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M&M Post-Graduate Topics

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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 focuses 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, making 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, Dr Steed and Dr Taylor co-supervise students. The Mechatronics, Automation and Design Research Group's website is at 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.		✓	✓	✓

Prof Annie Bekker

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

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Measurements and signal processing for the detection of train wheel damage The GIBELA Engineering Research Chair has developed a vibration measurement technique with laser triggers to detect individual train wheels that pass over an instrumented track section. The entry and exit of every train wheel and the known distance between train axels enables the instantaneous estimation of the train speed. Vibration peaks in the time signal on the track correspond to sections on the wheel where damage is present on the wheel tread. It remains to visualize and improve the interpretation of these signals by analysis in the angle domain - where vibration is mapped to the angle of wheel rotation. Another exciting development includes the use of high speed thermal imaging where differences in the wheel contact signature can be observed. This project will involve measurements on the rail track in the Gibela Paarden Eiland Depot. The work will include further development of sensing, signal processing and data management techniques. The classification of wheel faults will entail the development of a well-founded data-driven classification algorithm. This project will run under the GIBELA Engineering Research Chair (GERC). GIBELA is manufacturing 600 trains locally for the South African Rail Sector. The company is responsible to maintain this fleet of trains until 2035. Students who work in GERC enjoy access to industry interaction, work on real trains, presentation and evaluation of their work at the annual Gibela Research Seminar. Read more at: https://gerc.sun.ac.za/ **Requirements:** A background in vibration or strain measurement and some knowledge on signal processing is an advantage. The candidate should be a self-starter with a willingness to travel and to work hands-on with data and experiments.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A laser measurement system to monitor train wheel wear Rail wheel maintenance accounts for a major expense in the operation of a passenger rail fleet. Maintenance decisions are based on the monitoring of wheel wear and degradation of the train wheel profile. In practice, each train in South Africa's new X'trapolis train fleet undergoes wheel profile measurement in a depot environment every 2 months. The profile is measured by using a miniProf contact measurement device. An operator is required to perform manual measurements on each of 48 wheels, requiring about 2 hours to complete. The present project proposes the measurement of rail wheel profiles using a rail-mounted laser measurement system to capture the wheel profiles on a passing train. Currently, the Gibela Engineering Research Chair (GERC) has developed a system which is capable of capturing a single wheel profile on each passing wheel provided that the relative motion between the laser profile sensors and rail is not excessive. The lessons learnt from this first project point to clear improvements which are possible in terms of signal processing and mounting of the current prototype. Additionally, the deployment of such a system on the operational fleet has significant practical and research value. A student on this project will design, build and test a laser-based wheel profile measurement system in the laboratory and in a rail environment. The work will kick-off with the evaluation of the existing prototype rig and its measurements, along with design improvements to extract improved wheel profile measurements. The communication and format of data to the rail depot team should compliment existing wheel profile measurements. This project will run under the GIBELA Engineering Research Chair (GERC). GIBELA is manufacturing 600 trains locally for the South African Rail Sector. Students who work in GERC enjoy access to industry interaction, work on real trains, presentation and evaluation of their work at the annual Gibela Research Seminar. Read more at: https://gerc.sun.ac.za/ Supervisors: Prof Annie Bekker & Prof Kristiaan Schreve **Requirements:** The topic lends itself to individuals who enjoy geometry and the understanding of uncertainty / precision. Are you keen mind and genuine interest in engineering? Do you prefer to solve a research problem that benefits your education, whilst having research value AND an industry application?		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
On the optical inspection of train condition Camera systems are increasingly used in asset monitoring systems. The rail industry is no exception. This work will investigate sensing techniques and applications where camera footage in combination with other sensing techniques such as thermography or other mechanical sensors (strain / vibration) from a trackside monitoring rig to capture the condition of a passing train from a wayside vantage point or onboard, depending on the selected application. This project will run under the GIBELA Engineering Research Chair (GERC). GIBELA is manufacturing 600 trains locally for the South African Rail Sector. The company is responsible to maintain this fleet of trains until 2035. Currently, 280 X'Trapolis Mega trains have been manufactured. This dynamic train fleet incurs failures and requires maintenance. Despite the modern train design and onboard sensors, there is no means to detect mechanical degradation / faults. Optical techniques are promising to automate inspections that rely on manual observation. Cameras can be used to monitor mechanical failures such as bolts that have rotated, damaged windows or missing parts. Optical systems may also be used to investigate failure scenarios. An example is the observation of wheel-rail interaction when turning on a problematic rail section, where the dynamic situation requires to be observed. A student on this project will set up experimental rigs in the laboratory and in a rail environment. Environmental and societal (such as theft) considerations should be accounted for in rig design. The work will entail the acquisition of data, image analysis and signal processing to extract monitoring metrics. The communication and format of data to the rail depot team should additionally be considered. Students who work in GERC enjoy access to industry interaction, work on real trains, presentation and evaluation of their work at the annual Gibela Research Seminar. Read more at: https://gerc.sun.ac.za/ **Requirements:** Do you enjoy learning new skills? This work will require new background knowledge in optics, camera vision and signal processing when considering an engineering background. Are you a self-starter with a willingness to work hands-on in a research and industry application? It will take dedication to create surrogate tests and to gather / optimize footage from passing trains in an operational environment.		✓	✓	✓

Prof Deborah Blaine
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- **Research Field**
  Materials Engineering
- **General Description of Research Field**
  The majority of my research focuses on the link between manufacturing and processing procedures and the final properties of materials, working with the properties of materials to design functional materials that are fit for purpose. I particularly focus on powder metallurgy which includes a wide range of manufacturing processes, including additive manufacturing.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design of process for Wire Arc Additive Manufacturing technique (WAAM) in the hydrogen and aerostructure environment The South African Department of Trade, Industry & Competition (DTIC) has awarded funds through their THRIP programme to local aerospace composite manufacturer Petrawell (https://www.petrawell.com/) in collaboration with Stellenbosch University and the University of the Western Cape for the Scalable Metal Additive platform for hydRogen and space applicaTions (SMART) project. Funding is available for MEng(R) 2026-2027 with a focus on designing the control system for a robotic arm and developing the process for wire arc additive manufacturing. WAAM will be used to build metal moulds for the composite structures, such as hydrogen storage tanks, and composite structures for satellites. The project requires evaluation of the material built using this process in order to refine the process by controlling the process-properties link. Students with interest in materials and/or control systems are encouraged to apply. The THRIP programme is designed to integrate academic and industrial research - strong potential for joining the Petrawell team after graduation exists. **Requirements:** BEng Mechanical or Mechatronics, 60% average		✓		✓

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, primarily through frictional action. Examples of granular materials include sand, soil, mined ore, grains such as wheat and corn, powders, etc. These materials are abundant in nature and are also found in the mining, agricultural, food, and pharmaceutical industries, where the term "bulk solid" is commonly used to describe them. 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 20 years and have successfully developed equipment and techniques for the calibration of non-cohesive materials. This project aims 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 sort. For more information on our research group: https://blogs.sun.ac.za/gmrg/ **Requirements:** None		✓	✓	✓

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
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
Agricultural Engineering This is an open invitation for students interested in agriculture and engineering to propose any topic related to agricultural engineering. This can include any of the following (and more): - Soil tillage (ploughs). - Soil-tool interaction (see the topics on DEM for some background). - Earthmoving equipment - design and improvement/optimisation. - Agricultural equipment design and improvement/optimisation. - Bulk materials handling, such as grain silos, conveyors, and food processing (see the topics on DEM for some background). - Irrigation systems. - The cold chain (cooling and refrigeration). - Packaging design and improvement, in terms of structure and/or cooling requirements. - Design and/or application of sensors and control systems (mechatronic engineering). Funding in the form of a bursary/scholarship is not available for self-proposed topics, but direct project costs (materials and running expenses) will be covered. **Requirements:** Depends on the specific topic.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Predicting the cooling of citrus fruit in the cold chain 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 preserves 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 for 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 RCs is recorded, but the sensors are expensive. Machine learning should be used to develop models that can predict the temperature distribution inside an 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's study, which will provide a very good background and starting point for 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's and/or PhD student(s) is most likely available from 2026 onwards. **Requirements:** Students would be required to follow the CFD postgraduate course if not already followed as an undergraduate course at Stellenbosch.		✓	✓	✓

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
Using Magnesium alloys as a substitute for Aluminium and Titanium Alloys High performance metal alloys are of interest for a diverse amount of industries and applications. Magnesium alloys have gained interest in recent years as an alternative to Aluminium and Titanium alloys. For the Magnesium alloy to be considered as a viable option, we need to have confidence in the structural integrity of the material. Applications of interest are in the aerospace, automotive, transportation and many others. This investigation will focus on obtaining the mechanical properties such as fatigue, fracture, tensile and microstructural characterisation of a Magnesium alloy. This will need to be compared with "conventional" alloys to assess its viability for industry use. **Requirements:** Minimum: Strength of Materials W334 Advantageous: Finite Element Method	✓			✓
Building a predictive model for train derailment avoidance 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:** Strength of Materials W334 Finite Element Methods		✓		✓

Topics	**MEng Struct**	**MEng Resrch**	**PhD**	**Potential Funding**
The structural integrity of railway and train wheel interface One of the common problems our railways are facing are the defects which are forming due to wear occurring at the railway track and wheel interface. This often leads to flats spots on the wheel (the wheel is no longer fully circular) as well as track irregularities causing further problems such as unwanted vibrations, noise, material deterioration and more frequent shutdowns for maintenance. It is believed that by characterising the wear fracture properties (mode II fracture), a suitable model of the railway track and wheel's health (structural integrity) can be developed. **Requirements:** Minimum: Strength of Materials W334 Advantageous: Finite Element Methods	✓			✓
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		✓		
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		✓		

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 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		✓		✓

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

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
CFD modelling for wind resource measurements You need to model a large offshore body in CFD. This model will help decide on the placement for a met mast, to ensure minimal blockage effects from the base structure and nearby obstacles. Note this is not an Msc focused on computational fluid dynamics. CFD is just a tool for the project. The project explores wind measurement techniques, best practices as they line up with IEC 61400-12 and building knowledge for potential offshore studies in RSA **Requirements:** Wind energy background.	✓			
Techno-economic study of small wind turbines for City of cape town To assist in reducing the city's reliance on Eskom the student will investigate the range of small scale wind turbines in the market. The student will also make use of WASA 3 libraries to determine the wind conditions in and around the city. With the market survey complete the student will then have to site and model the distribution of small scale wind turbines. The output of the project is a proposed distributed wind plan for the city to increase their renewable energy implementation while keeping the costs as low as possible **Requirements:** wind energy course	✓			

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: Lymphatic flow is a very slow flowing, one dimensional system, which main function is to transport lymph from the extremities back to the circulatory system. Very little information exits on how the lymph flows through the ducts within the human body. 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 of the lymph within a peristaltic lymphatic duct and then verify the models by use of experimental work. **Requirements:** CFD	✓			

Dr. 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, heat pumps, 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
Comparison of conventional and physics-informed deep neural networks for surrogate modelling of sCO2 heat pumps This project aims to develop and demonstrate a methodology for creating surrogate models of supercritical CO2 (sCO2) heat pump cycles using physics-informed neural networks (PINNs). PINNs reduce the reliance on extensive experimental datasets typically required to train conventional neural networks by embedding physics based equations within the neural network's loss function. This shifts the training process from supervised learning, which relies on example data points, to unsupervised learning guided by the governing equations. The project will evaluate suitable existing PINN frameworks, potentially including graph-based PINNs, and explore libraries for implementation in the Python programming language. The hypothesis is that this approach will deliver computational performance comparable to or superior to conventional multilayer perceptron (MLP) neural networks, while providing highly efficient and adaptable surrogate models suitable for applications such as parameter identification and optimisation. The scope of work includes developing a comprehensive sCO2 heat pump cycle model in Python; generating pseudo-"measured" data using the Python model; training surrogate models based on conventional MLP neural networks using the simulated data; developing and training a PINN-based surrogate model; and analysing and comparing the performance of the PINN and MLP surrogate models based on metrics such as accuracy, training time, and runtime. (This project will be co-supervised by Dr Rashid Haffejee and Prof Pieter Rousseau) **Requirements:** Affinity for thermofluids, modelling, mathematics, and programming.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A condition monitoring methodology for heat pumps using physics-based thermofluid models, machine learning, and parameter identification Anticipating failures in industrial equipment can significantly reduce the adverse effects of unexpected downtime, particularly in scenarios involving complex logistics for repairs and maintenance. To this end, online condition-based monitoring can be employed to detect incipient faults before they result in breakdowns. These techniques can broadly be categorised into model-based or data-driven approaches. This project aims to develop and demonstrate a condition monitoring methodology for heat pumps, utilising fundamental physics-based thermofluid models together with machine learning and parameter identification to simultaneously detect, locate, and quantify degradation in heat pump system components. The scope of work includes developing a comprehensive heat pump cycle model in Python; conducting laboratory measurements; using these measurements to calibrate and validate the Python model; training surrogate models based on conventional multilayer perceptron (MLP) neural networks using various combinations of simulated and measured data; applying the surrogate model with parameter identification for condition monitoring; and demonstrating the methodology on the laboratory setup. (This project will be co-supervised by Dr Rashid Haffejee and Prof Pieter Rousseau) **Requirements:** Affinity for thermofluids, modelling, programming, and physical experimentation.		✓		

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**
Thermal management of a greenhouse in an arid environment Solar thermal energy is a clean alternative for fossil fuels in supplying heat to various industries. The downside is that energy is only available whilst the sun shines, and energy must be stored for continuous operation throughout the day. A system comprising of a packed bed of crushed rock using air as heat transfer fluid is one of the cheapest and most environmentally benign methods to store heat. Applications vary from (seasonal) temperature control in mines (heating in winter and cooling in summer), daily temperature control in greenhouses and buildings (cooling during the day and heating at night), heat for industrial process, and power generation to name a few. Designing a thermal energy system requires that engineers understand the various heat transfer processes happening simultaneously between the solid particles and the heat transfer fluid. Much work has been done for spherical particles in pebble bed nuclear reactors, but the is a lack of information on the heat transfer and pressure loss coefficients for irregular shaped particles. This research is aimed at determining these coefficients for rock beds. Access to this information will allow designers to find good cost/performance balance for rock bed thermal energy systems. In a hot and dry environment, it is imperative to minimize moisture loss, and keep temperatures down for optimum plant production. The greenhouse canopy is good at preventing moisture loss, but it increases the temperature inside the greenhouse. Shading, and using an earth heat exchanger to capture cool ambient air at night, and releasing it inside the greenhouse during the day can potentially lower the temperature inside the greenhouse. In winter, the earth heat exchanger can be used to capture warm air during the day for release in the greenhouse during the night. The objective of the study is to (a) model air flow in the greenhouse, (b) estimate the amount of shading that would reduce the heat load but won't affect photosynthesis significantly, and (c) size the earth heat exchanger for a particular application. **Requirements:** Students may find the following modules useful for their research: Advanced Fluid Mechanics, Advanced Heat Transfer, Numerical Fluid Dynamics and Solar Thermal Energy Systems.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Particle convective heat transfer coefficient in a packed bed of crushed rock General description of research field: Solar thermal energy is a clean alternative for fossil fuels in supplying heat to various industries. The downside is that energy is only available whilst the sun shines, and energy must be stored for continuous operation throughout the day. A system comprising of a packed bed of crushed rock using air as heat transfer fluid is one of the cheapest and most environmentally benign methods to store heat. Applications vary from (seasonal) temperature control in mines (heating in winter and cooling in summer), daily temperature control in greenhouses and buildings (cooling during the day and heating at night), heat for industrial process, and power generation to name a few. Designing a thermal energy system requires that engineers understand the various heat transfer processes happening simultaneously between the solid particles and the heat transfer fluid. Much work has been done for spherical particles in pebble bed nuclear reactors, but the is a lack of information on the heat transfer and pressure loss coefficients for irregular shaped particles. This research is aimed at determining these coefficients for rock beds. Access to this information will allow designers to find good cost/performance balance for rock bed thermal energy systems. The objective of this project is to express the heat transfer coefficient in a packed bed as a function of: • particle Reynolds number, • a particle diameter and shape factor, • particle/flow alignment, and • packing density. The work can be either experimental, numerical (using a combination of discrete element modelling and computational fluid dynamics), or a blend of both. **Requirements:** Students may find the following modules useful for their research: Advanced Fluid Mechanics, Advanced Heat Transfer, Numerical Fluid Dynamics and Solar Thermal Energy Systems.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Conductive and radiative heat transfer in a packed bed of crushed rock Solar thermal energy is a clean alternative for fossil fuels in supplying heat to various industries. The downside is that energy is only available whilst the sun shines, and energy must be stored for continuous operation throughout the day. A system comprising of a packed bed of crushed rock using air as heat transfer fluid is one of the cheapest and most environmentally benign methods to store heat. Applications vary from (seasonal) temperature control in mines (heating in winter and cooling in summer), daily temperature control in greenhouses and buildings (cooling during the day and heating at night), heat for industrial process, and power generation to name a few. Designing a thermal energy system requires that engineers understand the various heat transfer processes happening simultaneously between the solid particles and the heat transfer fluid. Much work has been done for spherical particles in pebble bed nuclear reactors, but the is a lack of information on the heat transfer and pressure loss coefficients for irregular shaped particles. This research is aimed at determining these coefficients for rock beds. Access to this information will allow designers to find good cost/performance balance for rock bed thermal energy systems. When a packed bed is fully charged, the bed is idle and there is no flow and convection become negligible. Heat is transferred by conduction between neighbouring particles via conduction through particles, particle/particle contacts (contact resistance to be determined) and the surrounding air, as well as thermal radiation. The objective of this study is to develop models that deal with conduction and radiation in a packed bed, either separately or in combination. **Requirements:** Students may find the following modules useful for their research: Advanced Fluid Mechanics, Advanced Heat Transfer, Numerical Fluid Dynamics and Solar Thermal Energy Systems.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Turbulence modelling in porous media Solar thermal energy is a clean alternative for fossil fuels in supplying heat to various industries. The downside is that energy is only available whilst the sun shines, and energy must be stored for continuous operation throughout the day. A system comprising of a packed bed of crushed rock using air as heat transfer fluid is one of the cheapest and most environmentally benign methods to store heat. Applications vary from (seasonal) temperature control in mines (heating in winter and cooling in summer), daily temperature control in greenhouses and buildings (cooling during the day and heating at night), heat for industrial process, and power generation to name a few. Designing a thermal energy system requires that engineers understand the various heat transfer processes happening simultaneously between the solid particles and the heat transfer fluid. Much work has been done for spherical particles in pebble bed nuclear reactors, but the is a lack of information on the heat transfer and pressure loss coefficients for irregular shaped particles. This research is aimed at determining these coefficients for rock beds. Access to this information will allow designers to find good cost/performance balance for rock bed thermal energy systems. Flow through porous media is tortuous, and the presence of the solid matric causes early transition to turbulent flow and 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:** Advanced fluid mechanics and Numerical Fluid Dynamics 414/814 or equivalent would be advantageous.		✓	✓	

Mrs. Lindi Grobler Kock
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- **Research Field**
  Biomedical engineering
- **General Description of Research Field**
  Biomedical engineering with a focus on cardiovascular disease modelling.

