## MSC412 - Research Project (2016)
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**09 November 2015**

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Investigation of a Hydrostatic Solar, Desalination Process in South Africa

Lecturer, Dr A Lexmond
Max students, 3

Project Description

1. Background
The demand for potable water in South Africa is increasing constantly as human population growth continues to escalate. As a result the current fresh water reserves are under strain due to pollution and over consumption in an already water short country. This increase in consumption has resulted in severe depletion of aquifers/ground water reserves. The National Water Resource Strategy, has identified a number of regions that could be in significant water deficit by 2025 if measures are not implemented to prevent this. In some of these instances, desalination is seen as a possible solution.
The aim of this project is to develop a Hydrostatic-Solar Desalination Process (HSDP).

2. Problem statement
For desalination to succeed in South Africa, reliable, cost-effective, and adoptable technologies are needed. This will require systematic advances in pre-treatment, characteristics of different sources of saline water, methods of salt separation, disposal of brine, effects of by-products on the environment, and management of desalination facilities. In light of this, the students are proposing to investigate these high priority issues by means of a hydrostatic, low pressure/vacuum desalination process utilising solar energy in this research proposal.
The proposed research will review the available technologies for seawater desalination with the possibility of integration with solar energy technologies. The aim/goal/objective of the research is to deliver an optimum design for sea water desalination from an innovation and techno-economic feasibility perspective, as well as a low-maintenance, robust solution for remote communities. It’s simple and reduced maintenance requirement may lead to a robust operation which should make it less sensitive to process fluctuations.
One of the major difficulties that must be overcome if the desalination of coastal waters is to become a reality involves evaluating the extent to which coastal ecosystems may be affected by the discharge of reject waters from these plants/systems.
The High Scenario of the National Water Resource Strategy states that the total national water deficit by 2025 is projected to be a massive 2 044- million cubic metres per year. (Holman, n.d.) Since there are no more room for massive water reservoirs such as dams, an alternative means of obtaining potable water is required. One such alternative is to desalinate ocean water and wastewater. The Department of Water Affairs (DWA) has indicated that desalination plants could account for between 7% and 10% of the country’s overall urban water supply by 2030.

Although desalination plants are not an unfamiliar sight on a global scale, especially in the Middle East where they have large centralised desalination plants and ample access to fossil fuels, they are extremely energy intensive. South Africa is a comparatively water scarce country, with large arid expanses that has access to brackish water that is unusable.

3. Theoretical and experimental objectives
The aim of this project is twofold. The first stage will consist out of designing a small scale Hydrostatic-Solar Desalination Plant for South Africa’s rural areas.
The second stage will consist out of building a working scale model to investigate the practical feasibility and efficiency of the plant.
Efficiency will be compared against a Photo Voltaic Reverse Osmosis System, as the scalability of the proposed system possibly closely matches the RO process.
Considering the design should cater for rural areas, additional focus will be placed on reducing capital and running costs.
In order to prove the concept successful the prototype needs to produce 10 litre of desalinated water per day.

5. Validation of theoretical predictions against experimental results

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A
**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Mr H Hamersma

Pipe plasma cutter

Lecturer, Mr H Hamersma
Max students, 2

Project Description

Background

The University of Pretoria recently designed and manufactured a CNC plasma cutter. The existing control algorithm allows for the manufacture of two dimensional components. A fourth axis has been developed and must now be integrated with the existing CNC plasma cutter to enable the cutting of pipes to be used in a tubular space frame (such as the TuksBaja vehicle’s roll cage).

Problem statement

The development of an algorithm to determine the intersecting profiles of pipes used on a tubular space frame is required. The algorithm must take the minimum amount of inputs (i.e. node locations and pipe diameters) and generate an algorithm that will determine the cutting profiles of the pipes at their intersections. Due consideration must be given to weld preparation at these intersections. An acceptable outcome is an example of a typical intersection of pipes at a node of a tubular space frame that has been cut with to the developed algorithm. (Note that this project may include extensive programming in Matlab or similar)

Theoretical objectives

The theoretical objectives of this project is the development of the abovementioned algorithm, specifically the intersection of the pipes and the resulting profile at the joints or nodes of a tubular space frame.

Experimental objectives

The experimental objective is to cut the profile as determined by the abovementioned algorithm and to join the pipes by tack welding them together. The experimental objective is to provide proof of concept of the developed algorithm

Validation of theoretical predictions with experimental results
Proof of concept that the algorithm generates an acceptable cutting profile on the pipes.

Category

Mechanical

Group

Vehicle Systems Group

External Leader

N/A

External Leader Location

N/A

External Organisation

N/A

Total Funding (ZAR)

500

Experimental Requirements

Must make use of the existing CNC plasma cutter in the Heavy Machinery Laboratories
**Damper test bench**

**Project Description**

**Background**

Dampers play a crucial role in the ride comfort and handling of any vehicle. Currently the University of Pretoria has the facilities to characterise a damper, but the process is tedious and complicated and takes up an unacceptable amount of time and resources.

**Problem statement**

The development of a dedicated test bench to characterise a damper is required. The test bench must enable the Vehicle Dynamics Group to quickly and efficiently characterise a damper’s various configurations. The test bench must allow for various input velocities and ranges of displacement.

**Theoretical objectives**

The theoretical objective of the project is to simply model an existing damper as proof of concept that the damper test bench meets the requirements as specified. The final outcome of this project is a plot of damper force as a function of input velocity.

**Experimental objectives**

The experimental objective of the project is the characterisation of a damper, which includes the development of a test bench to enable the vehicle dynamics group to investigate a range of input velocities quickly and efficiently. The control of the test rig must be simple and be able to accurately excite the damper with the specified inputs.

**Validation of theoretical predictions against experimental results**

A comparison of the measured and modelled damper force-velocity curves will provide sufficient validation.

**Category**

Mechanical

**Group**

Vehicle Systems Group

**External Leader**

N/A

**External Leader Location**

N/A

**External Organisation**

N/A

**Total Funding (ZAR)**

500

**Experimental Requirements**

The test bench to be designed must be a permanent setup and must have sufficient OHS protection.
**Project Description**

Background

Friction plays a major role in many dynamic vehicle manoeuvres and includes, but is not limited to, the friction between the tyres and the road surface, between seals and scrapers in a damper and between the leaves of a leaf spring.

Problem statement

The development and commission of a facility to investigate the friction between two objects is required. The facility must include the ability to characterise and parameterise the friction under different operating conditions with different normal loads and sliding speeds. The aim of the facility is to develop friction models of the components under investigation and a suitable method of proving the test facilities capability has to be developed.

Theoretical objective

The modelling of friction between two objects is the theoretical objective. The modelling must take into account different normal loads and sliding velocities.

Experimental objective

The experimental characterisation of the friction between two components is the experimental objective. The test facility must be able to test the friction between two components under various normal loads and sliding velocities.

Validation of theoretical predictions against experimental results

A comparison of the modelled and measured friction between two objects will serve as sufficient validation.

**Category**

Mechanical

**Group**

Vehicle Systems Group

**External Leader**

N/A

**External Leader Location**

N/A

**External Organisation**

N/A

**Total Funding (ZAR)**

500

**Experimental Requirements**

Experimental setup must make use of existing lab equipment, within reason
Quarter car test rig sensitivity analysis

Project Description

Background

A ¼ car test rig is often used to investigate semi-active suspension control methods, but poor results are obtained when comparing a ¼ car model’s predicted behaviour and that measured on a full vehicle.

Problem statement

The discrepancy between modelled and measured response may be attributed to several factors, such as the suspension kinematics, friction in the test rig and the excitation given to the model. A sensitivity analysis of the influence of these variables on the performance of the ¼ car test rig is required.

Theoretical objectives

The mathematical modelling of the quarter car test rig and its components may be seen as the theoretical objective

Experimental objective

The experimental objective is to replicate the modelled inputs to the quarter car model and measure the test rig’s response.

Validation of theoretical predictions against experimental results

A comparison of the modelled and measured response of the quarter car for the same input will serve as sufficient validation of the theoretical predictions.

Category

Mechanical

Group

Vehicle Systems Group

External Leader

N/A

External Leader Location

N/A

External Organisation

N/A

Total Funding (ZAR)

500

Experimental Requirements

The existing 1/4 car test rig may be used, but some redesign may be necessary
Sensitivity analysis of vehicle mass and moments of inertia properties influence on vehicle dynamics

Lecturer, Mr H Hamersma
Max students, 2

**Project Description**

**Background**

It is complicated to reliably and accurately obtain the position of a vehicle’s centre of mass and the corresponding mass moments of inertia about the longitudinal, lateral and vertical axis and this is often not known a priori when vehicle dynamics experts are developing vehicle control systems. This situation is further complicated by the fact that a position of the centre of mass of a vehicle and the mass moments of inertia may change due to large differences in the payload of a vehicle. A sensitivity analysis is required to investigate the effect of changing these values on the vehicle dynamics performance of a vehicle.

**Problem statement**

A sensitivity analysis is required to investigate the effect of changing these values on the vehicle dynamics performance of a vehicle. The investigation requires simulation and experimental work in this regard.

**Theoretical objective**

The modelling of the influence of changing a vehicle’s mass and moments of inertia properties on the vehicle dynamics, specifically the ride comfort and handling performance, is the theoretical objective.

**Experimental objective**

Experimental results showing the influence of different centre of mass positions and mass moment of inertia properties on the vehicle dynamics performance, specifically on the ride comfort and handling performance, are required.

**Validation of theoretical predictions against experimental results**

The theoretical investigation has to be validated by comparing it with the experimental results in a sensible and scientific manner.

**Category**

Mechanical

**Group**

Vehicle Systems Group

**External Leader**

N/A

**External Leader Location**

N/A

**External Organisation**

N/A

**Total Funding (ZAR)**

500

**Experimental Requirements**

Experimental validation is to be performed using an existing vehicle platform, such as the Land Rover Defender.
Tyre modelling on deformable terrains

Project Description

Background

The recent development of physical tyre models that accurately capture a tyre’s performance on hard terrain over rigid road profiles has opened the door to investigating a tyre’s performance on deformable terrains.

Problem statement

This project requires the investigation of the tyre properties critical to vehicle dynamics on deformable terrains such as sand, dirt, gravel and mud. The properties to be investigated include, but are not limited to, side-force as a function of slip and camber angle, braking force as a function of longitudinal slip and vertical excitation over uneven terrain.

Theoretical objectives

The modelling of the tyre properties on deformable terrains may be seen as the primary theoretical objective. The modelling may be divided into the six force components the tyre exerts on the vehicle and its subsystems.

Experimental objectives

The experimental characterisation of a tyre’s performance on a deformable terrain is the primary experimental objective. Suitable testing procedures are to be identified and performed.

Validation of theoretical predictions against experimental results

The modelled tyre properties are to be compared to the experimentally determined tyre properties.

Category

Mechanical

Group

Vehicle Systems Group

External Leader

N/A

External Leader Location

N/A

External Organisation

N/A

Total Funding (ZAR)

500

Experimental Requirements

Experimental tests are central to this project.
Ms B Huyssen

Optimization of Jet nozzle shape for minimum wake energy

Lecturer, Ms B Huyssen  
Max students, 2

Project Description

1. Background
On an aircraft configuration which does not make use of the typical empennage (horizontal and vertical tail wings) the after-body could be arranged such that the jet nozzle of a jet engine could exit in a slot-type nozzle. On any flight body the thrust should balance the drag and both the thrust and the drag signature are present in the wake. The amount of kinetic energy shed to the wake reflects the efficiency of the system. In the ideal case the thrust profile cancels the drag profile such, that wake shows no disturbance at all.

2. Problem statement
A jet nozzle shape needs to be found which would minimize the wake energy.

3. Theoretical objectives
Develop a theoretical model (CFD) to make predictions about the wake profile and propose a jet nozzle shape which would offer good wake quality.

4. Experimental objectives
Construct the proposed nozzle arrangement using an electric ducted fan and measure the wake profile by means of a 5-hole probe with the use of a transverse mechanism.

5. Validation of theoretical predictions against experimental results
Adapt the theoretical model in line with the experimental observations to refine the proposed jet nozzle shape.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Fan, Transverse Mechanism, data log, 5 hole pressure probe.
Development of an automated devise for five-hole pressure proble calibration

Lecturer, Ms B Huyssen
Max students, 2

Project Description

1. Background
The cascade wind tunnel is to be used to calibrate a five-hole pressure probe.

2. Problem statement
The device needs to set yaw and pitch angles from -45° to +45°, in steps of 2.5° to an accuracy of ±0.1° in an automated way.

3. Theoretical objectives
A calibration strategy has to be developed to meet the requirements within the given tunnel constraints.

4. Experimental objectives
The actual calibration needs to be performed.

5. Validation of theoretical predictions against experimental results
It must be demonstrated that the calibration results are reliable and satisfy the client requirements.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Motor, data log, 5 hole probe.
Project Description

1. Background
Aerosud is developing an MB326 jet training simulator, it will have a fully functional cockpit and visuals system, and needs to have representative handling qualities of the real aircraft, which will require the validation of the aerodynamic characteristics of the real aircraft.

2. Problem statement
To be able to determine the aerodynamic characteristics of an MB326 jet trainer, to enable key parameters to be input into the simulator control deck.

3. Theoretical objectives
The student will be tasked to be able to correctly model the flight characteristics of the MB326 in accordance with known flight manual parameters.

4. Experimental objectives
The student will be tasked to build an elevator.

5. Validation of theoretical predictions against experimental results
Qualitative assessment by Impala pilots will be part of the verification activity. Modifications to control hardware is likely to be required to carry this out.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
Rob Jonker

External Leader Location
Aerosud

External Organisation
Aerosud

Total Funding (ZAR)
500

Experimental Requirements
nothing
Design and testing of modular wing using AM

Lecturer, Ms B Huyssen
Max students, 1

Project Description

1. Background
The use of Additive Manufacturing (Rapid Prototyping / "grown") parts is gaining momentum; this project applies the technology to wind tunnel models. One of the restrictions of AM is the machine-bed size: in SA this is currently typically 350mm to 600mm depending on the material. This project will investigate the design of wind tunnel model wings grown in sections and assembled after manufacture to make up the complete wind tunnel model wing.

2. Problem statement
To design a wind tunnel model wing interface that is structurally similar to a wing manufactured in one part

3. Theoretical objectives
To design the modular wing such that the wing deflection (linear and twist) is within 5% of the wing manufactured in one part

4. Experimental objectives
Structural tests to demonstrate that the modular wing behaves structurally in the same manner as a wing made from one piece

5. Validation of theoretical predictions against experimental results
Comparison of (3) and (4) for the single-part wing and the modular wing

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
Charmaine Johnston

External Leader Location
CSIR

External Organisation
CSIR

Total Funding (ZAR)
500

Experimental Requirements
CSIR wind tunnel
Experimental analysis of the energy storage system used to propel a steam powered rocket.

Lecturer, Ms B Huyssen
Max students, 1

Project Description

1. Background
Steam powered or water powered rockets make use of the energy stored in compressed air propelled at a high velocity through a nozzle in order to create thrust. It is a property of water to boil at a higher temperature when it is subjected to a higher pressure. With this principle applied in a practical sense hot water can be stored inside a pressurised hot water tank and then accelerated through a small opening (typically a nozzle) which will produce a recoil of the rocket in the opposing direction. Due to the drop of pressure the water undergoes it flashes from water into steam.

2. Problem statement
There is a need of a research on how to exploit the available energy inside the pressure vessel, paying particular interest to the nozzle, and how such exploitation of energy can be applied in a practical sense.

3. Theoretical objectives
The student will be tasked to design the launch system and to test it with CFD.

4. Experimental objectives
A prototype of the energy storage system is expected to be built to generate experimental results under different input conditions.

5. Validation of theoretical predictions against experimental results

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
Hooseria

External Leader Location
CSIR

External Organisation
CSIR

Total Funding (ZAR)
500

Experimental Requirements
Temperature sensor, force measurements equipment.
Project Description

1. Background
The use of Additive Manufacturing (Rapid Prototyping / "grown") parts is gaining momentum; this project applies the technology to wind tunnel models. The surface finish achieved by the AM process is insufficiently smooth for wind tunnel models. One approach to achieve better surface finishes is to manufacture the wind tunnel model using two manufacturing techniques; NC machining and AM.

2. Problem statement
To design a wind tunnel model for manufacture using the two techniques.

3. Theoretical objectives
Design a manufacturing version of the wind tunnel model such that the model can be supported during NC machining without deformation.

4. Experimental objectives
To measure up the wind tunnel model (3D)

5. Validation of theoretical predictions against experimental results
Verify that the manufacture model matched the CAD version of the model.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
Charmaine Johnston

External Leader Location
CSIR

External Organisation
CSIR

Total Funding (ZAR)
500

Experimental Requirements
none
Investigation on Surface roughness in AM

Lecturer, Ms B Huyssen  
Max students, 1

Project Description

1. Background
The use of Additive Manufacturing (Rapid Prototyping / "grown") parts is gaining momentum; this project applies the technology to wind tunnel models. The surface finish achieved by the AM process is insufficient smooth for wind tunnel models.

2. Problem statement
Determine a surface finishing technique for polymers which achieves a smooth finish (e.g. N3) and which will survive wind tunnel test requirements (for a low speed wind tunnel). This is to be demonstrated on a wind tunnel model wing. More than one method may be proposed but they must be time and cost effective.

3. Theoretical objectives
To predict the finish which can be achieved by the proposed method. Predict the aerodynamic effect on the results with the use of CFD.

4. Experimental objectives
To measure the surface finish.
To test a wind tunnel model wing, using unfinished and the finished versions of the wing and to measure the aerodynamic effect.

5. Validation of theoretical predictions against experimental results
Direct comparison of (3) and (4)

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
Charmaine Johnston

External Leader Location
CSIR

External Organisation
CSIR

Total Funding (ZAR)
500

Experimental Requirements
None
Project Description

1. Background
CLFR systems are a type of Concentrated Solar Power (CSP) system that uses line concentration and flat mirrors mimicking a Fresnel lens to reflect sun energy onto multiple receivers. A new type of mirror layout is based on etendue conservation, leading to a curved mirror field that would be more prone to wind loads. In addition, CLFR plants have multiple receivers that are slanted, also increasing their frontal area for an oncoming wind. Traditionally, wind tunnel studies are performed to study wind loads on external structures like heliostats, parabolic troughs and other solar collectors. More recently, Computational Fluid Dynamics (CFD) is increasingly being used because of the growth in computational power. Both these analysis methods have their place and will be used in this topic. A 2015 topic considered the wind loads on the mirror field and receiver separately. This topic considers the convective heat transfer of the slanted receiver only.

2. Problem statement
Build a scale model of one of the receivers of the CLFR plant for testing in a wind tunnel. The receiver needs to be heated for testing (not through the sun). Construct a CFD model of the same geometry for a theoretical investigation. Investigate different insulation housing shapes to both reduce the drag force on the receiver and to limit convection heat losses.

3. Theoretical objectives
Learn to apply CFD to external flow around bluff bodies. Consider vortex shedding and other transient phenomena to ensure that they are not present in the final product.

