PhD & MEng
RESEARCH TOPICS
2022

Department of Mechanical & Mechatronic Engineering

PhD
(Engineering)

MEng Research
(Mechanical & Mechatronic Engineering)

MEng Structured
(Mechanical Engineering)

September 2021

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Design & Mechatronics Division

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

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

Research field:
Industry 4.0, cyber-physical systems, digital twins, virtual and augmented reality applications, and the integration of humans with digital environments.

General description of research field:

Cyber-Physical Systems, Digital Twins and Holonic Systems

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

(1) In the "Smart Connection Level", the acquisition, ingestion and integration of physical system IoT data from sensor networks and information systems are considered.
(2) The "Data-to-Information Conversion Level" considers issues related to data processing and aggregation to transform raw data into useful information.
(3) The "Cyber Level" considers issues such as the twin model (or Digital Twin) for systems to enable simulation and analysis using both models and real-world data.
(4) The “Services Level” implements software services, which build on Digital Twins, to support stakeholder decision making. Examples of such services are monitoring for anomaly detection, data analytics for prediction and data visualization through virtual and augmented reality.

Human integration

While Industry 4.0 research has paid notable attention to automation systems, the majority of South African enterprises will continue to rely heavily on people. As such, 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 investigating the adaptation of control architectures and the use of enabling technology (e.g. collaborative robots, pose sensing, and virtual and augmented reality), and careful consideration of human factors, to improve supervisory decision making, worker management and worker wellbeing.

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 data-led decision making. This includes modelling techniques for the physical system's behaviour in the digital world, mechanisms for data exchange between the digital and physical systems, as well as the development of value-adding digital services.		**X**	**X**	
2. Development of human-integrated work environments using collaborative robots, augmented reality 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 / Thermo Fluids / Renewable Energy

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

General description of research field:

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

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

Topics:	*Mark applicable degree with an X*			*Number of bursaries*
	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 2 x MEng (Research)

2. Further development and application of the Material Point Method (MPM). MPM is a *meshless* finite element method capable of modelling very large deformation and often used to model and analyse bulk (granular) material flow. Interestingly, MPM is also used by Walt Disney to model physics accurately in animation movies such as Frozen (https://www.disneyanimation.com/technology/matterhorn/) This topic requires an interest in solid mechanics, numerical modelling, FEM, and C++ programming. (https://en.wikipedia.org/wiki/Material_point_method)		✖	✖	Possibility of funding for: 1 x PhD 1 x MEng (Research)
3. Defining citrus pallet stability and modes of failure: developing tools to make stronger and cheaper cartons. Corrugated cartons are a critical component of the export and transport process of citrus fruit in South Africa (SA). Trends in market phytosanitary requirements indicate that the ventilation in citrus cartons need to be increased to more effectively apply cold disinfestation treatments. However, improvements in ventilation need to be approached through an optimisation process, whereby ventilation, strength and cost factors are simultaneously considered.		✖		1 x MEng (Research)
4. 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 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: Mrs LC Ginsberg	***Email*:**	ginsberg@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / 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.

Topics:	*Mark applicable degree with an X*			*Number of bursaries*
	MEng *(Structured)*	**MEng *(Research)***	**PhD**	**Funding**
1. CFD studies of detail micro-circulation in a lymphatic segment / duct				
2. Studies in micro flow of the lymphatic network system				

***Specific requirements*:**
CFD

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Lecturer: Dr WJ Smit	**Email:**	wjsmit@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division
Design & Mechatronics / Mechanics / Thermo Fluids / 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.

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

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Measure the optical quality of a heliostat with photogrammetry		X	X	
2. Estimate the pose of a drone with photogrammetry		X		
3. Closed-loop control of a heliostat For years this has been nearly impossible to achieve, but it has recently been solved. This project will aim to duplicate the results.		X	X	
4. Design and build a robot arena Scholars from all over the world can program a robot in a physical arena to do different tasks. They get real-time feedback of the arena via video streams.				

