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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. The research of the Mechatronics, Automation and Design Research Group 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).

  Prof Anton Basson and Dr Nicole Taylor co-supervise students in the Mechatronics, Automation and Design Research Group. Other co-supervisors include Prof Jacomine Grobler (Dept of Industrial Eng), Prof Karel Kruger (Univ of Cambridge, UK), Prof Herman Vermaak (extraordinary professor in M&M department), as well as Ms Santel de Lange and Ms Talita van Schalkwyk (Dept of Nursing and Midwifery, Faculty of Medicine and Health Sciences). More information can be found at https://www.sun.ac.za/mad.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
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. Our research relates to cyber-physical systems (CPSs), the use of the Internet of Things (IoT) and cloud computing services. Our research focusses on the development of Digital Twins (DTs), which are reality-reflecting architectures for CPSs updated in real time. The DTs are used for decision support and analysis. We develop software using the principles of Holonic Systems, Service Orientated Architectures (SOAs) and Microservices. Our DTs apply artificial intelligence (AI) including machine learning (ML) and expert systems. They are used for supporting maintenance, modelling sustainability, makings sense of Big Data, and improving data integrity. Our current industry partners include: BMW, Gibela/Prasa, Mediclinic, Rand Water, PV systems supplier RESEARCH GROUP INFORMATION Prof Basson and Dr Taylor co-supervise students in both research fields, directing the Mechatronics, Automation and Design Research Group (MAD website: https://www.sun.ac.za/mad). Our research group provides a supporting and stimulating environment where all students work with real-world applications. **Requirements:** We welcome students from any engineering background with a strong affinity for developing software for real-world applications.		✓	✓	✓
HUMAN-SYSTEM INTEGRATION (HSI) AND HUMAN CYBER-PHYSICAL SYSTEMS South African (and worldwide) enterprises will continue to rely heavily on people in the midst of Industry 4.0 and the paradigm shift to integrating human skills with advanced technologies in the rise of Industry 5.0. Our research integrates humans into/with CPSs, both as task executors and decision makers. We aim to retain people's exceptional capabilities and overcome their limitations using digital technologies. Our research employs enabling technologies such as collaborative robots, pose sensing, and virtual and augmented reality. Our current industry partners include: Mediclinic, Mandela Mining Precinct, Hortgro (agricultural producers' organisation), Mintek RESEARCH GROUP INFORMATION Prof Basson and Dr Taylor co-supervise students in both research fields, directing the Mechatronics, Automation and Design Research Group (MAD website: https://www.sun.ac.za/mad). Our research group provides a supporting and stimulating environment where all students work with real-world applications. **Requirements:** We welcome students from any engineering background with a strong affinity for developing software for real-world applications.		✓	✓	✓

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
Design and analysis of PV support structurers Cost effective and durable support structures are key to the success of solar photovoltaic power generation. Noval approaches are needed to quantify the loads and resistances associated with fixed-tilt and tracking structures to ensure structural reliability. The research is likely to involve both experimental and simulation work. The topic will be formulated in cooperation with an industry partner to address a specific need. There may be a possibility of funding. **Requirements:** FEM		✓		✓
Design and analysis of glass alternative concentrated solar power reflectors The most common material for reflectors used in the concentrated solar power (CSP) industry is mirrored glass. However, glass has many undesirable properties. The research aims to develop feasible glass alternative reflectors for CSP applications. The project will involve structural design, building of prototypes, and performance testing. Various simulation technologies can also be incorporated in the project. **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
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
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
Improving the structural integrity of cartons used for the export of citrus Agriculture plays a significant role in the global economy with an average contribution of 4% to the GDP across the globe and even reaching contributions up to 25% to the GDP in developing countries (World Bank, 2022). In South Africa it was reported that agriculture contributed R 127 960 million (2.8%) to the national GDP (Statistics SA, 2021; Trading Economics, 2021). De Lange et al. (2015) investigated the impact of food waste on the GDP of South Africa for the year 2013. Their investigation showed that food waste was equal to 2.2% of the national GDP. This is a significant loss and shows that management and reduction of food waste can produce a positive growth in the agriculture sector of South Africa. Oelofse et al. (2021) determined that three main areas of manageable food waste occur. These areas include post-harvesting and storage, processing and manufacturing and distribution. These three areas contribute approximately 74% of food waste produced. The focus of this research project is on the structural integrity of corrugated paperboard cartons (boxes) and stacked pallet stability in the South African citrus industry. Industry experiences box failure which results in damage to the produce and ultimately a loss in food production and income. The existing box designs should be investigated and analysed in terms of box failure and pallet stability. When a box fails, the whole stacked pallet can become unstable and this results in more box failures and even a complete collapse. It is also experienced that stacked pallets become unstable during transportation due to the dynamic load conditions. This study should analyse the existing problems using laboratory and field experiments, and propose and analyse possible solutions. The department has a large testing facility where a complete stacked pallet can be laterally accelerated and the stability and loads acting on the boxes measured. Various other facilities such as box compression testing are also available, and this is a continuation of previous projects. The majority of the work would be experimental and hands-on, however, there is also the opportunity for numerical analysis using the Finite Element Method and/or the Discrete Element Method. This project is ideal for a student interested in agricultural engineering and experimental testing and measurement. **Requirements:** A knowledge of the Finite Element Method (FEM) is advantageous, but not a prerequisite.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Predicting the cooling of citrus fruit 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 and predict the cooling inside a loaded container, using experimental measurements, Computational Fluid Dynamics (CFD) and Machine Learning. 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. The temperature distribution inside RC's is recorded, but the sensors are expensive. Machine learning should be used to develop models that can predict the temperature distribution inside a RC based on a minimal number of sensors/readings.Thus, instead of equipping the RC with 20 sensors, only 5 sensors might be used, combined with a trained model to predict the temperature distribution as accurately as 20 sensors would (as an example). This project is ideal for a student interested in agricultural engineering, experimental measurements (heat transfer and flow), CFD modelling and Machine Learning. 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 specific focus will also be adjusted to suit the student with more focus on experimental work, CFD modelling or Machine Learning. 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 2025 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 Agriculture plays a significant role in the global economy with an average contribution of 4% to the GDP across the globe and even reaching contributions up to 25% to the GDP in developing countries (World Bank, 2022). In South Africa it was reported that agriculture contributed R 127 960 million (2.8%) to the national GDP (Statistics SA, 2021; Trading Economics, 2021). The focus of this research project is on the structural integrity of corrugated paperboard cartons (boxes) and stacked pallet stability in the South African flower industry (Protea and Fynbos exports - Cape Flora). The industry experiences box failure which results in damage to the flowers and ultimately a loss in income. The existing box designs should be investigated and analysed in terms of box failure and pallet stability. When a box fails, the whole stacked pallet can become unstable and this results in more box failures and even a complete collapse. This study should analyse the existing problems using laboratory and field experiments, and propose and analyse possible solutions. The department has a large testing facility where a complete stacked pallet can be laterally accelerated and the stability and loads acting on the boxes measured. Various other facilities such as box compression testing are also available. This is a continuation of a previous project, and the student will work in close collaboration with Cape Flora (https://www.capeflorasa.co.za), local flower producers, and box manufacturers. The majority of the work would be experimental and hands-on, however, there is also the opportunity for numerical analysis using the Finite Element Method. This project is ideal for a student interested in agricultural engineering and experimental testing and measurement. **Requirements:** Finite Element Method is optional.		✓		✓

Dr Nur Dhansay
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- **Research Field**
  Fracture Mechanics
- **General Description of Research Field**
  The investigation of cracks propagating through a material. The focus typically lies in providing crack prediction models for the various mechanisms of fracture. The general fracture mechanisms include fatigue, creep, stress corrosion cracking and environmentally induced cracking. A variety components in real world applications undergo loading application which produces the failure mechanisms mentioned previously. It is therefor of benefit to better understand these mechanisms in order to produce more accurate crack prediction models and prevent any unwanted failure/fracture in components.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigating the fatigue fracture mechanisms of train axles Train derailments are often caused by fatigue failure of the train axle. One of the common areas for the fatigue failure is in the journal fillet radius as this is a difficult area to observe cracks in during inspections. Furthermore, these failures occur most commonly due to corrosion pitting in the fillet radius. Of the solutions to this problem is to find alternative ways to detect cracks in the fillet radius or to have better crack prediction models for this problem. This research focuses on investigating the fatigue fracture mechanisms of the train axle material. Furthermore, the research will investigate the corrosion mechanisms on the fatigue properties of the material to produce a suitable crack prediction model. **Requirements:** Ideally: Strength of Materials W334 Material Science A244		✓		
Crack tip strain localisation investigation of hydrogen-induced fracture mechanisms for pipeline metals Considering the drive towards “green energy”, it is believed that hydrogen will play a key role in transitioning from fossil fuels to renewable energy. Hydrogen gas requires transportation via pipeline. Unfortunately, metals are susceptible to hydrogen embrittlement (HE) which reduces the structural integrity of the material. Furthermore, the behaviour of HE metals tends to vary significantly, requiring special attention to be focussed on this topic. This research proposes to investigate the crack tip strain localisation of hydrogen-induced fracture mechanisms in pipeline steels using digital image correlation. **Requirements:** Ideally: Strength of Materials W334 Material Science A244		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigating the fracture mechanics failure mechanisms of additive manufactured alloys Laser powder bed fusion (LPBF) is one of many additive manufacturing (AM) techniques whereby a part is built up layer by layer using a laser and powdered metal. This allows for parts to be produced to a near-net shape and minimises material wastage. Unfortunately, this process produces parts which inherently has a brittle microstructure, porosity and high levels of residual stress, weakening the structural integrity of the part. More specifically, the fracture mechanics mechanisms such as fatigue crack initiation, propagation and fracture toughness (ductile and/or brittle) is affected. This research focusses on investigating the fracture mechanics behaviour of LPBF alloys. **Requirements:** Ideally: Strength of Materials W334 Material Science A244		✓		
Investigating a viable alternative method to the load-reduction technique for near-threshold fatigue crack growth rate tests, Part 1 This research investigation is one part of a two part investigation. This investigation is concerned with the strain field ahead of the crack tip using digital image correlation (DIC) for a viable alternative method to obtaining the intrinsic near-threshold, deltaKth, of a material. More specifically, it proposes that a link exists between the strain field ahead of the crack tip for the near-threshold regime and the ductile fracture toughness (J-integral), which may provide the footprint required for a viable alternative to obtaining the deltaKth of a material. The rationale behind why it is believed that a link exists between these two methods is because in both cases (near-threshold and J-integral): (i) a crack exists in the system and (ii) both undergo cyclic loading or load/unload cycles which develops plasticity ahead of the crack tip. For the near-threshold regime, the plasticity or strain field ahead of the crack tip is related to an already existing crack terminating its propagation/tearing. For the J-integral, the plasticity or strain field ahead of the crack tip is related to an already existing crack "initiating" its propagation/tearing. It stands to reason that a link exists between their strain fields which can be used to obtain a viable alternative to obtaining the deltaKth of a material. This investigation will focus on the near-threshold fatigue crack growth rate testing methodology. **Requirements:** The following would be ideal: Strength of Materials W334 Material Science A244		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigating a viable alternative method to the load-reduction technique for near-threshold fatigue crack growth rate tests, Part 2 This research investigation is one part of a two part investigation. This investigation is concerned with the strain field ahead of the crack tip using digital image correlation (DIC) for a viable alternative method to obtaining the intrinsic near-threshold, deltaKth, of a material. More specifically, it proposes that a link exists between the strain field ahead of the crack tip for the near-threshold regime and the ductile fracture toughness (J-integral), which may provide the footprint required for a viable alternative to obtaining the deltaKth of a material. The rationale behind why it is believed that a link exists between these two methods is because in both cases (near-threshold and J-integral): (i) a crack exists in the system and (ii) both undergo cyclic loading or load/unload cycles which develops plasticity ahead of the crack tip. For the near-threshold regime, the plasticity or strain field ahead of the crack tip is related to an already existing crack terminating its propagation/tearing. For the J-integral, the plasticity or strain field ahead of the crack tip is related to an already existing crack "initiating" its propagation/tearing. It stands to reason that a link exists between their strain fields which can be used to obtain a viable alternative to obtaining the deltaKth of a material. This investigation will focus on the J-integral methodology. **Requirements:** Ideally: Strength of Materials W334 Material Science A244		✓		✓

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
Comfort bed for premature babies Background: Kangaroo mother care is a method of care of premature infants. The method involves infants being carried, usually by the mother, with skin-to-skin contact. There is evidence that this method of care greatly helps in the development of the baby. The baby will be able to get warmth from the mother, feel her heart beat and breathing, hear her voice and of course cuddle on her body. However, this is not always possible immediately after birth. The mother may still be in recovery or she may be undergoing surgery. Problem: For premature babies born in rural hospitals that need not go to a secondary or tertiary hospital, a comfort bed is needed that best approximate the experience the baby would have had in kangaroo care with the mother. Additionally, the comfort bed should monitor the motion of the baby so that a warning can be given should the baby's condition deteriorate. It would be beneficial for this comfort bed to fit within an existing incubator. **Requirements:** Design	✓			
Studies of lymph micro-circulation Background: Very little information exits on the flow of lymph through the human body. It is a very slow flowing, one dimensional system, which main function is to transport lymph from the extremities back to the circulatory system. Problem: An in-depth literature study of the micro flow of the lymph in the lymphatic network needs to be conducted. The student needs to make use of CFD to model the micro flow movement of the lymph within a lymphatic segment / duct. **Requirements:** CFD		✓		

Mr. Rashid Haffejee
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- **Research Field**
  Thermofluid Systems Modelling
- **General Description of Research Field**
  Thermofluid network modelling is a powerful simulation tool that can be applied to study complex thermofluid systems, ranging from utility-scale power cycles, and heating and refrigeration to human cardiovascular dynamics. Thermofluid network models can be used to predict the performance of these complex systems for wide ranges of operating conditions, which helps to design, optimise and manage these intricate systems.