4. Experimental objectives
Test a model of the receiver in a wind tunnel using appropriate sensors, instrumentation and data capturing and post-processing.

5. Validation of theoretical predictions against experimental results

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Wind tunnel (open loop)
Development of Solar Cooker

Lecturer, Prof KJ Craig
Max students, 3

Project Description

1. Background
Solar cookers come in a variety of shapes and sizes. This project focuses on the development of a portable solar cooker that can be used for camping/picnic purposes. The different students will focus on different types, e.g., dish-type, circular Fresnel mirrors and parabolic trough types.

2. Problem statement
Model a solar cooker using Computational Fluid Dynamics (CFD) and/or ray-tracing software. Construct cooker and test.

3. Theoretical objectives
Build a CFD model of the solar cooker. Perform radiation analysis with specified radiative surface properties and heat transfer fluid characteristics. Determine optical and thermal efficiency.

4. Experimental objectives
Construct a solar cooker for testing and comparison with theoretical model. Use appropriate sensors, instrumentation and data capturing.

5. Validation of theoretical predictions against experimental results

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Instrumentation: thermocouples and flow measurement and data logger
Automatic tracking for Scale model of Compact Linear Fresnel Reflector (CLFR) plant

Lecturer, Prof KJ Craig
Max students, 2

Project Description

1. Background
A 2015 project developed the basic framework and operation of a scale model Compact Linear Fresnel mirror field based on etendue conservation. This project extends the infrastructure by providing actuation of the mirrors to enable tracking during the day. An actuation system needs to be designed and tested for optimal optical efficiency of a target receiver. A 2015 MOX design project looked at a possible actuation system. The 2 students will be considering different actuation mechanisms for different parts of the mirror field.

2. Problem statement
Model a CLFR system with mirror field and receiver using ray-tracing software. Develop an actuation system based on a kinematic analysis.

3. Theoretical objectives
Investigate the optical performance of the mirror field at different times during the day using ray tracing. Evaluate the tracking accuracy.

4. Experimental objectives
Construct actuation system and test in sunlight to estimate performance of the mirror field for comparison with modelled results.

5. Validation of theoretical predictions against experimental results

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Workshop for manufacturing of actuator components
Development of hybrid pressurized air receiver for parabolic dish

Lecturer, Prof KJ Craig
Max students, 1

Project Description

1. Background
Parabolic dish systems use a receiver at the focal point to transfer solar thermal energy to a working fluid. A 2015 project developed a receiver based on the HPAR (hybrid pressurized air receiver) concept for use in a Brayton cycle. This project extends that work by also considering external forced convection flow to enhance the heat transfer in the receiver. The insulation and ducting system around the receiver therefore needs to be developed to allow for limited heat loss and maximum heat transfer to the working fluid using Computational Fluid Dynamics (CFD).

2. Problem statement
Extend the receiver model with a ducting system to provide external forced convection in the receiver cavity. Construct a CFD model of the same geometry for a theoretical investigation.

3. Theoretical objectives
Build a CFD model of the solar cooker. Perform radiation analysis with specified radiative surface properties and heat transfer fluid characteristics. Determine optical and thermal efficiency of the HPAR.

4. Experimental objectives
Test a model of the receiver with an existing parabolic dish using appropriate sensors, instrumentation and data capturing and post-processing.

5. Validation of theoretical predictions against experimental results

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Thermocouples, flow measurement and data logger
Existing parabolic dish
Project Description

1. Background
CPV systems use concentrated solar energy with photovoltaic (PV) or solar cells. The addition concentration increases the electrical output but increases the cell temperature and can reduce the efficiency. The existing systems mostly use point concentration with high-cost multi-junction solar cells. This project evaluates lower concentration (line) in conjunction with cheaper solar cells to investigate whether this technology has an application between current 1-sun roof mounted PV panels and the high point concentration plants. The Compact Linear Fresnel Reflector scale model developed in 2015 and extend by other projects in 2016 will be used as the source of solar power in this project. The project will therefore consider the design of the receiver suitable for CPV. 2 students will evaluate different geometries and the use of secondary reflectors.

2. Problem statement
Model a CLFR receiver using ray-tracing software. Model the receiver layout including cooling of the PV elements using Computational Fluid Dynamics (CFD). Construct CPV receiver and test.

3. Theoretical objectives
Build a CFD model of receiver. Perform radiation analysis with specified radiative surface properties. Develop a cooling model for limiting the PV cell temperature.

4. Experimental objectives
Construct receiver and test for comparison with theoretical model. Use appropriate sensors, instrumentation and data capturing.

5. Validation of theoretical predictions against experimental results

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Thermocouples, flow measurement, current measurement and data logger
Existing parabolic dish
Improving Centrifugal Pump Efficiencies

Lecturer, Prof KJ Craig
Max students, 1

Project Description

1. Background
(In collaboration with Walter Meano Engineering who provide experimental and workshop facilities)
Pumps are involved in nearly every aspect of modern living. In businesses, buildings, households and industries, pumps exist - in some form or another. They are key components in maintaining comfort levels in buildings. They deliver and distribute clean drinking water from water treatment plants throughout cities, while at the same time removing wastewater and they are highly present within a wide range of industries. The world depends on them, but many pumps are also serious energy wasters, leaving behind a significant carbon footprint. This is because today's pumps account for no less than 22% of the world's electricity consumption. Two thirds of all pumps use up to 60% too much energy and if every business switched to a high efficiency pump system there could be global savings of 4% of the total electricity consumption - comparable with the residential electricity consumption of 1 billion people. An ideal example is the vertical spindle dewatering pumps that are being used in our mines, which have a maximum efficiency of 60% and with one impeller design being used for the range of pumps. With the use of Computational Fluid Dynamics (CFD) the performance of the different configuration parameters can be used to optimize performance for each type of pump. This topic is targeted at the student who is interested in numerical simulation and optimization of physical phenomena using computer software. Significant time would have to be spent learning the relevant software tools and impeller design variables, but the potential outcome would result in a significant energy saving in the mining sector and should be sufficient reward for this effort.

2. Problem statement
Maximize the efficiency of the VSE 100 Pump using a 2 Pole motor, with an improved impeller – volute design.

3. Theoretical objectives
Predict the performance of the chosen design and drive towards an optimal configuration that would maximize efficiency at the required performance.

4. Experimental objectives
Test at least one of the improved configurations.

5. Validation of theoretical predictions against experimental results

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Supplied by Walter Meano Engineering
Dr J Dirker

Renewable Fresnel solar collector adaption for water heating

Lecturer, Dr J Dirker
Max students, 4

Project Description

1. Background
Non-traditional innovative water heating systems can reduce the energy utility bill of users that require larger quantities of hot water. Such systems can also assist in reducing the burden on the power utility companies and reduce the impact of power production the environment.

2. Problem statement
A non-traditional water heating system concept that appears promising, is to be experimentally investigated in order to evaluate if there is technical merit in developing it further. The concept makes use of a Fresnel solar collector in a non-traditional manner to increase the heat flux on the outside of a horizontal water tube. The increased concentrated solar heat flux at the bottom of the tube has a dual purpose: (1) to increase the heat transfer coefficient inside the tube due to buoyancy driven secondary flow and (2) it reduces the exposed surface area of the water tube which might reduce in heat losses to the environment.

3. Theoretical objectives
Set-up a first order thermodynamic and heat transfer model to describe the semi steady state operation of such a system in terms of mass-flow rate and heat absorption ability. Extend the theoretical investigation to include a numerical approach if needed to improve calculation accuracy. Compare the expected performance of the proposed heating system with that of a traditional solar collector system.

4. Experimental objectives
Design and construct a set-up test-section and reference test section. The reference test section will of a traditional multiple pass tube lay-out without solar heat concentration. The other test-section will consist a Fresnel solar reflector to concentrate the rays onto a single tube. A water circulation system is to be developed such that the water flow rate can be controlled (laminar and turbulent flow regimes). Construct, calibrate and install suitable thermal probes. Determine semi-steady state temperature field, flow rate, and temperature responses to determine which system has the relative higher thermal efficiency. Different students will consider the effect of different aspects such as the tube diameter, water flow rate, and Fresnel collector concentration factor.

5. Validation of theoretical predictions against experimental results
Compare experimentally and theoretically obtained trends with each other. Comment on observable trends and the possible existence of an optimum flow rate.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Optimised rib heat transfer enhancement in water systems using liquid crystal thermography

Lecturer, Dr J Dirker
Max students, 2

Project Description

1. Background
Improved thermal systems required innovative enhancement of heat transfer mechanisms to reduce entropy generation. Several enhanced heat transfer systems exist, which increase local heat transfer coefficients. One such method makes use of ribbed walls on a heat transfer surface. These ribs disturb boundary layer development.

2. Problem statement
The local heat transfer coefficients on a ribbed wall with water as the fluid (having a relatively high Prandtl number) are to be determined experimentally and numerically for different water flow rates and ribbed geometric parameters (such as pitch, height and aspect ratio).

3. Theoretical objectives
Set up a numerical model which could be used to predict the wall heat transfer and temperature distribution on a ribbed wall with a uniform heat flux imposed on it. The flow is to flow perpendicular to the rib direction. Local heat transfer coefficients are to be determined for different flow rate and geometrical parameters of the ribs.

4. Experimental objectives
Design and construct a set-up test-section that will make use of liquid crystal thermography (a paint layer that will change colour in terms of temperature) to measure the local base wall temperatures of a ribbed wall. The test section is to be transparent to allow for visual recording of the colour response of the paint using an LCD camera. Based on the imposed heat flux and the energy balance principle, determine the local heat transfer coefficients for different flow rates and rib dimensional parameters. (Each student is to investigate a different geometrical parameter).

5. Validation of theoretical predictions against experimental results
Compare experimentally and theoretically obtained trends with each other. Comment on observable trends and the possible existence of an optimum rib parameter.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Thermocouples and data-logger
Natural renewable cooling using phase change material

Lecturer, Dr J Dirker
Max students, 3

Project Description

1. Background
Significant amounts of thermal energy are absorbed or released when a substance undergoes phase change. This latent effect can be used in a wide range of application including passive cooling systems that store the “coolness” of the atmosphere by solidification during night (charging phase) and releases the “coolness” by melting during the day (discharging phase) when cooling is needed. Several materials (such as paraffin-waxes) exist that undergo phase change in the thermal comfort range of humans. Unfortunately, many of these substances have low thermal conductivities, which inhibit the absorption and release heat rates. However, when harnessed correctly, this can dramatically reduce energy consumption of an air-conditioning plant.

2. Problem statement
Characterise of a simple phase-change latent storage geometry and optimise internal fin structures to increase the effective thermal conductivity of the geometry. Of interest are the charging and discharging cycles of the material for predefined geometric lay-outs (plates and cylinders) at different charging and discharging conditions.

3. Theoretical objectives
Understand the enthalpy method for predicting the phase-change process. Implement this method in a CFD program (such as Ansys Fluent) for one predefined geometric lay-out with and without internal fins. Perform a set of charging and discharging transient state analyses with different thermal boundary conditions.

4. Experimental objectives
Design and construct a set-up to match the predefined geometric lay-out selected. One test section should be without internal fins and the other with a preselected fin geometry. Construct, calibrate and install suitable thermal probes. Track the internal temperature response inside the phase change material during charging and discharging cycles to track the phase change process.

5. Validation of theoretical predictions against experimental results
Compare experimentally and theoretically obtained trends with each other. Comment on observable trends and whether the internal fins improved the effective performance of the system.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Thermocouples and data-logger
Repurposed Shipping Container thermal mass evaluation

Lecturer, Dr J Dirker
Max students, 1

Project Description

1. Background
An increasing number of libraries, classrooms, computer labs and buildings are being built by repurposing old containers, but many have poor thermal insulation (hot in summer, cold in winter, poor ventilation). The Scope would exist to align with an organization like http://breadlineafrica.org/ and to model and offer advice on optimizing their libraries. This initiative has helped a number of schools in disadvantaged communities gain access to classrooms and is currently used by the SHOUT initiative that aims to build libraries all over South Africa using these containers. Because these containers are made of steel, their thermal conductivity is high and thus temperature fluctuations are high. It is thus important to provide means of increasing time lag and decrease the decrement factor through increasing thermal energy storage capacity. By investigating different methods of increasing the thermal mass of the thin steel walls of the container by adding either insulation or something similar, one can increase the lag time and allow for fewer fluctuations in temperature. Thus introducing a possible solution to the problem, if it is feasible in the end.

2. Problem statement
The effect of the amount, type and positioning of thermal mass along with insulation material is not known. This effect is to be investigated numerically and experimentally to indicate if this is a viable thermal solution for repurposed container use.

3. Theoretical objectives
Clearly establish an understanding of the effects of varying amount and location of thermal mass on dynamic heat-transfer characteristics of insulated container walls using the same climate data from various locations within South Africa. To do this a number of parameters will be calculated and thus, a good understanding of key concepts such as time lag of the heat transfer, effective methods of energy conservation, thermal resistance, thermal conductivity, building envelope, decrement factor and more must be established. This is to be done using a commercial numerical packages such as Flow EFd, Ansys Fluent or Star CCM+

4. Experimental objectives
Design and construct a scaled setup to be investigated as well as a reference scaled set-up to represent a shipping container. The transient state effect of different thermal mass and insulation positions are to be compared with the reference set-up. The scaled experimental test can be conducted in controlled lab environments, or outdoors. Construct, calibrate and install suitable thermal probes. Track the internal temperature response inside the structures during parallel running test.

5. Validation of theoretical predictions against experimental results
Compare experimentally and theoretically obtained trends with each other. Comment on observable trends and whether additional thermal mass improves thermal comfort within the structure, and whether the placement of the insulation and thermal mass components are important. There is a possible scope extension to include the optimization of the positioning of the material components.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
Experimental Requirements
Thermocouples and data-logger
Project Description

1. Background: The TuksBaja team designed a new gearbox for the 2015 season. This gearbox requires further development in order to improve efficiency, determine optimal gear ratios and reduce mass.
2. Problem statement: Verify the existing design and reduce weight whilst maintaining life.
4. Experimental objectives: Measure fatigue loading under representative operating conditions.
5. Validation of theoretical predictions against experimental results: Test gearbox until failure to verify acceptable fatigue life and optimal design.

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Baja e-CVT development

Lecturer, Prof PS Els
Max students, 1

Project Description
1. Background: Baja SAE is an intercollegiate design event whereby students design, manufacture, assemble and race an all-terrain Baja vehicle. The rough terrain provides for various design opportunities and constant improvement by implementing designs practically.
2. Problem statement: The TuksBaja vehicle is currently making use of a mechanically controlled Continuously Variable Transmission (CVT). The transmission has been a problem in the past with effective gear ratios not matching situations and therefore not getting the maximum performance out of the vehicle. The current design for the transmission does not allow for easy change of transmission characteristics. One feasible solution is to replace the mechanical control system with an electronic system.
3. Theoretical objectives: Develop a mathematical model of a CVT that can be used to predict performance under various speed and load conditions for implementation of electronic control.
4. Experimental objectives: Characterise the CVT and measure performance under various speed and load conditions. Characterise parameters required for mathematical modeling e.g. friction coefficient.
5. Validation of theoretical predictions against experimental results: Compare theoretical results to experimental results. Adapt model if required. Use model to investigate optimal control of CVT shifting characteristics.

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
TuksBaja spring–damper development

Lecturer, Prof PS Els
Max students, 1

Project Description

1. Background: The TuksBaja vehicle makes use of four independent hydropneumatic spring-dampers to comfortably navigate off-road terrain. These spring-dampers are designed and manufactured in-house. The team implemented a new design for the 2015 vehicle. This design needs to be thoroughly characterised and modeled.

2. Problem Statement: Conduct tests on the 2015 spring–dampers and compare the results to the 2014 spring–damper results.

3. Theoretical Objectives: Develop a mathematical model to predict the spring and damping characteristics of the 2015 spring–dampers.

4. Experimental Objectives: Determine the spring and damper characteristics, as well as model parameters, experimentally under laboratory conditions.

5. Validation of theoretical predictions against experimental results: Extract the required model parameters from experimental data. Compare simulation results to experimental results and analyse possible discrepancies. Use model to improve the design.

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Project Description

1. Background

Globally there is growing interest in the development of smart phone based applications for maintenance, diagnostics and prognostics. It is envisaged that maintenance and operational personnel will in future be more and more equipped with devices such as these, to support the drive towards predictive maintenance and lower asset life cycle cost.

The use of these devices in this role has become feasible because of sensors such as accelerometers, gyroscopes, GPS and cameras which have now become commonplace on these phones, and the rapidly growing computational capability of these phones. In addition to the standard sensors, a range of specialized sensors such as distance and range sensors, infrared sensors and force transducers, are also becoming available.

This project is part of an initiative in the Centre for Asset Integrity Management to start develop algorithms suitable for mobile phone maintenance, diagnostics and prognostics applications.

2. Problem statement

Identify an interesting maintenance, diagnostics or prognostics problem that lends itself to implementation on a mobile phone. Examples of such problems might include: a) Determine how true a vibratory screen runs b) Determine the motion of a slender structure due ambient or other excitation c) Determine temperature fluctuations on electrical machinery d) Develop a two plane rotor balancing application e) Develop a helicopter/fan blade motion visualization tool.

Develop a simplified dynamic model of the system to allow numerical investigation of the effects of a fault on the system under investigation.

Develop diagnostic algorithms to capture the effects of the fault conditions under consideration.

Develop an experimental test setup to simulate the fault conditions.

Apply the diagnostic algorithms on the numerical model and the experimental setup.

Critically analyse your results.

The emphasis with these studies will be on the development of the algorithms and methodologies, and not on the real implementation on a cell phone. Students are welcome to implement the system in a Python and MATLAB environment rather than directly on the phone.

3. Theoretical objectives

Develop simulation model for investigating the effect of faults on system response.

Develop appropriate diagnostic algorithms.

4. Experimental objectives

Verify that the system performs as expected.

5. Validation of theoretical predictions against experimental results

Validate numerical predictions against experimental results and critically evaluate.
Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Equipment in the Sasol Laboratory for Structural Mechanics will be available.
We will consider buying special equipment such as a mobile phone compatible IR camera, if justified.


**Project Description**

1. Background
   A good understanding of fracture processes and the ability to model them accurately is essential for the design of components in many industries, particularly the aeronautical industry.

2. Problem statement
   Finite element modeling of fracture processes is limited in that cracking can only proceed along predetermined paths, such as along the boundaries between elements. This makes it very difficult to predict the behaviour of real materials. Students working on this project will have a choice of two approaches to solve this problem.

Franc2D is a finite element program which models crack propagation through automatic remeshing of the domain based on failure criteria.

http://www.cfg.cornell.edu/software/franc2d_casca.htm


The extended finite element method (often called XFEM) allows flexibility about the crack path by separating the definition of the mesh from the definition of the crack. The elements around the crack are enriched with additional functions which capture the discontinuity of the crack and the singularity ahead of the crack tip. A Matlab implementation of the method is available.

http://www.matthewpais.com/2Dcodes

The computational work will be supported by experimental investigation of fracture crack propagation paths in different geometries.