***Specific requirements*:**
All the topics require good programming skills.

Lecturer: Dr J van der Merwe	**Email:**	jovdmerwe@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

Research field:
Biomedical engineering, patient-specific implant design

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

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

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Development of an automated method for generating patient-specific implants for long bone defect reconstruction using active shape models and mechanobiology-based topology optimization.		X	X	
2. Development of a model of bone cell proliferation and differentiation from which to obtain gradient information to drive topology optimization of synthetic tissue scaffolds.		X	X	
3. Instrumentation of an Ilizarov external fixator and quantification of mechanobiological conditions during long bone healing.		X		
4. Development of an active shape model of the femur for the patient-specific estimation of missing geometry from CT scans of partial and misaligned bone fragments.		X		
5. Design and optimization of a total hip replacement stem for the South African population.		X		
6. Development of an automated method for generating patient-specific mandible reconstruction plates based on cephalometric measurements.		X	X	
7. Isogeometric design and analysis of a patient-specific femoral reconstruction plate.		X	X	

8. Development of an automated method for segmenting and reconstructing a patient-specific talus spacer.		X		
9. Development of a temporomandibular joint simulated wear testing standard.		X	X	

***Specific requirements*:**
Depending on the project, students must have a sound understanding of engineering design, some programming ability and sufficient mathematical background for further study in modelling, simulation, and optimization at a postgraduate level.

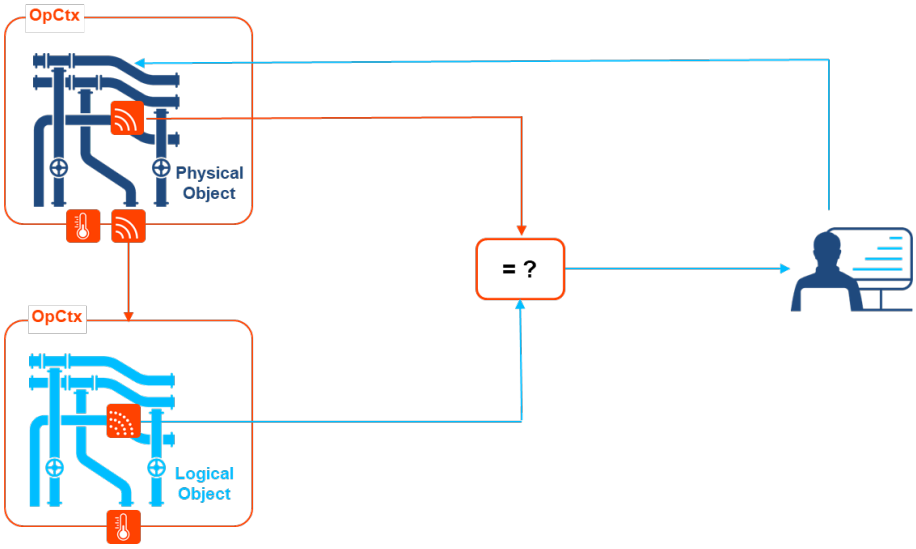
Mechanics Division

Lecturer: Prof Annie Bekker	**Email:**	annieb@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / 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 behavior 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 trialed 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.

Individual topics listed:	**MEng *(Structured)***	**MEng *(Research)***	**PhD**	**Funding**
1. A digital twin pump laboratory for water asset management		1	1	1xPhD or 1xM

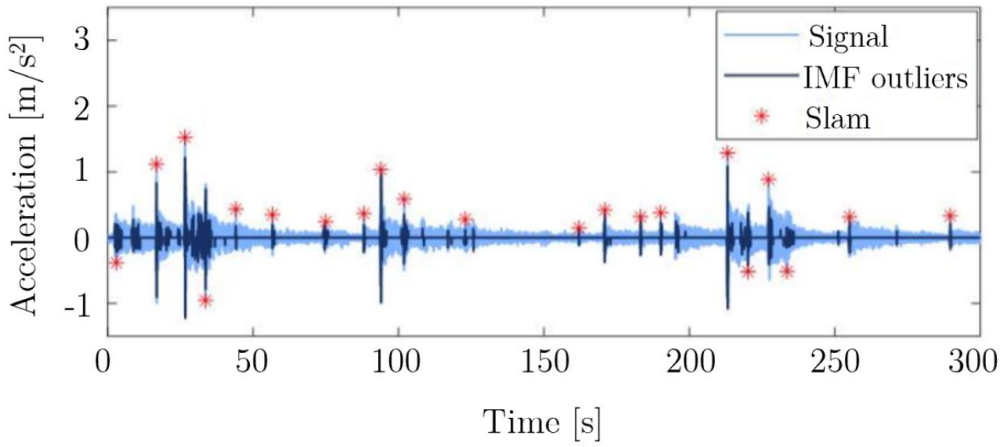
***Specific requirements*:** Students participating in this project must be self-driven, willing to spend time in the field and eager to break new ground in engineering science. The success of these projects are directly related to students’ curiosity, willingness to take initiative, find solutions through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

Lecturer: Prof Annie Bekker	**Email:**	annieb@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

Research field:
Vibration, modal analysis, fatigue, data analytics, data-driven models.

