Table 3 Compulsory Courses in Aerospace Engineering MSc. Program.

Course Code	Course Name	Credit-ECTS
AAM 501	Scientific Research Methods, Research and Publication Ethics Determining the priorities and conducting research studies on the subject Research methods, Designing, editing and writing a research proposal, Critical research, analysis, validity and reliability principles outlines, Ethics concept and applications.	2-2
AAM 505	Advanced Numerical Methods for Engineers Definitions and mathematical background. Numerical methods for linear and nonlinear algebraic systems. Linear and nonlinear regression, interpolations. Numerical integration and differentiation. Numerical methods for ODEs and systems of ODEs: finite difference and Runge-Kutta methods, adaptive methods, applications. Numerical Methods for PDEs: Finite difference and finite volume/element discretization schemes, analysis of the difference schemes, applications. Optimization.	3-8
AAM 506	Advanced Statistical Methods for Engineers Definitions and mathematical background. Statistical intervals for a single sample. Hypothesis testing for a single sample. Statistical inference for two samples. Simple linear regression and correlation. Multiple linear regression. Design and analysis of single-factor experiments: The analysis of variance. Design of experiments with several factors.	3-8

Table 4 Seminar, Research in Area of Specialization, and Thesis Study in Aerospace Engineering MSc. Program.

Course Code	Course Name	Credit-ECTS
AAM 590	Seminar I Presentations related to the current researches given by academicians and invited speakers.	0-2
AAM 591	Research in Area of Specialization Students acquire advanced knowledge in a field of his choice, to obtain research experience and begin to contribute to the academic literature on the subject is to provide formed. The student in an area of theoretical or experimental, and any subject of interest to learn the latest information for that day, and then the relevant literature to date, is expected to make an original and useful contribution.	0.5-2
AAM 592	Sepical Topics in Aerospace Engineering M.S. students choose and study a topic under the guidance of his/her advisor.	0-28

Table 5 Field Courses in Aerospace Engineering MSc. Program.

Course Code	Course Name	Credit-ECTS
AAM 520	Aviation Meteorology The Atmosphere, Heat Exchange Processes, Air Temperature, Density and Pressure, Atmospheric Stability, Moisture in the Atmosphere, Clouds, Wind, Thunderstorms and other Hazards, Major Weather Systems and Patterns, Meteorological Services for Aviation	3-8
AAM 521	Remote Sensing & Radiation The nature of the electromagnetic spectrum, the laws of radiation and physical principles of remote sensing. Interaction of radiation with the atmosphere and Earth surface. Introduction to remote sensing platforms and sensors; data capture and data types. Basic image pre-processing: noise & artefact removal, radiometric correction, atmospheric correction, geometric correction. Simple visual and numerical enhancement techniques for digital imagery; such as contrast stretching, convolution filtering, and hard classifiers. The theory of filter construction in the spatial and spectral domains; to include smoothing filters, edge enhancement filters and directional filters, Fourier filtering, and the problem of artefacts. Image histogram manipulation through linear and non-linear transforms. Visible to thermal infrared wavelength imaging. The basic principles of microwave remote sensing and	3-8

