Course name: Mathematical Models for Mechanical Systems	**Course code:** MA 503

Location in curricular map:
Specialization Axis

Course description:
The purpose of this course is to provide the student the methodologies for the analysis, modeling, synthesis and simulation, used for applications in the design of behaviors of mechanical, thermal, fluid, electrical, electromagnetic and electronic systems. Also, energy methods and state variables are studied. The course begins with the formulation of equations, linear system time response, Laplace transform, computational simulations, as well as the kinematics and kinetics of mechanisms for dynamic mechanical systems.

Course learning outcomes:
At the end of the course, the student will: Know and comprehend the formulation, modeling and simulation of mechanical systems. Know and apply mathematical modeling software to solve problems. Analyze the mathematical models of physical systems. Be able to change any analysis parameter considered in the mathematical formulation.

Course content:	Hours
1 Dynamic Systems 1.1 Introduction to dynamic systems 1.2 The Laplace transform 1.3 Mechanical systems 1.4 The transfer function as an approximation for modeling dynamic systems. 1.5 Steady state as an approximation for the modeling of dynamic systems.	22
2. Energy Systems 2.1 Electrical and electromechanical systems 2.2 Fluid and thermal systems	4
3. Synthesis of Mechanisms 3.1 Kinematics of mechanisms 3.2 Kinetics of mechanisms	10

Learning activities guided by professor:	Hours 36
1. Thematic exposition by professor	12
2. Laboratory practices and/or workshops guided by professor	12
3. Discussion and/or presentation plenary guided by professor	8
4. Small group activities guided by professor	2
5. Individual activities guided by professor	2

Independent learning activities:	**Hours 60**
1. Presentation of materials selected by professor. • The student must present thematic material • The student must read an application paper	12
2. Writing of an article, essay or reading summary. • The student must write a technical article that presents a real technical application	4
3. Solution of problems selected by professor. • The student must solve 16 total problems.	24
4. Laboratory practices. • The student must solve exercises in a guided workshop, as well as variations of these.	8
5. Integral course project. • This activity consists of the implementation of the solution presented in the technical article. However, hours can be exchanged with those of activity 3, with previous approval by the professor.	12

Evaluation procedures and instruments:

The evaluation procedures and instruments for this course are the following:

1. Presentations.
    - The student must prove to the professor and group that he or she has prepared for the presentation of the specific topic.
2. Deliverables.
    - The student must deliver a technical article that is derived from a professional inquiry or a topic assigned by the professor.
    - The student must deliver reports and files of the virtual designs in the formats of the physical prototype modeling tools.
3. Presentations of the final project prototype.

Evaluation criteria:

1. The evaluation instruments and procedures will be centered on the guided and non guided learning activities.
2. The professor will evaluate and assign a grade to each of the evaluation instruments. The grade must be within 0 and 100.
    - Technical article 25 points.
    - Solution to 16 problems 30 points.
    - Research and presentation of a topic 15 points.
    - Final project 30 points.
3. The professor will report to the Graduate College the grade average for all the evaluation instruments obtained by each student.
4. The minimum passing grade is 80 points.
5. A student may not obtain a failing grade due to accumulated non attendance.

Bibliography:

1. Rosenberg y Karnopp. Introduction to Physical Systems. Mc Graw Hill.
2. Katsuhiko Ogata, “System Dynamics", Prentice Hall, 2003
3. Sandor, “Design of Mechanisms” , Prentice Hall, 2001

Course name:	Course code:
Experimental Analysis of Mechanical Parts	MF 503

Location in curricular map:
Specialization Axis

Course description:
This course deals with stress, strain and resistance of different mechanical parts, subject to uni-axial, biaxial and tri-axial loads, the elastic relationship between stress and strain, fault theories, energy methods to calculate elastic deflection using the Castigliano method and impact loads, also the dimensions of these bodies are studied, and observation via experimental methods of design parameters and their relationship with experimental parameters, such as frailty, photo elasticity and strain gauges will be studied. The relevance of this course is evident due to the fact that it comprises knowledge of design and seeks application via methodologies. The Masters student is obliged to take this course participating actively in all learning activities, such as: analytic modeling of mechanical problems, that is, to do the necessary free body diagrams, calculate conventional stress, unitary strain, specific and total energies, all this in an analytic manner with software such as MAPLE, and virtual verification with the aid of COSMOSM, and in specific cases using experimental methods. For this, it is necessary that the student be willing to invest at least 6 hours a week to do the stated learning activities.