3. Theoretical objectives
   Explore the possibilities as well as the limitations of XFEM using a Matlab implementation of the method. / Explore the possibilities as well as the limitations of Franc2D.

4. Experimental objectives
   Perform at least one fracture experiment (such as a compact tension test, a four point bend test, or a miss-hole or sink-hole test).

5. Validation of theoretical predictions against experimental results
   Correlate the experimental results with results from computational modeling.

Note: Students need to be comfortable with programming.

**Category**

Mechanical

**Group**

Center for Asset Integrity Management

**External Leader**

N/A

**External Leader Location**

N/A
External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Access to 5 kN tensile testing machine
Mechanical properties of polymer-clay nanocomposites

Lecturer, Dr H Inglis
Max students, 4

Project Description

1. Background
Polymer-clay nanocomposites are polymers reinforced with nanoscale (1 – 100 nm dimension) clay inclusions, significantly improving the stiffness and strength of the polymer, as well as other mechanical, chemical and thermal properties. However, toughness or impact strength may be compromised, in ways which are not yet well-understood.

http://www.composites.northwestern.edu/research/nanomulticomp/index.htm


2. Problem statement
Investigate the effect of different size, shape and volume fractions of clay inclusions on the strength and toughness of polymers.

3. Theoretical objectives
Model the nanocomposite using either numerical techniques (FEM or XFEM) or mathematical techniques to help to understand the underlying mechanisms of failure.

4. Experimental objectives
Manufacture polymer-clay nanocomposites with clay inclusions of varying shape, size, volume fraction and type, and conduct tests to determine the mechanical properties of the nanocomposite, as well as observing the failure surfaces.

5. Validation of theoretical predictions against experimental results
Compare results of experimental and theoretical investigations.

Note: Students need to be comfortable with mathematical derivation or programming

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Access to 5kN tensile testing machine
Investigation of the use of vermiculite for energy absorption applications

Lecturer, Dr H Inglis
Max students, 4

Project Description

1. Background
Vermiculite is a layered micaceous mineral, which is produced as a by-product of mining activities. When exfoliated under exposure to heat or radiation, the flat layered material expands like a concertina, up to twenty times its original thickness.


2. Problem statement
In tests done on single grains of exfoliated vermiculite, it has been shown that this material can absorb energy when it is crushed. We would like to investigate whether this effect can be scaled up to large numbers of grains.

Investigate the design and properties of structures consisting of many grains of vermiculite, for use in energy-absorption applications (e.g. mine roof collapse). Vermiculite structures could absorb energy by acting as a damper during shock loading events. By testing different bulk vermiculite configurations, determine the energy absorption capacity of the material, and suitability for large scale applications.

3. Theoretical objectives
Model the crushing behaviour of exfoliated vermiculite, to predict the energy that will be absorbed during this process.

4. Experimental objectives
Test a number of different bulk vermiculite configurations to characterise the material properties under squeeze loading, and to determine the feasibility of using this material in large scale applications.

5. Validation of theoretical predictions against experimental results
Compare results of experimental and theoretical investigations.

Note: Students need to be comfortable with mathematical derivation or programming

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Access to 5kN tensile testing machine
Characterizing the effect of material removal defects on boiler tubes

Lecturer, Dr H Inglis
Max students, 4

Project Description

1. Background
In a high temperature, corrosive environment, boiler tubes suffer material loss due to corrosion and due to impacts. During a shutdown, defects are cataloged using NDT techniques as well as visual inspection, but there is not sufficient time to repair all the defects. It is important to develop decision-support tools to prioritise repair work.

2. Problem statement
Investigate a range of different material removal defects on a simplified geometry as a first step to categorising defects according to their severity and the urgency of repair.

3. Theoretical objectives
Model a range of material removal defects using nonlinear finite element methods, and categorise the defects as safe or unsafe.

4. Experimental objectives
Develop a simplified geometry which is representative of the failures of boiler tubes, and test a range of defect shapes and sizes.

5. Validation of theoretical predictions against experimental results
Compare results of experimental and theoretical investigations.

Note: Students need to be comfortable with mathematical derivation or programming

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Access to 50kN tensile testing machine.
Project Description

1. Background
Lumbosacral fracture-luxations are most commonly seen in younger dogs as a result of motor vehicle trauma (Seim, 2002). Since any instability over a fracture line will result in delayed healing and excessive callus formation, the ideal fixation methods should be able to withstand even minimal angular deformation. Various fixation methods exist having different advantages and disadvantages. It is required that these fixation techniques be tested in order to quantify their strength and determine their mode of failure.

In order to test and compare the various fixation techniques these fixation methods have to be applied to spine segments harvested from cadavers. It is difficult to get spine segments that are exactly similar and this makes comparison between fixation techniques difficult as there are a lot of variation introduced by the cadaver spine specimens that are used. This project requires a dedicated student that is up for a challenging and interesting project. The student should preferably have an interest in biomechanics as the student will have to read up on spine biomechanics. This project will require the use of CAE tools, such as a Multi-body dynamics software package (i.e. ADAMS/View), to perform the modelling. The student will therefore be required to familiarise him/herself with the required tools.

2. Problem statement
A spine segment model of the lumbar spine has been developed. Quantification of the repeatability of this spine segment model is required.

3. Theoretical objectives
An accurate model of the spine segment model is required that is able to capture the behavior of the spine segment in flexion and extension.

4. Experimental objectives
The existing spine segment model has to be improved. The spine segment model has to be characterized in order to obtain experimental measurements of the joint stiffness’s and its behavior in flexion-extension.

5. Validation of theoretical predictions against experimental results
The theoretical model of the spine segment has to be validated by comparing the predicted behavior to the experimentally measured behavior. Relevant validation metrics must be used.

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Improving biofidelity of the canine spine segment model

Lecturer, Dr CJ Kat
Max students, 2

Project Description

1. Background
Lumbosacral fracture-luxations are most commonly seen in younger dogs as a result of motor vehicle trauma (Seim, 2002). Since any instability over a fracture line will result in delayed healing and excessive callus formation, the ideal fixation methods should be able to withstand even minimal angular deformation. Various fixation methods exist having different advantages and disadvantages. It is required that these fixation techniques be tested in order to quantify their strength and determine their mode of failure.

In order to test and compare the various fixation techniques these fixation methods have to be applied to spine segments harvested from cadavers. It is difficult to get spine segments that are exactly similar and this makes comparison between fixation techniques difficult as there are a lot of variation introduced by the cadaver spine specimens that are used.

This project requires a dedicated student that is up for a challenging and interesting project. The student should preferably have an interest in biomechanics as the student will have to read up on spine biomechanics. This project will require the use of CAE tools, such as a Multi-body dynamics software package (i.e. ADAMS/View), to perform the modelling. The student will therefore be required to familiarise him/herself with the required tools.

2. Problem statement
A spine segment model of the lumbar spine has been developed. Currently it can only produce linear joint stiffness. The student needs to determine and improve, if needed, the biofidelity of the spine segment model.

3. Theoretical objectives
An accurate model of the spine segment model is required that is able to capture the behavior of the spine segment in flexion and extension.

4. Experimental objectives
The spine segment model has to be characterized in order to obtain experimental measurements of the joint stiffness’s and its behavior in flexion-extension. The experimental data can then be used to determine the biofidelity of the spine segment model as well as to validate the theoretical model. If the biofidelity of the spine segment model is found to be lacking the spine segment model has to be improved.

5. Validation of theoretical predictions against experimental results
The theoretical model of the spine segment has to be validated by comparing the predicted behavior to the experimentally measured behavior. Relevant validation metrics must be used.

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Uncertainty quantification of the muscle forces on a seated bicep curl exercise

Lecturer, Dr CJ Kat
Max students, 2

Project Description

1. Background
Design of exercise equipment is a complicated task and warrants consideration of a series of biomechanical and ergonomics factors. Furthermore, increased loading is inevitable on certain parts of the body due to the repetitive nature of exercises. Improvement in equipment design could reduce this hazard and offset such a negative effect on the body. Mathematical and computer modelling is suitable for a wide variety of applications such as sports and training equipment. Capable of simulating musculoskeletal human models with mechanical systems, three dimensional (3D) musculoskeletal modelling may be able to answer many questions concerning the effects of the resistance training equipment on the body.

This project requires a dedicated student that is up for a challenging and interesting project. The student should preferably have an interest in biomechanics as the student will have to read up on the biomechanics related to the bicep curl exercise. This project will require the use of CAE tools, such as a Multi-body dynamics software package (i.e. ADAMS/View), to perform the modelling. The student will therefore be required to familiarise him/herself with the required tools.

2. Problem statement
Various parameters (such as muscle insertion points) are difficult to obtain when creating musculoskeletal models. The effect of these parameters on the force produced in the muscle of the arm has to be investigated and quantified.

3. Theoretical objectives
Create a musculoskeletal model of the upper body/upper limbs of the human that are relevant to the bicep curl exercise. The musculoskeletal model should be able to perform a bicep curl and predict the forces in the prime flexors of the elbow. The musculoskeletal model should be parameterized such that it can be used to quantify the uncertainty of the model. Sources of uncertainty that the model needs to be able to capture is, but not limited to, muscle origin and insertion points.

4. Experimental objectives
Obtain relevant measurements on the mechanical arm-seated bicep curl exercise machine in order to validate the predictions of the musculoskeletal model created.

5. Validation of theoretical predictions against experimental results
Validation of the musculoskeletal model has to be performed by comparing the experimental measurements to the predictions of the model. The validation process must include uncertainty quantification and make use of relevant validation metrics.

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Ride evaluation optimisation of a bicycle

**Project Description**

1. **Background**
Cycling is a popular recreational past time for many. The terrain that many of these mountain bikers take on is in many cases extremely rough. Mountain bikes (MTB) have evolved from no suspension, to compliant front forks to the current full-suspension mountain bikes in order to improve handling as well as ride comfort to the rider. The ride of a bicycle is not only important in mountain biking but also for bike commuters using non-suspended bikes.

This project requires a dedicated student that is up for a challenging and interesting project. The student should preferably have an interest in human factors in vehicle dynamics as the student will have to read up on ride comfort standards. This project will require the use of CAE tools, such as a Multi-body dynamics software package (i.e. ADAMS/View), to perform the modelling. The student will therefore be required to familiarise him/herself with the required tools.

2. **Problem statement**
Ride of a bicycle is important from both a health and perception perspective. The optimal settings for a suspended and non-suspended bicycle is critical in obtaining the best ride.

3. **Theoretical objectives**
Model the bicycle (suspended or non-suspended) using a multi-dynamics software package such as ADAMS in order to evaluate and optimize the ride of the bicycle.

4. **Experimental objectives**
Obtain the required parameters needed to model the bicycle as well as the experimental measurements to validate the model.

5. **Validation of theoretical predictions against experimental results**
Validation of the model has to be performed by comparing the experimental measurements to the predictions of the model. The validation process must make use of relevant validation metrics.

Note that even though this project is suggested to make use of a bicycle the vehicle considered may also be a BAJA

**Category**
Mechanical

**Group**
Vehicle Systems Group

**External Leader**
N/A

**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Sensitivity analysis of ride comfort evaluations

Lecturer, Dr CJ Kat
Max students, 2

Project Description

1. Background
The ride of a vehicle (bicycle, motorcycle, car, etc.) is of critical importance and these days consumers expect exceptional levels of ride comfort from their vehicle. Vehicle manufacturers evaluate the ride comfort of the vehicle using applicable standards to ensure that it meets consumer expectations. It is therefore critical that the ride comfort evaluations are performed with a robust and reliable procedure.

This project requires a dedicated student that is up for a challenging and interesting project. The student should preferably have an interest in human factors in vehicle dynamics as the student will have to read up on ride comfort standards. This project will require the use of CAE tools, such as a Multi-body dynamics software package (i.e. ADAMS/View), to perform the modelling. The student will therefore be required to familiarise him/herself with the required tools.

2. Problem statement
Determine the sensitivity of ride comfort evaluations to important and relevant parameters (such as speed).

3. Theoretical objectives
Model the vehicle using a multi-dynamics software package such as ADAMS in order to determine the relevant parameters and perform the sensitivity analysis.

4. Experimental objectives
Obtain the required parameters needed to model the vehicle as well as the experimental measurements to validate the model.

5. Validation of theoretical predictions against experimental results
Validation of the model has to be performed by comparing the experimental measurements to the predictions of the model. The validation process must make use of relevant validation metrics.

Note that no vehicle has been specified. It is however suggested that the student make use of a bicycle or BAJA in this project.

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Repeatability of ride comfort evaluations

Project Description

1. Background
The ride of a vehicle (bicycle, motorcycle, car, etc.) is of critical importance and these days consumers expect exceptional levels of ride comfort from their vehicle. Vehicle manufacturers evaluate the ride comfort of the vehicle using applicable standards to ensure that it meets consumer expectations. It is therefore critical that the ride comfort evaluations are performed with a robust and reliable procedure.

This project requires a dedicated student that is up for a challenging and interesting project. The student should preferably have an interest in human factors in vehicle dynamics as the student will have to read up on ride comfort standards. This project will require the use of CAE tools, such as a Multi-body dynamics software package (i.e. ADAMS/View), to perform the modelling. The student will therefore be required to familiarise him/herself with the required tools.

2. Problem statement
Determine the repeatability of ride comfort evaluations.

3. Theoretical objectives
Model the vehicle using a multi-dynamics software package such as ADAMS that can be used to perform the ride comfort evaluations.

4. Experimental objectives
Obtain the required parameters needed to model the vehicle as well as the experimental measurements to validate the model.

5. Validation of theoretical predictions against experimental results
Validation of the model has to be performed by comparing the experimental measurements to the predictions of the model. The validation process must make use of relevant validation metrics.

Note that no vehicle has been specified. It is however suggested that the student make use of a bicycle or BAJA in this project.

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Analysis of the Morse taper abutment-implant interface

Project Description

1. Background
Dental implants have become the standard of care for replacing lost teeth. Implants consist of two components that are connected, namely the fixture (placed inside the jaw bone) and the abutment (protruding into the oral cavity). The two components were designed to avoid rotational movement when under function. The two components were kept together by a screw running through the centre of the abutment. This was a poor design as the two components had no friction fit and the screw would loosen over time due to the jiggling forces applied to the functional implant tooth. Not only did this lead to fractures of the screw, but the gap created by this non-friction fit, called the micro-gap, led to bacterial contamination of the inner parts of the implant and abutment, resulting in bone infection and destruction. Thus implants replacing lost teeth could in fact harm the patient by destroying the remaining jaw-bone. In 1985 an implant was designed (Figure 2 in Appendix) according to the best engineering principles for connecting two rotating components, namely the Morse taper. The quality of the cone-in-a-cone connection is however of paramount importance in preventing bacterial leakage, and it is not possible to extrapolate the benefits of evidence based systems to all systems on the market.

2. Problem statement
Quantify the quality of the cone-in-a-cone connection and the effect of loading on this connection.

3. Theoretical objectives
Model the fixture and the abutment in order to predict deformation of the connection and forces associated with it through finite element analysis.

4. Experimental objectives
Experimentally determine the quality of the cone-in-a-cone connection and the effect of loading on this connection. Also obtain the experimental data for validating the finite element analysis.

5. Validation of theoretical predictions against experimental results
Validation of the model has to be performed by comparing the experimental measurements to the predictions of the model. The validation process must make use of relevant validation metrics.

Equipment provided by School of Dentistry, Department of Periodontics and Oral Medicine.

Category
Mechanical

Group
Vehicle Systems Group

External Leader
Prof A.W. van Zyl

External Leader Location
Periodontics and Oral Medicine, University of Pretoria

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Prof S Kok

Assessing the effect of misalignment of large diameter water pipes on the efficacy of bolted flange

Lecturer, Prof S Kok
Max students, 3

Project Description

1. Background
A recent study done for Rand Water emphasized the importance of proper torqueing of bolts on large flanged connections subjected to high water pressures, to avoid failure by leaking. This study was done under the somewhat unrealistic assumption of properly aligned pipes.

2. Problem statement
It is known that technicians installing and maintaining water pipe lines regularly uses the fastening of flange bolts to correct pipe misalignment. To take the above mentioned study further it is necessary to quantify the effect of initial stress caused by misalignment corrected by bolt fastening practices. This is the goal of the proposed project.

3. Theoretical objectives
The study should include field visits and interviews with technicians and engineers of Rand Water, finite element analyses of flanged connection(s) with a significant lengths of pipe included in the model(s) on either side of the flanges.

4. Experimental objectives
Determine the effect of initial misalignment on flange leaking.

5. Validation of theoretical predictions against experimental results
Comparison of finite element results to experimental strain measurements.

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
No special requirements: existing lab infrastructure is adequate for the purposes of this topic.
Constitutive models for gaskets and O-rings

Lecturer, Prof S Kok
Max students, 3

Project Description

1. Background
In a recent study for Rand Water, it was found that the force-deflection behavior of gaskets and o-rings are nonlinear and time dependent. These gaskets and o-rings are used to seal flanged connections. If the contact pressure between the sealing surfaces drops below a critical value, a leak can occur at the flanged joints.

2. Problem statement
Select and calibrate material models to describe the force-deflection characteristics of typical gasket and o-ring materials. Investigate the effect of the prescribed bolt tightening procedure.

3. Theoretical objectives
Study visco-elastic material models, in order to model time dependent elastic response of materials. Significant competence in nonlinear finite element analysis is required for this part of the project.

4. Experimental objectives
Measure the creep response of gasket and o-ring materials using a creep test (constant load) and a stress relaxation test (constant displacement). Use these results to select appropriate material models.

5. Validation of theoretical predictions against experimental results
Calibrate the chosen material models in order to match the measured force-deflection curves, for each of the materials. Some finite element analysis expertise and other computer coding will be required.

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
No special equipment required: standard equipment available in the lab is adequate for the purposes of this study
Shim stack modelling and design

Project Description

1. Background
In suspension design, shim stacks are often encountered that provides a required force-deflection characteristic. The behavior can be nonlinear, and this makes the design of a shim stack in order to provide the correct force-displacement curve a tedious trial-and-error process.

2. Problem statement
Develop an automated design tool (finite element based) that takes a required force-deflection curve as input, and provides a specific shim stack as output (diameter and thickness for each element in the shim stack).

3. Theoretical objectives
Develop a finite element model of a shim stack. Given the geometry of the shim stack, predict the force-deflection characteristic. Use this model to build a database of shim stack curves. Given a required force-deflection curve, interpolate from the database to provide the actual shim stack design. Significant finite element expertise and other coding are required.

4. Experimental objectives
Validate the shim stack analysis model by constructing a large scale shim stack. Measure the force-deflection curve.

5. Validation of theoretical predictions against experimental results
Compare the measured and modeled force-deflection curves

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
No special equipment required.
Load reconstruction for a bicycle

Project Description

1. Background
Bicycle designs are varied. Input loads for the designs are not quantified accurately, and hence some designs fail prematurely.