  My research focusses on the fluid dynamics and structural mechanics of the cardiovascular system and the development of novel diagnostic parameter correlations. Modelling is applied to evaluate the influence that pathologies have on the normal functioning of the heart and the rest of the system.

  Computational fluid dynamics (CFD); fluid-structure interaction (FSI); lumped parameter modelling (LPM); soft tissue biomechanics; experimental validation.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Investigation into the effect of aortic root compliance on the haemodynamic environment of stenosed aortic heart valves Aortic stenosis (AS) is a valvular heart disease (VHD) caused by infection (rheumatic heart disease (RHD)), degeneration, or congenital malformation that results in inadequate valve opening. The underlying cause of AS determines the type and morphology of the diseased valve. AS is the most common VHD that requires surgical intervention in Europe and North America, while sub-Saharan African countries have among the highest prevalence of RHD. Accurate diagnosis of the underlying cause and severity of stenosis is necessary for both treatment and prognosis of patients with AS. Aortic valve haemodynamics are effectively characterised by the peak velocity and the mean transvalvular pressure gradient. These flow parameters are determined in clinical practice through Doppler echocardiography, where the velocity is measured and used to estimate the pressure gradient according to the simplified Bernoulli equation ($\Delta P = 4V^2$). The simplified Bernoulli equation is insensitive to valve morphology and often over- or underestimates the pressure gradients. In this project, fluid-structure interaction (FSI) modelling techniques will be used to evaluate the dynamic environment of aortic stenosis and investigate the effect that aortic root compliance has on the velocity profiles and transvalvular pressure gradients. The project aims to evaluate the accuracy of the pressure gradients estimated through the simplified Bernoulli equation when compared to validated simulated results. (This project will be co-supervised by Dr. Adam Venter) **Requirements:** BEng (Mechanical or Mechatronic). CFD and FEA will be used in this project and the student will be required to complete the relevant modules during the first semester of the MEng programme.		✓		

Prof Nawaz Mahomed
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- **Research Field**
  Computational Mechanics, Materials Engineering
- **General Description of Research Field**
  Computational mechanics modelling using finite element analysis applied to high viscous flows and deformation in solid materials.

  Solidification in steels (metalcasting processes), focusiing on porosity formation and microsegregation.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Mechanical Characterisation of meteoroid/asteroid break-up/fragmentation during atmospheric entry. Modelling and predicting the fragmentation of meteoroids/asteroids during atmospheric entry is critical in assessing the impact on the population of future entries. One of the challenges is to establish accurate material breakup models. Current models used in astrophysics are rather simplistic and are not based on mechanical models that take into account the energy storage capacity and fracture of brittle materials under high strain rate (atmospheric impact) conditions. Currently, the early break-up of meteoroids well below its material strength cannot be explained. Aim: Develop a well-posed fragmentation model for meteoroids based on their mechanical response to high strain rate loading that is consistent with strain energy conservation models. Failure models for brittle materials, such as the case of in rock blasting, will be investigated. Modelling will include energy storage capacity of the materials as well as energy deposition to shock wave formation due to hypervelocity atmospheric entry. The results from the experimental and modelling will be used to construct a material law that can be used in the modelling and simulation of atmospheric entry and trajectory of meteoroids/asteroids. Funding is dependent on student applying for the SANSA bursary. Closing date Sep 2025. **Requirements:** Background in Finite ELement Methods. Interest in materials.		✓		✓

Prof Craig McGregor

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- **Research Field**
  Solar thermal energy, concentrating solar power (CSP)

- **General Description of Research Field**
  Solar thermal energy and concentrating solar power research is conducted through the ACWA Power Research Chair in CSP at Stellenbosch University. This collaboration provides unique access to operational data from commercial CSP facilities, including the 50 MW Bokpoort parabolic trough plant and 100 MW Redstone central receiver plant in South Africa, as well as ACWA Power's global portfolio of 1,360 MW solar thermal capacity.

  Research focuses on addressing real operational challenges in commercial CSP plants while advancing fundamental understanding of solar thermal technologies. The program combines industry-validated research with cutting-edge methodologies across five thematic areas: systems engineering and optimisation; autonomous monitoring and predictive maintenance; artificial intelligence and digital twins; component and sensor prototyping; and thermal engineering and power generation.

  Current research priorities include machine learning optimisation of large-scale heliostat fields, predictive maintenance using operational plant data, advanced thermal energy storage systems, and grid integration services. Projects range from immediate operational improvements that can be implemented within 1-2 years to fundamental research establishing next-generation CSP technologies.

  The research group maintains active collaborations with international CSP research networks and regularly participates in Horizon Europe programs. Students benefit from industry mentorship, access to commercial plant data, international collaboration opportunities, and potential for technology commercialisation through the ACWA Power partnership.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a mirror reflectivity measurement using drones Stellenbosch University has a collaboration with ACWA Power, the owner of 1,360 MW of solar thermal capacity worldwide, including the Bokpoort and Redstone CSP plants in the Northern Cape and the 510 MW Noor CSP complex in Morocco. Heliostat mirror reflectivity is a critical parameter affecting CSP plant performance, but current measurement methods are labour-intensive and provide limited spatial coverage across large heliostat fields. At utility-scale plants like Redstone with over 40,000 heliostats, comprehensive reflectivity monitoring is essential for maintaining optimal energy yield. This project aims to develop an automated drone-based system for comprehensive reflectivity measurement across heliostat fields. The research will design and integrate spectral measurement equipment with drone platforms, developing automated flight patterns for systematic field coverage. Key technical challenges include calibration procedures for varying illumination conditions, compensation for atmospheric effects, and data processing algorithms that convert raw measurements into actionable reflectivity maps. The system will incorporate GPS positioning for precise spatial mapping and real-time data processing for immediate identification of degraded mirrors. The research will be validated using operational data from ACWA Power facilities, providing access to commercial-scale CSP plants for testing and demonstration. This collaboration enables validation under real operating conditions while addressing genuine industrial challenges. The project offers opportunities for technology commercialisation and potential patent development, with results directly applicable to CSP facilities worldwide. **Requirements:** Programming skills, interest in drone systems and automation		✓	✓	✓

Topics	**MEng Struct**	**MEng Resrch**	**PhD**	**Potential Funding**
Artificial Intelligence tool for solar field status management Stellenbosch University has a collaboration with ACWA Power, the owner of 1,360 MW of solar thermal capacity worldwide, including the Bokpoort and Redstone CSP plants in the Northern Cape and the 510 MW Noor CSP complex in Morocco. Current solar field monitoring at these facilities relies on manual data entry from drone surveys, daily performance evaluations, and visual inspections, creating delays and potential for human error in defect identification and management. With tens of thousands of components across large solar fields, efficient defect detection and classification are critical for maintaining plant performance and minimising maintenance costs. This project will develop an artificial intelligence system that automatically identifies and classifies defects from photographic data, converting results into formats compatible with existing plant management systems. The research will focus on computer vision algorithms trained on comprehensive datasets of CSP component conditions, including mirrors, absorber tubes, ball joints, collector structures, sensors, and hydraulic systems. The AI system will incorporate location and temporal data to track defect progression and prioritise maintenance activities. Machine learning models will be developed to recognise various defect types, assess severity levels, and integrate with existing plant databases. The tool will be designed for field operators to upload photos with location and time data, receiving automated defect classification and severity assessment for immediate integration into maintenance scheduling systems. Validation will be conducted using historical defect data from ACWA Power facilities, with performance benchmarking against current manual classification methods. The research provides opportunities for developing novel computer vision architectures while addressing real operational challenges in commercial CSP plants. **Requirements:** Programming skills, interest in machine learning and computer vision		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Hybrid dry cooling retrofit for Bokpoort CSP plant Stellenbosch University has a collaboration with ACWA Power, the owner of 1,360 MW of solar thermal capacity worldwide, including the Bokpoort and Redstone CSP plants in the Northern Cape and the 510 MW Noor CSP complex in Morocco. The Bokpoort CSP plant currently employs wet cooling technology that consumes significant amounts of water in the arid Northern Cape region, where water scarcity is an ongoing concern. Converting to hybrid dry cooling could substantially reduce water consumption while maintaining acceptable plant performance and potentially extending operational capacity during peak summer conditions. This project will evaluate the technical feasibility and economic viability of retrofitting Bokpoort with hybrid dry cooling systems. The research will develop thermodynamic models of hybrid cooling configurations, analysing the trade-offs between water consumption, parasitic power consumption, and thermal performance under varying ambient conditions. The study will include detailed design of cooling system modifications, assessment of required infrastructure changes, and quantification of environmental benefits, including water savings and reduced environmental impact. Economic analysis will consider capital costs, operational savings, and payback periods, while environmental assessment will evaluate sustainability improvements and carbon footprint reduction. The research will utilise operational data from Bokpoort to validate models and establish baseline performance metrics. Water consumption reduction targets of 70-90% will be evaluated against efficiency penalties and capital investment requirements. The project addresses critical water sustainability challenges in arid regions while providing a framework for similar retrofits across ACWA Power's global portfolio and the broader CSP industry. **Requirements:** Thermodynamics, heat transfer, and programming skills for modelling and optimisation		✓	✓	✓
Design and analysis of glass alternative concentrating 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
Optimisation of cleaning strategies for the solar field of Redstone CSP Stellenbosch University has a collaboration with ACWA Power, the owner of 1,360 MW of solar thermal capacity worldwide, including the Bokpoort and Redstone CSP plants in the Northern Cape and the 510 MW Noor CSP complex in Morocco. The Redstone central receiver plant features 41,260 heliostats across several hundred hectares in the arid Northern Cape environment. Mirror soiling from dust accumulation significantly reduces optical efficiency, with studies showing that uncleaned mirrors can lose 0.1-0.5% reflectivity per day depending on weather conditions. Optimising cleaning strategies is therefore critical for maximising energy yield while minimising operational costs. This project will develop comprehensive cleaning optimisation models that account for soiling patterns, cleaning method effectiveness, labour productivity, and economic trade-offs. The research will evaluate available cleaning methods, including manual techniques and mechanised systems, quantifying productivity rates and cleaning effectiveness for each approach. Seasonal soiling factor analysis will be conducted using weather data, dust measurements, and reflectivity monitoring to establish predictive soiling models. The study will integrate heliostat performance data with cleaning cost analysis to develop economic optimisation algorithms that maximise electricity generation while minimising operation and maintenance expenses. Machine learning approaches will be applied to predict optimal cleaning schedules based on weather forecasts, energy prices, and plant dispatch requirements. The optimisation framework will consider spatial variations across the heliostat field, as mirrors in different locations experience varying soiling rates due to local topography and wind patterns. Validation will be conducted using operational data from Redstone, with potential for implementation across ACWA Power's global CSP portfolio. The research addresses a multi-million rand annual operational challenge while providing opportunities for developing novel optimisation algorithms applicable to large-scale industrial systems. **Requirements:** Programming skills, interest in optimisation, machine learning and data analysis		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Predictive maintenance strategies for parabolic trough ball joints Stellenbosch University has a collaboration with ACWA Power, the owner of 1,360 MW of solar thermal capacity worldwide, including the Bokpoort and Redstone CSP plants in the Northern Cape and the 510 MW Noor CSP complex in Morocco. Ball joints in parabolic trough systems are critical components that enable collector tracking while accommodating thermal expansion and structural flexing. These joints operate under extreme conditions including high temperatures (up to 400°C), thermal cycling, mechanical loading, and exposure to dust and weather in desert environments. Ball joint failures can result in collector tracking errors, reduced energy yield, and costly unplanned maintenance outages. This project will analyse the mechanical and thermal stresses affecting ball joints in parabolic trough systems using finite element analysis and operational data from Bokpoort. The research will evaluate current operational practices and identify failure modes in ball joint assemblies through systematic analysis of maintenance records and field inspection data. A predictive maintenance framework will be developed using machine learning techniques to forecast component degradation based on operating conditions, thermal cycling patterns, and environmental factors. The study will propose optimised operational strategies that mitigate wear and extend component life through intelligent scheduling of cleaning cycles, tracking patterns, and preventive maintenance. Validation will be conducted through simulation, field data analysis from ACWA Power facilities, and comparison with existing maintenance protocols. The research addresses real operational challenges while providing opportunities for developing novel predictive maintenance methodologies applicable to other high-temperature mechanical systems. Outcomes include improved plant availability, reduced maintenance costs, and enhanced understanding of component degradation mechanisms in concentrated solar power applications. **Requirements:** Finite element analysis, programming skills, interest in mechanical systems and predictive maintenance		✓	✓	

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
Improving the performance of hydrogen electrolysers through additive manufacturing This project aims to leverage additive manufacturing (AM) methods (such as laser-powder bed fusion) to design and fabricate components for hydrogen electrolysers, with the primary goal of significantly boosting their efficiency, reducing manufacturing costs, and improving their operational lifespan. Green hydrogen is a cornerstone of future decarbonised energy systems, but its production via water electrolysis is currently hampered by the high cost and performance limitations of electrolysers. Conventional manufacturing methods restrict the geometric complexity of crucial components like flow field plates and electrodes, leading to suboptimal flow dynamics, limited active surface area, and inefficient use of expensive catalyst materials like platinum and iridium. In this project, AM will be used to create highly porous, lattice-based electrode structures and/or complex field plates. These structures will be characterised using advanced materials characterisation techniques (such as electron microscopy, digital image correlation, corrosion testing, etc.) and tested in current commercial electrolyser setups. The student involved in this project can communicate with the supervisor(s) about which aspects of this project (manufacturing, characterisation, testing) best suit their skill set and interest. **Requirements:** Computational fluid dynamics or finite element methods is not a requirement but could be useful in this project.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Enhancing the accessibility and standardisation of digital image correlation through a virtual laboratory and benchmarking framework Digital image correlation (DIC) is a powerful optical technique for full-field strain and deformation measurement. However, its broader adoption across scientific and engineering disciplines is often hindered by two significant barriers: the lack of standardised performance validation methodologies and limited access to specialised experimental hardware. Industry especially is hesitant to adopt this technology despite the numerous benefits associated with it. This project directly addresses these challenges by proposing the development of an integrated, open-access ecosystem. There are two sides to this project. Firstly, the aim is create a comprehensive suite of benchmarking tools, including standardised synthetic and real image datasets for both planar (1 camera) and stereo (>2 camera) DIC setups. These will enable users to assess the accuracy, precision, and reliability of various DIC algorithms and commercial software. The second aspect is to establish a novel virtual DIC laboratory. This platform will provide remote, web-based access to a physical, high-fidelity camera and loading setup, allowing users worldwide to design and execute real-world experiments, gain practical experience, and validate their own codes without the prohibitive cost of hardware acquisition. By creating these open-source resources, this project aims to democratise the use of DIC, foster greater community-wide standardisation, and ultimately enhance the technique's accessibility, reliability, and acceptance as a fundamental tool for mechanical analysis. The student can discuss which aspect of this project (benchmarking or virtual lab development) would be better suited to their skill set and interests. The student will have the support of an existing in-house open-source code named SUN-DIC (`https://github.com/gventer/SUN-DIC`). **Requirements:** Python coding would be very beneficial but can be learnt in situ.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Understanding additively manufactured superalloy materials in service of the aerospace industry Superalloys, such as Inconel 718, are very useful materials in the aerospace industry. Furthermore, additive manufacturing (such as laser-powder bed fusion) of these materials opens the possibility of creating lighter parts with a more material efficient process. However, the high temperature mechanical properties of additively manufactured superalloy materials is not well understood and sometimes falls short of the conventionally produced equivalents. Given the strict requirements of materials used in the aerospace industry, this uncertainty has placed a limit on the widespread adoption of additively manufactured parts. This project explores applying different heat treatments to additively manufactured superalloys, using advanced characterisation methods (such as electron microscopy, digital image correlation, miniature sample testing) to understand the behaviour of the material (especially at high temperatures) and looking at methods to improve the sustainability of the processing chain. The student can work with the supervisor(s) to select an aspect (e.g. manufacturing, mechanical testing, microscopy, sustainability, etc.) of this general topic that best suits their skill set and interests. **Requirements:** Some finite element methods background is useful but not compulsory. Full-time only. Programming skills (e.g. Python/MATLAB) will be very beneficial.		✓	✓	

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 This topic includes further research and development into inverse models for the estimation of propeller loads. Current models include estimation of propeller torque and ice-induced propeller moments from measured propulsion shaft response. Development of models for the estimation of bending loads at the propeller from transverse shaft response will be a focus for the project. 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 models.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Study of underwater noise from polar vessel propulsion system In polar waters, ships frequently encounter floating sea ice, which can be milled by the rotating propeller. This interaction generates transient forces that are transmitted through the propeller shaft and supporting structures, causing vibrations and contributing to radiated underwater noise. Understanding these forces and their dynamic transmission is critical for designing low-noise, environmentally responsible polar vessels and for ensuring the reliability of shipboard systems and acoustic instruments. **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 models.		✓		

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

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
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.		✓		

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

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
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 (Chart Industries - Netherlands). **Requirements:** The project requires the student to have completed, or to do, a CFD module (or have relevant experience with 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. 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
Development of a deployable inflatable safety device for impact protection in paragliding Current paragliding harnesses present pilots with a problematic trade-off between safety and utility. Traditional protective harnesses incorporate bulky foam or rigid impact protection that significantly increases weight and reduces packability, while lightweight alternatives sacrifice pilot protection entirely. Even existing protective systems offer limited coverage and effectiveness during emergency landings or unexpected impacts. This research project aims to develop an innovative harness design that integrates deployable inflatable safety technology to eliminate this compromise. The proposed system would maintain the lightweight, compact profile desired for thermal flying and cross-country adventures while providing superior protection when needed through rapid inflation during emergency situations. Key research objectives include (these need only be partially met in a MEng project): - Designing a reliable deployment mechanism triggered by impact sensors or manual activation. - Optimizing inflatable chamber geometry for maximum protection coverage of critical body areas - Identification of lightweight, durable materials suitable for the demanding paragliding environment - Creating a system that packs compactly when not deployed - Ensuring the technology integrates seamlessly with existing harness ergonomics and pilot comfort The successful completion of this project would represent a significant advancement in paragliding safety equipment, potentially reducing injury rates while encouraging broader participation in the sport through improved equipment utility. The research methodology should encompass computational modeling, material testing, prototype development, and validation through controlled impact testing. This interdisciplinary project combines aerospace engineering, materials science, and safety system design principles to address a real-world challenge faced by the paragliding community. The project will be co-supervised by Prof Martin Venter. **Requirements:** None		✓	✓	

