PhD & MEng RESEARCH TOPICS 2021

Department of Mechanical & Mechatronic Engineering

PhD
(Engineering)

MEng Research
(Mechanical & Mechatronic Engineering)

MEng Structured
(Mechanical Engineering)

August 2020

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Design & Mechatronics Division

Lecturers:
Prof Anton Basson
Dr Karel Kruger

Email: ahb@sun.ac.za; kkruger@sun.ac.za

Faculty:
Engineering

Department:
Mechanical and Mechatronic Engineering

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:
Industry 4.0, cyber-physical systems, digital twins, and the integration of humans with digital environments

General description of research field:
The fourth industrial revolution, or Industry 4.0, is the current trend of automation and data exchange in manufacturing technologies, and there is a growing interest in many other domains as well. The Industry 4.0 vision relies on key enabling technologies, such as cyber-physical systems (CPSs), the Internet of Things (IoT) and cloud computing services. Our research focusses on the development of reality-reflecting architectures for the multi-domain implementation of three levels of CPSs:

(1) In the "Smart Connection Level", IoT related issues such as tether-free communication and sensor networks are considered.
(2) The "Data-to-Information Conversion Level" considers issues such as smart analytics for component machine health and degradation and performance prediction.
(3) The "Cyber Level" considers issues such as the twin model (or *digital twin*) for components and machines, machine time-variation identification and memory, and data clustering for data mining.

We are also considering the role of humans and their integration, both as task executors and decision makers, as CPSs and with other CPSs within Industry 4.0 environments. We are interested in the adaptation of control architectures and the use of technology (e.g. collaborative robots and augmented reality) to facilitate this integration. More information can be found at www.sun.ac.za/mad.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Technologies for implementing a "digital twin" in a CPS for automated systems. This includes modelling techniques for the physical system's behaviour in the digital world, methods and formats for information exchange between the digital and physical systems, as well as between the digital twin and the cyber-space.		X	X	1 x MEng or PhD
2. Development of human-centred and human-integrated work environments using collaborative robots (Universal Robots UR5e), augmented reality (Microsoft Hololens) and software platforms for integrating humans with digital systems.		X	X	

Specific requirements:
Although preference is given to Mechanical and Mechatronic Engineering graduates, students from other engineering backgrounds will also be considered.

Lecturer:
Prof Corné Coetzee

Email: ccoetzee@sun.ac.za

Faculty:
Engineering

Department:
Mechanical and Mechatronic Engineering

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:
Two fields of research are available:
(1) **Granular material modelling** with applications in the mining and agricultural sectors.
(2) **Packaging engineering** with applications in the agricultural sector.

General description of research field:

(1) 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 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) 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.

Individual topics listed:	**MEng *(Structured)***	**MEng *(Research)***	**PhD**	**Funding**
1. **The modelling of bulk granular materials using the Discrete Element Method (DEM).** This will include experimental work using our unique large scale conveyor test facility, the calibration of material properties, and DEM modelling. The aim would be to develop experimental and numerical methods for calibrating the material properties of wet cohesive (sticky) materials. The methods should be validated by comparing the predicted material flow rates, flow patterns, build-up, etc. with measurements and observations. Applications of these methods would be in the mining and agricultural sectors.		✓	✓	Possibility of funding for: 1 x PhD 1 x MEng (Research)
2. **Refrigerated Container (RC) optimisation and characterisation for improved cold sterilisation treatments.** Over recent years the regulations governing the export of fresh produce have become substantially more stringent. This has mainly entailed the use of low temperature (<2°C) transport in combination with other pre- and postharvest		✓	✓	Possibility of funding for: 1 x PhD

treatments to control the incidence of live insect pests at markets. For South Africa, the use of these low-temperature conditions, in combination with a significant increase in production volumes has led to substantial pressure on the limited amount of precooling inland facilities. The large volume of citrus fruit exported would result in major logistical problems. The cooling characteristics (rate and heterogeneity) of ambient-loaded fruit in RCs have to date not been well documented and more information regarding factors influencing cooling performance is needed if these refrigerated shipping processes are to be optimised in the future. This project is supported and funded by the Citrus Research International Group and would include experimental measurements and CFD modelling of refrigerated containers and packaging.				Funding secured for: 1 x MEng (Research)
3. **The modelling of fruit packaging using the Finite Element Method (FEM).** The properties of paperboard used to manufacture boxes should be measured and used in a FEM model to predict the structural strength of the box under different loading and environmental conditions such as changes in temperature, humidity and creep loading. This will include experimental laboratory and field work as well as FEM modelling in collaboration with the department of horticultural sciences at Stellenbosch University.		✓	✓	Possibility of funding for: 1 x PhD 1 x MEng (Research)

Specific requirements:
Finite Element Method (FEM) and Computational Fluid Dynamics (CFD) where applicable. These modules are available at postgraduate level which can be followed during the first semester of studies, and is not a pre-requisite for applying or starting your studies.

***Lecturer*:**
Mr Cornel de Jongh

[illegible]: corneld@sun.ac.za

***Faculty*:**
Engineering

***Department*:**
Mechanical and Mechatronic Engineering

***Division*:**
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

***Research field*:**
Biomedical Engineering / Injury Biomechanics / Computational Biomechanics

***General description of research field*:**
Injury Biomechanics is the science relating the deformation of human tissue past its mechanical failure limit (resulting in subsequent clinical injury) to a mechanical causation using mechanistic classifications closely related to engineering mechanics. These mechanistic classifications have been determined and tabulated over years of research and cadaveric studies. Knowing mechanistic causation allows Engineers to quantify injuries either through experimental or numerical analysis on the anatomical region of interest by measuring the forces, bending moments and/or other biomechanical parameters occurring in these regions (e.g. in specific joints, head, neck etc. of a Anthropomorphic Test Dummy or ATD.) in response to an applied load. Having quantified the required parameters, the likelihood or risk of a specific injury can be determined by relating measured force parameters to established injury criteria or Injury Assessment Reference Values (IARV's). Furthermore, the clinical risk of specific injuries can be quantified by using established risk curves related to the risk of specific Abbreviated Injury Score (AIS) values (e.g. risk of AIS 2+ for upper neck injury) or Injury Severity Score (ISS) values. A component of Injury Biomechanics also involves determining injury thresholds and IARV's through experimental testing and in this way may contribute to available literature and improved product development.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. The development of a validated detailed musculoskeletal multi-body thoracic spine model for axially oriented impact conditions of the unrestrained torso.		X		
2. Head restraint vs. neck response – a Simulation Based Analysis.		X		
3. Can neck restraint positively influence head/brain response? – Reducing head injuries by limiting neck movement.		X		
4. Investigate viability for improved rugby caps for low speed impact and rotational acceleration reduction.		X		
5. The development of a device to reduce axially transmitted loads to the mid-thoracic spine following hyperflexion impact mechanism of the head and neck.		X		