2. Problem statement
Develop a numerical procedure to compute the input loads on a typical modern bicycle design

3. Theoretical objectives
Use a finite element based load reconstruction technique to determine the input loads from limited measured responses.

4. Experimental objectives
Instrument a bicycle and measure the response at appropriate locations.

5. Validation of theoretical predictions against experimental results
Compare measured and predicted input loads.

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
Derek Cloete

External Leader Location
Pretoria

External Organisation
Esteq

Total Funding (ZAR)
500

Experimental Requirements
Special equipment provided by Esteq for bursary student Delko van der Walt
Ms NM Kotze

The effect of multiple air gaps in insulation on a uniformly heated tube

Lecturer, Ms NM Kotze
Max students, 3

Project Description

1. Background

Heating and Cooling is used on a continuous basis in industry. Any heat loss/gain from the environment can be detrimental as it is costly to continually heat/cool equipment/people. An example of this is during heat transfer experiments. Heat loss to the environment severely affects the energy balance and thus the results of the experiment. Many different types of insulation is available. However, the conductivity of these products isn't always a known. Also, the quoted k value isn't reliable.

2. Problem statement

Determine the effect of different types of insulation, in combination with an air gaps, on the heat transfer of fluid in a tube to the environment.

3. Theoretical objectives

Model the expected heat transfer from a fluid in a tube to the environment. Axial conduction and diffusion must be included in this model. The fluid temperature must be varied as well. Different tube materials, tube wall thicknesses and tube diameters should be considered. Different heat fluxes must be applied to the tube.

4. Experimental objectives

Design and build an experimental set-up that will allow you to be able to measure the heat transfer of a stagnant fluid in tubes, at varying inlet temperatures, to the environment. The tubes should be of different material types, diameters and wall thicknesses. The insulation types should have a wide range of k values so that different rates of heat transfer can be measured. Air gaps must be included in the experimental design. If possible, students should try create a vacuum environment. Different heating fluxes should be considered.

5. Validation of theoretical predictions against experimental results

Using literature and classical correlations, compare your expected theoretical results with your experimental results.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Thermoflow Lab
Aglient modules cards
Power Supply
Pumps, reservoirs valves, available from N Kotze's equipment stored in Thermoflow lab
Copper pipe
Insulation
Thermocouple wire
Heating wire
Effect of multiple bends in pressure drop and heat transfer in a tube

Project Description

1. Background

Refrigeration/Heating is used on a continuous basis in industry. Dependent on the location, refrigeration piping may have any number of bends in order to transport the refrigerant from the compressor to the condenser/evaporator. This induces a fair amount of pressure losses along the way. The bends are difficult to insulate and heat losses may also be present.

2. Problem statement

Determine the effect of pressure drop and heat transfer in a copper pipe with various types/number of bends.

3. Theoretical objectives

Model the expected heat transfer from a fluid in a tube to the environment. Axial conduction and diffusion must be included in this model. Model the expected pressure drop over different types of bends (long radius, short radius, 45deg etc). The fluid temperature must be varied as well. Refrigerant copper tubing is to be used.

4. Experimental objectives

Design and build an experimental set-up that will allow you to be able to measure the theoretical objectives as stated above. The inlet temperature should be varied as well in order to test different isothermal conditions. Flow rates must be altered. The tubes should be copper and of the same type used in industry for refrigeration purposes. Different configurations of bends are to be used and the pressure drop over each must be measured. Pressure drop measurements must be taken manually. The insulation used must have a fixed k in order to eliminate variables in the study. Inlet and outlet temperatures are to be measured.

5. Validation of theoretical predictions against experimental results

Using literature and classical correlations, compare your expected theoretical results with your experimental results.

Category

Mechanical

Group

Thermofluids Research Group

External Leader

N/A

External Leader Location

N/A

External Organisation

N/A

Total Funding (ZAR)

500

Experimental Requirements

Thermoflow Lab
Pumps, reservoirs valves, available from N Kotze's equipment stored in Thermoflow lab
Copper pipe
Insulation
PT100's
Pressure capillary tubes
Manometer tubes
Characterization of fly ash in a pipe

Project Description

1. Background

Eskom is facing a crisis due to the decline in the quality of coal used to produce electricity. All of the Power Stations who utilize a wet-ash system were built by the early 1990’s. The ash content of coal that Eskom purchased at the time did not exceed 25%. However, the coal that is currently available to Eskom has Ash Contents ranging for 30% to as high as 45%. Thus a much higher tonnage of coal is burnt daily. This places a large strain on the Coal and Ash Handling plants at the Power Stations.

2. Problem Statement

Investigate ash slurry in a piping system with respect to water/ash ratio, settling velocities, wear patterns and pressure drop.

3. Theoretical Objectives

1. Determine if it is possible to scale a pipe diameter with regards to friction factors.
2. There are many slurry pumps on the market. Concentrating on the Weir Minerals brand of pumps, theoretically determine the maximum amount of fly/coarse ash that can be mixed into water that can be transported by a slurry pump. The slurry pump has a power supply of 250kW.
3. Ash slurry is non-Newtonian. Theoretically prove whether you can/can’t use Newtonian principles and model the expected pressure drop for a system.
4. Determine what your settling velocity will be for varying water/ash ratios.
5. Discuss the effect of high ash content in a slurry and its effect on the life cycle of a pipe.

4. Experimental Objectives

Design and build an experimental set up to determine:
1. The optimal velocity of the slurry to prevent settling
2. The best mass ratio to remove the maximum amount of ash
3. The expected pressure drop.

5. Validation of theoretical predictions against experimental results

Interpret your experimental results and compare with analytical data available in Literature and Industry. Scale your experimental results to current industry used equipment. Determine if increasing ash volumes can be mitigated by increasing water/ash ratios. Draw all the necessary conclusions.

Category

Mechanical

Group

Thermofluids Research Group

External Leader

N/A

External Leader Location

N/A

External Organisation

N/A

Total Funding (ZAR)

500
Experimental Requirements

Pressure drop measuring equipment
Flow measurement equipment
Tanks, pump and valves available next to electrical labs.
Study of water turbines in channel flow

Lecturer, Ms NM Kotze
Max students, 2

Project Description

1. Background

Renewable energy has become a major focus in the past number of years. Wind turbine technology has been advanced steadily over a number of years, whereby wind power is harnessed to produce electricity. However, water turbine technology is still reasonably new. The use of water turbines in channel flow is reasonably untapped.

2. Problem Statement

Design, build and test scale models of water turbines.

3. Theoretical Objectives

1. Theoretically investigate the design of water turbines in channel flow. Use a wind turbine as the basis of your design.
2. Model the effect of different blade angles, blades profiles and blade length on the power output of the turbine.
3. Determine a method to scale the design of water turbines so that it can be experimentally tested.
4. Determine a method to measure the power output of a water turbine.

4. Experimental Objectives

Design and build an experimental set up of a water turbine to determine:
1. The best blade angle
2. The best blade profile
3. The best blade length
4. The optimal number of blades of the hub
5. The most efficient combination of points 1-4.

The student will hopefully have the opportunity to use the water tunnel at the CSIR.

5. Validation of theoretical predictions against experimental results

Interpret your experimental results and compare with analytical data available in Literature and Industry. Draw all the necessary conclusions.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Water tunnel at the CSIR
Design, fabricate, and test/validate a thermocouple temperature boundary layer probe.

Lecturer, Dr G Mahmood
Max students, 2

Project Description
Thermal performance of heat exchangers and aero-thermodynamic performance of aerodynamic bodies are primarily dependent on the convection heat transfer coefficient on the body surface. To obtain estimations of the heat transfer coefficient experimentally, various intrusive and non-intrusive techniques of measurements are employed in simulated test environments. Some intrusive techniques include temperature measurement with surface thermocouples and heat-flux gages on the heated body. The most popular non-intrusive techniques of temperature measurement for the estimations of convection heat transfer coefficients are the infrared image thermography and liquid crystal thermography. However, these intrusive and non-intrusive measurements are difficult or impossible for the complex internal geometry of many heated bodies like pin-fins in channels, turbomachine blade surface, channel grooves, and jet cooling holes.

This project will design, fabricate, test, and validate a thermocouple probe that will measure the air temperature in the viscous sub-layer of the temperature boundary layer in a heated air stream. The air temperature in the viscous sub-layer can be extrapolated for the surface temperature. This type of probe can be employed in complex internal geometry as it measures the air temperature above the heated surface.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
The probe will be made of 20 micron thermocouple wires provided by the study leader. Because of the delicate nature of the wires, the student will require very steady hands and patience.
Design and fabricate film cooling slots, and measure discharge coefficients of the cooling slots.

Lecturer, Dr G Mahmood
Max students, 3

Project Description
Angled slots in the walls of gas turbine passage, combustor liners, and aerodynamic bodies are employed to deliver film cooling air-flow or just film air-jets on the wall surface. The film cooling flow protects wall from very hot gas in case of the gas turbine and combustor passages. The film jets on the aerodynamic bodies provide aerodynamic advantages such as drag reduction and preventing stall. The discharge coefficient of the film flow slot is an important parameter as it determines the pumping power requirements for the film flow and the required flow rate through the slot. The discharge coefficient is the ratio of actual flow rate to ideal air flow in the slot.

This project will design and fabricate angled slots in a plate to be used for film cooling air-flow. The discharge coefficients of the slots are to be measured for different flow rates and slot geometry. The supply line of the air flow to the slots including the flow measurement technique is also to be designed and fabricated to meet the project objectives. The pin-fin test facility of the study leader is to be used for the project.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
The design of slot will require CFD analysis using the Ansys-Fluent or Star-CCM+ in the first semester. These CFD softwares are available at the university including the training.
Design, fabricate, and test cylindrical turbulators in an annular tube.

Project Description
Flow turbulators are common passive devices employed in the heat exchangers and heating/cooling channels to enhance turbulent flow mixing and convective heat transfer from the channel walls. Typical flow turbulators include internal pin-fins, ribs, winglets, dimples, twisted tapes, and grooves. However, the heat transfer enhancement using these internal turbulators is accompanied by pressure losses increasing the requirement of flow pumping power. As a result, the thermal performance parameter of the heat transfer channels employing the turbulators is not always as good as expected. Thermal performance parameter is a measure of convective heat transfer enhancement in a channel relative to the pressure drop increase in the same channel when the flow turbulators are employed.

This project will design and fabricate cylindrical shape flow turbulators to be employed in an annular channel. An array of the turbulators must be employed in the annular channel. Measurements of pressure drop and convective heat transfer coefficients along the channel wall are to be obtained to quantify the thermal performance in the channel. The low speed atmospheric wind tunnel test facility of the study leader is to be employed for the test setup and measurements.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
The design of turbulators will require CFD analysis using the Ansys-Fluent or Star-CCM+ in the first semester. These CFD softwares are available at the university including the training.
Design, fabricate, and test pin-fin turbulators in an annular tube.

Lecturer, Dr G Mahmood
Max students, 2

Project Description
Flow turbulators are common passive devices employed in the heat exchangers and heating/cooling channels to enhance turbulent flow mixing and convective heat transfer from the channel walls. Typical flow turbulators include internal pin-fins, ribs, winglets, dimples, twisted tapes, and grooves. However, the heat transfer enhancement using these internal turbulators is accompanied by pressure losses increasing the requirement of flow pumping power. As a result, the thermal performance parameter of the heat transfer channels employing the turbulators is not always as good as expected. Thermal performance parameter is a measure of convective heat transfer enhancement in a channel relative to the pressure drop increase in the same channel when the flow turbulators are employed.

This project will design and fabricate internal pin-fin flow turbulators to be employed in an annular channel. An array of the turbulators must be employed in the annular channel. Measurements of pressure drop and convective heat transfer coefficients along the channel wall are to be obtained to quantify the thermal performance in the channel. The low speed atmospheric wind tunnel test facility of the study leader is to be employed for the test setup and measurements.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
The design of turbulators will require CFD analysis using the Ansys-Fluent or Star-CCM+ in the first semester. These CFD softwares are available at the university including the training.
Design and build a 3-D wing, and control flow separation employing slot/discrete jet.

Lecturer, Dr G Mahmood
Max students, 3

Project Description
The boundary layer flow separation on the aerodynamic wing shape bodies is an inherent property of the air-stream over the wing. The flow separation on the wing cause the drag force to be increased on the wing and can lead to the stall phenomena when the wing losses sudden lift and aerodynamic controls. The engineers sometimes employ air-jet on the wing surface to actively control the flow separation. The air-jet is forced from discrete holes/slots located in the wing. The design, configuration, and location of the jet holes/slots are important to successfully prevent or delay flow separation and depend on the wing shape.

This project will design and build a 3-D wing using the NACA airfoil profiles. The slots or discrete holes to provide the jet flow on the wing surface are to be designed and machined. The airflow to the slots/holes will be supplied by the compressed air of the UP Wind Tunnel Laboratory. Measurements of pressure on the wing surface must be obtained to quantify the location of the boundary layer separation and effectiveness of the jet flow. The large wind tunnels located at the Wind Tunnel Laboratory must be employed for the test setup and measurements.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
The wing design will require CFD analysis using the Xfoil/Fluent/Star-CCM+ in the 1st sem. Fluent and Star-CCM+ are available at the UP including the training. Xfoil is free to download from internet.
Project Description

1. Background
Eddy current brakes have been successfully implemented in many industries up to date. They pose many advantages over conventional friction brakes, due to it not having wearing components that require maintenance, and in the case of electromagnets the relatively easy control of braking force.

2. Problem statement
For this project the student is to investigate whether it would be possible to use Eddy-current devices as a means of approximately matching to rotating shafts’ speeds, thus acting similar to a clutch.

3. Theoretical objectives
A theoretical model of an Eddy-current device is to be constructed using basic electromagnetic and mechanical simulations.

4. Experimental objectives
The student is to build an appropriate test setup that is able to measure the ability to transmit power from one shaft to the other.

5. Validation of theoretical predictions against experimental results
From the test setup’s results conclusions can be made as to the restrictions and efficiency of the Eddy-current device.

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Deriving a topographic map from traction data for an underground locomotive

Lecturer, Mr RF Meeser  
Max students, 5

**Project Description**

1. Background
Hybrid vehicles are able to store energy in a battery system when decelerating, known as regenerative braking. There is however a problem with this; if the vehicle’s battery is fully charged the ability to regenerate when braking is lost and you will then have to rely on friction braking. So, if you know the terrain you are travelling over you can plan ahead for the load conditions that you expect to encounter next on your journey. In the underground mining sector a hybrid vehicle is used to transport goods in and out of the mine. To optimise the energy usage cycle it would be favourable to know the load cycle of the power train so as to be able to optimally manage the vehicle energy usage/storage. The problem with underground mining is that GPS systems do not work there, so using a GPS to know on which route the locomotive is at any given time is not possible.

2. Problem statement
The goal of this project is to try and derive a topographic map of the mine by looking at the electric motor power usage and locomotive displacement. If a topographic map is known it would be possible to optimally manage the electric power in the vehicle, as the vehicle would be able to identify route's previously travelled on and manage the power usage accordingly.

3. Theoretical objectives
The power usage of a vehicle will need to be modelled so that it is possible to gain the incline/decline information from the power consumed during operation. By analysing this data it is possible to construct the topographic map of the route travelled.

4. Experimental objectives
A suitable experimental setup needs to be conceived that would be able to verify if the theoretical model is capable of predicting the topographic information.

5. Validation of theoretical predictions against experimental results
Conclusions need to be made as to how accurately the model can predict the topographic information of the route.

**Category**
Mechanical

**Group**
Center for Asset Integrity Management

**External Leader**
N/A

**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Project Description

1. Background
Extensive tests were done to determine noises/vibrations felt by the driver originating from the propeller shaft whilst the vehicle was in motion. To determine if the propeller shaft was the source of the vibration, being either unbalanced or misaligned a GoPro camera was installed to observe whether excessive shaft movement was present whilst the vehicle is in motion (dynamic response of shaft and intermediate shaft bearings). This background then developed the need to develop a measuring device/measuring technique to quantify the results which were previously obtained by the GoPro camera.

2. Problem statement
Different techniques are to be investigated in order to quantify the shaft vibrations.

3. Theoretical objectives
The theoretical analysis of this project will be to determine the different analysis methods to measure imbalances on a Propeller shaft, investigating different sensing methods (optical, laser displacement, inductive, accelerometer). Balancing theory will also be important in this investigation. Thorough research will be done into the device that will measure shaft displacement through its length whilst in motion.

4. Experimental objectives
The experimental test will entail results obtained from the propeller shaft balancing machines “Schenk test bench” at the BMW premises which will be compared to the device which will be investigated and tested on the same workbench/vehicle.

5. Validation of theoretical predictions against experimental results
Compare the results obtained by the test bench to the results obtained by the student’s device and compare to the theoretically expected response.

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Increasing vehicle IC engine efficiency, focusing on the effect of intake air temperature

Lecturer, Mr RF Meeser
Max students, 2

Project Description

1. Background
The combustion process of an internal combustion (IC) engine involves the burning of Fuel and oxygen. These two components play a vital role on the power output and efficiency of the engine.

2. Problem statement
The air intakes of some existing vehicles are inefficient at supplying cold air to the cylinders, which leads to reduced air mass in the combustion process as well as reduced combustion efficiency. The goal of this study is to test various methods of insulating the intake system from the heat sources present in an engine bay. These include different materials used for components, as well as insulating materials between hot components and the air intake system.

3. Theoretical objectives
A study is to be done into the sources of heat in a typical engine bay as well as a typical intake system’s components and those materials’ heat transfer coefficients. A model of the increase/decrease in heat transferred to the intake air can be built based on the heat transfer of the various materials to the intake air.

4. Experimental objectives
For the experimental part of the research project the student is to investigate the placement of insulating materials between the heat sources and the intake air, as well as measuring the effect that different combinations of materials have on the intake air temperature, power delivery and fuel consumption. The effect of external cooling is also to be investigated to be able to comment on its feasibility.

5. Validation of theoretical predictions against experimental results
The experimental results will then be compared to the theoretical predictions with respect to temperature increases expected and sensible conclusions made.

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Prof JP Meyer

The influence of branching and scaling of blood vessels on heat transfer in clinical treatments of h

Project Description

Maintaining a constant temperature plays an important role in the functioning of biological systems. For humans, the core body temperature should be carefully controlled within a narrow band of approximately 37 deg C. This temperature control can be used for medical treatment such as: hyperthermia treatment against cancer, cooling of the head to prevent hair loss as a side effect of chemotherapy, and the cooling of patients during major surgery to protect the brain. To optimize these medical procedures it is important to be able to estimate the heat transfer and pressure drops.

Unfortunately, very little experimental work has been done to characterize the heat transfer rates and pressure drops. Existing correlations are not very helpful as they were developed for fully developed laminar flow in smooth tubes with square edges. However, the flow in the blood vessels are laminar and in the lungs $2^{17}$ bifurcations occurs that causes inlet effects that influences the heat transfer and pressure drop characteristics. Furthermore, cholesterol in the blood vessels changes the blood vessels from smooth tubes to rough tubes.

