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M&M Post-Graduate Topics

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forward together
sonke siya phambili
saam vorentoe

Mechanical & Mechatronic Engineering department
Departement Meganiese & Megatroniese Ingenieurswese
+27 21 808 4376 | meganies@sun.ac.za | https://www.eng.sun.ac.za/
Private Bag X1 | Privaat Sak X1 | Matieland 7602 | South Africa | Suid-Afrika

Contents

Mrs Liora Ginsberg

ginsberg@sun.ac.za

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

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

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

Prof Stephanus Malherbe

malherbe@sun.ac.za

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

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

Prof Josua Meyer
jpm2@sun.ac.za

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

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

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

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

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

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

Prof Martin Nieuwoudt

martin.nieuwoudt@gmail.com

- **Research Field**
  ML for Medical Imaging and Biostatistical modeling. Project Commercialization.
- **General Description of Research Field**
  Product Lifecycle Management for In vitro diagnostics development and commercialization. Biostatistical modeling. Machine Learning and AI for Medical Imaging applications.

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

Dr Michael Owen

mikeowen@sun.ac.za

- **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
Simulation of high flow nasal cannula ventilation in infants and children High flow nasal cannula therapy is a non-invasive respiratory therapy that involves delivering humidified respiratory gas (typically rich in O2) to a patient's nasal cavity via a nasal cannula. The therapy improves breathing efficiency but the high flow rates make it relatively expensive and the exact mechanisms through which it works are not well understood. A better understanding of fluid mechanics associated with the therapy has the potential to realize more effective treatment and reduced costs, particularly for therapy in infants and children where there is little literature available. High flow oxygen therapy through nasal cannula (HFNC) is a commonly used method of respiratory support for patients with respiratory failure. Heated, humidified air is blended with oxygen and delivered at high flow rates via a nasal interface. The therapy improves breathing efficiency but the high flow rates make it relatively expensive and the exact mechanisms through which it works are not well understood. Studies of the use of HFNC compared to standard nasal oxygen in infants and children have conflicting results and further analysis is required to refine the use of HFNC. This project involves the numerical simulation (using an appropriate computational fluid dynamics tool) of HFNC in infants and children. A numerical model must be developed and validated against published information (e.g. positive end-expiratory pressure measurements from model-based studies). The model will be used to conduct a parametric analysis which aims to contribute to the understanding of the mechanisms through which the therapy works and to identifying optimal operating parameters. The project will be co-supervised by Dr Andre Gie, a Paediatric Pulmonologist at Stellenbosch University.		✓		

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Requirements: This project will suit a candidate with a mechanical engineering background since it is heavily reliant on an understanding of fluid mechanics. CFD will be used as the primary tool in this work and the student should have completed a relevant CFD module (or must complete such a module in the first semester of the MEng programme).				

Prof Willie Perold

wjperold@sun.ac.za

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

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

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

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

Prof Kristiaan Schreve

kschreve@sun.ac.za

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

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

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

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

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

Mnr Wayne Swart

wswart@sun.ac.za

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

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

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

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

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

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

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

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

Dr Johan van der Merwe

jovdmerwe@sun.ac.za

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

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

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

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Development of additively manufactured synthetic bone grafts The focus for this project is the development of engineered and additively manufactured lattice structures for critically sized bone defect reconstruction. Applications include various anatomies but will most likely focus on the spine, femur, and mandible. Possible activities include needs identification and data collection, selection of appropriate lattice geometries, and development of implant fixation features to produce a functional design; Numerical optimization and simulation may be performed, along with experimental validation; Methods for the manufacture of synthetic bone grafts must be investigated; Extended scope would include design customization, automation, and early failure prediction. Individual topics include: Stochastic, bio-mimetic scaffold design, manufacture, and analysis. Development of a voxel-based anisotropic lattice homogenization code. Design of a low cost, ultrasonically controlled, micro deposition 3D printer for additive manufacturing of sintered or melted synthetic bone lattice grafts. **Requirements:** Students must have sufficient scientific or engineering background for further study at a postgraduate level in one or more of the following: statistics, scientific programming, machine learning, digital image processing, numerical simulation, optimization, metchatronics, and material science.	✓	✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Internal fixation implant analysis, design, and manufacture This project focuses on the analysis, design and manufacture of internal fixation implants. Applications considered for this project include fixation plates, pins, and screws for various anatomies. The scope may vary based on prior art as well as student background. Possible activities include needs identification via ethnographic research, market assessment and stakeholder engagement; Research questions and hypotheses must be developed, followed by data collection for morphological shape analyses and comparison to available implant geometry; Implant geometries must be proposed based on the findings and optimized for form and function; Manufacturing strategies must be proposed or developed. Verification will be done via simulation and experimental testing. Individual topics include: Design of patient specific or population-based fixation plates for the femur and tibia. Design of patient specific or population-based reconstruction plates for the mandible. Development of an automated mandible reconstruction plate bending machine. **Requirements:** Students must have sufficient scientific or engineering background for further study at a postgraduate level in one or more of the following: statistics, scientific programming, machine learning, digital image processing, numerical simulation, optimization, mechatronics, and material science.	✓	✓	✓	
Design of joint replacements This project investigates the design of joint replacement implants, such as for the hip, knee, mandible or shoulder, after needs identification and analysis of prior art and current challenges. Research questions and hypotheses must be developed, followed by data collection for morphological shape analysis in conjunction with biomechanical simulation and motion capture. The resulting database must be used to inform implant design, possibly based on patient specific, modular or standard components. Experimental verification will involve kinematic and wear testing. Project scope may vary based on prior art as well as student background. Current focus: Temporomandibular joint replacements. Total knee replacements. **Requirements:** Students must have sufficient scientific or engineering background for further study at a postgraduate level in one or more of the following: statistics, scientific programming, machine learning, digital image processing, numerical simulation, and optimization.	✓	✓	✓	

Topics	MEng Struct	MEng Resrch	PhD	Potential Funding
Data-informed bone models for preoperative planning and surgical navigation This project is concerned with the generation of 3D patient-specific or patient-matched bone models for use in preoperative planning and surgical navigation. Potential applications include surgery for large defect reconstruction, hip dysplasia, and ankle fractures. Data collection will occur after needs identification, and methods for matching or fitting models to individual patients must be investigated. Solutions may involve digital image processing, statistical learning, and automated 3D model registration. Verification will occur via simulated test cases. Individual topics include: Development of a statistical shape model based on robust point matching for outlier detection. Development of an enhanced statistical shape model for the reconstruction of displaced, partial inputs. Automated image segmentation with feature detection and a statistical shape model. Comparison of a statistical shape model and variational auto encoder. **Requirements:** Students must have sufficient scientific or engineering background for further study at a postgraduate level in one or more of the following: statistics, scientific programming, machine learning, digital image processing, numerical simulation, and optimization.	✓	✓	✓	
Development of titanium antibiotic eluding devices The aim of this study is to develop an antibiotic eluding device design method, intended to form part of custom, lattice-based titanium implants. Research questions would include how to achieve the ideal configuration for the desired antibiotic elution, the effect of kinetics on drug elution, and the investigation of implant coatings to drive an osmotic gradient and prevent biofilm formation. The envisioned study would make use of numerical simulation in porous media with possible particle tracking. Once verified in vitro, the simulation may be used to model antibiotic elution under various conditions and device configurations. Finally, animal models may be used to validate combined implant and elution devices. **Requirements:** Students must have sufficient scientific or engineering background for further study at a postgraduate level in one or more of the following: statistics, scientific programming, machine learning, digital image processing, numerical simulation, and optimization.	✓	✓	✓	✓