UNIVERSITY OF LIMERICK IRELAND

STEM Summer School Research Project

Summer 2022 sees the exciting return of our STEM Summer School project-based programme. As one of the leading Science and Engineering universities in Ireland, we are excited to offer ten research projects from our Faculty of Science and Engineering.

You will have the opportunity to work alongside researchers, where you will conduct your own pre-approved research project.

You'll enjoy all the benefits of studying in the west of Ireland where it is known for its electric atmosphere, scenic beauty and academic rigour. All while taking part in this prestigious and highly competitive programme which will be sure to set your resume aside from others.

ENGINEERING RESEARCH PROJECT SUMMER 2022

Development of a Biocatalytic Flow Reactor

Professor Edmond Magner

Enzyme Immobilisation
Catalysis
Flow Systems
Bio/Electrochemistry

BACKGROUND

Flow reactors are now frequently used to replace batch reactors as the can enable the use of more simplified manufacturing processes that can be scaled by the incorporation of additional flow channels. The challenge with enzymatic based systems is to ensure that the catalysts are immobilised in a mechanically stable manner with retention of activity. We have developed flow systems for single enzyme reactors and are now expanding this to multi-enzyme systems. As part of this work, the flow patterns, channel dimensions and methods of immobilising enzymes need to be optimised. This work is part of an ongoing project with the research centre SSPC (www.sspc.ie).

SCIENTIFIC HYPOTHESIS BEING TESTED

How to optimise the flow system and flow pattern in a reactor utilising enzymes as catalysts.

RELEVANT BACKGROUND THAT STUDENTS NEED TO HAVE

A background in Chemistry or Biochemistry or Bio/Chemical Engineering is preferred.

ANALYTICAL TECHNIQUES TO BE EMPLOYED

Electrochemical Techniques, CAD Systems, Enzymatic Assays, Characterisation (FTIR, Raman, SEM, Gas Shromatography).

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ENGINEERING RESEARCH PROJECT SUMMER 2022

Biomass Valorisation Into Value Added Compounds

Professor Witold Kwapinski
Advisor: Ayman Hijazi
Chemical Engineering
Catalyses

BACKGROUND

Our research is economy-oriented as we seek to develop a cost-saving catalytic system based on using non-expensive metal-doped supports. We look forward to conducting a small part of literature review that revolves around collecting thermodynamics data, kinetics and Gibbs free energy, for the reactions that take place during the reduction of LA in the presence of FA to yield GVL platform compound, both catalytic and side reactions inclusive. The outcome we sought is to publish a critical review journal paper in biomass-energy oriented journal.

RELEVANT BACKGROUND THAT STUDENTS NEED TO HAVE

Good Data and Information Collections Skills and Writing Skills.

ANALYTICAL TECHNIQUES TO BE EMPLOYED

Excel, EndNote.

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ENGINEERING RESEARCH PROJECT SUMMER 2022

Evaluating the Temperature Dependence of the Bauschinger Effect in Aerospace Aluminium Alloys.

Professor J S Robinson
Mechanical Engineering,
Aluminum Alloys,
Residual Stress

BACKGROUND

Aerospace aluminium alloys are routinely stress relieved by the application of plastic deformation. This takes place after the solution treatment and quenching stage of the heat treatment. Both stretching and compression can be used. This project will investigate the temperature dependence of the phenomena known as the Bauschinger effect which has a detrimental influence on the strength properties of materials that are subject to plastic deformation and then subsequently loaded in the reverse direction. The project will involve solution heat treating samples and then immediately subjecting them to approximately 2% plastic strain in compression, and then reversing the load into stretching, measuring the yield stresses in both compression and tension. The tests will be completed at room temperature and down to -197°C.

SCIENTIFIC HYPOTHESIS BEING TESTED

That the magnitude of the Bauschinger effect in heat treatable aluminium alloys is temperature dependent.

RELEVANT BACKGROUND THAT STUDENTS NEED TO HAVE

Strength of materials, engineering mechanics, engineering materials

ANALYTICAL TECHNIQUES TO BE EMPLOYED

Mechanical testing at sub-zero temperature including cryogenic temperatures.