***Specific requirements*:**
Modelling, Computational Biomechanics, Mechanics, Anatomy, Physiology, Test Design

Lecturer: Dr Gareth Erfort	***Email:***	erfort@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:
Computational fluid dynamics

General description of research field:
Making use of open source software (OpenFOAM) for CFD models. This includes, solver development, experimental design, coding for surrogate modelling and coupling.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Development of an OpenFOAM solver for use in pollution modelling.		x		TBC
2. Open source atmospheric modelling of air pollution.			x	TBC
3. Vertical axis wind turbines in urban areas, a cost analysis.	x			-

Specific requirements:

Lecturer: Mrs Liora Ginsberg	***Email:***	ginsberg@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

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.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. CFD studies of detail micro-circulation in a lymphatic segment / duct.		X		
2. Studies in micro flow of the lymphatic network system.		X		

Specific requirements:
CFD

Lecturer: Prof Nawaz Mahomed	***Email:***	nawaz@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:
Wind Energy

General description of research field:
Wind Resource Analysis and Modelling of Wind Power Generation Systems. The aim of this work is to optimise wind turbine selection and tower heights for maximising energy production against a given site, i.e. wind resource. Practical elements of wind measurement and wind data analysis is included to develop realistic approaches to wind power project feasibility.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
Optimisation of hub or tower height in a wind turbine installation is a critical consideration to ensure optimum power production. This project involves a case study in which anemometer data from a wind measurement mast will be analysed (using Symphonie) and converted into wind duration and probability curves. An optimisation model will be attempted, based on the maximisation of a power generation function for a given wind turbine model. The project requires familiarity with differential and integral calculus, programming in MATLAB (or similar), statistical analysis (such as Weibull probability functions), as well as an interest in wind energy and the deployment of wind turbines. Suitable for students with a good grounding in mathematics.	X			

Specific requirements:

Lecturer: Dr Willie (WJ) Smit	***Email:***	wjsmit@sun.ac.za		
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering			
Division: **Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy**				
Research field: Robotics; heliostat design and control				
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 thermal (CST) plants. We think that mulitcopters and ground-based robots will be able to provide services to CST plant operators.				
Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Measuring the optical quality of a heliostat with a multicopter.		X	X	
2. Estimating the pose of a drone using photogrammetry.		X		1x MEng
3. Developing a cheap heliostat.		X		
4. Closed-loop control of a heliostat.		X		
5. Design, build and test a quadcopter with a novel configuration for endurance flights.		X		
Specific requirements: Except for topic 3, the candidate should have good programming skills.				

Lecturer: Prof Dawie van den Heever	***Email:***	dawie@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:
Biomedical Engineering / Neural Engineering

General description of research field:
The brain is the most complex organ in the human body and is responsible for our every thought, action, memory, feeling and subjective experience. This is achieved by complex interactions between the staggering one hundred billion (in reality closer to 86 billion) neurons found in the human brain. Despite recent advances attempting to explain the puzzling science of the brain, this 1.4 kg jelly-like tissue that defines who we are, still holds crucial mysteries. Our proposed research aims to address some of these mysteries in order to answer more fundamental questions.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Decoding semantic categorisation in the brain using machine learning techniques. (basically – how do you categorise and retrieve information)		X		No
2. Using functional Near Infrared Spectroscopy (fNIRS) to examine the frontal lobes during free voluntary action. Can we predict action from brain signals before the subject is consciously aware of the decision to act? (do we have free will as is commonly understood?)		X		No
3. Training a machine learning algorithm on EEG data to perform real-time "mind-reading" – predict when a person will move a finger even before they have (consciously) made the decision to move.		X		No
4. Examining altered states of consciousness using Virtual Reality (VR). VR technology enables us to create novel environments and even novel perceptions of the world. How does this affect the brain?		X		No
5. If you have any of you own neuroscience questions you want to answer or ideas for projects, please contact me and we can discuss. I am keen for almost anything brain related.		X		No

Specific requirements:
A keen interest in neuroscience and understanding what makes us tick is preferable. In most of the above topics the student will also be working with machine learning techniques, so this is a skill that you will learn. If you come pre-equipped with this skill so much the better for you 😊

Lecturer: Dr Johan van der Merwe	***Email:***	jovdmerwe@sun.ac.za		
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering			
Division: **Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy**				
Research field: Biomedical Engineering: Orthopaedics				
General description of research field: In South Africa patients often present for medical care with severe musculoskeletal trauma and disease due to the high prevalence of personal violence, road traffic accidents, and insufficient early treatment. In such cases conventional orthopaedic treatment options may not be viable and instead the use of customized implants, instruments, surgical guides, navigation, or pre-operative planning tools may be required. However, developing patient-specific solutions is a multidisciplinary and iterative process that requires extensive and time-consuming effort on the part of various stakeholders. This leads to increased expense and delays in treatment within an already resource constrained healthcare system. Therefore, my research focuses on creating methods, techniques, and tools to automate and integrate the development of patient-specific orthopaedic solutions. The aim of this approach is to reduce the associated effort and cost by incorporating unique patient data into population-based models and from there to generate or adapt pre-programmed, customized solutions. In addition, special attention must be paid to the role and interaction of the various human stakeholders as truly robust and practical solutions must incorporate input and feedback from human specialists within the loop.				
Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Image guided functionally graded lattice structure generation for reconstruction of long bone defects. This project is concerned with the development of an automated method for generating functionally graded lattices based on patient-specific CT image data. The lattice should mimic the biomechanical properties of bone based on estimated image density to avoid stress shielding and allow for fluid transport. In addition, it should conform to an estimation of the patient's healthy bone shape.		X	X	
2. Scan free augmented reality surgical navigation. The aim of this project is to develop a low-cost method for surgical navigation that removes the need for expensive and harmful CT scans by incorporating statistical models of bone shapes into an augmented reality system. The system must track patient markers, estimate the occluded geometry from sparse inputs and overlay the result on the surgeon's view in order to assist them during procedures where only a small part of the patient's internal anatomy is visible.		X	X	
3. Development of a parametric mandible reconstruction plate. This project entails designing a parametric mandible reconstruction plate. The parameters must be derived from cephalometric markers and the design must adjust based on the unique measurements of an individual patient. Any measurements that are missing due to		X	X	

