AEROSPACE ENGINEERING

CURRICULUM

Professional Master's Diploma

DIPLOMA REQUIREMENTS

	PMDip Aerospace Design Management	**Credits**
AE8201	Aircraft Certification	1
AE8202	Aircraft Safety & Reliability	1
AE8203	Aircraft Systems Integration	1
AE8141	Adv Aero Manufacturing	1
AE8000	Diploma Report	Pass/Fail

Master of Applied Science

DEGREE REQUIREMENTS	**Credits**
Master's Thesis	(Milestone)
Five Elective credits	5

Master of Engineering

DEGREE REQUIREMENTS

Master's Project*	(Milestone)
Eight Elective credits	8

*students may apply to substitute 2 courses for the project.

Doctor of Philosophy

DEGREE REQUIREMENTS

Candidacy Examination	(Milestone)
Dissertation	(Milestone)
Four Elective credits	4

Electives		**Credits**
AE8102	Adv Fluid Mechanics	1
AE8104	Advanced Heat Transmission I	1
AE8105	Advanced Heat Transmission II	1
AE8106	Adv Mechanics of Solids	1
AE8108	Aircraft Turbine Engines	1
AE8112	Comp Fluid Dyn/Heat Transfer	1
AE8115	Finite Element Methods in Engr	1
AE8116	Flight Dyn/Control of Aircraft	1
AE8119	Intro to Composite Materials	1
AE8121	High Speed Aerodynamics	1
AE8129	Rocket Propulsion	1
AE8133	Space Mechanics	1
AE8135	Directed Studies/Aerospace Eng	1
AE8137	Advanced Systems Control	1
AE8138	Computational Dynamics	1
AE8139	Multi-Discip. Design/Aero Syst	1
AE8140	Adv Aero. Structural Design	1
AE8141	Adv Aero Manufacturing	1
AE8142	Aero Thermal Engineering	1

AE8143	Avionics and Navigation	1
AE8144	Comp Meth in Aero Analysis	1
AE8145	Nanomaterials and Nanocomposite	1
AE8146	Applied Aerodynamics	1
AE8147	Testing and Evaluation of Composites	1
AE8148	Spacecraft Dynamics and Control	1
AE8149	Aerospace Systems Design	1
AE8150	Special Topics: Aerodynamics & Propulsion	1
AE8151	Special Topics: Structures & Manufacturing	1
AE8152	Special Topics: Avionics & Systems	1
AE8201	Aircraft Certification	1
AE8202	Aircraft Safety & Reliability	1
AE8203	Aircraft Systems Integration	1

COURSE LISTING

Master's Thesis
The student is required to conduct advanced research on a topic related to one (or more) of the following fields: aerodynamics and propulsion; aerospace structures and aerospace manufacturing; and, avionics and aerospace systems. The topic is chosen in consultation with the student's thesis supervisor, the student presents the research plan in writing, and the research is carried out under the direction of the supervisor and monitored by a guiding committee. The student must submit the completed research in a thesis format to an examination committee and make an oral presentation of the thesis to this committee, which will assess and grade the thesis. Through the thesis, the student is expected to furnish evidence of competence in research and a sound understanding of the specialty area associated with the research. This is a "Milestone." Pass/Fail

Master's Project
The student is required to conduct an applied advanced research project involving one (or more)of the following fields: aerodynamics and propulsion; aerospace structures and aerospace manufacturing; and, avionics and aerospace systems. The student presents the project plan in writing, and the project is carried out under the guidance of the supervisor and monitored by a guiding committee. The student must submit the completed project in the form of a technical report to an examination committee and make an oral presentation of the report to this committee, which will assess and grade the report. This is a "Milestone." Pass/Fail

Candidacy Examination
The examination consists of two parts: (i) a written examination of three hours duration, the questions to be set by the student's Supervisory Committee; and (ii) an oral defense of (a) the written examination, and (b) dissertation proposal. This is a "Milestone." Pass/Fail

Dissertation
The student is required to conduct advanced research on a topic related to one (or more) of the following fields: aerodynamics and propulsion; aerospace structures and aerospace manufacturing; and, avionics and aerospace systems. The topic is chosen in consultation with the student's thesis supervisor. The student will prepare and present a detailed research proposal prior to starting the work. The research is carried out under the direction of the supervisor(s). The student must submit the completed research in a thesis format to an examination committee and make an oral presentation of the thesis. The thesis must present original research that makes a significant contribution to knowledge in the field of study. Through the thesis, the student is expected to furnish evidence of competence in research and a deep understanding of the specialty area associated with the research. This is a "Milestone." Pass/Fail