  By also incorporating machine learning techniques with thermofluid networks, condition monitoring tools can be developed to help detect anomalies, aid in design optimisation, and also drive breakthroughs in enhancing energy efficiency.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Optimization of a natural draft direct dry cooling system (NDDDCS) for a supercritical carbon dioxide (sCO2) power cycle using an artificial intelligence based surrogate model Global research interest into supercritical CO2 (sCO2) power cycles is increasing, due to their superior efficiencies and reduced component size requirements. These cycles, linked to concentrated solar power (CSP) applications represent a modern evolution to sustainable and efficient power production. The sCO2 cycle needs a heat rejection system to dissipate heat loads from the pre-cooler and intercooler heat exchangers to the environment. To further enhance cycle efficiency and promote sustainability, a heat rejection system with low parasitic power- and no water consumption requirements would be very beneficial. Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). This study will optimize a NDDDCS for the pre-cooler and intercooler heat loads of a sCO2 power cycle, linked to a 50 MWe CSP plant. The work will modify and utilize an existing co-simulation model (coupled Flownex one-dimensional and Fluent three-dimensional Computational Fluid Dynamics model) that has been developed to assess the performance of a NDDDCS specifically for this application. The optimization will consider alternative cooling tower shape and heat exchanger configurations. A neural network surrogate model, to be developed using the co-simulation model, will be used to perform the optimization. (This project will be co-supervised by Mr Rashid Haffejee and will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A condition monitoring methodology for heat pumps using a physics-based thermofluid model combined with parameter identification Being able to anticipate breakdowns to industrial equipment in advance can reduce the negative impacts caused by unexpected stoppages, especially where complicated logistics are involved to do repairs and maintenance. For this purpose, on line condition based monitoring can be applied to reveal incipient faults before breakdowns occur. These techniques can broadly be divided into model-based or data driven approaches. The aim of this project will be to develop and demonstrate a condition monitoring methodology for heat pumps using a fundamental physics-based thermofluid model combined with parameter identification to simultaneously detect, locate, and quantify degradation occurring in the different heat pump system components. The methodology will be demonstrated with the aid of measurements on a laboratory scale vapour compression heat pump cycle. (This project will be co-supervised by Mr. Rashid Haffejee (main supervisor) and Prof. Pieter Rousseau.) **Requirements:** Strong interest and performance in thermo-fluids modules Strong interest in numerical modelling Knowledge of machine learning is advantageous		✓		

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
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		✓	✓	

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.			✓	✓
Thermal radiation in a packed bed At high temperatures, radiation plays a significant role in the heat transfer in packed beds. This radiation may be modeled via a participating medium, but the absorption and scattering of radiation in the medium are expected to depend on particle size and shape, thermal conductivity, surface emissivity, and the porosity of the bed. Existing models make use of modifications to the effective thermal conductivity to cater for thermal radiation, but it gives poor results when the medium interacts with external structures. In this study, the student should extract the bulk radiation properties of the bed from CFD/DEM simulations, and validate it against experimental data. **Requirements:** good CFD skills will be advantageous.		✓	✓	
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.	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Particle characterization for pressure drop in an anisotropic packed bed The usual parameters like particle size, shape (sphericity or aspect ratio) and porosity fail to explain why the pressure drop in a packed bed of crushed rock particles differ for different flow directions through the bed. This is most notable when the flow is vertical or horizontal with respect to the pour direction of the particles. It is expected of the student to introduce new particle or bed (tortuosity) characteristics that can declare this behaviour. Using a CFD/DEM approach for particles with a simple geometric shape with aspect ratio's other than 1 may provide valuable information about the local flow patterns that contribute to the overall effect, but it will require experimental validation. **Requirements:** A working knowledge of CFD will be advatageous.		✓	✓	✓
Climate control in a greenhouse using solar thermal energy For optimal crop growth, greenhouse temperatures and humidity must be kept within narrow bands. Harvested solar energy collected during the day can be released to raise night-time temperatures, or cooler temperatures at night may be released to cool the greenhouse on warm days. The student should develop a thermal energy storage facility capable of preventing cold damage to crops, and evaluate its economic feasibility. **Requirements:** A working knowledge of CFD is recommended.	✓	✓		✓
Critical evaluation of the Ergun equation for anisotropic packed beds The Ergun equation is widely used in modelling flow through porous media for its simplicity. It depends on only a few parameters, like (the area equivalent) spherical diameter of the particles, fluid properties, and the porosity of the bed. The Ergun equation seems to work reasonably well for plug flow. However, the values of the (constant) coefficients in the Ergun equation is disputed in the literature. Some researchers reported a Reynolds number dependence of the coefficients, whilst other introduced extra (but often difficult to measure) parameters into the equation. It is expected that the student derive an alternative formulation for the pressure drop through an anisotropic bed, and validate it against experimental data. Using a combination of CFD and DEM will yield detailed information about the local flow patterns to inform the model, but isn't a necessary requirement to complete the project. **Requirements:** Good CFD skills might be advantageous.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Heat transfer and pressure drop in a packed beds of variable sized particles Flow and heat transfer in a packed beds is usually described in terms of a representative spherical particle. When the bed comprise of particles spanning a wide range of sizes (dmax > 5*dmin), this approximation may break down. It is expected of the student to come up with an appropriate formulation of the Reynolds number for the bed (usually a function of particle size, shape and porosity of the bed). Use this Reynolds number (and perhaps tortuosity) to define new correlations for the friction factor and Nusselt number. Using a CFD/DEM approach of the bed will give valuable insights into local flow and temperature profiles to inform the model(s). Validation of the model(s) against experimental data is required. Part of the project may be conducted at Sherbrooke or McGill University in Canada. **Requirements:** A working knowledge of CFD will be advantageous.		✓		

Prof Ryno Laubscher

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- **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
Development, validation and application of a thermofluid network-based model of combustion and aerodynamics in a microjet gas turbine cycle The micro gas turbine market for propulsion applications is projected to grow by 10% by 2030, driven by the increasing demand for both commercial and military applications. With a significant push in the aerospace industry towards sustainable fuels, hydrogen or hydrogen-energy carrier fuel sources such as ammonia are becoming increasingly important. However, information regarding the performance of micro gas turbines firing these fuels is scarce. Micro gas turbines, also called microjets, typically comprise of a diffuser, compressor, combustor, turbine, and nozzle, each of which is carefully designed to yield the maximum propulsive performance. Commercial design simulation tools typically omit details of the combustion performance. In the proposed work a detailed thermofluid network based model of an actual 250 N microjet will be developed that will include the necessary chemical kinetics to capture the combustion progression on a process level. This combustion functionality will be built on top of the South-African based software, Flownex SE. In addition to the combustor modelling, this project will also develop compressor and turbine models using validated loss modelling approaches and mean-line analysis to capture the steady-state and dynamic performance of the microjet when firing Jet A1. Results of the model will be compared to actual tests which will include pressure, temperature, mass flow rate and exit gas composition readings. The validated model will be used to simulate hydrogen and ammonia combustion in the 250 N microjet and if necessary, propose preliminary design modifications to the turbine and combustor. **Requirements:** BEng Mechanical		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Optimization of turbomachinery layout for concentrated solar sCO2 power cycles with the aid of integrated thermofluid network modelling Supercritical carbon dioxide (sCO2) power cycles have been identified as a promising future power conversion technology due to its high cycle efficiency and compact footprint. Using sCO2 power cycles with concentrated solar power (CSP) technology would lead to smaller mirror fields compared to Rankine-based CSP plants that has the same power output level, making it a more competitive renewable energy solution. One of the major costs associated with sCO2 power cycles is that of the large recuperator heat exchangers. Researchers have shown that the heat exchangers can be drastically reduced in size, and thus cost, if the turbomachinery efficiencies are increased even marginally. The present project sets out to compare and optimize various turbomachinery layouts for a 50 MWe CSP sCO2 power cycle with the aid of integrated thermofluid network models. The study will include different turbomachinery types, such as centrifugal and axial, along with different shaft configurations, such as dual- and single-shaft layouts. Gradient-based and metaheuristic optimization algorithms will be applied to the integrated cycle simulation models to tune turbomachine parameters such as blade solidity and blade aspect ratios for the various compressors and turbines. The study will cover both steady-state and transient operating scenarios. **Requirements:** Mechanical engineering undergraduate degree.			✓	
Design evaluation of gas turbine combustor for aerospace applications The current project focuses on evaluating two preliminary design methods for annular gas turbines. Its primary objective is to design a 1 kN microjet engine combustor tailored for aerospace applications, employing the Mattingly and Lefebvre methods. This will involve developing custom codes in MATLAB or Julia for design refinement. Subsequently, comprehensive CFD models will be created to assess the efficacy of these design methods, specifically targeting combustion efficiency, mixing characteristics, and cooling capabilities within the combustors. The project aims to optimize performance and reliability, contributing to advancements in aerospace propulsion technology. **Requirements:** BEng Mechanical Engineering		✓		

Prof Stephanus Malherbe

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- **Research Field**
  Clinical researcher
- **General Description of Research Field**
  Translational research in infectious diseases, primarily tuberculosis. Work include applying new technology to find better markers of disease and treatment response. Particular focus on the automated analysis of PET-CT scans to measure treatment response and disease severity.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Automated analysis of FDG PET-CT scans from patients with tuberculosis We are seeking one or two motivated post-graduate students for a joint project between the Department of Biomedical Sciences and the Institute of Biomedical Engineering (collaborator prof Martin Nieuwoudt). The successful candidate(s) will have the opportunity to work with a multidisciplinary team of researchers in the fields of medical imaging analysis. The research will focus on the development of powerful, robust and accessible software to segment and analyse medical images from PET and CT, in an automated and reproducible manner; with the aim to apply it to large scan datasets and extract and analyse anatomical and functional information. Applied technology will include machine learning (convolutional neural networks), radiomics, image processing and pre-processing. Further objectives may include database handling, optimisation, post-processing, front-end design, cloud/server integration. The research is at the juncture between biomedical engineering, data science, clinical research and computational analysis. Project scope may be tailored for either Masters or PhD degree in Engineering or Biomedical Engineering. If for Masters, may be part of a structured Masters programme. **Requirements:** Hold at least a BEng, a BScHons, or an alternative relevant four-year bachelor's degree, an MTech, a BTechEng(Hons), or a PGDip (Eng); Strong academic track record in Mathematics, Statistics or Applied Mathematics, and Computer programming.	✓	✓	✓	✓

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
Design and configuration of solar thermal multi-tower field layout Central receiver CSP plants, or power towers, are built on a 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. This project intends 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 supply a single power plant. Such a system has the potential to start generating electricity (and hence revenue) after the 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, which will be used to optimise the system's configuration. See e.g. https://doi.org/10.1063/5.0028916. **Requirements:** none		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Advanced Acoustic Monitoring for Predictive Maintenance in Concentrated Solar Power Plants This project aims to develop and implement an advanced acoustic monitoring system for predictive maintenance in parabolic trough concentrated solar power (CSP) plants. The research will focus on replacing manual listening techniques with a network of strategically placed acoustic sensors to detect early signs of thermal stress and metal fatigue in collector tubes and piping systems. The study will involve designing an array of acoustic emission (AE) sensors, developing signal processing algorithms to interpret the collected data, and creating machine learning models to predict potential failures. The project will explore integrating this acoustic monitoring system with other sensor data (e.g., temperature, pressure, flow rates) to enhance the accuracy of failure predictions and optimize maintenance schedules. The ultimate goal is to improve the reliability and efficiency of CSP plants while reducing downtime and maintenance costs, thus contributing to the broader objective of industrial decarbonization. **Requirements:** none		✓	✓	
Analytical Solutions to Non-imaging Solar Concentrator Optical Design This project aims to develop an analytical method for generating the optical surface of solar concentrators. The primary objective is to create a mathematical model that determines the ideal surface geometry to achieve a specified irradiance distribution on a target, given a set of input ray parameters. The study may incorporate varying solar irradiance data over daily and annual cycles to generate an optical surface design. The performance of the analytical solution will be comparatively assessed against conventional tracking troughs and heliostats, potentially offering insights into more efficient solar concentration techniques for industrial decarbonization applications. **Requirements:** none		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Novel Ceramic Composites for Thermal Energy Storage 1. Investigation of Novel Ceramic Composites for Thermal Energy Storage This project aims to develop advanced ceramic composite materials for thermal energy storage (TES) applications, particularly in molten salt storage systems. The research will explore innovative fabrication methods, material compatibility, the effects of additives (e.g., graphene), reliability, and novel compositions to improve the thermal and structural properties of the storage media. The project will involve material characterization, compatibility testing, and optimization to identify suitable ceramic-based alternatives to conventional molten salt storage materials. Additionally, the project includes the design, fabrication, and testing of an experimental TES testbed to validate the performance of the developed ceramic composites. 2. Transient Modeling and Simulation of Thermal Energy Storage Systems** This project focuses on developing a detailed transient model for thermal energy storage (TES) systems. The model will simulate the dynamic behaviour of the TES system, accounting for environmental factors, charge/discharge cycles, and design changes. The goal is to create a comprehensive simulation tool to provide insights into TES system performance and enable informed decision-making and optimization. The model will be extensively validated against experimental data from the TES testbed developed in the first project, and the model's limitations will be identified to ensure reliable and accurate predictions. **Requirements:** none		✓	✓	✓
High Temp Heat Pumps This project focuses on developing an advanced thermodynamic model for high-temperature industrial heat pumps. The model will simulate the performance and efficiency of heat pump systems capable of generating heat above 100°C, which is critical for displacing fossil fuel-based industrial heating processes. The project will involve gathering data on the latest heat pump technologies, incorporating realistic operating conditions, and validating the model against experimental results. The goal is to provide a robust tool for optimizing high-temp heat pump designs to support industrial decarbonization efforts. **Requirements:** none		✓	✓	✓
Mini Industry Heat Network Title: (District, Wooster) Description: This project aims to develop a detailed model and feasibility study for implementing a mini-industry heat network in the Wooster district. The goal is to analyze the potential for recovering and distributing waste heat from nearby industrial facilities to supply surrounding users. The project will involve mapping heat sources and sinks, designing an optimal heat distribution network, and evaluating such a system's technical and economic viability. The findings could inform future district-level decarbonization efforts in similar industrial areas.	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: none				
Design and thermodynamic modelling of a compound piston steam expander for concentrating solar thermal applications For several years, the Solar Thermal Energy Research Group has developed steam piston expansion (steam engine) technology optimized for application in concentrating solar power (CSP). This research culminated in 2022 when a previous student converted a Detroit diesel engine to run on compressed air and steam. This research topic expands this research by considering the application of compound (multi-stage) steam engines. Steam piston expanders offer advantages over steam turbines at smaller scales where turbines are costly, whilst compound engines offer higher cycle efficiencies than a single expansion cycle. The project has two primary focus areas: the Rankine cycle thermodynamic modeling and the mechanical design of a commercial-scale compound steam engine. The Rankine cycle thermodynamic model will enable the assessment of the system's performance across diverse conditions, ensuring optimal energy extraction from concentrated solar sources. The program's second facet delves into the mechanical realm, where the compound steam engine's crucial components are designed to enhance energy conversion efficiency and overall operational robustness. Practical application: The project offers a unique chance to develop energy modeling and design skills in a project that combines mechanical engineering with sustainable energy technology. **Requirements:** thermodynamics		✓	✓	
Design and analysis of glass alternative concentrated solar power reflectors Mirrored glass is the most common material for reflectors used in the concentrated solar power (CSP) industry. However, glass has many undesirable properties. The research aims to develop feasible glass alternative reflectors for CSP applications. The project will involve structural design, prototype building, and performance testing. Various simulation technologies can also be incorporated into the project. **Requirements:** none		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Concentrating Solar Power Grid Services for the South African Electricity Network This project aims to assess the ability of Concentrating Solar Power (CSP) technology to provide grid services and support the integration of renewable energy in the South African electricity network. The study will evaluate the performance and capabilities of various CSP technologies in providing services like grid stability, load balancing, and renewable energy integration. (i) Economic Evaluation: The project will model the impact of CSP technology in a competitive bid market, using classical programming languages (e.g., Python, MATLAB) coupled with optimization toolboxes. This analysis will quantify the economic benefits of deploying CSP-based grid services and make the models available to plant designers and grid managers. (ii) Grid Stability Analysis: The project will conduct a stochastic analysis to evaluate CSP technology's grid stability impacts based on realistic renewable resource variability modelling using South African meteorological data. The performance of CSP with thermal energy storage will be compared to the other technologies under different load scenarios, using a co-optimization approach that considers economic and risk-aversion criteria. Various simulation models, such as Python-based PyPSA and PLEXOS, will be considered to assess the grid services provided by the CSP technologies. The outcomes of this research can help inform policymakers, grid operators, and CSP developers on the potential benefits and strategies for leveraging CSP technology to enhance the resilience and sustainability of the South African power grid. **Requirements:** none		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
SU 1kW PEM Electrolyser Project SU has a commercial Hogen (Proton Energy Systems, now Nel Hydrogen) 1 kW PEM electrolyser system on a semi-permanent loan. Objective: to recommission the Hogen 1kW PEM electrolyser at SU and use it as a model system to reverse-engineer a prototype SU electrolyser. The Hogen electrolyser system comprises separable sub-systems, which may be categorized as follows: • PEM Stack – bipolar plates, MEA, seals & sealing, performance characterization. • Power Electronics – hardware, control and interface software, load/battery . . . • Balance of Plant (BoP) – water subsystem, H2 & O2 management (buffer, offtake). • Physical Embodiment – enclosure, HM interface, component layout, look & feel) • Safety Protocols – H2 and O2 management, high currents. Initial efforts aimed at the above objective point the following first development sub-projects as MSc studies, namely: 1. STACK (M&M) - involves the design, component manufacture, assembly and demonstration of a reverse-engineered 1 kW PEM stack for substitution into the Hogen reference system. Includes flow field end/bipolar plates, stack compression mechanism (sealing), H2, O2, H2O and electric current ducting, temperature management and necessary diagnostics/analytics – specifically excludes electrocatalyst/MEA development which is to be purchased/outsourced. 2. POWER ELECTRONICS (E&E) – involves designing, constructing and demonstrating an electrolyser stack power management system for substitution into the Hogen reference system. Includes electronics hardware, control software and diagnostic/analytics to monitor stack/system performance. 3. PRODUCT DESIGN (IND) – includes physical product embodiment and features (BoP and sub-system layout, operability, safety, look & feel, HM interface, IoT monitoring). Consists of the design and build of an SU system for incorporating stack and power electronics ex projects (1) & (2), above. Note: the above assumes the existing Hogen system is successfully commissioned and operational for access by the proposed project groups, i.e. this is not seen as part of the MSc studies themselves. **Requirements:** none		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Numerical Solution for a Solar Concentrating Optical Surface Design The project aims to investigate a numerical solution for the optical surface of a solar concentrator. The topic's primary objective is to develop a method to solve the analytical solution for an optical surface that would irradiate a given target, given a set of input rays. Using the developed model, a solution for the optical surface can be found for different input cases. An optimised optical surface can be found using an input dataset that is representative of solar irradiance over a day (or a year). The optimised solution can be compared to traditional tracking troughs/heliostats. This approach particularly applies to photoelectrochemical (PEC) hydrogen production, where reactors have unique irradiance requirements. The ability to control input and output rays during the design phase allows for carefully addressing these specific needs in PEC systems. The following paper shows how concentrating optics is incorporated into a PEC hydrogen production system: https://doi.org/10.1038/s41560-023-01247-2. **Requirements:** none	✓	✓		✓

