Research Project 3: Introduction to Research 2025/2026 Project Descriptions

Supplementary Book

October 2, 2025

Introduction

This document contains all the project descriptions for the RP3 unit. It is intended that you use a word search function in your PDF reader to find projects that may interest you. The project descriptions are offered to showcase the types of projects offered and guide the project development after the advisor allocation. The project description does not need to be executed verbatim, but they should be helpful to get started.

You can search by project type of which there are the following categories: Analytical, Design, Experimental, Simulation, Software, and Theoretical.

There is also the option to look through the skills that may be developed which include: Additive Manufacturing, Aerodynamics, Artificial Intelligence & Machine Learning, Avionics, Computer Aided Design (CAD), Computaional Fluid Dynamics (CFD), Composite Manufacturing, Data Analysis, Finite Element Analysis (FEA), Flight Dynamics & Stability, Instrumentation & Sensors, Material Testing (Destructive), Non-Destructive Testing (Thermal, Ultrasound, X-ray, etc...), Programming Tools (MATLAB, Python, etc...), Propulsion Systems (Gas Turbines, Electric, Hydrogen), Safety, Certification & Regulatory Compliance, Space Systems, Sustainability in Aerospace, Systems Integration, UAV/Drone Design & Testing, Vibration & Modal Testing, and Wind Tunnel Testing.

27: Aeroelastic Behaviour of Forward Swept Wings

Supervisor: Jonathan Cooper

Project Type: Software; Theoretical

Skills Developed: Aeroelasticity; ; Data Analysis; Finite Element Analysis (FEA); ; Programming Tools (MATLAB, Python, etc...); Vibrations

Resources: MATLAB and NASTRAN

Project Summary:

Conventional commerical aircraft have swept back wings to reduce the effects of drag at transonic speeds - however, from an aerodynamic viewpoint it is beneficial to sweep the wings forwards. This latter design approach has never come to commerical fruition due to the potential of structural failure (wings break) from aeroelastic divergence. The aim of this project is to investigate the effect of forwards and backwards sweep on the aeroelastic behaviour of a simple wing considering elastic axis position, vibration characteristics, divergence, flutter, loads distribution, steady trim angle and gust response. Simple mathematical models (programmed in MATLAB) and equivalent wing models using NASTRAN will be developed and parametric studies performed to explore the aeroelastic performance. If time allows, aeroelastic tailoring (use of anistropic composite layups) will be considered (as in the X-29 NASA research aircraft and several EU project studies) as a means to facilitate the use of forward swept wings. Undertaking this project will be very beneficial for any considering taking the 4th year ASDA (Advanced Structural Dynamics and Aeroelasticity) option.

40: Mitigating the climate impact of ash dieback: A comparative LCA of ash timber use scenarios

Supervisor: Neha Chandarana

Project Type: Analytical; Design

Skills Developed: Data Analysis; Finite Element Analysis (FEA); Other:

Resources: Ecoinvent; SimaPro; Abaqus

Project Summary:

Ash dieback is a destructive tree disease that is predicted to kill the vast majority of native ash trees in Great Britian. The widespread felling of these trees means that there will be a surplus of ash timber over the next few decades. Currently this timber is predominantly burned for fuel, releasing its stored biogenic carbon quickly. Using this wood in long-life products instead significantly delays this carbon emission, offering a climate benefit.

This project will use life cycle assessment, supported by structural modelling, to quantify the climate change mitigation potential of different uses of the surplus ash. A business-as-usual use scenario will be compared against scenarios where ash is used in various long-life products, such as glue laminated timber. These findings will provide timely recommendations to ensure the strategic use of ash timber minimises the overall carbon impact of ash dieback.

