Jordan University of Science and Technology

JUST

Faculty of Engineering

Mechanical Engineering Department

A Master's Program Proposal

In Mechanical Engineering

Thermo-fluid sciences

Jordan Universrsity of Science and Technology
Faculty of Graduate Studies

Master of Science in Mechanical Engineering
Program Manual

TABLE OF CONTENTS

SECTION 1. OBJECTIVES, CURRICULUM DESIGN, AND OUTCOMES
1.1 Objectives
1.2 Design of the curriculum
1.3 Expected student outcomes

SECTION 2. PROGRAM EVALUATION AND ASSESSMENT
2.1 Evaluation procedures and assessment strategies

SECTION 3. MECHANICAL ENGINEERING PROGRAM COURSES

3.1 Course titles and classification
3.2 Catalog description of courses

SECTION 1. OBJECTIVES, CURRICULUM DESIGN, AND OUTCOMES

1.1 Objectives

The primary objectives of the program are:

1. To foster high quality graduate level mechanical engineering education and research and to generate graduates with high levels of competence in fundamental and applied concepts of mechanical engineering with focus on thermo-fluid applications
2. To motivate students to seek life-long learning and professional development to help them advance rapidly in their careers and/or doctoral studies.
3. To enhance the students' recognition and understanding of the professional and societal responsibilities associated with working in the industry and academia.
4. To produce graduates well prepared for various mechanical engineering specializations to contribute effectively to the expansion of the country's economic development.
5. To enrich the research collaboration between the university and the industrial sectors in the country and worldwide.
6. To provide opportunities to address industrially important problems and to propose and investigate possible solutions.
7. To produce graduate professionals and leaders in the global industries.

1.2 Design of the Curriculum

The curriculum design includes an integrated thermo-fluid and solid mechanics disciplines. Aimed at fostering competency in

1. conducting quality research and development works;
2. showing mastery of the concepts, methodologies and techniques specific to their field of study;
3. communicating both orally and in writing with a high level of proficiency in their field of study;
4. team and leadership characteristics at work;
5. perform in their field of study at a professional level.

Consequently, the graduates of the mechanical engineering program will be leading in technology transfer and industry modernization. They are prepared to be better decision makers and team leaders of multidisciplinary engineering systems. This is in concurrence with the University mission to enable students to comprehend the dynamism and complexity of contemporary global processes and to empower them to guide these processes in constructive directions.

1.3 Expected Student Outcomes

Graduates of the MS in Mechanical Engineering program will have the following abilities:

1. Integrated systems: Work with, and develop, integrated mechanical systems through all stages. This includes modeling, design, development and fabrication.

2. Leadership: Lead industry modernization and automation effort; make decisions when selecting, procure and commission advanced engineering systems; lead and manage their multidisciplinary technical teams.

3. Innovation: Develop competitive and innovative technical solutions to complex engineering problems while driving innovations into the resulting product.

4. Broad-based: Adapt research and development to achieve optimal technical solutions, and take into account socioeconomic, environmental, and innovative technology.

SECTION 2. PROGRAM EVALUATION AND ASSESSMENT

2.1 Evaluation Procedures and Assessment Strategies

Evaluation will be conducted for the following program elements:

- Curriculum: How the curriculum accomplishes the program objectives?
- Students: How the student demonstrates course outcomes. Performance in class projects and open-ended engineering problems? How student performs on a multidisciplinary team. Are they learning to be innovative and creative?
- Faculty: How are the faculty interacting, motivating and challenging students to be more creative? Are students involved in research activities?
- Resources: How are resources serving program needs? Are they being developed to enhance program elements?

To assess these outcomes, evaluation tools other than regular course work assessment have been developed. These tools are managed, developed, and transformed into corrective measures for all the elements of the program from goals and objectives to individual course introduction, restructuring, or elimination. The assessment tools are as follows:

- Academic oriented tools for online tuning of the program (affecting individual courses)

1. Course portfolios and students' feedback
2. Projects, presentations
3. Comprehensive exams (course option) and thesis defense (thesis option)

- Industry feedback regarding a graduate's performance (affecting short term program goals and objectives)

1. Industry questionnaires
2. Graduate's promotion
3. Leadership of graduates in their workplace
4. Activities of graduates in local, regional, and international professional societies
5. Attracting industry projects and funds
6. Alumni feedback
7. Professional societies feedback
8. Local workshops and seminars