Course learning outcomes:
At the end of the course, the student will: Know the relationship between designs based on mathematical models and experimental models. Use software for the virtual verification of designs. Use experimental equipment for the acquisition of information, such as unitary strain for a quarter, half or full bridge, as well as the use of rosettes with gauges and compensation for temperature and other effects.

Course content:	Hrs.
1. BASIC CONSIDERATIONS FOR STRESS AND STRAIN. 1.1 Stress and strain concepts 1.2 Principal types of stress, planes and directions 1.3 Stress on a plane analysis. Analytic and graphic method 1.4 Three dimensional stress 1.5 Principal planes of strain	4
2. ELASTIC RELATIONSHIP AND STRAIN. 2.1 Hook's generalized law, stress vs. strain 2.2 Stress equations vs. strain in terms of stress and strain 2.3 Bulk module 2.4 Poisson values 2.5 Mohr circle for stress and strain 2.6 Polar diagram for stress and strain	4
3. EXPERIMENTAL STUDY OF PHOTO ELASTICITY, FRAILTY AND GAUGES. 3.1 Polarization plane 3.2 Materials, models and determination of concentration factors 3.3 Theoretical considerations for stress and strain related to frailty 3.4 Relationship between strain and change in resistance 3.5 Temperature compensation	6
4. STATIC FAULT AND FAULT THEORIES. 4.1 Types of fault 4.2 Theory of maximum normal stress 4.3 Mohr theory 4.4 Maximum stress theories 4.5 Maximum distortion energy theory 4.6 Criteria for the selection of fault theory	4
5. CYLINDRICAL MEMBERS WITH RADIAL LOADS. 5.1 Thin wall cylinders 5.2 Elastic stress in cylinders with a thick wall – general case 5.3 Elastic stress in cylinders with thick walls – special case 5.4 Application of fault theory to cylinders with thick walls	6
6. ELASTIC DEFLECTION – CASTIGLIANO METHOD. 6.1 Castigliano theorem 6.2 Strain energy due to: - Axial load. - Torsion load. - Flexional load. - Transversal load. 6.3 Determination of deflection via the Castigliano method.	6
7. IMPACT LOAD. 7.1 Introduction. 7.2 Approximate analysis of linear impact stress and deflections – general case 7.3 Approximate analysis of stress and strain in torsion impact 7.4 Impact analysis – special cases	6

Learning activities guided by professor:	**Hours** **36**
1. Thematic exposition by professor 2. Laboratory practices and/or workshops guided by professor 3. Discussion and/or presentation plenary guided by professor 4. Small group activities guided by professor 5. Individual activities guided by professor	15 15 2 2 2

Independent learning activities:	Hours 60
1. Reading of materials selected by professor. • The student must do individual reading to know and comprehend in detail the mechanical properties and their behavior with loads. • Students must read an application paper related to mechanical properties.	6
2. Writing of an article, essay or reading summary • The student must write a technical article that presents a design problem and a way to implement the technologies studied throughout the course to said problem.	4
3. Solution of problems selected by professor. • The student must solve 4 problems related to strain, stress, dimensioning, fault theories and stress concentration factors. • The student must present at least 2 solved exercises for each unit.	16
4. Field practices. • The student must test frailty in mechanical parts. • The student must fabricate transversal cuts in photo elastic materials. • The student will use equipment to measure unitary strain.	12
5. Computer laboratory practices. • The student must model, with the aid of MAPLE, the deflection behavior and/or energy of at least 10 problems, previously defined by professor. • The student will do finite element exercises using specialized software.	16
6. Integral course project. • Optional activity in which the student implements the solution established in the technical article. These hours may be exchanged for those of activity 3, with previous approval by the professor.	6

Evaluation procedures and instruments:
The evaluation procedures and instruments are the following: 1. Oral or written exam. • The student must prove to the professor via an oral or written exam, the knowledge of the primary course topics. 2. Deliverables. • The student must deliver a technical article in which he or she presents a technology or innovative application using the technologies studied during the course, indicating advantages and technical requirements. • The student will deliver a report, including programs, for each of the selected problems, which must be solved individually. • Alternatively, the student may deliver a technical memoir, including programs, used to solve the problem presented in the technical article. 3. Presentations. • All students must present the technical article as well as an application case solution, to the group, on the day and hour that is established by the group and professor. 4. Participation in discussion sessions. • This will not be subject to evaluation.