The purpose of this study is therefore to experimentally investigate the effects of branching and roughness on the heat transfer and pressure drop of blood vessels. Simulations need to be conducted to develop an experimental set-up with appropriate instrumentation. The experimental set-up needs to be designed and constructed. Four experiments needs to be executed for a range of Reynolds numbers from laminar through to transition and into the turbulent flow regime: two different types of inlets (one a squared edge for comparison purposes) needs to be tested with both a smooth tube (reference) and a rough tube.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Equipment available
Detailed investigation of serrated edges on the trailing edge of a NACA0012 airfoil

Lecturer, Mr L Page
Max students, 2

Project Description

1. Background
Vortex control is necessary to silence turbine blades also to control and reduce the drag effects on airfoils. Experimentally and numerically analyse the difference between a normal NACA0012 airfoil and an airfoil with serrated edges on the trailing edge by considering the polar curve (Lift vs drag coefficients) for low Reynolds numbers.

2. Problem statement
Design a NACA0012 airfoil with a serrated trailing edge in order to reduce the noise produced by the aifoil as well as reduce the drag effects on the airfoil.

3. Theoretical objectives
The airfoils will be numerically modelled and the performance characteristics of the airfoils should be determined. These performance characteristics should then used for comparison with the experimental results. The student must use the standard NACA0012 airfoil as a benchmark.

4. Experimental objectives
Identification of key characteristics of the airfoils that can be used to characterize the performance. Of these characteristics should be the polar curve (lift coefficient versus drag coefficient). Other possible characteristics could include the noise produced by the airfoil, the shape and dimensions of the serrated edges, etc. The student should select some of these characteristics and design experiments to accurately and repeat ably measure these characteristics.

5. Validation of theoretical predictions against experimental results
The experimentally measured and theoretically calculated characteristics of the airfoil should be intelligently and scientifically compared. Additionally, the theoretically calculated characteristics of the standard NACA0012 airfoil (without serrated edges) should be used as a benchmark. Any deviations between the experimentally measured and theoretically calculated characteristics should be investigated, reported and discussed in detail. Meaningful conclusions should than be made as well as recommendations for future research aspects.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Closed-loop Wind Tunnel with associated pressure transducers and data capturing equipment.
**Wing with Boundary Layer Suction**

**Project Description**

1. **Background**
The boundary layer which forms on the suction surface of a wing contributes to profile drag which is a major component of overall aircraft drag especially when separation occurs at larger angles of attack. This study will entail the design of a wing with a porous suction or an upper surface with a suction system to remove the boundary layer which forms during flight conditions. The experimental investigation will involve the manufacture, assembly and wind tunnel testing of a representative wing model.

2. **Problem statement**
Design a wing with either porous suction or an upper surface with a suction system to remove the boundary layer, which forms during flight conditions, in order to improve the performance of the wing.

3. **Theoretical objectives**
The wing will be numerically modelled and the performance characteristics of the wing should be determined. These performance characteristics should then be used for comparison with the experimental results. The student must use the standard wing (without suction) as a benchmark.

4. **Experimental objectives**
Identification of key characteristics of the wing that can be used to characterize the performance of the wing. Of these characteristics should be the polar curve (lift coefficient versus drag coefficient). Other possible characteristics could include the porosity, suction power, etc. The student should select some of these characteristics and design experiments to accurately and repeatably measure these characteristics.

5. **Validation of theoretical predictions against experimental results**
The experimentally measured and theoretically calculated characteristics of the wing should be intelligently and scientifically compared. Additionally, the theoretically calculated characteristics of the standard wing (without suction) should be used as a benchmark. Any deviations between the two should be investigated, reported and discussed in detail. Meaningful conclusions should then be made as well as recommendations for future research aspects.

**Category**
Aeronautical

**Group**
Thermofluids Research Group

**External Leader**
N/A

**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
Closed-loop Wind Tunnel with associated pressure transducers and data capturing equipment.
Helical Baffles for a Shell and Tube Heat Exchanger

Project Description

1. Background
A shell and tube heat exchanger is a class of heat exchanger design, that is used in a wide variety of industrial applications. As its name implies, this type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids. The set of tubes is called a tube bundle.

The classical shell and tube heat exchanger has straight baffles inside the shell, perpendicular to the shell's surface, to force the fluid over the tube bundles. However in many applications there is a build-up of sediment in the corners between the baffles and the shell surface and to overcome this problem the concept of helical baffles has become very popular.

2. Problem statement
Design, build and test a small scale shell and tube heat exchanger with helical baffles for the purposes of reducing the sediment build-up, while maintaining a high heat transfer rate and a low pressure drop.

3. Theoretical objectives
Investigate / research the effects of different baffle configurations (normal and helical) on sediment build-up, heat transfer rate and pressure drop of a shell and tube heat exchanger. Design the shell and tube heat exchanger and estimate its efficiency from available literature. CFD may be used to assist with the design and the estimation of the exchanger's efficiency.

4. Experimental objectives
Build a small scale shell and tube heat exchanger from the design. Determine the correct testing procedures and methodology for the testing of this heat exchanger and then test the heat exchanger for a few different flow rates. The experimental data obtained must then be compared to theoretical results and numerical data in order to assess the accuracy and validity of the heat exchanger design.

5. Validation of theoretical predictions against experimental results
The experimental data obtained must be intelligently and scientifically compared to theoretical and numerical results. Any deviations between results must be investigated, reported and discussed in detail. Meaningful conclusions should then be made as well as recommendations on how to improve the design of the heat exchanger.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
2x Thermocouples; Data Capturing Equipment; Make use of existing undergraduate Armfield test bench only for water heating flow control - no modification made and no existing equipment tampered with
Natural Convection for Heated Plates

Project Description

1. Background
Natural convection is a mechanism, or type of heat transport, in which the fluid motion is not generated by any external source (like a pump, fan, suction device, etc.) but only by density differences in the fluid occurring due to temperature gradients. A common industrial application of natural convection is free air cooling without the aid of fans: this can happen on small scales (computer chips) to large scale process equipment. Natural convection, however, has a lower heat transfer rate than that of forced convection and thus ways of augmenting the heat transfer rate, due to natural convection, are of interest.

2. Problem statement
Investigate the 3D effects on the heat transfer rate of heated plates cooled by natural convection as well as the effect of plate inclination.

3. Theoretical objectives
Through the use of CFD, numerically investigate the heat transfer rate of heated plates cooled by natural convection for various different parameters such as:
1) Rayleigh Number  
2) Plate spacing and dimensions  
3) Inclination

4. Experimental objectives
Determine the correct testing procedures and methodology for the testing of the heat transfer rate from heated plates cooled by natural convection. Build a test rig to experimentally validate the heat transfer characteristics, determined numerically, for a selected case (set of parameters). The experimental data obtained must then be compared to theoretical and numerical results.

5. Validation of theoretical predictions against experimental results
The experimental data obtained must be intelligently and scientifically compared to theoretical and numerical results. Any deviations between results must be investigated, reported and discussed in detail. Meaningful conclusions should then be made as well as any recommendations.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
+-6x Thermocouples; Data Capturing Equipment.
Project Description

1. Background
Every electronic equipment used on aircraft has to be analysed in order to verify the dynamic behaviour under different loading condition. The FE analysis is a powerful tool to determine the dynamic behaviour of electronic equipment in a very early stage of the design process. If the dynamic behaviour is not adequate, change in the virtual prototype can be easily applied to rectify the problem. The problem is to correctly create a virtual model capable to simulate the dynamic behaviour of the real electronic equipment.

2. Problem Statement
Create a FEA model of an existing electronic equipment. The FEA model will be validate by comparison with the test on the existing electronic equipment.
Once the model will be validated, design new solutions in order to improve the dynamic behaviour of the equipment: the requirement is no mode shapes with a frequency lower than 100 Hz.

3. Theoretical objective
Create and validate the FEA model of the electronic equipment. Improve the dynamic behaviour of the virtual prototype.

4. Experimental Objective
Analyse the dynamic behaviour of the original electronic equipment (modal analysis, dynamic response).

5. Validation of Theoretical Predictions Against Experimental Results
Experimentally validate the FEA model by comparison with the test results.

Category
Mechanical

Group
Dynamic Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Lab: Sasol Lab
Equipment: Laser Vibrometer
Turbine blade crack identification by modal testing

究竟描述

1. 背景

涡轮叶片是根据特定的自然频率设计的，以避免在正常操作条件下动态放大。可以假设，由于疲劳而在结构中产生的裂纹会改变涡轮叶片的自然频率，从而破坏设计。项目的目标是验证裂纹缺陷对涡轮叶片动态行为的有效能力，通过有限元分析（FEA）方法和实验方法。学生被要求创建一个简化的涡轮叶片形状，通过FEA（Ansys代码）分析其动态行为，选择两个/三个配置，并制造叶片以进行测试。

2. 问题陈述

分析裂纹缺陷对简化涡轮叶片动态行为的影响。

3. 理论目标

理解裂纹缺陷（长度和位置）在改变简化涡轮叶片形状的动态行为中的影响。分析将由FEA分析（Ansys代码）完成。

4. 实验目标

建造一个简化的涡轮叶片形状，引入裂纹缺陷。用实验模态技术测试结构，评估其自然频率的变化。

5. 验证理论预测与实验结果

实验验证FEA模态分析，通过测试真实结构来验证不同的裂纹位置。

类别

机械

组

动态系统组

外部领导

N/A

外部领导地点

N/A

外部组织

N/A

总基金（ZAR）

500

实验要求

实验室：Sasol实验室
设备：激光位移仪或麦克风
Project Description

1. Background
Laser shock peening (LSP), is a surface engineering processes used to impart beneficial residual stresses in materials. The deep, high magnitude compressive residual stresses induced by laser peening increase the resistance of materials to surface-related failures, such as fatigue, fretting fatigue and stress corrosion cracking. During processing the laser beam is targeted to the workpiece. The workpiece surface to be processed is covered by a transparent overlay (normally water). When the laser is triggered and the beam strikes the target surface a thin layer of material is vaporized to form a small cloud. The continued delivery of energy in the laser beam pulse rapidly heats the vapour and converts it to a plasma plume. This plasma rapidly expands and, when confined by the transparent overlay, reaches pressures to drive a shockwave into the target. Due to the extremely small time frame the process develops and the strong dependency to the strain rate, the simulations, so far, are based on Explicit solver using the Johnson-Cook material definition. In order to simulate the residual stress field imposed by the shock, two different simulation can carried out: the first is a pure Explicit analysis (shock and relaxation simulations) and the second is an Explicit analysis (shock) followed by an Implicit analysis (relaxation simulation).

2. Problem Statement
Simulate the single Laser Shock Peening process using an Explicit solver approach for both the shock and the relaxation simulation, and simulate the same process with an Explicit (shock) – Implicit (relaxation) approach.

3. Theoretical objective
Evaluate which of the two possible analysis strategies is better suited to evaluate the residual stress field due to a single Laser Shock Peening shock.

4. Experimental Objective
Determine experimentally the residual stress field due to a single shock.

5. Validation of Theoretical Predictions Against Experimental Results
Validate the simulated residual stress field obtained by the two simulations against the experimental results.

Category
Mechanical

Group
Dynamic Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
CSIR

Total Funding (ZAR)
500

Experimental Requirements
The Experimental part of the Project will be developed at CSIR.
Laser Shock Peening simulation (Project 2)

Lecturer, Mr F Pietra
Max students, 2

Project Description

1. Background
Laser Shock Peening (LSP) is an emerging advanced manufacturing and refurbishment technology in order to increase the fatigue and stress corrosion cracking performance of metal components. The significant performance enhancements are due to the generation of compressive residual stresses to depths far greater than conventional methods such as Shot Peening, whilst achieving a superior surface finish. The current LSP process development is achieved primarily through an experimental campaign. However, upon completion of process development, engineering tools and simulation routines will be required to facilitate implementation and industrial uptake. Therefore, this proposal is focused toward the development of FEA simulation capabilities representative of the LSP process.

Conventional FEA simulation of the LSP process typically uses explicit or a combination of implicit and explicit solvers to model each pressure pulse from each and every laser pulse. Since the application of LSP, especially without an absorbent coating, employs thousands of sequential laser pulses, the simulation is too computationally expensive for practical purposes. Therefore, this proposal seeks to develop alternative practical simulation tools for the LSP process.

2. Problem Statement
This project will investigate the use of an equivalent loading technique in order to simulate a multiple laser shock peening process. Essentially, the typical shape of the expected residual stress through the thickness of a material sample is well known. This is typically a hook shape, and can be described in terms of surface value, maximum compression, depth of compression, depth of maximum compression, and maximum tension. This project will investigate the use of a quenching simulation to generate the same bulk material response in terms of plastic distribution, and residual stress state. Thereafter, model inputs will need to be identified in order to virtually create any plastic distribution and residual stress profile.

3. Theoretical objective
Development of an equivalent quenching loading routine and model inputs in order to achieve typical residual stress distribution from the laser shock peening process.

4. Experimental Objective
Determine experimentally the residual stress field due to a LSP with multiple shocks.

5. Validation of Theoretical Predictions Against Experimental Results
Demonstrate the capability of the equivalent loading technique to simulate the experimental residual stress field.

Category
Mechanical

Group
Dynamic Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
CSIR

Total Funding (ZAR)
500

Experimental Requirements
The Experimental part of the Project will be developed at CSIR.
Laser Shock Peening simulation (Project 3)

Project Description

1. Background
Laser Shock Peening (LSP) is an emerging advanced manufacturing and refurbishment technology in order to increase the fatigue and stress corrosion cracking performance of metal components. The significant performance enhancements are due to the generation of compressive residual stresses to depths far greater than conventional methods such as Shot Peening, whilst achieving a superior surface finish. The current LSP process development is achieved primarily through an experimental campaign. However, upon completion of process development, engineering tools and simulation routines will be required to facilitate implementation and industrial uptake. Therefore, this proposal is focused toward the development of FEA simulation capabilities representative of the LSP process. One of the significant challenges for simulation of the LSP process is the correct representation of the LSP laser parameters as a physical pressure pulse in both time and space.

2. Problem Statement
Simulate the single Laser Shock Peening process using an Explicit solver approach for both the shock and the relaxation simulation. The simulations will be performed using an array of input variables for the spatial and temporal pressure profile.

3. Theoretical objective
Correlation of FEA simulation pressure input variables (pulse width, pulse shape, pressure magnitude, and pressure distribution) to laser power intensity for the single laser shot peening simulation.

4. Experimental Objective
This project will investigate the simulation of a single LSP event (i.e. one laser pulse) using surface deformations as an experimental benchmark. The material of interest been Ti6Al4V or AA7075-T7 or AA2024-T3 or SS316L is specifically selected for well-known material properties under high strain rate phenomena. Experimental benchmark samples will be provided by the CSIR National Laser Centre.

5. Validation of Theoretical Predictions Against Experimental Results
Correlation of the LSP simulation input variables to the laser power intensity by comparison of surface indentation geometry due to the single LSP event.

Category
Mechanical

Group
Dynamic Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
CSIR

Total Funding (ZAR)
500

Experimental Requirements
The Experimental part of the Project will be developed at CSIR.
Mr S Roux

Design, fabrication, and validation of a Trismus relief apparatus

Lecturer, Mr S Roux
Max students, 3

Project Description

1. Background
Trismus or hypo-mobility of the jaw is a common medical condition in which the muscles in the jaw experience stiffness. A cause of this can be disease but it is most commonly seen post-operatively in patients that have received radiation in the head and neck area as an adjunct to treating cancer surgically. It is also seen in patients who have had trauma, facial burns and stroke or those who have temperomandibular dysfunction.
Exercises do exist to relieve trismus but are not well controlled and apparati such as the TheraBite Rehab System are used but are not manufactured in South Africa and are extremely expensive.

2. Problem statement
Develop a human powered mechanism that can be cheaply manufactured in the workshop of the University of Pretoria

3. Theoretical objectives
The mechanism must be designed to provide patients of the Maxillo- Facial- and Oral Surgery Department at the Oral and Dental hospital that experience hypo-mobility of the jaw, a viable exercise option to rehabilitate their jaw.

4. Experimental objectives
Various configurations are required to be tested to allow for adequate characterisation of the applicable properties.

5. Validation of theoretical predictions against experimental results
Experimental results should correlate well with the literature.

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
Dr KH Merbold

External Leader Location
Oral and Dental Hospital, Prinshof Campus, University of Pretoria

External Organisation
Department of Maxillo-, Facial- and Oral Surgery, Oral and Dental Hospital, University of Pretoria

Total Funding (ZAR)
500

Experimental Requirements
None
Air flow optimisation of a ballistic grille for military vehicles

Lecturer, Mr S Roux
Max students, 3

Project Description

1. Background
The ballistic protection of military vehicles’ power packs have become an everyday requirement from armed forces due to the necessity to maintain vehicle mobility in combat situations. Penetrating a vehicle’s power pack compartment causes major financial losses as well as the loss of mobility which prevents the vehicle from further participating in the warfare theatre. One of the biggest challenges when ballistic protection is required for the power pack compartment is the addition of ballistic grilles to the air inlet and (sometimes the outlet if the design has an outlet). Although many configurations and solutions already exist, these designs are normally very heavy, and they cause large pressure drops over the grille, thus requiring a larger cooling fan to obtain the required air flow rate over the cooling pack. All of this causes an overall increase in mass and engine power of the vehicle.

2. Problem statement
Design a grille cross section that satisfies the various ballistic angles possible and also prevents shrapnel entering the engine compartment while at the same time reducing the pressure drop. Various designs and solutions exist that can be used as departure point.

3. Theoretical objectives
Analyse the air pressure drop for several designs and propose a concept to optimise. Optimise the design (include chamfers, add-on plates, shaped sheet metal plates, plastic features, etc) by conducting the required flow analysis and comparisons.

4. Experimental objectives
Build 2 -3 test samples and test them in a wind tunnel.

5. Validation of theoretical predictions against experimental results
Confirm numerical results with wind tunnel tests and do further optimisation if required.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
Wayne Clark

External Leader Location
Silverlakes, Pretoria

External Organisation
Pronex

Total Funding (ZAR)
500

Experimental Requirements
Closed-circuit wind tunnel
Centralised computer control, monitoring and data logging system for the closed-loop wind tunnel

Lecturer, Mr S Roux
Max students, 3

Project Description

1. Background
The closed-loop wind tunnel is not currently integrated and controlled from a single location. This makes testing inefficient and laborious.

2. Problem statement
A control system is required to monitor and control all aspects of the wind tunnel.

3. Theoretical objectives
The development of a comprehensive Labview system that can monitor and control all aspects of the wind tunnel as well as monitor and log data during testing.

4. Experimental objectives
The program must be tested against standard benchmarks to determine accuracy and reliability.

5. Validation of theoretical predictions against experimental results
The system must be able to calculate predicted theoretical results.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Close-circuit wind tunnel
Influence of electromagnetic noise on equipment signals

Project Description

1. Background
Electromagnetic noise influences the signals generated by measurement equipment with the magnitude of the influence often being difficult to calculate.