	RADAR. Photo-interpretation of aerial photographs, and analogue photogrammetric techniques.	
AAM 522	Cloud Physics Cloud condensation nuclei, formation of cloud droplets. Growth of cloud droplets by condensation and coalescence. Formation and growth of ice crystals. Mixing of air masses and convection. Precipitation processes, weather radar, thunderstorms, hail. Numerical cloud models.	3-8
AAM 527	Hydrometeorology and Renewable energy Definitions, brief history, meteorological measurements, hydrological cycle. General characteristics of the atmosphere: Origin, composition, vertical structure. Thermodynamics of the atmosphere: Laws of thermodynamics, laws of perfect gasses, water vapour in the atmosphere, changes of phase, changes of state. Radiation in the atmosphere – Energy budget. Atmospheric circulation: Atmospheric pressure and winds, regional and global meteorological systems, air masses, fronts, cyclones. Wind power. Transfer processes between atmosphere and land – vegetation – water surfaces. Evaporation and Transpiration: Energy approach, aerodynamic and combined approach. Precipitation: Physical context, meteorological context. Probable maximum precipitation: concept and estimation methodologies. Telemetric methods of precipitation measurements: satellite measurements, weather radar measurements. Hydrological models of precipitation forecasting. Introduction to climatology. Climatic variability and climatic change.	3-8
AAM 528	Air Pollution Basic concepts in physics and chemistry of the atmosphere. Production, transformation, transport, and removal of air pollutants. The problems of photochemical smog, the greenhouse effect & climate change, stratospheric ozone, acid rain, and visibility. Analytical techniques for gases and particles. Numerical simulation of air pollution. Health and environmental effects of air pollution in the developed and developing world.	3-8
AAM 529	Meteorological Instruments Problems related to time series analysis, sampling theorem, time constant and sampling rate. Theoretical analysis of different sensors for temperature, humidity, wind, and pressure. Discussion of effects disturbing the instruments. Principles of active and passive remote sensing. Measuring turbulent fluxes (e.g. heatflux) using eddy-correlation technique. Discussion of technical realizations of complex observing systems (radiosondes, automatic weather stations, radar, wind profilers). Demonstration of instruments.	3-8
AAM 530	Astro Physics and Dynamics This course provides an overview of the physical phenomena at play in the astronomical objects surrounding us, from planets and stars to the cosmic filaments, from galaxies such as our own Milky Way to large galaxy clusters. The course emphasizes the links between theoretical predictions and observations. This course covers the fundamentals of astrodynamics, focusing on the two-body orbital initial-value and boundary-value problems with applications to space vehicle navigation and guidance for lunar and planetary missions, including both powered flight and midcourse maneuvers. Other topics include celestial mechanics, Kepler's problem, Lambert's problem, orbit determination, multi-body methods, mission planning, and recursive algorithms for space navigation.	3-8
AAM 531	Hypersonic Flow Developing an understanding of inviscid hypersonic flows, viscous hypersonic flows and high temperature effects as they apply to hypersonic aerodynamics.	3-8
AAM 532	Impact Dynamics and Spacecraft Protection The consequences of resulting impacts can range from small surface pits for μm-size impactors, via clear hole penetrations for mm-size objects, to partial or complete destruction via shockwaves for projectiles larger than a few centimeters. The most probable impact velocities are in the range from 0 to 15 km/s for space debris, and between 5 km/s and 30 km/s for meteoroids (denoted as hypervelocity impacts or HVI). At such speeds, the impact of an aluminum sphere of 1 cm diameter deploys the same energy as an exploding hand-grenade, with equally devastating consequences, unless special protection measures are applied.	3-8
AAM 533	Rarefied Gas Dynamics Rarefied gas flows, Gas flow regimes based on the Knudsen Number, low density and micro gas flows, kinetic theory, molecule collisions, Fundamentals and simulations of the rarefied gas flows using direct simulation Monte Carlo method.	3-8