disease must be estimated. Plate fit is to be investigated by sampling a pre-existing population model. The stress distribution within the plate must be validated over the likely parameter range found within the population through FEA. Finally, a machine learning algorithm must be developed to predict plate failure based on cephalometric inputs and validated against the FEA results.				
4. **Feasibility of additively manufactured, patient-specific metallic articulating implant components.** The aim of this project is to investigate which articulating implants are candidates for customization and subsequent manufacture via additive manufacturing technologies. Articulating implants typically consist of a metallic and ceramic or plastic bearing component. Relative motion during activities of daily living cause the implant to wear, and accordingly impose specific requirements on the surface properties of the metallic components. However, while additive manufacturing is an enabler for designing complex, customized implant solutions, it is not clear whether parts manufactured in this way have suitable surface properties for use in articulating joints. Therefore, tribology experiments must be designed and conducted to determine if additive manufacturing in conjunction with suitable post surface treatment procedures are able to meet the requirements of various articulating joint implants.		X	X	
5. **Automated tool for image segmentation using statistical models of shape and appearance.** This project is concerned with creating a GUI-based tool for building statistical population models and subsequently using them for medical image segmentation. The result is to be validated in a simulated clinical setting and must therefore be based on the needs of orthopaedic surgeons with no programming knowledge and be robust in its application. Software tools such as MITK may be used.		X	X	
6. **Statistical deformation models for automated image segmentation, estimation, and landmark identification.** A statistical deformation model based on B-splines is to be created based on medical images of the human femur. It must be investigated for its ability to automate segmentation, estimate missing geometry and to accurately perform parametric measurements by adjusting predefined landmark coordinates.		X	X	
Specific requirements: Some projects require FEA and programming ability. Students are encouraged to consider completing additional machine learning and statistical modelling short courses during their postgraduate studies if relevant.				

Mechanics Division

<table>
<tr><td colspan="2"><u>Lecturer</u>:
Prof Thorsten (TH) Becker</td><td><u>Email</u>:</td><td colspan="3">tbecker@sun.ac.za</td></tr>
<tr><td colspan="2"><u>Faculty</u>:
Engineering</td><td colspan="4"><u>Department</u>:
Mechanical and Mechatronic Engineering</td></tr>
<tr><td colspan="6">Division:
Design & Mechatronics / <u>Mechanics</u> / Thermofluids / Renewable Energy</td></tr>
<tr><td colspan="6">Research field:
Materials Engineering</td></tr>
<tr><td colspan="6">General description of research field:
The Materials Engineering group focuses on investigating the material behaviour with the aim to understand material properties and property degradation mechanisms. We focus on:
• Develop numerical-experimental techniques for material characterisation and property analysis.
• Linking manufacturing processes to material performance and structural integrity.
• Develop component life prediction capabilities.

www.sun.ac.za/mateng</td></tr>
<tr><td colspan="2">Individual topics listed:</td><td>MEng (Structured)</td><td>MEng (Research)</td><td>PhD</td><td>Funding</td></tr>
<tr><td colspan="2">1. Power Plant reliability is critically dependent on the integrity of a broad range of materials that make up the structures, machines and systems within a power plant. It is paramount to accurately measure the material condition as well as to understand the damage mechanisms. This allows in predicting damage and the loss in design properties to avoid unplanned failures.

This topic focuses on development damage assessment tools using computational imaging, neural networks and the understanding damage mechanisms of high chrome steels.</td><td></td><td>x</td><td>x</td><td>1x MEng

1x PhD</td></tr>
<tr><td colspan="2">2. 3D printing of metallic components is seen as the next revolution in manufacturing. However, its mechanical properties and structural integrity needs to be well understood. Various studies have investigated the material performance of 3D printed metals. Investigations are, however, intricate due to 3D printing’s additive process.

This topic focuses on development of predictive capabilities in 3D printed titanium alloys material performance for biomedical and aerospace industries.</td><td></td><td>x</td><td>x</td><td>1x MEng

1x PhD</td></tr>
<tr><td colspan="6">Specific requirements:</td></tr>
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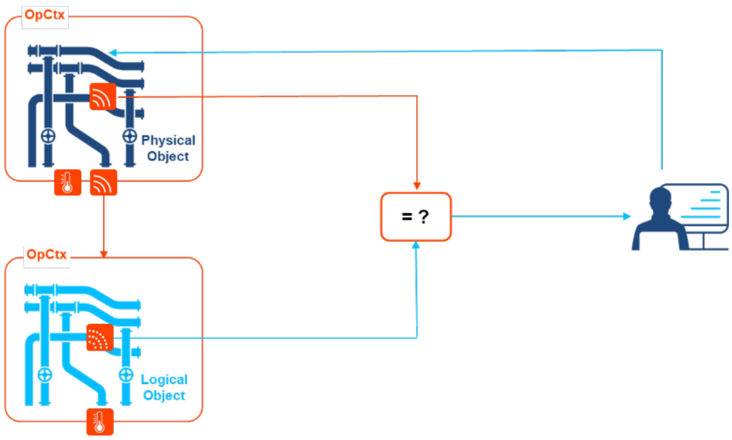
Lecturer: Prof Annie Bekker	**_Email_:**	annieb@sun.ac.za
Faculty: Engineering	**_Department:_** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / <u>Mechanics</u> / Thermofluids / Renewable Energy