AE8000 Diploma Report
A final report is expected to analyze a current aerospace design management concept that has significant impact at the diploma candidate's place of work, or is clearly articulated in an industry case study. This report should describe, define, and provide meaningful and realistic recommendations to a specific problem in aerospace design management, organization, operation, or certification compliance. And while the diploma candidates are all encouraged to define the scope, range, and format of their individual final reports, the report topics must all be pre-approved by the Diploma Report Coordinator. Pass/Fail

AE8102 Advanced Fluid Mechanics
A general review of principles, concepts and methods in fluid dynamics will be conducted. Advanced treatment with mathematical techniques for solving specific classes of fluid-flow problems will be introduced, including: surveys of governing equations and basis theories; two and three-dimensional potential flows; surface waves; boundary-layer theory; and, shock-wave phenomenon. Antirequisite ME8102. 1 Credit

AE8104 Advanced Heat Transmission I
An advanced study of the transmission of heat by conduction and convection. Derivation and application of their equations governing steady and unsteady conduction heat transfer, transient conduction, and numerical solutions are examined with selected topics. Governing equations for forced and natural convection; dimensional analysis and similarity transforms are applied. Antirequisite ME8104. 1 Credit

AE8105 Advanced Heat Transmission II
An advanced study of the transmission of heat by radiation. Topics covered include: physical properties of radiation, thermal radiation laws, characteristics of real and ideal systems, geometric shape factors, grey and non-grey system analysis, energy transfer in absorbing media and luminous gases, solar radiation. Antirequisite ME8105. 1 Credit

AE8106 Advanced Mechanics of Solids
The class provides an introduction to the general equations of the theory of elasticity of an anisotropic solid. Elastic equilibrium and boundary value problem formulations are considered. The theories of thermoelasticity, viscoelasticity and plasticity are introduced. The class also provides an introduction to modelling of inhomogeneous composite solids, the effective moduli theory, and the elasticity of composite laminates. The fundamentals of fracture mechanics and applications to mechanical design are considered. Antirequisite ME8106. 1 Credit

AE8108 Aircraft Turbine Engines
Fluid mechanics, thermodynamics, and solid mechanics of aircraft turbine engines. Two-dimensional and three-dimensional flow theories of compressors and turbines. Unsteady flow and noise production in turbomachinery and in complete engines. Operational limitations and instabilities. Stress and associated temperature limits and influence of blade cooling techniques on turbines. Antirequisite ME8108. 1 Credit

AE8112 Computat. Fluid Dynamics & Heat Transfer
The finite difference discretization method is applied to the solution of the partial differential equations arising from the mathematical modelling of fluid flow, heat transfer and combustion processes. The equations can be parabolic, elliptic or hyperbolic. Items like convergence, stability, consistency, numerical diffusion and turbulence modelling will also be presented. Antirequisite ME8112.
1 Credit

AE8115 Finite Element Method in Engineering
This class presents formulation and implementation of the Finite Element Method (FEM) in engineering applications. The theory of variational and weighted residual methods is introduced. Different types of elements used in FEM for discretization of PDEs, such as linear, quadratic, isoparametric and hybrid elements are covered. The numerical methods selected for spatial integration, solution of linear algebraic equations, evaluation of eigenvalues are addressed. Antirequisite ME8115. 1 Credit

AE8116 Flight Dynamics and Control of Aircraft
Various analyses and tools for designing a controllable aircraft. Six-degree-of-freedom flight simulation models. Classical and modem control system techniques. Adaptive control. Digital control. Pilot-in-the-loop considerations. Antirequisite ME8116. 1 Credit

AE8119 Introduction to Composite Materials
Intended as a first course in polymer-based fiber-reinforced composite materials. Quasi-isotropic random reinforcement, orthotropic, anisotropic and sandwich construction. Classical laminate theory: lamina/laminate stress, buckling and vibration analysis. Hydrothermal, radiation and service effects on performance. Impact, delamination and fatigue failure. Overview of basic manufacturing methods and usage in the aerospace industry. Antirequisite ME8119. 1 Credit