AAM 534	Electric Propulsion Review of Maxwell Equations, plasma physics, and electric propulsion techniques, kinetic theory and particle-in-cell solvers.	3-8
AAM 535	Interplanatery Navigation and Control Interplanetary trajectory construction; patched and multiconic techniques. Methods of orbit and attitude determination; applied Kalman filtering. Guidance algorithms and B-plane targeting. Interplanetary navigation utilizing in situ and radio techniques.	3-8
AAM 536	Advanced Materials in Space Constant swirls of innovative ideas are starting to push composites and hybrid metal-composite components for use in an ever expanding circle of products. Recent discoveries of Graphene/Au composites have invigorated innovations for its application to aerospace and space products.Attributes such as a low CTE, stiffness, and light weight attract other manufacturers of smaller products to use composites for enhanced performance and durability.The uses and economics of composites is an enormously broad subject. Examples of composite materials will be described in this course to provide samples of applications selected for their far reaching potential to enhance product performance.	3-8
AAM 537	High Power Lasers Performance parameters for each major class of lasers, high-power gas, chemical, and free-electron lasers and then discusses semiconductor diode lasers, along with the associated technologies of packaging, reliability, and beam shaping and delivery. Current research and development in solid-state lasers as well as scaling approaches for high CW powers, high pulse energies, and high peak powers.	3-8
AAM 538	Space Mission Analysis and Design Mission design, from orbit selection to ground operations. This course updates the technology, provides greater emphasis on small spacecraft design and the cost-reduction process, and includes more detail on multi-satellite manufacturing, space computers, payload design and autonomous systems.	3-8
AAM 539	Advanced Aerodynamics 2-D Potential flow, Lifting-line theory, 1-D gas dynamics, shock and expansion waves, incompressible and compressible viscous flow, ideal cycle analysis of a turbojet engine.	3-8
AAM 540	Aeroelasticity Introduction to aeroelasticity and aeroelastic phenomena, illustration of aeroelastic phenomena using simplified aerodynamic and structural models, subsonic and supersonic aerodynamic models for aeroelastic analysis, structural models for aeroelastic analysis, aeroelastic response to arbitrary excitation, aeroelastic models in state-space format, introduction to nonlinear aeroelasticity introduction to aeroelastic control, aeroelastic aspects in the design of aircraft, numerical aeroelastic calculations using software.	3-8
AAM 541	Advanced Flight Dynamics and Control Analytical tools, static stability and control concepts, unsteady motion, stability derivatives, stability of uncontrolled motion, open loop response to actuation of controls, closed loop control of aircraft	3-8
AAM 542	Nonlinear Control of Flight Vehicles Nonlinear system analysis: basic notions on dynamic systems; state equations; basic stability concepts; Lyapunov stability. Overview on different approaches: linearization and gain scheduling; feedback linearization; embedded model control; sliding-mode control; nonlinear model predictive control. Observer design for nonlinear systems: extended Kalman filter. Aerospace topics: coordinate reference systems; rotations and translations; rigid body attitude kinematics and dynamics; orbital dynamics. Aerospace applications/case studies will be about spacecraft orbit/trajectory control; spacecraft attitude control; aircraft flight control.	3-8
AAM 543	Viscous Flow	3-8

