University of Glasgow

SINGAPORE INSTITUTE OF TECHNOLOGY

Brief module descriptions related to **BEng (Honours) in Aerospace Engineering**

Year 1 – Trimester A

Engineering Mathematics I	This module refreshes the mathematics skills required to describe the engineering principles in this course. It commences with a review of the concept of functions and then discusses the basic concepts of limits, differentiation and integration followed by applications of the differential and integral calculus. The course ends with an introduction to complex numbers, vectors and matrices that prepare the students for other modules in Year 1 and provides a strong foundation in mathematics.
Engineering Physics I	What are the underlying physics of an unmanned aerial vehicle (UAV)? This module teaches the fundamental principles of mechanics and thermodynamics and their applications in engineering with application to aircraft. Necessary applied mathematical skills for advanced learning of engineering courses.
Engineering Mechanics	This module focuses on the physical and mathematical fundamentals on which engineering products are based on and aims to establish a firm foundation for the development of design skills and applications in the programme. The module introduces students to mathematical models of mechanical systems and simple UAV designs.
Fundamentals of Electronics & Circuits	This module introduces the electronic aspects of unmanned vehicles and focuses on developing a basic understanding of the principles of analogue circuits. Students will study methods for calculating the behaviour of analogue circuits, including topics such as Ohm's Law, Kirchhoff's Laws; voltage and current generators both ideal and practical; Thèvenin and Norton Theorems; superposition; nodal analysis and AC circuit analysis using complex numbers. These topics will be demonstrated in practical lab sessions on essential UAV components.
Fundamentals of Programming	Programming is key to automating any engineering product such as UAVs. This module therefore introduces the basic concepts in programming (Data types, Control structures, Functions, Arrays, pointers, Files) and the running, testing and debugging of scripts and programmes. Programming concepts are demonstrated in a variety of languages and practiced in a standard programming language (C) which is used to programme the autopilot in most UAV applications. The module will also introduce students the best practices in secure coding such as input validation and issues such as integer exploits and buffer overflows.
Engineering Design	Understanding engineering designs is a basic skill expected of all engineers. During the module students learn how to generate 2D drawings and 3D computer models which are universal means of communicating design ideas and allowing the idea to be converted into physical products. Topics covered include: 3D visualization and spatial reasoning; engineering sketching; basic descriptive geometry; fundamentals of orthographic projection; parametric and feature-based solid modelling; assembly modelling; geometric dimensioning and tolerance; drawing convention and presentation of 3D geometry on 2D media. Students will use computer-aided design (CAD) software as the major tool for graphical analysis and design of a basic UAV concept.

Year 1 – Trimester B

Engineering Mathematics II	This module provides an extension of the basic concepts of differentiation and integration learned in Engineering Mathematics I which builds the foundation for the advanced engineering modules in this course. It covers operations of functions with multiple variables, advanced applications of differential and integral calculus, as well as series and ordinary differential equations.
Dynamics	This module introduces students to modelling and analysis of dynamic systems, with emphasis on free and forced oscillations, and investigation of the system response. In addition, the solution of the resulting differential equations and the application to simple vibration problems will be discussed.
Control	The module aims to introduce students to the problems of automatic control, with practical illustrations on UAVs,to provide a basic understanding of techniques used to model engineering systems and to allow students to gain a physical understanding of the factors influencing the steady-state and dynamic response of practical systems. The module also provides an understanding of the time-domain and frequency-domain methods of analysis of control systems, an understanding of the properties of proportional, integral and derivative controllers and to allow students to gain experience of real closed-loop control systems and to learn about analysis methods using computer-based techniques.

Effective Communications	This module aims to help students develop effective written and oral communication skills through academic essay and reflective writing, technical report writing, small group discussions, oral pitching and presentation to technical and non-technical audiences. A process-based, reading-into-writing approach is adopted so that students have the chance to learn/unlearn/relearn from the multiple drafting experience of each writing assignment. For the principal instructional focus of the module, a project-based approach is used that requires teams of students to explore authentic engineering problems and develop viable solutions within real-world contexts. Students will read discipline-specific articles, do writing assignments and a project with an engineering focus, and interview engineers or related experts, thus facilitating greater acquaintance with the field.
Aerospace Engineering Skills	This module is a compilation of workshops that deliver brief introductions to tools, techniques and methodologies for aerospace engineering and UAVs. To provide a holistic view of the engineering profession the module will also focus on project management, sustainability, ethics, renewable and green energy.
Fluid Mechanics	Understanding the fluid motion around aircraft is crucial in predicting the vehicle response. Hence, this module provides a grounding in the fundamental methods of fluid mechanics in both static and dynamic situations. It also introduces general principles such as dimensional analysis, which are widely applicable in engineering and will demonstrated on a scaled model of a UAV.