Prof Chris Meyer

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- **Research Field**
  Thermo-Fluids
- **General Description of Research Field**
  My research interests are very broad with the common denominators being fluid mechanics, thermodynamics and heat transfer.

  Amongst the topics of interest are the development of fit-for-purpose axial flow fans for the cooling, agricultural and aviation industries. Steam expanders for use in concentrated solar power (CSP) systems.

  I also have a special interest in the development of high-speed water craft where we develop novel hydrofoil and other drag-reducing concepts for planing vessels. We like our boats to go fast!

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigate the Effect of Hub Configuration on Axial Flow Fan Performance It is a known fact that the hub configuration of an axial flow fan has a significant effect on fan performance. However, the mechanisms of this influence is not well understood. Depending on the nature of the research (PhD or MEng), a combination of experimental and computational fluid dynamics (CFD) techniques are to be used to investigate the flow patterns around the blade root area in an effort to better understand the nature of this influence. **Requirements:** A solid academic record, a strong work ethic and a passion for turbomachinery.		✓	✓	✓
High Speed Watercraft Drag Reduction - various topics Depending on the nature of the degree program (MEng/PhD) a combination of experimental techniques and CFD is to be used to develop low-drag solutions for high-speed watercraft. This would usually include hydrofoil systems combined with multi-hulled vessels in different configurations. **Requirements:** Solid academic record, a strong work ethic and a passion for high speed boats.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Develop a 3D Axial Flow Fan Design Methodology The design of axial flow fans usually makes use of a two-dimensional approach where flow in the radial direction is not only assumed zero, but the methodology itself is formulated to prevent any radial flow component through the fan. Three dimensional effects are usually encountered close to the fan hub. The task at hand is to develop a design methodology that would incorporate three-dimensional flow effects without compromising the advantages provided by a purely 2D design approach. The use of a cascade design approach close to the hub, coupled with an isolated airfoil design approach for the blade outer regions is but one of the exciting possibilities. For a PhD study both experimental as well as CFD will be required where a CFD approach will be used at Master's level. **Requirements:** A solid academic record combined with a strong work ethic and a passion for turbomachinery is what is needed.		✓	✓	✓

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
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 measuring the high temperature mechanical properties of high density nickel superalloy parts manufactured using laser powder bed fusion. Defect-free printed parts with superior high temperature properties are essential for aerospace applications. Specimen-efficient techniques will be applied including small sample testing and the use of digital image correlation. Post-processing methods and understanding structure-property relations are also necessary for full qualification of these printed materials. The student will collaborate closely with the Centre for Materials Engineering at the University of Cape Town. **Requirements:** Good materials science background understanding and MATLAB coding skills for analysing large and different data sets. Most of this can be learnt along the way.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Additive manufacturing for membrane-less hydrogen electrolysers Hydrogen (in particular green hydrogen) is of great interest to companies and research institutions who are part of the efforts to decarbonise industries in Africa. Besides its usefulness as a potential clean fuel source, hydrogen production could also benefit the agricultural sector through the production of ammonia needed in fertilisers. Hydrogen production from electrolysers has received growing attention with focus placed on incorporating the geometrical flexibilities offered by additive manufacturing. In this project, the student will work with several researchers tasked with placing Stellenbosch University at the forefront of hydrogen research. The project aims to investigate the potential of additive manufacturing (AM) for developing cost-effective and efficient membrane-less hydrogen electrolysers. By leveraging AM's design flexibility, electrolyser components incorporating non-platinum group metal catalysts, such as titanium, can be fabricated to significantly reduce production costs. The use of membrane-less designs also hosts potential to overcome the inefficiencies of electrolyser designs that do incorporate separator membranes. Potential funding is available. **Requirements:** None.		✓		✓
Two-phase flow and surface effects in proton exchange membrane hydrogen electrolysers This project aims to investigate the intricate relationship between two-phase flow, surface characteristics, and geometric configurations within proton exchange membrane (PEM) hydrogen electrolysers. By systematically studying the effects of various surface conditions (rough, polished, and anodized) on additively manufactured titanium components, we seek to optimise electrolyser efficiency and performance. Specifically, the project will delve into understanding how different surface textures influence bubble nucleation, growth, and detachment, thereby impacting mass transfer and ohmic resistance. Additionally, the role of component geometry in managing two-phase flow patterns, reducing pressure drops, and enhancing reactant distribution will be explored. Through a combination of experimental analysis and computational modeling, we aim to develop a comprehensive understanding of these factors and provide valuable insights for the design and optimisation of high-performance PEM electrolysers for hydrogen production. Possible funding is available. **Requirements:** Computational Fluid Dynamics (CFD) modelling experience.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a low-cost and versatile digital image correlation system Digital image correlation (DIC) is a very useful optical-based extensometry technique that can be used to provide full field displacement and strain data of deforming structures. Applications of this technique is often hampered by the cost of commercial systems and software, necessitating the development of fine-tuned, in-house options. This project aims to design and construct a comprehensive DIC system capable of both planar and stereo image acquisition, processing, and analysis. The system will incorporate advanced features such as synchronised data acquisition from multiple sensors (load cells, temperature, extension, etc.), robust calibration methodologies, and a user-friendly graphical interface. Key components of the system include: - Image acquisition hardware: High-resolution cameras with adjustable parameters, along with appropriate lenses and optics. - Lighting system: Flexible and adjustable lighting solutions to optimise image quality under various experimental conditions. - Mechanical setup: A stable and adaptable framework for camera and specimen positioning, including tripod or camera fixture options. - Data acquisition and synchronisation: Hardware and software for simultaneous acquisition of image and sensor data. - Calibration system: Rigid body displacement stands and software for accurate camera calibration and geometric parameter determination. This includes developing various calibration targets and testing their calibration abilities. - Software development: Expansion of existing DIC code to include new features, improved algorithms, and a user-friendly graphical interface. The developed DIC system will provide a powerful tool for experimental mechanics research, enabling precise measurement of displacement, strain, and deformation fields in a wide range of materials and structures. **Requirements:** Python skills are useful but can be learnt along the way.		✓		

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.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Railway ground vibrations induced by wheel-rail contact loads Railway vehicles often cause large vibration responses during operation, both in the vehicle and in the track on which they travel. Vibrations from the track can travel into the ground and further travel as ground-borne vibrations. Ground-borne vibrations can have negative impacts on the environment, especially in urban areas. Monitoring of these vibrations is important to make sure they do not exceed thresholds set down by standards and regulation agencies. Defects or irregularities on wheels or rails can often cause large contact forces which excite large vibrations, exacerbating the issue if ground-borne vibrations. This research project will focus on quantifying these vibrations through numerical modelling and experimental measurement. The project is supported by the Gibela Engineering Research Chair, at the Department of Mechanical and Mechatronic Engineering. Please see the following article for additional context: https://doi.org/10.1080/00423114.2015.1062116 **Requirements:** Potential applicants should have an interest in railway vehicles, numerical modelling, and experimental testing. Applicant will need to create and validate multi-body dynamic models and finite element models, and potentially interface between the two. Applicant will need to complete laboratory/field experiments to validate		✓		✓

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
Axial fan operation in hybrid cooling towers Mechanical draft hybrid cooling towers combine wet (evaporative) and dry cooling to provide compact and effective industrial cooling solutions in demanding operating environments. A typical hybrid cooling tower is an induced draft system with an axial flow fan drawing air through a counterflow wet cooling section and a cross-flow air-cooled heat exchanger (located between the wet cooling section and the fan). Louvers are used to control the air flow through the air-cooled heat exchanger to (a) assist with plume abatement (by reducing the relative humidity of the exhaust air), and (b) reduce water consumption by providing some dry cooling capacity. Because of this variable air flow nature, the operating conditions experienced by the fans are complex (multiple duty points, non-uniform inlet velocity profiles) and the fans are exposed to non-ideal operating conditions, notably in terms of dynamic blade loading and associated vibrations and fan component fatigue. This project involves the numerical simulation of a hybrid cooling tower using computational fluid dynamics. The objective of the work is to quantify the nature of the operating conditions experienced by the axial flow fan for different cooling tower operation modes. The project will be co-supervised by Dr Jacques Muiyser (Howden Netherlands). **Requirements:** The project requires the student to have completed, or to do, a CFD module (or have relevant experience with CFD). ANSYS FLUENT is the preferred software.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Reduced-order modelling of air-cooled condenser performance under windy conditions Air-cooled condensers (ACCs) are a direct dry cooling technology that significantly reduces the water footprint of thermal power generation. These systems are widely used in concentrating solar power (CSP) plants since these plants are typically built in arid regions with high solar resource but limited water availability. The performance of the condenser direclty impacts the thermal efficiency of the power plant (by influencing the turbine back pressure) and is thus a critical (but often overlooked) component in the power cycle. The majority of ACCs are mechanical draft systems where air flow is driven by large axial fans. As an alternative, natural draft systems use bouyancy as the motive force and thus eliminate the need for fans (thus offering benefits in terms of net power output). There is currently only one natural draft ACC at a CSP in the world (Khi Solar 1, Upington South Africa), and the relative performance and costs (compared to mechanical draft systems) are not well understood. Ultimately, our aim is to conduct a direct comparison of mechanical and natural draft ACCs for application in CSP based on life-cycle cost. This comparison requires an understanding of how these two systems would perform over a typical meteorological year in a representative location (taking into account ambient conditions including temperture and wind). In this project, we will develop a reduced order model of the performance of a mechanical draft ACC (using CFD simulations to generate training data) as a function of both ambient temperature and wind. This model will be applied in the overarching comparitive study mentioned previously. **Requirements:** The project requires the student to have completed, or to do, a CFD module (or have relevant experience with CFD). ANSYS FLUENT is the preferred software.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a reduced order model (ROM) for a bespoke natural draft direct dry cooling system (NDDDCS) finned tube heat exchanger Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems are relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensure high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers in a natural draft cooling tower. This study will develop a reduced order parametric model (ROM) of the thermo-hydraulic performance of a flattened finned tube heat exchanger, based on the results of multiple Computational Fluid Dynamics (CFD) simulations. The intention is to find the best combination of tube and fin geometry that would provide an optimal finned tube for application within a given NDDDCS. The work will continue the development of a current CFD model and ROM that evaluated limited parameter variations. The ROM will also be integrated into an existing one-dimensional NDDDCS model to predict the optimal tube configuration based on the selected NDDDCS design. (This project will be co-supervised by Dr Hannes Pretorius and will form part of research conducted by the Solar Thermal Energy Research Group). **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling annual performance of a natural draft direct dry cooling system (NDDDCS) for a 50 MWe concentrating solar power (CSP) application Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems are relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensure high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers in a natural draft cooling tower. This study will develop a reduced order model (ROM) of NDDDCs performance as a function of ambient conditions (including wind), based on the results of multiple Computational Fluid Dynamics (CFD) simulations. The intention is to evaluate the annual performance of a NDDDCS without having to simulate each ambient condition using CFD. The work will continue development of an existing CFD model of a NDDDCS, and the investigation will consider system performance as part of a 50 MWe concentrating solar power (CSP) plant. The NDDDCS will be sized for a typical CSP application and design of experiments will be used to develop the ROM. (This project will be co-supervised by Dr Hannes Pretorius and will form part of research conducted by the Solar Thermal Energy Research Group). **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigating the impact of site winds on utility-scale PV power plant output Solar power generation using Photovoltaic (PV) power plants has seen a dramatic rise in popularity in recent years. Large PV plants continue to be constructed all around the world, including South Africa. Due to the continually decreasing price of PV panels and the relative construction simplicity of such power plants, it is expected that they will remain competitive in the medium to long term. The efficiency of PV modules is negatively affected by an increase in operating temperature of the module. To predict power output accurately, it is important that the heat dissipation from the PV module is accurately modelled. Forced convection heat transfer from modules due to winds at a PV power plant site can reduce the operating temperatures of the modules. This reduction in temperature improves their efficiency and ultimately enhances the plant's output. The impact of wind on module temperature is likely to be different across the PV array and sensitive to both wind speed and direction. There is little understanding of this behaviour at present. This study will evaluate the impact of winds on the module temperature and corresponding output of a utility-scale PV power plant. Computational Fluid Dynamics (CFD) models will be used to evaluate the flow over the modules in order to determine their effective temperature. Existing one-dimensional models and / or commercial software will be used to assess the resulting impact on plant performance. With a better understanding of wind effects and associated temperature distributions, several possible research questions can be interrogated (e.g. is there a potential benefit to accounting for prevailing wind direction in the orientation of a PV plant?). This topic will be co-supervised by Dr Hannes Pretorius and Dr Arnold Rix (E&E). **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		✓
Optimising specific energy consumption in raceway ponds for large scale aquafarming of seaweed for biofuel generation Seaweed is emerging as prominent resource in the transition to sustainability in many industries. A common type of farming occurs in onshore ponds, where the seaweed is kept in suspension using aeration or paddle wheels to introduce turbidity into the water. A key parameter for the economic feasibility of any land-based aquaculture project is the energy required to keep the seaweed suspended. This study will use numerical models to optimise raceway pond geometry for minimum specific energy consumption while maintaining adequate turbidity distribution. This project will be co-supervised by Dr Adam Venter and will be in collaboration with an industry partner. **Requirements:** CFD		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Curbing food losses through solar drying integrated with biogas-assisted dehumidification See full topic description under Prof Eugene van Rensburg. The project will be co-supervised by Prof van Rensburg and myself. **Requirements:** See full topic description.	✓	✓		✓
Simulation of high flow nasal cannula ventilation in infants and children High flow oxygen therapy through nasal cannula (HFNC) is a commonly used method of respiratory support for patients with respiratory failure. Heated, humidified air is blended with oxygen and delivered at high flow rates via a nasal interface. The therapy improves breathing efficiency but the high flow rates make it relatively expensive and the exact mechanisms through which it works are not well understood. Studies of the use of HFNC compared to standard nasal oxygen in infants and children have conflicting results and further analysis is required to refine the use of HFNC. This project involves the numerical simulation (using an appropriate computational fluid dynamics tool) of HFNC in infants and children. A numerical model must be developed and validated against published information (e.g. positive end-expiratory pressure measurements from model-based studies). The model will be used to conduct a parametric analysis which aims to contribute to the understanding of the mechanisms through which the therapy works and to identifying optimal operating parameters. The project will be co-supervised by Dr Andre Gie, a Paediatric Pulmonologist at Stellenbosch University. **Requirements:** This project will suit a candidate with a mechanical engineering background since it is heavily reliant on an understanding of fluid mechanics. CFD will be used as the primary tool in this work and the student should have completed a relevant CFD module (or must complete such a module in the first semester of the MEng programme).		✓		