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
Biosensing using 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		✓		
Microfluidic Organ-on-Chip system to model the respiratory system of insects Insects have a fundamentally different respiratory system compared to other animals. While most animals rely on specialized exchange surfaces (lungs, gills, etc.), combined with circulatory transport of oxygen and carbon dioxide, insects largely bypass circulatory gas transport. Instead, their system represents a major evolutionary shift in respiratory biology, relying less on internal oxygen-carrying liquids and muscular pumps. It will be required that the student design, simulate and manucfacture a microfluidic organ-on-chip system to mimic the respiratory system of insects in order to better understand the breathing process. Collaboration: E&E Engineering, Department of Conservation Ecology and Entomology **Requirements:** Suitable for students in engineering, as well as the life and applied sciences.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
The manufacture of micron-sized electrodes for electrochemical biosensing applications The nano-laboratory in E&E Engineering has the capability to define and manufacture structures down to 600 nm feature size. For Electrochemical Impedance Spectroscopy (EIS) interdigitated electrodes (IDEs) are used where linewidths are typically around 100 micrometres. These sensing substrates are currently imported from overseas at quite a large cost, while the quality is below standard. It is envisaged that these electrodes can be manufactured in the nano-laboratory at a fraction of a cost of the imported electrodes and with better reproducibility. The student will be required to design, simulate and manufacture these structures. The efficacy of the electrodes will be verified in the laboratory for biosensing applications, which will also involve immobilisation of biorecoginition elements (e.g. antibodies) to capture target pathogens. Collaboration: E&E Engineering, Physiological Sciences **Requirements:** Multiphysics simulation, electrochemistry		✓		
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.		✓		
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		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Machine Learning Analysis of Blood Cell Deformability in Chronic Disease Using Real-Time Deformability Cytometry Real-time deformability cytometry (RTDC) is a new cell analysis technique that classifies cells based on the measure of deformation when placed under stress. This image-based system is capable of capturing thousands of images of cells in a short period of time. The student will collect samples in the Physiology Blood Research laboratory at Stellenbosch. Various chronic disease states (long-Covid, Type 2 Diabetes Mellitus, etc.) on the deformability of blood cells will be investigated. First, the student must collect new data and use existing data to compile an image dataset. This involves working with other students in the Blood Research laboratory. Next, they must devise a method of extracting useful features from the images. The following part of the project is open ended and the student should explore the collected data and search for meaningful correlations between samples. One possible application is the prediction of disease state based on the images or other derived features. Collaboration: E&E Engineering, Physiological Sciences **Requirements:** A background in applied mathematics and machine learning.		✓		

Prof Hannes Pretorius
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- **Research Field**
  Thermofluids
- **General Description of Research Field**
  Simulation of dry cooling systems for power generation applications; Simulation of turbomachinery for supercritical CO2 power cycles; Axial flow fan performance; Thermo-economic evaluations

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Numerical simulation of mitigation strategies for wind-induced performance degradation in Natural Draft Air-Cooled Condensers for Concentrated Solar Power applications Concentrated Solar Power (CSP) plants are anticipated to contribute to the reduction of global carbon dioxide emissions by providing an alternative for dispatchable power compared to conventional fossil fuel power generation. However, their deployment is hindered by comparatively high capital costs relative to other renewable technologies, such as photovoltaic (PV) and wind energy systems. To be competitive, CSP plants therefore need to be as thermally efficient as possible, while adhering to stringent water conservation efforts in the typically arid or semi-arid regions in which they are constructed. Natural Draft Air-Cooled Condensers (NDACCs) represents a modern evolution to direct condensation of the working fluid in steam power cycles using dry-cooling methods compared to traditional mechanical draft Air-Cooled Condensers (ACCs). By eliminating the requirement for mechanically driven fans, these systems offer reduced operating costs and enhance the net power output of the cycle by reducing auxiliary power consumption. Despite their benefits, recent research has shown that NDACCs exhibit comparable performance degradation to ACCs under windy conditions. Although numerous publications have explored strategies to mitigate wind-related performance losses in ACCs, minimal research has been conducted on similar mitigation strategies for NDACCs. This study investigates measures to mitigate against performance degradation under wind for a NDACC sized for a 50 MWe CSP application. A Computational Fluid Dynamics (CFD) model of the NDACC is developed, validated, and used to simulate the performance of reference and modified system configurations under calm and windy conditions. Various wind-breaker mechanisms, including extended clapboard and screens, louvers, extended baffles and internal wind-cross are evaluated, while the effect of porosity and combined mechanisms are also assessed. (NOTE: This topic has already been allocated to a student for 2026.) (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
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 air-cooled condenser (NDACC). 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 NDACC 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. Additionally, the sensitivity of LCOE to variations in load profile, geographic location, and electricity tariff structures is assessed. (NOTE: This topic has already been allocated to a student for 2026.) (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 air-cooled condenser (NDACC) 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 air-cooled condenser (NDACC). 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 NDACC 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 NDACC 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 NDACC 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
Multi-objective optimisation of a natural draft air-cooled conder using deep-learning Natural draft air-cooled condensers (NDACCs) are a promising new alternative for heat rejection systems in thermal power plants. These technologies minimise water use, eliminate parasitic power consumption and reduce maintenance costs. NDACCs are sensitive to changes in ambient conditions, which deteriorate cooling performance, increasing turbine back pressure and reducing power plant efficiency. However, these applications exhibit a large design parameter space that can be explored to obtain an optimal solution during design point conditions to minimise these performance changes. The operational resilience and robustness of the system geometry can further be enhanced by investigating off-design operating conditions, such as changes in plant load or varying ambient temperature and crosswinds. Therefore, a system geometry can be determined that covers a vast design and operational variable space, ensuring an efficient and durable solution. This study aims to perform multi-objective optimisation with the use of deep-learning based neural networks to find an optimised NDACC design under the full range of expected operational conditions. The design space consists of varying ambient temperatures and crosswinds, plant loads, as well as tower and heat exchanger geometric parameters and wind mitigation features. A computational fluid dynamics model (CFD) of the cooling system will be used to generate the required performance data from a design of experiments (DOE) that varies the design variables, boundary conditions and operational conditions across the design space. A deep-learning based surrogate model is subsequently trained on the CFD output data to find an optimal NDACC configuration. (NOTE: This topic has already been allocated to a student for 2026.) (This project will form part of research conducted by the Solar Thermal Energy Research Group, and will be co-supervised by Prof Ryno Laubscher) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.			✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design of an axial-flow cooling fan for enhanced supercritical carbon dioxide air-cooled heat exchanger performance Concentrated Solar Power (CSP) plants are expected to play an important role towards the stabilisation of power grids where intermittent renewable energy generation sources are becoming increasingly prevalent. However, these plants have not seen the same implementation rates as wind and photovoltaic solar plants, due to high capital costs. By combining the CSP plant with advanced supercritical carbon dioxide (sCO2) cycles, thermal efficiencies and cost-effectiveness can be significantly enhanced. CSP plants typically employ mechanical draft dry cooling systems to conserve water in the arid or semi-arid areas where these plants are located. These air-cooled heat exchangers (ACHEs), which operate using axial-flow fans, have a major impact on the efficiency of the power cycle. It is therefore critically important that these systems are designed to operate optimally. Recent studies into the axial-flow fan design for SCO2 ACHEs have highlighted potential areas of improvement. This study therefore performs a re-design, simulation and test of such an axial-flow fan, based on a revised sCO2 ACHE specification and fan design point, with the intention of enhancing overall cooling system performance. (NOTE: This topic has already been allocated to a student for 2026.) (This project will form part of research conducted by the Solar Thermal Energy Research Group, and is co-supervised by Prof Johan van der Spuy) **Requirements:** Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.		✓		
Evaluating the impact of operational and wind effects on cooling fan performance for a supercritical carbon dioxide (sCO2) air-cooled heat exchanger Mechanical draft air-cooled heat exchangers can be used as coolers for supercritical carbon dioxide (sCO2) Brayton cycles which form part of Concentrated Solar Power (CSP) plants. Prevailing winds typically have a major effect on the fan performance of air-cooled heat exchangers. In addition, it is important to understand multi-fan interactions and the impact of non-operational fans within a bank of fans which form part of the heat exchanger design. This study will evaluate the effects of prevailing winds over a range of velocities and directions, as well as operational outage scenarios, on the performance of the fans and heat exchanger. The performance of the system will be simulated using a co-simulation method, where the sCO2-side is simulated using a one-dimensional code (Python), coupled to a Computational Fluid Dynamics model (Fluent) which simulates the air-side. (This project will form part of research conducted by the Solar Thermal Energy Research Group, and is co-supervised by Prof Johan van der Spuy)		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Strong interest and performance in Thermo-fluids modules. Computational Fluid Dynamics.				
Performance modelling of axial compressors 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 axial compressors for a 50 MWe CSP plant using a sCO2 power cycle. This involves preliminary compressor 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 compressor designs at their selected operational speeds. (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.		✓		

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
Dynamic Analysis and Modelling of Reconfigurable Robotic Welding Jig for transport manufacturing industry Welding plays a crucial role in the transport manufacturing industry. Most welding activities are still performed manually, leading to safety concerns, quality inconsistencies, and inefficiencies caused by human errors. Traditional welding jigs are often rigid and lack adaptability to accommodate variations in component geometries, which limits productivity and increases setup times. Therefore, more intelligent and automated welding solution such as robotic welding jigs are required to ensure high precision, consistent weld quality, improved operator safety, and continuous availability of equipment during production. This project aims to model and simulate a Reconfigurable Robotic Welding Jig to perform automated welding 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 welding robotic system will be modelled in MATLAB environment, including the kinematic motion and trajectory of the robotic welding system 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 no funding is available. 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
Digital Twin-Enabled Modeling and Optimization of Reconfigurable Machine Tool (RMT) Performance for Multi-Part Family Production A reconfigurable manufacturing system (RMS) is one designed at the outset for rapid change in its structure, as well as its hardware and software components, in order to quickly adjust its production capacity and functionality within a part family in response to sudden market changes or intrinsic system change (Koren, 1998). A major component of RMS is the reconfigurable machine tool (RMT). A well designed RMT should exhibit the following RMS characteristics, (i.e. scalability, modularity, convertibility, integrability, diagnosability and customized flexibility). These machines are emerging as new generation machine tools for dealing with the fluctuating market demands and ever-changing customer requirements in the industry. The aim of this project is to investigate how digital twin technology can be applied to model, predict, and optimize RMT performance across different configurations. The study will focus on developing a coupled digital twin framework that integrates Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) models with real-time Internet of Things (IoT) sensor data. This coupling will enable the validation of dynamic changes in stiffness, accuracy, vibration response, and energy consumption during reconfiguration. To achieve this, the existing RMT machine prototype solution will be studied and analysed. The prototype will be instrumented with sensors to capture real-time operational data, which will be fed into the digital twin for continuous validation and predictive analytics. 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 purchase the sensor that will be used on the prototype solution. 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, Control System and Strength of Materials.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Advanced design models and cyber-physical social systems (CPSS) for innovative mobility systems and 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.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design of a Modular Open Architecture controller for a Reconfigurable Machine Tool Controllers for dedicated machines, while effective for specific tasks, often face several limitations that hinder their adaptability and performance in modern manufacturing environments. These controllers are not suitable for reconfigurable manufacturing systems (RMS). RMS demands highly adaptable and modular controllers capable of integrating new hardware and software modules without significant reprogramming or downtime. This project aims to design a modular open-architecture controller (MOAC) for a reconfigurable machine tool (RMT) to enable seamless plug-and-play functionality. The proposed MOAC will integrate modular design and open communication protocols to ensure compatibility with various machine tool configurations and components. The controller will be designed with a layered architecture comprising hardware abstraction, communication, and application layers, ensuring scalability and ease of integration. Plug-and-play functionality will be achieved through standardized interfaces, automatic detection of modules, and dynamic reconfiguration capabilities. The controller will be validated through simulations as well as implementation on the existing RMT prototype machine. 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 controller development. 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 System, Machine Design and Strength of Materials.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Simulation-Based Design and Optimization of Reconfigurable Automotive Assembly Lines for Multi-Variant Production The automotive industry is increasingly challenged by the demand for high product variety, shorter product life cycles, and rapid market fluctuations. Traditional assembly lines, designed for mass production, often lack the flexibility to efficiently accommodate multi-variant production, leading to increased costs, downtime, and suboptimal resource utilization. This research investigates the simulation-based design and optimization of reconfigurable automotive assembly lines (RALs) to address these challenges. This research work will include determining optimal line configurations, assessing resource allocation strategies, and evaluating system responsiveness to product variant changes. The work will make use of case studies and virtual experiments to validate the methodology, focusing on metrics such as throughput, cycle time, utilization, and reconfiguration cost etc. This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from Stellenbosch University (SU) & 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 co-supervised by Dr Clint Steed an expert in Assembly System from Department of Mechanical & Mechatronics at Stellenbosch University. 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
Energy-Efficient Reconfiguration Strategies in Manufacturing Systems Reconfigurable Manufacturing Systems (RMS) are designed for rapid structural, hardware, and software modifications to meet fluctuating production demands and diverse product families (Koren, 1998). A central element of RMS is the Reconfigurable Machine Tool (RMT), which embodies the system's core principles such as scalability, modularity, convertibility, integrability, diagnosability, and customized flexibility. While significant research has been conducted on the structural and functional adaptability of RMS, limited attention has been given to the energy efficiency strategies associated with reconfiguration process, such as machine setup, operational transitions, and idle states. Thus, this PhD project aims to investigate and minimize energy consumption during reconfiguration processes in RMS through a combination of modeling, simulation, and experimental validation. The study will model energy flows across different machine states (setup, operation, idle) and develop intelligent control strategies for optimizing power usage. 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-DSTI 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
Modelling and performance evaluation of a reconfigurable fixture system for machining complex geometries in manufacturing The increasing demand for customized products and shorter production lead times has driven the adoption of reconfigurable manufacturing systems (RMS) in modern industrial environments. A critical component of RMS is the fixture system, which must adapt to varying workpiece geometries while maintaining high precision and stability during machining operations. This study focuses on the modelling and performance evaluation of a reconfigurable fixture system designed for machining complex geometries. 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 fixture mechanism for producing various components of the same part family, (iii) To perform a Finite Element Analysis (FEA) of the proposed RFS, (iv) To model and simulate the design using applicate software platforms and conduct a performance evaluating of the developed RFS system. This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from Stellenbosch University (SU) & 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 co-supervised by Dr Clint Steed an expert in Assembly System from Department of Mechanical & Mechatronics at Stellenbosch University. 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
Control and Optimization of Reconfigurable Machine Tools for Adaptive Metal Parts Manufacturing Reconfigurable Manufacturing Systems (RMS) are designed to rapidly adapt their structure, hardware, and software to accommodate dynamic production demands and evolving product designs. At the core of RMS are Reconfigurable Machine Tools (RMTs), which embody principles such as modularity, scalability, convertibility, integrability, diagnosability, and customization. The integration of mechatronic system including sensing, actuation, control algorithms, and embedded intelligence enhances the adaptability and operational performance of RMTs in machining diverse part families. This research aims to control and optimize an RMT for adaptive metal parts manufacturing. Advanced mechatronic control strategies will be developed and applied to improve system responsiveness, machining accuracy, energy efficiency, and reconfiguration time. A hybrid approach combining model-based simulation and experimental validation will be employed to evaluate the performance of the proposed system under varying geometric and operational constraints. This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from Stellenbosch University (SU), 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 controller development. 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 System, Machine Design and Strength of Materials.		✓		

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
A condition monitoring methodology for heat pumps using physics based thermofluid models, machine learning and parameter identification Anticipating failures in industrial equipment can significantly reduce the adverse effects of unexpected downtime, particularly in scenarios involving complex logistics for repairs and maintenance. To this end, online condition-based monitoring can be employed to detect incipient faults before they result in breakdowns. These techniques can broadly be categorised into model-based or data-driven approaches. This project aims to develop and demonstrate a condition monitoring methodology for heat pumps, utilising fundamental physics-based thermofluid models together with machine learning and parameter identification to simultaneously detect, locate, and quantify degradation in heat pump system components. The scope of work includes developing a comprehensive heat pump cycle model in Python; conducting laboratory measurements; using these measurements to calibrate and validate the Python model; training surrogate models based on conventional multilayer perceptron (MLP) neural networks using various combinations of simulated and measured data; applying the surrogate model with parameter identification for condition monitoring; and demonstrating the methodology on the laboratory setup. (This project will be co-supervised by Dr Rashid Haffejee and Prof Pieter Rousseau) **Requirements:** Affinity for thermofluids, modelling, programming, and physical experimentation.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Comparison of conventional and physics-informed deep neural networks for surrogate modelling of sCO2 heat pumps This project aims to develop and demonstrate a methodology for creating surrogate models of supercritical CO2 (sCO2) heat pump cycles using physics-informed neural networks (PINNs). PINNs reduce the reliance on extensive experimental datasets typically required to train conventional neural networks by embedding physics based equations within the neural network's loss function. This shifts the training process from supervised learning, which relies on example data points, to unsupervised learning guided by the governing equations. The project will evaluate suitable existing PINN frameworks, potentially including graph-based PINNs, and explore libraries for implementation in the Python programming language. The hypothesis is that this approach will deliver computational performance comparable to or superior to conventional multilayer perceptron (MLP) neural networks, while providing highly efficient and adaptable surrogate models suitable for applications such as parameter identification and optimisation. The scope of work includes developing a comprehensive sCO2 heat pump cycle model in Python; generating pseudo-"measured" data using the Python model; training surrogate models based on conventional MLP neural networks using the simulated data; developing and training a PINN-based surrogate model; and analysing and comparing the performance of the PINN and MLP surrogate models based on metrics such as accuracy, training time, and runtime. (This project will be co-supervised by Dr Rashid Haffejee and Prof Pieter Rousseau) **Requirements:** Affinity for thermofluids, modelling, mathematics, and programming.		✓		

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
Design Improvement of a Robotic Laparoscopic Camera Positioning System Dr Diayar developed a 5-degree-of-freedom (DoF) robotic laparoscopic camera positioning system. The novel design ensures a simple one-to-one correspondence between motors and four of the DoFs by ensuring that the laparoscope pivots at the abdominal port, while the fifth DoF is adjusted through image-based control. The device was tested by practising surgeons in a training laboratory with promising results. Further development is needed to bring the device closer to clinical readiness. For example, the device must be sterilisable, or at least designed in such a way that the exposed components can be sterilised and other components can be isolated. The stiffness of the device needs to be improved to make sure that a stable image can always be obtained. A method for setting up the device in a way that ensures that the pivot point of the laparoscope is at the abdominal port is needed. A user-friendly way to insert and remove the laparoscope before, during and after the surgical procedure is needed. Temporary or permanent methods of modifying the laparoscopic instruments to allow them to be compatible with the device's computer vision system are needed. Practical aspects such as the method of transporting the device into the operating theatre and setting it up in a way that does not impede the staff's working space should be considered. The revised device needs to be systematically tested in a laboratory. The purpose of the testing is to show the ability of the device to reliably track the laparoscopic instruments and to show that the design of the device, incorporating the aforementioned considerations, is practically viable. Controlled versions of the device's design data need to be created so that further development of the device will be possible. Ideally, the end product for this design iteration must also be usable during an open day for visitors to get a realistic laparoscopic experience from a surgeon's perspective! This project will be co-supervised by Dr Diayar.	✓	✓		