AE8121 High Speed Aerodynamics
Planar and conical shock waves. Expansion and shock wave interference, shock tubes. Method of characteristics. Supersonic nozzle design. Airfoil theory in high subsonic, supersonic and hypersonic flows. Conical flows. Yawed, delta and polygonal wings; rolling and pitching rotations. Wing-body systems. Elements of transonic flows. Antirequisite ME8121. 1 Credit

AE8129 Rocket Propulsion
Theory, analysis and design of rocket propulsion systems. Emphasis on liquid and solid propellant systems with an introduction to advanced propulsion concepts. Review of nozzle and fluid flow relationships. Antirequisite ME8129. 1 Credit

AE8133 Space Mechanics
Motion in outer space poses complex engineering problems, the solution of which require a thorough knowledge and understanding of the pertinent principles of mechanics and techniques of analysis. The class provides an introduction to such topics as astromechanics, satellite orbits, rotating structures with varying configuration and mass, optimization of spacecraft motion, launch dynamics, microgravity, space robotics, large displacement low frequency vibrations, ground-based and in-orbit testing. Antirequisite ME8133. 1 Credit

AE8135 Directed Studies in Aerospace Eng.
This course is available to graduate students enrolled in Aerospace Engineering, who wish to gain knowledge in a specific area for which no graduate level courses are offered. Students are required to present a formal report, or take a formal examination, at the end of the course. Registration approval is required from the Graduate Program Director. 1 Credit

AE8137 Advanced Systems Control
Overview of classical controls and introduction to modern control theory. Control system modeling and analysis in state space. System controllability and observability. Pole placement control design. State observers. Introduction to nonlinear control systems. Fundamentals of Lyapunov theory. Lyapunov's direct method. System linearization. Adaptive control. Antirequisite ME8137.
1 Credit.

AE8138 Computational Dynamics
The objective of this course is to study the basic modeling and computational methods for rigid and flexible multi-body systems. Computational dynamics provides a fundamental tool for analyzing and computing the motion and force for large complex mechanical

systems, such as robots, mechanisms, machines, automobiles. Applications of computational dynamics include analysis, design and control. Analysis is to study system behaviours for given inputs through modelling and simulation. Design is to determine the prescribed functions through synthesis and optimization. Control is to control mechanical systems based on the dynamic model. Antirequisite ME8138. 1 Credit

AE8139 Multi-disciplinary Design Optimization of Aerospace Systems
Aerospace systems modeling for design and optimization. MDO concepts including selection of design variables, objective functions, and constraints. Decomposition in multi-disciplinary, coupling variables and sensitivity analysis. Soft computing in MDO. Overview of principles, methods (such as Multi-disciplinary feasible, Individual discipline feasible , Concurrent subspace optimization, Collaborative optimization, and Bi-Level Integrated Synthesis System) and tools (such as iSIGHT) in MDO for aerospace systems. 1 Credit

AE8140 Advanced Aerospace Structural Design
Structural design from a fatigue perspective involving fail-safe, safe-life and damage tolerance methodologies applied to aerospace structures manufactured from advanced materials. Major focus will be on integral aerospace structures manufactured by laser welding, laser consolidation, autoclave curing, resin-transfer molding, and adhesive bonding processes. Advanced computation techniques will be used for structural design and analysis. 1 Credit

AE8141 Advanced Aerospace Manufacturing
Aerospace manufacturing systems will be introduced at both system and machine level. The system level includes convention systems and emerging systems in terms of product quantity and variety. Conventional systems cover job shops (low quantity, high variety, such as aircraft assembly), manufacturing cells (medium quantity, medium variety, such as wing assembly), and transfer lines (high quantity, low variety, such as turbine blades manufacturing). Emerging systems cover reconfigurable systems that can be changed from a type of the conventional system to another. The machine level includes computer controlled machines and robots. The course project will focus on automation of manual processes using robotic technologies. 1 Credit

AE8142 Aerospace Thermal Engineering
Review of heat transfer fundamentals. Steady state and transient problem modeling and
computational solution techniques. Thermal management in avionics systems, jet engine components, and aircraft and spacecraft structures. Thermal management of high-speed flight, energy management and vehicle synthesis. Nucleonics, and heat transfer of nuclear-heated rockets. Thermal management in micro-propulsion systems. Applications to electronic packages, solar arrays, cryogenic and optical systems. 1 Credit