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 of a microbead-based test for diagnosis of (infant) TB Meningitis TB Meningitis is a largely overlooked threat in developing countries, especially in South Africa. The disease usually goes unnoticed until treatment is no longer useful, and very few testing methods currently exist to address this problem. This project would develop a handheld microbead-based assay to detect and quantify biomarkers associated with TBM in resource constrained settings like South Africa. Collaboration: Medical Physiology, BMRI, Immunology Research Group (Tygerberg) **Requirements:** Image processing, machine learning, fluid mechanics, microfluidics		✓		
High-frequency sensing technologies High-frequency electronics provides an extremely versatile method of measuring material characteristics in a non-destructive manner. Particularly, biosensing and the detection of bacteria can be done with relatively simple electronics and structures. This project would focus on the development and optimisation of ultra-high frequency structures for biosensing applications. Collaboration: Physiology, Tygerberg **Requirements:** Signal processing, electromagnetics, optimisation, multiphysics modelling		✓		
Electrochemical biosensors Electrochemical biosensors, particularly those applying one of the many voltammetry formats, have been shown to be a low-cost and extremely sensitive biosensor format. These sensors can be used to measure quantities of almost any molecule, from antibodies to bacteria, in media ranging from blood to untreated water from streams. This project would focus on developing a custom electrochemical sensor for an application of the student's choosing, in collaboration with the department of Physiology. Collaboration: Physiology, Tygerberg, Microbiology		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Signal processing, electrochemistry, statistics				
Microfluidic sample preparation Recent work has shown that relatively simple techniques can be used to greatly simplify sample preparation procedures for complex diagnostics through the use of microfluidics. This project would apply those methods to an assay in an attempt to improve lab-throughput of such tests by reducing or eliminating operator involvement. This is especially of interest for precision medicine applications. Collaboration: UCT, Physiology **Requirements:** Microfluidics, additive manufacturing, biochemistry		✓		
Wearable EEG device for disabled persons EEG has long been known to be a versatile and precise method of interfacing the human brain directly with computers, especially for persons with disabilities. However, EEG hardware is currently still very expensive and the use of such devices is limited to indoor settings where the bulky headgear will not be a problem. Additionally, the electrodes commonly used for EEG measurements require a conductive gel to be applied during use, which can be messy and difficult to remove. This project would apply modern fabrication methods to develop electrodes that are better suited to everyday use, as well as the necessary electronics for a wireless, wearable EEG system. Collaboration: Physiology **Requirements:** Integrated development, IOT, PCB design and fabrication, materials science, signal processing		✓		
Low-cost potentiostat device for IOT applications Voltammetry and related methods are fast becoming popular as a method of biosensing and environmental monitoring, especially in resource-limited settings such as Africa and Asia. Development of a low-cost, handheld potentiostat device capable of sensitive measurements and IOT connectivity would be a significant step towards bringing precision healthcare to rural Africa. This project would focus on developing such a low-cost potentiostat device. **Requirements:** Integrated development, IOT, PCB design and fabrication		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Blood spectroscopy for early detection of non-communicable diseases Recnt findings have shown that UV-VIS spectroscopy can easily be used to extract important information from unprocessed blood samples, potentially pointing to a method of detecting certain diseases without need of expensive biological reagents or chemicals. Combining this approach with suitable machine learning techniques could result in a powerful method for detecting the early signs of many non-commmunicable diseases. This project would focus on using existing equipment to gather data and perform machine learning to extract information from patient blood samples. Collaboration: Physiology **Requirements:** Signal processing, statistics, machine learning		✓		
Fabrication and optimisation of extreme optical transmission (EOT) sensors Exploitation of the wave-nature and quantum behaviour of light allows for very interesting behaviour in sensing devices. One such device with very promising characteristics is the EOT sensor, which may allow low-cost sensing to be done in the field with smartphones and little to no other instrumentation. This project would focus on optmising and refining an in-house fabrication method for realising EOT sensors. Collaboration: Physics **Requirements:** Multiphysics simulation, optics, electromagnetics, chemistry, numerical modelling		✓		
Optical waveguide sensors Optical sensors are a wide and versatile field of study, especially in precision sensing and non-destructive testing. Optical waveguides exploit the wave-nature of light to extract information about material properties from very small-scale structures, and if modified in appropriate ways these could even be used as ultra-sensitive biosensors. New fabrication methods and modelling techniques allow for more sensitive measurements than ever, and new machines in the E&E department now make in-house manufacture of such devices possible. This project would focus on the modelling and fabrication of an array of such devices and their use as sensors. Collaboration: Physics **Requirements:** Multiphysics simulation, optics, electromagnetics, lithography.		✓		

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
Comparative techno-economic assessment of dry cooling system alternatives for a 50 MWe concentrating solar power (CSP) application Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems is relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensures high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers situated inside a natural draft cooling tower. This study will evaluate the Levelized Cost of Electricity (LCOE) for each cooling option, as part of a 50 MWe concentrating solar power plant. The investigation will build on one-dimensional thermo-fluid models which have been developed for each of these systems to evaluate the performance of each over an annual basis. Costing models will also be developed towards performing the techno-economic evaluation for each alternative. (This project will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Sensitivity analysis on a natural draft direct dry cooling system (NDDDCS) for large- and medium-scale power generation applications Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems is relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensures high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers situated inside a natural draft cooling tower. This study will conduct a sensitivity analysis on the performance of a NDDDCS for changes to the heat exchanger configuration, heat exchanger performance characteristics, tower geometry and shape, and inclusion of wind mitigation measures. The investigation will build on current Computational Fluid Dynamics (CFD) models of a NDDDCS which have been developed for medium (100 MW CSP) and large (900 MW thermal) scale power generation applications. CFD simulations will be executed based on the updated geometries and features and the impact on system performance assessed. (This project will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a reduced order model (ROM) for a bespoke natural draft direct dry cooling system (NDDDCS) finned tube heat exchanger Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems is relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensures high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers situated inside a natural draft cooling tower. Mechanical draft ACCs employ flattened finned tube heat exchanger tubes. These tubes were specifically developed for mechanical draft applications and may not be optimal within the context of a NDDDCS. This study will develop a reduced order parametric model (ROM) of the thermo-hydraulic performance of a flattened finned tube heat exchanger, based on the results of multiple Computational Fluid Dynamics (CFD) simulations. The intention is to find the best combination of tube and fin geometry that would provide an optimal finned tube for application within a given NDDDCS. The work will continue the development of a current CFD model and ROM that evaluated limited parameter variations. The ROM will also be integrated into an existing one-dimensional NDDDCS model to predict the optimal tube configuration based on the selected NDDDCS design. (This project will be co-supervised by Prof Mike Owen and will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling annual performance of a natural draft direct dry cooling system (NDDDCS) for a 50 MWe concentrating solar power (CSP) application Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems is relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensures high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers situated inside a natural draft cooling tower. This study will develop a reduced order model (ROM) of NDDDCS performance as a function of ambient conditions (including wind), based on the results of multiple Computational Fluid Dynamics (CFD) simulations. The intention is to evaluate the annual performance of a NDDDCS without having to simulate each ambient condition using CFD. The work will continue development of an existing CFD model of a NDDDCS, and the investigation will consider system performance as part of a 50 MWe concentrating solar power (CSP) plant. The NDDDCS will be sized for a typical CSP application and design of experiments will be used to develop the ROM. (This project will be co-supervised by Prof Mike Owen and will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling annual performance of a natural draft direct dry cooling system (NDDDCS) using a deep-learning-based surrogate model and Monte Carlo analysis Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems is relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensures high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers situated inside a natural draft cooling tower. The aim of this study is to evaluate the annual performance of a NDDDCS as part of a large-scale (900 MWth) thermal power generation unit. It will continue the development of a Computational Fluid Dynamics (CFD) simulation model of the NDDDCS. However, the CFD cannot be used for the full year analysis due to the long simulation times. Therefore, the CFD model will be used to evaluate the performance for a limited number of ambient temperature and wind conditions to generate a data set that covers the complete envelope of operation. This data set will be used to train a deep-learning-based surrogate model of the system. The surrogate model will then be used to do a full-year Monte Carlo analysis based on appropriate meteorological and climatological data, without having to simulate each ambient condition using CFD. (This project will be co-supervised by Prof Pieter Rousseau) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Performance modelling of axial drive- and power turbines for a supercritical carbon dioxide (sCO2) power cycle Concentrated Solar Power (CSP) is a renewable energy source that generates electricity using direct solar radiation. CSP complements traditional energy sources like coal, natural gas, and nuclear. Environmental fluctuations and varying output requirements impact CSP plants' thermal and economic performance, causing efficiency reductions when operating off-design. Consequently, large and costly CSP plants are needed to meet energy demands. Techno-economic analyses indicate that improving power block efficiency can significantly reduce costs. Global research interest into supercritical carbon dioxide (sCO2) power cycles is increasing, due to their superior efficiencies and reduced component size requirements. These cycles, linked to CSP applications represent a modern evolution to sustainable and efficient power production. The design of turbomachinery for sCO2 cycles is critical, as efficiency greatly affects the system. The unique properties of CO2 in the critical region pose challenges, prompting extensive research. One-dimensional (1D) mean-line models are favoured for analysis and design due to their lower computational cost compared to three-dimensional (3D) Computational Fluid Dynamics (CFD) models. Choosing suitable loss correlations is key for accurate turbomachinery modelling and reliable efficiency results. This work aims to design efficient drive and power turbines for a 50 MWe CSP plant using a sCO2 power cycle. This involves preliminary turbine designs as well as developing 1D models that account for the real gas effects of CO2 and various loss mechanisms. Additionally, CFD simulations will validate the turbine designs at their selected operational speeds. (NOTE: This topic has already been allocated to a student for 2025.) (This project will be co-supervised by Prof Ryno Laubscher and will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Optimization of a natural draft direct dry cooling system (NDDDCS) for a supercritical carbon dioxide (sCO2) power cycle using an artificial-intelligence-based surrogate model Global research interest into supercritical CO2 (sCO2) power cycles is increasing, due to their superior efficiencies and reduced component size requirements. These cycles, linked to concentrated solar power (CSP) applications represent a modern evolution to sustainable and efficient power production. The sCO2 cycle needs a heat rejection system to dissipate heat loads from the pre-cooler and intercooler heat exchangers to the environment. To further enhance cycle efficiency and promote sustainability, a heat rejection system with low parasitic power- and no water consumption requirements would be very beneficial. Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). This study will optimize a NDDDCS for the pre-cooler and intercooler heat loads of a sCO2 power cycle, linked to a 50 MWe CSP plant. The work will modify and utilize an existing co-simulation model (coupled Flownex one-dimensional and Fluent three-dimensional Computational Fluid Dynamics model) that has been developed to assess the performance of a NDDDCS specifically for this application. The optimization will consider alternative cooling tower shape and heat exchanger configurations. A neural network surrogate model, to be developed using the co-simulation model, will be used to perform the optimization. (NOTE: This topic has already been allocated to a student for 2025.) (This project will be co-supervised by Mr Rashid Haffejee and will form part of research conducted by the Solar Thermal Energy Research Group) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigating the impact of site winds on utility-scale PV power plant output Solar power generation using Photovoltaic (PV) power plants has seen a dramatic rise in popularity in recent years. Large PV plants continue to be constructed all around the world, including South Africa. Due to the continually decreasing price of PV panels and the relative construction simplicity of such power plants, it is expected that they will remain competitive in the medium to long term. The efficiency of PV modules is negatively affected by an increase in operating temperature of the module. To predict power output accurately, it is important that the heat dissipation from the PV module is accurately modelled. Forced convection heat transfer from modules due to winds at a PV power plant site can reduce the operating temperatures of the modules. This reduction in temperature improves their efficiency and ultimately enhances the plant's output. The impact of wind on module temperature is likely to be different across the PV array and sensitive to both wind speed and direction. There is little understanding of this behaviour at present. This study will evaluate the impact of prevailing winds on the module temperature and corresponding output of a utility-scale PV power plant. Computational Fluid Dynamics (CFD) models will be used to evaluate the flow over the modules in order to determine their effective temperature. Existing one-dimensional models and / or commercial software will be used to assess the resulting impact on plant performance. With a better understanding of wind effects and associated temperature distributions, several possible research questions can be interrogated (e.g. is there a potential benefit to accounting for prevailing wind direction in the orientation of a PV plant?) (NOTE: This topic has already been allocated to a student for 2025.) (This topic will be co-supervised by Prof Mike Owen and Dr Arnold Rix (E&E), and a full scholarship from SCATEC will most likely be available) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		✓