Evaluation criteria:
1. The evaluation instruments and procedures will be centered on the guided and non guided learning activities. 2. The professor will evaluate and assign a grade to each of the evaluation instruments. The grade must be within 0 and 100. • Technical article 20 points. • Solution of problems 60 points. • Research and presentation of a topic 20 points. 3. The professor will report to the Graduate College the grade average for all the evaluation instruments obtained by each student. 4. The minimum passing grade is 80 points. 5. A student may not obtain a failing grade due to accumulated non attendance.

Bibliography:

1.- BUDYNAS, R.G.,
ADVANCED RESISTANCE AND APPLIED STRESS.
MCGRAW-HILL, 1977

2.- DAILY, RILEY,
EXPERIMENTAL STRESS ANALYSIS
MCGRAW-HILL, 1978

3.- ROBERT C. JUVINALL
ENGINEERING CONSIDERATION TO STRESS, STRAIN AND RESISTANCE
MCGRAW-HILL, 1983

4.- PERRY, LISSNER
THE PRINCIPLES OF STRAIN GAUGES
MCGRAW-HILL, 1962

5.- RAYMOND ROARK
FORMULAS FOR STRESS AND STRAIN
MCGRAW-HILL, 1975

6.- JOSEPH H. FAUPEL, PH.D., FRANKLIN E. FISHERN PH. D.
ENGINEERING DESIGN
JOHN WILWY & SONS, 1981

7.- BORESI AND CHONG,
ELASTICITY IN ENGINEERING
INTERSCIENCE, 1999

Course name:	**Course code:**
Energy Design using CAD-CAE Tools	MF 504

Location in curricular map:
Specialization Axis

Course description:
This course is focused on general tool design, for which analytic details that cover various energetic methods are discussed, as well as solving of typical problems. Topics such as security, dimensioning, resistance will be covered, emphasizing the use of software languages, spreadsheets, and/or software design software, such as CAE tools and finite element methods. Lab practices will also be done to observe the behavior of hardness in machine tooled elements, and how these change with thermal treatments.

Course learning outcomes:
At the end of the course, the student will: Design tool holders, and templates using analysis techniques and methods. Determine vía software the finite element of dimensional aspects, security factor, stress and energy density. Identify stress generated on tools due to the application of various types of loads. Analyze and calculate stress due to impact loads. Select the fault theory or theories to analyze various tools. Calculate the energies in metal mechanical processes. Know and use the symbols and concepts relating to loads and stress. Develop the analytic capacity for the solving of problems in this field of knowledge.

Course content:	Hrs.
1. Relationships between stress and strain. 1.1 Introduction. 1.2 Stress. 1.2.1 Tension stress. 1.2.2 Compression stress. 1.2.3 Relationship between stress and strain 1.2.4 Stress-strain graph. 1.2.5 Allowable stress, security factor.	4
2.- Plastic zone behavior. 2.1 Mechanical tests. 2.2 Hardness. 2.3 Tension stress ASTM A-370. 2.4 Behavior curve adjustment ASTM E-646. 2.5 Strain in a metallic plate ASTM E-643. 2.6 Strain energy.	4
3.- Bending fundamentals. 3.1 Introduction. 3.2 Energy required for bending. 3.3 Absorbed energy. 3.4 Security factor.	4
4.- Design of parts for bending and folding. 4.1 Parts for bending. 4.2 Folding requirements. 4.3 Energy calculations. 4.4 Force and power. 4.5 Design and selection of parts for folding. 4.6 Common faults. 4.7 Calculation of length for a plate. 4.8 Parts design using finite element.	4
5.- Design of parts for rolling. 5.1 Requirements for rolling. 5.2 Energy calculations. 5.3 Required torque and power.	4
6.- Design of parts for forming. 6.1 Forming requirements. 6.2.Energy analysis. 6.3.Absorbed energy. 6.4.Power calculations. 6.5 Design via finite element.	4
7.- Design of parts for filling 7.1 Filling requirements. 7.2 Energy calculations. 7.3 Sections method. 7.4 Determining tons. 7.5 Design via finite element.	4
8.- Design of pincers 8.1 Metallic cuts requirements 8.2 Energy calculations 8.3 Force and power. 8.4 Design via finite element. 8.5 Security factor.	2
9.- Matrix design 9.1 Matrix definitions and nomenclature.	2

