Teaching program leading to a Master's degree in the field of Science and Technology, sector: Mechanical Engineering Specialty: Materials and Surface Engineering

Semestre 1 :

Teaching Units	Course Title	Credits	Coefficient	الحجم الساعي الاسبوعي			half-yearly hourly volume (15 week)	others	Evaluation mode	
				دروس	اعمال موجهة	اعمال تطبيقية			Continuous	Exam
Basic Teaching Unit **Code: BTU 1.1** **Credits: 8** **Coefficient:4**	Phase Transformations	4	**2**	1H30	1H30		45H00	55H00	40%	60%
	Ferrous and Non-Ferrous Materials	4	2	1H30	1H30		45H00	55H00	40%	60%
	Surface Engineering	2	**1**	1H30			22H30	27H30		100%
Basic Teaching Unit **Code: BTU 1.2** **Credits: 8** **Coefficient:4**	Mechanical Properties of Materials	4	2	1H30	1H30		45H00	55H00	40%	60%
	Shaping of materials	4	2	1H30	1H30		45H00	55H00	40%	60%
Teaching Unit **Methodological** **Code: TUM 1.1** **Credits: 9** **Coefficient:5**	Applied numerical methods	4	2	1H30		1H30	45H00	55H00	40%	60%
	Practical work Mechanical Properties of Materials	2	1			1H30	22H30	27H30	100%	
	Practical work Surface Engineering	2	1			1H30	22H30	27H30	100%	
	Practical work Shaping of materials	1	1			1H30	15H00	10H00	100%	
	Advanced Python Programming	2	2	1H30		1H30	45H00	55H00	40%	60%

Teaching Unit **Discovery** **Code: TUM 1.1** **Credits: 2** **Coefficient:2**	Course of your choice	1	1	1H30			22H30	2H30		100%
Total Semester 1		30	17	13h30	6h00	5h30	375h00	375h0		

Semestre 2 :

Teaching Units	Course Title	Credits	Coefficient	Weekly hourly volume			half-yearly hourly volume (15 week)	others	Evaluation mode	
				Courses	Tutorials	Practical work			Continuous	Exam
Basic Teaching Unit **Code: BTU 1.2.1** **Credits: 10** **Coefficient:5**	Surface Treatment	6	**3**	3H00	1H30		67H30	82H30	40%	60%
	Thermal Treatment and Thermochemical Treatment	4	2	1H30	1H30		45H00	55H00	40%	60%
Basic Teaching Unit **Code: BTU 1.2.2** **Credits: 8** **Coefficient:4**	Damage and Fracture Mechanics	4	2	1H30	1H30		45H00	55H00	40%	60%
	Tribology	4	2	1H30	1H30		45H00	55H00	40%	60%
Teaching Unit **Methodological** **Code: TUM 1.2** **Credits: 9** **Coefficient:5**	Simulation of Forming Processes	4	2	1H30		1H30	45H00	55H00	40%	60%
	Materials Analysis and Characterization Techniques	3	2	1H30		1H30	37H30	37H30	40%	60%
	Practical work. Surface Treatment, Thermal Treatment and Thermochemical Treatment	2	1			1H30	22H30	27H30	100%	
Cross-Curricular teaching unit **Code: TUM 1.2** **Credits: 3** **Coefficient:3**	Respect for Norms and Ethical and Integrity Rules	1	1	1h30			22h30	2h30		100%
	Elements of Applied Artificial Intelligence	2	2	1h30		1h30	45H00	55H00	40%	60%

Total Semester 2	30	17	15h00	6h00	4h00	375h00	375h00		

Semestre 3 :