Dr Boitumelo Ramatsetse
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- **Research Field**
  Reconfigurable Manufacturing Systems, Advanced Manufacturing Systems, Maintenance Systems and Life Cycle Assessment
- **General Description of Research Field**
  Reconfigurable Manufacturing Systems (RMS) are complex type of manufacturing systems designed to respond or address changes in demands in the manufacturing industry. Unlike dedicated manufacturing systems (DMS) and flexible manufacturing systems (FMS), which are often rigid and specialized for specific tasks or products, RMS are designed to be responsive to changes in product designs, production volumes, and process requirements. The most important Reconfigurable Manufacturing Systems (RMS) characteristics includes modularity, integrability, customization, convertibility and diagnosability. Reconfigurable Manufacturing Systems offer manufacturers a more agile and responsive approach to production, allowing them to adapt quickly to changing market demands and maintain a competitive edge in today's dynamic manufacturing environment. Thus, my research niche will focus on design of reconfigurable mobility platforms and systems to support integration of digital technologies for maintenance activities in various manufacturing industries.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling and performance evaluation of a reconfigurable assembly systems for production of automobile parts in manufacturing industries. An assembly system is a working arrangement where individual components are combined and joined to form a unit that may be further integrated with other components to create a final product. The purpose of this work is to design, manufacture, and testing of a Reconfigurable Assembly Systems (RAS) for production of automobile parts. This will be achieved by executing the following sub-objectives: (i) To conduct a part family classification of the sub-components, (ii) To develop an assembly mechanism for producing various components of the same part family, (iii) To perform a Finite Element Analysis (FEA) of the proposed RAS, (iv) To model and simulate the design using applicate software platforms and conduct a performance evaluating of the developed RAS system. This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from Tshwane University of Technology (TUT) & University of Johannesburg (UJ) to develop innovative reconfigurable manufacturing systems (RMS) solutions for addressing challenges in manufacturing industries. This research is led by the Principal Investigator (PI) Dr. Ramatsetse (NRF Y-Rated Researcher) and will be supported by NRF-DSI Chair in Future Transport Manufacturing Technologies. At this stage, funding is available only for the development of prototype solutions. Additional research funding will be sourced through the Technology Innovation Agency (TIA) seed funding programme. Upon selection of the topic, the candidate will be guided with the application of NRF Masters Scholarship using the project reference number. Should the application be successful, the candidate will be based full-time at Stellenbosch Campus, Mechanical & Mechatronics (M&M) building. **Requirements:** The prospective candidate must have sufficient scientific or engineering background in one or more of the following: Finite Element Methods, Machine Design and Strength of Materials. In addition, the candidate should be vast and experienced with the use of CAD software's such SolidWorks, Autodesk Inventor etc for modelling and simulation of industrial products.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling and performance evaluation of reconfigurable mobility systems in complex manufacturing environments. The need to respond rapidly to changes of market demands has posed new challenges for manufacturing systems paradigms. To sustain competitiveness in the dynamic and turbulent markets, manufacturing organizations should come up with innovative ways of re-designing products that adaptable, customised and agile to respond to the various client requirements. This project aims to design, simulate and prototype a reconfigurable mobility cart capable of adjusting its own shape, according to the environment, realizing a transformation of the structure into various configurations and vice versa while enhancing the functional capabilities of end-users. To achieve this, various concepts will be generated and compared using decision techniques such as Analytical Hierarchy Process (AHP) and Weighted Decision Matrix (WDM) etc. Furthermore, the Computer Aided Design (CAD) of the selected design will be subjected to Finite Element Analysis (FEA), tested and prototyped using available resources. This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from Tshwane University of Technology (TUT) & University of Johannesburg (UJ) to develop innovative reconfigurable manufacturing systems (RMS) solutions for addressing challenges in manufacturing industries. This research is led by the Principal Investigator (PI) Dr. Ramatsetse (NRF Y-Rated Researcher) and will be supported by NRF-DSI Chair in Future Transport Manufacturing Technologies. At this stage, funding is available only for the development of prototype solutions. Additional research funding will be sourced through the Technology Innovation Agency (TIA) seed funding programme. Upon selection of the topic, the candidate will be guided with the application of NRF Masters Scholarship using the project reference number. Should the application be successful, the candidate will be based full-time at Stellenbosch Campus, Mechanical & Mechatronics (M&M) building. **Requirements:** The prospective candidate must have sufficient scientific or engineering background in one or more of the following: Finite Element Methods, Machine Design and Strength of Materials.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a functional prototype of a full-scale reconfigurable mobility system with enhanced crab steering for ease of mobility in confined spaces Reconfigurable mobility systems have become an integral part of sustainable transportation. However, the challenge of maneuverability in confined spaces remains significant. While traditional steering mechanisms limit agility, crab steering, which allows for sideways movement, offers a promising solution. This proposal outlines a project aimed at producing a working prototype of a reconfigurable mobility system with enhanced crab steering specifically designed for ease of mobility in confined spaces. Although preliminary work has been conducted, additional resources are required to bring this project to the level of a fully functional and demonstrable prototype. In summary, the project aims to enhance vehicle maneuverability, providing a foundational platform for future autonomous mobility applications. The research will focus on the design, implementation, and testing of a reconfigurable mobility system with a unique steering mechanism. The expected outcome is a versatile reconfigurable mobility system with superior navigation capabilities in complex environments, setting the stage for future advancements in autonomous vehicle technologies. Objectives Primary Objective: Develop a working prototype of a small electric vehicle equipped with advanced crab steering technology tailored for urban environments. Secondary Objective: Demonstrate the enhanced maneuverability and operational capabilities of the vehicle in various urban scenarios. Tertiary Objective: Establish a platform for future research into the integration of this technology with autonomous driving systems. This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from Tshwane University of Technology (TUT) & University of Johannesburg (UJ) to develop innovative reconfigurable manufacturing systems (RMS) solutions for addressing challenges in manufacturing industries. This research is led by the Principal Investigator (PI) Dr. Ramatsetse (NRF Y-Rated Researcher) and will be supported by NRF-DSI Chair in Future Transport Manufacturing Technologies. At this stage, funding is available only for the development of prototype solutions. Additional research funding will be sourced through the Technology Innovation Agency (TIA) seed funding programme. Upon selection of the topic, the candidate will be guided with the application of NRF Masters Scholarship using the project reference number. Should the application be successful, the candidate will be based full-time at Stellenbosch Campus, Mechanical & Mechatronics (M&M) building. **Requirements:** The prospective candidate must have sufficient scientific or engineering background in one or more of the following: Finite Element Methods, Machine Design and Strength of Materials.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Dynamic analysis and modelling of reconfigurable robotic systems for complex maintenance activities in the manufacturing industry. Maintenance plays a crucial role for transport manufacturing industry. Most maintenance activities are still performed manually, thus resulting in safety concerns and inconsistencies due to human errors. Thus, more intelligent, and automated type of maintenance solutions are required to guarantee safety of operations as well as continuous availability of equipment during operations. This project aims to model and simulate a robotic end-effector to perform automated maintenance operations in the transport manufacturing industry. The Computer Aided Design (CAD) and the Finite Element Analysis (FEA) will be carried out using CAD design software's under different loading conditions. Furthermore, kinematics models of the designed end-effector will be modelled in MATLAB environment, including the kinematic motion and trajectory of the robotic end-effector along the X-Y and Z coordinates. This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from Tshwane University of Technology (TUT) & University of Johannesburg (UJ) to develop innovative reconfigurable manufacturing systems (RMS) solutions for addressing challenges in manufacturing industries. This research is led by the Principal Investigator (PI) Dr. Ramatsetse (NRF Y-Rated Researcher) and will be supported by NRF-DSI Chair in Future Transport Manufacturing Technologies. At this stage, funding is available only for the development of prototype solutions. Additional research funding will be sourced through the Technology Innovation Agency (TIA) seed funding programme. Upon selection of the topic, the candidate will be guided with the application of NRF Masters Scholarship using the project reference number. Should the application be successful, the candidate will be based full-time at Stellenbosch Campus, Mechanical & Mechatronics (M&M) building. **Requirements:** The prospective candidate must have sufficient scientific or engineering background in one or more of the following: Control Systems, Machine Design and Mechatronics		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a robust design methodologies for gearbox lubrication using data-driven and model-based approaches Gearbox damage and increased power loss can lead to extended downtime and higher repair costs, particularly in applications like wind turbine gears. Effectively designed lubrication systems, integrating data-driven insights and model-based simulations, are crucial for extending operational lifespan, reducing maintenance costs, and ensuring gearbox reliability. The main contribution of the proposed research work is to develop of a robust design methodologies for gearbox lubrication using data-driven and model-based approaches. The study begins with the development of a model that adequately captures the dynamic interaction between the gearbox and its tribological components. Following that, a sensitivity analysis is carried out, with an emphasis on geometry and lubricant parameters, using data received from a functioning gearbox. The following stage is to develop solid design methods and recommendations for effective gearbox lubrication. A test rig is then built to validate the established procedures. This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from Tshwane University of Technology (TUT) & University of Johannesburg (UJ) to develop innovative reconfigurable manufacturing systems (RMS) solutions for addressing challenges in manufacturing industries. This research is led by the Principal Investigator (PI) Dr. Ramatsetse (NRF Y-Rated Researcher) and will be supported by the NRF-DSI Chair in Future Transport Manufacturing Technologies. At this stage, funding is available only for the development of prototype solutions. Additional research funding will be sourced through the Technology Innovation Agency (TIA) seed funding programme. Upon selection of the topic, the candidate will be guided with the application of NRF Masters Scholarship using the project reference number. Should the application be successful, the candidate will be based full-time at Stellenbosch Campus, Mechanical & Mechatronics (M&M) building. **Requirements:** The prospective candidate must have sufficient scientific or engineering background in one or more of the following: Computer Aided Design (CAD), Mechanical Machine Design, Control Systems, Finite Element Analysis etc.			✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Advanced design models and cyber-physical social systems (CPSS) for enabling innovative mobility systems and supporting infrastructural services. This will be achieved by executing the following sub-objectives: (i) To identify major requirements for developing a CPSS framework model for transportmanufacturing sector. (ii) To develop a framework for implementation of a CPSS for the transport manufacturing sector (iii) To develop decision support system that will aid participation of users into new product design variants This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from University of Tweente, Netherlands to develop innovative reconfigurable manufacturing systems (RMS) and cyber-physical social systems for addressing challenges in manufacturing industries. This research is led by the Principal Investigator (PI) Dr. Ramatsetse (NRF Y-Rated Researcher) and will be supported by Prof Khumbulani Mpofu (NRF-DSI Chair in Future Transport Manufacturing Technologies). At this stage, funding is available only for the development of prototype solutions. Additional research funding will be sourced through the Technology Innovation Agency (TIA) seed funding programme. Upon selection of the topic, the candidate will be guided with the application of NRF Masters Scholarship using the project reference number. Should the application be successful, the candidate will be based full-time at Stellenbosch Campus, Mechanical & Mechatronics (M&M) building. **Requirements:** The prospective candidate must have sufficient scientific or engineering background in one or more of the following: Mechanical Engineering, Advanced Manufacturing, Data Science. In addition, the candidate should have interest in learning various simulation platforms used in the design and modelling of such systems.		✓		

Prof Pieter Rousseau
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- **Research Field**
  Thermofluid systems modelling
- **General Description of Research Field**
  Thermofluid systems include gas turbine, concentrated solar, nuclear, biomass, and coal-fired power plants; heat pumps and refrigeration cycles; water and gas distribution networks. Fundamental principles involved are thermodynamics, fluid mechanics, heat transfer, combustion, work/power. Modelling is applied to evaluate novel technologies, optimize system designs, improve efficiency and control, and detect anomalies for condition monitoring. Methods and tools include integrated process modelling (thermofluid networks), Computational Fluid Dynamics (CFD), surrogate models (Deep Neural Networks), and optimization techniques.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling annual performance of a natural draft direct dry cooling system (NDDDCS) using a deep-learning-based surrogate model and Monte Carlo analysis Modern thermal power plants in arid and semi-arid locations employ water conserving dry cooling technologies to reject the required heat from the cycle to the environment. Among these technologies are traditional mechanical draft air-cooled condensers (ACCs), natural draft indirect dry cooling systems and a new alternative, the natural draft direct dry cooling system (NDDDCS). ACCs employ a multitude of large diameter axial flow fans to force airflow across heat exchanger bundles. The capital cost of these systems is relatively low, but operational costs are high due to parasitic power consumption and maintenance cost on the many moving parts. Direct steam condensation inside the finned tubes of the heat exchangers ensures high thermal efficiencies. In contrast, natural draft indirect dry cooling systems use the natural draft created by buoyancy effects to drive airflow through a large cooling tower, and across heat exchanger bundles around the tower periphery at ground level. Such systems utilize a shell-and-tube condenser to condense the turbine exhaust steam, while a separate loop pumps the cooling water to be re-cooled in the cooling tower. Due to their large footprint, these systems have high capital costs, but operational costs are much reduced compared to the ACC due to the reduced rotating mechanical equipment requirement. Indirect steam condensation to cooling results in lower thermal efficiencies compared to direct systems. The NDDDCS combines the advantages of reduced operational cost of a natural draft system with the higher thermal efficiencies of direct steam condensation, as steam is conveyed directly from the turbine exhaust into heat exchangers situated inside a natural draft cooling tower. The aim of this study is to evaluate the annual performance of a NDDDCS as part of a large-scale (900 MWth) thermal power generation unit. It will continue the development of a Computational Fluid Dynamics (CFD) simulation model of the NDDDCS. However, the CFD cannot be used for the full year analysis due to the long simulation times. Therefore, the CFD model will be used to evaluate the performance for a limited number of ambient temperature and wind conditions to generate a data set that covers the complete envelope of operation. This data set will be used to train a deep-learning-based surrogate model of the system. The surrogate model will then be used to do a full-year Monte Carlo analysis based on appropriate meteorological and climatological data, without having to simulate each ambient condition using CFD. (This project will be co-supervised with Dr Hannes Pretorius) **Requirements:** Affinity for thermofluids, modelling and programming.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Optimization of turbomachinery layout for concentrated solar sCO2 power cycles with the aid of integrated thermofluid network modelling Supercritical carbon dioxide (sCO2) power cycles have been identified as a promising future power conversion technology due to its high cycle efficiency and compact footprint. Using sCO2 power cycles with concentrated solar power (CSP) technology would lead to smaller mirror fields compared to Rankine-based CSP plants that has the same power output level, making it a more competitive renewable energy solution. One of the major costs associated with sCO2 power cycles is that of the large recuperator heat exchangers. Researchers have shown that the heat exchangers can be drastically reduced in size, and thus cost, if the turbomachinery efficiencies are increased even marginally. The present project sets out to compare and optimize various turbomachinery layouts for a 50 MWe CSP sCO2 power cycle with the aid of integrated thermofluid network models. The study will include different turbomachinery types, such as centrifugal and axial, along with different shaft configurations, such as dual- and single-shaft layouts. Gradient-based and metaheuristic optimization algorithms will be applied to the integrated cycle simulation models to tune turbomachine parameters such as blade solidity and blade aspect ratios for the various compressors and turbines. The study will cover both steady-state and transient operating scenarios. (This project will be co-supervised with Prof Ryno Laubscher) **Requirements:** Affinity for thermofluids, modelling and programming.			✓	
Design evaluation of gas turbine combustor for aerospace applications The current project focuses on evaluating two preliminary design methods for annular gas turbines. Its primary objective is to design a 1 kN microjet engine combustor tailored for aerospace applications, employing the Mattingly and Lefebvre methods. This will involve developing custom codes in MATLAB or Julia for design refinement. Subsequently, comprehensive CFD models will be created to assess the efficacy of these design methods, specifically targeting combustion efficiency, mixing characteristics, and cooling capabilities within the combustors. The project aims to optimize performance and reliability, contributing to advancements in aerospace propulsion technology. (This project will be co-supervised with Prof Ryno Laubscher) **Requirements:** Affinity for thermofluids, modelling and programming.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A condition monitoring methodology for heat pumps using a physics based thermofluid model combined with parameter identification Being able to anticipate breakdowns to industrial equipment in advance can reduce the negative impacts caused by unexpected stoppages, especially where complicated logistics are involved to do repairs and maintenance. For this purpose, online condition-based monitoring can be applied to reveal incipient faults before breakdowns occur. These techniques can broadly be divided into model-based, or data driven approaches. The aim of this project will be to develop and demonstrate a condition monitoring methodology for heat pumps using a fundamental physics-based thermofluid model combined with parameter identification to simultaneously detect, locate, and quantify degradation occurring in the different heat pump system components. The methodology will be demonstrated with the aid of measurements on a laboratory scale vapour compression heat pump cycle. (This project will be co-supervised with Dr Rashid Haffejee) **Requirements:** Affinity for thermofluids, modelling, programming, and physical experimentation.		✓		
Development, validation and application of a thermofluid network-based model of combustion and aerodynamics in a microjet gas turbine cycle The micro gas turbine market for propulsion applications is projected to grow by 10% by 2030, driven by the increasing demand for both commercial and military applications. With a significant push in the aerospace industry towards sustainable fuels, hydrogen or hydrogen-energy carrier fuel sources such as ammonia are becoming increasingly important. However, information regarding the performance of micro gas turbines firing these fuels is scarce. Micro gas turbines, also called microjets, typically comprise of a diffuser, compressor, combustor, turbine, and nozzle, each of which is carefully designed to yield the maximum propulsive performance. Commercial design simulation tools typically omit details of the combustion performance. In the proposed work a detailed thermofluid network based model of an actual 250 N microjet will be developed that will include the necessary chemical kinetics to capture the combustion progression on a process level. This combustion functionality will be built on top of the South-African based software, Flownex SE. In addition to the combustor modelling, this project will also develop compressor and turbine models using validated loss modelling approaches and mean-line analysis to capture the steady-state and dynamic performance of the microjet when firing Jet A1. Results of the model will be compared to actual tests which will include pressure, temperature, mass flow rate and exit gas composition readings. The validated model will be used to simulate hydrogen and ammonia combustion in the 250 N microjet and if necessary, propose preliminary design modifications to the turbine and combustor. (This project will be co-supervised with Prof Ryno Laubscher and Dr Rashid Haffejee)		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Affinity for thermofluids, modelling, programming, and physical experimentation.				

