Form: Study Plan- Doctorate		
	Form Number	EXC-01-03-05A
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1.	School	**Engineering**
2.	Department	**Mechanical Engineering**
3.	Degree title (Arabic)	الدكتوراه في الهندســـــة الميكانيكيـــة
4.	Degree title (English)	**PhD in Mechanical Engineering**

Plan Number	Thesis/ Comprehensive	Specialization #	Degree	Department #	School #	Year
1	Thesis	9	Doctorate	04	09	2024

First: General Rules & Conditions:

1. This plan conforms to valid regulations of the programs of graduate studies.
2. Specialties of Admission :
   - First Priority: M.Sc. in Mechanical Engineering.
   - Second Priority: M.Sc. in Renewable Energy (based on a BSc in an Engineering field), M.Sc. in Chemical Engineering, M.Sc. in Civil Engineering, M.Sc. Industrial Engineering. with the registration of remedial courses determined by the department.

Second: Special Conditions:

- The applicant must sign a declaration of readiness to travel and study in Germany.
- The applicant must study the German language and achieve an A1 proficiency level before registering for the PhD dissertation hours.
- The student must publish a scientific paper in a reputable journal (Q1/Q2) before starting work on the dissertation, as an alternative to the PhD qualifying exam (exception).
- Two supervisors, one from each university, must be appointed for the PhD dissertation starting from the student's first semester in the program (exception).

Third: Study Plan: Studying (54) Credit Hours as following:

1. Obligatory Courses (21) credit hours:

Course No.	Course Title	Credit Hours	Theory	Practical	Pre/Co-requisite
0904901	Advanced Mathematical Methods in Mechanical Engineering	3	3	-	-
0904902	Optimization	3	3	-	0904901
0904903	Continuum Mechanics	3	3	-	-
0904904	Experimentation	3	3	-	0904903
0904905	Scientific Research (I)	3	3	-	-
0904906	Advanced Theoretical Mechanics	3	3	-	0904903
0904907	Scientific Research (II)	3	3	-	0904905

2. Elective Courses (15) Credit Hours:

Course No.	Course Title	Credit Hours	Theory	Practical	Pre/Co-requisite
0904908	Computational Mechanics and Advanced Techniques	3	3	-	-
0904909	Turbulent Flow	3	3	-	-
0904910	Viscous Flow	3	3	-	-
0904911	Convection Heat Transfer	3	3	-	-
0904912	Radiation Heat Transfer	3	3	-	-
0904913	Optimal Control	3	3	-	-
0904914	Socio-economic and Environmental Aspects of Energy	3	3	-	-
0904915	Wave Propagation in Solid Mechanics	3	3	-	-
0904916	Elasticity and Plasticity	3	3	-	-
0904917	Solar Energy and Power Generation	3	3	-	-
0904918	Intercultural competences	3	3	-	-
0904919	Non-Linear Vibrations	3	3	-	-
0904920	Selected Topics in Mechanical Engineering	3	3	-	-

3. Publish a review paper in a top tier journal.
4. Thesis: (18) Credit hours. Course Number: (0904999).

Course Description

0904901 **Advanced Mathematical Methods in Mechanical Engineering** **Face-to-Face** **(3 Credit Hours)**

Prerequisite: **None**

Calculus of Variation, vector calculus; multivariable calculus and analytic geometry; Introduction to perturbation theory, Hankel, Mellin transforms, Green function method, fractional differential equations; Introduction to modern methods of applied mathematics, including non-depersonalization and scaling analysis, regular and singular asymptotic; Ordinary, partial and stochastic differential equations, introduction to engineering statistics, probability, and Markov chains.

0904902 **Optimization** **Blended** **(3 Credit Hours)**

Prerequisite: **0904901**

Optimization and its use in engineering design, analysis, and operation. Problem formulation, classical solution techniques, and heuristic approaches, and their applications to the disciplines within engineering.

0904903 **Continuum Mechanics** **Face-to-Face** **(3 Credit Hours)**

Prerequisite: **None**

Strain tensor, deformation rate, coordinate systems, strain-displacement relations, compatibility equations. Stress tensor, balance laws, stress coordinate transformation, deviatory stresses, stress and motion with large strain. Elastic solids, Navier equations, energy principles, thermodynamics of solids, finite elasticity. Newtonian fluids, constitutive equations, laws of thermodynamics, compressible, ideal and rotational flows, turbulence, boundary layer, heat transfer. Applied topics in continuum mechanics.

0904904 **Experimentation** **Blended** **(3 Credit Hours)**

Prerequisite: **0904903**

This course covers design of experiment, experiment conduction procedures, and analysis of experimental data. Various experiment design methods and their respective characteristics are studied. In particular, factorial and fractions of two-level, three-level, and mixed-level factorials designs are discussed in greater detail. Statistical methods of experimental data, robust statistics methods; reliability and accuracy of statistical modelling and data analysis are covered with computational examples. Individual projects on applications of material studied will be assigned.

