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M&M Post-Graduate Topics

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forward together
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Contents

Prof Anton Basson

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- **Research Field**
  Research field: Industry 4.0, cyber-physical systems, digital twins, and the integration of humans with digital environments
- **General Description of Research Field**
  CYBER-PHYSICAL SYSTEMS, DIGITAL TWINS, HOLONIC SYSTEMS The fourth industrial revolution, or Industry 4.0, is the current trend of automation and data exchange in manufacturing technologies and many other domains. The Industry 4.0 vision relies on technologies such as cyber-physical systems (CPSs), the Internet of Things (IoT) and cloud computing services. Our research focusses on the development of reality-reflecting architectures for CPSs – incorporating Digital Twins (DTs) – using principles of Holonic Systems. We consider the multi-domain implementation of four levels of CPSs: (1) Smart Connection Level: e.g. ingestion of physical system IoT data from sensor networks. (2) Data-to-Information Conversion Level: data processing from raw data to useful information. (3) Cyber Level: twin models (or Digital Twin) to simulate and analyse real-world systems. (4) Services Level: software services and Digital Twins to support decision making, e.g. monitoring, anomaly detection, data analytics for prediction, and visualization through augmented reality HUMAN-SYSTEM INTEGRATION (HSI) AND HUMAN CYBER-PHYSICAL SYSTEMS Industry 4.0 research has paid notable attention to automation systems, but South African enterprises will continue to rely heavily on people. We research the integration of humans into/with CPSs, both as task executors and decision makers, within Industry 4.0 environments. We aim to retain people's exceptional capabilities and overcome their limitations using digital technologies, for example by adapting control architectures and using enabling technology (e.g. collaborative robots, pose sensing, and virtual and augmented reality). CURRENT AND RECENT APPLICATION AREAS BMW: DTs of each vehicle built, supporting machine learning, cloudification, and the circular economy. Mediclinic: HSI in an emergency centre and DTs to improve patients' clinical pathways. Hortgro: DTs to manage a fruit treatment facility's information related to physical infrastructure and processes. Complex facilities: DTs to monitor/manage complex operations in, e.g., a university campus and a smart village. Mines: DTs and HSI to support integrated and worker-centric mining environments for improved safety, productivity and efficiency.

  Prof Basson and Dr Kruger co-supervise students in this research area. More information can be found at https://www.sun.ac.za/mad.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Digital twins for data-led decision making Technologies for implementing a "digital twin" in a CPS for data-led decision making. This includes modelling techniques for the physical system's behaviour in the digital world, mechanisms for data exchange between the digital and physical systems, as well as the development of value-adding digital services. **Requirements:** Although preference is given to Mechanical and Mechatronic Engineering graduates, students from other engineering backgrounds will also be considered. A strong affinity to software development is required.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Human cyber-physical systems Development of human-integrated work environments using collaborative robots, augmented reality and software platforms for integrating humans with digital systems. **Requirements:** Although preference is given to Mechanical and Mechatronic Engineering graduates, students from other engineering backgrounds will also be considered. A strong affinity to software development is required.		✓	✓	✓

Prof Annie Bekker

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- **Research Field**
  Vibration, measurement, signal processing, data, digital twins
- **General Description of Research Field**
  With the onset of Industry 4.0, vibration measurement and analysis is no longer constrained to the delivery of information about an asset in hindsight. Digital twin technology creates a niche where operational data can be fed directly to engineering models to detect anomalies / deliver insights to assist better decisions about the management and operation of engineering assets. Reliable measurement, smart signal processing and rapid models are crucial to enable these ideas which are trailed in real-world environments.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A digital mirror towards visibility of train operations This work entails the specification and selection of sensors and signal processing to plot operational metrics of a train along its track. It is envisaged to collect vertical vibration measurements along with GPS data at the driver seat location of GIBELA trains. Within the correct framework, this accelerometer data could be used to inform on the condition of the rail track. The use of a standardized whole-body vibration filter could benchmark the occupational comfort and vibration exposure of train drivers. A laboratory rig could be considered as a sub-step to enable the in-situ operation of the final solution. This project will run under the newly established GIBELA Engineering Research Chair. GIBELA will manufacture 600 trains locally for the South African Rail Sector. The company is responsible to maintain this fleet of trains for the next 19 years. **Requirements:** A background and passion for sensors, measurement, signal processing and data would be beneficial.		✓		✓
Measurements and signal processing for the detection of flat spots on train wheels Sensing and signal processing techniques will be researched to determine the state-of-the-art in rail wheel monitoring. A laboratory rig will be developed to prototype the performance of different sensing technologies. One emerging technology includes the use of optical sensors on rail tracks where passing wheels create optical signatures through which flat spots in train wheels can be identified through signal and image processing techniques. This open-ended project aims to progress to full-scale implementation where the ultimate solution would index and track the condition of individual wheels that pass over an instrumented track section. This project will run under the newly established GIBELA Engineering Research Chair. GIBELA will manufacture 600 trains locally for the South African Rail Sector. The company is responsible to maintain this fleet of trains for the next 19 years.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: A background in vibration or strain measurement and some knowledge on signal processing is an advantage. The candidate should be a self-starter with a willingness to travel and to work hands-on with data and experiments.				
Digital services for the health monitoring of a polar vessel propulsion system Become part of an international research project (South Africa, Norway, Germany) where sensor placement, signal processing and pattern recognition techniques will be used to inform the condition and operational safety margins of the SA Agulhas II. The work will entail new measurements and the analysis of historical data. The data entails strain gauge measurements as well as observations of ice and weather along the ship track on voyages of the vessel to Antarctica. The instantaneous shaft torque can be calculated from shaft strain measurements which can be related to fatigue damage and the estimation of remaining useful life. Insights can be derived to inform the types of ship manoeuvers and ice conditions that are most damaging to the shaft and other propulsion system components. It remains to consider if data is best presented in hindsight or insight and if reliable predictions of remaining useful life are possible using digital twin technology. The results of this work is of interest to the polar shipping sector where operational conditions and maintenance strategies are not sufficiently informed by operational ship studies and data. **Requirements:** Work on the SA Agulhas II is inter-disciplinary and demanding. Group efforts are required to gather data and this required interaction with other students, the ship crew, collaborators and researchers outside the ambit of engineering. Applicants should be highly motivated, curious and self-driven.		✓		✓
A laboratory structure to prototype a digital twin of ship fatigue damage The SA Agulhas II is prone to wave slamming which causes “jelly-ship”, a lasting whipping vibration of her structure. A flexible model must be constructed to mimic the dynamic bending response and the measurement system of the full-scale vessel. This scale model will be used to evaluate and develop methods (sensing and analysis) to prototype the monitoring of hull fatigue damage. The primary advantage of a laboratory structure is the ability to induce a measurable force from which strain and acceleration responses can be used to infer the resulting fatigue damage. Operational modal analysis will be used to troubleshoot a novel calculation framework where the input force is not known. This topic is open in scope and can incorporate the use of CFD, FEM, a practical scale model or simulated data. The work can be extended to include the investigation of the full-scale vessel and her historical data. The ship is currently a case study of the International Committee of Ships and Offshore Structures where new methods of "high frequency fatigue damage prediction" are being investigated.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: This work requires genuine interest, a strong affinity to independent learning and critical thinking. A background in FEM or CFD is an advantage.				
On the optical inspection of train condition Camera systems are increasingly used in a plethora of applications that touch every conceivable industry - the rail industry is no exception. This work will investigate sensing techniques and applications where camera footage from a stationary monitoring station can be used to monitor the condition of a passing train. Examples include the detection of damaged doors or windows which should be reflected against the last known condition of the rail car / locomotive condition. Other contactless techniques such as thermal sensing may be investigated. This project will run under the newly established GIBELA Engineering Research Chair. GIBELA will manufacture 600 trains locally for the South African Rail Sector. The company is responsible to maintain this fleet of trains for the next 19 years. **Requirements:** This work will require new background knowledge in optics and signal processing when considering an engineering background. The candidate should be a self-starter with a willingness to travel and to work hands-on to create surrogate tests and to gather / optimize footage from passing trains.		✓		✓
A sensor system for bogie health monitoring Sensor installations will be evaluated to monitor the dynamic response of a train bogie assembly. The purpose of such a system would be to benchmark the assembled condition of the system in newly built trains and to progressively monitor the degradation of the vibration state owing to increasing wear. Analytical models of the vehicle-track system will be considered to model signature responses for healthy and faulty bogie systems. The work can consider the required data pipeline and metrics with more sophisticated signal processing solutions to compliment traditionally recorded r.m.s. metrics. This project will run under the newly established GIBELA Engineering Research Chair. GIBELA will manufacture 600 trains locally for the South African Rail Sector. The company is responsible to maintain this fleet of trains for the next 19 years. **Requirements:** A background in vibration and an affinity for mathematical modelling is an advantage. The candidate should be a self-starter with a willingness to travel and to work hands-on with data and experiments.		✓		✓

Mr Johann Bredell
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- **Research Field**
  Structural analysis and design. Wind engineering.
- **General Description of Research Field**
  Structural analysis and design. Wind engineering. Solar tracking structures. Finite element analysis.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Experimental study of fatigue failure in photovoltaic modules and mounting structures Wind loads result in significant variable stresses in PV module structures. In addition, mechanical loads may cause reduction in power yield due to cracking of solar cells. This study aims to investigate the failure mechanisms in the solar cells, glass, frame, fasteners, and mounting rail. An experimental test rig must be developed to perform accelerated tests that are representative of wind loads. Structural simulation will form part of the design process. **Requirements:** FEM		✓		✓
Alternative structural designs for natural draft cooling towers The proposed topic forms part of a larger project in which the feasibility of using natural draft dry cooled steam condensers in thermal power plants is investigated. Dry cooled steam condenser systems are preferred over wet indirect systems due to their relatively high thermal efficiency and reduced environmental impact. Despite the virtues of natural draft dry cooled systems, traditional designs and construction methods make hyperbolic concrete towers prohibitively expensive. The aim is to investigate alternative structural designs for natural drafts cooling towers. Specifically, the feasibility of tensile membrane structures is of interest. A concept structure must be developed and compared to a traditional concrete structure. One of the metrics for comparison must be carbon footprint. **Requirements:** FEM		✓		✓
Proof of concept aluminium heliostat Traditional heliostat designs use glass as the reflective surface. Although glass has good optical performance, it has several disadvantages. This study aims to investigate the merit of using aluminium as the primary construction material for heliostats including the reflective surface. A practical structural concept must be developed that considers the shape of the mirror and distribution of stiffness. Wind loading considerations are of specific importance. Carbon footprint should also be used as a performance measure.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: FEM				
Experimental study of heliostat reflective losses due to wind loads The pointing accuracy of heliostats is adversely influenced by wind loads which will result in reduced performance in a solar thermal power plant. This study will investigate reflective losses using model-scale wind tunnel testing. The measurement of small angular deviations will form an important part of the study. The effect of various design parameters on pointing accuracy can be tested. **Requirements:** FEM		✓		✓

Prof Corne Coetzee

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- **Research Field**
  Two fields of research are available: (1) Granular material modelling with applications in the mining and agricultural sectors, (2) Agricultural engineering focussing on packaging.
- **General Description of Research Field**
  (1) Granular material modelling: The Discrete Element Method (DEM) is a numerical method used to model granular materials and industrial processes. Mining applications include the calibration of material properties as well as the modelling of typical mining processes and bulk material handling such as the flow of ore on conveyor belts, transfer chutes and hoppers. The aim of such a study would be to optimise the process in terms of mass flow rates while limiting wear and spillage. Agricultural applications include the modelling of post-harvest handling to predict damage and bruising of fruit and vegetable as well as soil-tool interaction with the aim of improving implements such as ploughs and discs. Students with a mining bursary are welcome to propose a related topic which is of interest to them and the bursary provider and extend their stay in Stellenbosch rather than working in Middelburg or Secunda:-). This research is done in collaboration with researchers from Australia, the Netherlands and Germany, with opportunities for the student to visit one or more of our collaborators.