Prof Kristiaan Schreve

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- **Research Field**
  Machine vision; Biomedical Engineering
- **General Description of Research Field**
  I am interested in applications and basic research related to machine vision in industrial and biomedical engineering environments. My main focus is on dimensional measurements and accuracy prediction in 3D applications using cameras (e.g. quality control, reverse engineering, diagnostics, etc.), however the field is also related to applications in robot navigation.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Integrated Length and Weight Measurement for Infants A crucial activity in nutrition surveillance is growth monitoring and promotion to timeously identify and treat children who are malnourished or at risk for malnutrition. Malnutrition, specifically stunting is much more than a physical condition. Stunting is when a child plots more than 2 standard deviations below the WHO Child Growth Standards' median. The nutritional status of infants is directly linked to their anthropometrical data, specifically weight and length. In a previous study, a device was built that integrates these two measurements and allows for the digital recording of the data and plotting on a growth chart. The current device is in a prototype stage. For effective use by clinicians, the device needs to be redesigned for usability and robustness. Firstly, the principal components of the device need to be packaged robustly. The measurement process must be stream lined so that it can be done fast and accurately. The data recording (including age, ID, clinician, photo's, etc.) must be automated as much as possible keeping in mind the clinical setting. Fail safes need to be built into the device to prevent incorrect recording of data. **Requirements:** Python programming experience. CAD modelling.	✓			
Anti-rotation device for patients lying in traction Patients with femur fractures in some rural hospitals wait a very long time for surgery, some times up to 6 weeks. During this time, the patient lies in traction and it is not unusual that the fracture heals during this time. With current traction systems it is not always possible to prevent rotation of the foot, which means that the fracture can heal in the wrong orientation. To some extent, Thomas splints (e.g. https://emed.ie/Procedures/Thomas_Splint.php) can help in these instances, but there are some practical problems with their use, e.g. many different sizes are required for different sized patients. Some patients also refuse to wear them. A low cost anti-rotation device is needed that can be incorporated into existing traction systems in typical South African rural hospitals. It also requires a low cost weight system.	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: CAD modelling.				
Design of a low-cost intraosseous needle In many parts of the world, a high number of deaths among small children and babies result from dehydration that can be prevented with suitable fluid resuscitation treatment (https://www.rch.org.au/clinicalguide/guideline_index/intraosseous_access/). An intraosseous needle, inserted into the tibia or distal femur, is typically needed for this treatment. These needles currently can cost more than R2000 (https://be-safe.co.za/product/nio-intraosseous-needle/). Compared to the cost of a typical syringe needle of less than R1, this is very expensive. Although syringe needles can be used for this procedure, there are a number of detractors. The long bevel of the typical needle means that it must be inserted deep into the bone. If it is inserted too deep, especially in small children, one can drill through the bone, and if it is not inserted deep enough, the fluid will leak. A bone marrow biopsy needle is an alternative solution. This needle is too long for the fluid resuscitation treatment, because it is not easy to fasten to the skin to hold the needle in place for several hours while administering the fluid. A possible design alternative is a needle with a threaded shaft (https://patents.google.com/patent/EP0490517A1/en). Making the needle strong enough to penetrate the bone, having an appropriate bevel for this procedure, and making the needle thin enough to minimise the impact of the procedure, cost, and manufacturing are some of the major design considerations making this a very challenging project. In this project, a needle must be designed, manufactured and tested. **Requirements:** n/a	✓	✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Low cost, do-it-yourself, below knee prosthesis There is a dire need for access to prosthetics in South Africa. In the Western Cape alone, it is estimated that there are 1000+ lower limb amputations annually. The main causes of these are firstly diabetes, peripheral vascular disease and secondly trauma due to road accidents. It is not unusual for patients to wait 2 years or longer for a prosthetic limb, many patients are excluded due to strict criteria being applied in the public health system. High costs involved in the production of prosthetics necessitate the application of these criteria so that only small portion of amputees with the highest fitness level and those close to the relevant facilities can access this benefit. There can also be considerable delays, of up to several months, between the initial fitment to the provision of the prosthesis. This can result in the prothesis not fitting any more. After provision of the prothesis, patients typically require several weeks of assistance from clinicians such as physiotherapists. In this research a low cost, do-it-yourself solution is proposed in combination to self-help video training aids if the patient cannot get access to a therapist. The solution should give the patient at least some use of the amputated leg to the extent that they can walk with limited use or without a walking aid. There are several design challenges: the materials should be readily obtainable and of low cost, the design must as far as possible be manufacturable with basic "handyman" tools, a load bearing attachment for the prothesis to the leg is needed and a foot with rotatable or flexible angle is needed that makes walking on level and inclined surfaces possible. As a first phase of the project, existing approaches to below knee prosthetics must be researched, preferably in terms of the main functions of the prosthetic. The ideal of DIY prosthetics is not new. One example is: https://www.dezeen.com/2019/09/06/diy-prosthetics-guide-desiree-riny/. This is a continuation of existing projects. New projects will focus on one or more of the following aspects: building prototypes and testing on amputees; developing fitment procedures for the DIY user; developing training assistance for the DIY user. **Requirements:** To be determined	✓	✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Trail Runner Motion Capture In sports science, motion capture is the process of measuring the motions of an athlete during normal sports activities. The measurements are useful to help athletes and trainers improve techniques, assisting with rehabilitation after injuries, better understanding of the sports discipline, etc. There are many commercially available motion capture systems available, e.g. the Vicon system (https://www.vicon.com/) which is an camera based system, or inertial systems https://www.vicon.com/hardware/blue-trident/. Camera based systems are widely considered the gold standard, but they often are limited to laboratories, indoor training areas, or limited outdoor use, because the cameras are typically connected in a wire network and mounted on heavy tripods and require lots of ancillary equipment. This makes it difficult to use in some sports disciplines, e.g. cycling, running, etc. We are currently working on a mobile system, where the cameras can be mounted on drone following the athlete. Our first prototype system can capture the motion of a cyclist. However, to use this system in its current format for trail running, will not be possible, since the markers are not ideal and it also requires reference markers on the bicycle frame. In this project, the system must be developed further so that it can be used for trail runners as well. **Requirements:** Programming (python). Mathematics at 2nd year level. Knowledge of image processing and/or stereovision will be useful, but not required.		✓	✓	

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
The Accuracy of Pose Estimation in a Photogrammetry Photogrammetry is a technology that utilizes photographs of an environment to generate a 3D model of that particular space. The cost of cameras has decreased significantly, while their quality has improved. Cameras designed for precise measurements are now employed in various applications, ranging from high-accuracy surveying to robotics. In the field of photogrammetry, the primary focus traditionally lies in assessing how accurately an environment can be mapped using two-dimensional images to reconstruct three-dimensional spaces. This involves analyzing and processing image data to create detailed and precise representations of physical locations. However, a crucial aspect that is often overlooked is the accuracy with which the pose, or the position and orientation, of the cameras used in the imaging process can be determined. While photogrammetry has made significant strides in improving the precision of environmental mapping, this research shifts the focus to evaluating the accuracy of camera pose (position and orientation) estimation. This project seeks to address the question of how precisely the pose of cameras can be estimated, given various influencing factors such as camera calibration, image quality and landmarks. **Requirements:** A love for programming.		✓		
A Novel Heliostat Facet Design A heliostat is a facet (mirror) placed on a pedestal. The facet is controlled by two actuators so that it reflects and concentrates solar rays onto a target that can be hundreds of meters away. Our research group has done a lot of work on new heliostat designs. The design shows a lot of promise. This project aims to design a heliostat facet for mass production. The design should then be built and tested. **Requirements:** None.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
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. **Requirements:** Good programming skills.		✓		
Closed-loop Control of Heliostats Heliostats are essential components in concentrated solar power (CSP) systems. They track the sun and reflect sunlight onto a central receiver. Traditionally, heliostats have operated using open-loop control systems, relying on pre-calculated sun positions and a fixed set of instructions to orient the mirrors. This approach uses mathematical models of the sun's trajectory and the heliostat's position to ensure that the reflected sunlight is directed accurately to the receiver. The downside of open-loop control is that the heliostat structure needs to be very stiff and the foundations expensive, as even the slightest deformation of the structure or settling of the ground can cause the heliostat to reflect the solar rays away from the receiver. A commercial company has recently developed a solution to the closed-loop control problem. They have implemented a system that uses four cameras around the central receiver. These cameras look back at the heliostat field and capture the corona of the sun reflected by the heliostats. The images from the four cameras are used to control the heliostats. **Requirements:** None.		✓	✓	

Mnr Wayne Swart

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- **Research Field**
  Biomedical Engineering
- **General Description of Research Field**
  Biomedical engineering encompasses many fields of research, including biomechanics predominantly for orthopaedic applications, implant design, prosthetics, diagnostic devices and technology that supports therapeutic applications. The Biomedical Engineering Research Group (BERG) have strong ties with various practitioners at Tygerberg campus, most notably in the fields of orthopaedics and psychiatry. We also strive for continual industry engagement with various companies with different specialties.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Olfactory stimulus for augmented VR anxiety treatment This project is in collaboration with the Tygerberg Psychiatric department. The purpose of this project is to determine the efficacy of olfactory stimulation as a fear enhancement tool during the use of VR (virtual reality) exposure therapy procedures. VR has proven to be a useful tool for exposure therapy purposes in anxiety conditions (Freitas et al., 2021). Olfactory enhanced VR treatment could be relevant in treatment procedures for anxiety and related disorders. The primary objective of the project will be to develop, test and validate an olfactory stimulus device that can accurately control smell intensity and guarantee quick response times in smell dissipation after delivery. This will require a rigorous test methodology to ensure a high confidence that the desired stimulus intensity is being achieved. The secondary objectives will be to investigate the effect of olfactory stimulus in VR environments in terms of subject response; and the development of a closed-loop control system for anxiety level stimulus using heart rate variability and EDA (electrodermal activity) response. This project will require the student to design an electromechanical device and therefor the candidate should be comfortable with multi-disciplinary applications. A background in electronics and measurement will be an advantage. Additionally, some control theory may have to be applied in the design. This project forms part of a collaborative research effort with the Department of Psychiatry at Tygerberg campus and may require the candidate to visit Tygerberg campus to discuss and experience the clinical nature of the aimed applications. As such, the candidate will be expected to conduct themselves in a respectful and professional manner. Freitas, J.R.S., Velosa, V.H.S., Abreu, L.T.N., Jardim, R.L., Santos, J.A.V., Peres, B., Campos, P.F., 2021. Virtual Reality Exposure Treatment in Phobias: a Systematic Review. Psychiatr. Q. 92, 1685–1710. https://doi.org/10.1007/s11126-021-09935-6	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Some electronics and measurement background will be beneficial. Some programming background (predominantly C based applications) will be beneficial.				
Exploring the use of Virtual Reality Based Visualization for pain management in burn care This project is in collaboration with the Tygerberg Psychiatric department. Although some studies suggest that virtual reality (VR) serves as a useful addition to burn wound pain management techniques, it is not yet fully understood whether VR simply serves as a distraction or if it affects pain perception. The purpose of this project will be to investigate the affect of VR in pain management through the design of an experimental procedure and the associated stimulation and monitoring equipment, which will include a finely controlled temperature stimulus device as well as ambient temperature sensing. Furthermore, a measuring technique to quantify subject reflex response to the stimulus in terms of time and acuteness of physical motion will have to be designed and developed. The VR stimulus will be delivered by means of a commercial VR system; however, some digital environmental design will be required. A background in temperature measurement and control as well as electronic design is highly recommended to any candidate for this project. This project will require the student to design a controlled electrically driven device and therefor the candidate should be comfortable with electronic applications. A background in electronics and measurement will be an advantage. Additionally, some control theory may have to be applied in the design. This project forms part of a collaborative research effort with the Department of Psychiatry at Tygerberg campus and may require the candidate to visit Tygerberg campus to discuss and experience the clinical nature of the aimed applications. As such, the candidate will be expected to conduct themselves in a respectful and professional manner. **Requirements:** A background in driving electronics, measurement and control will be beneficial. Some programming background (predominantly C based applications) will be beneficial.	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of modular fNIRS platform Functional near infrared spectroscopy (fNIRS) is an affordable alternative to fMRI. The compact nature of the technology also makes it useful for studies that require subjects to perform tasks, which is why it is frequently implemented in psychiatric interventions. The current state of the art in commercial devices does not, however, provide researchers with modular options that can be integrated with other devices such as virtual reality (VR). As VR is currently a popular tool for exploring new exposure based interventions, a combined system that can stimulate the subject and measure hemodynamic responses at the same time. The objectives of this project are to develop and validate a modular fNIRS system as well as investigating the optimal number and placement of emitter-sensor pairs for reliable hemodynamic measurements. The successful candidate will have to apply knowledge in electronic design, firmware and software development as well as signal processing. A mechanical design for the head mounted sensors will also be needed. Finally, the candidate will have to demonstrate competence in various experimental designs to both validate and inform optimized placement of the emitter-sensor pairs. Thie will require thorough testing on human subjects which means the candidate will have to acquire ethics approval for their project. **Requirements:** Candidate must be competent in the fields of electronic design, firmware and software development, signal processing and mechanical design procedures. Candidate must also be able to design experimental procedures and be comfortable with interaction with human subjects.	✓	✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigation into the Mechanical Behavior of External Fixator Wires This project is in collaboration with the AOTC at Tygerberg campus. External fixators such as the Ilizarov frame are frequently employed in the treatment of bone fractures, particularly in the lower limbs. Healing mechanics require the relative movement at the fracture site along the axis of the bone whilst constraining lateral motion. This is achieved by the surgeons by connecting the bone on each side of the fracture to the frame by means of a crossed K-wire configuration. Some questions remain about the optimal K-wire tension particularly regarding wire tension as a function of time. Contradictory reports in literature concerning slippage and plastic deformation create an ambiguity which poses the need for further investigation. The aim is to determine the mechanical behavior of wires to provide a better understanding of how these wires could be utilized more efficiently in a clinical setting. The purpose of this project is not to investigate the optimal wire tension to facilitate healing mechanisms, but rather to provide insight into the properties of the K-wire throughout the clinical application cycle. The primary objectives are therefore to provide a comprehensive analysis of K-wire properties through the development of theoretical models and validation with experimental procedures. The project will require the development of an appropriate tensiometer that can be used to determine the tension of K-wires during post-operative consultations. The candidate should also have a strong professional work ethic as they will be expected to interact with researchers at Tygerberg campus and possibly make use of their laboratory services. **Requirements:** Mechatronics Mechanics modelling Mechanical design Experimental design Measurement and analysis		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Quantization of Bacilli Density in TB Research This project is in collaboration with the Division of Molecular Biology and Human Genetics at Tygerberg Campus. As part of the investigation into the efficacy of pharmaceutical interventions in Tuberculosis (TB) research, bacteria cultures are frequently exposed to mechanical stresses through various means in order to "declump", or, separate the bacteria colonies into smaller concentrations. The measure of separation remains a qualitative process through which researchers use a yes / no criteria on whether the culture have been sufficiently declumped. The purpose of this project is develop a quantization tool that can process microscope images of the cultures and give feedback on the density of bacilli by means of image processing. The algorithm should also be able to detect damage to the bacilli cell walls. Validation of the algorithm through experimental procedures and comparison with the qualitative analysis of expert researchers will be required. The ultimate goal is to be able to investigate the effects of the different mechanical separation methods over a range of parameters. The successful candidate will have to demonstrate competence in image and signal processing, experimental design and an understanding of statics and dynamics. Candidate should also have a strong professional work ethic as they will be expected to interact with researchers at Tygerberg campus and possibly make use of their laboratory services. **Requirements:** Signal processing background. Skills in programming. Experimental design. Understanding of statics and dynamics.	✓	✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Optimization of Declumping Parameters This project is in collaboration with the Division of Molecular Biology and Human Genetics at Tygerberg Campus. As part of the investigation into the efficacy of pharmaceutical interventions in Tuberculosis (TB) research, bacteria cultures are frequently exposed to mechanical stresses through various means in order to "declump", or, separate the bacteria colonies into smaller concentrations. Three primary declumping methods, namely centrifuging, ultrasound baths and syringing are commonly employed to achieve declumping of the bacteria culture. The centrifuge method is commonly employed to separate fluids of different density by spinning the culture around a vertical rotation axis at high speed. Ultrasound treatment makes use of high frequency excitation in which formation of cavitation bubbles in the solution destroy the bacteria clumps. Finally, syringing is a mechanical treatment method that forced the culture back and forth through a thin aperture between two syringes. The primary objective of this project is to identify the optimal parameters for these methods in terms of achieving the desired concentration of bacilli, i.e. rotational speed and time, excitation frequency and time and aperture size vs. plunger speed etc. Furthermore, an investigation into the threshold for cell damage will need to be conducted. Since the mechanical interventions are frequently destructive to bacilli cell membranes. The successful candidate needs to demonstrate an understanding of the mechanics and dynamics in the methods to be investigated and demonstrate competence in experimental design. This project has strong modelling, analysis and experimental components. The candidate should also have a strong professional work ethic as they will be expected to interact with researchers at Tygerberg campus and possibly make use of their laboratory services. **Requirements:** Competence in multidisciplinary experimental work. Good understanding of mechanics and dynamics. Strong affinity for modelling and analysis.	✓	✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of Mechanical Declumping Device This project is in collaboration with the Division of Molecular Biology and Human Genetics at Tygerberg Campus. As part of the investigation into the efficacy of pharmaceutical interventions in Tuberculosis (TB) research, bacteria cultures are frequently exposed to mechanical stresses through various means in order to "declump", or, separate the bacteria colonies into smaller concentrations. One commonly used technique to declump cultures is the syringing method. This is a mechanical treatment method that forces the culture back and forth through a thin aperture between two syringes. Currently this is makeshift application wherein the researcher will couple two syringes together nozzle to nozzle and push down the plungers sequentially. This poses a significant risk to the researcher as mechanical failure of the device can cause injury and exposure to the bacterial culture. Furthermore, the parameters of the process, i.e. plunger force and speed, are uncontrolled, resulting in non-repeatable interventions. The primary objective of this project is to develop an automated syringing device, providing a user-friendly procedure to mount the syringes and add the culture in a safe and time efficient manner. Variable apertures and programmable cyclic frequencies must be implemented. The device should also implement force feedback from the plungers to determine the resistance to flow. The candidate should be proficient in mechatronic applications. I.e. mechanical and electronic and sensing designs are required. This includes the development of control and analysis software. The project also has a strong experimental component. The candidate should also have a strong professional work ethic as they will be expected to interact with researchers at Tygerberg campus and possibly make use of their laboratory services. **Requirements:** Mechatronics Control implementation Electronics Mechanical design Software development Experimental design and execution	✓	✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
NONINVASIVE FETAL BRAIN TEMPERATURE (FBT) PROJECT The fetal brain has to operate with narrow thermal margins and is generally well protected against maternal hyperthermia. Global warming and several obstetric conditions may result in safety limits to be exceeded. Fetal temperature is generally considered to be 0.5 °C (0.3-1 °C) warmer than the mother. Hyperthermia-induced malformations particularly involve the central nervous system during elevation of maternal core temperature by 1.5 to 2 °C above the baseline, (= 39 °C), which has been demonstrated to be the threshold above which there are fetal developmental consequences in most mammalian species. In humans, ethical considerations prevent the type of interventional studies performed extensively in other species to examine harmful effects during pregnancy. Consequently, advice for pregnant women about heat exposure is inconsistent, and not evidence-based. A project will now be undertaken by the Biomedical Engineering Research Group at the University of Stellenbosch, to investigate the feasibility of developing mobile, "point-of-care" methods to perform non-invasive FBT measurements under field circumstances and in clinics. This research has the potential to improve antenatal care through the establishment of new pregnancy management guidelines when incriminating FBT's are encountered and will especially be of value to the most vulnerable communities unable to protect themselves from high ambient temperatures. The objectives of the project are to design and develop a suitable phantom model that can simulate the temperature dynamics for a fetus in utero to serve as a validation for the temperature measurements, and to investigate and evaluate various non-invasive and non-destructive temperature measurement techniques that may be utilized for point-of-care applications. The successful candidate will have to develop and implement temperature control systems and be competent in the development and execution of experimental design procedures. **Requirements:** Measurements and actuation Experimental design	✓	✓		

