DESCRIPTION OF OPTIONAL MODULES

This document provides a brief content description of optional modules to help you to select your choices. **Please note, the modules listed here are not necessarily all available on your programme.** Please refer to your Programme Specification or Module Choice Form for information about the options available to you.

New modules (2024/25 versions) will not be shown on the Module Catalogue until early August. However, you can view the previous 2023/24 versions of the Module Specifications at:
https://lucas.lboro.ac.uk/epublic/wp5016.main?dept=TT&dept2=TT

Part D

Semester 1

Module Title: **Advanced CFD** **AERO/AUTO**	**Module Code:** 24TTD020 **Module Leader:** Dr Hao Xia	**Pre-requisites:** TTC102 **Exam/CW split:** 100% CW

Aims:
The aim of this module is for the student to understand and apply advanced simulation methods for ground and air vehicle aerodynamics applications. This module is suitable for both Aero and Auto students. Students with an FYP using CFD may find this module particularly useful.

Contents:
Introduction and History of CFD Compressible and incompressible formulations

Multiphysics simulation (heat transfer, stress, multiphase)

Laminar to turbulent transition, RANS turbulence models

CAD manipulation and surface repair for CFD

Mesh generation. Computer architecture and parallel computing Unsteady methods and temporal discretisation

Scale resolving methods, flow visualisation and post-processing

Module Title: **Propulsion Design for the Environment** **AERO ONLY**	**Module Code:** 24TTD105 **Module Leader:** Prof Adrian Spencer	**Pre-requisites:** TTC011, TTC050 **Exam/CW split:** 100% CW

Aims:
To provide current understanding and initiate independent research in areas that can or may reduce environmental impacts of aeronautical propulsion systems.
Contents:
Key impacts of propulsion systems on the environment can be described under one, two or three of the headings; Carbon, Emissions and Noise. The material introduced during lectures will reflect current thinking and future research directions aimed at reducing these environmental impacts. For example;

Introduction
- Background.
- Motivation, legislation, impacts environment/health

Carbon
- Cycle impacts, constraints on optimum GT cycle efficiency.
- Advanced cycles - intercooling, water injection, industrial cycles.
- Advanced Design - integrated system design and component efficiency.
- Advanced Materials - enabling higher temperature cycle with reduced cooling.
- Cooling: Theory & Technology. Cooling cost and cycle benefit.
- Carbon Economy: offset, trading and taxation.
- Hybridisation and electrification of aircraft.

Emissions
- Combustion Theory - combustion basics, emissions.
- Cleaner combustion design and technology.
- Aircraft Operation / Engine Optimisation.
- Gas Turbine Alternatives - all electric aircraft.
- Alternative Fuels. Sulphur. Power density.

Noise
- Background, airport environment and definitions.
- Installation - powerplant-airframe integration issues.
- Open rotor and jet mixing - carbon cost & public perception.

Module Title: Autonomous Vehicles **AERO/AUTO**	**Module Code:** 24TTD106 **Module Leader:** Dr Jun Yang	**Pre-requisites:** TTB202 **Exam/CW split:** 100% CW

Aims:
This module aims to provide an introductory overview on fundamental technologies in autonomous vehicles and to familiarise the students with common vehicle control methods, sensor fusion techniques, path planning/following algorithms and example driving-assistance functions.
Contents:
INTRODUCTION TO AUTONOMOUS GROUND VEHICLE SYSTEMS
- Recent developments
- System integration (sensors, actuators, communications etc).

VEHICLE DYNAMICS, CONTROL AND SIMULATION
- Modelling vehicle dynamics and their environment
- Classical and state feedback control
- Computer based design and simulation in MATLAB/Simulink

AUTONOMOUS VEHICLE PATH PLANNING/FOLLOWING
- Path planning principles
- Path following algorithms

SENSOR FUSION AND SITUATION AWARENESS
- Kalman filtering methods
- Vehicle localisation (position and orientation)
- External environment sensing (object detection, tracking and mapping).

AUTONOMOUS FUNCTIONS
- Case studies on driving-assistance functions.

Module Title: Experimental Fluid Mechanics **AERO/AUTO**	**Module Code:** 24TTD014 **Module Leader:** Dr Dan Butcher	**Pre-requisites:** TTB101, TTB039 **Exam/CW split:** 100% CW

Aims:
The aim of this module is for the student to be able to discuss the application of various experimental methods used to measure, characterise and analyse fluid flows.
Contents:
- Motivation, Planning and Design of Experiments.

- Error Analysis and Measurement Uncertainty.
- Analysis and Presentation of Results.
- Conventional Pressure Probes.
- Hot-Wire Anemometry.
- Wind Tunnel Methods - Balance Measurements, Surface Pressure Measurements and Flow Visualisation.
- Point Laser Based Flow Measurements.
- Planar Laser Based Flow Measurements.
- Aerothermal (Heat Transfer) Measurements.

The theory, application and use of each of the measurement techniques will be presented and illustrated with the use of relevant case studies. These will form the basis of experimental demonstrations and coursework assessments.