21: The Equivalent Thermal Conductivity and Diffusivity of Sierpiński Carpets

Supervisor: Giuliano Allegri

Project Type: Theoretical; Simulation

Skills Developed: Finite element modelling of thermal problems; metamaterials; optimisation; Python scripting

Resources: Abaqus Standard

Project Summary:

The Sierpiński carpet is a classical fractal generated by the iterative subdivision of a square. Thermal metamaterials are synthetic materials engineered to manipulate heat conduction, enabling properties not found in nature. This project will investigate the thermal conductivity and diffusivity of hierarchical porous media with geometrically anisotropic Sierpiński-carpet architectures. The ultimate aim is to design minimum-mass thermal cloaking solutions for engineering applications. The study will be primarily simulation-based, involving the development of parametric models in Abaqus Standard to simulate unsteady two-dimensional heat transfer in porous media. The work will also require the automation of geometry and mesh generation in Abaqus using Python scripting, enabling a systematic exploration of the design space for this new class of thermal metamaterials.

56: All-cellulose composites

Supervisor: Stephen Eichhorn

Project Type: Analytical; Experimental

Skills Developed: Composite Manufacturing; Material Testing (Destructive); Analytical Chemistry measurements (AFM/Raman)

Resources: AFM/Raman in Chemistry

Project Summary:

All-cellulose composites get around the need for a separate matrix and fibre components, making a truly sustainable composite material. This project will explore some recent work to make all-cellulose composites from natural fibres and dissolved resin material. The student will undertake some mechanical testing of the materials, and also some analytical measurements using AFM and Raman to map the different phases in the material. There will be some potential to also try and make some materials of their own in the lab, dissolving cellulose using an ionic liquid.

13: Investigation into identification of subcritical flutter conditions.

Supervisor: Djamel Rezgui

Project Type: Experimental; Design; Simulation; Analytical;

Skills Developed: Aerodynamics and aeroelasticity; Computer Aided Design (CAD); Computaional Fluid Dynamics (CFD); Data Analysis; Finite Element Analysis (FEA); Instrumentation & Sensors; Programming Tools (MATLAB, Python, etc...); Safety, Vibration & Modal Testing; Wind Tunnel Testing; Nonliear Dynamics

Resources: Flutter rig, continuation and bifircation tools, matlab models

Project Summary:

Flutter is an aeroelastic instability that affect the design of aircraft. Having nonlinearities in the wing (aerodynamics or structural) can make the flutter analysis complex and can lead on early onset of oscillations know as Limit cycle oscillations (LCO's). The flutter of flexible wings can be dangerous in a wind tunnel or in flight and hence developing tools to predict this behaviour and understanding its nonlinear effects is very critical. Particularly, when there is sub-critical flutter (sub-critical Hopf Bifurcation). This project tries to investigate the parameters that affect the hysteresis region emerging because of sub-critical flutter. This investigation is to be done experimentally using the experimental Flutter Rig (already available), complemented with nonlinear numerical analysis (using nonlinear simulations and continuation techniques). This project is supported with ongoing industrial research projects (which is providing the main experimental wind tunnel apparatus).

29: Snowdon Space Weather Station Communications Upgrade

Supervisor: Karen Aplin

Project Type: Design; Experimental;

Skills Developed: Instrumentation & Sensors; Programming Tools (MATLAB, Python, etc…); Space Systems; Systems Integration

Resources: The satellite lab will be used

Project Summary:

The Snowdon Space Weather station is a measurement system located on the summit of England and Wales's highest mountain. It has many similarities with a space mission due to its inaccessibility and stringent design requirements. The "payload" is meteorological instruments and sensors that respond to natural radioactivity and space weather. The SSWS needs a new communications system which is cheaper and more reliable than the previous proprietary modem. LoRa seems the most promising in terms of meeting the requirements which are real-time line of sight transmission over a few km with limited power. The student will review the design requirements, come up with a suitable design and if possible prototype this design in the lab.

19: Sustainable hydrogel materials for vibration and energy dissipation

Supervisor: Fabrizio Scarpa

Project Type: Design; Experimenta

Skills Developed: Sustainability in Aerospace; Vibration & Modal Testing

Resources: Existing vibration rigs; existing hydrogel production rigs (SCMM); Matlab/Python for data processing

Project Summary:

Current vibration dampers and energy-dissipating materials rely on fossil-based polymers—but we've discovered a game-changing alternative: sustainable, biodegradable hydrogels that deliver superior performance at low-frequency excitations (see: https://www.nature.com/articles/s43246-025-00857-5 and https://doi.org/10.1063/5.0280619). This project will develop and characteriSe these next-gen hydrogels using advanced vibration transmissibility techniques, uniting expertise from the School of Cellular and Molecular Medicine and CADE to pioneer eco-friendly solutions for dynamic applications.