Topics	**MEng Struct**	**MEng Resrch**	**PhD**	**Potential Funding**
Requirements: Programming experience, preferably python. Mathematics.				
Abdominal Wall Closure Device After a laparotomy, the abdominal wall is usually closed again but in certain instances, this is not possible due to excessive swelling of the intestines and retraction of the abdominal wall musculature. This is termed an “open abdomen”. The intestines are usually protected with a negative pressure wound therapy (NPWT) dressing system. Sometimes the abdomen can be closed once the intestinal swelling subsides but more often than not the abdominal wall musculature has retracted and cannot be pulled together to close the abdomen, requiring the surgeon to place a skin graft on the intestines. This leaves the patient with a massive hernia, which will need to be fixed at a later stage, with considerable difficulty and risk of perforating an intestine when removing the graft. Purpose of Prof Kairinos’ invention: To provide for a modification of the NPWT system that facilitates closure of the abdomen when the intestinal swelling has subsided. **Requirements:** Programming background, preferably python. Electronics background, preferably with Arduino or Raspberry Pi.	✓	✓		
Tissue Plain Dissector The dissection of anatomical tissue plains is often required during many surgical procedures. Finding this plain is sometimes easy but may be difficult due to scarring or inexperience. Being in the correct plain is often critically important to avoid damage to important structures, such as nerves or blood vessels. In order to dissect a tissue plain one usually needs to separate two layers, which are bound by a looser connective tissue layer. This is accomplished by either using scalpel dissection or (more often) dissecting scissors. The latter allows for “blunt dissection” of the tissues by opening the scissors between these tight areas, allowing them to separate, rather than cutting one’s way through them. However, dissection is slow, particularly for an inexperienced dissector, for fear of cutting or stretching an important structure. Purpose of Prof Kairinos’ invention: To create a device using proprietary information, which can be pushed forward into tissues, allowing the device to “find” the correct plane of least resistance. **Requirements:** tbd	✓	✓		
Exercise ball – Sensor miniaturisation The Institute for Biomedical Engineering is developing a smart exercise ball. It allows users to get feedback, e.g. force feedback. The ball is a large “yoga” ball with some sensors and related electronics inside. The first prototype was made by cutting a ball open and sealing it again with shoe glue! While functional, this is not ideal from a production point of view. We are looking for an alternate design, probably miniaturising the electronic design, that is more suitable for mass production.	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Electronic or mechatronic engineering background.				
Gibela – Train inspection Mechanical components of trains must be regularly inspected. The trains are normally taken to a depo, where the inspections are performed manually. Typically, the trains must be inspected from below to check the integrity of components such as brakes, wheels, etc. Gaining access to this area is difficult, time consuming and dangerous. It furthermore requires that the train be moved over a pit that provides sufficient access for a person to perform the inspection. In collaboration with Gibela, the company in South Africa that manufacturers our commuter trains, and the Gibela Research Chair at Stellenbosch University, a project must be undertaken to develop a system to semi-automatically perform visual inspections. The project will expose students to machine vision, artificial intelligence and system design. **Requirements:** Engineering background		✓		✓
Stents and Heart Phantom Mechanical hearts, such as the HeartMate 3 LVAD, are implanted into the left ventricle of the heart. It is possible for the ventricle to collapse on occasion and block the pump intake. While the system can cope with this event, it is obviously not ideal. The Institute for Biomedical Engineering is planning a collaborative research project that will address this challenge. In order to lay the foundation for this project, experiments must be conducted with the local manufacture of stents. A heart phantom is also needed to perform laboratory testing of the proposed system. Working from a porcine heart, a phantom must be manufactured. **Requirements:** CAD modelling	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Frame Running Tricycle Frame running is a new Para sport which allows individuals with more severe disabilities, like cerebral palsy, to participate in exercise and sport. These individuals use wheelchairs every day and are given the physiologically important opportunity to ambulate (weight-bear) assisted with the frame runner. Frame running is fun for these individuals and holds great potential for increasing physical activity in this population. It is the fastest growing Para sport globally and has recently been added to the Paralympics programme. There are strong followings in the UK, Europe and Australia. However, the sport has not yet reached South Africa due to the cost of the frame runner tricycles, despite the need for an activity like this in the country. Stellenbosch University is developing this activity in South Africa through the social impact project Framing Mobility, and want to develop affordable equipment. Therefore, the current project will include designing and manufacturing a low-cost frame runner which can be used by people in South Africa participating in frame running. Website to social impact project: https://www.framingmobility.co.za/. Co-supervised by Prof Phebe Runciman (Department of Exercise, Sport and Lifestyle Medicine) **Requirements:** Mechanical design background	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A software tool for high precision laser correction of errors in thin components The proposed project is to create a laser forming technique for thin stainless-steel components. The proposal is for a generalized software tool that is used in combination with existing hardware to improve the flatness and position of components that incorporate complex flat and thin components. The software tool should incorporate an optical flatness map and output laser pathways and intensities such that the flatness of a thin plate component or assembly can be corrected using existing laser forming machines. Frencken (Dutch company) currently manufactures a catalogue of complex components which are characterized by a thin plate structure (thickness « length). These components are used in the high tech semi-conductor industry and typically incorporate sensitive laser or other structures on the plate structures. Typical flatness tolerances can be as low as 10μm in local regions. Typically, such components are produced within specification, however once assembled are out of specification at the assembly level. Part non-conformance is caused by deformations caused in the assembly process by joining operations such as laser welding or brazing and handling errors. Typical errors are seen in the magnitude of 0.01-0.5mm (10-500 μm). The masters project at Stellenbosch University should focus on the delivery of a general manufacturing capability to remove mixed mode deformation in flat plate components with a thickness less than 2mm. The output of this project should be a software tool which takes as input an optical surface map of a product and product characteristics and outputs all the necessary inputs for a laser machine to correct the deformation from the optical map. The validation of this model and software package using a simplified validation case and complex dummy part is within the scope of the project. Final production tooling and hardware over and above needed for validation is not within the project scope. The selection and definition of an appropriate optical surface mapping technique as input and validation of the model is within the scope of the study. The development of a novel or unique mapping technique is outside the project scope. The project is proposed and sponsored by Frencken. The student must be willing and able to travel to The Netherlands as needed. The availability of the topic is dependent on the necessary agreements between Stellenbosch University and Frencken. Final selection of the student will be by Proff Venter and Schreve and a representative from Frencken. A strong mathematics, FEM and programming background is recommended. **Requirements:** A strong mathematics, FEM and programming background is recommended.		✓		✓

Dr Vinay Shekhar
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- **Research Field**
  Blast testing, impact testing, composites manufacturing and testing, sandwich and foam materials, Finite element modelling, high-strain rate material testing, structural design optimisation
- **General Description of Research Field**
  Numerical simulations of blast and impact testing using Finite element (FE) software for structural optimisation to maximise blast and ballistic resistance and minimise mass. Material testing under high strain rates with full-field strain measurements to develop and optimise the material models used in the simulations. Development of laboratory equipment for impact testing, such as a drop tester and projectile impact test rig. Composites manufacturing, material testing, and modelling under quasistatic and dynamic testing conditions to determine failure propagation and energy absorption characteristics.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Numerical modelling of welded joints in explicit FEA solvers like LS-DYNA ADG mobility designs, develops, and manufactures Mine-Resistant Ambush-Protected vehicles (MRAPs) for landmine, Improvised explosive device (IED), and ballistic protection. They work closely with the CSIR on full-scale high-explosive blast testing and structural analysis. With an aim of creating structures to increase the survivability of people subjected to blast and ballistic events. This project involves the development and validation of best-practice FEA modelling methodologies for common weld joints (i,e. fillet, lap, butt). The eventual aim is to study these joints under blast/impact loading conditions with a direct application to MRAP design for blast mitigation. The proposed study will Investigate the choice of element, ties/connectors, contact material strength modification to take account of HAZ and practical failure criteria. Suitable materials must be source and welded before mechanical testing is done. Full-field strain measurements must be used to gather as much data on the heterogeneity of the material with direct strength comparisons to the mother material. Since the analysis time steps for explicit solvers are governed by the minimum element edge length, welded joints can in general not be modelled in detail. A typical compromise is to “weaken” a row of shell elements parallel to the area where welds occur. This is done to take account of the weakening of the mother material in the HAZ. The question is however how much the elements must be weakened, should the material property still be rate dependent, which material model is most appropriate, what geometric strategy is best for fillet-, lap- and butt joints? These are some of the questions that will be considered as part of this study. You will be involved in real-world testing and design aimed at optimising structural design for the increase of the survivability of people exposed to explosive and impact events. This project will involve blast test field work with ADG mobility and the CSIR. A student who chooses this project will develop skills in dynamic explicit FE analysis (useful in the automotive industry), material testing and characterisation, parameter optimisation, structural design and material selection. **Requirements:** This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master’s programme), material characterisation and optimisation using skills learned in strength of materials and material science.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a cost-effective quarter symmetry hull model to account for landmine blast scaling effects ADG mobility designs, develops, and manufactures Mine-Resistant Ambush-Protected vehicles (MRAPs) for landmine, Improvised explosive device (IED), and ballistic protection. They work closely with the CSIR on full-scale high-explosive blast testing and structural analysis. With an aim of creating structures to increase the survivability of people subjected to blast and ballistic events. This project involves the development of a validated scaling methodology (building on the work done by the CSIR) for affordable laboratory tests of a quarter symmetry MRAP hull subjected to underbody blast events using scaled hulls and controlled soil/-explosive charge conditions or blast emulators. Full-scale blast testing is costly and time-consuming due to the size of the vehicle hulls and the amount of explosives required. It is still, however, an essential part of the development process of MRAPs. Scaled blast testing can provide rapid and reliable insights and allow for design optimisation if similitude (i.e. structural geometry, soil type, and explosive charge shape) is respected and boundary effects are controlled. This project will involve MRAP hull modelling in explicit FEA software under blast loading conditions, with the inclusion of soil modelling. An investigation into the influence of the dimensions of the soil enclosure on the blast wave propagation should also be considered as part of the study. These scaled test results should be correlated with full-scale field tests that can be performed as part of the study. You will be involved in real-world testing and design aimed at optimising structural design for the increase of the survivability of people exposed to explosive and impact events. This project will involve blast test field work with ADG mobility and the CSIR. A student who chooses this project will develop skills in dynamic explicit FE analysis (useful in the automotive industry), material testing and characterisation, parameter optimisation, structural design and material selection. **Requirements:** This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development and validation of a closed-cell foam model for motorcycle protective gear simulation in LS-DYNA Leatt is a world-leading South African company that designs and manufactures protective equipment for adventure sports ranging from mountain biking to motorcross. The company boasts state-of-the-art research and testing facilities to develop and optimise helmets, bracing, and soft armour to protect riders participating in extreme sports. Motorcycle safety protective gear has improved dramatically in the last 20 years. From hard plastic inserts with little to no energy absorption, the industry has adopted various types of polyurethane and EVA foams in back, chest, elbow, hip, and shoulder protective garments to produce safer riding gear. The European standard EN 1621 specifies thresholds for transmitted force for motorcycle protective garments for the chest, the back, and the limbs. This standard classifies the garment as either Level 1 (< 18 kN) or Level 2 (< 9 kN) based on the transmitted force from a 50 J impact, measured with a load cell below the protective garment. The objective of this project will be to test a polyurethane foam typically used in motorcycle back protectors and characterise its response during impact. These materials are highly non-linear, and their characteristics change according to environmental factors, especially when subjected to extreme heat and extreme cold. This project will characterise a material model for impact protection foams in LS-DYNA and validate the model with physical drop tests for ambient, +50°C, and -20°C conditions. See https://lsdyna.ansys.com/dynamat/ for more information on available material models for closed-cell foams in LS-DYNA. You will be involved in real-world testing and design aimed at optimising structural design for the increase of the survivability and the minimisation of injury of people subjected to crash impact events. This project will be done in partnership with Leatt. A student who chooses this project will develop skills in dynamic explicit FE analysis (useful in the automotive industry), material testing and characterisation of soft materials, parameter optimisation, structural design and material selection. **Requirements:** This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development and blast modelling of scaled composite V-structures for MRAPs including failure modelling This project will involve the manufacturing and material testing of composite specimens to characterise a suitable material model in LS-DYNA. LS-DYNA will then be used to model composite structures under near-field air-blast loads. The simulated results will be validated against scaled blast experimental data in terms of both the transient deformation and the failure modes observed. The explosive blast load, the geometry, and other design parameters can then be varied to investigate their influences on the damage propagation and energy absorption characteristics of these composite structures. You will be involved in real-world testing and design aimed at optimising structural design for the increase of the survivability of people exposed to explosive and impact events. You will gain skills in dynamic explicit FEA software aimed at industries such as MRAP design and manufacturing, and the automotive sector. **Requirements:** This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science.		✓		✓
Development and blast modelling of scaled armour steel V-structures for MRAPs including failure modelling This project will involve the material testing of armour steel specimens at varying strain rates to characterise a suitable material model in LS-DYNA. LS-DYNA will then be used to model armour steel structures under near-field air-blast loads. The simulated results will be validated against scaled blast experimental data in terms of both the transient deformation and the failure modes observed. The explosive blast load, the geometry, and other design parameters can then be varied to investigate their influences on the damage propagation and energy absorption characteristics of these composite structures. You will be involved in real-world testing and design aimed at optimising structural design for the increase of the survivability of people exposed to explosive and impact events. You will gain skills in dynamic explicit FEA software aimed at industries such as MRAP design and manufacturing, and the automotive sector. **Requirements:** This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Full-scale versus scaled V-structure numerical blast modelling for MRAP design optimisation Scaled blast experiments are a useful way to investigate and optimise the design of MRAP hulls for energy absorption and ballistic protection. These tests rely on scaling laws. The aim of this project is to determine via numerical simulations, if MRAP hulls and the explosive charge can be accurately scaled in these simulations to replicate the same transient and damage response characteristics of the MRAP hulls. An additional possible extension to the study will involve the use of the scaled model to determine the effect of changing the position of the explosive charge and moving this away from the centre of the MRAP hull. You will be involved in real-world testing and design aimed at optimising structural design for the increase of the survivability of people exposed to explosive and impact events. You will gain skills in dynamic explicit FEA software aimed at industries such as MRAP design and manufacturing, and the automotive sector. **Requirements:** This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a physics-based quarter symmetry MRAP hull model capable of rapid prediction of key failure modes under varying loading conditions ADG mobility designs, develops, and manufactures Mine-Resistant Ambush-Protected vehicles (MRAPs) for landmine, Improvised explosive device (IED), and ballistic protection. They work closely with the CSIR on full-scale high-explosive blast testing and structural analysis. With an aim of creating structures to increase the survivability of people subjected to blast and ballistic events. This project aims to predict the underbody structural response of a quarter-symmetry model of an MRAP hull to different types of blast loads using existing test data to train a model for rapid prototyping and design decision-making. A quarter symmetry model is currently being used by ADG mobility to do scaled simulation tests of the hull material, construction method, explosive stand-off distance and the vehicle underbelly geometry. Full simulations involving the modelling of the blast load are generally slow and suboptimal for rapid prototyping. The development of a surrogate can accelerate the concept design phase if trained on existing experimental data with an understanding of the system specification for the particular tests. The design parameters are rupture (i.e. tearing of the hull) and both transient and permanent deformation. The model developed must be capable of accurately predicting these parameters for a given hull design and blast loading condition. This project will involve field work with ADG mobility and the CSIR. A student who chooses this project will develop skills in dynamic explicit FE analysis (useful in the automotive industry), material testing and characterisation, parameter optimisation, structural design and material selection. **Requirements:** This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science. This project will also involve the use of statistical modelling and machine learning techniques to generate the parametric model.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a workflow for full body kinematics simulation for motorcycle fall conditions Leatt is a world-leading South African company that designs and manufactures protective equipment for adventure sports ranging from mountain biking to motorcross. The company boasts state-of-the-art research and testing facilities to develop and optimise helmets, bracing, and soft armour to protect riders participating in extreme sports. When developing novel protective equipment, it is important to understand the accident dynamics and body kinematics. Unfortunately, fall data for motorcycle or bicycle-related accidents is difficult to obtain. Traditional methods such as optical motion capture would be well-suited for recording fall-kinematics, but unfortunately, this is primarily a lab-based tool. Small, wearable high-speed dataloggers enable measurement of rider kinematics, but the number of participants, the number of fall-events needed and the cost implications of deploying many dataloggers make this an expensive and time-consuming exercise. One solution to streamline the process of kinematic data-acquisition is to simulate accidents using multi-body or finite element (FE) models. The objective of this study is to develop a workflow using a multi-body or FE solver to predict head and torso kinematics during an accident. The resulting head and torso kinematics will be used to train a machine learning model for fall detection. The workflow must allow simulation for a variety of impact locations, impact velocities and motorcycle rider positions. Kinematics may be obtained from multibody simulation packages, like MSC Adams, or Simcentre Madymo. Madymo is often used in conjunction with LS-DYNA, and would be a good choice for this project as there are previous studies which utilized this approach. There are multiple options for human body models (HBMs) in LS-DYNA, such as THUMS, ATD dummies of THOR-50th male, and some paid models, like Humanetics Hybrid III 50th male. Humanetics also license a specialty model for a motorcycle rider dummy (https://www.humaneticsgroup.com/products/virtualmodels/specialty-virtual-models/powered-two-wheeler-dummy-ptw). Results of simulations will be exported to a database and post processed in MATLAB or Python. The machine learning model is beyond the scope of this project but could be added as a scope extension. You will be involved in real-world testing and design aimed at optimising structural design for the increase of the survivability and the minimisation of injury of people subjected to crash impact events. This project will be done in partnership with Leatt. A student who chooses this project will develop skills in dynamic explicit FE analysis (useful in the automotive industry), material testing and characterisation of soft materials, parameter optimisation, structural design and material selection.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science.				
Simulation of a wearable inflatable motorcyclist protective device in LS-DYNA Leatt is a world-leading South African company that designs and manufactures protective equipment for adventure sports ranging from mountain biking to motorcross. The company boasts state-of-the-art research and testing facilities to develop and optimise helmets, bracing, and soft armour to protect riders participating in extreme sports. Airbags have been commonplace in the automotive industry for many years and are effective at reducing the accelerations and forces that occupants are subjected to during an accident. However, wearable airbags have not been commercially available for motorcyclists until the early 2010s, as the technology was still in development, with the majority of research and testing happening in Moto GP. Experimental testing of wearable airbags has shown a substantial reduction in transmitted force from an impact to the wearer's torso. Parameters like pressure, internal volume and airbag bladder material elasticity all contribute to the efficacy of impact force attenuation, but the relative importance of each parameter is yet to be determined for a wearable airbag garment. The objective of this study will be to develop a model for a simple wearable airbag jacket in LS-DYNA. The airbag model will be validated by drop testing experiments measuring relative deformation and force transmittance to a load cell under the garment. Parameters like inflation pressure, material elasticity and airbag volume will be investigated during physical testing. Finally, the airbag model will be simulated in LS-DYNA with an openly available human body model (THUMS - https://www.toyota.co.jp/thums/) to predict its protective capabilities in mitigating internal organs and skeletal structure injury. You will be involved in real-world testing and design aimed at optimising structural design for the increase of the survivability and the minimisation of injury of people subjected to crash impact events. This project will be done in partnership with Leatt. A student who chooses this project will develop skills in dynamic explicit FE analysis (useful in the automotive industry), material testing and characterisation of soft materials, parameter optimisation, structural design and material selection.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science.				
Development and validation of a mountain-bike helmet model with rotational impact mitigation technology in LS-DYNA Leatt is a world-leading South African company that designs and manufactures protective equipment for adventure sports ranging from mountain biking to motorcross. The company boasts state-of-the-art research and testing facilities to develop and optimise helmets, bracing, and soft armour to protect riders participating in extreme sports. This project is related to "Development and validation of an expanded polystyrene foam model for motorcycle helmet simulation in LS-Dyna", but with a reduced emphasis on the EPS material characterisation (i.e. only one or two densities need to be used), and it should be more focussed on incorporating a rotational impact mitigation technology in the model. This project will focus on validating a model of an existing helmet and the helmet component that aims to reduce linear acceleration of the head during impact. This project will incorporate a hyper-elastic material model for Leatt's 360° turbine, a small elastomeric disc that is positioned in between the EPS and the helmet-wearer's head. Upon impact, this disc moves and deforms, decoupling the wearer's head from the helmet, resulting in a reduction in rotational velocity and acceleration of the head. Material testing has been completed in laboratory-based experiments, and the material model parameters have been derived. However, the material model has not yet been incorporated in an FE model or validated against experimental data. The end goal of this project is to develop a model of a mountain bike helmet which includes rotational impact mitigation technology, to perform simulated drop tests in accordance with the EN 1078 standard, and to validate the results with physical drop-test results (obtained from the Leatt Lab). The project outcome would be to have a standalone LS-DYNA keyword file of a Leatt 360° Turbine. This project will be done in partnership with Leatt. A student who chooses this project will develop skills in dynamic explicit FE analysis (useful in the automotive industry), material testing and characterisation of soft materials, parameter optimisation, structural design and material selection.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science.				
Development and validation of an expanded polystyrene foam model for motorcycle helmet simulation in LS-Dyna Leatt is a world-leading South African company that designs and manufactures protective equipment for adventure sports ranging from mountain biking to motorcross. The company boasts state-of-the-art research and testing facilities to develop and optimise helmets, bracing, and soft armour to protect riders participating in extreme sports. This project aims to develop a model of an existing motorcycle helmet in LS-DYNA. The focus will be on the characterisation of expanded polystyrene (EPS) foam, which is the primary material used in most motorcycle helmets currently on the market. A polycarbonate or plastic shell will be used (with a possible extension to include a composite shell). The model will be used to recreate physical helmet tests, and it will be validated against experimental data obtained from helmet drop tests using an instrumented headform. The desired model outputs will be the predicted head kinematics (i.e. linear and angular velocity and acceleration) while damage propagation of the helmet model will also be investigated. You will be involved in real-world testing and design aimed at optimising structural design for the increase of the survivability and the minimisation of injury of people subjected to crash impact events. This project will be done in partnership with Leatt. A student who chooses this project will develop skills in dynamic explicit FE analysis (useful in the automotive industry), material testing and characterisation of soft materials, parameter optimisation, structural design and material selection. **Requirements:** This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development and validation of a soft open-cell foam model for motorcycle helmet simulation in LS-DYNA Leatt is a world-leading South African company that designs and manufactures protective equipment for adventure sports ranging from mountain biking to motorcross. The company boasts state-of-the-art research and testing facilities to develop and optimise helmets, bracing, and soft armour to protect riders participating in extreme sports. Soft foams are often used in motorcycle helmet comfort liners. These foams are usually open-cell polyurethane and experience large deformations during impact. One of the challenges of modelling soft foams is that models become unstable during high deformation. This topic is related to "Development and validation of an expanded polystyrene foam model for motorcycle helmet simulation in LS-DYNA", but with the focus on soft open-cell foams and developing a strategy to ensure numerical stability during high deformation. The student will be encouraged to investigate a variety of foam material models in LS-DYNA and compare the performance of the different models. Additional material data could be supplied to help the student with a full helmet simulation, but the focus will be on the soft open-cell foam materials. Additional information on the materials can be found on: https://lsdyna.ansys.com/dynamat/ You will be involved in real-world testing and design aimed at optimising structural design for the increase of the survivability and the minimisation of injury of people subjected to crash impact events. This project will be done in partnership with Leatt. A student who chooses this project will develop skills in dynamic explicit FE analysis (useful in the automotive industry), material testing and characterisation of soft materials, parameter optimisation, structural design and material selection. **Requirements:** This project is suitable for someone who enjoys numerical modelling techniques, such as finite element methods (FEM) (which can be learned during the project development phase of the master's programme), material characterisation and optimisation using skills learned in strength of materials and material science.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
High strain-rate tensile testing with a drop-weight rig ADG mobility design, develop, and manufacture Mine-Resistant Ambush-Protected vehicles (MRAPs) for landmine, Improvised explosive device (IED), and ballistic protection. They work closely with the CSIR on full-scale high explosive blast testing and structural analysis. With an aim of creating structures to increase the survivability of people subjected to blast and ballistic events. Design, build, and validate a compact, instrumented drop-weight tensile test rig to obtain true stress–strain curves at 10^2–10^3 s^{-1} (to be confirmed). Output material cards suitable for explicit FEA. The Split Hopkinson pressure bar test generally loads material samples in compression, while real-world structural loading is more likely to be tensile. Currently, the Johnson-Cook (JC) high strain rate material model is used for structural landmine simulations, Thus, it would be ideal to determine the JC material model parameters based on high strain rate tensile loading. This project will involve the design, development, and commissioning of a drop weight tester that can be used to achieve the target strain rates for armoured steels, such as Armox 500T. This project will involve field work with ADG mobility and the CSIR. **Requirements:** This project is suitable for someone who enjoys the design and commissioning of testing equipment and the application of this equipment to material testing and characterisation. The candidate would need to make use of skills learned in design, strength of materials, and material science.		✓		✓