2. Problem statement
Develop a model for approximating the influence of electromagnetic noise and test this model in the wind tunnel labs.

3. Theoretical objectives
A theoretical model must be developed that takes into account sources of noise, signal cable length, shielding, grounding etc.

4. Experimental objectives
Testing will be done with various measurement equipment with and without electromagnetic interference (wind tunnel motors etc.).

5. Validation of theoretical predictions against experimental results
The experimental results must be compared to the model to determine validity.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Datalogger and various transducers.
Dr M Sharifpur

Numerical simulation and experimental investigation into natural convection of Nanofluids (including)

Project Description

Numerical simulation and experimental investigation into natural convection of Nanofluids (including the preparation of the cavity)
Nanofluids are engineered colloids containing solid nanoparticles suspended in a base fluid which they are within top recent researches in heat transfer field. Base fluids can be (but not limited to) water or organic liquid. The nanoparticles in the base fluid can enhance the heat transfer performance of the base fluids. Fluids such as water, oils and ethylene glycol are extensively used as heat transfer working fluids in various heat-exchanger processes. However, the performance of the heat-exchange process is limited to the property of the working fluids. The size of solid nanoparticles can be between 1nm and 100nm. In this project in order to investigate the natural convection of a nanofluid experimentally, a rectangle cavity will be designed and built. The student will start the investigation for pure water and if the set-up works, will continue with Nanofluid. A benchmark will be provided with software simulation and available empirical models for the nanofluids. For this project the student must increase his/her knowledge in heat transfer and one of the available licensed CFD software packages. This project has the capability to publish a paper in an international conference if the student offers a proper work.
You should have a strong background in heat transfer and mathematics.

You should read the study guide of the course carefully and your final report should include the following:
1. Cover sheet
2. Abstract
3. Introduction
4. Literature review
5. CFD Simulation
6. Theoretical investigation
7. Design and build the cavity
8. Thermocouples calibration
9. Set-up the experiment
10. Model development, analysis and calculations
11. Safety issues
12. Test, benchmark and comparison with the CFD simulation
13. Discussions
14. Conclusion

Category

Mechanical

Group

Thermofluids Research Group

External Leader

N/A

External Leader Location

N/A

External Organisation

N/A

Total Funding (ZAR)

500
Experimental Requirements

Everything is available
Numerical simulation and experimental investigation into effective thermal conductivity of nanofluid

**Project Description**

Numerical simulation and experimental investigation into effective thermal conductivity of nanofluids (including the preparation of the thermal conductivity meter)

Nanofluids are the suspension of nanoparticles (1nm to 100nm) in a conventional heat transfer fluids (called base fluid). They have received a lot of attention by researchers around the world in last two decade while they can improve the thermal conductivity of the base fluids. Fluids such as water, oils and ethylene glycol are extensively used as heat transfer working fluids in various heat-exchange processes. The thermal conductivity of the working fluids can influence on the heat-exchange process. This enhancement in heat transfer extremely depends on the effective thermal conductivity of a nanofluid. In this project in order to investigate the effective thermal conductivity of a nanofluid, an experimental set-up will be designed and built. The student will start the investigation for pure water and then continuing with Nanofluid. A benchmark will be provided with software simulation and available models for the effective thermal conductivity of nanofluids. For this project the student must increase his/her knowledge in heat transfer. This project has the capability to publish a paper in an international conference if the student offers a proper work.

You should have a strong background of heat transfer and mathematics.

You should read the study guide of the course carefully and your final report should include the following:

1. Cover page
2. Abstract
3. Introduction
4. Literature review
5. CFD Simulation
6. Theoretical investigation
7. Design and build the cavity
8. Thermocouples calibration
9. Set-up the experiment
10. Model development, analysis and calculations
11. Safety issues
12. Test, benchmark and comparison with the CFD simulation
13. Discussions
14. Conclusion

**Category**

Mechanical

**Group**

Thermofluids Research Group

**External Leader**

N/A

**External Leader Location**

N/A

**External Organisation**

N/A

**Total Funding (ZAR)**

500

**Experimental Requirements**
Designing, building and testing a particle-fluid two-phase flow pump

Lecturer, Dr M Sharifpur
Max students, 1

Project Description

One of the problems for building an experimental investigation regarding particle-fluid two-phase flow is the lack of a particle-fluid two-phase flow pump. The important thing in this challenging project is to be under controlled the volume fraction of the particles in the two phase test section. In this project we will use different size spherical particles (for example from 1 to 10 mm). Finally, the student must measure the mass flow rate and the pressure difference of the test section for different conditions. Regarding the results a correlation will be produced. This project has the capability to publish a paper in an international conference if the student offers a proper work. However, you should have a strong background in fluid mechanics.

Your work should contain the following:
1. Literature review
2. Developing the idea
3. Design
4. Built
5. Test and Benchmark
6. Preparing progressing and final report
7. Oral presentation

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
N/A
Numerical simulation and modifying available set-up for natural convection in a cavity

Lecturer, Dr M Sharifpur
Max students, 1

Project Description
Cavity flow is one of the ways in order to investigate natural convection. In this project in order to investigate the natural convection by cavity, an experimental set-up is available which should be modified. The set-up includes: rectangle cavity, constant temperature cooled bath, constant temperature hot bath, data acquisition system, flow meters, pressure gauges...). After the modification, the student will start the investigation for pure water and then will continue with other heat transfer fluids. A benchmark will be provided with software simulation and available models. Inclined cavity flow will be investigated as well. For this project the student must increase his/her knowledge in heat transfer and one of the available CFD software packages. This project has the capability to publish a paper in an international conference if the student offers a proper work.

Your work should contain the following:

1. Literature review
2. Developing the idea
3. Modifying the experimental set-up
4. Test, benchmark and simulation
5. Preparing progressing and final report
6. Oral presentation

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Everything is available
Experimental study and numerical Simulation of Impact of water Jet from different nozzle shapes on different surfaces

Project Description

Experimental study and numerical Simulation of Impact of water Jet from different nozzle shapes on different surfaces
One of the apparatus which helps to understand the application of the momentum equation is “Impact of a Jet on a Surface”. In this apparatus, the force generated by impact of an upward and also horizontal water jet on the different surface will be investigated. The student must design and build different nozzle and test them with the available apparatus. The apparatus needs to modify as well. For the benchmark of the accuracy of the data, a CFD simulation with ANSYS-FLUENT or STAR CCM+ must be down. This project has the capability to publish a paper in an international conference if the student offers a proper work. However, you should have a strong background in fluid mechanics and increase your knowledge about ANSYS-FLUENT or STAR CMM+ software.

Your work should contain the following:
1. Literature review
2. Developing the idea and modification
3. Design the experiment
4. Built the experiment
5. Test, benchmark and CFD simulation
6. Preparing progressing and final report
7. Oral presentation

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Everything is available
Designing, building and testing Nanofluid laboratory equipment (including water jackets)

Lecturer, Dr M Sharifpur
Max students, 1

Project Description
A water jacket is an especial container which we can measure different properties of fluids in side it while outside the container is a water jacket to cool or heat the fluid inside the container to keep it at exact temperature during measurements. In this project two (different sizes) especial water jacket must be simulated, designed, built and tested in order to use for Nanofluids viscosity measurements. There is one commercial water jacket available which needs to be considered for the new design. The details will be offered by the study leader in the meeting.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
N/A
Ms L Smith

Design, build and test force measurement device for UP LSWT (Low speed wind tunnel)

Project Description
A range of measuring probes, force balances and rakes are required to conduct flowfield surveys and aerodynamic force measurements in the UP LSWT (Low Speed Wind Tunnel).

Make use of the LSWT testing wing (NACA0012) and develop a cheap 3-component force balance to measure lift, drag and pitching moment in the wind tunnel. The device must be able to interface with different wind tunnel models easily and have a calibration procedure which each new test set-up will have to go through before actual testing.

Conduct XFOIL and CFD simulations to obtain a comparison between wind tunnel and theoretical results. The wing will be placed at angles of attack -5 to 15 degrees at 15, 30, and 45 m/s. Output the drag polars, lift vs angle of attack and pitching moment results.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Build a system that includes load cells to measure the three components.
Use existing wing for the low speed wind tunnel to take force measurements and covert these into the required results.
Design, build and test a launch dolly for the AREND UAV

Project Description
Team AREND will design a technological solution to aid Kruger National Park (KNP) rangers in the protection of black and white rhinos from poaching. The solution shall constitute, but not be limited to, an unmanned aircraft (18kg, 4.2m wingspan, cruise speed 20m/s, stall speed 15m/s) capable of conducting remote surveillance of large park areas such as KNP. The UAV shall be operable from a central base within KNP, have extended flight endurance (~120 min), and be able to detect/distinguish humans and animals with onboard sensors.

The final deliverable of the AREND project shall be an aircraft test flight to demonstrate flight worthiness and provide a validation document. Initial flight tests are done using a RC controller but the intention is that the aircraft will later fly autonomously. Within this context team AREND requires a launch device that can ideally also act as a flight testing device. The UAV is designed without a dedicated undercarriage and therefore requires a device to assist in the runway launch process.

Design, build and test a dedicated launch dolly for the existing AREND UAV. This launch device needs to travel at a maximum speed of 15 – 20m/s on an uneven bushvelt terrain. The device needs to be lightweight, portable and robust. The device must be easy to maintain and store.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
2000

Experimental Requirements
Launch dolly must be able to show it can carry and have the UAV take off from it as a final test.
Investigate the impact of the trailing edge truncation on airfoil aerodynamic performance

Project Description

The aerodynamic performance of airfoils can be enhanced by modifying the trailing edge region. Blunt and divergent trailing edge (DTE) airfoils are one of the recent and effective developments introduced to airfoils for both high and low Reynolds number applications, i.e., wind turbine blades and supercritical airfoils, respectively.

Conduct an experimental investigation in the UP low speed wind tunnel on the DLBA 186 airfoil and the DTE modified airfoil DLBA 243 and provide insight into the movement of the pressure recovery region and the near-body wake.

Using a CFD observe the lift to drag ratio and the pressure recovery movement and compare the results to that of the wind tunnel results. Comment on the flow separation, vortex shedding and wake development and the effects of these on the pressure drag of the airfoil.

Category

Aeronautical

Group

Thermofluids Research Group

External Leader

N/A

External Leader Location

N/A

External Organisation

N/A

Total Funding (ZAR)

500

Experimental Requirements

Manufacture two wings with pressure taps for the wind tunnel. Test these wings in the wind tunnel taking pressure readings from the wings as well as in the wake.
Design, build and test a landing skid for AREND UAV

Project Description
Team AREND will design a technological solution to aid Kruger National Park (KNP) rangers in the protection of black and white rhinos from poaching. The solution shall constitute, but not be limited to, an unmanned aircraft (18kg, 4.2m wingspan, cruise speed 20m/s, stall speed 15m/s) capable of conducting remote surveillance of large park areas such as KNP. The UAV shall be operable from a central base within KNP, have extended flight endurance (~120 min), and be able to detect/distinguish humans and animals with onboard sensors.

The landing of a UAV presents the most challenging phase of flight. The success and the cost of UAV operations depend largely on the success of the landings. UAVs are still lost at unacceptable high percentage due to landing incidents. For these reasons the design of the landing systems is receiving the highest priority in the design and development of the Arend airframe. Design, build and test a model for a landing skid system for the existing AREND UAV. The system has to be retractable during flight in order to not contaminate the aerodynamic body and during landing strong enough to survive a controlled crash into terrain. The device must be light weight and able to integrate with the existing structure of the AREND UAV.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Final test must show that the skid design meets all design requirements. Either be shown on a full scale test rig or implemented into the full UAV system.
Implementation of full-scale parachute emergency system for the AREND UAV

Lecturer, Ms L Smith
Max students, 1

Project Description
According to legislation for UAV operations requires an emergency recovery system, since flight may have to be terminated at any stage or location. Additionally the expensive payload can be recovered if an emergency recovery system is available. It is therefore conceivable to land the system by default by means of this recovery system. A well refined recovery system may offer the easiest and most reliable landing strategy.

A pneumatically activated parachute emergency recovery system (ERS) has been developed on a small scale for the AREND UAV. Develop a full-scale dynamic model for the system, design and construction of test hardware and the testing of the system elements for full-scale implementation. Testing included the pressure testing of the pressure elements and dynamic testing of the deployment strategy.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Final test must show that the parachute system can successfully deploy in the full scale system. Testing on a simulation rig which also needs to be developed.
Investigation of wind turbine layout for optimum wind farm power output

Lecturer, Ms L Smith
Max students, 2

Project Description

Turbines in series have an inherent loss of power due to turbulent winds generated from upwind turbines. Investigate the layout of a wind farm using three successive turbines to find the optimal setup in terms of horizontal layout and height.

Design and manufacture 3 small scale turbines (0.2 - 0.5m) to investigate the influence of proposed optimal position that consecutive horizontal wind turbines on a plane should have to extract optimal energy from the wind farm layout. Determine the effect that wind turbine blade designed vs two other existing blade types have on the overall efficiency.

Using theoretical simulation to obtain the optimum position first, compare it with experimental wind tunnel results. Investigate the wake effects of the first wind turbine and determine the influencing factors. Also take into account the scaling factors of the wind turbines.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
1500

Experimental Requirements

Experiments will be conducted at the CSIR atmospheric wind tunnel. Turbine blades and full models need to be manufactured for the WT set-up.
Low noise propulsion testing for the AREND UAV

Project Description
Team AREND will design a technological solution to aid Kruger National Park (KNP) rangers in the protection of black and white rhinos from poaching. The solution shall constitute, but not be limited to, an unmanned aircraft (18kg, 4.2m wingspan, cruise speed 20m/s, stall speed 15m/s) capable of conducting remote surveillance of large park areas such as KNP. The UAV shall be operable from a central base within KNP, have extended flight endurance (~120 min), and be able to detect/distinguish humans and animals with onboard sensors.

One of the novel requirements on the AREND UAV is the requirement of silent flight. In this context two aspects are important: 1) The aerodynamic shape of the airframe and 2) The propulsion system. Investigate size and configuration of different propulsion systems that will meet the energy requirements of the AREND UAV. Test two of these configurations as pusher or puller propeller systems and propose guidelines of the propeller configuration for silent aircraft flight.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Build a test bench to measure the noise from different propeller arrangements and configurations.
Prof NJ Theron

Modelling of boundary conditions

Project Description

1. Background
When an elastic body is incorporated in an ADAMS multi-body dynamics model, in the sense that the elastic behaviour of this body needs to be incorporated in the modelling, this can be done by using a modal superposition method. For this ADAMS require the so-called modal neutral file, in which the natural vibration modes that the engineer would like to include in the modal superposition model are specified. This modal neutral file is typically generated by a finite element based modal analysis of the elastic body on its own, carried out using any commercial FEM package. This raises the question: what boundary conditions should be used during this FEM based modal analysis? ADAMS prescribe that full free-free boundary conditions should be used, even though the actual boundary conditions with the elastic body inserted in the multi-body system is not at all free-free.

2. Problem statement
It is believed that ADAMS is actually justified in its requirement and that this can be mathematically proven. The purpose of this project is to prove that this is possible and correct, without necessarily performing an ADAMS analysis.

3. Theoretical objectives
The student must select a suitable elastic body and a bigger dynamic system — which may or may not be a multi-body system with rigid bodies — within which this body will be functional. The whole system should be modelled with the aim of proving the hypothesis.

4. Experimental objectives: validation of theoretical predictions against experimental results
An accompanying experimental rig should be built to experimentally illustrate the theoretical findings.

Category
Aeronautical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Laboratory space, equipment to measure structural dynamics
Active structural control: multimodal pole placement

Project Description

1. Background
In 2015 two final year research projects managed to illustrate the pole placement control technique by shifting the lowest natural vibration frequency of a cantilevered beam inside a control loop to a pre-determined frequency. The two projects used two different feedback measurements. The one used a laser vibrometer to measure the beam tip velocity, while the second project used a laser displacement meter to measure the tip displacement. Both projects had to employ an observer to estimate the second state not measured: the displacement in the first case and the velocity in the second case. In both cases the observer and feedback gains were implemented as a second order digital compensator on a National Instruments CompactRIO control computer.

2. Problem statement
This experiment now needs to be expanded to shifting both the first and second natural vibration modes, using a single actuator and using the measurement of strain at two different span-wise locations as displacement based feedback signals. An observer will once again have to be implemented to estimate the velocity states not measured, which implies a fourth order digital compensator, also to be implemented on a CompactRIO or other real time control computer. Using strain measurement with strain gauges as feedback signals will further build on another 2015 final year research project, in which the use of strain measurements to determine modal coordinate histories was investigated.

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Real time control computer, bridge amplifier
Active structural control: tracking system

Lecturer, Prof NJ Theron
Max students, 2

Project Description

1. Background
In 2015 two final year research projects managed to illustrate the pole placement control technique by shifting the lowest natural vibration frequency of a cantilevered beam inside a control loop to a pre-determined frequency. The two projects used two different feedback measurements. The one used a laser vibrometer to measure the beam tip velocity, while the second project used a laser displacement meter to measure the tip displacement. Both projects had to employ an observer to estimate the second state not measured: the displacement in the first case and the velocity in the second case. In both cases the observer and feedback gains were implemented as a second order digital compensator on a National Instruments CompactRIO control computer.

2. Problem statement
Whereas the above mentioned experiments were both focusing on regulator systems, the current project should expand this control to a tracking system, where not only the first vibration mode is shifted, but the beam can be caused to track a desired control input. This means that electromagnetic actuator that has been used before, may no longer be effective and the student should investigate the use of alternative actuators like hydraulic actuators.

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Real time control computer, hydraulic actuator, feedback measurement system
**Project Description**

1. **Background**
   A large number of isolation valves used by Rand Water in their water distribution system have not been closed in a number of years of operation. This means that large uncertainty exist regarding the condition of these valves.

2. **Problem statement**
   This project will initiate a study into ways to assess the condition of valves in situ, while in operation. It is not envisaged that this project will cover the use of remote controlled underwater cameras inside pipelines, but the larger study will probably at a later stage include this.

3. **Theoretical objectives**
   The study will start off with interviews with Rand Water personnel to determine all requirements and the constraints on the project. It will include a literature study on methods that can be used for this kind of assessment.

4. **Experimental objectives**
   A small experimental installation needs to be built in the laboratory to implement and investigate methods identified.

**Category**
Mechanical

**Group**
Center for Asset Integrity Management

**External Leader**
N/A

**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
5000

**Experimental Requirements**
Laboratory space for a small pipe system
Development of an experimental modal analysis system

Lecturer, Prof NJ Theron
Max students, 2

Project Description

1. Background
The Department has for many years used various different data acquisition systems to perform experimental modal analyses. The availability in the Department of National Instruments hardware and its LABVIEW software package has not yet been explored.

2. Problem statement
It is the purpose of this project to develop an experimental modal analysis system specifically using LABVIEW and both the National Instruments CompactDAQ and CompactRIO systems, with two simultaneously sampling four channel C-series modules, both of which have build-in anti-aliasing filters: the NI 9234 analogue voltage input module and the NI 9237 half bridge / full bridge analogue input module. Provision should be made for sinusoidal, random and chirp excitation with a NI 9263 analogue output module.