0904905 Scientific Research (I) Online (3 Credit Hours)

Prerequisite: None

This course is designed to equip PhD students in Mechanical Engineering with foundational skills in scientific research methodologies. Emphasis is placed on literature review techniques, identifying research gaps, and formulating research questions. Students will begin the process of selecting a research topic that will serve as the foundation for their PhD thesis. The course will guide students in preparing a comprehensive review paper on their chosen topic, providing a critical analysis of existing research and establishing the context for their own work. By the end of the course, students are expected to have a well-structured research proposal related to their PhD topic.

0904906 Advanced Theoretical Mechanics Face-to-Face (3 Credit Hours)

Prerequisite: 0904903

Introduction to planar Dynamics: Systems of Particles and Rigid Bodies. Analytical Mechanics: Constrains, Virtual Displacement and Work, Generalized Forces, Principles of D'Alembert, Hamilton and Lagrange. Three-Dimensional Kinematics and Dynamics of Rigid Bodies, Dynamics of Flexible Bodies, Non-Linear Interaction and Internal Resonances in Vibratory Systems.

0904907 Scientific Research (II) Online (3 Credit Hours)

Prerequisite: 0904905

Building on the foundations established in Scientific Research I, this course focuses on advanced research methods, data collection, and analysis techniques relevant to Mechanical Engineering. Students will refine their research topic and further develop their review paper, integrating theoretical and practical aspects to outline their research proposal. The course also includes training in scholarly writing, peer review processes, and the preparation of publications. By the end of the course, students are expected to have a review paper ready for submission to a peer-reviewed, Q1/Q2 journal.

0904908 Computational Mechanics and Advanced Techniques Blended (3 Credit Hours)

Prerequisite: None

This course covers design of experiment, experiment conduction procedures, and analysis of experimental data. Various experiment design methods and their respective characteristics are studied. In particular, factorial and fractions of two-level, three-level, and mixed-level factorials designs are discussed in greater detail. Statistical methods of experimental data, robust statistics methods; reliability and accuracy of statistical modelling and data analysis are covered with computational examples. Individual projects on applications of material studied will be assigned.

0904909 Turbulent Flow Face-to-Face (3 Credit Hours)

Prerequisite: None

Basic concepts of turbulent flow: statistical descriptions of turbulence. Isotropic turbulence. Homogeneous, shear flow turbulence. Free turbulent shear flows. Wall turbulent shear flows. Principles of measurement methods and techniques in turbulent flows. Turbulence modelling.

0904910 Viscous Flow Face-to-Face (3 Credit Hours)

Prerequisite: None

Navier-Stokes equations. Exact solution of Navier-stokes equations, Stokes and Oseen approximations. Laminar-boundary-layer calculation procedures: Self-similar and non-similar boundary layers, Integral and differential methods. Stability of laminar boundary layer flows, transition to turbulence. Turbulent flow: calculation of boundary-layers wakes and jets, viscous compressible flow

0904911 Convection Heat Transfer Face-to-Face (3 Credit Hours)

Prerequisite: None

Differential and integral equations including continuity, momentum, and energy equations. Solutions of momentum and energy boundary layer equations under laminar and turbulent flow conditions. Similarity transformation and solution methods. External and internal heat transfer by convection in both laminar and turbulent flow regimes. Free convection. Heat transfer enhancement techniques, advanced topics in heat transfer; freezing and ablation heat transfer, microscale heat transfer, large scale environmental heat transfer in atmosphere, open reservoirs and ground.

0904912 Radiation Heat Transfer Face-to-Face (3 Credit Hours)

Prerequisite: None

Introduction to radiative heat transfer, materials radiative properties, radiation energy exchanges between black isothermal surfaces. Radiation energy exchange in an enclosure composed of diffuse gray and direct-non-gray surfaces. Radiation in absorbing, emitting and scattering media.

0904913 Optimal Control Face-to-Face (3 Credit Hours)

Prerequisite: None

Optimal control of continuous time systems: Calculus of variation, LQR, Tracking problem, Output feedback and structured control. Robust output feedback design, Observers and the Kalman filter, LQG, and H∞ design.

0904914 Socio-economic and Environmental Aspects of Energy Blended (3 Credit Hours)

Prerequisite: None

The interactions between energy consumption and supply and socio-economic development; The mechanisms and channels of relations between energy supply and demand policies and economic and social development. A scenario approach which integrates the national and regional energy policies in synergy with the socio-economic development of the region; Basic relations between human needs, human activities, energy services and energy used.