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

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

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A Drone Based System to Measure Soiling of Heliostats Cameras are relatively inexpensive sensors that can provide valuable information, such as identifying objects in view and accurately measuring their sizes. This research project aims to develop a new application for cameras: measuring the soiling of heliostats using a drone. A heliostat is a large mirror that reflects sunlight onto a receiver mounted on a tall tower. Concentrated solar power plants contain tens of thousands of these mirrors. The system's efficiency significantly decreases when the mirrors become dirty and gather dust. This research project will explore how accurately soiling can be measured using only a camera mounted on a drone. While some work has been done in this area, there remain many opportunities for improvement. Through this project, you will develop skills to use cameras for remote sensing. **Requirements:** A love for coding	✓	✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a Motor-Propeller Model for Drone Design One of the many design choices a drone designer has to make is to select a motor and propeller combination. This is especially difficult for hovering drones, since the weight of the motor contributes to the weight that needs to be lifted by the motor. In general, a larger propeller is more efficient than a smaller one. However, a larger propeller uses a larger motor, which is heavier. The heavier motor, in turn, requires the motor and propeller to produce more lift and use more power. Currently, designers iterate through many motor-propeller combinations to find one that balances weight, lift, and power consumption effectively. This project will examine the characteristics of commercially available motors and propellers to develop a motor-propeller model that designers can utilise. This model should ideally be simple enough so that it can be widely adopted by industry. **Requirements:** None specifically.		✓		
Autonomous Ground Vehicle to Serve a Tethered Drone A drone can be seen as an extremely versatile robotic arm with a very long reach. The drone carries the end effector, rather than having it supported by multiple arm segments and joints. The main disadvantage of drones is their flight time. However, many applications can use tethered drones - drones connected to a ground station via an umbilical cord. This cord supplies power to the drone, allowing it to fly for hours nonstop. The cord can also include features like pressurised water or pesticides, such as when the drone is used for window washing or crop spraying. This project will develop an autonomous ground vehicle that will contain the electrical supply, containers to hold water or pesticide, as well as the pump. The ground vehicle should be autonomous and able to navigate around buildings or in an orchard. **Requirements:** None in particular		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Analysis of the X-shaped Tilt-Wing Quadcopter Configuration Quadcopters are versatile and easy to use. They can take off and land in almost any terrain, they have few moving parts and can hover in place. Their main drawback is their short flight times and limited range. van Deventer developed an X-shaped Tilt-Wing Quadcopter that addresses these drawbacks by adding a few more moving parts. The drone is a normal quadcopter, but with wings placed on the arms. The arms can rotate to change the angle of the wings. This drone has three flight modes: classical quadcopter mode, helicopter mode and fixed wing mode. This drone has a longer flight time and range than a traditional drone, while only adding a few extra moving parts. Van Deventer built and tested the drone. It performed as expected in quadcopter mode and fixed-wing mode; however, it underperformed in helicopter mode. This project aims to do a theoretical analysis of the aerodynamics of the drone in order to understand why it underperformed, and then to redesign, build and test the next iteration of this promising configuration. Reference: https://scholar.sun.ac.za/items/20324f4d-107a-46b0-8f03-6b6e8b989207 Video: https://scholardata.sun.ac.za/articles/media/X-Wing_Flight_Video/27698856 **Requirements:** Comfortable with microcontrollers.		✓		

Dr Clint Steed

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- **Research Field**
  Production Engineering | Engineering training and education | Socio-technical system
- **General Description of Research Field**
  (1) Virtual Prototyping of Manufacturing Assembly Systems

  Manufacturing assembly is a critical generator of economic value, with human operators remaining essential to system performance. While Industry 4.0 was largely techno-centric, Industry 5.0 introduces a human-centric paradigm that emphasizes technologies which are practical, applicable, and socially sustainable.

  This research applies state-of-the-art tools to support resilient (reconfigurable) manufacturing assembly, contributing to the revitalization of South Africa's declining manufacturing sector. Virtual prototyping enables the development of solutions tailored to small-scale manufacturing, allowing SMEs to respond rapidly to market fluctuations and to leverage advanced technologies in ways that are often inaccessible to larger firms.

  (2) Virtual Reality in Engineering Training and Education

  The demand for engineering training is increasing, with growing class sizes and technological disruptions requiring large-scale retraining. The ability to scale engineering experience is therefore of strategic importance.

  Virtual reality provides a viable means of offering industrially relevant learning experiences when physical site visits are impractical or unsafe. It also facilitates immersive, practice-oriented training that enhances learning outcomes. Gamification has demonstrated improvements in knowledge retention among both students and professionals, though it requires significant development resources. Furthermore, technological transitions, such as the shift from internal combustion engines to electric vehicles, highlight the urgent need for scalable retraining solutions.

  By integrating virtual training environments into engineering education, learners can engage with advanced technologies at scale, overcoming barriers of cost, accessibility, and safety.

  (3) The African Infrastructure Transition

  Africa's development context is shaped by a large and dispersed rural population, which challenges conventional assumptions about infrastructure. Centralized, capital-intensive systems, common in industrialized nations, are often unsuitable for African realities due to their high costs and cultural misalignment.

  This research explores alternative, African-centric infrastructure models that prioritize cultural relevance and social acceptance while addressing urgent development needs. Leapfrogging conventional infrastructure pathways may provide more sustainable and equitable solutions for the continent.

  "It is important to remember that technology should serve people, and not the other way around."

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Virtual Programming by demonstration Data based Re-targeting human trajectories for industrial robots: Virtual reality based Industrial robot trajectory programming by demonstration Programming by demonstration (PbD) is an end-user development technique for teaching a computer or a robot new behaviors by demonstrating the task to transfer directly instead of programming it through machine commands. While there are numerous challenges in developing an end-to-end PbD framework, new technologies permit a deeper exposition of the human operator. Virtual reality developers greater control of a virtual environment to with practical implications such as allowing the exploration of multiple environments, remote interaction, and a deeper control of the environment from the developers perspective. This technology can be combine with wearable sensors to further enlighten the operators intent. This work attempts to develop a framework for VR PbD with the following sub-studies: 1. Trajectors capture of operator trajectories via VR controllers. These trajectories from hand/controller tracking will be translated to the Industrial robot trajectories (IK planning) and used for automating processes. 2. Wearable sensors integration of operators into VR assembly tasks for intention estimation. Wearable sensors with EKG and Accelerometers are integrated into VR controllers to measure operator state. These are compared with activity menu results to validate the ability to determine operator intention in the predefined scopes. 3. User testing of common assembly tasks. **Requirements:** We welcome students from any engineering background with a strong affinity for developing software for real-world applications.		✓	✓	✓
Reconfigurable manufacturing assembly systems using the human buffers Reconfigurable assembly systems can be developed to stack and assemble components for manufacturing. To reduce risk, these subsystems should be cost-effective, modular, and possess sufficient reliability. This work aims to demonstrate a manual singulation robotic feeding station, which will be evaluated in terms of its reconfigurability. **Requirements:** Strong background/interest in systems/software engineering.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Virtual Prototyping of Manufacturing Assembly Systems Manufacturing assembly is a major generator of economic wealth, and human operators remain a crucial component of manufacturing systems. While Industry 4.0 was techno-centric, Industry 5.0 brings with it a redefined value system that is human-centric, with an emphasis on making technologies practical and applicable. In this line of research, we focus on applying bleeding-edge tools to create systems that support resilient manufacturing assembly, strengthening South Africa's atrophying manufacturing industry. Through virtual prototyping, we can develop tools appropriate for small-scale manufacturing, enabling SMEs to respond quickly to market changes and exploit modern tools and technologies in ways that larger businesses cannot. **Requirements:** Creativity, systems (engineering, thinking, science), typical engineering background		✓	✓	✓
Virtual Reality Engineering Training and Education The demand for engineering training is scaling rapidly. Class sizes are increasing, and technology-driven disruptions will result in large-scale (re)training. Scaling engineering experience has become an urgent priority. From an engineering education perspective, virtual reality makes it possible to provide industry-like experiences when physical site visits are impractical or unsafe, while still allowing visceral and practical (pre)experiences. Gamification has been shown to improve knowledge retention in both staff and students, but it requires significant development time. Disruptions such as the transition from internal combustion engines to electric vehicles mean that large numbers of maintenance employees will need retraining. By developing virtual training and educational experiences, we can enable greater engagement with cutting-edge technologies that would otherwise be too expensive to experience at scale. These involve developing Android apps, VR experiences, Digital twins, and integrated solutions. **Requirements:** Basic programming skills, Typical engineering background, Creativity and Ambition.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
The African Infrastructure Transition Africa is characterized by a large rural population that is sparsely distributed. This situation demands a re-examination of common infrastructure assumptions. Aging and expensive infrastructure, designed for centralized and globally integrated cultures, is often poorly suited to African contexts. The question here is simple: should we not consider African-centric solutions, thereby leapfrogging much of the proposed infrastructural change? A few examples come to mind. If you had the choice, would you not prefer to cook by fire? This line of investigation examines solutions to current problems in ways that respect local cultures and the people affected by them. “It is important to remember that technology should serve people, and not the other way around.” I’m currently investigating: 1. Low-cost solar PV 2. Direct DC low-cost mini-grid solutions 3. Cultural and circular cooking methods (Rocket stoves). **Requirements:** Strong sense of community or engineering for the greater good. Good sense of practical engineering knowledge, Determination and patience.		✓	✓	✓
Automated control of steady state processes using deep active learning Process control parameter tuning is often challenging requiring in depth knowledge of a process and the control strategies. This is considered a bottom-up rigorous approach. These solutions are adaptive, but not resilient as unforeseen changes may change the behavior making the control strategy unsuitable. Active learning is machine learning technique that allows the system to concurrently learn and optimize a process. With the advent of deep learning, top down approaches to control allow more resilient systems.The current issue is that it is not clear when established machine learning techniques outperform deep learning techniques. Any topics investigating this should be proposed with a supervisor that is a domain expert. For example fluid flow or material flow. **Requirements:** Candidates should possess sufficient background or be willing to explore random processes.		✓	✓	

Topics	**MEng Struct**	**MEng Resrch**	**PhD**	**Potential Funding**
Reconfigurable manufacturing for the transition to Electric Vehicles The automotive industry will likely transition to EV's leaving a large gap for retraining Internal combustion maintenance staff. Moreover, the technology is being rapidly developed and automotive vendors have specific implementations (batteries, drive-trains, etc.). Reconfigurable manufacturing is a paradigm that allows for variation in product and production. Here the objective is to develop reconfigurable (re)manufacturing tools, methods, and processes to improve the transition from internal combustion maintenance to EV maintenance. This requires re-imagining manufacturing at the system level (Layout and Production throughput) and the sub-system interaction (Product and production subsystems, including human operators). Topics exploring this these can be further developed through discussion. This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from Stellenbosch University (SU) & 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 co-supervised by Dr Clint Steed an expert in Assembly System from Department of Mechanical & Mechatronics at Stellenbosch University. At this stage, funding is available only for the development of prototype solutions. 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 simulation or system design/engineering.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Simulation-Based Design and Optimization of Reconfigurable Automotive Assembly Lines for Multi-Variant Production The automotive industry is increasingly challenged by the demand for high product variety, shorter product life cycles, and rapid market fluctuations. Traditional assembly lines, designed for mass production, often lack the flexibility to efficiently accommodate multi-variant production, leading to increased costs, downtime, and suboptimal resource utilization. This research investigates the simulation-based design and optimization of reconfigurable automotive assembly lines (RALs) to address these challenges. This research work will include determining optimal line configurations, assessing resource allocation strategies, and evaluating system responsiveness to product variant changes. The work will make use of case studies and virtual experiments to validate the methodology, focusing on metrics such as throughput, cycle time, utilization, and reconfiguration cost etc. This work forms part of the ongoing research project (REF: CSRP23030881449) funded by National Research Foundation (NRF) consisting of partners from Stellenbosch University (SU) & 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 co-supervised by Dr Clint Steed an expert in Assembly System from Department of Mechanical & Mechatronics at Stellenbosch University. At this stage, funding is available only for the development of virtual simulation model. 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.		✓	✓	✓