Year 2 – Trimester C

Engineering Mathematics III	This module completes the series of mathematics modules in the course and focuses on the computational solution of important problems of matrix algebra, eigenvalues and mathematical modelling. The topics covered include matrix algebra, eigenvalues and eigenvectors, mathematical modelling, numerical integration and differentiation to describe complex engineering phenomena.
Aircraft Performance	This module covers basic aspects of flight to determine climb and descent operations and the Breguet range equation based on physical parameters of the vehicle. It also explores the effects of aircraft propulsion systems on range and duration as well as take-off and landing performance. The theoretical aspects in this module will be demonstrated in virtual flight experiments using VR technology.
Aerospace Propulsion	The propulsion system is a crucial component in all aircraft. This module covers thermodynamics and methods of mathematical modelling of propulsion systems, specifically air-Breathing propulsion systems and components, combustion thermodynamics and combustors, nozzles and afterburners. The module also explores electrical propulsion systems found in most UAV systems and will characterise typical engines in flight experiments.
Engineering Systems Modelling and Simulation	Simulation forms an important aspect in the design of UAVs. Such continuous-time systems can be simulated by means of the numerical solution of mathematical models. The module introduces simulation tools and numerical methods commonly used in aviation industry. It also considers the real-time application of simulation for hardware in the loop analysis and simulators for immersive training which will be demonstrated on a VR-based simulator.
Flight Mechanics	This module combines all aspects of aerodynamics, dynamics and propulsion to describe the flight physics of aircraft. The module specifically equips the students with a robust theoretical basis to formulate the equations of motion of a typical UAV configuration and will demonstrate the elementary concepts in aircraft performance, stability and flight control in flight simulation.

Year 2 – Trimester D

Aerospace Control	This module forms the core of the UAV autopilot design and focuses on flight control. The students will learn how to analyse various problems in aerospace engineering as describe them as advanced linear and non-linear systems. Advanced control aspects include multivariable control, advanced feedback controllers as well as digital implementation of such controllers. The module gives students a sound understanding of control systems analysis and synthesis using state-space techniques to develop a UAV flight controller which will be applied on a UAV testbed.
Flight Dynamics	This module completes the description of the aircraft flight physics and explores the mathematical modelling and simulation of fixed wing aircraft. In particular, will learn to linearise the equations of motions to describe the dynamic stability of aircraft and the response to control inputs. The analytical description will be compared to results obtained using software tools for aircraft design and simulation for an existing UAV design.
Computational Aerodynamics	This module aims to develop a basic understanding of the aerodynamic behaviour for both 2D and 3D wings. Students will be required to demonstrate knowledge from Fluid Mechanics leading up to Kutta-Joukowski Theorem. Students then apply General Thin Airfoil theory to develop 2D wing flow characteristics and Prandtl's lifting line theory to derive Aerodynamic coefficients for 3D finite wings. Students will also be required to apply knowledge through computational methods to demonstrate the derived theory and analyse the aerodynamics of a UAV wing.
Career & Professional Development	This module aims to help develop the necessary career and professional skills to meet the demands of today's workplace. The module comprises three main components: job search skills, written workplace communication and oral workplace communication. The job search component takes you through the entire process of job search, from planning your career to drafting your application and attending the job interview. The second component, with its focus on written communication, introduces you to good practices in written workplace communication, including email correspondence and drafting of technical minutes. The third component looks at oral workplace communication, with opportunities for you to hone your skills in conducting meetings, pitching ideas and presenting technical information.