9.2 Energy requirements. 9.3 Energy absorption calculations. 9.4 Matrix design. 9.5 Matrix selection. 9.6 Security factors.	
10.- Design of blades for guillotines. 10.1 Requirements for blades without inclination. 10.2 Requirements for blades with inclination. 10.3 Energy calculations. 10.4 Power calculations. 10.5 Determination of tons.	2
11.- Design of cutting discs. 11.1 Introduction to cutting with discs. 11.2 Determining required energy. 11.3 Determining absorbed energy.	2

Learning activities guided by professor:	**Hours** **36**
1. Thematic exposition by professor	16
2. Laboratory practices and/or workshops guided by professor	16
3. Discussion and/or presentation plenary guided by professor	4
4. Small group activities guided by professor	2
5. Individual activities guided by professor	2

Independent learning activities:	Hours 60
1. Presentation of material by professor. • Problem solving by students. • Research on three dimensional stress.	6
2. Writing of an article, essay or reading summary • The student must write a technical article that presents a design problem and a way to implement the technologies studied throughout the course to said problem.	8
3. Solution of problems selected by professor. • The student must solve 4 problems related to strain, stress, dimensioning, fault theories and stress concentration factors. • The student must present at least 2 solved exercises for each unit.	18
4. Field practices. • Preparation of test probe. • Follow through of test. • Elaboration of report with conclusions. • Find adjustment to behavior points. • Probing of adjustments of the curve of power type. • Graph nominal and real stress-strain. • Homework: Find area under curve for range of strain. • Masurement of superficial hardness in products that present bending.	12
5. Computer laboratory practices. • The student must model, with the aid of MAPLE, the deflection behavior and/or energy of at least 10 problems, previously defined by professor. • The student will do finite element exercises using specialized software.	12
6. Integral course project. • Optional activity in which the student implements the solution established in the technical article. These hours may be exchanged for those of activity 3, with previous approval by the professor.	6

Evaluation procedures and instruments:

The evaluation procedures and instruments are the following:

1. Oral or written exam.
    - The student must prove to the professor via an oral or written exam, the knowledge of the primary course topics.
2. Deliverables.
    - The student must deliver a technical article in which he or she presents a technology or innovative application using the technologies studied during the course, indicating advantages and technical requirements.
    - The student will deliver a report, including programs, for each of the selected problems, which must be solved individually.
    - Alternatively, the student may deliver a technical memoir, including programs, used to solve the problem presented in the technical article.
3. Presentations.
    - All students must present the technical article as well as an application case solution, to the group, on the day and hour that is established by the group and professor.
4. Participation in discussion sessions.
    - This will not be subject to evaluation.

Evaluation criteria:

1. The evaluation instruments and procedures will be centered on the guided and non guided learning activities.
2. The professor will evaluate and assign a grade to each of the evaluation instruments. The grade must be within 0 and 100.
    - Technical article 25 points.
    - Solution of problems 60 points.
    - Research and presentation of a topic 15 points.
3. The professor will report to the Graduate College the grade average for all the evaluation instruments obtained by each student.
4. The minimum passing grade is 80 points.
5. A student may not obtain a failing grade due to accumulated non attendance.