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ENGINEERING RESEARCH PROJECT SUMMER 2022

Comparing Stress-relieving Methods for Heat Treatable Aerospace Aluminium Alloys

Professor J S Robinson
Mechanical Engineering,
Aluminum Alloys,
Residual Stress

BACKGROUND

Aerospace aluminium alloys are amenable to stress relieving by the application of plastic deformation where the geometry permits it, for example rectilinear blocks, shapes with constant cross sectional area. For complex shapes post solution treatment and quenching deformation, is not always practicable. Alternative methods like quenching into a polyalkylene glycol solution (PAG) can be used. This project will investigate the impact of both cold compression and PAG quenching on the surface residual stresses remaining in fully heat treated rectilinear blocks made form the very high strength aerospace aluminium alloy 7449. It will also determine the impact on the mechanical properties of the alloys.

SCIENTIFIC HYPOTHESIS BEING TESTED

Impact of quench rate and plastic deformation on residual stress in heat treated aluminium alloys.

RELEVANT BACKGROUND THAT STUDENTS NEED TO HAVE

Strength of materials, engineering mechanics, engineering materials.

ANALYTICAL TECHNIQUES TO BE EMPLOYED

Residual stress measurement by X-ray diffraction, tensile testing, indentation hardness testing, electrical conductivity testing

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ENGINEERING RESEARCH PROJECT SUMMER 2022

Evaluating the magnitude of the Bauschinger effect in an aerospace aluminium alloy.

Professor J S Robinson
Mechanical Engineering,
Aluminum Alloys,
Residual Stress

BACKGROUND

Aerospace aluminium alloys are routinely stress-relieved at room temperature by the application of plastic deformation after solution treatment and quenching. Both stretching and compression can be used. This project will investigate the influence of the magnitude of the initial stress-relieving compressive plastic strain on the ensuing tensile yield stress. The tensile yield stress is significantly lower than the initial compressive yield stress, and this is widely known as the Bauschinger effect. The project will involve solution heat treating tensile test samples and then immediately subjecting them to varying degrees of plastic strain in compression (up to ~5%) and then reversing the load into stretching, measuring the tensile yield stress.

SCIENTIFIC HYPOTHESIS BEING TESTED

That the magnitude of the Bauschinger effect in heat treatable aluminium alloys is influenced by the magnitude of initial plastic strain.

RELEVANT BACKGROUND THAT STUDENTS NEED TO HAVE

Strength of materials, engineering mechanics, engineering materials.

ANALYTICAL TECHNIQUES TO BE EMPLOYED

Mechanical testing on a 300kN servo-hydraulic load frame.

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ENGINEERING RESEARCH PROJECT SUMMER 2022

Role of Meninges in Concussion: Mechanical and Structural Characterisation of Porcine Meninges Membrane

Dr. John Mulvihill,
Biomedical Engineering,
Soft Biomechanics, Concussion

BACKGROUND

Concussion awareness is increasing almost daily in most mainstream sports. Concussion is one of the mildest forms of brain damage. However, it is this mildness of injury which makes it one of the most insidious, as repeated and undetected concussions can lead to permanently altered brain function. There is currently no scientific test for concussion – only a subjective assessment. The meninges is a series of membranes that envelops the brain to protect it during impact. The purpose of this project is to mechanically characterise this membrane using, uniaxial, biaxial and fracture toughness techniques, along with electron microscopy. The project will also apply an injury mimicking concussion on the brain and comparing the effect of concussion on mechanical and structural properties of the tissue

SCIENTIFIC HYPOTHESIS BEING TESTED

Are the mechanical properties of the meninges location dependent within the brain? What affect would this have on location specific concussive impacts, and cortical protection design?

RELEVANT BACKGROUND THAT STUDENTS NEED TO HAVE

The students should have a lot of knowledge and experience in mechanical characterisation experiments, and hyper/linear elastic stress analysis. The students should have a basic background in biology.

ANALYTICAL TECHNIQUES TO BE EMPLOYED

Uniaxial testing of porcine tissue, stress/strain analysis, statistics, electron microscopy (will provide training)

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ENGINEERING RESEARCH PROJECT SUMMER 2022

Computational modelling of mechanical behaviour of lightweight carbon fibre materials

Professor Noel O'Dowd,
University of Limerick Chair in
Mechanical Engineering
Computional Mechanics

BACKGROUND

Engineering design is increasingly based on computational tools such as the finite-element method. The use of microstructurally based numerical models has gained increasing acceptance in engineering design and have been shown to provide accurate predictions of mechanical behaviour. Such models can also be used to optimise the material microstructure to improve performance. This project will focus on carbon fibre reinforced composites, lightweight materials, previously used mainly in aerospace but now increasingly used in automotive and energy applications (e.g. wind turbine blades). These materials are important because of their light weight in conjunction with excellent mechanical properties.