  (2) Agricultural engineering: Packaging (plastic bags, carton boxes, etc.) is used to protect fruit and vegetables during handling and transportation. However, the fruit need to be kept cooled while mechanical damage should be minimised. Boxes that are structurally strong will prevent any mechanical damage to the produce but might prevent proper cooling of the fruit and might be too expensive. On the other hand, a box which will allow the fruit to cool properly might be less expensive, but not able to prevent mechanical damage to the produce. The optimum design should be found which is inexpensive, provides sufficient structural protection and allow for proper cooling of the produce. Tools such as the Finite Element Method (FEM) and Computation Fluid Dynamics (CFD) are used and combined with experimental techniques. This research is done in close collaboration with various departments from Agricultural Sciences at Stellenbosch University.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Further development and application of the Material Point Method (MPM) The Finite Element Method (FEM) is a numerical method often used for structural analysis. FEM uses a mesh (elements and nodes) to discretise the material, and as the material deforms, so does the mesh. When the deformation becomes too large, and (some of) the elements too distorted, the whole approach collapses - the mathematics no longer applies, and a solution can not be obtained. To overcome this problem, special techniques such as re-meshing is required. Hower, for a 3D domain, this is not a trivial task. An alternative approach is to make use of a so-called "meshless" method. There are a number of meshless methods available, but we have focussed on the Material Point Method (MPM) over the last 20 years. MPM is a meshless finite element method capable of modelling very large deformation and is often used to model and analyse bulk (granular) material flow and soil mechanics. Although it has been shown that MPM can accurately model a large number of applications, it is still continuously being developed and improved. The aim of this project is to continue the development of MPM and to model unique applications, specifically in bulk solid handling and/or soil mechanics (geotechnical engineering). Interested students are encouraged to propose their own specific topic or application of interest. This topic requires an interest in solid mechanics, numerical modelling, FEM, and C++ programming, and is ideal for students in mechanical engineering and in civil engineering (geotechnical). For more details on MPM: https://en.wikipedia.org/wiki/Material_point_method Interestingly, MPM is also used by Walt Disney to model physics (such as snow) accurately in animation movies such as Frozen: https://www.disneyanimation.com/technology/matterhorn/ **Requirements:** Background in Finite Element Modelling is essential.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
The modelling of bulk granular materials using the Discrete Element Method (DEM) A granular material is defined as a collection of individual or discrete particles. The particles make contact with one another, resulting in the dissipation of energy, mainly through the action of friction. Examples of granular materials include sand, soil, mined ore, grains such as wheat and corn, powders, etc. These materials are abundant in nature, and also found in the mining, agricultural, food, and pharmaceutical industries where the term "bulk solid" is often used to describe the material. Equipment and machinery are used to handle, transport, convey, store, and process the materials. Examples include silos, hoppers, bins, conveyors, trucks, excavators, mixers, crushers, mills, ploughs, planters and seeders, harvesters, etc. The Discrete Element Method (DEM) is a software tool often used in modelling and analysing the behaviour of granular materials. DEM is also used as a design tool, to analyse the flow of the granular material and how it interacts with the equipment, in order to design better equipment, or to optimise it for a specific application and material. However, for the DEM model to be accurate, the user needs to specify the material properties as input parameters. The material properties are not readily available, and a process called "DEM calibration" should be followed for each material sample. We have been working on DEM calibration for the last 15 to 20 years and have successfully developed equipment and techniques for the calibration of non-cohesive materials. The aim of this project is to better understand the behaviour of cohesive (wet) materials, and to further develop a calibration process for these materials. This should then be validated using laboratory experiments. The project will include experimental work using our unique large scale conveyor test facility, shear testers, a newly developed centrifuge tester, etc. This project is ideal for a student interested in mining activities and/or agricultural engineering, laboratory test work, and numerical modelling. Commercial DEM software is used, and there is no need for programming. The balance between experimental (practical) work and numerical modelling can be adjusted to best suit the student's interests. Also, the applications investigated can be either aligned with the mining or the agricultural sector, depending on the student's interests. Students can also propose their own topic, as long as it includes a granular material of some sorts. For more information on our research group: https://blogs.sun.ac.za/gmrg/ **Requirements:** None		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Analysing and improving the cooling inside a freight container South Africa's Citrus exports reached record-breaking numbers in 2020, shipping 146 million cartons, making it the second-largest citrus exporter in the world. An effective and efficient transport and distribution system is thus of utmost importance to utilise this fresh produce. Citrus fruits are mostly transported in freight (shipping) containers that have built-in cooling units; these types of containers are referred to as reefer containers (RC). Recently, the regulations and compliance rules regarding fresh produce exports have become much more stringent than in the past. These regulations are applicable to transport where temperatures are to be kept below 2°C. The RC's role is to maintain a safe temperature inside the container, which preserve fruit quality through the reduction of respiration rates. In the case of some niche markets, the container is also used to apply in-transit cooling to eradicate insect larvae, which may be seen as a pest by the importing market. These pests can cause containers to be rejected, leading to substantial financial losses and lost potential in food production. Optimisation of refrigerated container usage and cooling is thus a priority to the South African citrus industry, which would allow for more controlled cooling processes during shipping. The aim of this project is to analyse the cooling inside a loaded container, using experimental measurements and Computational Fluid Dynamics (CFD). Where possible, new aids and changes to the container should be proposed to achieve optimal and uniform cooling rates. This will not only preserve more of the produce, but also reduce the RC's energy consumption. This project is ideal for a student interested in agricultural engineering, experimental measurements (heat transfer and flow), and CFD modelling. This is not the first project on this topic undertaken by us, but is the continuation of a Master study, which will provide a very good background and starting point to the project proposed here. The project will be run in close collaboration with the Faculty of Agri Sciences (Stellenbosch, horticultural sciences). A student bursary for a Master and/or PhD student(s) is available from 2023 onwards. **Requirements:** Students would be required to follow the CFD postgraduate course if not already followed as an undergraduate course at Stellenbosch.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Improving the structural integrity of cartons used for the export of flowers Indigenous floral products from South Africa (SA) should meet the export market's expectations in order for them to maintain and improve their industry's reputation and market share, and this requires innovative freight and storage technologies. Cape Flora cut flowers are currently transported in ventilated cartons (boxes) manufactured from corrugated paperboard. Transport duration via air freight is short, about 48 hours. Sea freight is a cost-effective alternative, reducing rates by 50-60%, but require a significantly longer cold-storage period of up to 21 days or more for SA producers delivering to the European market. Export by sea is particularly suitable for heavy and bulky cut flower products such as Protea. However, independent of the mode of transport, Cape Flora SA (CFSA) has identified that cartons often collapse during transportation, which damages the flowers. Based on industry feedback, there is a need to establish minimum specifications for cartons in terms of structural strength. This industry survey, amongst SA exporters and European importers, indicated that on average, approximately 5% to 13% of the products are currently transported in substandard cartons. All the respondents also indicated that they would fully support an industry initiative to impose minimum specifications on carton quality. Although the box sizes are standardised, manufacturers make use of different paperboard specifications for the manufacturing of the board, and thus the cartons. The differences range from the paper grammage (weight per square metre) used, Kraft (virgin and stronger) and recycled (weaker) paper, and the fluting size (B or C corrugation). Other design differences include aspects such as the corner design which can increase the vertical strength of the carton. However, the large number of variations in specifications, designs and loading conditions, make it difficult to identify the most suitable carton from those currently in use. The purpose of this study is to determine the minimum structural (strength) specifications for the cartons, and to develop a test methodology for measuring the performance of existing and any newly designed cartons against these specifications. This includes the design and manufacture of a device to measure the loads acting on a typical carton in the field and under controlled laboratory conditions. The stability of a stacked pallet (cartons stacked on a wooden pallet) should also be evaluated. Then, an improved carton should be designed, which can withstand the loads, but it should also be cost effective to manufacture. The work will be done in close collaboration with Cape Flora SA, Faculty of Agri Sciences (Stellenbosch), and participating farmers: https://www.capeflorasa.co.za/ This project is ideal for a student interested in agricultural engineering and experimental testing and measurement. A bursary for a Master student is available for 2023 and 2024.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: A knowledge of the Finite Element Method (FEM) is advantageous, but not a prerequisite.				

Dr Danie Els
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- **Research Field**
  Bio-veterinarian & Granular matter
- **General Description of Research Field**
  Research into the tranquiliser darting system of wild animals. This includes gas gun characterises, external ballistics and wound ballistics of darts. Wound ballistics is modelled with Discrete Element Method (DEM)

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Tranquiliser dart wound Ballistics Modelling of ballistic gel and skin membranes to simulate the wound ballistics of tranquiliser darts on wild animals. This is performed with Discrete Element Method (DEM) software and verified with experiments. **Requirements:** Dynamics		✓	✓	

Dr Gareth Erfort
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- **Research Field**
  wind energy, CFD
- **General Description of Research Field**
  Open source CFD - extrnal aerodynamics Wind energy - resrouce assessment, small scale implementation, blade design and structural interactions

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Resrouce assessment sensitivity The student will use two packages to perform resource assessment. The one an open source package called Continuum and the other an industry std call WASP. The student must build a wind farm in both packages and compare the results. One of the biggest differences in these package is the data sets used. the student must reconcile the surface roughness maps used by each package and determine how influential these maps are in the AEP and CF estimates produced. If possible a real world wind farm will serve as the base case. **Requirements:** wind energy course		✓		
Renewbale energy database development Use Eskom supplied data to develop a dashboard on REIPPPP projects power output. Dashborad should break down power out to various farm operating. As the farm and Eskom will not provide this resolution the student must use WASA data to estimate farm performance and determine the % power each farm would theoretically provide **Requirements:** Coding based project - needs a strong background in handling datasets	✓			
Floating foundation development As South Africa looks offshore with unique water conditions require custom design for wind turbine floating foundations The student will investigate what makes our waters different from the locations currently hosting floating wind farms. They would then design a structure capable of handling these conditions using CFD and linear elastic models. The project will include field work and collaboration with multiple institutions **Requirements:** Structural mechanics (FEM) slow mechanics (CFD) numerical modelling experience			✓	✓

Dr Andrew Gill
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- **Research Field**
  Fluid Mechanics, Thermodynamics, Turbomachinery
- **General Description of Research Field**
  Experimental and CFD turbomachinery research, Multi-phase CFD simulation for industrial applications

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Fuel Octane Testing of Pure Component Blends for Automotive engines There is currently an intentional move away from the use of fossil fuels in industry. This has also impacted the transport industry and various options for the replacement of current forms of transport are being considered. The reduction of carbon emissions has led to a need for research into the use of alternative fuels for internal combustion engines. There is thus a need for fuel octane testing of pure component blends for automotive engines. Stellenbosch University's Department of Mechanical and Mechatronic Engineering have extensive and well-maintained engine test facilities. In particular, the testing will be performed on the existing CFR engine.The CFR engine has been modified in accordance with DIN 51 756 and SAE 820002 to determine octane numbers of pure alcohols and petrol-alcohol blends. Octane numbers of the spark ignition fuel indicate the propensity of the fuel to auto-ignite under different engine operating conditions. Lower octane number fuels have a lower resistance to auto-ignition, and the auto-ignition of the fuel during combustion can lead to high levels of knock intensity resulting in engine damage. For this research, higher octane number fuel blends will be formulated using pure components and established blending models (where available). Octane numbers of the blends are determined by running the fuel in the CFR engine and adjusting the compression ratio to produce a standard knock intensity which is measured using the engine's detonation meter. CFR engine In-cylinder combustion pressures captured during testing can be used to provide additional information for fuel blend analyses. **Requirements:** Students will be required to do large amounts of hands-on experimental work involving internal combustion engines. Students will benefit from a strong understanding of thermodynamics, fluid dynamics and heat transfer fundamentals at undergraduate level.		✓		✓

Mrs Liora Ginsberg

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- **Research Field**
  Biomedical engineering - Microcirculation flow pattern in the lymph
- **General Description of Research Field**
  The lymphatic system is an important biological system, with main functions of immunity and transportation of excess fluid from amongst the capillaries in the loose connective tissue into the vascular system. Much research has been conducted on the flow patterns of the circulatory system, into which the lymphatic system flows, however little has been attempted on the lymphatic system.