Bibliography:

1. Juvinlall R. C. “Engineering Considerations of Stress, Strain and Strength”,. Mc Graw-Hill.USA, 1977
2. Laue K. y Stenger H., “Extrusion”, American Society for Metals, USA, 1985.
3. Gegel H. , Altan T. y Soo-Ik, “Metal Forming”, “American Society for Metals”, USA, 1990.
4. Lange K. “Handbook of Metal Forming”, Society of Manufacturing Engineers, USA, 1995
5. Hoffman E., “Fundamentals of Tool Design”, Society of Manufacturing Engineers, USA, 1996.
6. Pollack H. W., “Tool Design”,. Reston Pub. Co., USA, 1980.
7. Young W. C. y Roark “Formulas for Stress and Strain”, McGraw-Hill., USA, 1983.
8. Wagoner R., “Fundamentals of Metal Forming Analysis”, USA, 1995.
9. Elastic - Plastic Problems. Annin, and Cherepanov. ASME Press.
10. Mechanics in Materials Processing and Manufacturing. AMD-VOL 194. ASME Press.
11. *Serope Kalpakjian. “Manufacturing Processes for Engineering Materials”, 3rd. Ed. Addison Wesley.1997.*
12. Serope Kalpakjian. “Manufacturing Engineering and Technology”, 3rd. Ed. Addison Wesley. 1995
13. *Amirouche, F M. L. 2003.* Principles of Computer Aided Design and Manufacturing, Second Edition. Prentice *Hall International*

Course name:	**Course code:**
Product Prototype Generation	MF 505

Location in curricular map:
Specialization Axis

Course description:
The course is oriented towards the different methodologies for product development, the design of parts with computer aids, the design for assembly, as well as the various techniques used to generate rapid prototypes.

Course learning outcomes:
At the end of the course, the student will: Select and improve manufacturing operations that involve the fabrication of metal-mechanical products, via the selection of materials, modification of mechanical properties, fabrication process selection, creation, fabrication and assembly of rapid prototypes of special materials and with modern manufacturing techniques, that allow for the visualization in a better context of the functionality of the product, therefore implementing methodologies of higher quality.

Course content:	Hours
1. Introduction to product development.	2
2. Tools for the process of product development.	2
3. Client needs.	2
4. Establishing product functionality.	2
5. Engineering specifications.	2
6. Computer aided design.	4
7. Good and bad designs.	3
8. Interoperability in design formats.	4
9. Conceptual modeling in RP.	4
10. Generators and modelers of physical prototypes.	4
11. Secondary physical generators.	4
12. Robust design.	2
The course contemplates the development of a design or redesign project for a product or component.	1

Learning activities guided by professor:	Hours 36
1. Thematic exposition by professor 2. Thematic exposition by student. 3. Discussion and/or presentation plenary guided by professor. 4. Lab work designing virtual prototypes. 5. Lab work with physical modelers.	12 12 4 4 4

Independent learning activities:	**Hours 60**
1. Presentation of materials selected by professor. • The student must present thematic material • The student must read an application paper	12
2. Writing of an article, essay or reading summary • The student must write a technical article that presents a real technical application	8
3. Solution of problems selected by professor. • The student must solve 4 problems relating to product improvement.	8
4. Laboratory practices. • The student must solve exercises in a guided workshop, as well as variations of these.	12
5. Integral course project. • This activity consists of the implementation of the solution presented in the technical article. However, hours can be exchanged with those of activity 3, with previous approval by the professor.	20

Evaluation procedures and instruments:
The evaluation procedures and instruments for this course are the following: 1. Presentations. • The student must prove to the professor and group that he or she has prepared for the presentation of the specific topic. 2. Deliverables. • The student must deliver a technical article that is derived from a professional inquiry or a topic assigned by the professor. • The student must deliver reports and files of the virtual designs in the formats of the physical prototype modeling tools. 3. Presentations of the final project prototype.

Evaluation criteria:

1. The evaluation instruments and procedures will be centered on the guided and non guided learning activities.
2. The professor will evaluate and assign a grade to each of the evaluation instruments. The grade must be within 0 and 100.
   - Technical article 25 points.
   - Solution of 4 problems 30 points.
   - Research and presentation of a topic 15 points.
   - Final project 30 points.
3. The professor will report to the Graduate College the grade average for all the evaluation instruments obtained by each student.
4. The minimum passing grade is 80 points.
5. A student may not obtain a failing grade due to accumulated non attendance.