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
Instrumentation of Illizarov Frame Illizarov frames are frequently used to fix tibial fractures and facilitate bone healing at the fracture site. Healing of these fractures requires an optimal fixture of the fractured ends relative to one another in order to allow relative displacement between the fixed ends and facilitate the generation of the healing tissue. That is, if the fractured ends are fixed too rigidly in close proximity to each other or if the fracture ends are fixed with too much clearance relative to one another, the healing process does not occur correctly. Literature, based on in-vitro test data, suggests that there is an optimal relative displacement range that leads to a faster healing. An instrumented Illizarov frame that can accurately estimate the relative displacement within the fracture will provide surgeons with valuable feedback on the potential efficacy for the given frame setup in any clinical setting. The objectives of this project are to instrument an Illizarov frame and to validate fracture displacement estimations through load frame testing. The frame needs to be instrumented in such a manner that data can be collected outside of a laboratory context, i.e. the instrumentation can be done on an Illizarov frame fixed to a patient. The instrumentation should be able to accurately estimate the relative bone displacement at the fracture site based on measurements and known heal strike force data. Validation will require a rigorous experimental design process including the creation of a representative model of the surrounding tissue and a thorough experimental procedure that can be used to relate the measurements to the actual relative displacement at the fracture site. Any candidate for this project will require a background in Mechanical or Mechatronic Engineering and should be comfortable multi-disciplinary applications. This project forms part of a collaborative research effort with the Advanced Orthopaedic Training Centre 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:** Mechanical / Mechatronic Engineering degree.		✓		
Development of a decision matrix for fracture treatment procedures The purpose of this study is to create a framework describing a typical healing process related to fracture treatment. This should include all possible parameters influencing the healing process, including temporal weighting. The objective of the study is to support health care providers by providing them with a decision matrix for optimizing healing time by highlighting the most prominent health risk factors at any given stage of treatment. Candidates should take note that this thesis will be literature focused. Given the vast scope and open-ended nature of the proposed research this project may be tailored to fit the background of the successful candidate.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Background dependent				

Dr Nicole Taylor
nctaylor@sun.ac.za

- **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
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		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
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!				
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.		✓	✓	✓

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
Smart Hydrogen Lab: Development of an Automated Electrolyzer Test Bench This project involves designing and constructing a comprehensive, budget-conscious automated test bench for PEM water electrolysis characterization. Students will integrate low-cost sensors, microcontroller-based control systems, and data acquisition hardware with the existing Gamry potentiostat setup. The system will feature automated testing protocols, real-time monitoring of key parameters (temperature, pressure, flow rates, gas purity), gas detection systems for safety monitoring, user-friendly interface design, and cloud-based data logging. The project combines mechatronic design, programming, and process control engineering to create a platform that can run standardized performance tests, durability studies, and efficiency optimization experiments. Students will gain hands-on experience with industrial automation concepts while contributing to hydrogen energy research infrastructure. **Requirements:** none	✓	✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Precision Stamping Manufacturing of High-Performance Bipolar Plates for Hydrogen Production This manufacturing-focused project develops cost-effective stamping processes for producing high-precision bipolar plates with complex flow field geometries. Students will design and optimize stamping dies, conduct material formability studies, and establish quality control protocols for dimensional accuracy and surface finish. The research includes finite element analysis of the stamping process, material selection based on formability and electrochemical performance, and development of automated production workflows. Key deliverables include process parameter optimization, tooling design specifications, and economic feasibility analysis comparing stamping to alternative manufacturing methods. The project provides hands-on experience with precision manufacturing, tool design, and production scaling while addressing the critical need for cost-effective hydrogen energy component manufacturing. **Requirements:** none		✓		
Advanced Porous Transport Layer Engineering: Multiscale Design for Enhanced Hydrogen Production This cutting-edge research project focuses on designing and manufacturing next-generation porous transport layers (PTLs) with engineered microstructures for optimal electrolyzer performance. Students will develop laser process parameter optimization combined with fine lattice structure CAD design for 3D-printed titanium mesh architectures with gradient porosity designs. The research encompasses multiscale engineering from nanoscale surface functionalization to macroscale mechanical properties, including water management enhancement through controlled wettability. Advanced characterization includes porosity analysis, electrical/thermal conductivity measurements, mechanical property testing, and in-situ testing of the PTL in a single cell PEM water electrolyzer. CFD analysis may be incorporated depending on student skills. The project combines materials science, CFD, and additive manufacturing to push the boundaries of hydrogen production efficiency and durability. **Requirements:** none		✓	✓	✓

M.Sc. M.Sc. Paul Thiele
pault@sun.ac.za

- **Research Field**
  Hydrogen Engineering
- **General Description of Research Field**
  I investigate the integration of hydrogen into the renewable energy system. This includes electrolysis to produce hydrogen from electrical energy and fuel cells to generate electrical energy again from hydrogen. These technologies are used in combination as energy backup and to fuel hydrogen vehicles. To optimise such systems, artificial intelligence and machine learning methods will play a big role in the future for optimizing the hybrid strategy of the system with respect to energy efficiency but also lifetime improvement. Therefore, degradation analysis and mitigation are other aspects of the research.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Digital Twin Development for H2 Microgrid-Refuelling Station Components Advanced simulation modelling for integrated hydrogen infrastructure systems Hydrogen microgrid-refuelling station systems represent a cutting-edge solution for South Africa's energy security challenges, enabling long-term storage of renewable energy through hydrogen conversion. These systems store electricity from solar and wind power as hydrogen via electrolysis, providing energy independence during periods of low renewable generation or grid instability (see `https://www.iwu.fraunhofer.de/en/press/2025-Hydrogen-Microgrids-Make-Sun-and-Wind-Storable.html` for technical background). By storing excess solar and wind energy as hydrogen, these integrated systems provide both grid stabilisation and clean transportation fuel, bridging the gap between intermittent renewable generation and continuous energy demand. Develop comprehensive digital twin models for individual components of hydrogen microgrid-refuelling station systems. Focus on high-fidelity simulation models with detailed parameterisation and experimental validation for components such as electrolysers, fuel cell systems, high-pressure storage vessels, or dispensing units. Apply advanced modelling techniques including multi-physics simulations, thermal dynamics, and electrochemical processes to enable grid-independent renewable hydrogen production. **Requirements:** Some pre-knowledge in modelling and renewable energy technologies beneficial		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
AI/ML Optimisation of Integrated H2 Microgrid-Refuelling Systems Machine learning approaches for intelligent energy management and control Hydrogen storage offers significant advantages over battery storage for renewable energy systems, particularly its very low self-discharge rate making it ideal for seasonal energy storage and bridging "dark doldrums" when there is no wind or sunshine. Combined hydrogen microgrid-refuelling station systems address the critical challenge of renewable energy intermittency by using hydrogen as a chemical battery to store excess solar and wind energy during peak production periods. The produced hydrogen can either be reconverted to electricity during shortages or load shedding events or be used to refuel hydrogen powered vehicles (technical details: https://www.iwu.fraunhofer.de/en/press/2025-Hydrogen-Microgrids-Make-Sun-and-Wind-Storable.html). Develop and implement advanced artificial intelligence (AI) and machine learning (ML) algorithms for optimal operation of these integrated systems that maximise renewable energy utilisation through intelligent power-to-hydrogen conversion. Focus can include, among others, neural network-based control strategies, reinforcement learning for energy management, predictive maintenance algorithms, and degradation mitigation through intelligent operation. Address challenges of grid instability, load balancing, and autonomous system operation while maintaining continuous energy supply from stored renewable hydrogen when grid power is unavailable. **Requirements:** Some pre-knowledge in modelling and renewable energy technologies beneficial		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Degradation Analysis & Lifetime Modelling of H2 Infrastructure Components Comprehensive lifetime assessment for sustainable hydrogen infrastructure Hydrogen microgrid-refuelling systems enable long-term storage of renewable energy by converting excess solar and wind power to hydrogen via electrolysis, providing energy security during grid instability and load shedding events (see https://www.iwu.fraunhofer.de/en/press/2025-Hydrogen-Microgrids-Make-Sun-and-Wind-Storable.html for microgrid functionality). These systems designed for seasonal energy storage face unique operational challenges, particularly when capturing abundant solar energy during summer months and storing it as hydrogen for use during winter periods when solar irradiation is reduced. Components must withstand frequent charge-discharge cycles as renewable energy availability fluctuates, requiring robust infrastructure design for renewable energy integration in regions with seasonal variations and grid instability. Conduct detailed degradation analysis and lifetime modelling of critical components in hydrogen microgrid-refuelling systems that enable seasonal energy storage from renewable sources. Focus includes accelerated ageing studies, degradation mechanism identification, materials characterisation, and predictive lifetime modelling for PEM electrolysers and fuel cells operating under cyclic renewable energy conditions. Develop reliability-centred maintenance strategies for components operating in challenging renewable energy integration scenarios. **Requirements:** Some pre-knowledge in electrochemical processes beneficial		✓	✓	✓

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
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, Thermodynamics		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Experimental exergetic analysis of hydrofoils 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 support this new line of exergetic MDAO research at the university, it is necessary to establish a methodology for experimentally validating future exergetic computational models. This study will therefore focus on developing and verifying an approach for post-processing exergetic information derived from submerged particle-image-velocimetry (PIV) experimental data. This project will entail the design, build, and testing of an experimental apparatus to enable efficient PIV flow-field measurements in the M&M Department's large towing tank. This research will be co-supervised by Prof. Johan van der Spuy. **Requirements:** CFD, Thermodynamics		✓		
Experimental performance measurement of marine propellers based on exergy characterization Enhancing the performance of marine propellers offers a pathway to meet the growing efficiency demands of the marine transport sector and to support the development of a more sustainable "blue economy." One innovative approach to achieving this is through propeller shape optimization based on exergetic analysis. Exergetic assessment allows researchers to decompose a system's total energy into its recoverable portion (exergy) and its non-recoverable portion (anergy), thereby revealing performance improvement opportunities that may be overlooked by conventional methods. This approach is expected to yield new insights and inspire novel propeller designs. To support this line of investigation, the project will focus on developing the necessary capabilities to experimentally characterize marine propeller performance and extract exergetic parameters, ultimately enabling the validation of future exergetic-based numerical optimization models. This study will assess the feasibility of using tonal measurements for this purpose. The experimental setup will consist of an open-water testing apparatus integrated into the large towing tank facility at Stellenbosch University.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Thermodynamics				
Open-source modelling of large-scale wind turbine farms A range of potential topics in wind-farm modelling, using cost-efficient open-source modelling codes, will be on offer in collaboration with an industry partner. These projects will only be defined towards the end of the year in partnership with the collaborator. If you are interested in pursuing a project in the renewable energy field and working closely with industry, please contact Dr. A. Venter to be added to the waitlist for more info on these potential projects. **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		✓		
Geometric deep learning for surrogate modelling of hydrofoil-supported catamarans using computational fluid dynamics simulation data Hydrofoil-supported catamaran (Hysucat) designs offer significant advantages in vessel efficiency, stability, and ride comfort by reducing hull resistance and enhancing performance at speed. The optimisation of these hydrofoil systems is critical to achieving these benefits, yet it remains a complex and computationally demanding task when relying on high-fidelity CFD-based simulation methods. To accelerate the design and analysis process, this project aims to develop accurate surrogate models based on geometric deep learning algorithms. These models are intended to provide rapid and accurate predictions of the complex flow fields and key performance metrics associated with different hydrofoil configurations. The surrogate models are anticipated to serve as efficient analysis tools for future hydrofoil-supported catamaran designs, enabling faster design iteration and refinement. In the longer term, this approach can contribute to integrated whole-vessel optimisation frameworks, supporting the development of the next generation of Hysucat vessels. **Requirements:** CFD, Deep learning		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Geometric deep learning for surrogate modelling of marine propeller hydrofoils using computational fluid dynamics simulation data Simulation-based optimisation is a valuable approach to developing advanced propeller designs that meet the ever-growing demand for improved vessel efficiency. However, numerical optimisation is computationally intensive, limiting its practical use in iterative design and development workflows. To address this challenge, surrogate models that provide accurate representations are sought. Geometric deep learning algorithms show strong potential in this role, as they can provide cost-effective predictions hydrofoil flow fields, developed from complex, unstructured CFD datasets. The resulting surrogate models are expected to serve as efficient component-level design tools and, over time, may be integrated with other subsystem models to enable whole-vessel optimisation. **Requirements:** CFD, Deep learning		✓		✓

Prof Gerhard Venter

gventer@sun.ac.za

- **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
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 2026 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 8. High level modelling of the electric drive train The 2026 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		✓		✓
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. The MOD research group has recently developed the open-source SUN-DIC software (https://github.com/gventer/SUN-DIC), which has already attracted international attention and is being actively used by skripsie and postgraduate students and collaborators. The project has now grown to include the development of a stereo vision version of the software, along with an open hardware setup. Our long-term goal is to deliver a complete open-source DIC system that includes both hardware and software, that can replace commercial systems costing over one million rand. Such a system has the potential to transform the Southern African research landscape by making advanced experimental mechanics accessible to institutions and researchers with limited resources. Within this research effort, there are many sub-projects that will deal with specific aspects related to the SUN-DIC project. Examples include speckle pattern optimization, automatic subset sizing, speeding up the code, developing experimental test cases and many more. If you are interested in this general area, please make contact with myself or Dr Melody Neaves to discuss specific projects. I am sure we will be able to formulate something that aligns with your interests. Dr Neaves and myself co-supervise most projects related to SUN-DIC.		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
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.				

Prof Martin Venter

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- **Research Field**
  Generative Design, Machine Learning, Material Modelling, Soft Robots and Inflatables, simulation of biomaterials

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

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

Topics	**MEng Struct**	**MEng Resrch**	**PhD**	**Potential Funding**
Digital Design and Simulation for Soft Robotics The Challenge of Designing Soft Robots Soft robots, made from highly deformable materials like silicone, offer unique advantages over traditional rigid robots. Their inherent compliance makes them safer for human interaction, more adaptable to unstructured environments, and capable of complex motions. However, this very compliance also makes them incredibly difficult to design. Unlike rigid robots, which can be created with a high degree of certainty using well-established principles, the behaviour of a soft robot is highly non-linear and difficult to predict. Currently, the design of a soft robot is a laborious, trial-and-error process. A designer must physically fabricate each new design idea (a process that can take days or weeks) and then test it in a lab. If the design fails, they must repeat the process. This slow feedback loop severely limits the pace of innovation. While numerical simulations, such as Finite Element Analysis, are used to understand a design after it has been created, they are rarely integrated into the initial creative and iterative design process. This project aims to change that by developing a systematic workflow for digital design, moving away from physical prototyping as the primary design tool. Research Aims and Objectives The overarching goal of this research is to develop and validate a robust, generic workflow for designing soft robots entirely within a digital environment. This will accelerate the design process by enabling rapid iteration and performance evaluation before any physical prototyping begins. The specific objectives are: Objective 1: Investigate and establish a digital geometry creation pipeline. This involves exploring and evaluating various software tools and methods for creating complex, bio-inspired, and functional geometries for soft robots. The output of this objective will be a set of best practices and a recommended toolchain for generating diverse soft robot designs. Objective 2: Develop a reliable simulation methodology for soft robots. This objective will focus on the technical challenges of simulating hyperelastic materials and complex interactions. The output will be a detailed, repeatable process for successfully running accurate simulations of various soft robot designs. Objective 3: Validate the digital workflow against physical prototypes. To ensure the digital design tools are meaningful, their predictions must be verified. This objective will involve fabricating and testing a small number of soft robot prototypes based on the developed digital designs and comparing their real-world performance with the simulation results. The output will be a quantitative assessment of the accuracy of the proposed digital design workflow. **Requirements:** Students who will thrive in this project will have an interest in structural simulation, programming and providing practical solutions to abstract problems.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Computational Design of Novel Soft Sensors The Challenge of Designing Soft Sensors Soft sensors, inspired by biological systems, are highly sought after for their ability to conform to complex shapes and interact safely with delicate and irregular surfaces. They have applications in various fields, including robotics, healthcare, and wearable technology. However, designing soft sensors with desired sensing properties and performance remains a significant challenge. The relationship between a sensor's geometry, material properties, and its sensing output is highly complex and non-linear, making traditional design methods of trial-and-error inefficient and time-consuming. This project addresses this challenge by proposing a computational design approach. By leveraging numerical optimisation and Finite Element Analysis, we can move beyond physical prototyping as the primary design tool, enabling rapid iteration and performance evaluation of sensor designs in a virtual environment. This will not only accelerate the pace of innovation but also allow for the discovery of novel sensor geometries and material arrangements that would be difficult to conceive of through intuition alone. Research Aims and Objectives The primary goal of this research is to develop and validate a computational framework for the design and optimisation of novel soft sensors. The specific objectives are: Objective 1: Characterise Material and Sensing Properties. This objective will involve a comprehensive literature review and, if possible, experimental testing to characterise the mechanical and sensing properties of common soft sensor materials. This data will be crucial for building accurate and representative numerical models. Objective 2: Develop a Computational Design Framework. A core part of this project is the creation of a working framework that integrates FEA simulations with optimisation algorithms. The student will model the deformation and strain distribution of soft sensor designs under various loading conditions. This framework will be used to explore and identify optimal sensor designs based on specific performance criteria (e.g., sensitivity, resolution). Objective 3: Explore Machine Learning Integration. This objective will investigate how machine learning techniques can be integrated into the design process. The student will explore using datasets generated from FEA simulations to train machine learning models. This could enable the rapid prediction of sensor performance for untested designs, significantly accelerating the optimisation process. Objective 4: Validate Optimised Designs. A limited number of the computationally optimised sensor designs will be fabricated and tested in a laboratory setting. The experimental data will be compared with the simulation results to validate the accuracy of the computational framework and demonstrate the effectiveness of the optimised designs. **Requirements:** Students who will thrive in this project will have an interest in structural simulation, programming and providing practical solutions to abstract problems.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Shape Control of Inflated Structures through Selective Reinforcement The Challenge of Controlling Inflatable Structures Inflatable structures, from airbags and deployable space habitats to soft robotic grippers, offer significant advantages due to their lightweight nature, compact stowage, and adaptability. However, achieving precise shape control and structural stability once inflated remains a considerable design challenge. A simple inflated membrane tends to balloon into a basic spherical or cylindrical shape. To create more complex, functional geometries, engineers must resort to complex cutting patterns or cumbersome external supports. This limits their application in fields that require high precision and tailored shapes. This project addresses this fundamental challenge by proposing a novel, computational approach to shape control through selective reinforcement. Instead of designing a complex initial shape, we will explore how to strategically add reinforcing elements, such as fibres, patches, or tendons, to a simple inflatable membrane to force it into a desired, functional shape upon inflation. By using computational tools to predict and optimise the placement of these reinforcements, we can design structures with enhanced performance characteristics and precise shape control, unlocking new possibilities for their use in aerospace, architecture, and robotics. Research Aims and Objectives The primary goal of this research is to develop a computational framework for designing and optimising the shape of inflated structures through selective reinforcement. The specific objectives are: Objective 1: Conduct a Comprehensive Literature Review. This objective will involve a thorough investigation of existing methods for controlling the shape of inflated structures, from cutting patterns and origami-inspired folds to the use of internal or external reinforcement. This will provide a foundation for identifying the most promising reinforcement techniques and key research gaps. Objective 2: Develop a Computational Framework for Shape Control. This is the core of the project. The student will develop a numerical framework, likely using Finite Element Analysis, to accurately model the complex, non-linear behaviour of an inflated membrane. This framework will be extended to incorporate various reinforcement strategies, such as the embedding of inextensible fibres or the attachment of rigid elements. Objective 3: Optimise Reinforcement Strategies. The computational framework will be coupled with optimisation algorithms to determine the ideal distribution, orientation, and stiffness of reinforcing elements to achieve a specific target shape. The optimisation process will consider factors such as material properties, geometric constraints, and the expected loading conditions of the final structure. Objective 4: Validate Optimised Designs. The student will fabricate and test a small number of prototypes based on the computationally optimised designs. The prototypes will be tested under pressure, and their final inflated shape and structural stability will be measured and compared with the simulation results to validate the accuracy of the computational design approach.		✓	✓	✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Students who will thrive in this project will have an interest in structural simulation, programming and providing practical solutions to abstract problems.				