Research field:
Vibration, measurement, signal processing, machine learning, digital twins

General description of research field:



Digital twins are likely a key enabler of Water 4.0. A digital twin entails the entangled use of a software representation / model of a real asset with engineering sensors to communicate the state and behaviour of a real asset. It is proposed to explore the value of digital twin technology in the controlled environment of a pump laboratory to establish an innovative niche for water-related asset management technologies. An existing pump laboratory at Stellenbosch University is equipped with pressure sensors, piping and valves to circulate water. This facility will be upgraded to include further sensors, analytics and digital models through which decision support strategies will be trailed in a controlled environment for future expansion to implementations in the field. The specific decision support offering of digital twins will be evaluated in the controlled environment of a Pump Test Laboratory. In order to achieve a maximum value-add at minimum cost, the research will focus on so-called "benchmark digital twin" solutions and “fingerprint digital twins” where field measurements are compared to healthy system data towards:

1.) The detection of system faults
2.) Diagnostics of the faults detected
3.) Prognostics, which assesses the impact of faults on system degradation of water-related assets.

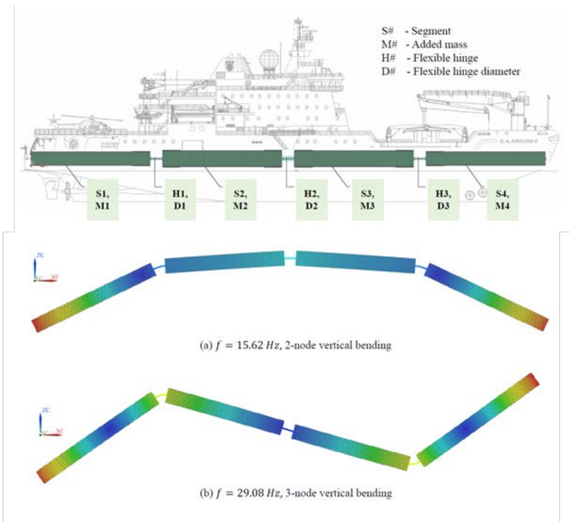
Help to establish in collaborations with the Fraunhofer Institute in collaboration with the Stellenbosch Water Institute and the Norwegian Institute of Science and Technology.

Individual topics listed:	**MEng *(Structured)***	**MEng *(Research)***	**PhD**	**Funding**
1. A digital twin pump laboratory for water asset management with possible field studies for Rand Water and the Water Research Council.		1	1	1 x PhD (junior lecturer), 1 x MEng (Research)

***Specific requirements*:**
Students participating in this project must be self-driven, willing to spend time in the field and eager to break new ground in engineering science. The success of these projects is directly related to students’ curiosity, willingness to take initiative, find solutions through networking and independent reading ability.

Research field:
Vibration, modal analysis, finite element models, fluid-structure interaction

General description of research field:



The SA Agulhas II is a polar supply and research vessel, which undertakes annual scientific and supply voyages to Antarctica and the South Sea Islands. She is scientifically instrumented for full-scale engineering measurements of operational parameters, ice loads, shaft-line strain and vibration. The focus is now to use these operational measurements for their predictive and decision-aiding potential. Work on this project is highly international and comprises collaborations and possible exchanges with Norwegian, Finnish and German research partners. The SA Agulhas II is pre-disposed to wave slamming which causes "jellyship", a lasting vibration of her structure.
A scale model will be built to resemble the geometry and scaled stiffness of the vessel. The scaled hull will be instrumented with pressure sensors in order to measure synthesized wave impacts on the model hull. The work will delve into challenging methods to establish the wave impact force and likely include work using techniques such as inverse force estimation using operational modal analysis or advanced CFD simulations in collaboration with NUMECA Fine Marine.

Individual topics listed:	**MEng *(Structured)***	**MEng *(Research)***	**PhD**	**Funding**
1. A flexible scale model and sensing to investigate digital twin solutions for operational management of wave slamming and whipping fatigue.		1		

Specific requirements:
Students participating in this project must be self-driven, willing to spend time in the field or abroad and eager to break new ground in engineering science. The success of these projects are directly related to students' curiosity, willingness to take initiative, find solutions through networking and independent reading ability.

Lecturer: Mr Johann (JR) Bredell		**Email:**	jrbredell@sun.ac.za	
Faculty: Engineering	**Department:** Mechanical and Mechatronic Engineering			
Division: **Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy**				
Research field: Sound & Vibration Research Group (SVRG)				
General description of research field: Marine engineering and structural analysis				
Individual topics listed:	**MEng *(Structured)***	**MEng *(Research)***	**PhD**	**Funding**
1. Failure modes and effects analysis of the propulsion system of the SA Agulhas II polar supply and research vessel. The SA Agulhas II has been a topic of investigation within the SVRG for many hears. The propulsion system of the SAAII is required to operate safely in harsh and extreme environmental conditions. A rigorous Failure Modes and Effects Analysis (FMEA) on this system will seek to identify potential failure modes and investigate the consequences of these various failure modes. This will also form part of the larger goal to develop a Digital Twin of the propulsion system. The project will focus on the use of machine design calculations, finite element analysis (FEA) and interpretation of experimental data to investigate critical failure modes.		X		Partial funding available
2. Dynamic analysis to calculate the fatigue damage of the propulsion system of the SA Agulhas II polar supply and research vessel. Random dynamic loading on a system, such as ice loads on a ship propeller, can be described by means of a power spectral density (PSD) function. Experimental full-scale torque data should be used to extract loading parameters that can be used in advanced dynamic finite element analysis (FEA) for detailed fatigue life calculations. Fatigue life calculations should also be compared to the latest ship propulsion design rules. This investigation is relevant to development of a reduced order model (ROM) to be used in the Digital Twin of the propulsion system.		X		Partial funding available
Specific requirements: Finite element analysis				

Lecturer: Prof Gerhard Venter	***Email:***	gventer@sun.ac.za

Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:
Computational (structural) mechanics

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 industry. Currently my group does some work in load recovery of real world forces on complex structures, material characterization using inverse modelling, optimum design of a truck chassis and an investigation into the fatigue life of welded joints in high strength steels.