Bibliography:

1) Product design, techniques in reverse engineering and new product development. Kevin Otto & Kristin Wood.Prentice Hall, 2001.

2) Engineering design. A systematic approach. G. Pahl and W. Beitz Springer, 2002.

3) The engineering design process, second ed. A. Ertas and J. Jones Prentice Hall, 1999.

4) Rapid Prototyping Technology**:** Selection and Application ***Kenneth G. Cooper*** Marcel Dekker,2001

5) Rapid Prototyping: Principles and Applications (2nd Edition), Chua Chee Kai, Leong Kah Fai, Lim Chu-Sing, Wspc; 2nd Bk&Cdr edition (March 2003)

Course name:	**Course code:**
Materials Engineering	MF 506

Location in curricular map:
Specialization Axis

Course description:
The course is focused on the comprehension and knowledge of materials in engineering and the behavior of these when they are subject to work conditions and environments, as well as the processing that allows for them to yield products with diverse degrees of functionality.

Course learning outcomes:
At the end of the course, the student will: Know and comprehend the behavior of materials and their classification. Analyze the specific and combined parameters for the selection of materials.. Know the primary manufacturing processes that exist in the region and be able to detail and calculate them. Do reverse engineering for a product.

Course content:	**Hours**
1. Materials fundamentals	4
2. Fundamentals of mechanical behavior of materials.	5
3. Dimensional and superficial characteristics.	5
4. Processing and equipment for melting of metals and thermal treatments.	4
5. Volumetric strain processes.	8
6. Metal forming processes.	6
7. Material removal processes.	4

Learning activities guided by professor:	**Hours** **36**
1. Thematic exposition by professor	12
2. Laboratory practices and/or workshops guided by professor	8
3. Discussion and/or presentation plenary guided by professor	10
4. Small group activities guided by professor	4
5. Individual activities guided by professor	2

Independent learning activities:	Hours 60
1. Presentation of materials selected by professor. • The student must present thematic material • The student must read an application paper	12
2. Writing of an article, essay or reading summary • The student must write a technical article that presents a real technical application	8
3. Solution of problems selected by professor. • The student must solve 4 process design problems.	8
4. Laboratory practices. • The student must solve exercises in a guided workshop, as well as variations of these.	12
5. Integral course project. • This activity consists of the implementation of the solution presented in the technical article. However, hours can be exchanged with those of activity 3, with previous approval by the professor.	20

Evaluation procedures and instruments:

The evaluation procedures and instruments for this course are the following:

1. Presentations.
   - The student must prove to the professor and group that he or she has prepared for the presentation of the specific topic.
2. Deliverables.
   - The student must deliver a technical article that is derived from a professional inquiry or a topic assigned by the professor.
   - The student must deliver reports and files of the virtual designs in the formats of the physical prototype modeling tools.
3. Presentations of the final project prototype.

Evaluation criteria:

1. The evaluation instruments and procedures will be centered on the guided and non guided learning activities.
2. The professor will evaluate and assign a grade to each of the evaluation instruments. The grade must be within 0 and 100.
    - Technical article 25 points.
    - Solution of 4 problems 30 points.
    - Research and presentation of a topic 15 points.
    - Final project 30 points.
3. The professor will report to the Graduate College the grade average for all the evaluation instruments obtained by each student.
4. The minimum passing grade is 80 points.
5. A student may not obtain a failing grade due to accumulated non attendance.

Bibliography:

1. Serope Kalpakjian, Manufacturing processes for engineering materials, Prentice Hall
2. Serope Kalpakjian. "Manufacturing Engineering and Technology", 3rd. Ed. Addison Wesley. 1995
3. Gegel H. , Altan T. y Soo-Ik, "Metal Forming", "American Society for Metals", USA, 1990.
4. 4. Lange K. "HandBook of Metal Forming", Society of Manufacturing Engineers, USA, 1995
5. 5. Hoffman E., "Fundamentals of Tool Design", Society of Manufacturing Engineers, USA, 1996.
6. Wagoner R., "Fundamentals of Metal Forming Analysis", USA, 1995.