  Parametric studies and numerical modelling of the micro-circulation of specific regions of the lymphatic system need to be conducted. The project takes place in the context on on-going final year projects and a PhD study.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Studies of lymph micro-circulation Study of the micro flow of the lymph in the lymphatic network. Use of CFD to model the micro flow movement of the lymph within a lymphatic segment / duct. **Requirements:** CFD		✓		

Prof Jaap Hoffmann

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- **Research Field**
  Solar thermal energy
- **General Description of Research Field**
  Solar thermal energy is a source of clean energy for electricity generation, process heat and thermal comfort that is unfortunately only available while the sun is shining. Thermal energy storage in rock beds using air as heat transfer fluid provides a low cost solution to store energy harvested during the day for night-time use. The large size of rock bed thermal energy storage, and irregular nature of crushed rock particles means that much of previous research done on prismatic beds of spherical particles is inadequate to describe pressure drop and heat transfer through packed beds. Hydrogen fuel cells and electric vehicles are the most promising substitutes for petrol and diesel driven vehicles in a post fossil fuel work. Hydrogen vehicles offer ranges and refueling times like those achieved by internal combustion engines. Hydrogen is a form of chemical energy that can be stored indefinitely. On the downside, hydrogen infrastructure is lagging that of electricity distribution. Overall, the outlook for hydrogen as a replacement for petrol and diesel in the transport sector is positive provided that it can be produced competitively. The copper-chlorine cycle as the most promising of all the thermochemical cycles for hydrogen production. In this cycle, water (steam) first reacts with CuCl2 to form HCl, and the HCl is then split into H2 and CuCl in an electrolyzer. Splitting HCl requires only about a third of the electricity input of that of splitting H2O. To facilitate the chemical reactions and recycle chemicals, the cycle requires several heat inputs at different temperatures. Some reactions are exothermic, and the heat released can be internally recycled to reduce the overall heat requirement of the cycle.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Green hydrogen via CSP pathways Evaluate the technology pathway(s) required, the current and future levelized cost of green hydrogen, and South Africa's potential for producing green hydrogen via the Cu-Cl cycle **Requirements:** Solar Thermal Energy Systems 814		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Solar hydrogen generation using the Cu-Cl cycle The Cu-Cl cycle was developed and demonstrated by Ontario Tech in Canada. This cycle requires a heat source (about 530 °C) and electricity. Both requirements can be met by a molten salt concentrated solar power (CSP) plant. The challenge is to find a suitable configuration of CSP plant to serve both high and low (100 °C) temperature heat exchangers - molten salts typically solidifies at about 250 °C. The student must develop, validate, and integrate working models of a CSP plant and the Cu-Cl cycle. The models (s) should be able to predict the shut-down procedure required when the CSP plant is running low on (stored) thermal energy. Several of these plants might be situated around South Africa where there are sufficient solar and (fresh) water resources to run the plant, and the necessary infrastructure to transport the product to a point of export/end use. Site selection forms part of the project, as well as the economic feasibility of the project. The student will spend 3 - 6 months at Ontario Tech. **Requirements:** Solar Thermal Energy Systems 814 A strong background in thermofluids will be advantageous.			✓	✓
Optimization of a packed bed thermal energy facility. Maximize bed utilization and minimize pumping cost for several discrete and continues design variables, such as number and size of inlets and outlets, bed length, bed height, particle size, etc. Since the flow is expected to be fully three dimensional, validated CFD model(s) of the bed (flow through porous media) is required. Existing models can be used/refined. The time scales for heat transfer and fluid flow is substantially different - the student must investigate ways to accommodate both in the same model, while keeping the simulation time down to levels that lend themselves to formal mathematical optimization. **Requirements:** Numerical Fluid Dynamics 414/814 or equivalent Advanced Design 814 or equivalent qualification in optimization A solid foundation in fluid dynamics and heat transfer will be advantageous		✓	✓	
Develop a low-cost passive condenser for a solar still A solar still using concentrated sunlight benefits from a small size and high evaporation rate. The high evaporation rate necessitates a condenser that can continually remove vapour from the still, and condense it into potable water. The application targets small rural communities, and robustness is key. A passive air-cooled condenser should fit the bill. The student should develop a model to predict the behaviour of such a condenser, and demonstrate it on laboratory scale. **Requirements:** CFD might be beneficial		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Solar still with a submerged absorber Interfacial evaporation in a solar still make effective use of the available sunlight as the bulk water remains cold, whilst evaporation happens only at the top of a membrane. The membrane wicks water to its upper surface. When using concentrated sunlight, the evaporation rate can exceed the transport rate of water through the membrane, leading tot dry-out. When this happens, evaporation stops. A submerged absorber can take advantage of a high surface temperature, whilst providing free access of water to the surface. The challenge is to develop a submerged membrane that mimics interfacial evaporation without any liquid flow restriction. **Requirements:** A solid background in undergraduate thermofluids subjects is required.	✓			
Turbulence modelling in porous media Flow through porous media is tortuous, and the presence of the solid matric causes additional turbulence production that is not present in flow through open channels. This turbulence helps to redistribute heat and momentum in a porous media. There are a few models in the literature to capture the extra turbulence production in the k-epsilon framework, but none (or few) for the k-omega turbulence models. Develop and validate (through the use of appropriate source terms) a model that can predict the extra turbulence dispersion in packed beds. Closure might be achieved on RANS, LES or DNS level. This project is expected to be mathematically intensive. **Requirements:** Numerical Fluid Dynamics 414/814 or equivalent		✓	✓	
Effect of surface roughness on internal laminar flow The effect of surface roughness on laminar, internal forced convection flows is often neglected. Experimental work indicated that surface roughness may augment heat transfer and influence the onset of transition. However, creating and measuring surface roughness inside small bore tubes is experimentally challenging. An alternative is to explore this phenomenon numerically. It is expected that the student study the effect of surface roughness on laminar flows numerically, and compare the results with experimental work by Prof. Josua Meyer and his group at the University of Pretoria. Results should be presented over a wide range of laminar flows; a typical Nusselt number vs Reynolds number plot for different surface roughnesses is required, similar to the Moody Chart but limited to the laminar regime. Sound skills in Heat Transfer and Fluid Mechanics is required, and students should benefit from taking these modules as part of their coursework. Prof. Meyer is now at Stellenbosch, and will co-supervise the project. **Requirements:** Numerical Fluid Dynamics, Advanced Heat Transfer, Advanced Fluid Mechanics		✓		

Dr Karel Kruger

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- **Research Field**
  Industry 4.0, cyber-physical systems, digital twins, and the integration of humans with digital environments
- **General Description of Research Field**
  Cyber-Physical Systems, Digital Twins, Holonic Systems:

  The fourth industrial revolution, or Industry 4.0, is the current trend of automation and data exchange in manufacturing technologies, and there is a growing interest in many other domains as well. The Industry 4.0 vision relies on key enabling technologies, such as cyber-physical systems (CPSs), the Internet of Things (IoT) and cloud computing services. Our research focusses on the development of reality-reflecting architectures for CPSs – incorporating Digital Twins (DTs) – using principles of Holonic Systems. We consider the multi-domain implementation of four levels of CPSs: (1) Smart Connection Level: e.g. ingestion of physical system IoT data from sensor networks. (2) Data-to-Information Conversion Level: data processing from raw data to useful information. (3) Cyber Level: twin models (or Digital Twin) to simulate and analyse real-world systems. (4) Services Level: software services and Digital Twins to support decision making, e.g. monitoring, anomaly detection, data analytics for prediction, and visualization through augmented reality

  Human-System Integration (HSI) and Human Cyber-Physical Systems:

  Industry 4.0 research has paid notable attention to automation systems, but South African enterprises will continue to rely heavily on people. We research the integration of humans into/with CPSs, both as task executors and decision makers, within Industry 4.0 environments. We aim to retain people's exceptional capabilities and overcome their limitations using digital technologies, for example by adapting control architectures and using enabling technology (e.g. collaborative robots, pose sensing, and virtual and augmented reality).

  Current and recent application areas:

  BMW: DTs of each vehicle built, supporting machine learning, cloudification, and the circular economy. Mediclinic: HSI in an emergency centre and DTs to improve patients' clinical pathways. Hortgro: DTs to manage a fruit treatment facility's information related to physical infrastructure and processes. Complex facilities: DTs to monitor/manage complex operations in, e.g., a university campus and a smart village. Mines: DTs and HSI to support integrated and worker-centric mining environments for improved safety, productivity and efficiency.

  More information can be found at https://www.sun.ac.za/mad.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of human-integrated work environments Development of human-integrated work environments using collaborative robots, augmented and virtual reality, and innovative software platforms for integrating humans with digital systems. Opportunities for this topic may be available in different application domains (e.g. healthcare, mining, manufacturing, agriculture, etc.).		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Although preference is given to Mechanical and Mechatronic Engineering graduates, students from other engineering backgrounds will also be considered. A strong affinity to software development is required.				

Prof Ryno Laubscher
rlaubscher@sun.ac.za

- **Research Field**
  Thermal-fluid dynamics
- **General Description of Research Field**
  Fundamental and applied research in combustion systems, heat exchangers and power cycles. Additionally my research focusses on the development of novel AI-based partial differential equation solvers for thermal-fluid problems.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Process modelling of a 50 MWe direct-fired sCO2 Brayton cycle using H2 and natural gas. Development of a network-based thermal-fluid process modelling code to simulate combustion, heat transfer and work transfer in a direct-fired recompression with inter-cooling sCO2 Brayton cycle. The goal is to verify the simulation code using commercial software, such as GT Suite, and then to use the software to investigate the effect of selected design parameters on cycle efficiency. The combustion will be simulated using hydrogen and natural gas as fuels. **Requirements:** Computational fluid dynamics 414.		✓		
Design of a sCO2 compressor for a 50 MWe concentrated solar Brayton cycle using mean line analysis and CFD. Using mass flow rate, pressure ratio, pressure and temperature inputs from a previously performed cycle analysis, this projects sets out to perform a preliminary design analysis of a sCO2 compressor, through applying mean line methods and CFD. The end-goal is to develop a more accurate compressor map that can be fed back into the power cycle process model for further analysis. **Requirements:** Computational fluid dynamics 414.		✓		
Preliminary thermal-fluid and mechanical analysis of a solid-fuel fired sCO2 heater. The goal of this project is to perform a preliminary thermal and mechanical design of a 50 MWe solid fuel fired sCO2 heater. This entails developing a thermal-fluid network simulation model using commercial software such as Flownex or GT Suite to size the heater and calculate the various material pressures and temperatures. Using these parameters, a mechanical analysis using pressure vessel codes should be competed. Once the heater has been designed, the thermal design will be verified using a CFD model of the gas side combustion and heat transfer. **Requirements:** Mechanical engineering student.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design of a combustor testing facility. The goal of the current project is to design an experimental setup capable of the testing various combustor designs for gas turbine applications. The experimental setup should include flow, temperature and gas species measurements. **Requirements:** None.		✓		