Most of my research projects have some finite element, some meta-modelling (machine learning) and some optimization components associated with it. The vast majority of the topics requires programming, typically in Python. An interest in these fields, or at least a willing to learn, is thus a requirement for potential students16.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Material characterization of rubber isolators for use in vibrating screen applications.		X		Possible
2. How to best make use of a large number of low cost sensors to obtain accurate measurement results		X		Partial
3. Developing an open source digital image correlation software system in Python.		X		Partial
4. Investigate the best optimization algorithm for performing material characterization of soft rubber materials.		X		Partial
5. Fatigue life investigation of bolted connections in a truck chassis application. This project is done in collaboration with an industry partner and is fully funded with a job opportunity after completion of the post-graduate studies.		X		Full

Specific requirements:
A general interest in structural analysis, optimization and programming.

Lecturer: Dr Martin (MP) Venter	***Email:***	mpventer@sun.ac.za

Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research fields:
Generative Design, Machine Learning, Material Modelling, Soft Robots and Inflatables

General description of research field:
I am interested in teaching a computer how to design 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 to the fields of pressure rigidized structures and soft robotics. Our research group are interested in finding ways to combine 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 multi-disciplinary field taking elements from a number of computational fields. Researchers in this area will develop skills in non-linear finite element methods, numerical design optimization, programming and machine learning. Much of what we do requires the insightful experiment planning in tandem with advanced tools to deal with extremely large volumes of data. This is a new field and is open to exploration which can be both challenging and rewarding.

Individual topics listed:	***MEng (Structured)***	***MEng (Research)***	**PhD**	**Funding**
1. Intelligent reinforcement and programmable elastic response of highly compliant silicon for use in soft robots. Programmable elastic response in soft robots.		2	1	
2. Soft robot behaviour predictor using machine learning.		2	1	
3. Computational design of soft robot actuator modules.		2	1	
4. Design space exploration for soft robots using computational tools.		2	1	
5. A digital twin for soft robots.		2	1	

Specific requirements:
Students interested in this field of research should enjoy the challenge of an open-ended project, have basic programming and simulation skills and a will to learn more.

Renewable Energy

Lecturer: Dr Jaap (JE) Hoffmann	***Email:***	hoffmaj@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:
Thermal Engineering (Fluid Mechanics, Heat Transfer and Thermodynamics)

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.
A combination of two or more of the projects marked suitable for a MEng might be combined for a PhD.

Individual topics listed:	***MEng (Structured)***	***MEng (Research)***	**PhD**	**Funding**
1. **Transition to turbulence and its modelling in packed beds** Modelling flow at pore level in packed beds are computationally expensive, and beyond the capacity of most available computer hardware. A porous model formulation of the bed is preferred. Transition to turbulence in packed beds occur at superficial particle Reynolds numbers as low as 350. Furthermore, turbulent source terms depends on the order of time and space averaging. Previous research focused on structured beds and a representative unit cell approach. The objective of this project is to extend the work to random beds, using a combination of computational fluid dynamics (LES or DNS) and experimental techniques (mainly for validation purposes). A strong background in CFD and fluid dynamics will be advantageous.		X	X	
2. **Crushed rock particle shape characterization for pressure drop and heat transfer prediction** Crushed rock particles are irregular in shape, whilst pressure drop and heat transfer correlations are usually expressed in terms of simple shapes (spheres or ellipsoids). Furthermore, a specific shape might capture pressure drop satisfactorily, but fails to capture heat transfer, and vice versa. Compare various shape descriptors (e.g. volume or surface equivalent diameter, sphericity, aspect ratio, angularity, roundness, etc.) for crushed rock particles. A measuring method that is independent of operator error is preferred. It might be necessary to develop an entirely new shape descriptor if none of the available descriptors performs satisfactorily in predicting heat transfer and pressure drop in a packed bed.		X		
3. **Effect of polydisperse particle size on pressure drop and heat transfer in packed beds** Polydisperse (similar particles that differ in size and/or shape) particles pack differently from monodisperse particles in a packed bed, and as a result, the pressure drop and heat transfer in poly- and monodispersed beds will differ. Derive a correlation for the pressure drop and/or heat transfer in a	X	X		

packed bed experimentally for at least two different particle shapes/sizes. Results may depend on packing density, particle size and/or shape, mass fraction of particle class, particle orientation, etc. You may need discrete element modelling for the latter.				
4. **Evaluation of the packing density variation in a randomly packed bed of ellipsoids** Near walls, packing structure is disrupted by the walls, resulting in large changes in packing density near the walls, whilst the packing density is more or less constant in the interior of the domain. This often leads to preferential flow paths near the walls, whilst the interior of the domain is starved for flow. Small beds with bed diameter less than about 20 particle diameters are more severely affected than large beds. Most work reported in the literature is on spherical particles in prismatic containers. Rock beds are often conical in shape, with one or more free surface. Data may be generated experimentally or via a calibrated discrete element model. The expected outcome is a correlation/plot of the packing density against some macroscopic bed parameter.		X		
5. Evaluation of the mechanical properties of ellipsoidal cement particles Much of the rock bed research at Stellenbosch presumes that crushed rock particles can be approximated by simple ellipsoidal shapes. These are then casted in a 1:1 sand and cement mix, that is typically not used in building and construction. Mechanical properties for this material is required to calibrate discrete element models of packed beds. Derive protocols to determine the mechanical properties such as hardness, Young's modulus, Poisson ration, friction coefficient, restitution coefficient, angle of repose, etc. experimentally.	X	X		
6. Design and test a tubular cavity solar air receiver Sun-tracking mirrors (heliostats) allow very high irradiation flux on a receiver, but few simple air receiver designs are in existence that can cope with the combination of high temperature and high heat flux. The project envisage the design (tube size and material, coil depth and diameter, number of flow paths, etc. of a basket type receiver. On-sun testing to proof the receiver concept on the SunRoof Laboratory is required.	X	X		
Specific 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.				