Course name:	**Course code:**
Thermo-fluids Fundamentals	MF 507

Location in curricular map:
Specialization Axis

Course description:
This course has the objective to introduce the first year graduate student to the fundamental aspects of fluid mechanics, heat transfer and thermodynamics. The emphasis of the course is in the application of fundamental principles of these sciences and the practical understanding of the operation of various devices, processes and systems in industry. During class sessions, the basic theory will be accompanied by multiple practical problems. During the course the student will do reading and homework independently. At the end of the course the student will do a final project that applies the principles studied throughout the course.

Course learning outcomes:
At the end of the course, the student will: Know and comprehend the fundamentals of fluid mechanics, heat transfer and thermodynamics. Solve industrial application problems using the principles of fluid mechanics, heat transfer and thermodynamics. Solve various thermal energy consumption systems and various energy conversion systems. Identify areas of opportunity for the improvement of industrial systems.

Course content:	Hours
1. Fundamentals of heat transfer 1.1 Introduction 1.1.1 Conduction 1.1.1.1 Heat conduction in 1D, 2D y 3D 1.1.1.2 Transient heat conduction 1.1.2 Convection 1.1.2.1 Forced convection 1.1.2.2 Free convection 1.1.2.3 Heat transfer with phase change 1.1.3 Radiation	12
2. Fundamentals of thermodynamics 2.1 Basic concepts, definitions, pure substance properties 2.2 Heat, work and energy 2.3 First law of thermodynamics 2.4 Second law of thermodynamics	12
3. Fundamentals of fluid mechanics 3.1 Introduction 3.2 Fluid statics 3.3 Fluid dynamics 3.4 Viscous fluid flow 3.5 Flow of submerged bodies .4. Fundamentals of psychrometrics 4.1 Properties of wet air 4.2 Psychrometric processes and applications	12

Learning activities guided by professor:	Hours 36
1. Thematic exposition by professor	28
2. Laboratory practices and/or workshops guided by professor	4
3. Discussion and/or presentation plenary guided by professor	4
4. Small group activities guided by professor	OP
5. Individual activities guided by professor	OP

Independent learning activities:	Hours 60
1. Reading of materials selected by professor.	15
2. Writing of an article, essay or reading summary	OP
3. Solution of problems selected by professor.	25
4. Field practices.	OP
5. Research and development of a topic assigned by professor.	OP
6. Integral course project.	20

Evaluation procedures and instruments:

The evaluation procedures and instruments are the following:

1. Oral or written exam.
    - The student must prove to the professor via an oral or written exam, the knowledge of the primary course topics.
2. Deliverables.
    - The student will deliver a report for each of the selected problems, which must be solved individually.
    - The student will deliver a report of the final project.
3. Presentations.
    - All students must present the final project, on the day and hour that is established by the group and professor.
4. Participation in discussion sessions.
    - This will not be subject to evaluation.

Evaluation criteria:
1. The evaluation instruments and procedures will be centered on the guided and non guided learning activities. 2. The professor will evaluate and assign a grade to each of the evaluation instruments. The grade must be within 0 and 100. • Written or oral exam 30 points. • Solution and implementation of 4 problems 40 points. • Final project 30 points. 3. The professor will report to the Graduate College the grade average for all the evaluation instruments obtained by each student. 4. The minimum passing grade is 80 points. 5. A student may not obtain a failing grade due to accumulated non attendance.

Bibliography

	Type	Title	Author	Publisher	Year
	Reference	Heat transfer a practical approach 2nd Edition	Cengel Y.A.	McGraw-Hill	2003
	Reference	Thermodynamics an Engineering approach 4th Edition	Cengel Y.A., Boles M.A.	McGraw-HIll	2002
	Reference	Fluid Mechanics 5th Edition	White F.M.	McGraw-HIll	2003

Course name:	Course code:
Design and Applications of Thermal Systems	MF 508

Location in curricular map:
Specialization Axis

Course description:
The objective of this course is to apply the fundamental principles of thermal engineering to the practical understanding of the operation of various industrial devices, processes and systems. The emphasis will be to understand these processes and systems seeking a design and operation that is optimal from the energy efficiency point of view. During the course, the basic theory will be presented accompanied by multiple practical problems. During the course, the student will do reading and homework independently. At the end of the course the student will do a project that applies the principles studied throughout the course.