- Program response emerging and projected trends in science and technology (affecting long term and short term program goals and objectives)

1. Faculty participation in major professional meetings
2. Graduates participation in major professional meetings
3. Publication in refereed journals and major conferences
4. Admission to PhD programs in high quality research institutions
5. Partnership with world class institutions in the field

Course Curriculum for Master Degree in Mechanical Engineering / Thermal Power

The Master Degree in Mechanical Engineering is awarded by the Faculty of Graduate Studies at Jordan University of Science and Technology (JUST) upon the fulfillment of the following requirements:

1. Compliance with the J.U.S.T. Master Degree regulations approved by the Dean Council (No. 25/2017), dated 19/6/2017.
2. Successful completion of (34) credit hours in one of the following tracks**:**

First: Thesis Track

1. Compulsory Requirements: (16) credit hours as follows:

Course Symbol and Number	Course Name	Credit
ME 701	Advanced Applied Mathematics	3
ME 703	Numerical Methods For Mechanical Engineering	3
ME 710	Research Methodology	3
ME 741	Advanced Heat Transfer	3
ME 742	Advanced Fluid Mechanics	3
ME 790	Seminar	1

2. Elective Requirements: (9) credit hours from the following*:

Course Symbol and Number	Course Name	Credit
ME 712	Continuum Mechanics	3
ME 713	Finite Element Techniques	3
ME 715	Advanced Vibration	3
ME 716	Advanced Strength of Materials	3
ME 717	Advanced Composite Materials	3
ME720	Renewable Energy Systems	3
ME 729	Energy Conversion Technologies	3
ME 735	Turbo Machinery	3
ME 738	Advanced Internal Combustion Engines	3
ME 743	Combustion	3
ME 744	Advanced Thermodynamics	3
ME 745	Computational fluid dynamics (CFD)	3

ME 747	Advanced Thermal Environmental Engineering	3
ME 748	Compressible Flows	3
ME749	Special Topics in Thermo-fluid sciences	3
ME 760	Advanced Power Plants	3
ME 762	Project Management	3
ME 768	Microfluidics	3
ME 773	Modeling and Simulation of Dynamics Systems	3
ME776	Electro-Pneumatic and Hydraulic Systems	3

* The student may study not more than 6 credit hours from courses of 700 or 800 level offered by other programs related to his field of study upon approval of the Dean of Graduate Studies based on the recommendation of the departmental graduate studies committee.

3. Master Thesis: total of 9 credit hours as follows:

Course Symbol and Number	Course Name	Credit
ME 799 A	Master Thesis	9
ME 799 B	Master Thesis	6
ME 799 C	Master Thesis	3
ME 799 D	Master Thesis	0

Second: Comprehensive Exam Track

1. Compulsory Requirements: (25) credit hours

Course Symbol and Number	Course Name	Credit
ME 701	Advanced Applied Mathematics	3
ME703	Numerical Methods For Mechanical Engineering	3
ME 710	Research Methodology	3
ME 741	Advanced Heat Transfer	3
ME 742	Advanced Fluid Mechanics	3
ME 743	Combustion	3
ME 744	Advanced Thermodynamics	3
ME 745	Computational fluid dynamics (CFD)	3
ME 790	Seminar	1

2. Elective Requirements: (9) credit hours from the following*:

Course Symbol and Number	Course Name	Credit
ME 712	Continuum Mechanics	3
ME 713	Finite Element Techniques	3
ME 715	Advanced Vibration	3
ME 716	Advanced Strength of Materials	3
ME 717	Advanced Composite Materials	3
ME720	Renewable Energy Systems	3
ME 729	Energy Conversion Technologies	3
ME 735	Turbo Machinery	3
ME 738	Advanced Internal Combustion Engines	3
ME 747	Advanced Thermal Environmental Engineering	3
ME 748	Compressible Flows	3
ME749	Special Topics in Thermo-fluid sciences	3
ME 760	Advanced Power Plants	3
ME 762	Project Management	3
ME 768	Microfluidics	3
ME 773	Modeling and Simulation of Dynamics Systems	3
ME776	Electro-Pneumatic and Hydraulic Systems	3

* The student may study 6 credit hours from courses of 700 or 800 level offered by other programs related to his field of study upon approval of the Dean of Graduate Studies based on the recommendation of the departmental graduate studies committee.