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Soft Robot Poise Control The Challenge of Controlling Soft Robots Soft robots are valued for their inherent compliance and ability to safely interact with humans and complex environments. However, their very softness makes them difficult to control. Unlike rigid robots, which have well-defined kinematics and can be precisely positioned, a soft robot's pose, or 'poise', is highly susceptible to external forces, internal material nonlinearities, and gravity. Achieving and maintaining a stable, desired posture in a soft robot is a significant and largely unsolved challenge, limiting their ability to perform delicate tasks or maintain stability during locomotion. This project aims to address this fundamental problem by developing and validating novel control strategies for soft robot poise. We will move beyond simple open-loop actuation and explore a range of advanced control techniques that use real-time sensing and computational models to manage the robot's posture actively. By developing a robust control framework, this research will enable soft robots to perform tasks with a new level of precision, stability, and reliability in unstructured and dynamic environments. Research Aims and Objectives The primary goal of this research is to develop, simulate, and experimentally validate a control framework for achieving and maintaining poise control in soft robots. The specific objectives are: Objective 1: Model the Mechanics and Dynamics of a Soft Robot. This objective will involve a thorough study of a chosen soft robot platform (e.g., a multi-chambered gripper or a multi-segment arm). The student will develop a computational model, likely using Finite Element Analysis or a simplified multi-body dynamics approach, to accurately simulate the robot's large deformations, dynamic response, and interactions with its environment. Objective 2: Develop and Implement Control Strategies. This objective will focus on designing and implementing a control system for the soft robot. The student will investigate and compare various control strategies, such as feedback control, model predictive control, or bio-inspired control, to maintain the robot in a desired posture. The student will also explore the integration of sensors (e.g., accelerometers, strain sensors) to provide real-time feedback. Objective 3: Explore Machine Learning for Enhanced Control. The student will investigate the use of machine learning to enhance the control system's performance. This could involve using reinforcement learning to train a control policy to achieve a target posture or using neural networks to create a more accurate and efficient model of the robot's dynamics. Objective 4: Validate the Control System on a Physical Platform. The final and crucial objective is to test the developed control strategies on a physical soft robot prototype. The student will compare the simulated performance with the real-world results to validate the effectiveness of the control system and refine the computational models.		✓	✓	

Topics	**MEng Struct**	**MEng Resrch**	**PhD**	**Potential Funding**
Requirements: Students who will thrive in this project will have an interest in structural simulation, programming and providing practical solutions to abstract problems.				

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling Growth and Remodelling of Bone using Peridynamics The Challenge of Modelling Living Tissue Bone is a remarkable living tissue that actively adapts to its mechanical environment. For example, a tennis player's dominant arm often shows increased bone density, a process known as remodelling, in response to the stresses of the sport. Similarly, when a fracture occurs, the bone undergoes a complex healing process involving both growth (the addition of new mass) and remodelling (the change of material properties) over time. Modelling these biological processes is a significant challenge for traditional engineering methods, which typically assume a static material. Capturing the interplay between mechanical loads and biological adaptation is crucial for applications such as predicting fracture healing, optimising implant design, and understanding diseases like osteoporosis. This project will tackle this challenge by using Peridynamics, a novel computational method particularly well-suited for modelling fracture and material evolution. Unlike traditional Finite Element Analysis, which relies on local interactions, Peridynamics is a non-local theory that considers the forces between particles at a distance. This makes it inherently better at handling discontinuities, such as cracks, and changes in material properties, making it an ideal tool for modelling the dynamic processes of bone growth and remodelling. The project will investigate how to incorporate the effects of mechanical stimuli into a peridynamic model, moving us closer to a powerful predictive tool for biomechanical applications. Research Aims and Objectives The primary goal of this research is to develop and validate a peridynamic computational model for simulating bone growth and remodelling. The specific objectives are: Objective 1: Model the Mechanical Behaviour of Bone. The student will first develop a baseline peridynamic model to simulate the mechanical behaviour of bone, including its elastic and fracture properties. This will serve as a foundation for incorporating growth and remodelling. Objective 2: Integrate Growth and Remodelling Mechanisms. The student will investigate and implement algorithms within the peridynamic framework to simulate the bone's adaptive response to mechanical loads. This will involve incorporating biological rules (e.g., Wolff's Law) to govern how bone density and material properties change over time in response to stress and strain. Objective 3: Investigate the Role of Configurational Forces. This objective will explore the use of advanced theoretical concepts, such as configurational forces, within the peridynamic model. The student will investigate whether these forces can provide a valuable metric for predicting where material changes or growth should occur, offering a powerful new insight into the modelling process. Objective 4: Validate the Model against Existing Data. The final step will be to validate the computational model against existing experimental or clinical data. This may involve simulating the remodelling of bone under a known loading condition (e.g., simulating a tennis player's arm) or the healing process of a simple fracture and comparing the model's predictions with the known outcomes.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: The student who will flourish in this project will have some understanding of mechanics, mathematics and programming.				

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Design Methods for Foam Structures with Multi-Scale Properties The Challenge of Designing Multi-Functional Materials Lattice and foam structures, often referred to as architected or cellular materials, are a rapidly developing class of materials that can be engineered to have unique and highly tailored properties. Unlike traditional materials, where properties are determined by their chemistry, the performance of a foam and lattice structures are defined by their geometry, at both the micro-scale of its individual struts and the macro-scale of its overall shape. This presents an enormous design space, allowing for the creation of materials that are simultaneously strong, lightweight, and porous, or have complex thermal and acoustic properties. However, designing a lattice structure to meet a set of conflicting, multi-scale requirements (e.g., stiffness for load-bearing and porosity for fluid flow) is a significant challenge that traditional design methods are ill-equipped to handle. This project addresses this challenge by developing computational design tools that can automate the discovery of novel geometries for these materials. By leveraging advanced simulation and optimisation techniques, we will move beyond manual design and create a systematic approach to finding optimal structures that meet a range of competing performance criteria. This will unlock the full potential of these materials for high-impact applications, such as orthopaedic implants, lightweight aerospace components, and advanced heat exchangers. Research Aims and Objectives The primary goal of this research is to develop a computational design framework for generating foam structures that meet a range of multi-scale design requirements. The specific objectives are: Objective 1: Survey and Characterise Existing Lattice Structures. The student will begin by conducting a comprehensive review of existing lattice geometries (e.g., cubic, octet, triply periodic minimal surfaces). They will also use computational tools (e.g., Finite Element Analysis) to characterise the mechanical, thermal, or flow properties of these structures. This will provide a baseline for comparison and a starting point for the design process. Objective 2: Develop a Generative Design Toolchain. The student will develop a computational workflow that links a design parameterisation to a performance prediction. This may involve using scripting tools to generate complex geometries and linking them to a simulation environment to predict properties such as stiffness, porosity, or thermal conductivity. Objective 3: Implement Multi-Objective Optimisation. The core of the project is to implement multi-objective optimisation algorithms that can navigate the vast design space. The student will define competing performance objectives (e.g., maximise stiffness while minimising weight and maximising porosity). The optimisation tool will then iteratively search for and discover new, high-performing geometries that satisfy these requirements. Objective 4: Validate Optimised Designs. The student will select a small number of the computationally discovered geometries and fabricate them using an advanced manufacturing method, such as 3D printing. The physical prototypes will then be tested to experimentally validate their performance and confirm that the computational model's predictions were accurate.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Students who will thrive in this project will have an interest in structural simulation, programming and providing practical solutions to abstract problems.				

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Smart Gyms: Leveraging Exercise Science for Next-Generation Training Technology The Challenge of Personalising Exercise Technology The fitness and sports industries are experiencing an explosion of data-driven insights from exercise and sports science. We now have a deeper understanding of the biomechanics, physiology, and neurological adaptations that drive strength and muscle growth. However, this growing body of scientific knowledge is not yet fully integrated into the design of gym equipment. Most "smart" fitness technologies today are dominated by software solutions, but fail to leverage advanced training principles and scientifically optimised equipment. This project aims to bridge this gap by designing and developing new "smart" gym technologies that are directly informed by modern exercise science. We will move beyond simple data tracking and create a system that can adapt to a user's unique physiology, goals, and performance in real time. This will maximise efficiency and results and reduce the risk of injury. Research Aims and Objectives The primary goal of this research is to design and develop a prototype of a smart gym system that integrates advanced exercise science principles. The specific objectives are: Objective 1: Review and Synthesise Exercise Science Principles. The student will conduct a comprehensive literature review to identify key principles from sports and exercise science that are relevant to training for strength and hypertrophy. This includes concepts such as variable resistance, time under tension, concentric vs. eccentric loading, and adaptive rep/set schemes. Objective 2: Develop a Sensor and Actuator Framework. The student will design and build a prototype of a smart gym machine (e.g., a smart dumbbell, a variable resistance cable machine). This will involve selecting and integrating a combination of sensors (e.g., accelerometers, load cells, encoders) to measure movement and force in real-time, as well as actuators (e.g., motors, clutches, magnetic brakes) to dynamically adjust resistance. Objective 3: Implement Intelligent Control Algorithms. The core of the project is the development of a control system that can apply the scientific principles identified in Objective 1. This could involve using feedback control loops to maintain a specific time under tension, or implementing algorithms that automatically adjust weight or reps based on the user's fatigue and performance. Machine learning techniques could be used to create an adaptive training model that learns a user's unique biomechanics over time. Objective 4: Validate the Prototype's Effectiveness. The final step is to validate the prototype's performance through a series of pilot studies. The student will compare the effectiveness of the "smart" training system to traditional training methods by measuring key metrics such as force output, time under tension, and user feedback on perceived exertion and satisfaction. **Requirements:** Students who will thrive in this project will have an interest in biomechanical simulation and programming.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Gearbox Loading Estimation for Next-Generation Offshore Wind Turbines The Challenge of Modelling Extreme Loads in Offshore Wind Turbines As the wind energy industry moves into deeper waters, offshore wind turbines are evolving into colossal structures. The next generation of turbines will have blades exceeding 150 meters in length mounted on 200-meter-high floating platforms. However, their sheer size and location expose them to a confluence of extreme and complex environmental loads. The drivetrain, particularly the gearbox, is the critical link that transfers the kinetic energy of the rotating blades into electrical power. This gearbox is subjected to a unique combination of aerodynamic forces, wave-induced motions, and the platform's dynamic response, resulting in highly variable and unpredictable loading. Accurately predicting these loads is crucial for ensuring the reliability and longevity of the turbine, preventing costly failures, and advancing the design of these immense machines. This project addresses this challenge by creating a dynamic computational model of an entire offshore wind platform. The model will integrate all realistic load sources to provide a comprehensive and accurate estimation of the forces and moments acting on the gearbox. This research will move beyond static or simplified models and provide a vital tool for engineers designing the next generation of these essential renewable energy systems. Research Aims and Objectives The primary goal of this research is to develop a dynamic, multi-domain model of a floating offshore wind turbine to estimate gearbox loading accurately. The specific objectives are: Objective 1: Model the Aerodynamic and Hydrodynamic Loads. The student will begin by developing sub-models for the two primary environmental load sources. This includes an aerodynamic model of the massive rotating blades and a hydrodynamic model of the floating platform's interaction with waves and currents. Objective 2: Integrate the System Dynamics. The core of the project is to integrate the sub-models into a single, cohesive dynamic system model. This will involve using multi-body dynamics software to simulate the complex coupled motions of the floating platform, tower, and nacelle in response to the applied forces. The model will need to account for gyroscopic effects and the non-linear coupling between the different domains. Objective 3: Estimate and Analyse Gearbox Loading. The model will be used to simulate the turbine's operation under various realistic environmental conditions (e.g., different wind speeds, wave heights, and turbulence levels). The student will then extract and analyse the resulting forces and moments at the gearbox to determine peak loads, fatigue cycles, and the overall load spectrum. Objective 4: Validate the Model. The student will validate the model by comparing its predictions against existing experimental data from scaled-down prototypes or publicly available data from similar full-scale systems. This will ensure the model is robust and its predictions are reliable..		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Students who will thrive in this project will have an interest in structural, fluid and dynamic simulation and programming.				

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Key Technologies for Integrated Offshore Floating Photovoltaic-Wave Energy Converter Equipment The Challenge of Harnessing Coastal Renewable Energy South Africa, with its extensive coastline, possesses a vast and largely untapped renewable energy resource in its coastal waters. While land-based solar and wind projects are expanding rapidly, the potential of the ocean, specifically solar and wave energy, remains underexplored. A hybrid system that integrates both floating solar photovoltaic and wave energy converters into a single platform offers a powerful solution. Such a system can provide a more consistent energy output than a single source, as solar and wave resources often peak at different times of the day or year. However, designing a single, stable, and cost-effective platform that can efficiently harness both forms of energy is a complex challenge, requiring a deep understanding of hydrodynamics, structural engineering, and systems integration. This project aims to address this challenge by developing a location-specific design methodology for a hybrid floating platform. The research will not only provide a theoretical and technical framework for future floating platform research in South Africa but also demonstrate the socio-economic benefits of this technology, encouraging the country to open a new renewable energy market and contribute to its energy security. Research Aims and Objectives The primary goal of this research is to design, model, and validate a location-specific floating platform that integrates both photovoltaic and wave energy conversion. The specific objectives are: Objective 1: Site Identification and Characterisation. The student will begin by identifying and evaluating potential deployment sites in South Africa and, for a comparative analysis, in China. This will involve an analysis of environmental data, including wave characteristics, solar irradiance, sea state variability, and other relevant parameters for hybrid energy generation. Objective 2: Environmental Modelling and Resource Assessment. Based on the identified sites, the student will define the specific coastal and marine conditions at each location. This will involve using modelling software to create realistic environmental models that capture wave characteristics and solar irradiance, providing the necessary inputs for the platform design simulations. Objective 3: Design Concept Development. The student will develop an initial conceptual design for a hybrid PV-wave energy system to serve as a common baseline. This design will be a versatile platform that can be adapted to different environmental conditions. The design will integrate the two energy technologies, for example, by incorporating wave energy converters within the platform's mooring or structural elements. Objective 4: Comparative Design Evaluation. Using the baseline model, the student will adapt the design to be site-specific, optimising its performance based on the local environmental conditions of the chosen South African and Chinese sites. This will involve using a design-by-simulation approach, likely with multi-domain modelling software, to assess energy output, structural resilience, and cost-effectiveness across both regions. The outcome will be a validated design method that can be applied to other locations in the future.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Students who will thrive in this project will have an interest in simulation, programming and providing practical solutions to broadly framed problems.				

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a Deployable Inflatable Safety Device for Impact Protection in Paragliding The Challenge of Balancing Safety and Utility in Paragliding Paragliding is a sport that balances exhilaration with calculated risk. A critical piece of equipment is the harness, which provides a comfortable seat for the pilot and, in many cases, a layer of impact protection. However, a significant design trade-off exists: traditional protective harnesses use bulky foam or rigid plates that provide a good level of safety but are heavy and difficult to pack, while lightweight alternatives, favoured by performance and adventure pilots, offer minimal to no impact protection. This forces pilots to make a difficult choice between safety and utility, potentially exposing them to a higher risk of injury during an emergency landing or unexpected impact. This project addresses this fundamental compromise by developing an innovative, deployable inflatable safety device. The goal is to create a system that remains compact and lightweight during normal flight but can be rapidly inflated to provide superior protection on demand. By leveraging modern materials and sensor technology, this research aims to create a new paradigm in paragliding safety, reducing injury rates while preserving the freedom and utility that pilots desire. Research Aims and Objectives The primary goal of this research is to design, prototype, and validate a deployable inflatable safety system that provides enhanced impact protection for paragliding pilots. The specific objectives are: Objective 1: Design a Reliable Deployment Mechanism. The student will investigate and design a mechanism for the rapid inflation of the safety device. This will involve the integration of impact sensors (e.g., accelerometers) to detect a crash scenario and a system for rapid inflation, such as a compressed gas cylinder or a pyrotechnic inflator. The student will also design a manual override for pilot activation. Objective 2: Optimise Inflatable Chamber Geometry. The student will use computational modelling (e.g., Finite Element Analysis) to design and optimise the geometry of the inflatable chambers. The goal is to maximise the protective coverage of critical body areas while minimising the required gas volume and ensuring the structure maintains its shape under impact loads. Objective 3: Identify Suitable Materials and Develop a Prototype. The student will research and identify lightweight, durable, and highly packable materials for the inflatable device. This will involve material testing to assess tensile strength, abrasion resistance, and airtightness. A functional prototype will then be developed, integrating the inflatable chambers and the deployment mechanism into a harness or a separate module. Objective 4: Validate Performance through Controlled Testing. The student will conduct controlled impact tests on the prototype. This will involve using a test dummy to simulate crash scenarios and measuring key safety metrics, such as peak acceleration and impact force, to evaluate the system's effectiveness. The results will be compared against the performance of a traditional foam-based harness. Objective 5: Integrate with Harness Ergonomics. The project will ensure the final system is not just safe but also practical. The student will consider the ergonomics and comfort of the pilot, ensuring the deflated device can be integrated into an existing harness design.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Students who thrive in the project will enjoy multi-physics simulation, programming, practical experiments and design.				