Prof Craig McGregor

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- **Research Field**
  Solar thermal energy, green hydrogen
- **General Description of Research Field**
  Solar thermal Energy and Green Hydrogen research, focusing on:

  * techno-economic analysis * systems engineering and optimization * heliostat design and mechatronics * thermofluid design of solar receivers and thermal energy storage systems * industrial application of solar thermal heat * power cycle design for CSP and high temperature heat pumps

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A review of recent CSP cost reductions through a technical and economic assessment of recent tariff price bids Concentrating solar power (CSP) has seen considerable cost reductions over the past decade, with installed costs having halved according to IRENA (2021). Given our excellent solar resources in South Africa, CSP offers an excellent opportunity to address our current electricity supply constraints whilst establishing a significant manufacturing industry in the country. This project will study the landscape of recent international CSP projects to model and review the causes of the cost trends over the past 5 years and to assess the implications for CSP technology deployment in South Africa. Technical and economic models of each of the recent CSP plants will be built in NREL's System Advisory Model and compared with published performance data on the plants. The economic model will be used to calculate the levelised cost of electricity and bid tariffs. The cost model must finally be fine-tuned to accurately predict the bid tariffs of the modelled projects. This cost model can then be used to forecast future cost trends for CSP in South Africa. **Requirements:** none	✓	✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Fuel-fired augmentation of CSP plants in South Africa as back-up for poor solar days Given our excellent solar resources in South Africa, concentrating solar power (CSP) offers an excellent opportunity to address our current electricity supply constraints whilst establishing a significant manufacturing industry in the country. Because a CSP plant includes a significant amount of thermal energy storage it can dispatch power throughout the night. Even in the desert locations such as the Karoo of the Northern Cape where CSP plants are located, there are periods of overcast or cloudy weather that would interrupt generation. A CSP plant that includes a fuel-fired system that would be able to continue generating electricity during periods of low solar resource, making CSP a firm and dependable power source. This project will study the technical and economic aspects of such a fuel-fired augmentation of CSP. The project should consider biomass and fossil fuel sources and investigate the best power cycle configuration (direct integration through the addition of a fuel-fired boiler, or an integrated solar combined cycle mode obtained by adding an open cycle gas turbine to the existing steam Rankine cycle of the CSP plant). **Requirements:** thermodynamics	✓	✓		
Design and configuration of solar thermal multi-tower field layout Central receiver CSP plants, also known as power towers, are built at very large scale (typically 50 to 100 MW or more). They require significant capital, and the 150- to 250-metre-tall tower can take up to two years to build. Conversely, utility photovoltaic (PV) plants can potentially be constructed within six months and require much less upfront capital. The intent of this project is to design and optimise a CSP plant composed of an array of heliostat field/tower modules (multi-tower system) that can be constructed quickly and sequentially, and that all supply a single power plant. Such a system has the potential to start generating electricity (and hence revenue) after completion of the first module of the array. The study will develop a simulation of the multi-tower including optical and thermal components, together with a cost model, will be used to optimise the configuration of the system. See e.g. https://doi.org/10.1063/5.0028916 **Requirements:** none		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Structural design and testing of advanced polygonal heliostat facets for advanced assembly line manufacturing A heliostat is a mirror assembly with dual-axis tracking that focuses solar irradiation on to the central receiver of a concentrating solar power (CSP) plant. Heliostats are high precision "robotics" systems that are costly to manufacture and constitute roughly 40% of the capital of a CSP plant, and a significant portion of the heliostat cost is the structure that supports and moves the aligned heliostat facets. Significant cost reductions in heliostat manufacture can possibly be achieved by applying a design for manufacturing approach on a novel heliostat facet sandwich structure and high reflectivity anodised aluminium sheeting, configured into a polygonal shape for increased optical and structural performance. The structural design, considering assembly line manufacturing, will be completed in the study followed by the fabrication of a large-scale facet for characterisation and testing. See e.g. http://dx.doi.org/10.1016/j.solener.2017.03.029 and https://doi.org/10.1063/1.5067066. **Requirements:** none		✓	✓	✓
Design and testing of a winch actuated heliostat A heliostat is a mirror assembly with dual-axis tracking that focuses solar irradiation on to the central receiver of a concentrating solar power (CSP) plant. Heliostats are high precision "robotics" systems that are costly to manufacture and constitute roughly 40% of the capital of a CSP plant, and a significant portion of the heliostat cost are the two actuators that perform the dual axis tracking of the sun. Typical commercial heliostats use worm drives for the azimuth drive and linear actuators with lead screws for the elevation drive. This study will design, build, and test a heliostat using a novel winch and cable actuation. See safeTrack H4™ - Trackers - Products - Ideematec safeTrack H4™ - Trackers - Products - Ideematec for a similar winch actuation concept applied to single-axis PV tracking. **Requirements:** good mechatronics topics, but suitable for mechanical stream students as well		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Thermofluid design and modelling of a thermosyphon liquid sodium receiver concept The central receiver is a critical component of a power tower concentrating solar thermal power system, cf. https://www.solarpaces.org/how-csp-works/. Solar energy is concentrated onto heat exchanger tubes in the receiver, where the heat is typically carried away by a heat transfer fluid such as molten nitrate salt or used to raise steam. The design of the receiver is complicated by the high temperatures and very heat fluxes (MW/m2) involved, and the need to make sure that the structural and material properties of the heat exchanger tubes of the receiver do not deteriorate. A novel concept using a loop thermosiphon (https://www.1-act.com/products/loop-thermosyphon/) has been proposed as an alternative to the conventional design. In the loop thermosyphon a working fluid evaporates to carry heat to a heat exchanger surface where is condenses, setting up a loop that can transport heat with no active pumping of the working fluid. The objective of this project is to develop a conceptual design and thermofluids model of a loop thermosyphon based solar receiver, using boiling liquid sodium metal as the working fluid. Students with a more practical inclination build and test a working prototype loop thermosyphon receiver that operates at a lower temperature, and that uses a safer working fluid. Co-supervised with Prof Ryno Laubscher. **Requirements:** CFD experience not required, would be an advantage		✓	✓	
Comparison of electrification of the South African Railroad network to the use of hydrogen fueled locomotives Railroad networks around the world have moved to electrification to eliminate greenhouse gas emissions. However, electrification of the networks involves the installation and maintenance of large systems of electric power distribution systems with the associated risk of restrictions on usage from vandalism or natural events. Traditionally, for many areas, the choice has been the usage of diesel fuelled locomotives over some or all the system. The South African rail system has challenges unique to this country. The limits of an economically justifiable electrified system should be investigated, and the economic analysis of hydrogen fuelled locomotives quantified. The use of hydrogen fuelled locomotives will require an entirely new infrastructure for production, storage, and distribution of the fuel. This fuel supply must be considered in the choice to use hydrogen fuel. As the development of this application proceeds, this supply question could determine its economic value to the user and to the transition to a sustainable energy system. Co-supervised with Dr Steve Clark. **Requirements:** none		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Exploitation of excess renewable generation Solar and wind generation are well known to be variable and dependent on weather rather than demand. Major usage of these resources requires overbuilding of the system to account for times when they do not meet the demand. The focus in designing these systems has been in meeting the times when they fail to meet the demand. Little effort has been expended in finding viable uses for the excess power that will be generated from these systems. Systems around the world are already faced with times where excess generation must be handled, leading to curtailment or negative prices. This situation will grow as the transition continues. Modelling indicates that this excess production could be over 30% of the overall energy generated with a system having generation completely from wind and solar resources, which in South Africa would be over 100 TWh of available energy annually. Any use of this excess energy must have the flexibility to use the energy when it is available with daily and seasonal variation. With little research and development in this area, there is a very large scope for innovation and open thinking in identifying and developing opportunities. Co-supervised with Dr Steve Clark. **Requirements:** none	✓	✓		

Prof Josua Meyer
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- **Research Field**
  Heat transfer
- **General Description of Research Field**
  Heat transfer conveys energy from a high temperature to a lower temperature. The mechanisms of heat transfer are defined as conduction, radiation and convective. In convective heat transfer the heat transfer might be external forced convection, internal forced convection, or natural convection. Heat transfer has many applications and happens everywhere.

  The human body is constantly generating and/or rejecting heat by metabolic processes and exchanged with the environment and among internal organs by conduction, convection, evaporation, and radiation. Heat transfer is also one of the most important factors to consider when designing household appliances such as a heating and air-conditioning system, refrigerator, freezer, water heater, personal computer, mobile phone, TV, etc.

  Heat transfer also occurs in many other applications such as in car radiators, solar collectors, orbiting satellites, etc. However, one of the most important applications is in the generation of electricity which can happen in fossil fuel power plants, nuclear power plants or concentrating solar plants. The heat transfer during the generation of electricity happens in heat exchangers which normally has at least one passage through which a fluid flows. The passage geometry can be as simple such as a circular tube or it can have a very complex geometry with fins that not only enhances the heat transfer but induces flow rotation which reduces the size of the heat exchanger.

  For all these configurations empirical correlations are required for design and analyses purposes that can be used to estimate heat transfer rates. To develop thousands of empirical equations are not desirable as we first need to have a better understanding of the fundamentals and flow phenomena. Furthermore, different flow regimes (laminar, transitional or turbulent) normally each require its own empirical equations. Thus, to be able to understand complex heat transfer flow phenomena in complex geometries we must first understand what happens in simple geometries, such as in circular tubes.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Developing flow in smooth circular horizontal tubes with a uniform wall temperature; forced and mixed convection. Relevant to concentrated solar power (CSP) generation and heat transfer in blood vessels through human organs. A lot of work has been conducted in the field of heat transfer in circular tubes. Most of this work was limited to forced convection flow through horizontal tubes, and with fully developed flow. Thus implying that the flow was both hydrodynamically and thermally fully developed. However, forced convection occurs very rarely in practical applications. It only occurs for heat transfer in small tube diameters, low heat fluxes and for flow in zero gravity conditions. Therefore, if the heat transfer condition does not satisfy forced convection conditions the heat transfer phenomena would definitely and most probably result in mixed convection. However, no work has been done for mixed convection with a uniform wall temperature during developing conditions. The purpose of this study would therefore be to numerically investigate and compare with CFD in a circular tube developing flow for forced and mixed convection with a uniform wall temperature. **Requirements:** CFD		✓	✓	✓
Local and average heat transfer coefficients for developing single-phase laminar flow in horizontal circular tubes with a constant heat flux boundary condition. Wide range of Prandtl numbers. Relevance: concentrated solar power (CSP) generation and heat transfer in blood vessels through human organs. Correlations to calculate the local and average heat transfer coefficients for single-phase laminar flow in horizontal circular tubes with a constant heat flux are usually restricted to fully developed flow, high Prandtl numbers or constant fluid properties. Recently work has been conducted with water (see URL: 10.1016/j.ijheatmasstransfer.2017.10.070). The purpose of this study is to conduct a similar study, however, using CFD, and as working fluids air and glycol. The reason for air and glycol is that its Prandtl numbers are about an order of magnitude lower and higher than that of water. The equations that were developed in the previous study for water can therefore not be used for a wide range of Prandtl number applications. **Requirements:** CFD		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Local and average heat transfer coefficients for developing single-phase laminar gas and glycol flow in horizontal circular tubes with a uniform temperature boundary condition. Relevant to concentrated solar power (CSP) generation and heat transfer in blood vessels through human organs. Correlations to calculate the local and average heat transfer coefficients for single-phase laminar flow in horizontal circular tubes with a uniform heat flux are usually restricted to fully developed flow, high Prandtl numbers or constant fluid properties. Recently work has been conducted with water (see URL: 10.1016/j.ijheatmasstransfer.2017.10.070). The purpose of this study is to conduct a similar study, however, using CFD, with air and glycol as working fluid. The reason for air and glycol is that its Prandtl numbers are about an order of magnitude lower and higher than that of water. The equations that were developed in the previous study for water can therefore not be used for a wide range of Prandtl number applications and were also developed for a constant heat flux boundary condition – not a uniform wall temperature. In this study a uniform heat flux needs to be used. **Requirements:** CFD		✓	✓	✓
Local and average heat transfer coefficients for developing single-phase laminar gas and glycol flow in horizontal circular tubes with a uniform heat flux boundary condition. Relevant to concentrated solar power (CSP) generation and heat transfer in blood vessels through human organs. Correlations to calculate the local and average heat transfer coefficients for single-phase laminar flow in horizontal circular tubes with a constant heat flux are usually restricted to fully developed flow, high Prandtl numbers or constant fluid properties. Recently work has been conducted with water (see URL: 10.1016/j.ijheatmasstransfer.2017.10.070). The purpose of this study is to conduct a similar study, however, using CFD, with and air and glycol as working fluid. The reason for air and glycol is that its Prandtl numbers are about an order of magnitude lower and higher than that of water. The equations that were developed in the previous study for water can therefore not be used for a wide range of Prandtl number applications and were also developed for a constant heat flux boundary condition – not a uniform wall temperature. In this study a uniform heat flux needs to be used. **Requirements:** CFD		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Effect of surface roughness on internal laminar flow The effect of surface roughness on laminar, internal forced convection flows is often neglected. Experimental work indicated that surface roughness may augment heat transfer and influence the onset of transition. However, creating and measuring surface roughness inside small bore tubes is experimentally challenging. An alternative is to explore this phenomenon numerically. It is expected that the student study the effect of surface roughness on laminar flows numerically, and compare the results with experimental work by Prof. Josua Meyer and his group at the University of Pretoria. Results should be presented over a wide range of laminar flows; a typical Nusselt number vs Reynolds number plot for different surface roughnesses is required, similar to the Moody Chart but limited to the laminar regime. Sound skills in Heat Transfer and Fluid Mechanics is required, and students should benefit from taking these modules as part of their coursework. Prof Jaap Hoffmann will co-supervise the project. Prof Josua Meyer is currently with Stellenbosch University. **Requirements:** Numerical Fluid Dynamics, Advanced Heat Transfer, Advanced Fluid Mechanics		✓		