SCIENTIFIC HYPOTHESIS BEING TESTED

Can the mechanical response of carbon fibre composites under complex loading conditions be accurately predicted using microstructurally accurate models.

RELEVANT BACKGROUND THAT STUDENTS NEED TO HAVE

Mechanical Engineering (or related discipline) and an interest in mechanics of materials

ANALYTICAL TECHNIQUES TO BE EMPLOYED

Mechanics of materials, finite-element analysis, possible extended finite-element methods (XFEM), depending on experience.

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ENGINEERING RESEARCH PROJECT SUMMER 2022

An Experimental Investigation of Secondary Bending in Double Layer Bending Active Gridshell Assemblies

Professor Tom Cosgrove,
Civil Engineering

BACKGROUND

Shells are curved 3-dimensional, structurally efficient forms. Gridshells are similar but made from long laths arranged in a curved grid. A bending active gridshell [BAG] is made by bending a flat grid into a double curved gridshell. BAG members must both flexible and strong. For larger spans, multiple layers, each relatively flexible, may be independently formed and then locked together using shear blocks to yield a composite BAG of great stiffness and strength. Research at the University of Limerick being conducted in conjunction with our industrial partner, Smartply-Medite, suggests that secondary bending occurs for some grid geometries. The research is both experimental and computational and examines the factors affecting the deformation of BAG's

SCIENTIFIC HYPOTHESIS BEING TESTED

How does the influence of secondary bending on the deformation of curved double layer gridshell assemblies vary with grid geometry?

RELEVANT BACKGROUND THAT STUDENTS NEED TO HAVE

Elementary mechanics of materials, standard engineering theory of bending, MS Excel. For a student with Finite Element modelling (FEM) skills, there are a variety of modelling problems to be examined. This work is relevant to the design of a large range of structural forms and materials.

ANALYTICAL TECHNIQUES TO BE EMPLOYED

Reviewing supplied literature and updating literature database, experimental testing of steel double layer curved steel assemblies, modelling work for a student with FEA skills, analysing and writing up results.

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ENGINEERING RESEARCH PROJECT SUMMER 2022

Cyber Security for Electric Vehicles

Dr. Thomas Newe,
Senior Lecturer,
Centre for Robotics and
Intelligent Systems,

BACKGROUND

With the worldwide growth of Electric vehicles, the topic of car hacking and connected vehicle security is poised to become one of the most talked-about (and worried-about) issues in the industry. The electric vehicle, by its very nature, has large computing capabilities and this capability makes it susceptible, and a target for hackers. In recent years the movie industry has dramatized car hacking in movies such as the Fast and the Furious movie, The Fate of the Furious. While the movie is fictional it will prompt a lot of what-if comments and this will attract the hacker to have a go.

SCIENTIFIC HYPOTHESIS BEING TESTED

This project will investigate the possibilities of hacking the modern vehicle and it will outline measures (IDS-Intrusion Detection Systems and IPS-Intrusion Prevention Systems) that can be taken to prevent such hacking. The networks involved in such systems; for vehicle control, vehicle-to-vehicle communications, charging, roadside communications, systems interconnect etc. will be documented as will the security measures/protocols they implement.

RELEVANT BACKGROUND THAT STUDENTS NEED TO HAVE

The student should have a basic background in data communications and security.

ANALYTICAL TECHNIQUES TO BE EMPLOYED

Hacking techniques and IDS/IPS methods employed to detect and prevent them.

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ENGINEERING RESEARCH PROJECT SUMMER 2022

Blockchain and its use in Smart Manufacturing

Dr. Thomas Newe,
Senior Lecturer,
Centre for Robotics and
Intelligent Systems,

BACKGROUND

The digital twin is being used to provide the link between the physical manufacturing world and the digital one, and blockchain is necessary to guarantee security and traceability of data used for this. Blockchain has evolved into the essential tool necessary for providing full transparency for the transfer of data into the Digital Twin.

SCIENTIFIC HYPOTHESIS BEING TESTED

This project is to investigate how blockchain can be used for traceability and what tools are necessary for its deployment in the digital twin.

RELEVANT BACKGROUND THAT STUDENTS NEED TO HAVE

This project is to investigate how blockchain can be used for traceability and what tools are necessary for its deployment in the digital twin.

ANALYTICAL TECHNIQUES TO BE EMPLOYED

Blockchain and how it is employed for secure traceability of data, in this case the data is for use in a Digital Twin for a smart manufacturing process..

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