Year 2 – Semester E

Aerospace Manufacturing Processes, Materials & Structures	The course provides the fundamentals of building an aircraft, and specifically focuses on the structural design of UAVs, starting with three major requirements, including market, design, and engineering materials. The course also forms an introduction to structural aspects including the concepts of shear flow and shear centre and will develop an understanding of the behaviour of structural materials under various load systems.
Risk & Reliability	This module develops the students understanding of Availability, Reliability, Maintainability thereby enhancing the students' ability to evaluate design proposals from a number of related viewpoints. The module further aims to illustrate and develop an understanding of robust design from functional performance and manufacture viewpoints and to expose students to the discipline involved in researching a technical area and produce a report and presentation.
Software Engineering	This module builds on the basic introduction to Engineering Programming and highlights the importance and need for software engineering as part of the design of complicated autonomous UAV system. The module teaches how to use common software engineering processes and models for developing software as well as common project development processes. Python programming language is used in this module which will be used to implement a mini project to programme a UAV to demonstrate the application of common design patterns and validating software through testing and run-time checking.
OIP Design Project	This is an intensive 3-week group design project where students will take as an overseas immersion programme (OIP) at UofG. The project-based subjects in which students are required to undertake as group projects will cover both the conceptual and detailed aspects of design. It involves different areas of the civil engineering discipline such as ground investigation, planning, transportation design, social, foundation design, structural design, and buildability of the construction. As part of the module students will develop a UAV design.

Year 3 – IWSP

IWSP	This is an uninterrupted 8-month duration (2 trimesters) structured learning and work programme which will provide students with unique learning opportunities to achieve the following objectives, i.e. (1) applied learning – integration of theory and practice, acquisition of specialist knowledge and development of professional skills, (2) exposure to real-world conditions - appreciation of real-world constraints in respective industry contexts to develop skills of adaptability, creativity and innovation, and (3) smooth transition to jobs - practical experience which shortens work induction period. Students will have the opportunity to develop innovative solutions for the design and construction projects they are working on. In this way, the IWSP will be a key platform to inculcate the SIT-DNA in every student.

Year 3 – Trimester F

Data Analytics	This module introduces computational approaches to process numerical data on a large scale. Computation on arrays of continuous variables underpins machine learning, data analytics, and signal processing. Vectorized operations on numerical arrays, fundamental stochastic and probabilistic methods and scientific visualization. Manipulating continuous data, specifying problems in a form that can be solved numerically, dealing with unreliable and uncertain information, and communicating these results. Operations on vectors and matrices, specifying and solving problems via numerical optimization, time series modelling, scientific visualization and basic probabilistic computation.
Flight Systems	This module completes aspects required to complete the full automation of UAV including navigation, guidance and flight control. The first part covers the engineering principles behind navigation systems used for flight control of UAVs and conventional aircraft, including inertial and GPS-based navigation as well as Kalman filtering for sensor fusion. The module concludes with the application of guidance and control strategies on existing UAV testbeds in flight experiments.
Professional Engineering Practice	This module is designed to introduce the concepts of new venture and entrepreneurial planning through knowledge, understanding and practice in the use of developing the business plan. The module is also designed to introduce students to the issues crucial to the development of new ventures, the role of the entrepreneur and the entrepreneurial team, and the relationship of the new venture to its environment. It will also include the main functional areas of marketing, operations and finance. The module will draw on the growing body of research and literature related to the development of new ventures.
Composite Materials and Finite Element Analysis	This module aims to develop a basic understanding in modern lightweight composite materials which are being used in an ever-increasing range of applications, especially in the growing UAV market. Basic knowledge of composites will allow engineers to understand the issues associated with using these materials, as well as gain insight into how their usage differs from other engineering materials. The finite element analysis (FEA) technique will be introduced as a tool to perform stress analysis of engineering problems, and commercial FEA software will be used. Fundamental concepts of the FEA and various formulations and element types will be covered. Students will acquire the basic FEA skills in carrying out stress analyses of composite or 3D-printed components of existing UAV designs.
Capstone Project	Final year students will carry out the project work from any discipline within aerospace engineering with focus on UAV-related problems. The project will focus on computational analysis and design, integration and R&D. Students would ideally start their capstone project during the IWSP and carry it out with the guide of IWSP work supervisor. The project duration is over the entire academic year. An individual formal report is required. Each student is required to make an oral presentation