Dr Melody Neaves

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- **Research Field**
  Materials Engineering
- **General Description of Research Field**
  Materials Engineering looks at material characterisation of new or rare materials using novel experimental techniques (such as small sample testing, or optical strain measurement techniques). It also involves the study of additively manufacturing alloys with the main focus being on Ti6Al4V and nickel superalloys produced through laser powder bed fusion processes. I also follow the chain of processing for materials including heat treatments, printing process parameter selection, powder characterisation methods. Power station piping research looks at studying damage of ex-service steel piping material subjected to creep at high temperatures and pressures.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Dealing with noisy data in digital image correlation (DIC) Digital Image Correlation (DIC) is a popular non-contact, optical technique for measuring full field displacement data of a specimen under load. With the displacement data available, the corresponding strain data can be calculated. DIC thus provides a convenient way of obtaining full field strain data, as compared to a strain gauge that only provides strain data at the point where the strain gauge is applied. DIC can be performed in 2D using a single camera or in 3D using more than one camera. This research will focus on some of the errors (or noise) that one encounters when working with DIC data. Specifically the noisy displacement data that must be differentiated to obtain the strain data. Numerical differentiation of the noisy displacement data amplifies the noise, which results in strain data of lower quality as compared to the displacement data. This research will investigate, implement and validate (both numerically and with real experiments) different techniques for dealing with the inherent noisy nature of the displacement data. This research will be co-supervised by Dr Melody Neaves. **Requirements:** Familiarity with Python programming or at the very least a willingness to learn Python programming.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Additive manufacturing of nickel based superalloys for aerospace applications Additive manufacturing is a disruptive technology revolutionising the manner in which industries are approaching complex designs. South Africa has gained tremendous traction on the research front of additively manufactured titanium alloys. Research is still required for printing with more specialised nickel superalloys for the aerospace industry. This topic focuses on identifying the optimal parameters for printing high density nickel superalloy parts using laser powder bed fusion. Defect-free printed parts are essential for aerospace applications. Post-processing methods and property measurements are also necessary for full qualification of these printed materials. **Requirements:** Good materials science background understanding and MATLAB coding skills for analysing large and different data sets.		✓		

Dr Brendon Nickerson
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- **Research Field**
  Vibration, modal analysis, data analytics, inverse problems
- **General Description of Research Field**
  The SA Agulhas II is a polar supply and research vessel, which has been scientifically instrumented for full-scale engineering measurements. Included in these measurements are propulsion shaft torque (strain) and vibration. For this ship, we are particularly interested in the propeller loading for the purposes of condition monitoring and operational insight.

  Ideally, the loads on the propeller blades would be determined through direct measurements made on the blades. However, direct measurements are not always feasible due to the risk of sensor damage and the difficulty of installation. The torque and thrust loads experienced by the propulsion shaft are therefore used to estimate the propeller loading through an inverse problem.

  There exists potential for the further development and implementation of inverse models for the estimation of propeller loads. This includes, but is not limited to: 1. Further increases in efficiency of various models 2. Further development/refinement of models 3. Integration of models into operational decision making on board vessels

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of inverse models for the estimation of propeller loads Topic includes further research and development into existing inverse models for the estimation of propeller loads. This will be supported through full-scale measurements on board the SA Agulhas II. Historical data is available, with the potential for further data capture during upcoming voyages. **Requirements:** Students should have a general interest in conducting engineering measurements, working with large datasets, and numerical modelling. Background in vibration theory is beneficial for the understanding of existing inverse models.		✓		