Teaching Units	Course Title	Credits	Coefficient	Weekly hourly volume			half-yearly hourly volume (15 week)	others	Evaluation mode	
				Courses	Tutorials	Practical work			Continuous	Exam
Basic Teaching Unit **Code: BTU 3.1** **Credits: 10** **Coefficient:5**	Adhesion and Cohesion of Materials	4	**2**	1H30	1H30		45H00	55H00	40%	60%
	Welding Processes	4	2	1H30	1H30		45H00	55H00	40%	60%
	Thermal Spraying	2	**1**	1H30			22H30	27H30		100%
Basic Teaching Unit **Code: BTU 3.1** **Credits: 8** **Coefficient:4**	Machine Elements	4	2	1H30	1H30		45H00	55H00	40%	60%
	Materials Selection	4	2	1H30	1H30		45H00	55H00	40%	60%
	Formation and Control of Sintered Microstructures	4	2	1H30		1H30	45H00	55H00	40%	60%
Teaching Unit **Methodological** **Code: TUM 3.1** **Credits: 9** **Coefficient:5**	Practical work Welding	1	1			1H30	15H00	10H00	100%	
	Practical work Thermal Spraying	4	2			3H00	45H00	55H00	100%	
Teaching Unit **Discovery** **Code: TUM 3.1** **Credits: 2** **Coefficient:2**	Course of your choice	1	1	1H30			22H30	2H30		100%
	Course of your choice	1	1	1H30			22H30	2H30		100%
Cross-Curricular	Literature									

teaching unit Code: TUM 3.1 Credits: 1 Coefficient:1	Review and Thesis Design	1	1	1h30			22h30	2h30		100%
Total Semester 3		30	17	13h30	6h00	5h30	375h00	375h0		

I – Detailed program by subject for Semester S1.

Semester: 1
Subject: Phase Transformations

Teaching Objectives:

Understand and master the mechanisms of transformations in the solid state;

Understand and master the relationships between microstructure and properties.

Recommended Prerequisite Knowledge:

Materials Science courses;

Fundamentals of Thermodynamics.

Course Content:

Chapter 1: Thermodynamics of Phase Transformations (3 weeks)

Chapter 2: Solidification (3 weeks)

Chapter 3: Recrystallization and Grain Growth (3 weeks)

Chapter 4: Diffusion-Controlled Transformations (3 weeks)

Chapter 5: Diffusion less (Displacive) Transformations (3 weeks).

Semester: 1
Subject: Ferrous and Non-Ferrous Materials

Teaching Objectives:

At the end of the course, the student should be able to distinguish between steels, cast irons, and alloys, and understand some properties of the main ferrous and non-ferrous materials, as well as their designations.

Recommended Prerequisite Knowledge: Iron–Carbon Phase Diagram.

Course Content:

Chapter 1: Ferrous Alloys (3 weeks)

Chapter 2: Non-Ferrous Alloys (2 weeks)

Chapter 3: Copper Alloys (2 weeks)

Chapter 4: Magnesium Alloys (2 weeks)

Chapter 5: Zinc Alloys (2 weeks)

Chapter 6: Titanium Alloys (2 weeks)

Chapter 7: Refractory Alloys (2 weeks).

Semester: 1
Subject: Surface Engineering

Teaching Objectives:

Describe an industrial surface and its physicochemical properties, and understand surface analysis techniques and characterization methods;

Identify the physical mechanisms of surface damage and degradation.

Recommended Prerequisite Knowledge: None.

Course Content:

Chapter 1: Surface Properties and Topography (6 weeks)

Chapter 2: Surface Mechanics (3 weeks)

Chapter 3: Experimentation and Measurement of Surface Finish (6 weeks).

Semester: 1
Subject: Mechanical Properties of Materials

Teaching Objectives:

At the end of the course, the student should understand the crystal structure, microstructure, and mechanical properties of the main ferrous and non-ferrous materials, as well as their designations.

Recommended Prerequisite Knowledge: Fundamentals of Materials Science.

Course Content:

Chapter 1: General Concepts of Stress and Strain (1 week)

Chapter 2: Mechanical Behavior (2 weeks)

Chapter 3: Elastic Properties: Spring Models, Electrostatic Models, Brittle Materials (3 weeks)

Chapter 4: Plastic Properties (2 weeks)

Chapter 5: Main Types of Defects (Point, Line, Surface, and Volume Defects) (3 weeks)

Chapter 6: Role of Dislocations in Plastic Deformation (2 weeks)

Chapter 7: Modification of Properties (2 weeks).