Course learning outcomes:
At the end of the course, the student will: Know and comprehend how to apply the fundamentals of thermal engineering to the optimal design of thermal energy consumption systems. Solve industrial application problems using the principles studied in class. Evaluate various thermal energy consumption systems and converters for various forms of energy. Identify areas of opportunity to improve industrial systems.

Course content:	**Hours**
1 Fundamentals of refrigeration and air conditioning	18
1.1 Basic refrigeration cycle	
1.2 Practical refrigeration cycle	
1.3 Efficient use of refrigeration systems	
2 Introduction to the design of thermal systems	18
2.1 Types of thermal systems	
2.1.1 Insulation systems	
2.1.2 Modeling of pipe systems	
2.1.3 Modeling of refrigeration systems	
2.2 Introduction to mathematical modeling techniques	
2.3 Introduction to economic analysis	
2.4 Introduction to thermo-economic analysis	

Learning activities guided by professor:	**Hours** **36**
1. Thematic exposition by professor	28
2. Laboratory practices and/or workshops guided by professor	4
3. Discussion and/or presentation plenary guided by professor	4
4. Small group activities guided by professor	OP
5. Individual activities guided by professor	OP

Independent learning activities:	Hours 60
1. Reading of materials selected by professor.	15
2. Writing of an article, essay or reading summary	OP
3. Solution of problems selected by professor.	25
4. Field practices.	OP
5. Research and development of a topic assigned by professor.	OP
6. Integral course project.	20

Evaluation procedures and instruments:
The evaluation procedures and instruments are the following: 1. Oral or written exam. • The student must prove to the professor via an oral or written exam, the knowledge of the primary course topics. 2. Deliverables. • The student will deliver a report for each of the selected problems, which must be solved individually. • The student will deliver a report of the final project. 3. Presentations. • All students must present the final project, on the day and hour that is established by the group and professor. 4. Participation in discussion sessions. • This will not be subject to evaluation.

Evaluation criteria:
1. The evaluation instruments and procedures will be centered on the guided and non guided learning activities. 2. The professor will evaluate and assign a grade to each of the evaluation instruments. The grade must be within 0 and 100. • Written or oral exam 30 points. • Solution and implementation of 4 problems 40 points. • Final project 30 points. 3. The professor will report to the Graduate College the grade average for all the evaluation instruments obtained by each student. 4. The minimum passing grade is 80 points. 5. A student may not obtain a failing grade due to accumulated non attendance.

Bibliography

	Type	Title	Author	Publisher	Year
	Reference	Thermal environmental engineering 3rd edition	Kuehn T.H., Ramsey J.W., Threldeld J.L.	Prentice hall	1998
	Reference	Design of thermal systems	Stoecker W.F.	McGraw-HIll	1989
	Reference	Thermal design and optimization	Bejan A. Tsatsaronis G., Moran M.	Wiley-INterscience	1996

Course name: Application Project	**Course code:** CS 501

Location in curricular map: Terminal Axis

Course description: Throughout the course, the student will develop pan application project that demonstrates the capacity for analysis, team work, interpretation and application of knowledge and tools acquired throughout the masters program

Course learning outcomes: The student will be capable of applying the knowledge and abilities acquired throughout the courses of the masters program, contributing to the development of practical solutions that benefit the community.

Course Content	Hours
1. **Definition of application pre-project.**	**16**
2. **Ethics in professional services.**	**4**
3. **Project presentation.**	**4**
4. **Follow up by professor.**	**4**
5. **Presentation of pre results.**	**4**
6. **Presentation of final results.**	**4**

Learning activities:	
• **Guided activities:** - Presentation of subject by professor. - Presentation by guest researchers. - Discussions of subjects and cases. - Final project presentation.	**36**
• **Independent activities:** - Applied research case reading. - Information gathering. - Research reports. - Problem analysis. - Solution design.	**60**

Evaluation criteria and procedures:
The evaluation instruments are the following: Homework and research work Final project research Participation The points distribution for each instrument will be established in accordance with the group in the first class session.

Bibliography

	Type	Title	Author	Publisher	Year
1	None				