Dr Michael Owen
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- **Research Field**
  Heat transfer, thermodynamics, fluid mechanics
- **General Description of Research Field**
  Overall my research aims to contribute to sustainable production, use and manipulation of thermal energy. I make use of a combination of experimental, numerical (typically by means of CFD) and analytical methods to investigate thermodynamic cycles, thermal energy systems and components at a number of levels including high level feasibility analysis, system testing and analysis and component-level testing and simulation. There is a strong focus on industrial heat exchangers and cooling towers in particular (dry, wet and hybrid), as these systems directly affect thermal power plant efficiency (fossil-fuelled, nuclear and renewable) and have a direct influence on the energy/water nexus.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigation of module temperatures in floating solar photovoltaic arrays Floating solar photovoltaic (PV) power systems are being implemented as a means to generate power in a more efficient way. They have received attention internationally at large scale and have the potential to be implemented at multiple scales (e.g. on agricultural dams in South Africa). Installing PV arrays on still water bodies results in reduced module temperatures and associated increases in solar-to-electricity efficiency. Additional advantages include avoiding the need to utilize expensive land area and reducing water evaporation. PV power simulation software requires the input of heat dissipation factors to predict module temperatures and efficiencies during design and analysis simulations. These factors are typically only available for terrestrial open-rack configurations. Little research is available on what these factors are for floating applications. The purpose of the study will be to use a combination of experimental and numerical methods to model and quantify the thermal behaviour of a floating solar PV system. This will allow for specific heat dissipation factors to be derived which will support the accurate design and simulation of floating solar PV systems. This project will be co-supervised by myself, Dr Hannes Pretorius (M&M) and Dr Arnold Rix (E&E). (Note: this project has been allocated to a student for 2023.) **Requirements:** Students will benefit from a strong understanding of heat transfer and fluid dynamics fundamentals at undergraduate level. This topic will include both experimental and numerical work and may require use of CFD.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Uniformity index as a universal air-cooled condenser fan performance metric Mechanical draft direct dry cooling systems (typically referred to as air-cooled condensers or ACCs) are widely employed in thermal power plants where they offer considerable water savings relative to evaporative cooling towers. ACCs employ an array of axial flow fans whose operation is sensitive to distorted inflow conditions caused by ambient wind. CFD simulations are frequently used to interrogate wind effects on ACC fans but their accuracy is often questioned due to limitations in the implicit fan models. A recent CFD study identified a strong correlation between the uniformity of the flow at the fan inlet and the fan volumetric performance and dynamic blade loading (as expected), both important fan performance metrics. The form of this correlation has subsequently been verified through inspection of on-site measurements taken at an operating ACC fan. This study will attempt to enhance our understanding and better quantify the relationship between fan inlet flow uniformity (quantified by means of a uniformity index) and the two fan performance metrics of interest using laboratory scale experiments. A secondary objective is to interrogate whether the prediction of uniformity index in CFD is sensitive to the type of fan model used. With the combination of this information we hope to determine if CFD based ACC wind effect analysis can be uncoupled from the fan model such that accurate and reliable results can be generated at reduced computational cost. **Requirements:** Experience with CFD and experimental work is recommended.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Solar-aided power generation in the South African context: "greening" our coal South Africa's energy supply is highly dependent on its fleet of coal-fired power plants, with over eighty percent of electricity demand being met with this fossil-fuel energy source. Considering that we will remain dependant on our coal power plants for several decades, the question arises as to how we can reduce the environmental footprint of our coal power or leverage the infrastructure at our coal stations to bring renewable energy online quickly and at lower cost? Solar-aided power generation (SAPG) is a hybridized approach in which solar thermal energy is incorporated into existing thermal power plants to improve the overall performance of the plant. Studies have considered using solar thermal heat for feedwater heating in coal-fired (Rankine cycle) plants to reduce the extraction of steam from the turbines for this purpose. In this way, the efficiency benefits of feedwater heating are realized while the steam flow through the turbines remains higher and thus (a) the turbine power output is greater for the same fuel consumption; or (b) the same power output can be achieved with lower fuel consumption. At the same time, the solar thermal energy is effectively converted to electricity but via the higher thermal efficiency of the coal-fired plant and at lower cost since it uses the existing power block and transmission infrastructure. Previous work on this topic at Stellenbosch University identified SAPG as an attractive option for the South African context. The work was however based on several simplifying assumptions and more work is required to better understand the techno-economic feasibility of this concept. This study aims to develop a more detailed thermodynamic model capable of simulating the performance of a SAPG plant under varying operating conditions (e.g. varying solar resource, ambient conditions and part load operation) and incorporating thermal energy storage. The study aims to answer the question of whether SAPG can and should be considered in South Africa. The project will be co-supervised by myself and Prof. Ryno Laubscher. **Requirements:** A strong grounding in fundamental heat transfer and thermodynamics at undergraduate level is required.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Natural draft direct dry cooling tower steam-side analysis In the context of thermo-electric power generation (including fossil fuel, nuclear and renewable energy systems such as solar- or geothermal), natural draft (ND) direct dry cooling systems or air-cooled condensers (ACCs) combine the water saving advantages of direct steam condensing with mechanical draft ACCs with the benefits of low auxiliary power consumption (elimination of fans) and insensitivity to wind. They also offer potential cost benefits over natural draft indirect dry cooling systems since they eliminate the need for a separate surface condenser. Very little research has been conducted on this promising technology and this project forms part of a wider study aimed at characterizing the thermo-flow performance of NDACCs under steady and transient operating conditions, and under favourable and adverse weather conditions at various application scales. Specifically, this project will investigate the steam flow in the NDACC under steady operating conditions using a combination of one-dimensional analytical and three-dimensional numerical (CFD) approaches. The project aims to identify appropriate steam supply duct and heat exchanger configurations to provide uniform steam distribution and reduce the risk of non-condensable gas accumulation in the system. This project will be co-supervised by myself and Dr. Hannes Pretorius who is driving the overall NDACC study. (Note: this project has been allocated to a student for 2023.) **Requirements:** This project relies heavily on CFD and successful completion of an undergraduate CFD course is required.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Finned tube optimization for natural draft direct dry cooling systems In the context of thermo-electric power generation (including fossil fuel, nuclear and renewable energy systems such as solar- or geothermal), natural draft (ND) direct dry cooling systems or air-cooled condensers (ACCs) combine the water saving advantages of direct steam condensing with mechanical draft ACCs with the benefits of low auxiliary power consumption (elimination of fans) and insensitivity to wind. They also offer potential cost benefits over natural draft indirect dry cooling systems since they eliminate the need for a separate surface condenser. Very little research has been conducted on this promising technology and this project forms part of a wider study aimed at characterizing the thermo-flow performance of NDACCs under steady and transient operating conditions, and under favorable and adverse weather conditions at various application scales. NDACCs make use of finned tube heat exchangers borrowed from mechanical draft ACCs. The tubes in these bundles aim to maximize the air side heat transfer coefficient and heat transfer surface area but this comes at the expense of relatively high losses. This study is premised on the hypothesis that existing finned tubes may not be optimal for the NDACC application where the draft (air flow) through the system will be strongly influenced by the air-side losses through the heat exchanger. The study will involve coupling parameterized finned tube performance characteristics (developed using a combination of numerical and experimental approaches) with a one-dimensional NDACC model in order to identify an optimal tube configuration for the given context. **Requirements:** This study requires some background experience with CFD and practical laboratory skills.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Towards flow-accelerated corrosion alleviation by numerical analysis of two-phase steam flow in air-cooled condensers In light of growing global water conservation efforts and a focus on improved sustainability in the energy sector, dry-cooled industrial cooling systems, predominantly Air Cooled Condensers (ACCs), are increasingly being installed. These ACCs are widely used as the cold end for power cycles of conventional, combined cycle, concentrated solar, geothermal and biomass power generation applications. Two-phase flow-accelerated corrosion (FAC) on the steam side of ACCs has been a recognized concern for power plant operators over the past number of decades. These concerns mainly relate to the material loss on thin-walled heat exchanger tube entries and on structural members within the ducting system of the ACCs. Through-wall material losses on tube entries cause air ingress, which leads to steam cycle contamination and ultimately reduces overall ACC and power plant performance. Material loss on structural members results in elevated iron transport and deposition within the steam cycle and thus increases the polishing requirements of the Condensate Polishing Plant (CPP). This project aims to investigate the macro and micro flow structures of two-phase steam flow in ACC ducting and at the heat exchanger tube inlets, with specific focus on how these flows contribute to accelerated corrosion in the ACC. The goal of the investigation is to understand the flow mechanisms and to identify and evaluate potential solutions which could mitigate the effects of FAC while having minimum impact on instantaneous ACC performance. This project will be co-supervised by Dr Hannes Pretorius. **Requirements:** This project relies heavily on CFD and successful completion of an undergraduate CFD course is required.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Liquid extraction for alleviation of flow-accelerated corrosion in air-cooled condensers In light of growing global water conservation efforts and a focus on improved sustainability in the energy sector, dry-cooled industrial cooling systems, predominantly Air Cooled Condensers (ACCs), are increasingly being installed. These ACCs are widely used as the cold end for power cycles of conventional, combined cycle, concentrated solar, geothermal and biomass power generation applications. It has been observed that flow accelerated corrosion (FAC) in ACCs occurs where the initial condensate droplets, entrained in the low pressure (LP) turbine exhaust steam, are transported at high velocities and come into contact with the metal surfaces of structural members / tube inlets. Measurements have shown a significantly greater concentration of impurities within this condensate compared to the steam vapor that does not condense until it travels into the heat exchanger tubes. If successful extraction of the high-impurity condensate in the LP turbine exhaust ducts is possible without a significant ACC performance impact, major reductions in FAC could be achieved. If this is feasible, another benefit could potentially be realized – the opportunity to restrict the polishing of condensate from the condenser mainly to the extracted liquid with high impurity levels, instead of the full ACC condensate flow. This would result in major cost savings in terms of required CPP plant size. This study aims to investigate, by numerical and (potentially) experimental methods, the possibility of extracting liquid in the LP exhaust steam ducts in order to limit the FAC experienced downstream. This project will be co-supervised by Dr Hannes Pretorius. **Requirements:** Students will benefit from a strong understanding of heat transfer and fluid dynamics fundamentals at undergraduate level. This topic will include both experimental and numerical work and will require use of CFD.		✓		
Data centre cooling: a review of technological approaches, implications and opportunities for reduced energy / water footprint Data storage is expanding at an exponential rate and data centers are now consuming energy on the same scale as entire countries. Much of the energy consumption is consumed for the purpose of keeping the electrical equipment in these centers cool. This project will investigate current approaches and technologies applied in data center cooling, determine the energy and water footprint of these technologies and identify (and evaluate) opportunities to reduce the footprint of these systems. **Requirements:** Students will benefit from a strong foundation in heat transfer and thermodynamics.	✓	✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Athlone Power Station site redevelopment: a green energy hub for Cape Town The Athlone Power Station (APS) site is a 36 ha City-owned property that is located on the N2 freeway between the Cape Town Central Business District and the Cape Town International Airport. APS was a coal-fired power station (commissioned in 1962 and permanently terminated in 2003) and the site has recently been flagged for redevelopment into an innovative green energy utility site. Through the use of the APS site as a green energy utility and infrastructure site, the City of Cape Town intends to support economic growth and the provision of quality basic services. The site must contribute towards a cleaner, more affordable and reliable energy system that also responds to various interconnected social, environmental, and developmental priorities, for example, skills development, job creation and energy access. This project aims to investigate possible socio-technical innovations that demonstrate how different energy and industrial technologies can be combined to best meet these objectives. Attention may be given to the following points (amongst others): - Identifying which technologies best serve the primary energy targets of the development (120 MWe dispatchable generation); - Scoping various social, economic, environmental and developmental priorities from surrounding communities and the wider City of Cape Town to inform appropriate socio-technical options; - Identifying opportunities for alternative energy sources and technologies on site and how they can be integrated into local value chains to make a meaningful impact; - Evaluating how the site can be used to further promote and support green energy generation in and around Cape Town; - Conceptualizing how the site and technologies should be configured with concerns about visual, noise and air pollution in mind; - Evaluating how existing and legacy infrastructure (rail, road, waste, water, power evacuation, buildings) at the site can be utilised as part of an appropriate technical solution. This project will be co-supervised by myself and Dr Megan Davies from the Centre for Sustainability Transitions. **Requirements:** A sound understanding of energy systems and a willingness to tackle a multidisciplinary project is required.	✓	✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigating aeration for temperature control in silo storage of Rooibos tea Vertical silos are widely used for bulk storage of agricultural produce because they offer a high volume to footprint ratio. One of South Africa's largest Rooibos tea suppliers recently started using vertical silos (instead of stacked bags), a first in the Rooibos industry, but have experienced high temperatures in the silos that pose a significant product loss and safety risk. Aeration (forcing air through stored product) is widely used for temperature control in silo storage but requires an understanding of the thermal and hydraulic characteristics of the product for proper design. No such information exists for Rooibos tea and the nature of the tea differs significantly from typical products stored in silos (e.g. grains or pellets). The aims of this project are to (a) determine the hydraulic characteristics of bulk-stored Rooibos tea, and (b) use these to investigate aeration concepts using numerical simulation. This project will therefore offer the opportunity to engage in laboratory and on-site experimentation and simulation in the context of a local agricultural problem. The project will be co-supervised by myself, Prof. Corne Coetzee and/or Prof Jaap Hoffman. **Requirements:** N/A		✓		✓

Prof Willie Perold

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- **Research Field**
  Biosensors
- **General Description of Research Field**
  The Sensor Applications & Nano-Devices (SAND) research group focusses on the development of sensing devices applicable to human disease (cancer, HIV, TB, Covid, etc.), plant disease, animal disease and water and soil pollution. The sensors are fabricated in the nanotechnology-laboratory at Electrical & Electronic Engineering. The research is multidisciplinary by nature.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development and evaluation of a surface plasmon resonance device for biomarker detection Surface plasmon resonance (SPR) has been used extensively as a method of biosensor and biomarker evaluation. SPR is at the interface of optics and electromagnetics, where light is used to excite a metal layer at the interface of two dielectric materials. The result is a highly sensitive method of measuring small changes in dielectric constant at or near the dielectric-metal-dielectric interface. This project would require a student to first evaluate an existing SPR device, before continuing to develop their own as a biosensing platform. **Requirements:** Nano-fabrication Optics		✓		
Development of a membrane-based digital LAMP device Nucleic acid amplification techniques and assays based on them have revolutionised the fields of biotechnology, immunology, and pathology, to name but a few. The current standard, qPCR, is well-suited to lab-based implementations, but is difficult to perform otherwise due to the complexity of temperature control necessary for such a device. Isothermal amplification techniques, such as LAMP, are poised to change this, although several significant hurdles are still to be overcome before that can happen. One of these is the qualitative nature of LAMP, which can be overcome by converting the assay to a digital format. The membrane-based dLAMP assay has recently been proved to be a viable candidate for this role, whereby the LAMP reaction is performed in the micropores of commercial filter membranes instead of microfabricated reaction volumes. This project would require a student to design, build and test a device that integrates most of the processing steps necessary to perform and evaluate a digital LAMP assay. **Requirements:** Nano-fabrication Biochemistry/Microbiology		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of an automated immuno-PCR device The standard immunological test for biomarkers is the Enzyme-linked Immunosorbent Assay (ELISA), through which a colour change directly proportional to the concentration of a target analyte present in a sample is measured by a device to determine the concentration of that analyte. The development of the ELISA assay revolutionised the world of immunology, and made all of the analytical tests we know today possible. The next step in the evolution of the ELISA assay is to, instead of using a colour-changing enzyme to present a result, rather use fluorescent nucleotide tags that can be amplified through thermal cycling in the same manner as a PCR test, and have been shown to increase the sensitivity of such a test by up to 1000x. This project would require a student to develop a device with which to perform an automated immune-PCR assay and evaluate the feasibility of using such an assay as a point-of-care test. **Requirements:** Nano-fabrication Biochemistry/Microbiology		✓		

Dr Hannes Pretorius

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- **Research Field**
  Thermofluids & Solar Energy
- **General Description of Research Field**
  Dry cooling systems for power generation applications; Axial flow fan performance; Heat transfer analysis from PV panels; Floating solar PV power generation; Thermo-economic evaluation on CSP / PV power plants