Semester: 1
Subject: Materials Forming (Materials Processing / Shaping of Materials)

Teaching Objectives:

The objective of this course is to provide the student with the different techniques for shaping materials, so that by the end of the course they can determine the technological process for a mechanical part.

Recommended Prerequisite Knowledge: Materials Science courses.

Course Content:

Chapter 1: Shaping by Casting (5 weeks)

Chapter 2: Shaping by Plastic Deformation (10 weeks).

Semester: 1
Subject: Applied Numerical Methods

Teaching Objectives:

The objective of this course is to provide a set of basic numerical tools for scientific computing in general.

Recommended Prerequisite Knowledge: General Mathematics.

Course Content:

Chapter 1: Introduction to Numerical Computation (1 week)

Chapter 2: Function Approximation (Interpolation, Least Squares) (3 weeks)

Chapter 3: Solving Linear and Nonlinear Algebraic Systems (2 weeks)

Chapter 4: Numerical Integration (3 weeks)

Chapter 5: Differential and Partial Differential Equations (3 weeks)

Chapter 6: Eigenvalue Problems

Practical Work (Labs) Content:

Lab 1: Introduction to Programming in MATLAB (scripts/functions/matrices/common matrix functions, loops, control structures, etc.) (3 weeks)

Lab 2: Programming Exercises (input/output management, graphical representation, etc.) (3 weeks)

Lab 3: Numerical Integration Methods (Interpolation, Least Squares) (3 weeks)

Lab 4: Direct Methods for Solving Linear Systems (3 weeks)

Lab 5: Iterative Methods for Solving Linear Systems (Gradient Methods, Jacobi Method, Gauss-Seidel Method) (3 weeks).

Semester: 1
Subject: Lab – Mechanical Properties of Materials

Teaching Objectives:

Be able to perform a basic mechanical test according to standardized procedures. Relate the mechanical properties of materials to the corresponding mechanical tests. Identify a material based on its standardized designation. Interpret and report the results of a test.

Recommended Prerequisite Knowledge:

Fundamentals of Strength of Materials and Materials Science.

Course Content:

Chapter 1: Mechanical Testing Methods (8 weeks)

Chapter 2: Metallographic Examination Methods (7 weeks).

Semester: 1
Subject: Lab – Surface Engineering

Teaching Objectives:

Understand the experimental methods currently used in fundamental, applied, and developmental research on material surfaces. Be able to discuss with a colleague regarding potential collaboration: what information can be obtained from an experimental technique? Nature of the samples? Sensitivity? Limitations?

Recommended Prerequisite Knowledge:

Fundamentals of Strength of Materials and Materials Science.

Course Content (Labs):

Lab 1: Surface Topography Characterization (4 weeks)

Lab 2: Microscopy Methods (4 weeks)

Lab 3: Indentation Testing (4 weeks)

Lab 4: Residual Stress Measurement (3 weeks).

Semester: 1
Subject: Lab – Materials Forming

Teaching Objectives:

Highlight the influence of forming processes on material properties and provide the student with various material shaping techniques so that, by the end of the course, they can determine the technological process for a mechanical part.

Recommended Prerequisite Knowledge:

Fundamentals of Strength of Materials and Materials Science.

Course Content (Labs):

Lab 1: Welding (3 weeks)

Lab 2: Bending (4 weeks)

Lab 3: Cutting and Stamping (4 weeks)

Lab 4: Casting (4 weeks).

II – Detailed program by subject for Semester S2.

Semester: 2
Subject: Surface Treatment

Teaching Objectives:

Provide theoretical and practical knowledge on thermochemical treatments as well as thin-film deposition techniques using dry processes.

Recommended Prerequisite Knowledge: Materials Science courses.