	Derivation and discussion of the basic equations for viscous fluid flow, including heat conduction and compressibility. Molecular background for viscosity. Exact solutions like; Couette flow, Stokes 1. and 2. problem, Hiemenz stagnation point flow, Von Karman flow near a rotating disk. The boundary layer approximation, Blasius and Falkner-Skan solutions, effects of pressure gradient; Pohlhausen's method, criteria for separation. Non-steady boundary layers. Stability of laminar flow, Kelvin-Helmholtz instability, Orr-Sommerfeld equation and transition to turbulence.	
AAM 544	Engineering Optimization One-dimensional optimization problems, multi-dimensional optimization problems, constrained optimization problems, generalized reduced gradient method, optimization case studies.	3-8
AAM 545	Advanced Heat and Mass Transfer General conservation equation for transport phenomena and basic laws; Basic concepts and definitions in mass transfer; Conservation equations for mixtures; Simultaneously heat and mass transfer. Analogy between momentum, heat and mass transfer; Heat and mass transfer in climatology; Equations of turbulent boundary layer. Eddy fluctuations.	3-8
AAM 546	Turbomachinery Dimensional Analysis, Cavitation, Euler's Equation of Motion, Definitions of efficiency, Cascade Analysis (two-dimensional), Lift and Drag, Cascade Test Results, Off-Design Performance, Thermodynamics of Axial Flow Turbine Stage, Stage losses and efficiency, Soderberg Correlation, Theory of axial flow turbines, Turbine flow characteristics, Multistage Turbine, Two-dimensional Analysis of Axial Flow Comp, Axial flow compressor stage losses and efficiency, Stage loading, Stage Pressure Rise, Pressure ratio of Multi-stage compressor, Characteristics Map of axial flow compressor, Three-dimensional flows in Axial Turbomachines, Theory of Radial Equilibrium, Blade design, Off-design performance analysis, Centrifugal compressor, Pump, Fans, Theoretical analysis of centrifugal compressor, Concept of Pre-whril, slip Factor in Centrifugal Comp, Radial Flow Turbines, Types of inward Flow radial Turbines	3-8
AAM 547	Composite Materials Mechanic Composite materials: types, properties, applications, fibers, matrices, forming processes., Micro-mechanics approaches (homogenization theories)., Anisotropic elasticity. Behavior of a single layer (micro- and macro-mechanics)., Classical laminate theory: constitutive equations, strength criteria, simple computation methods, inter-laminar stresses and edge effects. Bending, vibration and buckling of anisotropic laminated plates. Basic equations and energy methods (finite elements). Hygro-thermo-elasticity. Experimental methods for material properties measurement.	3-8
AAM 548	Turbulent Flows Turbulence: its production, dissipation, and scaling laws. Reynolds averaged equations for momentum, energy, and species transfer. Simple closure approaches for free and bounded turbulent shear flows. Applications to jets, pipe and channel flows, boundary layers, buoyant plumes and thermals, and Taylor dispersion, etc., including heat and species transport as well as flow fields. Introduction to more complex closure schemes, including the k-epsilon, and statistical methods in turbulence.	3-8
AAM 549	Aeroacustics Computational issues unique to aeroacoustics. Optimized dispersion-relation-preserving marching algorithms with minimal numerical dispersion and dissipation. Radiation, inflow, outflow and wall numerical boundary conditions Artificial selective damping; choice of damping stencils and mesh Reynolds number. Nonlinear wave propagation, shock capturing and multi-scale aeroacoustics problems. Examples of applications to aircraft, automobile and flow noise problems.	3-8
AAM 550	Numerical Combustion Turbulence modelling: Introduction, Direct numerical simulation (DNS), Large-Eddy • Simulations (LES), Turbulent-viscosity models, Reynolds stress models (RSM) • Turbulent combustion: Transport equations for species and enthalpy, Scales in • Turbulent combustion, Combustion types and regimes • Non-premixed turbulent combustion: Examples, Mixture fraction, Combustion • Turbulence - chemistry interaction and Models	3-8

	• Premixed turbulent combustion: Examples, Burning velocity, Regimes, Bray-Moss- • Libby model (BML), Other models	
AAM 551	Aircraft Guidance Navigation and Control Mathematical modeling and simulation of vehicles in 6 degrees of freedom. This includes mathematical modeling of aircraft and unmanned aerial vehicles (UAV). Introduction to aerodynamics, hydrodynamics and sealoads as well as mathematical modeling of the environment (waves, ocean currents and wind). Kinematics (Euler angles and quaternions), transformations, rotation matrices, geographical and body-fixed coordinates systems, rigid-body kinetics and vectorial mechanics.	3-8
AAM 552	Neurotechnology Applications in Aerospace Engineering This course consists of a basic introduction to neural information processing systems, neurocomputation, and deep neural networks followed by readings from the current literature the applications of neural processsing for sensory, reactive and cognitive autonomy, neural indoor navigation systems and machine intelligence in science, technology and the future of small autonomous drones.	3-8
AAM 553	Nanotechnology and Smart Materials in Aerospace Engineering This course consists of a basic introduction to nanotechnology and functional materials, followed by readings from contemporary literature of the techniques used to develop smart, functional, nanostructured materials that has applications in aerospace engineering including fibers, composites, nano-enhanced structural materials, Bragg fibers for structural testing and materials for nanophotonics.	3-8
AAM 554	Advanced Dynamics The aim of this course is to present the dynamics of particles and rigid bodies using vectorial and analytical methods. The topics include: vector analysis, curvilinear coordinates, change of coordinates, relative motion analysis, inertial/noninertial frames of reference, moment of inertia tensor, principal axes, Euler's equations of motion, Euler angles, gyroscopic motion, generalized coordinates, degrees of freedom, holonomic/nonholonomic constraints, generalized forces, Hamilton's principle, Lagrange equations of motion, Hamilton's equations of motion.	3-8