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigation of module temperatures in floating solar photovoltaic arrays Floating solar photovoltaic (PV) power systems are being implemented as a means to generate power in a more efficient way. They have received attention internationally at large scale and have the potential to be implemented at multiple scales (e.g. on agricultural dams in South Africa). Installing PV arrays on still water bodies results in reduced module temperatures and associated increases in solar-to-electricity efficiency. Additional advantages include avoiding the need to utilize expensive land area and reducing water evaporation. PV power simulation software requires the input of heat dissipation factors to predict module temperatures and efficiencies during design and analysis simulations. These factors are typically only available for terrestrial open-rack configurations. Little research is available on what these factors are for floating applications. The purpose of the study will be to use a combination of experimental and numerical methods to model and quantify the thermal behaviour of a floating solar PV system. This will allow for specific heat dissipation factors to be derived which will support the accurate design and simulation of floating solar PV systems. This project will be co-supervised by myself, Dr Mike Owen (M&M) and Dr Arnold Rix (E&E). (Note: this project has been allocated to a student for 2023.) **Requirements:** Students will benefit from a strong understanding of heat transfer and fluid dynamics fundamentals at undergraduate level. This topic will include both experimental and numerical work and may require use of CFD.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Towards flow-accelerated corrosion alleviation by numerical analysis of two-phase steam flow in air-cooled condensers In light of growing global water conservation efforts and a focus on improved sustainability in the energy sector, dry-cooled industrial cooling systems, predominantly Air Cooled Condensers (ACCs), are increasingly being installed. These ACCs are widely used as the cold end for power cycles of conventional, combined cycle, concentrated solar, geothermal and biomass power generation applications. Two-phase flow-accelerated corrosion (FAC) on the steam side of ACCs has been a recognized concern for power plant operators over the past number of decades. These concerns mainly relate to the material loss on thin-walled heat exchanger tube entries and on structural members within the ducting system of the ACCs. Through-wall material losses on tube entries cause air ingress, which leads to steam cycle contamination and ultimately reduces overall ACC and power plant performance. Material loss on structural members results in elevated iron transport and deposition within the steam cycle and thus increases the polishing requirements of the Condensate Polishing Plant (CPP). This project aims to investigate the macro and micro flow structures of two-phase steam flow in ACC ducting and at the heat exchanger tube inlets, with specific focus on how these flows contribute to accelerated corrosion in the ACC. The goal of the investigation is to understand the flow mechanisms and to identify and evaluate potential solutions which could alleviate / mitigate the effects of FAC while having minimum impact on instantaneous ACC performance. This project will be co-supervised by Dr Mike Owen. **Requirements:** This project relies heavily on CFD and successful completion of an undergraduate CFD course is required.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Natural draft direct dry cooling tower steam-side analysis In the context of thermo-electric power generation (including fossil fuel, nuclear and renewable energy systems such as solar- or geothermal), natural draft (ND) direct dry cooling systems or air-cooled condensers (ACCs) combine the water saving advantages of direct steam condensing with mechanical draft ACCs with the benefits of low auxiliary power consumption (elimination of fans) and insensitivity to wind. They also offer potential cost benefits over natural draft indirect dry cooling systems since they eliminate the need for a separate surface condenser. Very little research has been conducted on this promising technology and this project forms part of a wider study aimed at characterizing the thermo-flow performance of NDACCs under steady and transient operating conditions, and under favourable and adverse weather conditions at various application scales. Specifically, this project will investigate the steam flow in the NDACC under steady operating conditions using a combination of one-dimensional analytical and three-dimensional numerical (CFD) approaches. The project aims to identify appropriate steam supply duct and heat exchanger configurations to provide uniform steam distribution and reduce the risk of non-condensable gas accumulation in the system. This project will be co-supervised by myself and Dr. Mike Owen. (Note: this project has been allocated to a student for 2023.) **Requirements:** This project relies heavily on CFD and successful completion of an undergraduate CFD course is required.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Liquid extraction for alleviation of flow-accelerated corrosion in air-cooled condensers In light of growing global water conservation efforts and a focus on improved sustainability in the energy sector, dry-cooled industrial cooling systems, predominantly Air Cooled Condensers (ACCs), are increasingly being installed. These ACCs are widely used as the cold end for power cycles of conventional, combined cycle, concentrated solar, geothermal and biomass power generation applications. It has been observed that FAC in ACCs occurs where the initial condensate droplets, entrained in the low pressure (LP) turbine exhaust steam, are transported at high velocities and come into contact with the metal surfaces of structural members / tube inlets. Measurements have shown a significantly greater concentration of impurities within this condensate compared to the steam vapor that does not condense until it travels into the heat exchanger tubes. If successful extraction of the high-impurity condensate in the LP turbine exhaust ducts is possible without a significant ACC performance impact, major reductions in FAC within the ACC could be achieved. If this is feasible, another benefit could potentially be realized – the opportunity to restrict the polishing of condensate from the condenser mainly to the extracted liquid with high impurity levels, instead of the full ACC condensate flow. This would result in major cost savings in terms of required CPP plant size. This study aims to investigate, by numerical and (potentially) experimental methods, the possibility of extracting liquid in the LP exhaust steam ducts in order to limit the FAC experienced downstream. This project will be co-supervised by Dr Mike Owen. **Requirements:** Students will benefit from a strong understanding of heat transfer and fluid dynamics fundamentals at undergraduate level. This topic will include both experimental and numerical work and will require use of CFD.		✓		

Dr Willie Smit
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- **Research Field**
  Robotics and Control in Concentrated Solar Power Plants
- **General Description of Research Field**
  The Solar Thermal Energy Research Group (STERG) is researching environmentally friendly and sustainable solar thermal technologies. In particular, we are looking at concentrated solar power (CSP) plants. We think that multi-copters and ground-based robots can provide services to plant operators.

  Here is a good video that gives an overview of the state-of-the-art CSP plant: https://youtu.be/QW42wBthN2A

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A novel heliostat facet design A heliostat is a facet (mirror) placed on a pedestal. The facet is controlled so that it reflects and concentrates solar rays onto a target that can be hundreds of meters away. A master's student has done a lot of theoretical work on a novel heliostat facet design. The preliminary results are promising. This project aims to design a heliostat facet for mass production. The design should then be built and tested. **Requirements:** None.		✓		
The control of a novel quadcopter configuration for long flight times A master's student designed and built a drone with a novel configuration. The new quadcopter can fly for more than an hour. The dynamics of the quadcopter have not been fully analysed. As a result, the control system is not as stable and robust as one would like. This research topic aims to analyse the dynamics of the quadcopter and to implement and test a better control system for it. The main tasks of the project will be to: - Model the quadcopter in Simscape - Develop a controller in Simscape - Implement the controller on the Pixhawk autopilot - Test the performance of the physical drone **Requirements:** Good programming skills.		✓		
Locating a drone close to a parabolic trough Parabolic troughs concentrate solar rays onto a central tube. The tube contains oil that heats up to close to 400 'C. The heated oil is used to generate steam which powers a turbine. The mirrors need to be cleaned every few days. It should be easy for a drone to automatically clean the mirrors. This project aims to develop a system with which the drone can accurately locate itself inside the parabolic trough. The system might use ultrasonic sensors, cameras, laser range finders and so on.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Good programming skills.				

Prof Gerhard Venter

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- **Research Field**
  Computational (structural) mechanics with focus on structural analysis and numerical design optimization and related technologies
- **General Description of Research Field**
  My research typically deals with complex finite element analyses combined with structural and/or multi-disciplinary optimization. These techniques are applied to a wide range of interesting topics, typically driven by and in collaboration with an industry partner. Currently my group does some work in load recovery of real world forces on complex structures, material characterization using inverse modelling, optimum design and investigation into the fatigue life of welded and bolted connections in high strength steels.

  Most of my research projects have some finite element, some meta-modelling (machine learning) and some optimization components associated with it. The vast majority of the topics requires programming, typically in Python. An interest in these fields, or at least a willingness to learn, is thus a requirement for potential students.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Material characterization of viscous, hyper-elastic materials The MOD research group has a strong background in characterizing hyper-elastic material models using an inverse finite element (FE) updating method. These models are typically used to model rubber or rubber-like materials. Past work concentrated on hyper-elastic material models that does not include the viscous nature of the material. The resulting material models are of value for static simulations, but has limitations when considering dynamic modelling. This project will be performed in conjunction with an industry partner with specific focus on rubber isolators used in engine mounts. Other applications are in the the mining industry where vibrating screens are extensively used. This work will focus exclusively on the material characterization of rubber like materials. Machine learning and numerical modelling and optimization will be used to obtain the appropriate material parameters from experimental data. The experiments will involve the design and creation of test specimens, force measurement and full field displacement measurements using digital image correlation. The numerical modelling will involve non-linear finite element analysis. The student will also have to design and build a validation test. The project is funded from industry with a full bursary. The student will work with the industry partner's engineers and will most probably spend some time at the industry partner to get up to speed with the modelling techniques that they currently use. **Requirements:** A general interest in structural analysis (FE analysis), optimization and Python programming.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Dealing with noisy data in digital image correlation (DIC) Digital Image Correlation (DIC) is a popular non-contact, computer vision technique for measuring full field displacement data of a specimen under load. With the displacement data available, the corresponding strain data can be calculated. DIC thus provides a convenient way of obtaining full field strain data, as compared to a strain gauge that only provides strain data at the point where the strain gauge is applied. DIC can be performed in 2D using a single camera or in 3D using more than one camera. This research will focus on some of the errors (or noise) that one encounters when working with DIC data. Specifically the noisy displacement data that must be differentiated to obtain the strain data. Numerical differentiation of the noisy displacement data amplifies the noise, which results in strain data of lower quality as compared to the displacement data. This research will investigate, implement and validate (both numerically and with real experiments) different techniques for dealing with the inherent noisy nature of the displacement data. This research will be co-supervised by Dr Melody Neaves. **Requirements:** Familiarity with Python programming or at the very least a willingness to learn Python programming.		✓		✓
CFD Analysis and Optimization of a Truck Body One of the key strategic goals in the truck manufacturing industry today is to reduce emissions. One way of doing this is to improve the aerodynamic performance of the truck. This topic will be completed in conjunction with an industry partner. The goal is to make use of CFD analysis and optimization to improve the aerodynamic performance of a new truck design. The project is open ended in the sense that any modifications to the current design that will improve the aerodynamic performance can be considered. However, all modifications have to satisfy a number of constraints, for example the interior space requirements for the cab, the engine compartment, etc. Modifications will thus be limited to the truck body only. The student will be using CFD and numerical design optimization extensively. The project is funded with a full bursary and will be co-supervised by Prof Johan van der Spuy. The student will be exposed to interaction with the industry partner's engineers and would most probably spend some time at the engineering company to get up to speed with their current design procedures. **Requirements:** CFD		✓		✓

Prof Martin Venter

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- **Research Field**
  Generative Design, Machine Learning, Material Modelling, Soft Robots and Inflatables
- **General Description of Research Field**
  I am interested in computational methods as part of the design process. This allows us to share the burden of making design decisions that can become complex, like biologically inspired artificial creatures and inflatable structures. Over the past few years, I have been exploring the potential applications of compliant and selectively reinforced materials in the fields of pressure-rigidised structures and soft robotics. In addition, our research group is interested in combining powerful non-linear simulation tools, such as finite element methods, with the ever more important field of machine learning in a modern generative design approach.