Course Content:

Chapter 1: Classification of Surface Treatments (1 week)

Chapter 2: Surface Characteristics (2 weeks)

Chapter 3: Surface Preparation Methods (2 weeks)

Chapter 4: Surface Treatment by Coatings (2 weeks)

Chapter 5: Conversion Treatments (2 weeks)

Chapter 6: Organic Coatings (2 weeks)

Chapter 7: Selection of a Surface Treatment (2 weeks)

Chapter 8: Methods for Controlling Surface Treatments and Coatings (2 weeks).

Semester: 2
Subject: Heat and Thermochemical Treatments

Teaching Objectives:

Provide theoretical and practical knowledge on various heat and thermochemical treatments for steels, cast irons, aluminum alloys, and copper alloys.

Recommended Prerequisite Knowledge: Materials Science courses.

Course Content:

Chapter 1: Heat Treatments of Steels (3 weeks)

Chapter 2: Thermochemical Treatments by Diffusion (3 weeks)

Chapter 3: Heat Treatments of Cast Iron (2 weeks)

Chapter 4: Heat Treatments of Aluminum and Its Alloys (2 weeks)

Chapter 5: Heat Treatments of Copper and Its Alloys (2 weeks)

Chapter 6: Selection of a Treatment (3 weeks).

Semester: 2
Subject: Damage and Fracture Mechanics

Teaching Objectives:

This course focuses on predicting the reliability, safety, and service life of materials and structures in the presence of defects and cracks using fracture mechanics.

Recommended Prerequisite Knowledge:

Materials Science courses, Strength of Materials (SOM/Mechanics of Materials).

Course Content:

Chapter 1: Brittle and Ductile Fracture (3 weeks)

Chapter 2: Linear Elastic Fracture Mechanics (LEFM) (4 weeks)

Chapter 3: Toughness Testing, Measurement of the Stress Intensity Factor (5 weeks)

Chapter 4: Limitations of LEFM (3 weeks).

Semester: 2
Subject: Tribology

Teaching Objectives:

Provide the student with the fundamental principles of wear, friction, and lubrication.

Recommended Prerequisite Knowledge: Materials Science courses.

Course Content:

Chapter 1: Introduction to Tribology (1 week)

Chapter 2: Fundamentals of Tribology (3 weeks)

Chapter 3: Materials for Tribology (3 weeks)

Chapter 4: Surface Protection (4 weeks)

Chapter 5: Tribological Coatings (4 weeks).

Semester: 2
Subject: Simulation of Material Forming Processes

Teaching Objectives:

The objective of this module is to provide the student with theoretical tools for modeling and simulating thermal problems in certain material forming processes.

Recommended Prerequisite Knowledge: Heat Transfer.

Course Content:

Chapter 1: Review of the Main Modes of Heat Transfer (2 weeks)

Chapter 2: Modeling of Heat Transfer (4 weeks)

Chapter 3: Heat Transfer in Casting (3 weeks)

Chapter 4: Heat Transfer in Welding (3 weeks)

Chapter 5: Heat Transfer in Machining (3 weeks).

Semester: 2
Subject: Material Analysis and Characterization Techniques

Teaching Objectives:

The goal of this course is to introduce students to the main physical techniques for material characterization. Students will be able to determine the number and crystal structure of the phases in an alloy using a diffraction diagram.

Recommended Prerequisite Knowledge: Materials Science courses.

Course Content:

Chapter 1: X-Ray Diffraction (3 weeks)

Chapter 2: Chemical Analysis Methods (5 weeks)

Chapter 3: Microscopic Methods (3 weeks)

Chapter 4: Thermal Analysis Methods (4 weeks)

Lab Content (Practical Work):

Lab 1: X-Ray Diffraction Methods (3 weeks)

Lab 2: Microscopic Methods (4 weeks)

Lab 3: Thermal Analysis Methods (4 weeks)

Lab 4: Chemical Methods (4 weeks).