3. Experimental objectives
To demonstrate the built modal analysis system, the student should do an experimental modal analysis on a beam structure, where both the displacement mode shape and the strain mode shape of the first two lateral vibration modes in a single plane are measured. (The measurement of strain mode shapes is somewhat unusual.)

4. Validation of theoretical predictions against experimental results
The measured displacement and strain mode shapes need to be compared with analytical and/or FEM predicted mode shapes.

Category
Aeronautical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
National Instruments equipment mentioned in description (all available in SASOL labs)
Prosthetic leg for aircraft pilot

**Project Description**

1. Background
   Prosthetics are artificial limbs used to substitute missing or defective limbs. Due to the ever developing technology of prosthetics many disabled individual are able to pursue very active lifestyles. This specific prosthetic leg will enable its users to fly airplanes. The leg will be controlled via an electronic system and provide the user with better control over the rudder. The design will be optimized for an above knee amputee.

   Aeromedical concerns are mainly based on pilot’s ability to safely operate the aircraft during standard and extreme conditions. The pilots are also required to wear their prosthetics throughout the entire flight according to aviation regulations.

   The Rheo knee from Nissur is an exceptionally well-engineered prosthetic and “provides the most natural knee function among all microprocessor knees.” The Rheo knee ensures stability and dynamics in every situation by means of the five-sensor gait detection. The constant power spring enables the artificial joint to swing effortlessly and allows the user to maintain a smooth walking style. The advanced actuator and resistance control enables the user superior control over their movements. Magnetorheologic technology enables the prosthetic to be synchronous with one’s movement.

   The adapted divers foot is a prosthesis used to best simulate the extension attributes of the ankle joint. The divers foot enables the pilot to fully extend his foot when controlling the rudder.

2. Problem statement
   The client has an above knee amputation and uses a Rheo knee in combination with an adapted divers foot to control the right rudder of an airplane. This mechanism is purely mechanical. The clients requires a prosthetic leg, which is electronically controlled, to enable him more control over the rudder with less effort.

3. Experimental objectives
   The mechanical design of the proposed prosthetic leg needs to be performed and a full working mechanical and electronic prototype needs to be developed and evaluated.

   **Category**
   Mechanical

   **Group**
   Center for Asset Integrity Management

   **External Leader**
   N/A

   **External Leader Location**
   N/A

   **External Organisation**
   N/A

   **Total Funding (ZAR)**
   5000

   **Experimental Requirements**
   Work to be done at the CSIR
Dr N Wilke

One to three blade leaf-spring hysteresis characteristics

Lecturer, Dr N Wilke
Max students, 3

Project Description

1. Background
During a quasi-static loading and unloading cycle (force-deflection response) a characteristic hysteresis response for a leaf-spring blade configuration is obtained. This defines the stiffness and dissipation characteristics of the system. Leaf-spring blade characteristics depend on numerous factors that include geometry, number of blades, bolt force pre-tension and inter-blade friction.

2. Problem statement
Develop an experimental setup on which one, two and three blade leaf-spring hysteresis characteristics can be measured. A simulation of this setup need to be developed. It is then required to estimate the predictive capability and innate flexibility of the simulation model.

3. Theoretical objectives
Simulate the loading and unloading cycle of a one, two and three leaf-spring blade configuration to obtain the simulated hysteresis response.

It will be necessary to experimentally measure the identified parameters required to conduct the simulation. This is essential to estimate the predictive capability of the simulation model.

It will be necessary to select the identified parameters to best estimate the response by solving an inverse problem. This is essential to estimate the flexibility of the simulation model.

4. Experimental objectives
Develop an experimental setup on which one, two and three blade leaf-spring hysteresis characteristics can be measured.

Measure the force displacement characteristics for loading and unloading of a leaf spring with one, two and three blades.

In addition experimentally measure the identified parameters required to conduct the simulation.

5. Validation of theoretical predictions against experimental results
Critically compare the simulated hysteresis response against the measured hysteresis response. Critically assess the predictability and flexibility of the simulation model.

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500
Experimental Requirements

Actuator with load control or weight stack
Mechanical deflection measurement
Camera to compare of actual versus simulated deflected shapes
Two blade leaf-spring hysteresis sensitivity study

Lecturer, Dr N Wilke
Max students, 3

Project Description

1. Background
During a quasi-static loading and unloading cycle (force-deflection response) a characteristic hysteresis response for a leaf-spring blade configuration is obtained. This defines the stiffness and dissipation characteristics of the system. Leaf-spring blade characteristics depend on numerous factors that include geometry, number of blades, pre-tension on the bolt force and inter-blade friction.

2. Problem statement
Develop an experimental setup on which the two blade leaf-spring hysteresis characteristics can be measured. A simulation of this setup need to be developed. It is then required to conduct a sensitivity study (or a study of changes) that includes changing the support positions, bolt force pre-tension and the inter-blade friction.

3. Theoretical objectives
Simulate the loading and unloading cycle of a two leaf-spring blade configuration to obtain the simulated hysteresis response. It is required to conduct a simulated sensitivity study (or a study of changes) that includes changing the support positions, pre-tension of the bolt-forces and the inter-blade friction.

It will be necessary to experimentally measure the identified parameters required to conduct the simulation.

4. Experimental objectives
Develop an experimental setup on which the two blade leaf-spring hysteresis characteristics can be measured. It is required to conduct an experimental sensitivity study (or a study of changes) that includes changing the support positions, pre-tension of the bolt-forces and the inter-blade friction.

In addition experimentally measure the identified parameters required to conduct the simulation.

5. Validation of theoretical predictions against experimental results
Critically compare the simulated hysteresis response against the measured hysteresis response. Critically assess to which extent the simulated and experimental sensitivity responses and trends are in accordance

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Actuator with load control or weight stack
Mechanical deflection measurement
Camera to compare of actual versus simulated deflected shapes
Particle funnel discharge investigation

Project Description

1. Background
The computationally exhaustive discrete element method has become a popular modelling tool for particulate flow. Funnel / silo discharge is particularly important as unforeseen decreases in discharge rates to blockages can easily become the bottleneck for a process operation.

2. Problem statement
Investigate the effect that either particle size (homogenous), particle geometry (various shapes), inter-particle friction, particle size (inhomogeneous smaller and larger) or external vibration has on particle funnel discharge. In all studies a range of funnel angles and inlet/outlet area ratios need to be investigated.

3. Theoretical objectives
Discrete element simulations of the funnel discharge experiment needs to be conducted. The identified simulation parameters need to be experimentally estimated to be able to estimate the predictive capability of the simulation model. The simulation parameters need to be tuned using inverse analysis to estimate the flexibility of the simulation model.

4. Experimental objectives
A single combined experimental setup needs to be constructed that would allow all studies for this project to be conducted. Funds from all students will be combined to construct a single experimental setup.

5. Validation of theoretical predictions against experimental results
The experimental and simulated responses need to be critically compared. Critically assess the prediction capability and innate flexibility of the simulation model.

Category
Mechanical

Group
Center for Asset Integrity Management

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Video and photo to visually capture the experimental discharge.
Scale to measure the weight of the experimental setup.
Mr J Huyssen

Development of an Electric Propulsion System integrated into a Wing

Lecturer, Mr J Huyssen
Max students, 3

Project Description

1. Background
Any aircraft propulsion system has to provide the thrust to overcome drag. Therefore, any power system which actively reduces drag would be a part of a propulsion system. With electric power systems becoming useful in full-scale aviation the opportunity emerges to provide small distributed electric power units along the entire wing.
In the sport of gliding there exists a class of propulsion systems called ‘sustainers’. These are only used to extend the range of a sailplane if necessary. When not in use, the propulsion system is aerodynamically hidden away to avoid any additional parasitic drag.
Boundary layer suction and blowing can be used to change the airfoil performance. The concept of an air-amplifier can perhaps be used to do the required pump work.

2. Problem statement
A system is needed by which electric power can be used to compress the air for the primary injector flow of a linear air amplifier. An arrangement should be proposed for the integration of such a system inside a wing.

3. Theoretical objectives
Develop a CFD based model of a standard air amplifier to understand the concept of operation and to allow performance predictions to be made. Based on this understanding design a linear air amplifier suitable for distributed propulsion along the span of a wing.

4. Experimental objectives
Construct an experimental setup by which a CFD model of a working air amplifier can be bench marked. Construct the proposed linear air amplifier and test its properties.

5. Validation of theoretical predictions against experimental results
Compare the measured amplifier performance with the numerical results and predict a system efficiency of a proposed implementation into a glider wing.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Needed will be a desk space in a laboratory with compressed air supply, equipment to measure air flow rates, air speed, air pressure and forces.
Development of a Tracking Antenna System

Lecturer, Mr J Huyssen
Max students, 2

Project Description

1. Background
For the telemetry on a UAV an up and down-link antenna system is needed to remain in contact with a UAV for over 40km away. The use of directional antennas could be useful to provide good signal strength. As long as both stations know the GPS position of each other the antennas can be made to look at each other. If a signal strength parameter can be measured the tracking direction could be fine-tuned to maximize signal strength.

2. Problem statement
Develop a tracking antenna system for a base station mast by which signal strength can be maximized for communication with a UAV flying up to 40km away at various heights above the ground.

3. Theoretical objectives
Predict the signal strength dependence on antenna orientation and height above the ground and design a system and an algorithm by which ideal antenna orientation can be actively maintained.

4. Experimental objectives
Fly a GPS receiver and a telemetry receiver and transmitter within the operational sector around a tracking base antenna and monitor the signal strength of transmissions under a variety of conditions.

5. Validation of theoretical predictions against experimental results
Report on the quality of transmission with and without active tracking.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Ideally the mobile pack will be placed in a aircraft to be flown within a general flying area. Appropriate transmitters and receivers, a data acquisition laptop, a GPS unit and servos will be needed.
Development of a heated Ball Nose Cutter for CNC Machining

Lecturer, Mr J Huyssen
Max students, 3

Project Description

1. Background
In aviation polystyrene is a very useful material to make large moulds or cores for light composite structures. It can be easily and fast milled on a 3 axis milling machine. However it is soft and thus sensitive. If the material is melted rather then cut a much harder surface forms. Therefore, it is conceivable to cut the shape to a certain oversize and then to melt it down to a smaller oversize, thereby hardening the surface. Final cutting could then be done in the hardened surface to render a better medium for precision machining and to offer a more robust surface.

2. Problem statement
Develop a heated ball nose ‘cutter’ for melting the surface of a pre-cut polystyrene shape.

3. Theoretical objectives
Predict heating power and temperature ranges suitable for surface hardening of polystyrene of various densities. Predict the surface shrinkage and hardening depth. Choose a suitable concept for ball nose heating. Design a heated ball nose cutter.

4. Experimental objectives
Find a suitable ball nose temperature, melting contraction offset and feed rate. Try if a rotating nose or a stationary nose would work better. Try if contact-less melting can be achieved. Build a prototype ball nose cutter and test it on a CNC machine. Determine the surface quality after the final cut.

5. Validation of theoretical predictions against experimental results
Describe the final surface quality of various machining parameters and comment on the feasibility of this approach.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
Needed: access to a 3 axis CNC milling machine and a high current DC power supply, lab space where polystyrene cutting can be done.
Development of a combustion chamber for periodic continuous combustion

Lecturer, Mr J Huyssen
Max students, 2

**Project Description**

1. **Background**
Combustion of fuel is done in repeated cycles in the reciprocating combustion engine or on a continuous basis in the continuous cycle engine like the gas turbine. There are applications in which periodic continuous combustion is required to maintain a desired operating pressure and temperature in a thermodynamic cycle.

2. **Problem statement**
Develop a system of fuel and air feeding, fuel ignition, and flame holding inside a high pressure combustion chamber.

3. **Theoretical objectives**
Understand the principle of combustion to predict the temperature and pressure change in a combustion chamber as a result of fuel burning. Develop a theoretical model to predict the feed rates of fuel and air to provide a desired flow delivery at a desired operational temperature and pressure.

4. **Experimental objectives**
Construct an experimental setup by which high pressure feed air can be delivered into a combustion chamber. Also fuel needs to be injected into the combustion chamber where it needs to ignite to maintain combustion as long as fuel is being injected. Monitor the pressure, temperature and flow rate at which the combustion chamber can deliver flow.

5. **Validation of theoretical predictions against experimental results**
Compare the measured parameters with those predicted to evaluate the quality of the theoretical combustion model.

**Category**
Aeronautical

**Group**
Thermofluids Research Group

**External Leader**
N/A

**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
Needed: Desk space in an engine test cell with compressed air supply; equipment to measure air flow rates, pressure and temperature; a Diesel fuel injector and igniter.
Prof L Dala

Effects of an opposing jet in Shock Wave Reduction around a Blunt Body

Lecturer, Prof L Dala
Max students, 2

Project Description

Introduction
The configuration of modern supersonic vehicles is such that the majority contain a blunted body at a given point on the structure. For 30 years investigations have been aimed at reducing the heat flux and surface pressure acting on the blunted bodies. The optimal results have generally been a case of a balancing surface pressure (reduced by a smaller blunt body radius) and heat flux (reduced by increasing the blunt body radius). Further studies have shown that the attachment of a thin spike to the front of the bodies reduces the heat flux and surface pressure considerably without the need to change the need to the radius of the body. This technique is commonly implemented in a variety of missiles and aircraft.

A second method of controlling the flow characteristics is the implementation of an opposing jet into oncoming flow. This method was developed to control the descent of planetary vehicles though atmospheres containing different types of media. There is potential for this method to reduce the max heat flux and surface pressure below figures observed in spike investigations. Refinement of this technique may produce a more flexible method of reducing drag. This will give supersonic vehicle designers the ability to optimise the drag reducing affects on a given aircraft for a multitude of situation using a single device.

This investigation aims to further refine the second method of drag and heat flux reduction by simulating an opposing jet originating from a blunt body. Computational fluid dynamics will be used to investigate two dimensional behaviour of opposing jets with an aim to obtain shock frequency to further develop understanding of the low parameters.

Aim
The major objectives of this investigation are as follows.
1. Developing an understanding of the parameters governing the behaviour of fluid in opposing supersonic flow situations and the drag reducing factors of spikes attached to blunted bodies.
2. Develop a computational fluid dynamic (CFD) model capable of simulating realistic opposing jet flows.
3. Compute a variety of two dimensional steady state flow parameters
4. Compute the effects of different spike length attached to the blunt body (steady State)

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Investigation of a New Aerofoil-Spoiler Configuration

Lecturer, Prof L Dala
Max students, 2

Project Description

Introduction
The project is a preliminary study to investigate a proposed new concept for configuration of control surfaces such as aerofoil - spoiler; to study its effectiveness to improve the aerodynamic efficiency and Aeroacoustics in comparison with the conventional aerofoil - spoiler configuration.

Aim
The outcomes of the research is the basis and concrete foundation for further research and development of devices for a new flow control technology for the wing of the aircraft and entirely new configuration, that is in sequence with the Advisory Council for Aeronautics Research in Europe - ACARE 2020 requirements. It is likely that the research will be continued towards further advancement and could be extended for a MSc research.

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
CFD Analysis of Split Ailerons

Project Description

Introduction
Efficiency, economy and environmental friendliness are the main issues that have to be taken into account when developing new aircraft. The Flying Wing configuration is predicted to cope with all of these in regions that conventional aircraft cannot achieve (NASA, 2001). This is mainly due to the shape of the flying wing, an airfoil-shaped fuselage affecting the whole body to create lift. Loosely connected to the European New Aircraft Concept research project, this investigation will deal with split ailerons: a special feature that could be applied to a flying wing in order to improve its performance.

Aim
The main aim of this investigation is to gain a set of numerical data in order to analyse the effects caused by the split ailerons for a low speed arrangement. As all of the findings described in the literature review have been obtained using wind tunnel measurements, a numerical analysis could help to better understand both the profits and the problems attached to this type of control device.
In addition, another objective is to explore the split ailerons at cruise speed (M=0.85).

Category
Aeronautical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
**Fluidic thrust vectoring of an axisymmetric nozzle**

**Lecturer, Prof L Dala**  
**Max students, 2**

**Project Description**

An engineering-type analysis will be developed and used to investigate the performances of thrust vectoring by fluidic injection in the divergent of a supersonic axisymmetric convergent-divergent nozzle. This method will include several approaches which consist mainly of a fluidic obstacle height evaluation and the prediction of the separation line that results upstream of the fluidic obstacle. The construction of the separation line is also based on some separation correlations proposed in the literature. The nozzle thrust deviation will be then calculated by taking into account the injecting fluid momentum rate contribution and the integration of the pressure acting on the nozzle inner wall.  
The sensitivity of the model developed versus some separation criteria will be discussed.  
This research is based on the development of a analytical model and compared to CFD calculations.

**Category**  
Aeronautical

**Group**  
Thermofluids Research Group

**External Leader**  
N/A

**External Leader Location**  
N/A

**External Organisation**  
N/A

**Total Funding (ZAR)**  
500

**Experimental Requirements**

List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Mr BD Bock

Characterization of Arduino Uno for temperature measurement and control

Lecturer, Mr BD Bock
Max students, 2

Project Description

1. Background

Data acquisition and control and is ubiquitous task in modern industry and research, with the logging of sensor readings such as temperatures and pressures and the subsequent control of devices based on these inputs a common example of this.

Research particularly requires accuracies that are often above industry standards, with current devices often prohibitively expensive. As developed nations continue to expand scientifically and catch up to their developed counterparts, a large need is apparent for lower cost accurate data acquisition and control devices.

The Arduino Uno, a commercially available low cost microcontroller, offers the opportunity to meet this need. Combined with open-source software, if can be used for a variety of temperature and control activities, as evident in a variety of projects listed on Instructables.com and other sites:

Note: Students who choose this topic will have to learn some basic coding to communicate with the Arduino Uno Board. No previous experience is required though.

2. Problem statement

A thermal bath must be heated and controlled to a set temperature. The Arduino Uno’s ability to perform this task must be characterized in terms of temperature measurement accuracy and speed as well as the temperature control ability.

3. Theoretical objectives

Model the heating of a thermal bath and the expected temperature control achievable as well as determining the uncertainties of the temperature measurement devices as per JCGM 100:2008 ( see www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf )

4. Experimental objectives

Build a data acquisition and control device based on the Arduino Uno that can measure temperature using three different methods, namely thermocouple, resistance thermometer and a silicon temperature sensor chip as well as control a heating element for a thermal bath.

Control a thermal bath to a specified temperature and characterise the performance of the system and accuracy of the temperature measurement devices employed.

5. Validation of theoretical predictions against experimental results

Compare the theoretical model to the measured performance as well as industry available devices of this sort

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A
**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
Testing space
Build and model a low cost hydrocyclone

Project Description

1. Background

Hydrocyclones are used to separate particulates from liquids through the use of centrifugal motion. They are often used as first pass separators, due to their low cost and ease of use.