6: Transformer based stress prediction in Composites

Supervisor: Bassam El Said

Project Type: Analytical; Design; Experimental; Simulation; Software; Theoretical

Skills Developed: Artificial Intelligence & Machine Learning; Data Analysis;Programming Tools (MATLAB, Python, etc…); Composite Damage

Resources: N/A

Project Summary:

This project addresses computational challenges in modelling advanced composite materials used in automotive, aerospace, and renewable energy applications. While these materials offer excellent strength-to-weight ratios, they exhibit complex damage and failure behaviours that traditional modelling approaches struggle to capture effectively. Machine learning, particularly deep recurrent neural networks like LSTMs, has emerged as a successful method for modelling the history-dependent damage behaviour in these materials. However, LSTM-based stress prediction networks, despite their accuracy, impose high computational costs during inference, limiting their practical application in large-scale industrial simulations. This research investigates transformer-based learning models as alternatives to current LSTM networks. This includes developing custom lightweight transformer architectures and adapting existing transformer models, including large language models, for stress prediction tasks. The project aims to produce a comparative analysis of transformer models' advantages and limitations for material behaviour modelling, utilizing an extensive pre-existing dataset of material time-history responses for training and evaluation.

11: Multi-objective optimisation of the AVDASI2 aerofoil

Supervisor: Daniel Poole

Project Type: Simulation; Software

Skills Developed: Aerodynamics; Artificial Intelligence & Machine Learning; Computaional Fluid Dynamics (CFD); Data Analysis; Programming Tools (MATLAB, Python, etc…).

Resources: Matlab (or Python)

Project Summary:

The aerodynamic design of AVDASI2 required choosing an aerofoil given some competing aerodynamic requirements. Commonly, this is tackled by running XFOIL for different aerofoil shapes and picking the single aerofoil that provides the best trade-off of the various performance metrics. Instead, this project will take a more robust optimisation approach. You will need to develop an optimisation process that calls XFOIL within an optimisation loop and alters an aerofoil shape. As there are multiple objectives, a suitable optimiser (such as NSGA-II) will need to be used. The result will be the family of aerofoils that is most optimal for the problem. Objectives/tasks: • Develop a process in Matlab that can automatically run XFOIL for some given parameter set (e.g. the NACA 5-series parameters) to give lift, drag and moments for different flight conditions. • Wrap on optimiser around this process such that the optimiser controls the design (recommend to use a multi-objective optimiser e.g. gamultiobj. • Perform studies on the hyperparameters of the optimiser and run the process to obtain an optimal aerofoil.

34: Aerodynamics and aeroacoustics of novel propellers

Supervisor: Prof Mahdi Azarpeyvand

Project Type: Experimental; Simulation

Skills Developed: Aerodynamics; Data Analysis; Instrumentation & Sensors; Programming Tools (MATLAB, Python, etc…); Wind Tunnel Testing;

Resources:

Project Summary:

As part of this project you will use the National Aeroacoustic wind tunnel facility to perform aerodynamic and noise tests for a set of novel propeller designs. You will make use of state-of-the-art measurment techniques, such as PIV and HTW to perform flow-field charactrisation and use microphone arrays in an anechoic chamber to measure the far-field noise.

23: Recycling Prepreg Scrap into Chopped Composite Laminates

Supervisor: Iryna Tretiak

Project Type: Experimental

Skills Developed: Composite Manufacturing, Material Testing (Destructive), Data Analysis

Resources: Access to BCI Lab

Project Summary:

Composite materials are extensively used in industries such as aerospace and automotive because of their excellent strength-to-weight ratio. However, during manufacturing processes large amounts of prepreg scrap are produced. These waste materials are typically landfilled, creating both environmental and economic challenges. The aim of this project is to investigate the feasibility of recycling prepreg scrap into composite laminates by using chopped prepreg and to evaluate the mechanical performance of the recycled material. Student will develop a method to produce composite samples from chopped prepreg, manufacture test specimens, characterise the mechanical performance and assess the potential applications of recycled prepreg composites.