of the Project.	
Teaching Methodologies	Learning oriented to projects	
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.	

15. Salient poles generator		**4 hours**
Specific Objective:	Analyze equivalent circuit of the salient poles generator to interpret its behavior in permanent state.	

15.1.- 2 Shafts theory 15.2.- Generator equivalent circuit. 15.3.- Phasor diagram of generator. 15.4.- Power and induced torque	
Readings and other resources	Internet, bibliography according needs of the Project.
Teaching Methodologies	Learning oriented to projects
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.

16. Transient analisys and nominal values.		**3 hours**
Specific Objective:	Identify the transient state in a synchronous generator as well as its capacity curves.	
16.1.- Transient state in synchronous generator. 16.2.- Transitional and subtransitional reactances. 16.3.- Capacity curves of the generator.		
Readings and other resources	Internet, bibliography according needs of the Project.	
Teaching Methodologies	Learning oriented to projects	
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.	

17. Synchronous motor		**10 hours**
Specific Objective:	Analyze operation in permanent state of the synchronous motor.	
17.1.- Induced force in a powered conductor. 17.3.- Vector diagram of the motor. 17.4.- Power and inducted torque of the motor. 17.5.- V curve of the motor. 17.6.- Power factor correction 17.7.- Boot methods of the motor. 17.8.- Dataplate		
Readings and other resources	Internet, bibliography according needs of the Project.	
Teaching Methodologies	Learning oriented to projects	
Learning Activities	Manual elaboration of operations and written final report. Oral exposing.	

E) TEACHING AND LEARNING METHODOLOGIES

Exhibition of topics: Analysis of the concepts exposed in the course. Using tools like online digital platforms, homework discussion or investigations that stimulate teamwork between students, exams application and development of little projects. The imparting scheme of the course is purposed by more than one teacher, in such a way that at the end it will be evaluated by a project that integrate knowledge and abilities developed in the course.

F) EVALUATION CRITERIA:

Evaluation:	Schedule	Suggested Form of Evaluation and weighing	Topics
First partial exam		Written exam: 80% Homework, projects: 20% Total 100%	Unit 1, 2 ,3 y 4
Second partial exam		Written exam: 80% Homework, projects: 20% Total 100%	Unit 4 5, 6 y 7
Third partial exam		Written exam: 80% Homework, projects: 20% Total 100%	Unit 8, 9, 10 Y 11
Fourth partial exam		Written exam: 80% Homework, projects: 20% Total 100%	Unit 12,13 y 14
Total	16 weeks		100%
Ordinary		Average of the four partial grades	
Laboratory		Needed to pass the course	
Extraordinary exam		All units theoretical exam 100%	
Title Exam		All units theoretical exam 100%	
Regularization exam		All units theoretical exam 100%	

G) BIBLIOGRAPHY AND ELECTRONIC RESOURCES

Main Books

El ABC de la calidad de energía eléctrica. Gilberto Enríquez Harper. Limusa

La calidad de la energía en los sistemas eléctricos. Gilberto Enríquez Harper. Limusa

Power quality in power systems and electrical machines FUCHS/MASSOM-A-PRESS

Distribution Reliability and Power Quality Dugan, McGranaghan, Santoso Mc Graw Hill

Complementary Books

AC Power Systems Hand Book Jerry C Whitaker 3ª Ed. CRIPRESS

Curso de Ahorro de energía FIDE, CONAE

Harmonics and Power system Francisco de Rosa Marcel

Decker

Standars IEEE: 141 rojo, 142 verde, 1100 esmeralda. 519
Control de armónicas, 493 dorado, 739 bronce

Internet Links
http://www.icase.com.mx/
http://www.sfindustrial.com/
http://www.fide.org.mx/
http://www.conae.gob.mx/wb/
http://www.conuee.gob.mx/
http://www.energia.org.mx/