They are used in various industries, such as waste water treatment in the removal of particles prior to filtration, petrochemical plants where they separate oil from water and coal processing where they separate coal particles from mineral matter.

2. Problem statement

Access to clean water is a challenge in rural areas, where low cost portable methods are required to achieve similar results as urban waste water treatment plants.

Carrying on from the work done in MSC 412/422 in 2015, continue the development of a low cost hydrocyclone that meets these needs.

3. Theoretical objectives

Develop a model to predict the performance of the hydrocyclone.

4. Experimental objectives

Design and build a low cost hydrocyclone and characterise its performance by measuring pressure drop and separation efficiency.

5. Validation of theoretical predictions against experimental results

Compare the theoretical model to the measured performance as well as literature standards.

Category

Mechanical

Group

Thermofluids Research Group

External Leader

N/A

External Leader Location

N/A

External Organisation

N/A

Total Funding (ZAR)

500

Experimental Requirements

Testing Space
Investigation into Surface roughness influence on Enhanced Boiling Heat transfer

Lecturer, Mr BD Bock
Max students, 3

Project Description

1. Background

Boiling heat transfer is a fundamental industrial phenomenon that is an ever present topic of research and development. Through the use of newly developed enhancements, such as fins and 3D surface structures, boiling heat transfer coefficients are constantly being increased.

Tubular evaporators are common pieces of equipment throughout industries such as the HVAC, desalination and petrochemical sectors and these heat exchangers are a prime example of the use of these external surface enhancements.

2. Problem statement

Investigate the influence of surface roughness on boiling heat transfer coefficients, through the construction of a simple set-up using an electrical heating element.

3. Theoretical objectives

Develop a model of the experimental set-up to allow for its design. Develop a model of the boiling heat transfer expected on the finned heating element.

4. Experimental objectives

Design and build a simple boiling heat transfer rig, consisting of a cartridge heater in a water bath that can be fitted with various copper tubes that have been roughened. Measure the heat transfer coefficients achieved with various surface roughness’s.

5. Validation of theoretical predictions against experimental results

Compare the theoretical model to the measured performance as well as literature standards. Make use of a smooth tube for initial experimental set-up verification.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements

Temperature Logger - (available through booking system via Chris Govinder and Donald Keeste)

Testing space
Polymeric Heat Sink Development

Project Description

1. Background

Heatsinks are mass produced products typically used to shed heat into the surrounding atmosphere. They have traditionally made from metals due to their high thermal conductivity, with aluminium a common choice.

An opportunity exists to rather manufacture these heatsinks from polymeric material so as to lower their cost. However the technical challenge exists to find a polymeric material that offers sufficient thermal conductivity to work effectively as a heatsink. A composite of some sorts is a likely candidate.

2. Problem statement

Polymeric heatsink compositions need to be tested to determine their thermal effectiveness.

3. Theoretical objectives

Develop a model to predict a polymeric composite’s thermal conductivity and effectiveness of a heatsink built from this.

4. Experimental objectives

Build a simple test stand to heat polymeric heatsinks and measure the resulting temperature.

Manufacture polymeric heat sinks with a high thermal conductivity and test them.

5. Validation of theoretical predictions against experimental results

Compare the theoretical model to the measured performance as well as literature standards.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements

Temperature Logger- (available through booking system via Chris Govinder and Donald Keeste )

Testing Space
Project Description

1. Background
Nanoparticles offer great merits over controlling rheological, thermal, chemical and physical properties of solutions. The effectiveness of a nanoparticle to modify the properties of a fluid depends on its diffusive properties with respect to the fluid. In this study, viscosity of aqueous fluids (i.e. water) will be investigated with the addition of different nanoparticles. This study will be characterized by the outcomes of simulation and experimental results of nanofluids. However, this study develops the understanding of how the rheological properties are affected due to the addition of nanoparticles in a fluid.

2. Problem statement
Measuring thermo-physical properties of nanofluids is essential and first step for heat transfer modelling.

3. Theoretical objectives
The movement of nanoparticles in the fluidic media will be simulated by large-scale molecular thermal dynamic program (i.e. LAMMPS). The COMPASS force field will be employed with smoothed particle hydrodynamic potential (SPH) and discrete particle dynamics potential (DPD). Numerical simulation could also be done by ANSYS or STARCCM++ but understanding of the smoothed particle hydrodynamic potential (SPH) method is essential.

4. Experimental objectives
The experimental work will be done at UP Nanofluid Lab.

5. Validation of theoretical predictions against experimental results
Numerical simulation and experimental results will be compared against each other.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
An investigation into mixed convection heat transfer in a driven cavity filled with nanofluids

Lecturer, Dr M Mehrabi
Max students, 5

**Project Description**

1. **Background**
   Numerical simulation and experimental investigation of an unsteady, periodic, laminar mixed-convection in a cavity utilized with nanofluid will be investigated. In this study both top and bottom walls are assumed to be isolated, meanwhile sidewalls are considered under constant temperature condition. We consider a time-dependent oscillating wall on top to fulfill a periodic mixed-convection inside the cavity. In this type of problems both Grashof and Reynolds numbers play a great role in flow pattern and heat transfer characteristics, so we focus our study on four major parameters that can be crucial such as Grashof and Reynolds numbers, nanoparticle volume fraction and the non-dimensional lid frequency.

2. **Problem statement**
   Over the past several years, natural and mixed convection in a cavity filled with fluid has received a remarkable attention because of its wide and practical applications in real world engineering concerns. These concerns can be observed in various fields such as cooling of electronic packages, solar energy collectors, ventilation and heating of living space and cooling of nuclear reactors.

3. **Theoretical objectives**
   After mathematical formulation of the problem the numerical simulation will be done by ANSYS or STARCCM++ or open source CFD codes.

4. **Experimental objectives**
   The experimental work will be done at UP Nanofluid Lab.

5. **Validation of theoretical predictions against experimental results**
   Numerical simulation and experimental results will be compared against each other.

**Category**
Mechanical

**Group**
Thermofluids Research Group

**External Leader**
N/A

**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements


**Dr W LeRoux**

**Testing and development of a dish-mounted solar still for water desalination/purification**

Lecturer, Dr W LeRoux
Max students, 2

**Project Description**

1. **Background**
   Water can be purified by boiling it and capturing the condensate. By doing this, all the heavy ingredients in the water stay behind and can be separated from the pure water condensate. Water can be boiled with concentrated solar heat from a solar dish reflector. A desalination/water purifying unit can be placed at the focus point of a small-scale solar dish which tracks the sun.

2. **Problem statement**
   Water is an important resource, especially for the water-scarce Southern Africa. Water is often dirty and not safe for drinking. The small-scale purification of water is also expensive. The solar desalination and purification of water in South Africa would be useful since South Africa has a good solar resource.

3. **Theoretical objectives**
   The unit should be modelled mathematically. The amount of water purified per minute should be anticipated.

4. **Experimental objectives**
   A dish-mounted solar water purification/desalination unit should be built and tested. The amount of water treated per minute should be measured. A small-scale solar tracking system and dish is already available and can be used for the testing.

5. **Validation of theoretical predictions against experimental results**
   Theoretical and experimental results should be compared, typically in terms of litres of water purified per hour.

**Category**
Mechanical

**Group**
Thermofluids Research Group

**External Leader**
N/A

**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
A small solar tracking system and dish are available for the experiments
Testing and development of a small-scale dish-mounted solar still for fuel production

Lecturer, Dr W LeRoux
Max students, 1

**Project Description**

1. **Background**
Alcohol can be purified by boiling it and capturing the condensate. By doing this, all the heavy ingredients stay behind and can be separated from the pure condensate. Boiling can be done with concentrated solar heat from a solar dish reflector. A distillation unit can be placed at the focus point of a small-scale solar dish which tracks the sun. Alcohol can be used in the production of fuel.

2. **Problem statement**
Fuel is an important resource world-wide but is also expensive. The production of solar fuels in South Africa would be useful since South Africa has a good solar resource.

3. **Theoretical objectives**
The unit should be modelled mathematically. The amount of fuel created per minute should be anticipated.

4. **Experimental objectives**
A dish-mounted solar still unit should be built and tested. The amount of fuel created per minute should be measured. A small-scale solar tracking system and dish is already available and can be used for the testing.

5. **Validation of theoretical predictions against experimental results**
Theoretical and experimental results should be compared, typically in terms of litres of fuel created per hour.

**Category**
Mechanical

**Group**
Thermofluids Research Group

**External Leader**
N/A

**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
A solar tracking system and dish are available for the experiments
High-temperature solar receiver testing

**Project Description**

1. **Background**
   A solar receiver captures heat from a solar concentrator. The tubular solar cavity receiver heats air for the operation of a micro-turbine as used in a small-scale solar thermal Brayton cycle. The solar receiver operates at very high temperatures and loses heat mostly due to radiation heat loss.

2. **Problem statement**
   A tubular solar cavity receiver should be tested at high temperature to determine its heat losses, especially due to radiation heat loss. The solar receiver is mounted at the focus point of a small-scale solar dish which follows the sun during the day. The receiver is thus mounted at different angles throughout the day. Depending on the wind direction and receiver angle, heat loss due to convection can also be significant.

3. **Theoretical objectives**
   The heat loss from the solar cavity receiver at high temperature should be modelled.

4. **Experimental objectives**
   Convection, conduction and radiation heat loss rates at high receiver temperatures should be measured. The receiver should be heated up to a high temperature and should then be allowed to cool down, during which measurements will be taken to determine the heat loss rate due to radiation, conduction and convection. The receiver efficiency can also be determined by measuring the inlet and outlet temperature of air while the receiver is at the focus point.

5. **Validation of theoretical predictions against experimental results**
   The theoretical and experimental results should be compared and discrepancies should be explained.

**Category**
Mechanical

**Group**
Thermofluids Research Group

**External Leader**
N/A

**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
A small solar tracking system and dish are available for the experiments
Testing and development of a small-scale thermoelectric generator using concentrated solar power

Lecturer, Dr W LeRoux
Max students, 1

Project Description

1. Background
A thermoelectric generator generates electricity directly from a temperature difference. This is also known as the Seebeck effect. The Seebeck effect is also used in thermocouples for temperature measurement. A thermocouple consists of two metal wires welded at the tip where it measures the temperature of a surface/fluid by generating a small voltage. The Seebeck effect can be used to generate electric power from concentrated solar heat so that electricity can be produced directly, eliminating the need for a power cycle.

2. Problem statement
In a thermoelectric generator, two different metals make contact between a hot and cold surface. Many different combinations of metals can be used to produce a voltage with the Seebeck effect. Different combinations of metals, as typically used in thermocouple wires, can be tested to determine which combination would be the most cost effective and useful in small-scale solar thermoelectric power generation. Semi-conductors can also be used in the investigation.

3. Theoretical objectives
The electricity produced with the thermoelectric generator can be modelled mathematically.

4. Experimental objectives
A dish-mounted thermoelectric generator unit should be built and tested. Different material combinations should be tested. Thermocouple wire can be used in the investigation. A small-scale solar tracking system is available for the testing of the units.

5. Validation of theoretical predictions against experimental results
The results should be compared theoretically and experimentally to validate the results.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
A small solar tracking system and dish are available for the experiments
Build a test-rig for a micro-turbine to be used in a small-scale solar thermal Brayton cycle

Project Description

1. Background
A micro-turbine can be driven from the heat of burning fuel or the heat from concentrated solar power. A number of turbochargers from the motor industry are available to act as micro-turbines in a small-scale solar thermal Brayton cycle.

2. Problem statement
Turbochargers have to be tested for performance experimentally before operation in a solar thermal Brayton cycle can take place. A test-rig is required to test different micro-turbines using a gas burner to simulate the heat input from the recuperator and the solar receiver.

3. Theoretical objectives
The performance of a micro-turbine and the heat input from the gas burner should be modelled mathematically.

4. Experimental objectives
A test-rig should be built and tested. A gas burner should be constructed to provide heat for the turbine to simulate the solar and recuperator heat input of a typical solar thermal Brayton cycle. To simulate the compressor, air should be pressurised before it is heated by the gas burner. The turbine in the turbocharger drives a compressor which can be used to measure the power output of the turbine.

5. Validation of theoretical predictions against experimental results
The experimental results of the gas burner and turbocharger performance should be compared with the anticipated results as obtained theoretically.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
A turbocharger and gas burner is available for the experiments
High-temperature solar heat storage using sand and rock

Lecturer, Dr W LeRoux
Max students, 1

Project Description

1. Background
Concentrating solar power can be used for power generation during the day with a solar thermal Brayton cycle. During the night however, high temperature heat storage is required so that power generation can continue. Sand and rock can be used to store heat at very high temperatures.

2. Problem statement
High temperature heat storage is required for a solar thermal Brayton cycle. Different types of sand and rock should be tested to determine its heat storage capacity.

3. Theoretical objectives
The heat storage of different types of sand and rock will be modelled to determine the time needed to increase and decrease the temperature of the sand or rock.

4. Experimental objectives
A small-scale solar tracking system with a solar dish is available for testing. Different samples of rock and sand should be placed at the focus point of the solar dish. Measurements of temperature as a function of time should be made for the different samples.

5. Validation of theoretical predictions against experimental results
The results should be compared theoretically and experimentally to validate the results and a recommendation should be made on the feasibility of the different samples to be used for high-temperature storage of concentrated solar heat.

Category
Mechanical

Group
Thermofluids Research Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
A small solar tracking system and dish are available for the experiments
Mr T Botha

Measurement system for obtaining soil properties used in terremhanics

Lecturer, Mr T Botha
Max students, 2

**Project Description**

1. Background
More and more vehicle simulations are conducted to evaluate the performance of the vehicle. Many simulations are also being conducted on deformable terrains such as sand, mud, clay and snow. To successfully conduct simulations on these surface using a multibody simulation package requires the modelling of the terrain.

2. Problem statement
Develop a experimental test setup which can be used to obtain soil properties required for simulation purposes

3. Theoretical objectives
Obtain theoretical curves for soil properties from literature and simple theoretical models

4. Experimental objectives
Conduct experimental tests using the designed experimental setup

5. Validation of theoretical predictions against experimental results

Comparing results between theoretical/simple models and experimental results

**Category**
Mechanical

**Group**
Vehicle Systems Group

**External Leader**
N/A

**External Leader Location**
N/A

**External Organisation**
N/A

**Total Funding (ZAR)**
500

**Experimental Requirements**
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Electronic Continually Variable Transmission (e-CVT)  

Project Description

1. Background
In the mini baja competition most teams utilise an off the shelf continuously variable transmission (CVT). These CVT’s are typically designed for use in larger vehicles and at higher speeds than possible on a baja vehicle. To optimise the CVT is a difficult process and the performance is not ideal at all operating conditions. An electronic CVT which can adapt to the driving conditions to obtain the best possible performance is desired.

2. Problem statement
Develop the setup and control of an e-CVT for use in a baja vehicle

3. Theoretical objectives
Develop the control setup in simulation for an e-CVT

4. Experimental objectives
Build an e-CVT setup and conduct experimental validation of control system

5. Validation of theoretical predictions against experimental results
Compare results obtained in simulation and experiments

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Four wheel steering on mini-baja

Project Description

1. Background
The mini-baja is a small off-road vehicle which has no differential on the driving wheels. Since both wheels are forced to rotate at the same speed the maneuverability of the vehicle is severely reduced. A possible solution is to equip the vehicle with rear wheel steering to compensate for the lack of differential and to improve the maneuverability of the vehicle.

2. Problem statement
The aim of this project is to refine the existing design of the 4 wheel steering system in use on a Baja vehicle to improve the maneuverability.

3. Theoretical objectives
Develop the steering system in simulation to improve the maneuverability of the mini-baja vehicle

4. Experimental objectives
Manufacture and test steering system on a mini-baja

5. Validation of theoretical predictions against experimental results
Compare the results between simulation and experimental results

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Hardware in the Loop brake robot

Lecturer, Mr T Botha
Max students, 2

Project Description

1. Background
Hardware in the Loop (HiL) tests are often used to simplify the modelling of complex components. Rather than model the component the physical component is placed in the simulation with inputs from the simulation to the component which is then used to obtain the necessary outputs which is fed back into the simulation.

2. Problem statement
The aim of this project is to transform the brake robot in an existing vehicle into a brake HiL system which can be used to simulate the brake performance of the vehicle.

3. Theoretical objectives
Develop the control algorithm in simulation which can control the brake robot to supply the correct inputs

4. Experimental objectives
Implement system on existing brake robot of a vehicle

5. Validation of theoretical predictions against experimental results
Validate control algorithm obtain in simulation with experimental results

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
MR-damper development for mini baja vehicle

Lecturer, Mr T Botha
Max students, 2

Project Description

1. Background
Magneto-Rheological fluid is used in dampers to obtain variable damping characteristics. The fluid contains magnetizable particles which when subjected to a magnetic field changes the viscosity of the fluid which can be used to change the damping of a damper.

2. Problem statement
This project aims at refining the existing design of an MR damper for use on a Baja vehicle

3. Theoretical objectives
Refine the design of the damper using simulation software

4. Experimental objectives
Manufacture and test refined design

5. Validation of theoretical predictions against experimental results
Compare experimental results to determine if simulated results have been obtained

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
**Project Description**

1. **Background**
   Magneto-Rheological fluid is used in dampers to obtain variable damping characteristics. The fluid contains magnetizable particles which when subjected to a magnetic field changes the viscosity of the fluid which can be used to change the damping of a damper. These dampers are currently used on small and mid sized vehicles (SUV) the systems are currently not used on large off-road military and agricultural vehicles.

2. **Problem statement**
   The aim of this project is to assess the feasibility of the system on these vehicles by developing a system and investigating the possible performance gains.

3. **Theoretical objectives**
   Determine design envelope and obtained simulation results

4. **Experimental objectives**
   Create MR valve and conduct basic experimental tests

5. **Validation of theoretical predictions against experimental results**
   Compare experimental with design simulations

**Category**

Mechanical

**Group**

Vehicle Systems Group

**External Leader**

N/A

**External Leader Location**

N/A

**External Organisation**

N/A

**Total Funding (ZAR)**

500

**Experimental Requirements**

List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements
Steady state modeling of continuously variably transmission (CVT)

Lecturer, Mr T Botha
Max students, 2

Project Description

1. Background
In the mini baja competition most teams utilise an off the shelf continuously variable transmission (CVT) with a fixed set of parts which can be changed to optimise the performance of a CVT. A model which can predict the performance of the CVT will improve the time needed to optimise the CVT.
The model can also be used to develop in-house parts to obtain the best performance.
2. Problem statement
This project aims at modelling the steady state performance of a CVT which can be used for CVT tuning

3. Theoretical objectives
Develop the theoretical model using fundamental equations
4. Experimental objectives
Conduct experimental test on the CVT using the test bench
5. Validation of theoretical predictions against experimental results
Compare experimental results with simulations results

Category
Mechanical

Group
Vehicle Systems Group

External Leader
N/A

External Leader Location
N/A

External Organisation
N/A

Total Funding (ZAR)
500

Experimental Requirements
List Any Specific Experimental Requirements e.g. specific lab equipment, services or space/location requirements