***Lecturer*:** Prof Craig McGregor	***Email*:**	craigm@sun.ac.za		
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering			
Division: **Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy**				
Research field: Concentrating solar power; system modelling and optimisation; thermal energy storage; high temperature process heat; green hydrogen.				
General description of research field: Concentrating solar is a technology that combines optics and heat transfer and thermal storage to either generate electricity or to supply high temperature process heat. Unlike wind turbines and solar photovoltaics, it is the only renewable energy technology that can supply dispatchable electricity when the wind does not blow and the sun doesn't shine. Hence, it can play a critical role in the future energy systems. In addition, solar thermal technologies offer a way to decarbonise high temperature manufacturing processes that have no alternative. Research and innovation is critical to enable concentrating solar to be deployed at large scale.				
List of topics:	***MEng (Structured)***	***MEng (Research)***	**PhD**	**Funding**
1. Configuration and testing of a steam expander / generator demonstrator for medium-scale CSP applications (w C Meyer).		x	x	1× MEng or PhD
2. Design and experimental testing of a gabion packing in thermal energy storage (w T von Backström).		x		1× MEng
3. Design and performance of an engineered material for thermal energy storage (TES) in hot oil or molten salt CSP plants.		x	x	
4. Construction and testing of a circular beam-down Fresnel reflector concentrator.		x	x	
5. Design and testing of a solar receiver based on heat pipes (w C Meyer).		x	x	
6. Techno-economic assessment of electricity generation from a 10 MW medium-scale CSP plant using a steam expander/generator.	x	x		
7. Techno-economic assessment and optimisation of a hybrid CSP/PV power plant.	x	x		
8. Optical performance and economic assessment of a glasshouse enclosed heliostat field for a CSP plant.	x	x		
9. Design of the thermal transport and heat transfer equipment for particle-based receivers in a CST plant.		x		
***Specific requirements*:**				

Lecturer: Prof Chris (CJ) Meyer	**Email:**	cjmeyer@sun.ac.za
Faculty: Engineering	**Department:** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:
Computational Fluid Dynamics (CFD), Axial Flow Fans, Air-Cooled Condensers, Steam Expander, Solar Collector, high-speed marine craft (high speed boats)

General description of research field:
Axial flow fans form an integral part of Air-Cooled Condensers (ACCs) as well as other fan-heat exchanger configurations. My research is focussed on the design and optimization of axial flow fans as well as the integration of the fans into ACCs or general air-cooled systems. To this end a suite of CFD routines (implemented in OpenFOAM) have been developed to not only model fans, but large ACC systems where the effect on performance of, for example, wind can be investigated.

The development of a reciprocating steam expander for the specific use in solar thermal electricity generation is an ongoing body of work that is attracting attention due to a move towards more modular solar thermal systems. Both academic and commercial efforts are currently under way to develop a 100 kW working prototype of such a steam expander. There is also an ongoing effort to develop a heat pipe solar collector for solar thermal systems that would greatly reduce the pump losses associated with these systems.

Various topics of interest in the development of high-speed marine craft (boats) are in progress. To this end new concepts are being tested and developed in the Stellenbosch towing tank.

Individual topics listed:	**MEng** *(Structured)*	**MEng** *(Research)*	**PhD**	**Funding**
1. Configuration and testing of a steam expander / generator demonstrator for medium-scale CSP applications (w C McGregor).		X	X	1 x MEng or PhD
2. Design and testing of a solar receiver based on heat pipes (w C McGregor).		X	X	
3. Various topics in CFD modelling of axial flow fans and systems incorporating axial flow fans.		X	X	
4. Various topics in the development of high-speed marine craft.		X	X	

Specific requirements:

Lecturer: Dr Mike Owen	**Email:**	mikeowen@sun.ac.za
Faculty: Engineering	**Department:** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:
Heat transfer, fluid dynamics and thermal energy systems.

General description of research field:
The research aims to contribute to sustainable energy production and use in traditional and non-traditional contexts. There is a strong focus on industrial heat exchangers and cooling towers (dry, wet and hybrid) in particular as these systems directly affect thermal power plant efficiency (fossil-fuelled, nuclear or renewable) and have a strong influence on the energy/water nexus.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. An integrated solar thermal system for decentralized, small scale desalination / water purification and power generation.		X		Project funding is pending.
2. Design of a passive condenser for an interface evaporation based solar still.		X		

Specific requirements:
Topic 1 is in collaboration with the University of Southampton and is subject to the UK academic schedule. Work will need to begin before the initiation of the 2021 academic year in South Africa (i.e. the student will need to work during December 2020 / January 2021) and the student will need to work closely with researchers from the partner institution.

For both topics, students will benefit from a strong understanding of heat transfer, fluid dynamics and energy systems fundamentals at undergraduate level.

Lecturer: Prof Johan (SJ) van der Spuy	**Email:**	sjvdspuy@sun.ac.za
Faculty: Engineering	**Department:** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:

1) Turbomachinery:
   a. Axial flow fans for cooling systems
   b. Micro gas turbines
   c. Supercritical CO2 compressor specification

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 two related topics below are as follows:
   a. Experimental evaluation of the existing micro gas turbine compressor test facility. Upgrade the test facility to run the large compressor test bench.
   b. Experimental evaluation of the solarised micro gas turbine test facility. Evaluate proposal for improving the efficiency of the gas turbine.
3) The use of supercritical CO_2 as working fluid for power generation cycles. Current investigations indicate very specific compressor pressure ratio requirements for recuperated sCO_2 loops. This thesis will specifically investigate this requirement further.

Individual topics listed:	***MEng (Structured)***	***MEng (Research)***	**PhD**	**Funding**
1. Design of an axial flow fan for a unique cooling application.		X	X	Project funding available
2. Measuring the performance of the 24 ft. installed MinwaterCSP axial flow fan.		X	X	Project funding available
3. Modelling the noise of a large diameter axial flow cooling fan.		X		Project funding available
4. The development of a test facility for a micro gas turbine compressor stage.		X		limited funding available
5. The development of a micro gas turbine for solar-hybrid application.		X	X	Project funding available
6. The specification of a compressor for a recuperated supercritical CO2 loop.		X	X	Limited funding available

Specific requirements:
Thermofluids 344, Computational Fluid Dynamics.