Dr Nicole Taylor

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- **Research Field**
  Mechatronic Engineering
- **General Description of Research Field**
  I am a Lecturer in Mechatronic Engineering that has an interest in human-centred design approaches for the development of digital twin systems.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
HUMAN-SYSTEM INTEGRATION (HSI) AND HUMAN CYBER-PHYSICAL SYSTEMS RESEARCH FIELD DESCRIPTION South African (and worldwide) enterprises will continue to rely heavily on people in the midst of Industry 4.0 and the paradigm shift to integrating human skills with advanced technologies in the rise of Industry 5.0. Our research integrates humans into/with CPSs, both as task executors and decision makers. We aim to retain people's exceptional capabilities and overcome their limitations using digital technologies. Our research employs enabling technologies such as collaborative robots, pose sensing, and virtual and augmented reality. Our current industry partners include: Mediclinic, Mandela Mining Precinct, Hortgro (agricultural producers' organisation), Mintek RESEARCH GROUP INFORMATION Prof Basson and Dr Taylor co-supervise students in both research fields, directing the Mechatronics, Automation and Design Research Group (MAD website: https://www.sun.ac.za/mad). Our research group provides a supporting and stimulating environment where all students work with real-world applications. CONTACT DETAILS Dr Taylo: nctaylor@sun.ac.za Prof Basson: ahb@sun.ac.za **Requirements:** We welcome students from any engineering background with a strong affinity for developing software for real-world applications.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
DIGITALISATION OF SOUTH AFRICAN ASSETS RESEARCH FIELD DESCRIPTION Industry 4.0 has enabled revolutionary digital transformations in the transportation sector worldwide. In this research, we advance the novel development of digital technologies enabled through digitalisation and its application in a South African context. Two national treasures are focussed on: • The SA Agulhas II, South Africa's polar supply and research vessel; and • Commuter trains manufactured specifically for South Africa. We aim to improve the management capabilities of these assets through building digital twins for the SA Agulhas II, called Vessel 4.0 (https://svrg.sun.ac.za/digital-transformation-of-sa-agulhas-ii/), and commuter trains, including the X'Trapolis Mega (https://www.gibela-rail.com/our-trains). The digital twins' functionalities are diverse, from integrating structural vibration techniques and complex signal analysis to human-system integration for smart asset health monitoring and maintenance. Our current programme and industry partners include: the South African National Antarctic Programme and Gibela Rail Transport Consortium. INDIVIDUAL TOPICS 1. Transformation of models from hindsight to insight/foresight providers for Vessel 4.0 (potential funding relies on successful NRF application by student) 2. Development of a human cyber-physical system for train operational maintenance support (potential funding available) RESEARCH GROUP INFORMATION Prof Bekker directs the Sound and Vibration Research Group (SVRG website: https://www.svrg.sun.ac.za). Together with Dr Taylor, they co-supervise students interested in digitalisation of South African assets. The SVRG provides an interactive and stimulating research environment with group meetings during the semester that supplement weekly individual meetings. CONTACT DETAILS Dr Taylor: nctaylor@sun.ac.za **Requirements:** Please note potential funding availabilities by the listed individual topics. If you have any ideas outside of the listed individual topics, please reach out to Dr Taylor (nctaylor@sun.ac.za). We welcome students with initiative!		✓	✓	✓

Dr Gerrit Ter Haar
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- **Research Field**
  Overcoming metal corrosion degradation in hydrogen cells
- **General Description of Research Field**
  Metal corrosion is a significant challenge in hydrogen electrolyzers and fuel cells, primarily due to the harsh electrochemical environments present in these devices. In electrolyzers, the anode experiences highly oxidizing conditions during the oxygen evolution reaction, leading to corrosion of metallic components. This corrosion can result in the degradation of electrode materials, reduced efficiency, and contamination of the produced hydrogen. This metal degradation not only diminishes the performance and lifespan of the devices but can also lead to the release of metal ions that may poison catalysts or contaminate membranes. Consequently, the development of corrosion-resistant materials and protective coatings is crucial for enhancing the durability and efficiency of hydrogen electrolyzers and fuel cells. Corrosion-resistant materials such as titanium are popular, but expensive. Therefore, to reduce costs, materials engineers are investigated alternative approaches. One such approach is in using low-cost material (e.g., stainless steel) and applying ani-corrosive surface treatments. This project entails investigating cheaper alternative materials, characterising them and validating their performance in an anodic environment that matches that of real-world cell conditions. Potential funding is available.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Overcoming metal corrosion degradation in hydrogen cells Metal corrosion is a significant challenge in hydrogen electrolyzers and fuel cells, primarily due to the harsh electrochemical environments present in these devices. In electrolyzers, the anode experiences highly oxidizing conditions during the oxygen evolution reaction, leading to corrosion of metallic components. This corrosion can result in the degradation of electrode materials, reduced efficiency, and contamination of the produced hydrogen. This metal degradation not only diminishes the performance and lifespan of the devices but can also lead to the release of metal ions that may poison catalysts or contaminate membranes. Consequently, the development of corrosion-resistant materials and protective coatings is crucial for enhancing the durability and efficiency of hydrogen electrolyzers and fuel cells. Corrosion-resistant materials such as titanium are popular, but expensive. Therefore, to reduce costs, materials engineers are investigated alternative approaches. One such approach is in using low-cost material (e.g., stainless steel) and applying ani-corrosive surface treatments. This project entails investigating cheaper alternative materials, characterising them and validating their performance in an anodic environment that matches that of real-world cell conditions. **Requirements:** Interested in materials science and comfortable working in a materials laboratory.	✓	✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design, build and test a solid oxide electrolysis cell A Solid Oxide Electrolysis Cell (SOEC) is a device that uses electricity to split water (or sometimes carbon dioxide) into hydrogen (and potentially carbon monoxide). Operating at high temperatures (600-900°C), SOECs are highly efficient, particularly when using waste heat or renewable electricity. This makes them a promising technology for large-scale hydrogen production, energy storage, and carbon utilization. However, the high operating temperatures present challenges, such as material degradation, thermal cycling stress, and high costs. Research is focused on improving durability, reducing costs, and optimizing integration with renewable energy sources. This project entails the design, manufacturing and testing of a small-scale SOEC with a focus on materials engineering to overcome the challenges mentioned. **Requirements:** Previous experience with design and manufacturing of mechanical systems will be useful. Interested in materials engineering.		✓		✓
Materials engineering of metal hydride hydrogen storage structures Hydrogen is emerging as a crucial tool in the global effort to reduce carbon emissions. One of the main challenges remains safe storage of hydrogen. Storing hydrogen in compressed tanks is dangerous and therefore other methods are being researched such as metal hydrides. Metal hydride technology allows for solid-state hydrogen storage through absorption and desorption processes. This method is safer than pressurized tanks and suitable for distributed storage, especially in South Africa where it reduces the need for extensive hydrogen infrastructure. To enhance reaction kinetics, powdered metal hydrides with large surface areas are used in storage tanks. Powdered metal hydrides however have poor thermal diffusivity, causing inefficiencies such as uneven temperatures in the tank, longer activation times, slower hydrogen loading, and difficulties in scaling up tank size. This project aims to develop novel metal hydride storage tanks that are structurally optimize for improved thermal management. These tanks are to be build using additive manufacturing (3D printing) from metal hydride materials. The feasibility of using additive manufacturing to build complex porous structures from metal hydride materials remains uncertain. Therefore, this research investigates additively manufactured porous (e.g., periodic and random open cellular porous) metal hydride structures. **Requirements:** Interest in materials science / engineering and design for additive manufacturing.		✓	✓	✓