Semester: 2
Subject: Lab – Surface, Heat, and Thermochemical Treatments

Teaching Objectives:

The goal of this lab is to familiarize students with the main techniques of surface, heat, and thermochemical treatments. Students will be able to select the appropriate process for a given material, determine the desired characteristics, and understand thin-film deposition techniques using dry methods.

Recommended Prerequisite Knowledge: Materials Science courses.

Lab Content:

Lab 1: Treatments by Structural Transformation (3 weeks)

Lab 2: Chemical Depositions (3 weeks)

Lab 3: Organic Coatings (3 weeks)

Lab 4: Bulk Heat Treatments: Quenching, Tempering (3 weeks)

Lab 5: Thermochemical Treatments by Diffusion (3 weeks).

Semester: 2
Subject: Ethics, Professional Conduct, and Intellectual Property

Teaching Objectives:

Develop students' awareness of ethical principles. Introduce them to the rules governing life at the university (their rights and responsibilities within the academic community) and in the workplace. Raise awareness about respecting and valuing intellectual property. Explain the risks of moral misconduct, such as corruption, and ways to combat them.

Recommended Prerequisite Knowledge: None.

Course Content:

A – Ethics and Professional Conduct (3 weeks)

B – Intellectual Property (9 weeks).

III – Detailed program by subject for Semester S3.

Semester: 3
Subject: Adhesion and Cohesion of Materials

Teaching Objectives:

Understand the different mechanisms of adhesion and cohesion, the techniques for testing and characterizing material adhesion, and their limitations and conditions of use.

Recommended Prerequisite Knowledge: None.

Course Content:

Chapter 1: Adhesion and Cohesion (2 weeks)

Chapter 2: Thermodynamic Aspects of Adhesion (3 weeks)

Chapter 3: Theories of Adhesion (Mechanical, Chemical, Electrical, Thermodynamic, and Others) (3 weeks)

Chapter 4: Review of Mechanics and Rheology of Metals and Polymers (3 weeks)

Chapter 5: Surface Preparation (2 weeks)

Chapter 6: Adhesion Testing (2 weeks).

Semester: 3
Subject: Welding Processes

Teaching Objectives:

At the end of this course, the student should be familiar with the main welding assembly techniques. They will have acquired fundamental knowledge of welding metallurgy, the main welding defects, as well as the different techniques for inspecting and characterizing welded joints.

Recommended Prerequisite Knowledge:

Different classes of materials and their designations.

Course Content:

Chapter 1: Introduction (1 week)

Chapter 2: Main Welding Processes (3 weeks)

Chapter 3: Welding Metallurgy (4 weeks)

Chapter 4: Welding Testing and Inspection (4 weeks)

Chapter 5: Preparation of Parts for Welding (3 weeks).

Semester: 3
Subject: Thermal Spraying

Teaching Objectives:

At the end of the course, the student should be familiar with the main thermal spraying techniques. They should be able to select the most suitable technology for a given problem, including an appropriate choice of alloyed or non-alloyed powders for the application.

Recommended Prerequisite Knowledge:

Major families of current alloys to make an appropriate powder selection.

Course Content:

Chapter 1: History of Thermal Spraying (1 week)

Chapter 2: Flame Torches (2 weeks)

Chapter 3: Refusion Flame Torches (2 weeks)

Chapter 4: Flame Torches for Ceramic Rods (2 weeks)

Chapter 5: Supersonic Flame Torches: Wire and Powder Types (HVOF) (2 weeks)

Chapter 6: Supersonic Air Flame Torches (HVAF) (2 weeks)

Chapter 7: Supersonic Detonation Torches (2 weeks)

Chapter 8: Plasma Torches (1 week)

Chapter 9: New Technologies (1 week).

Semester: 3
Subject: Machine Elements

Teaching Objectives:

The purpose of this course is to provide the student with applications in a mechanical context.

Recommended Prerequisite Knowledge: None.

Course Content:

Chapter 1: Introduction and Review of Strength of Materials (2 weeks)

Chapter 2: Connections Between Two Parts in Mechanical Design (5 weeks)

Chapter 3: Assembly and Transmission Elements (5 weeks)

Chapter 4: Lubricants (3 weeks).