Module Title: **Advanced Reliability, Availability and Maintainability** **AERO/AUTO**	**Module Code:** 24TTD100 **Module Leader:** Prof Lisa Jackson	**Pre-requisites:** None **Exam/CW split:** 100% CW

Aims:
The aim of this module is to give students an understanding of reliability and availability concepts and their interaction, modelling systems with dependencies, phased mission, and maintainability issues.

Contents:
Definition of key reliability, availability and maintainability terms, including dependency and where this arises in practice, Markov methods, Monte Carlo simulation and petri net modelling, definition and analysis of maintainability, Maintenance modelling, definition of phased mission & phased mission analysis for repairable and non-repairable systems.

Module Title: **Vehicle Handling** **AUTO ONLY**	**Module Code:** 24TTD017 **Module Leader:** Dr Matt Best	**Pre-requisites:** TTC066 **Exam/CW split:** 100% CW

Aims:
The aim of this module is for the student to develop their understanding of the principles of vehicle handling using modelling techniques, which were introduced in module TTC066. The module concentrates on the core areas of tyres, suspension and steering, and it also extends the students knowledge and experience of simulation tools by the development of a realistic rigid body handling model.

Contents:
Introduction. Tyres; principles of the brush tyre model, combined slip Pacejka model. Suspension and Steering; roll centre location, suspension derivatives (camber / scrub); forces and moments in the steering system, suspension jacking and anti-squat / anti-dive effects. Design and stability analysis of the 'bicycle' handling model. Development of 6DOF nonlinear handling model in Matlab/Simulink comprising: nonlinear tyre, lateral load transfer and roll moment distribution, understeer components, stability and vehicle attitude, analysis of simulated open-loop vehicle response using computer laboratories. Experience of closed-loop vehicle response to parametric variations on a moving platform vehicle simulator.

Module Title: **Fuel Cell Technology** **AERO/AUTO**	**Module Code:** 24TTD101 **Module Leader:** Dr Ashley Fly	**Pre-requisites:** TTB211 **Exam/CW split:** 20% CW, 80% Exam

Aims:
The aim of this module is to enable the student to understand the fundamental theory, design and operation of hydrogen fuel cells and fuel cell systems with application to propulsion applications and focus on the proton exchange membrane fuel cell (PEMFC).

Contents:
- Introduction to fuel cell technology, motivation, current state of the art and challenges - Hydrogen safety - Electrochemistry and Thermodynamics for hydrogen fuel cells - Electrochemical fundamentals, Cell potential, kinetics, and efficiency. - Fuel cell fundamental theory - Fuel cell components, reaction rates, stoichiometry, and water management. - Operation of fuel cells - Effective operation of hydrogen fuel cells, including polarisation, temperature and pressure optimisation. - Fuel cell stack design - Design, optimisation and manufacturing of large-scale fuel cell stacks. - Fuel cell systems - System requirements and balance of plant for hydrogen fuel cell

systems, including hydrogen storage. - Fuel cell control - Control methodology for large scale fuel cell systems. - Fuel cell degradation - Understanding performance loss in fuel cell systems over time and with use and performance characterisation techniques.

Module Title: **Power Electronics, Machines, and Drives (PEMD)** **AUTO ONLY**	**Module Code:** 24TTD108 **Module Leader:** Dr Jun Yang	**Pre-requisites:** TTB211 **Exam/CW split:** 100% CW
Aims: To introduce the constructions, function and performance of Power Electronics, Machines and Drives in a mobile application context. To appreciate the opportunities, the engineering choices and the trade-offs inherent in the application of complex electric machines. **Contents:** Intro to Electromagnetism Impedance; power factor; flux linkage; Faraday's Law; left-hand rule; magnetic circuits; solenoids and linear motors; magnet materials Power Conversion Electric power; mechanical power; calculating electromagnetic forces; shear force in air gap Stator Winding types, shape, pole count, slots, electric model, 3 phase system, winding losses, high power density for automotive applications Rotor PMSM operating principles, hybrid concepts (such as PMASynRM), coordinate systems, performance, saliency Power Converters Devices (IGBTs, Mosfets); converter topologies (DC-DC converter, DA-AC inverter); SiC, GAN; benefits/drawbacks of each; control of power converters Modulation & Transformation Basics of PWM; Sinusoidal Carrier-Based PWM; Space vector PWM Modelling of Electric Machines Sinusoidal three phase system; motor control reference frames (Park & Clark) alpha-beta; d-q reference frame; Control-oriented modelling of electric machines including DC motor, permanent magnet synchronous motor, and induction motor Field-Oriented Control (FOC) Basics of motor control; principle of AC motor control; field-oriented control of PMSM and induction motor; cascade PI control; parameter tuning of cascade FOC Advanced Control strategies Direct torque control; model-based control approaches; flux weakening control for automotive applications Perspectives of PEMD Trends of Power Electronic devices; trends for electric machines; advanced drive and control.		