<table>
<tr><td colspan="2"><u>Lecturer</u>:
Prof Theo (TW) von Backström</td><td><u>Email</u>:</td><td colspan="3">twvb@sun.ac.za</td></tr>
<tr><td colspan="2"><u>Faculty</u>:
Engineering</td><td colspan="4"><u>Department</u>:
Mechanical and Mechatronic Engineering</td></tr>
<tr><td colspan="6"><u>Division</u>:
Design & Mechatronics / Mechanics / Thermofluids / <u>Renewable Energy</u></td></tr>
<tr><td colspan="6"><u>Research field</u>:
Thermal energy storage in rock beds.</td></tr>
<tr><td colspan="6"><u>General description of research field</u>:
A rock bed using air as heat transfer fluid is potentially the cheapest energy storage system, but the rock bed shape, and its containment and thermal insulation as well as the air ducting layout must be optimised.
A disadvantage of using air as a heat transfer fluid is its low density, resulting in a relatively large solar receiver and associated ducting. Recent improvements to the SCRAP (Spiky Central Receiver Air Pre-heater) receiver tip must still be incorporated.</td></tr>
<tr><td colspan="2">Individual topics listed:</td><td>MEng
(Structured)</td><td>MEng
(Research)</td><td>PhD</td><td>Funding</td></tr>
<tr><td colspan="2">1. Redesign the existing rock bed thermal energy storage system at Mariendahl,* using calcium carbonate panels or similar as thermal insulation, and gabions to allow a steep-walled rock pile, and allow flow passages.*</td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td colspan="2">2. Investigate the possibility of using the recently built biogas generator at Mariendahl to replace the use of LPG to heat the rock pile at Mariendahl.*</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td colspan="2">3. Incorporate the Tadpole concept into the SCRAP receiver and model its performance experimentally and numerically.</td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td colspan="2">4. Ambient interaction of the SCRAP.</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td colspan="2">5. Manufacturing considerations of the SCRAP.</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Specific requirements:
*Students must preferably have transport to and from the farm about 15 km from Stellenbosch
Students must do CFD for items 3 and 4, and FEM for item 5.</td></tr>
</table>

Thermofluids Division

Lecturer: Dr Gareth Erfort	***Email:***	erfort@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	
Division: **Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy**		
Research field: Computational fluid dynamics		
General description of research field: Making use of open source software (OpenFOAM) for CFD models. This includes, solver development, experimental design, coding for surrogate modelling and coupling.		

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Development of an OpenFOAM solver for use in pollution modelling.		x		TBC
2. Open source atmospheric modelling of air pollution.			x	TBC
3. Vertical axis wind turbines in urban areas, a cost analysis.	x			-
Specific requirements:				

Lecturer: Dr Jaap (JE) Hoffmann	***Email:***	hoffmaj@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:
Thermal Engineering (Fluid Mechanics, Heat Transfer and Thermodynamics)

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.
A combination of two or more of the projects marked suitable for a MEng might be combined for a PhD.

Individual topics listed:	***MEng (Structured)***	***MEng (Research)***	**PhD**	**Funding**
1. Transition to turbulence and its modelling in packed beds Modelling flow at pore level in packed beds are computationally expensive, and beyond the capacity of most available computer hardware. A porous model formulation of the bed is preferred. Transition to turbulence in packed beds occur at superficial particle Reynolds numbers as low as 350. Furthermore, turbulent source terms depends on the order of time and space averaging. Previous research focused on structured beds and a representative unit cell approach. The objective of this project is to extend the work to random beds, using a combination of computational fluid dynamics (LES or DNS) and experimental techniques (mainly for validation purposes). A strong background in CFD and fluid dynamics will be advantageous.		X	X	
2. Crushed rock particle shape characterization for pressure drop and heat transfer prediction Crushed rock particles are irregular in shape, whilst pressure drop and heat transfer correlations are usually expressed in terms of simple shapes (spheres or ellipsoids). Furthermore, a specific shape might capture pressure drop satisfactorily, but fails to capture heat transfer, and vice versa. Compare various shape descriptors (e.g. volume or surface equivalent diameter, sphericity, aspect ratio, angularity, roundness, etc.) for crushed rock particles. A measuring method that is independent of operator error is preferred. It might be necessary to develop an entirely new shape descriptor if none of the available descriptors performs satisfactorily in predicting heat transfer and pressure drop in a packed bed.		X		
3. Effect of polydisperse particle size on pressure drop and heat transfer in packed beds Polydisperse (similar particles that differ in size and/or shape) particles pack differently from monodisperse particles in a packed bed, and as a result, the pressure drop and heat transfer in poly- and monodispersed beds will differ. Derive a correlation for the pressure drop and/or heat transfer in a	X	X		

packed bed experimentally for at least two different particle shapes/sizes. Results may depend on packing density, particle size and/or shape, mass fraction of particle class, particle orientation, etc. You may need discrete element modelling for the latter.				
4. Evaluation of the packing density variation in a randomly packed bed of ellipsoids Near walls, packing structure is disrupted by the walls, resulting in large changes in packing density near the walls, whilst the packing density is more or less constant in the interior of the domain. This often leads to preferential flow paths near the walls, whilst the interior of the domain is starved for flow. Small beds with bed diameter less than about 20 particle diameters are more severely affected than large beds. Most work reported in the literature is on spherical particles in prismatic containers. Rock beds are often conical in shape, with one or more free surface. Data may be generated experimentally or via a calibrated discrete element model. The expected outcome is a correlation/plot of the packing density against some macroscopic bed parameter.		X		
5. Evaluation of the mechanical properties of ellipsoidal cement particles Much of the rock bed research at Stellenbosch presumes that crushed rock particles can be approximated by simple ellipsoidal shapes. These are then casted in a 1:1 sand and cement mix, that is typically not used in building and construction. Mechanical properties for this material is required to calibrate discrete element models of packed beds. Derive protocols to determine the mechanical properties such as hardness, Young's modulus, Poisson ration, friction coefficient, restitution coefficient, angle of repose, etc. experimentally.	X	X		
6. Design and test a tubular cavity solar air receiver Sun-tracking mirrors (heliostats) allow very high irradiation flux on a receiver, but few simple air receiver designs are in existence that can cope with the combination of high temperature and high heat flux. The project envisage the design (tube size and material, coil depth and diameter, number of flow paths, etc. of a basket type receiver. On-sun testing to proof the receiver concept on the SunRoof Laboratory is required.	X	X		
Specific 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.				