Semester: 3
Subject: Materials Selection

Teaching Objectives:

Demonstrate the importance of material selection in the design process. Implement a material selection approach by considering functional, technological, and economic requirements. Justify the choice of a material and develop a specification sheet that lists the properties to be optimized.

Recommended Prerequisite Knowledge:

Knowledge of the major classes of materials and their specific properties.

Knowledge of processing and assembly methods.

Course Content:

Chapter 1: Material Requirements and Usage Properties: Functional, Technological, Economic, and Social (2 weeks)

Chapter 2: Classification of Materials by Physical State, Properties, and Processing Methodologies (2 weeks)

Chapter 3: Physical Laws Governing Material Behavior (2 weeks)

Chapter 4: Material Selection Strategy (2 weeks)

Chapter 5: Material-Function Suitability: Specification Sheet, Selection Criteria, Performance Indices, Selection Charts (2 weeks)

Chapter 6: Material-Process Suitability: Form-Process-Material Interactions, Processes and Their Attributes, Process Feasibility, Viability (2 weeks)

Chapter 7: Multi-Criteria Selection (1 week)

Chapter 8: Application of the Selection Procedure to Concrete Case Studies (2 weeks).

Semester: 3
Subject: Formation and Control of Sintered Structures

Teaching Objectives:

Provide the student with practical knowledge related to the main steps of manufacturing, shaping, and consolidation of parts by sintering.

Recommended Prerequisite Knowledge: Materials Science courses, Chemistry.

Course Content:

Chapter 1: Production of Metal Powders (3 weeks)

Chapter 2: Characterization and Properties of Metal Powders (3 weeks)

Chapter 3: Shaping and Different Types of Compactions (3 weeks)

Chapter 4: Properties of Compacts (3 weeks)

Chapter 5: Sintering (Basic Concepts, Material Transport Mechanisms, Stages of Sintering).

Semester: 3
Subject: Lab – Thermal Spraying

Teaching Objectives:

At the end of these labs, the student should be familiar with the main thermal spraying techniques. They should be able to select the most suitable technology for a given problem, including the appropriate choice of alloyed or non-alloyed powders for the application.

Recommended Prerequisite Knowledge:

Major families of current alloys to make an appropriate powder selection.

Lab Content:

Lab 1: Surface Preparation Techniques (sandblasting, shot blasting, grinding, etc.) (3 weeks)

Lab 2: Flame Torches (3 weeks)

Lab 3: Thermal Spraying of Metals (3 weeks)

Lab 4: Spraying of Ceramics and Cermets (3 weeks)

Lab 5: Thermal Spraying of Polymers (3 weeks).

Semester: 3
Subject: Non-Destructive Testing (NDT)

Teaching Objectives:

The objective of this course is to learn the set of methods that allow the characterization of the integrity of structures or materials without damaging them, whether during production, in service, or as part of maintenance.

Recommended Prerequisite Knowledge: Materials Science courses.

Course Content:

Chapter 1: Introduction and Review (1 week)

Chapter 2: Dye Penetrant Testing (1 week)

Chapter 3: Magnetic Particle Testing (1 week)

Chapter 4: Eddy Currents (2 weeks)

Chapter 5: Barkhausen Noise (2 weeks)

Chapter 6: Ultrasonics (2 weeks)

Chapter 7: X-ray and Gamma Radiography (2 weeks)

Chapter 8: Thermography (2 weeks)

Chapter 9: Applications to Surface Treatments (2 weeks)

Semester: 3
Subject 1: Literature Research and Thesis Design

Teaching Objectives:

Provide the student with the necessary tools to search for useful information and effectively use it in their final year project. Guide them through the steps leading to the writing of a scientific document. Emphasize the importance of communication and teach them how to present their work in a rigorous and pedagogical manner.

Recommended Prerequisite Knowledge:

Writing Methodology, Presentation Methodology.

Course Content:

Part I: Literature Research

Part II: Thesis Design