3. Passing the Comprehensive Exam (ME 798): zero credit hour.

Catalog Description of Courses

ME 701: Advanced Applied Mathematics
Integral Transforms, Fourier Transforms, Legendre Transforms, two-sided Laplace transforms, special functions (Gamma, Beta, and Bessel functions), Legendre polynomials, and error function. Partial differential equations (different methods of solution). Linear algebra. Applications in Mechanical Engineering.

ME 703: Numerical methods for Mechanical Engineering
Nonlinear algebraic equations, sets of linear algebraic equations, eigenvalue problems, interpolation, curve fitting, ordinary differential equations, and partial differential equations, solution of partial differential equations of the parabolic, elliptic and hyperbolic type. Applications include fluid mechanics, gas dynamics, heat and mass transfer, thermodynamics, vibrations, automatic control systems, kinematics, and design.

ME 710: Research Methodology
Methods of research in advanced fields of mechanical and energy engineering. Design of Experiments. Statistical tools. Methods of solution: analytical, numerical and experimental methods. Measurement systems, instruments and data acquisitions. Report writing: abstract, introduction, analysis, description of the experiment, experimental procedure, results, discussion, conclusions, recommendations and references.

ME 712: Continuum Mechanics
Review of linear algebra and tensor analysis; kinematics of the deformation; deformation and strain tensors; strain rates; balance equations and equations of motion; stress principle; stress power and conjugated stress-strain couples; stress rates; elements of Lagrangian and Hamiltonian Mechanics for discrete and continuum systems; thermo-mechanics and constitutive theory; isotropic and anisotropic hyper-elasticity; composite materials.

ME 713: Finite Element Techniques
Stiffness matrices. Assembly. One- and two-dimensional elements. Vibration Problems. Writing computer programs.

ME 715: Advanced Vibration
Elements of analytical dynamics: Principle of Virtual work, Hamilton's principle and Lagrange's Equation. Forced damped vibration of multi degree of freedom systems. Exact and approximate vibration solutions of continuous systems. Finite Element Method in vibration. Introduction to Experimental Modal Analysis. Machine vibration measurements and analysis for machine fault diagnoses.

ME 716: Advanced Strength of Materials
This course is dedicated to the review and further development of notions of mechanics of materials, including stress, strain, and constitutive laws for linear elastic materials; tension and bending of symmetric beams; torsion of circular bars; statically determinate and indeterminate systems; thin-walled pressure vessels; stress concentration factors. This course aims at providing through understanding of these notions. The notions above will be generalized by addressing non-symmetric beams and prismatic bars; thick-walled pressure vessels; buckling; material response beyond the elastic regime; residual stresses; failure criteria in static loading fatigue; impact stresses.

ME 717 Advanced Composite Materials
This course focuses on fiber-reinforced polymer composites, and covers design, manufacture, analysis, testing and through-life performance of composite structures. The topics covered in the course include design, advanced manufacturing processes, micromechanics, laminate theory, finite element modeling, mechanical properties, fracture and fatigue, durability, damage tolerance, repair and non-destructive evaluation of composites. The course enables students to obtain knowledge, skills and expertise needed for the optimum design and manufacture of advanced composite components and structures.

ME720 Renewable Energy (RE) Systems (3 credit hours)
Scientific and technological fundamentals of renewable energy sources: passive and active solar systems (high, medium and low temperature thermal solar collectors; photovoltaic systems); wind energy; biomass and bio-energy; waste management; hydrogen production, hydroelectric power; geothermal. Practical aspects of renewable energy systems; design development, exploitation and monitoring. Introduction to social, legal and market challenges of RE systems. Prospective of RE technologies, factors affecting the deployment of RE systems.

ME 729: Energy Conversion Technologies
Forms of energy. Development of energy, sources and energy needs. Petroleum. Coal, oil shale and tar sand. Natural gas and hydrogen power. Principles of nuclear power. Conversion of chemical energy into thermal energy, including gas, liquid and solid fuel combustion systems. Conversion of thermal energy into mechanical energy, including power, and heat engine cycles, internal and external combustion systems and turbines. Conversion of thermal energy into electrical energy including thermoelectric converters, thermoelectric systems, electric generators and alternators, solar and fuel cells.

ME 735: Turbo Machinery
Theoretical analysis of energy transfer between fluid and rotor. Principles of axial-, mixed-, and radial-flow pumps and turbines and Compressors. Radial and axial flow compressors (and pumps). Radial and axial flow turbines. Prediction of performance of simple gas turbines. Prediction of performance of multi-spool engines.