***Lecturer*:** Prof Chris (CJ) Meyer	***Email*:**	cjmeyer@sun.ac.za
***Faculty*:** Engineering	***Department*:** Mechanical and Mechatronic Engineering	

***Division*:**
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

***Research field*:**
Computational Fluid Dynamics (CFD), Axial Flow Fans, Air-Cooled Condensers, Steam Expander, Solar Collector, high-speed marine craft (high speed boats)

***General description of research field*:**
Axial flow fans form an integral part of Air-Cooled Condensers (ACCs) as well as other fan-heat exchanger configurations. My research is focussed on the design and optimization of axial flow fans as well as the integration of the fans into ACCs or general air-cooled systems. To this end a suite of CFD routines (implemented in OpenFOAM) have been developed to not only model fans, but large ACC systems where the effect on performance of, for example, wind can be investigated.

The development of a reciprocating steam expander for the specific use in solar thermal electricity generation is an ongoing body of work that is attracting attention due to a move towards more modular solar thermal systems. Both academic and commercial efforts are currently under way to develop a 100 kW working prototype of such a steam expander. There is also an ongoing effort to develop a heat pipe solar collector for solar thermal systems that would greatly reduce the pump losses associated with these systems.

Various topics of interest in the development of high-speed marine craft (boats) are in progress. To this end new concepts are being tested and developed in the Stellenbosch towing tank.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Configuration and testing of a steam expander / generator demonstrator for medium-scale CSP applications (w C McGregor).		X	X	1 x MEng or PhD
2. Design and testing of a solar receiver based on heat pipes (w C McGregor).		X	X	
3. Various topics in CFD modelling of axial flow fans and systems incorporating axial flow fans.		X	X	
4. Various topics in the development of high-speed marine craft.		X	X	

***Specific requirements*:**

Lecturer: Dr Mike Owen	***Email:***	mikeowen@sun.ac.za		
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering			
Division: **Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy**				
Research field: Heat transfer, fluid dynamics and thermal energy systems.				
General description of research field: The research aims to contribute to sustainable energy production and use in traditional and non-traditional contexts. There is a strong focus on industrial heat exchangers and cooling towers (dry, wet and hybrid) in particular as these systems directly affect thermal power plant efficiency (fossil-fuelled, nuclear or renewable) and have a strong influence on the energy/water nexus.				
Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Natural draft dry-cooling: steam-side analysis of ducting and bundle layout.		X		1 x MEng bursary (unconfirmed)
2. Experimental analysis of wet, dry and hybrid cooling tower heat / mass transfer component performance: propagation of experimental uncertainty to performance prediction.		X		Limited funding is available
3. Data centre cooling: review of technological approaches and associated implications in terms of energy sustainability.	X			
Specific requirements**:** Students will benefit from a strong understanding of heat transfer, fluid dynamics and energy systems fundamentals at undergraduate level. Topics may include large amounts of experimental work and / or numerical simulation.				

Lecturer: Dr Hannes (JP) Pretorius	***Email:***	jpp@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / <u>Thermofluids</u> / Renewable Energy

Research field:

1) Dry cooling systems for power generation applications
2) Axial flow fans for cooling system applications

General description of research field:

1) In the quest for water conservation in arid and semi-arid countries, dry cooling systems are often employed as main cooling technology in modern power generation. Although Air Cooled Condensers (ACCs) are popular, indirect systems with dry cooling towers still hold advantages above ACC's in terms lower of auxiliary power consumption and relative insensitivity to windy conditions, but cannot compete in terms of life-cycle costing with ACC's. This project (topic 1) will investigate natural draft direct dry cooled systems, which combine the advantages of direct steam condensing of an ACC with the benefits of low auxiliary power consumption and insensitivity of natural draft dry cooling towers to wind. This research topic will focus on the thermo-fluid simulation, annual performance evaluation and life-cycle cost analysis of this system.

2) In the quest for water conservation in arid and semi-arid countries, Air Cooled Condensers are popular dry cooling systems employed in modern power generation. These systems reject heat to the environment via banks of large axial flow fans, typically 10m in diameter. The efficient operation of these fans is essential to ensure a well-performing and stable system. This research topic will focus on the numerical modelling of such an axial flow fan (scale fan) in a test facility and the comparison of the results with existing experimental data.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Natural draft direct dry cooling system performance characteristics, annual performance evaluation and life-cycle costing.			X	Limited funding available
2. Numerical modelling of an axial flow fan in an experimental test facility.		X		Limited funding available

Specific requirements:
Thermofluids 344, Computational Fluid Dynamics

Lecturer: Prof Johan (SJ) van der Spuy	**Email:**	sjvdspuy@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermofluids / Renewable Energy

Research field:

1) Turbomachinery:
   a. Axial flow fans for cooling systems
   b. Micro gas turbines
   c. Supercritical CO2 compressor specification

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 two related topics below are as follows:
   a. Experimental evaluation of the existing micro gas turbine compressor test facility. Upgrade the test facility to run the large compressor test bench.
   b. Experimental evaluation of the solarised micro gas turbine test facility. Evaluate proposal for improving the efficiency of the gas turbine.
3) The use of supercritical CO_2 as working fluid for power generation cycles. Current investigations indicate very specific compressor pressure ratio requirements for recuperated sCO_2 loops. This thesis will specifically investigate this requirement further.

Individual topics listed:	***MEng (Structured)***	***MEng (Research)***	**PhD**	**Funding**
1. Design of an axial flow fan for a unique cooling application.		X	X	Project funding available
2. Measuring the performance of the 24 ft. installed MinwaterCSP axial flow fan.		X	X	Project funding available
3. Modelling the noise of a large diameter axial flow cooling fan.		X		Project funding available
4. The development of a test facility for a micro gas turbine compressor stage.		X		limited funding available
5. The development of a micro gas turbine for solar-hybrid application.		X	X	Project funding available
6. The specification of a compressor for a recuperated supercritical CO2 loop.		X	X	Limited funding available

***Specific requirements*:**
Thermofluids 344, Computational Fluid Dynamics.