  This is a multidisciplinary field taking elements from several computational fields. Researchers in this area will develop non-linear finite element methods, numerical design optimisation, programming and machine learning skills. Much of what we do requires insightful experiment planning in tandem with advanced tools to deal with large volumes of data. This new field is open to exploration, which can be both challenging and rewarding.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Silicone elastomer testing methods and simulation Silicone elastomer, in its various forms, is the material of choice for the construction of soft robots. This material is easy to cast into complex shapes and is exceptionally compliant. However, previous research shows that simulated soft robots' stress and deformation results are susceptible to minor changes in the material model parameters. In most applications, soft robots undergo large deformations with large strains. It is therefore critical to ensure that the material model chosen performs well over the entire strain range. Research Questions: 1. Which material models can capture the mechanical behaviour of silicone elastomers subjected to high strains? 2. What test methods are suitable for are compatible with these material models, and how sensitive is the fitting process to small perturbations in the test data? 3. How should a researcher account for the uncertainty resulting from the geometric and model fitting sensitivity? **Requirements:** Must have completed intro to FEM within first six months. Must enjoy programming.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design pipeline for soft robots At present, the rate at which researchers can evaluate new designs restricts much of the development of soft robots. To assess a design, a full prototype must be fabricated and tested. Although several research groups use numerical simulations of soft robots, the simulations are typically used for design validation or insight. They play no active role in the design process. This research will attempt to create a robust generic workflow for generating and verifying new numerical models to make meaningful progress towards a digital twin for soft robots. Research Questions: 1. What tools are suitable for generating arbitrary soft robot geometries? 2. What processes result in the successful simulation of a soft robot? 3. How can the performance of a generalised simulation of a soft robot be verified? **Requirements:** Must complete FEM by the end of the first six months. Must enjoy programming.		✓		✓
Digital twin for soft robots. A Digital Twin is the coupling of a digital replica and a physical soft robot that allows us to gain insight into the physical system remotely. Using this insight, a user can better control the physical system or propose modifications based on real-world use cases. This tool will make it feasible to incorporate more soft robots into a range of new technology. With greater predictability and responsiveness, innovators will be able to predict more accurately the behaviour of a soft robot in a new environment. Research Questions: 1. How can model complexity be reduced to reduce the computational burden of simulating soft robots? 2. How should the digital and physical soft robots be connected to form a Digital Twin? 3. How can the exploration of the design space be automated? **Requirements:** Student must be familiar with FEM and enjoy programming.			✓	✓

Dr Andie de Villiers

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- **Research Field**
  Computational Mechanics
- **General Description of Research Field**
  This field involves the modelling and simulation of mechanical problems. The field comprises of three parts: modelling, numerical implementation and computational implementation. The appropriate equations and boundary conditions need to be identified/developed to capture the physics of a system. It is often difficult to find analytical solutions for these problems, and numerical methods such as the finite element method is used to solve the equations. These problems can not be solved by hand and should be solved computationally. Depending on the problem at hand commercial software may or may not be useful.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A peridynamic model of skin Skin is a living material. Not only is the material properties anisotropic and incompressible but it is also influenced by the environment and changes over time. Mechanobiology is a multidisciplinary field that study the way that cells and their environment influence each other. Mechanical forces can regulate a wide range of biological activities including cell behaviour and growth. Peridynamics is a non-local continuum mechanics framework originally developed to overcome challenges that classical continuum mechanics encounter when modelling discontinuities, such as cracks, as well as long-range forces. The aim of this project is to develop a peridynamic model to skin and investigate how mechanobiology of the skin can be captured. **Requirements:** Students should have a background in solid mechanics and a love for mathematics and programming.		✓	✓	✓
Peridynamic model of tendons Tendons can be modelled by a visco-elastic material. Injuries to tendons are very common in runners. To capture damage and rupture in biological tissue can be a challenge. Peridynamics is a non-local continuum mechanics framework originally developed to overcome challenges that classical continuum mechanics encounter when modelling discontinuities, such as damage and fracture. The aim of this project is to develop a visco-elstic peridynamic model of a tendon and compare data captured when running (force-plate and motion data). The long-term vision of the bigger project is model tendon injuries. **Requirements:** Students should have some background in mechanics and an interest in mathematics and programming.	✓	✓	✓	

Dr Johan van der Merwe

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- **Research Field**
  Endoprosthesis design and biostatistical modelling
- **General Description of Research Field**
  In South Africa patients often present for medical care with severe musculoskeletal trauma and disease due to the high prevalence of personal violence, road traffic accidents, and insufficient early treatment. In such cases conventional orthopaedic treatment options may not be viable and instead the use of customized implants, instruments, surgical guides, navigation, or pre-operative planning tools may be required. However, developing patient-specific solutions is a multidisciplinary and iterative process that requires extensive and time-consuming effort on the part of various stakeholders. This leads to increased expense and delays in treatment within an already resource constrained healthcare system.

  Therefore, this research focuses on creating methods, techniques, and tools to automate and integrate the development of patient-specific implant solutions. The aim of this approach is to reduce the associated effort and cost by incorporating unique patient data into population-based models and from there to generate or adapt pre-programmed, customized solutions. In addition, special attention must be paid to the role and interaction of the various human stakeholders as truly robust and practical solutions must incorporate input and feedback from human specialists throughout the process.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Mandible reconstruction using linear and non-linear machine learning methods The purpose of this project is to investigate linear and non-linear machine learning methods for reconstruction of simulated mandible defects according to the Jewer or Brown classification schemes. Linear principal component analysis may be compared to the use of techniques such as variational autoencoders and generative adversarial networks to reconstruct healthy patient geometry from sparse inputs. **Requirements:** Students must have a sound programming ability and sufficient mathematical background for further independent study in machine learning at a postgraduate level.		✓		
Development of a statistical shape model of the shoulder for patient-specific implant generation The purpose of this project is to first identify design parameters required for patient-specific shoulder implant design, and then to construct a statistical shape model with the required information embedded. When presented with a new patient case, the model must be able to provide an estimate of the patient's healthy situation given sparse data. The result will be used to create a patient-matched implant.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Students must have a sound understanding of engineering design, programming ability and sufficient mathematical background for further study in modelling, simulation, and optimization at a postgraduate level.				
Automated generation of patient-specific mandible reconstruction plates The purpose of this project is to develop a method for automatically generating a patient-specific mandible reconstruction plate for simulated defects according to the Jewer or Brown classification schemes. A statistical model of a population's mandible curve will be used to estimate an individual's pre-pathological state from minimal, clinically available inputs such as patient meta-data, cephalometric measurements, and / or sparse misaligned anatomic landmarks. The curve must be adapted to accommodate a specified number of fibular graft segments and will serve as input to a parametric CAD modeler to automatically generate the plate geometry along with other required features such as fixation holes. A systems engineering approach must be followed. **Requirements:** Students must have a sound understanding of engineering design, programming ability and sufficient mathematical background for further study in modelling, simulation, and optimization at a postgraduate level.		✓	✓	
Development of a temporomandibular joint replacement wear simulator standard The purpose of this project is to develop a temporomandibular wear simulator standard for pre-clinical assessment of implant wear. It will require identification of kinetic and kinematic motion profiles most representative of activities of daily living, as well as an assessment of primary implant characteristics and design requirements. General purpose finite element and wear simulation must be performed in LS Dyna, and a single-station concept demonstrator must be designed and built. **Requirements:** Students must be able to program, have a background in finite element analysis, and a sound understanding of statics and dynamics.		✓	✓	
Image-based patient-specific isogeometric analysis of a hip replacement Isogeometric analysis enables the integration of finite element analysis and CAD into one process. The purpose of this project is to implement a method for applying grid based finite element analysis directly on a CT image of a patient's hip containing an implant. The hip implant may be designed in CAD and manually placed on the image volume, or generated procedurally using constructive solid geometry and landmarks placed in the image. Results must be compared against standard mesh-based FEA. **Requirements:** The student must be able to program and have a background in FEA and CAD. This project will require independent self-study and custom implementation of isogeometric code.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design of a femoral hip stem for a local population This project involves studying the shape of the local population's hip through morphometric analyses and statistical shape modelling, to investigate how well commercially available hip implants fit the individuals in question. As a follow up, classification techniques will be used to determine the level of specificity required for implant design, which could range from a single mean shape representing the entire population to fully patient-specific models. A method for designing a hip stem based on the morphometric measurements and shape of the hip must be developed and applied to the representative shapes. **Requirements:** Students must have a sound understanding of engineering design, programming ability and sufficient mathematical background for further study in statistical learning and optimization at a postgraduate level.		✓	✓	
An investigation of shoulder morphology for implant design The purpose of this project is to assess joint morphology relevant to implant design. The work will include, but is not limited to, a review of implant geometry, data collection, image segmentation, definition of landmarks and measurements, morphometric analyses, geometric morphometrics, and statistical shape modelling. **Requirements:** Interested candidates must have a strong foundation in anatomy and statistics. They must have sufficient background in mathematics for further study in statistical learning at a postgraduate level and will be required to learn Matlab programming independently.		✓		

Prof Johan van der Spuy

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- **Research Field**
  Turbomachinery
- **General Description of Research Field**
  1) The use of direct dry-cooling in power generation systems is a means of ensuring sustainable water usage. The efficient, low noise, operation of the axial flow fans that form part of such an air-cooled system is essential for a well-performing system. These research topics (topics 1, 2 and 3) focus on the design, testing and analysis of axial flow fans for these systems. 2) The use of micro gas turbines (MGTs) for the propulsion of aerial vehicles or solar thermal power applications hold specific advantages. The topic is related to the development of a turboshaft micro gas turbine.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Reducing the noise signature of a large diameter axial flow cooling fan. Existing work has focused on the measurement and modelling of the noise emitted by a large diameter cooling fan. This project will now attempt to reduce the noise characteristics of such a fan by altering the blade configuration of the fan, without replacing the fan blades. Modifications must therefore be made in the form of attachments added to the fan blade. The work will involve intensive experimental evaluation, as well as numerical modelling of the flow around the fan blades. **Requirements:** CFD	✓	✓		
The development of a 30 kW turboshaft micro gas turbine. An existing project has developed the methodology for the design of a 30 kW turboshaft micro gas turbine. This project will continue this work by developing an actual gas turbine engine. Once completed, the engine will be tested and its performance verified. **Requirements:** CFD, thermofluids 344		✓		
Measuring the performance of the 24 ft. installed MinwaterCSP axial flow fan. The project will specifically focus on modelling and accurately measuring the performance of the 24 ft MinwaterCSP axial flow fan. Existing work has focused on the measurement and modelling of this fan's performance under stable conditions. The idea is to expand this work in order to monitor the fan's performance under varying atmospheric conditions. These will be correlated to existing CFD models of the fan and expanded to correlate with the effect of variable atmospheric conditions. **Requirements:** CFD		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design and develop a gas generator and impulse turbine for the SAFFIRE Rocket Engine Pumps Collaborative Project with UKZN Aerospace Systems Research Institute UKZN Contact: Prof G Snedden The gas generator will run on LOX and Kerosene and must generate 85kW at between 20000 and 33500 RPM. Provision must be made for material limitations in so far as the available materials and manufacturing techniques in South Africa. Axial thrust imbalance between the pumps amounts to as much as 12kN and this must also be accommodated in the system design. **Requirements:** CFD, turbomachinery		✓		✓
Sudden expansion pressure loss and recovery in fans Collaborative Project with UKZN UKZN Contact: Prof G Snedden In ventilation fans the fan blading sits in an annulus with the hub forming a barrel inside a duct. Once the motor barrel terminates there is effectively a sudden expansion of an annulus into a duct. The frictionless Carnot-Borda assumption is often used to account for losses and the static pressure recovery in this sudden expansion, however Carnot-Borda was intended for small to large pipe sudden expansions and is, as stated, frictionless. The aim of this work is to develop a validated correlation for the losses in fan arrangement. This correlation should account for variation in: • Fan velocity • Duct diameter ratio • Changes in inlet swirl • Changes in hub to tip velocity profile Note: Funding from Industry partners/THRIP to be applied for but not yet assured. **Requirements:** CFD		✓		✓
CFD Analysis and Optimization of a Truck Body One of the key strategic goals in the truck manufacturing industry today is to reduce emissions. One way of doing this is to improve the aerodynamic performance of the truck. This topic will be completed in conjunction with an industry partner. The goal is to make use of CFD analysis and optimization to improve the aerodynamic performance of a new truck design. The project is open ended in the sense that any modifications to the current design that will improve the aerodynamic performance can be considered. However, all modifications have to satisfy a number of constraints, for example the interior space requirements for the cab, the engine compartment, etc. Modifications will thus be limited to the truck body only. The student will be using CFD and numerical design optimization extensively. The project is funded with a full bursary and will be co-supervised by Prof Gerhard Venter. The student will be exposed to interaction with the industry partner's engineers and would most probably spend some time at the engineering company to get up to speed with their current design procedures. **Requirements:** CFD		✓		✓