ME 738: Advanced Internal Combustion Engines
Fuel-Air cycles; Engine Testing and Control; Gas Exchange Processes; Swirl introduction and measurement; Combustion and Emissions in spark and compression; Ignition Engines; Engine Heat Transfer; Engine Operating and Performance Characteristics.

ME 741: Advanced Heat Transfer
Governing equations. Exact and approximate solutions of: steady and unsteady conduction; forced, natural, and mixed convection. Introduction to radiation.

ME 742: Advanced Fluid Mechanics
Kinematics of fluid motion. Constitutive equations of viscous compressible fluids (tensor notation). Compressible Navier-Stokes system. Special exact and similarity solutions. Admissibility of idealizations and their applications: inviscid, adiabatic, irrotational, incompressible, boundary layer, linearized, and creeping flows. Introduction to potential flows. Introduction to turbulent flows.

ME 743 Combustion
Advanced combustion concepts; chemical kinetics; introduction to turbulent premixed and non-premixed flames; turbulent combustion modeling; multiphase combustion; literature review of recent theoretical, computational, and experimental approaches.

ME 744: Advanced Thermodynamics
Mathematical formulation of thermodynamics (thermodynamics relations), equations of state for real gases, properties departure charts. Availability and irreversibility analysis. Phase equilibrium in one component and multi-component systems. Chemical equilibrium in reacting systems. Entropy generation.

ME 745: Computational Fluid Dynamics (CFD)
Spatial and temporal discretization in CFD, Introduction to grid generation, Finite Volume method, solution of diffusion equation, solution of the Navier-Stokes and energy equations, modeling of turbulent flows, modeling of non-isothermal flows, modeling of multiphase flows, process of modeling in CFD, analysis and quality of CFD simulations. Applications using software packages.

ME 747: Advanced Thermal Environmental Engineering.
Absorption cooling. Cryogenics. Psychrometric processes and applications. Heating and cooling of moist air by external surface coils. Human thermal comfort and Indoor air equality.

ME 748: Compressible Flow
Differential and integral equations for compressible fluid flows; Constitutive equations; Entropy equation; Compressible boundary layers; Area-averaged equations for one-dimensional steady flow; Shock waves; Channel flow with heat addition and friction; Flow in nozzles and inlets; Oblique shock waves; Prandtl-Meyer expansion; Unsteady one-dimensional flow; The shock tube; Acoustics in one-dimension; Potential flow; Linearized potential flow; Lift and drag of thin airfoils.

ME 749: Special Topics in Thermo-fluid sciences
Offered as a structural course in Thermo-fluid Science related topics.

ME 760: Advanced Power Plants
Steam Generators; turbine; condensers and feed-water heaters; Cogeneration and Combined systems; Energy storage; Fuel cell; Economic analysis; Thermodynamic Analysis and Evaluation; Thermodynamic Optimization; Degradation.

ME 762 Project Management
This course focuses on the management and reporting activities of typical engineering development projects. Through seminars and workshops it builds the student's skills at estimating project cost and schedule, keeping a project on track, and handing over the completed project to a customer or another

team. A writing workshop emphasizes techniques for writing proposals, and writing and controlling documentation.

ME 768: Microfluidics

Overview of microfluidics; Passive forces in micro-scale fluid systems; Magnetophoresis, dielectrophoresis and other active forces; Flow mixing; Flow focusing; Multi-phase flow in microfluidics; Lithography and other microfabrication techniques; Research and commercial Applications; Lab on Chip and other emerging applications; Computational and modeling techniques.

ME 773: Modeling and Simulation of Dynamics Systems

Introduction to multi-domain systems. Mechanical, thermal, fluid, electrical, electronic, electromechanical system dynamics, emphasis on modeling and simulation of hybrid systems using modern computer-aided tools.

ME 776 Electro-Pneumatic and Hydraulic Systems

Fluids and fluid flows in high-performance actuators and controllers. Power flow and fluid power elements, valve and pump control, linear and rotary motion. State space descriptions. Design of electrohydraulic position and velocity control servomechanisms for high performance with stability.

ME 790: Seminar

Special topics in Mechanical Engineering presented by post-graduate students, invited speakers from industry and academia.

ME 799 Research Thesis

The thesis is an individual and original work by the student that is completed over a period of two semesters.

ME 799A: M. Sc. Thesis (9 cr.)

ME 799B: M. Sc. Thesis (6 cr.)

ME 799C: M. Sc. Thesis (3 cr.)