AE8143 Avionics and Navigation
This course studies navigation and estimation for air, ground, and space vehicles. We consider state estimation strategies that utilize inertial navigation systems as well as those that use external navigational aids such as GNSS and other sensor systems. Modern aircraft and spacecraft avionics systems will be studied, with particular emphasis on predicting performance and accuracy.
1 Credit

AE8144 Computational Methods in Aerodynamic Analysis
An introduction to the development of computational fluid dynamics used in aerodynamic analysis. The equations of compressible fluid dynamics and their classification will be studied. Topics in finite difference methods such as discretization, numerical stability, time marching techniques and boundary conditions will be explored using selected problems. Grid generation methods applied to structured and unstructured grids are used in solution development. The course will focus on algorithm characteristics and will rely on computer programming skills. 1 Credit

AE8145 Nanomaterials and Nanocomposities
This will be a survey course introducing some of the fundamental principles behind nanotechnology, emphasizing on nanomaterials, nanocomposites and their aerospace applications. Diverse nanomaterials and their unique mechanical, electronic, magnetic, chemical and biological properties will be reviewed. Nanoscale characterization working principles and instruments will be introduced. Various nanomaterials synthesis methods will be covered. Processing and application of nanocomposities will be discussed in detail. 1 Credit.

AE8146 Applied Aerodynamics
This course introduces students to analytical and numerical methods applicable to airfoils and wings. Students will be able to model two- and three-dimensional flows. Students will understand how to estimate lift, drag and moment of wings using analytical and numerical methods. Students will have an understanding of high-lift systems and of rotor aerodynamics. 1 Credit

AE8147 Testing and Evaluation of Composites
Quality assurance of composites; theory and practice for the determination of tensile, compressive, and shear properties of composite materials and sandwich structures; techniques for the determination of physical and chemical properties of composites; environmental testing of composite materials and structures; non-destructive techniques such as ultrasonic, acoustic emission, infrared, and lasers for evaluation of composite structures. Project on selected topics of current interest. 1 Credit

AE8148 Spacecraft Dynamics and Control
This course presents advanced methods of modelling spacecraft orbital and attitude dynamics, as well as advanced methods of orbital and attitude control. Topics covered include Lagrangian and Hamiltonian dynamics formulations, flexible spacecraft modeling, dynamical systems approach to orbital mechanics, input-output control methods and application to attitude control, optimal control and applications to low thrust trajectory design 1 Credit

AE8149 Aerospace Systems Design
Students will work as part a small team to produce a design of a special-purpose aerospace system. The project will be assigned with an emphasis on mission requirements, subsystem-oriented, team-based engineering methodology, performance modelling, optimization and trade-off studies, to produce a design that is both viable and comprehensive. Specific projects will alternate between aircraft and spacecraft applications and project details will be provided before the start of the course. 1 Credit

AE8150 Special Topics: Aerodynamics & Propulsion
This course consists of lectures, seminars, and readings covering the latest advances and research in the fields of Aerodynamics and Propulsion. The course description will be announced prior to scheduling of the course. 1 Credit

AE8151 Special Topics: Structures & Manufacturing
This course consists of lectures, seminars, and readings covering the latest advances and research the field of Aerospace Structures and Manufacturing. The course description will be announced prior to scheduling of the course. 1 Credit

AE8152 Special Topics: Avionics & Systems
This course consists of lectures, seminars, and readings covering the latest advances and research in the field of Avionics, Controls, and Systems Engineering. The course description will be announced prior to scheduling of the course. 1 Credit

AE8201 Aircraft Certification

The objective of this course is to give an understanding of the aircraft certification process in Canada, the oversight structure, and the relationship between aircraft certification in Canada and jurisdictions throughout the world. The course will concentrate on the role of Transport Canada in regulation, and the design approval structure within large aerospace manufacturers in Canada. 1 Credit

AE8202 Aircraft Safety & Reliability
Assessing aircraft safety and reliability is an integral part in the aircraft certification process. This course provides an understanding of Reliability, Maintainability, and Safety (RMS) principles, and highlights the role of RMS in aircraft design for certification and airworthiness. The1 course covers the mathematics of reliability analysis, failure modes, and fault-tree analysis. Safety assessment procedures are examined in the context of real-world examples. 1 Credit

AE8203 Aircraft Systems Integration
This course introduces integration of many key systems found in the design of an aircraft. The course will examine flight control systems, propulsion systems, hydraulic systems, electrical systems, environmental systems, avionic systems and safety systems. The course will consider system integration in the context of aircraft reliability and the certification process. 1 Credit

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