Dr Adam Venter
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- **Research Field**
  Aerodynamics, Computational Fluid Dynamics, Turbomachinery
- **General Description of Research Field**
  Computational fluid dynamics modelling, principally encompassing: the design and analysis of next-generation aerodynamic architectures; the development of robust low-fidelity turbomachine rotor models for large-scale industrial system analyses, and high-fidelity modelling of renewable energy systems.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Experimental exergetic analysis of airfoils Traditional multidisciplinary design, analysis and optimization (MDAO) studies are often limited by the clumsy process of heuristically assigning scaling coefficients to the different criteria that make up their composite objective functions. However, recently, it has been proposed that this limitation can be removed by using a unified exergetic analysis approach, where each contributing mechanism of the objective function is described in consistent terms. For instance, consider some representative flight vehicle: an exergetic analysis could determine that the propulsion system is destroying 8 MW of exergy, while its other subsystems are only destroying 500 kW. From this analysis, it would then make sense for the optimizer to further focus on the propulsion system to find the greatest performance gains. Exergetic analyses are also considered to be more intuitive and could enable novel insights not discernible by classical methods. To facilitate this new track of exergetic MDAO research at the university, a methodology to experimentally validate future exergetic computational models is needed. This study will therefore focus on developing and verifying a means of postprocessing exergetic information from experimental particle-image-velocimetry data. This research will be co-supervised by Prof. Johan van der Spuy. **Requirements:** CFD		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Enhanced low-fidelity modelling of industrial cooling fans at off-design flow conditions Reduced-order turbomachine rotor models find widespread application in industrial system simulations, given their favourable computational overheads. However, their simplified nature extracts a penalty in terms of accuracy as these models can only provide a limited approximation of real rotor behaviour. Nonetheless, their use in large-scale system investigations is anticipated to persist for the foreseeable future given the highly prohibitive nature of alternative higher-fidelity numerical models. The continued improvement of reduced-order rotor models is therefore of key importance. The development of actuator-disk type rotor models has been a historically important research field at Stellenbosch University, where our latest efforts have led to the development of a new model formulation called the Augmented Actuator-Disk Method (AADM). The AADM has since demonstrated promising performance capabilities and holds promise to notably enhance our ability to accurately model system dynamics; however, further verification of the model's performance, over a wider spectrum of fan types and inlet flow conditions, is still required. This study will therefore concentrate on completing this verification process. This study will consider benchmark testing of the new AADM model for a host of different fan-types under both ideal and, more complex, cross flow (off-axis) inlet flow operating conditions. **Requirements:** CFD		✓		
Optimising specific energy consumption in raceway ponds for large scale aquafarming of seaweed for biofuel generation Seaweed is emerging as prominent resource in the transition to sustainability in many industries. A common type of farming occurs in onshore ponds, where the seaweed is kept in suspension using aeration or paddle wheels to introduce turbidity into the water. A key parameter for the economic feasibility of any land-based aquaculture project is the energy required to keep the seaweed suspended. This study will use numerical models to optimise raceway pond geometry for minimum specific energy consumption while maintaining adequate turbidity distribution. Co-supervised with Prof. Michael Owen **Requirements:** CFD		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
The design of novel wing-tip flow devices for general aviation (GA) aircraft based on exergy destruction (anergy) minimization The exergetic analysis method is gaining recognition as a game-changing assessment tool for the design of future aircraft configurations. An exergetic assessment enables researchers to break down the total energy of a flight vehicle/system into its 'recoverable part' (exergy) and its 'non-recoverable' part (anergy), highlighting where further gains invisible to classical methods could be made. It is therefore expected that the exergetic method could lead to new insights and novel aerodynamic designs (as already seen in emerging boundary-layer ingestion (BLI) and blended-wing aircraft designs). Accordingly, to explore the potential advantages of the exergetic approach and to further verify it as a useful tool for next-generation aircraft design, this study will look at optimizing the wing-tip shape of an existing representative GA aircraft (Cessna 210) based on this new approach. This study will also consider the use of adjoint optimization solvers in commercial CFD codes to facilitate the emerging aerodynamic research field at the university. **Requirements:** CFD		✓		
Exploring the use of exergy as a low-cost drag indicator for rapid numerical optimization of aerodynamic bodies The optimization of aircraft based on classical aerodynamic analysis techniques is a highly expensive exercise. Classical aerodynamic calculations require us to accurately resolve the pressure distributions along an aircraft's lifting surfaces which demand computationally large, finely discretized CFD models. This presents a challenge to aircraft optimization studies, and we would like to find ways to circumvent this high computational expense. Accordingly, this study will investigate whether a comparative exergy-based aerodynamic analysis (based on far-field flow phenomena) can serve as an appropriate low-cost (course resolution CFD model) calculation alternative. Preliminary research supports the use of an exergy-based approach to accurately predict aircraft drag using lower-resolution CFD models; however, further investigation is needed to better understand the reliability of the method concerning changing flight conditions (Mach number, flow separation etc.) and other model parameters. This research will be facilitated by Prof. Markus Rumpfkeil from Dayton University, Ohio. **Requirements:** CFD		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
An assessment of different atmospheric flow modelling approaches for a wind farm site in South Africa Research collaboration with industry partner. Accurately predicting the long-term energy production at a wind farm is a multi-faceted, non-trivial engineering problem. To support this task, an engineer needs to forecast the long-term wind resources across a site using relatively short-term onsite wind measurements. However, available short-term measurements can only be extrapolated so far until uncertainty levels become too high – especially for sites with complex terrain and complex atmospheric flow scenarios. Accordingly, wind farm designers use a multitude of wind flow modelling and prediction software, ranging in complexity from simple linear flow solvers to high-fidelity computational fluid dynamics (CFD) models. A recent trend in industry has been the development and implementation of 'high-resolution' large-eddy simulation (LES) based numerical weather prediction (NWP) models, which are directly applied to estimate wind farm losses and turbine field energy production. The inclusion of atmospheric physics within LES-based simulations represents a significant potential advancement in prediction accuracy. However, the relative advantage of a fully-fledged LES NWP model (which can resolve flow features directly down to 20m), over a meso-micro coupled RANS CFD approach, is not yet fully quantified. This study therefore aims to implement, verify and evaluate the advantage of LES-based weather prediction modelling using candidate open-source flow solvers and validation data from an existing wind site in South Africa. This project will be co-supervised by Dr. Andrew Gill **Requirements:** CFD		✓		✓

Prof Gerhard Venter

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- **Research Field**
  Computational (structural) mechanics with a 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 biomedical applications, material characterization using inverse modelling, several topics related to automotive truck design, digital stereo vision and digital image correlation (DIC) software development and related topics.

  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
Characterizing Friction Losses in a Bicycle Drive Train The MOD group recently developed an experimental setup for measuring losses in a bicycle drive train. This setup can measure friction losses in bearings, the chain under full tension and the complete drive train under full load. From a practical perspective, the bearing tests are always required. For the friction losses in the chain, the full tension load test is preferred, but it is not clear how to relate this data to the full load test which better approximates the real life use of the drive train. This project will be a follow up project from a previous MEng study that will concentrate on two aspects to better understand the relationship between the full tension and the full load tests. The project will involve: 1. Fine tuning of the current experimental setup to obtain the most accurate data possible. This will involve small design changes that should be incorporated into the current design where necessary 2. Analytic and numerical modelling of the drive train to better understand the losses in each of the different tests. The modelling aspect will be a major new thrust for this project 3. Validation of the these analytical and numerical models against the experimental setup. The project is in a unique position to have the experimental setup available for the validation of the analytical and numerical models The goal would be to use the analytic and numerical models as a basis for better understanding the correlation needed between the full tension and full load tests. This will be a major contribution to industry which currently does not have a clear means of making this correlation. This project will include a practical design aspect, experimental work as well as programming in the Python programming language. Numerical modelling will be done using the rigid body dynamics code Adams. **Requirements:** Python programming, numerical simulation, experimental work		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Several Topics in Commerical Truck Design and Manufactoring The MOD group has a long standing collaboration with a commercial company that is involved in designing commercial trucks for the American market. The design office is located in South Africa and sponsors multiple topics in this general area each year. These projects come with partial or full funding plus a job commitment after completion of the studies. The new topics for 2025 have not been released yet, but past topics included: 1. Structural optimization of chassis components 2. Load recovery from experimental strain gauge data 3. Fatigue testing of welded connections in high strength steel and of bolted connections in high strength steel 4. CFD simulation and aerodynamic optimization of truck bodies 5. Digital vision applications for self driving trucks 6. High level modelling of heat recovery in electric vehicles 7. Hyper-elastic and visco-elastic material characterization of rubber material used as vibration isolators The 2025 topics will be released shortly and one can expect topics in these same general areas. **Requirements:** Generally these topis require numerical simulation, some programming (typically in Python) and the application of optimization techniques		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Open Source DIC Software Development Digital Image Correlation (DIC) is a non-contact optical method for obtaining full field displacement and strain data from the surface of a structure under load. Commercial systems (hardware and software) exist to do this and the department currently have two such systems available. Due to the high cost associated with the commercial solutions combined with the growing the need for the technology from our under-graduate and post-graduate students, the MOD group is developing an open source DIC software system. This software is currently able to solve the planar (or 2D) problem, but needs to be extended to also solve the stereo (or 3D) problem. In addition, integration with hardware (cameras and lighting) is also required to provide a complete solution for future researchers. This project will be heavily software based where the student will be tasked to extend the current version of the software to the stereo environment using two cameras. The student will also integrate the software with off the shelf hardware to provide a fully functional planar and/or stereo solution for future use by under-graduate and post-graduate students. The main components of the project will be: 1. Python software development to expand from the planar to the stereo version 2. Hardware selection and integration to provide a complete hardware and software system for future use 3. Comparison of the results obtained from the open source version with that obtained from the commercial solutions 4. Experimental work to validate the results obtained **Requirements:** A strong desire for become proficient in open source software development in the Python programming environment. Both Mechanical and Mechatronic students could be ideally suited for this topic, provided they have a strong interest in software development.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Numerical Modelling of Flat Spots on Train Wheels This topic will develop a numerical model that can be used to simulate the effect of railway wheel and track defects (discontinuities) on ground vibration generation and propagation. A specific focus will be on flat spots on the wheels, which represent is a serious maintenance issue for the rail industry. This will most probably require the development of a simplified dynamic model of the train and the defect to generate input to a finite element model of the trail and the ground surrounding the rail. Such a numerical model can be used to investigate the effect of different defects on the environment, specifically from a vibration point of view. Critical parameters and the sensitivity of ground vibration to these parameters can be investigated. The model can also be used to help detect defects in wheels from experimental data. A large library of experimental data is already available for use in this project. This project will be co-supervised by Dr Brendon Nickerson. Funding is available in the form of a bursary from the Gibela chair. **Requirements:** Interest in numerical modelling		✓		✓

Prof Eugene van Rensburg
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- **Research Field**
  Renewable energy, Bioprocess development, Fermentation, Mushroom valorisation
- **General Description of Research Field**
  Prof van Rensburg's main research interests include (i) bioprocess development with emphasis on fermentation systems and associated up- and downstream processing where microbes and their products are exploited for commercial gain, (ii) biomass processing and extraction of valuable products, and (iii) energy generation from agricultural, bioprocessing and industrial wastes. He seeks to integrate these foci in a multidisciplinary approach where bio-based technologies can be applied to address the Food-Energy-Water Nexus triple challenge within the context of sustainable development in rural Africa.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Curbing food losses through solar drying integrated with biogas-assisted dehumidification Solar thermal drying is a mature technology and converting perishable food to shelf-stable commodities through dehydration is a proven practice. Yet, effective technologies remain under-utilised in rural African settings that are frequently characterised by high levels of poverty and malnutrition. More than 30% of all fresh produce in sub-Saharan Africa (SSA) is lost or wasted after harvesting due to spoilage or damaged during storage, transport and at markets. Affordable and low technology level interventions are thus required to lower the barriers to innovative technology deployment. On-farm drying is a potential solution to this challenge, which additionally empowers rural small farmers to add value and serve more predictable markets. Anaerobic digestion (AD) of farm wastes e.g., offcuts generated in the preparation for drying, such as peeling and trimming, in combination with farm animal manure, is a synergistic technology that can provide biogas as a source of heat for absorption cooling or dehumidifying desiccation, to provide a dehumidification system integrated with solar drying. This study aims to assess the effectiveness of AD in combination with on-farm solar drying on representative food applications, such as fish, fruit, vegetables and leafy greens, as part of a circular food waste prevention system. An opportunity is available for postgraduate research to investigate the use of waste to generate cooling through the combustion of biogas from anaerobic digestion (AD) to avoid food spoilage, especially at the post-harvest stage. Integration of the AD technology with a solar drying system forms a unique aspect of the work. Such technology is specifically targeted at subsistence farmers in rural settings throughout the African continent where such a robust and rugged system will serve as a key intervention to minimise food losses by drying. The project will include (i) technical modelling to determine mass and energy balances to determine the sizing of all equipment components, including AD reactor, dehumidifier components and the contribution of solar radiation, (ii) development, commission, and test a drying system, (iii) integrate the dehumidifier into a real size (ca. 80 kg capacity) hybrid solar drying technology system consisting of a solar drying tunnel with forced air circulation, and (iv) use experimental data to populate a simulation model to estimate financial return and benefits through avoided food waste. Note, the project will use synthetic biogas, which means the incumbent will not be required to do anaerobic digestion. The project will be fully funded and will include a competitive bursary. **Requirements:** BEng Mechanical Engineering	✓	✓		✓

Dr Johan van der Merwe
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- **Research Field**
  Data-informed preoperative planning and endoprosthesis design.
- **General Description of Research Field**
  Conventional implant systems may result in sub-optimal patient outcomes due to a mismatch between implant geometry and pathological anatomy. Potential causes include misrepresentation of the target population or severe defects outside of the original system's design scope.

  Patient-specific solutions are an attractive alternative due to the capabilities afforded by additive manufacturing. However, the development of patient-specific devices is a multidisciplinary and iterative process that requires extensive effort on the part of various stakeholders. This could lead to increased expense and delays in treatment within an already resource constrained healthcare system. Ideally, the benefits associated with standardized implant systems such as economy of scale, logistical efficiency, and quality control, should be pursued where possible.

  Therefore, this research follows a data-informed approach to implant design and preoperative planning, to enable targeted standardization of implant systems and design processes, and predictive automation of patient-specific solutions. Applications in orthopedic and maxillofacial surgery include planning, fixation, large defect reconstruction and joint replacement.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design of internal fixation implants for the femur and tibia Anecdotal evidence suggests that imported fixation plates for the femur and tibia fit poorly during the treatment of South African patients. Local surgeons speculate that this may be due to a mismatch between the geometry of their patients and that of the subjects' data used when designing the implants. Therefore, the aim of this project is to design a series of internal fixation plates that best fit a sample of South Africans. Project objectives include construction of a statistical shape model of the femur and tibia, followed by analysis of the captured shape variation, and the subsequent design and evaluation of a parametric plate model from which to generate the implant series. **Requirements:** Engineering design, statistics, programming.	✓	✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design and characterization of synthetic bone grafts Critically sized bone defects do not heal without surgical intervention. Autografts, the current preferred treatment option, results in secondary morbidity, while allografts are limited by donor availability and may be subject to transplant rejection. Therefore, additively manufactured synthetic bone grafts made from engineering materials such as titanium, are an attractive possible alternative treatment for critical sized bone defects. The aim of this project is to design and characterize a stochastic lattice that mimics the structure and mechanical properties of bone, such as porosity and anisotropic stiffness. Generation of implant geometry will be subject to various parameters which affect the properties of the lattice. These relationships must be characterised so that future biomedical engineers may tailor the desired implant properties to suit a specific patient's needs. The use case for this project will be the treatment of critically sized defects in the femur. **Requirements:** Finite element analysis, experimental techniques, computer aided design, programming	✓	✓	✓	
Design of a temporomandibular joint replacement wear simulator Joint replacements are subject to wear, which must be characterised before new implants are made available on the market. Currently, there are no wear test standards or simulators available for temporomandibular joint replacements. Therefore, the aim of this project is to design a temporomandibular joint replacement wear simulator. Specific objectives include identifying relevant displacement and loading profiles, mechatronic design of the wear simulator including modelling and control, and the construction and testing of a suitable prototype. Wear protocols may be adapted from existing standards for knee and hip replacements. **Requirements:** Mechatronic design, systems engineering, modelling and control systems design	✓	✓	✓	
Design and simulation of an antibiotic eluding device Space filling, truss-based, metallic implants are accompanied by the risk of reinfection. One possible solution to this problem is to incorporate a reservoir of bioresorbable material embedded with antibiotics into the implant itself, that releases the antibiotics over time. The aim of this project is to design an additively manufactured, lattice-based reservoir that may be filled with the antibiotic material. Specific objectives include programming a simulation of Fick's law of diffusion to characterise important properties such as the antibiotic release rate and duration to design parameters such as volume, surface area, and porosity. In vitro experimental validation of the simulation must be conducted. **Requirements:** Scientific programming, engineering design, experimental techniques	✓	✓	✓	✓

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
The development of a 30 kW turboprop micro gas turbine. An existing project has developed the methodology for the design of a 30 kW turboprop micro gas turbine. This project will continue this work by developing an actual gas turbine engine. Specific emphasis will be placed on the engine's drivetrain components. **Requirements:** CFD, thermofluids 344		✓		✓
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. A current master's has already done a first round concept design of the turbine. This project will look at the final design of the turbine, as well as its manufacturing. **Requirements:** CFD, turbomachinery		✓		✓
Developing a mixed flow compressor for a micro gas turbine An existing micro gas turbine engine is equipped with a centrifugal compressor and diffuser stage. Existing work has looed at replacing the centrifugal compressor with a mixed flow design that promises to improve the performance of the gas turbine. The purpose of this work will be to complete the development of the mixed flow stage, for installation in an existing gas turbine platform. The work will require significant co-operation with outside companies. Specific emphasis will be placed on the possible use of additive manufacturing processes for the compressor stage.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: CFD, thermofluids 344, strong CAD skills				
Improving 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 both stable and unstable conditions. The idea is to expand this work in order to improve the fan's performance under various operating conditions. The possible improvements will be modelled in CFD and implemented in the large diameter fan. **Requirements:** CFD		✓	✓	✓
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	✓	✓	✓	✓