0904915 Wave Propagation in Solid Mechanics Face-to-Face (3 Credit Hours)

Prerequisite: None

Phenomenology of wave propagation (plane waves, harmonic waves, harmonic analysis and synthesis, dispersion, attenuation, group and phase velocity), Elements of wave motion, Wave propagation in unbounded elastic media, plane, cylindrical and spherical waves, Harmonic and transient waves in half-space, Surface waves. Waves in layered media, Waves in rods, experimental and numerical methods. Examples are chosen from elasticity, blood flow, non-destructive evaluation, and other applications.

0904916 Elasticity and Plasticity Face-to-Face (3 Credit Hours)

Prerequisite: None

Stress and strain tensors; Strain-displacement relations; Compatibility equations; Constitutive equations; Plane strain; plane stress; Biharmonic equation; Polynomial solutions; Fourier series solutions; Axisymmetric problems, torsion, bending, yield criteria; Plastic-stress strain relations; Work-hardening; Extremum principles; Plastic potential and uniqueness; Elasto-plastic problems; Plane stress and plane strain (theory of slip-line field with some applications); Geometric effects; Plastic anisotropy.

0904917 Solar Energy and Power Generation Blended (3 Credit Hours)

Prerequisite: None

Introduction. Primary energy and consumption, available solar energy Physics of the ideal solar cell. Light absorption PN junction characteristic values of the solar cell efficiency. Physics of the real solar cell. Charge carrier recombination characteristics, junction layer recombination, and equivalent circuit. Increasing the efficiency. Methods for increasing the quantum yield, and reduction of recombination. Straight and tandem structures. Hetero-junction, Schottky, electrochemical, MIS and SIS-cell tandem cell. Concentrator. Concentrator optics and tracking systems. Technology and properties: types of solar cells, manufacture, single crystal silicon and gallium arsenide, polycrystalline silicon, and silicon thin film cells, thin-film cells on carriers (amorphous silicon, CIS, electrochemical cells) Modules. Circuits.

0904918 Intercultural Competences Online (3 Credit Hours)

Prerequisite: None

Social competences; dimensions of culture; management style in different cultures; signs of conflict; possibilities of conflict resolution; how to give and take feedback; values in different cultures; manners and rules at work; different cultures in meetings; identification of competences. Target is that the students do get a better understanding of different cultures and varying cultural behavior. Additionally, they should get some insight how the German and the European society works.

0904919 Non-Linear Vibrations Face-to-Face (3 Credit Hours)

Prerequisite: None

Vibrations of non-linear single-degree-of-freedom systems; Singular points; Liapunoff function; Approximation techniques used in nonlinear vibration; Perturbation theory for the eigenvalue problem; Stability; Self-excited vibrations; Vibrations of non-linear multi-degree-of-freedom systems; bifurcations and chaos in dynamical systems. For simulation and analysis, this course will use computer programming such as MAPLE and MATLAB.

0904920 Selected Topics in Mechanical Engineering Blended (3 Credit Hours)

Prerequisite: None

This course is delivered according to the availability of staff members in light of the advent of new specializations in the fields of thermal sciences and applied mechanics. The student is not allowed to take this course more than once, even if the subjects are different.

Inclusion rates in the program:

A. Courses that will be taught on the principle of full online:

Course No.	Course Title	Credit Hours	Theory	Practical	Pre/Co-requisite
0904905	Scientific Research (I)	3	3	-	-
0904907	Scientific Research (II)	3	3	-	0904905
0904918	Intercultural competences	3	3	-	-

Total hours that will be taught on the principle of full online in this program: (9 hours).

The percentage achieved for the subjects that will be taught on the principle of full online in this program: (16.67%).

B. Subjects to be taught on the blended learning principle:

Course No.	Course Title	Credit Hours	Theory	Practical	Pre/Co-requisite
0904902	Optimization	3	3	-	0904901
0904904	Experimentation	3	3	-	0904903
0904908	Computational Mechanics and Advanced Techniques	3	3	-	-
0904914	Socio-economic and Environmental Aspects of Energy	3	3	-	-
0904917	Solar Energy and Power Generation	3	3	-	-
0904920	Selected Topics in Mechanical Engineering	3	3	-	-

The total number of hours that will be taught on the principle of blended learning in this program: (18 hours).

Percentage achieved for subjects that will be taught on the principle of blended learning in this program: (33%).

C. Face-to-face learning courses:

Course No.	Course Title	Credit Hours	Theory	Practical	Pre/Co-requisite
0904901	Advanced Mathematical Methods in Mechanical Engineering	3	3	-	-
0904906	Advanced Theoretical Mechanics	3	3	-	0904903
0904903	Continuum Mechanics	3	3	-	-
0904999	Thesis	18	-	-	-

Number of hours of face-to-face education: (27 hours).