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Key Features of Box Compression Simulation The Challenge of Accurately Simulating Corrugated Boxes Box compression testing (BCT) is the industry standard for evaluating the strength and performance of corrugated paperboard boxes. In the multi-billion-dollar packaging industry, an accurate BCT value is crucial for optimising material usage, reducing costs, and ensuring products are protected during transport and storage. However, predicting a box's compression strength is a complex challenge. The behaviour of corrugated board is highly non-linear and anisotropic (its properties vary with direction), and its response to load is heavily influenced by regional variations in materials and manufacturing processes. Traditional simulation methods often fail to capture these subtle but critical nuances, leading to inaccurate predictions and suboptimal designs. This project addresses this challenge by combining physical experiments with advanced numerical simulations to identify and incorporate the "key features" that govern box compression. By developing a more accurate and robust simulation methodology, we can move beyond the limitations of current models and provide the packaging industry with a powerful tool for designing more efficient, sustainable, and reliable packaging solutions. Research Aims and Objectives The primary goal of this research is to identify and model the key features that influence the compression performance of corrugated boxes, and to use these insights to develop a more accurate simulation framework. The specific objectives are: Objective 1: Conduct a Comprehensive Review of Corrugated Board Behaviour. The student will begin by researching the mechanical properties of corrugated paperboard, focusing on how regional variations in material, manufacturing, and environmental conditions (e.g., humidity) affect its performance. This will include reviewing existing constitutive models and failure criteria. Objective 2: Perform Physical Compression and Material Tests. The student will conduct a series of physical tests on real-world corrugated boxes and material samples. This will involve standard Box Compression Tests (BCT) and may also include ring crush tests, edge crush tests, and tensile tests to characterise the board's anisotropic properties. This data will serve as the ground truth for validating the numerical models. Objective 3: Develop and Calibrate a Numerical Simulation Framework. Using a suitable Finite Element Analysis software, the student will develop a numerical model of a corrugated box. A key part of this objective is to investigate different modelling approaches, such as using homogenised shell elements or more detailed models that capture the geometry of the flutes. The model will be calibrated using the data from the physical tests to ensure its predictions are accurate. Objective 4: Identify and Model Key Features. The student will use the validated model to perform a series of simulations to systematically investigate how specific features—such as the geometry of the flutes, the adhesive bonds, the presence of creases, and regional material variations—affect the overall compression performance. The findings will be used to refine the simulation methodology to be more predictive and efficient.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: A student who will thrive in this project will enjoy hands-on experimental work and simulation, while being detail-oriented and pragmatic.				

Dr Rudolph Venter
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- **Research Field**
  Biomedical Engineering/Orthopaedic Surgery
- **General Description of Research Field**
  Low cost 3D Printing for pre-operative surgical planning and training, at tertiary and secondary level hospitals: Clinician friendly 'plug-ins' for 3D Slicer (https://www.slicer.org/). The aim for this project is to develop software plugins to help clinicians at Tygerberg hospital or Worcester hospital with segmentation and/or surgical planning with/or without patient specific guide creation. Student that will enjoy this project: someone who knows how to code with python, can familiarize themselves with medical image segmentation to create anatomical models and are familiar with how commercially available 3D Printers work.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Low cost simulation models for training in a clinician-run 3D Printing lab. Training of clinicians is a multifaceted process, and learning specific motor skills form a major component of this. However, opportunities for clinical simulation are few and commercially available training models or simulators are expensive. The aim for this project is to develop a low cost clinical simulator for a technically demanding clinical procedure (Like the placement of percutaneous Sacro-Iliac screws, or the percutaneous pinning of hand or foot fractures) using available 3D Printers or other appropriate materials. Decisions will have to be made about what procedure to simulate, what materials are to be used who the persons are who are going to use the models for training. **Requirements:** Skills: design process thinking, and will probably be a very practical project.	✓			
Low cost 3D Printing for pre-operative surgical planning and training, at tertiary and secondary level hospitals: Clinician friendly 'plug-ins' for 3D Slicer Low cost 3D Printing for pre-operative surgical planning and training, at tertiary and secondary level hospitals: Clinician friendly 'plug-ins' for 3D Slicer (https://www.slicer.org/). The aim for this project is to develop software plugins to help clinicians at Tygerberg hospital or Worcester hospital with segmentation and/or surgical planning with/or without patient specific guide creation. **Requirements:** Student that will enjoy this project: someone who knows how to code with python, can familiarize themselves with medical image segmentation to create anatomical models and are familiar with how commercially available 3D Printers work.	✓			

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Low cost 3D Printing for pre-operative surgical planning and training, at tertiary and secondary level hospitals: Designing an online repository of anatomical models and 3D Printable equipment for training The aim of this project is to build an online repository of Anatomical 3D models (from the library of previous complex cases performed at Tygerberg, and new cases) for surgeons to rehearse on and train on. These are for use in the orthopaedic 3D Printing Lab at Tygerberg Hospital and at Worcester hospital where we have recently put an FDM printer to support the clinicians. See the american NIH 3D PRint exchange (https://3d.nih.gov/). Decisions will need to be made about which software or online platform is most appropriate, who the target audience will be (eg secondary level hospitals, what level of surgical training) and what kind of clinical cases or other 3D Printable objects to include on the repository. **Requirements:** Skills: Design process and coding/website building skills, basic understanding of 3DPrinting.	✓			

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

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling skin using Peridynamics This is an interdisciplinary project that involved processing experimental data, modeling, simulations and optimization. Digital image correlation (DIC) data obtained at Southampton University on a thin, incompressible biological-like material will be processed and an optimization process followed to find material parameters suitable for a Peridynamic model. The investigation will include investigating the non-local effects of this material. The project will be supervised by Andie de Villiers (Stellenbosch), Melody Neaves (Stellenbosch) and Georges Limbert (Southampton). **Requirements:** The student flourishing in this project would have a wide field of interest that should include mathematical modeling, scientific computing and biological materials.	✓	✓	✓	
Peridynamic model of rupture in soft tissue Soft tissue such as muscles and tendons is subjected to large deformations. To model rupture in these soft materials is a challenge. Peridynamics is a non-local continuum mechanics framework originally developed to overcome challenges that classical continuum mechanics encounter when modelling discontinuities, such as damage and fracture. The aim of this project is to extend an in-house peridynamic code to include rupture of the material based on configurational forces and the J-integral. **Requirements:** Students should have some background in mechanics and an interest in mathematics and programming.	✓	✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Modelling growth and remodeling of bone using Peridynamics Bone is sensitive to its mechanical environment. Think about the increased density in some tennis players' arms for example. When a fracture occurs, the healing process is complex and the material between the fragments changes from no bone, to soft cartilage and eventually to bone. Both remodeling (changing of the material parameters) and growth (new mass added to the bone) are complex mechanisms to model. This project will aim to answer questions such as how to include the effects that the mechanical environment has on the microstructure and growth of the bone. Will configurational forces be a helpful measure to use? This project will be supervised by Andie de Villiers, Martin Venter and Rudolph Venter. **Requirements:** The student that will flourish in this project will have some understanding of mechanics, mathematics and programming.	✓	✓	✓	

Dr Johan van der Merwe
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- **Research Field**
  Methods for endoprosthesis design, robotic testing and qualification

- **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 investigates data-informed, computational methods of implant design to enable targeted standardization of implant systems and design processes, and predictive automation of patient-specific solutions.

  Furthermore, robotic testing platforms are being developed to support experimental verification and qualification of newly developed endoprosthesis systems. These platforms reproduce the biomechanical environment to investigate implant performance under static and dynamic loading conditions, and are vital to furthering research and product development in local industry.

  Applications in orthopedic and maxillofacial surgery include planning, fixation, large defect reconstruction and joint replacement.

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of a parallel robot manipulator for general biomechanical joint testing applications Biomechanical testing and simulation are important components of joint replacement research, design, and qualification. Closed-chain parallel manipulators like the Stewart platform have seen some use in recent biomechanical testing and simulation studies [1, 2, 3], perhaps due to advantages such as higher stiffness, better precision and dynamic behavior, and large payload support compared to open-chain serial robot configurations [4, 5]. However, the multiaxial actuation described in literature appears to oversimplify the complexity of human joint biomechanics. This may be due to the mechanical advantages provided by a closed chain parallel manipulator configuration resulting in difficulties with dynamic modelling and control. Where the control axes can be decoupled in serial devices, all actuators of a Stewart platform must act in concert to achieve the same displacement or load along one axis. Forward kinematics, inverse dynamics, workspace constraints and load singularities are aspects of Stewart platform design optimization that are undergoing further research [6, 7], and warrant special attention to realize the potential mechanical advantages of the technology in future biomechanical applications. Therefore, the aim of this study is to assess the feasibility of using a Stewart manipulator for general biomechanical joint replacement research. This study will follow an engineering design research methodology. The project activities include the design of a Stewart platform according to relevant joint load and displacement requirements, construction of a concept demonstrator based on said design, followed by experimental performance validation. [1] Bain, G.I., Bellringer, S.F., Russo, M.P., Amin, D. and Costi, J.J., 2025. Biomechanical analysis of cadaveric wrists before and after MOTEC wrist arthroplasty using a hexapod robot. Journal of Hand Surgery (European Volume), 50(4), pp.492-499. [2] Foroutan, P., Quarrington, R.D., Russo, M.P., Ding, B., Cripton, P.A., Costi, J.J. and Jones, C.F., 2024. Facet deflection and strain are dependent on axial compression and distraction in C5–C7 spinal segments under constrained flexion. JOR spine, 7(3), p.e1360. [3] Bennett KJ, Foroutan P, Fairweather E, Al-Dirini RM, Sobey SA, Litchfield N, Roe M, Reynolds KJ, Costi JJ, Taylor M. Development and validation of a biomechanically fidelic surgical training knee model. Journal of Orthopaedic Research. 2024 Oct;42(10):2181-8. [4] Dasgupta, B. and Mruthyunjaya, T., 2000. The Stewart platform manipulator: a review. Mechanism and machine theory, 35(1), pp.15-40. [5] Furqan, M., Suhaib, M. and Ahmad, N., 2017. Studies on Stewart platform manipulator: A review. Journal of Mechanical Science and Technology, 31(9), pp.4459-4470. [6] Shahbazi, M., Heidari, M. and Ahmadzadeh, M., 2024. Optimization of dynamic parameter design of Stewart platform with Particle Swarm Optimization (PSO) algorithm. Advances in Mechanical Engineering, 16(6), p.16878132241263940. [7] Yang, F., Tan, X., Wang, Z., Lu, Z. and He, T., 2022. A geometric approach for real-time forward kinematics of the general Stewart platform. Sensors, 22(13), p.4829.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Engineering design, modelling, control systems, mechatronics				

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
A data-informed design method for anatomical femoral fixation plates Fixation plates contoured to the typical femur's anatomy are used to treat periarticular fractures. However, these off-the-shelf plates often fit poorly due to shape variation within populations [1]. This observation has been confirmed anecdotally by local surgeons, suggesting that available fixation plates do not always fit the South African population well either. Statistical shape modeling (SSM) is a machine learning approach to modelling complex shape variation, such as anatomy [2]. This study proposes the use of an SSM of the South African femur to generate a finite number of discrete representative shapes that adequately describe the local anatomical region of interest [3, 4, 5]. Once representative shapes have been determined, the use of the representative shapes must be demonstrated by designing fixation plates according to clinically relevant requirements [6, 7]. Therefore, the aim of this study is to develop a method for creating population-specific representative shapes for the design of internal anatomical femoral fixation plates. This study will follow an engineering design research methodology. The project activities include the decomposition of a pre-existing Statistical Shape Model (SSM) of the femur to extract the component scores of the original data that relate to the region of interest. This will be followed by generating representative shapes based on the distribution of the principal component scores for use in implant design. Afterwards, the fit of the resulting representative shapes will be assessed against the surrounding femurs via clinically relevant metrics. Finally, the concept of using representative shapes as part of the design process will be demonstrated by designing fixation plates according to clinically relevant specifications. [1] Harith, H., Schmutz, B., Malekani, J., Schuetz, M.A. and Yarlagadda, P.K., 2016. Can we safely deform a plate to fit every bone? Population-based fit assessment and finite element deformation of a distal tibial plate. Medical engineering & physics, 38(3), pp.280-285. [2] Cootes, T., 2024. Statistical shape models. In Medical Image Analysis (pp. 201-225). Academic Press. [3] Tarpey, T., 2007. A parametric k-means algorithm. Computational statistics, 22(1), pp.71-89. [4] Fang, K.T. and Pan, J., 2023. A review of representative points of statistical distributions and their applications. Mathematics, 11(13), p.2930. [5] Yu, J., Ai, M. and Ye, Z., 2024. A review on design inspired subsampling for big data. Statistical Papers, 65(2), pp.467-510. [6] Cronier, P., Pietu, G., Dujardin, C., Bigorre, N., Ducellier, F. and Gerard, R., 2010. The concept of locking plates. Orthopaedics & Traumatology: Surgery & Research, 96(4), pp.S17-S36 [7] Brouwer de Koning, S.G., de Winter, N., Moosabeiki, V., Mirzaali, M.J., Berenschot, A., Witbreuk, M.M.E.H. and Lagerburg, V., 2023. Design considerations for patient-specific bone fixation plates: a literature review. Medical & Biological Engineering & Computing, 61(12), pp.3233-3252.		✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: Scientific programming, statistics, finite element analysis, engineering design				
Investigating the influence of polishing on the wear of boost-diffused additively manufactured Ti-6Al-4V against UHMWPE Metal Additive Manufacturing (AM) facilitates the development of custom medical implants. Ti-6Al-4V is a commonly used AM alloy for biomedical applications due to advantageous biocompatibility, fatigue and corrosion resistance [1]. However, the alloy suffers from poor tribological performance, making it unsuitable for use in applications with articulating interfaces such as joint implants, without further treatment [2]. Recently, a boost diffusion treatment has been developed in order to create a hard, wear-resistant oxide layer on the surface of AM Ti6Al-4V parts [3]. While promising, the case hardening process results in the formation of protruding oxygen grain clusters, which increases surface roughness. Automated abrasive or electropolishing is recommended to achieve the required surface finish specified by implant standards while preserving the complex articulating geometry of the custom designed implant. Therefore, the aim of this project is to develop a polishing process for use in conjunction with boost diffusion to improve the wear behavior of AM Ti-6Al-4V articulating against cross linked UHMWPE. This study will follow a material design research methodology. The project activities include an investigation into suitable automatic polishing processes based on compatibility with the prior boost diffusion treatment, availability of the technology, and articulating implant requirements. This will be followed by the experimental verification of oxygen diffusion depth and layer adhesion for polished AM Ti-6Al-4V to select a promising polishing process for further testing. Finally, material pair wear of polished AM Ti-6Al-4V samples articulating against UHMWPE according to ASTM F732 will be assessed and compared with published literature. [1] Bose, S., Ke, D., Sahasrabudhe, H. and Bandyopadhyay, A., 2018. Additive manufacturing of biomaterials. Progress in materials science, 93, pp.45-111. [2] Dong, H. and Li, X.Y., 2000. Oxygen boost diffusion for the deep-case hardening of titanium alloys. Materials Science and Engineering: A, 280(2), pp.303-310. [3] Cremer, L., van der Merwe, J. and Becker, T.H., 2025. Oxygen boost diffusion of additively manufactured Ti-6Al-4V for improved oxide layer adhesion. Journal of Alloys and Compounds, p.180857. **Requirements:** Material science, strength of materials, engineering design		✓	✓	

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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 a 30 kW turboprop micro gas turbine. This project will continue this work by re-developing the engine. Specific emphasis will be placed on modelling of the complete engine performance, including the drivetrain and then refinement of the design of the engine's power turbine. **Requirements:** Numerical fluids 414 thermofluids 344		✓		✓
Design and develop a gas generator for the SAFFIRE Rocket Engine Collaborative Project with UKZN Aerospace Systems Research Institute UKZN Contact: Prof G Snedden A previous project performed a first-round gas generator design for the SAFFIRE rocket motor. This project will evaluate the feasibility of this design using CFD and manufacture and test at least a sector of the designed generator. Specific attention will be given to the manufacturability and material specification of the manufactured product. **Requirements:** CFD, turbomachinery		✓		✓

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Sudden expansion pressure loss and recovery in fans Collaborative Project with UKZN UKZN Contact: Prof G Snedden In ventilation fans the fan blading sits in an annulus with the hub forming a barrel inside a duct. Once the motor barrel terminates there is effectively a sudden expansion of an annulus into a duct. The frictionless Carnot-Borda assumption is often used to account for losses and the static pressure recovery in this sudden expansion, however Carnot-Borda was intended for small to large pipe sudden expansions and is, as stated, frictionless. The aim of this work is to develop a validated correlation for the losses in fan arrangement. This correlation should account for variation in: • Fan velocity • Duct diameter ratio • Changes in inlet swirl • Changes in hub to tip velocity profile **Requirements:** CFD		✓		✓
Analysing the performance of the 24 ft. installed MinwaterCSP axial flow fan. The project will specifically focus on modelling and accurately measuring the performance of the 24 ft MinwaterCSP axial flow fan. Existing work has focused on the measurement and modelling of this fan's performance under stable conditions. The idea is to expand this work in order to improve the fan's performance under various operating conditions. The possible improvements will be modelled in CFD and implemented in a digital representation of the Minwater facility (read: Digital Twin). **Requirements:** Numerical Fluids 414		✓	✓	✓
Design of a cooling fan for enhanced sCO2 air-cooled heat exchanger efficiency Co-supervision with Prof JP Pretorius A previous student successfully designed a fan for an sCO2 air-cooled heat exchanger. However, further work showed that there is potential for re-designing the fan and possibly improving its performance by reconsidering the design parameters. The project will involve the complete design, build, test and numerical analysis of the fan. Project funding for building the fan is available. **Requirements:** Heat transfer 414 Thermofluids 344 Numerical Methods 414		✓		
Impact of operational and wind effects on sCO2 air-cooled heat exchanger cooling fan performance Co-supervision with Prof JP Pretorius Python sCO2-side model, co-sim with actuated disk fan model (with updates from Adam's work). Investigate effect of winds on fan and ACHE performance, investigate effect of multi-fan interactions, hot air recirculation and fan outage on ACHE performance. **Requirements:** Numerical fluids 414		✓		✓

Topics	**MEng Struct**	**MEng Resrch**	**PhD**	**Potential Funding**
Improving the performance of a solarised micro gas turbine The performance of an existing micro gas turbine needs to be improved. A New impeller and diffuser has been design for the gas generator component and needs to be manufactured and tested on the gas turbine. The power turbine has to be replaced with a smaller, more realistically sized unit and a concept for an actual generator has to be developed. The system was developed to originally operated under solarised conditions but is currently being converted for research on hydrogen combustion. This work will be done in conjunction with the PhD student currently working on the system. **Requirements:** CFD, good CAD skills		✓		