General description of research field:



The SA Agulhas II is a polar supply and research vessel, which is scientifically instrumented for full-scale engineering measurements of operational parameters, ice loads, shaft-line strain and vibration. The current research focus is to propel the digital transformation of this vessel as a flagship for Vessel 4.0. SA Agulhas II is pre-disposed to wave slamming which causes "jellyship", a lasting vibration of her structure – she is currently a case study for the International Committee in Ships and Offshore structures. In July 2022 she will undertake a research voyage to the Southern Ocean with a team of scientists on board. A new student will participate in this voyage and be responsible for slamming measurements and observations in the Stellenbosch research team (comprising post-graduate students from Stellenbosch, Norway and Germany). Data-driven techniques and analysis will be investigated to predict slamming and damaging conditions and avoid this in operation. The work will demand significant data processing and focus on data-driven techniques, benchmarked against physics-based models.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
2. Slamming detection and fatigue analysis on the SA Agulhas II		1	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 JR Bredell	**Email:**	jrbredell@sun.ac.za		
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering			
Division: **Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy**				
Research field: Modelling, optimisation, and design (MOD)				
General description of research field: Structural analysis and design				
Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Fatigue assessment on single axis tracking PV support structures To be economically competitive, the design of the supporting structures in utility scale ground mounted PV plants must be highly optimised. Material costs must be kept to a minimum whilst still providing sufficient protection against failure due to static and dynamic loads to ensure long-term reliability. Unlike traditional building structures, the lightweight structures typically found in PV installations are extremely susceptible to wind loads. Static and dynamic wind loads typically govern the design of these structures. The single axis tracking (SAT) capability of these systems add additional complexity. Currently there are no dedicated design codes for these structures and research in this field in ongoing. Of specific interest in this project is the correlation between wind conditions and dynamic or fluctuating loads on the structural system, as this information can be used to estimate the fatigue life of components. It is envisaged that the project will make extensive use of finite element analysis (FEA) supported by experimental work.		X		Possibility of funding
2. Performance degradation of PV modules due to mechanical loads It is known that mechanical stresses result in performance degradation of crystalline silicone PV modules. Of particular concern is the fact that this effect is not immediately apparent but results in gradual reduction in power output over time. It is therefore likely that mechanical loads such as wind loads may result in long-term performance degradation of a PV installation. The relationship between wind induced mechanical stresses and design life will be investigated. This may provide valuable insight for design engineers and plant owners. This study may be of particular interest for bifacial modules where continuous rear supporting structures are not present. Bifacial panels offer between 5-10% gain in efficiency compared to mono-facial PV modules, which will make it a strong		X		Possibility of funding

contender for future installations. The current design trend of using larger module configurations may possibly make these modules more susceptible to mechanical damage caused by wind loads. The lightweight supporting structures, typically found in single axis tracking (SAT) installations, may not provide sufficient stiffness under certain wind conditions to prevent damage to the modules. Detailed structural analyses of the modules and supporting structures may provide valuable insight to the problem.				
3. Alternative structural designs for natural draft cooling towers The proposed topic forms part of a larger project in which the feasibility of using natural draft dry cooled steam condensers in thermal power plants is investigated. Dry cooled steam condenser systems are preferred over wet indirect systems due to their relatively high thermal efficiency and reduced environmental impact. The main advantages of natural draft systems as opposed to forced-draft systems, relate to the absence of costly and maintenance intensive mechanical components i.e. motors, gearboxes, bearings and fans. Despite the virtues of natural draft dry cooled systems, traditional design and construction methods make hyperbolic concrete towers prohibitively expensive. The aim is to investigate alternative structural designs for natural drafts cooling towers, using the latest advancements in design methods, materials, and construction methods. Specifically, the feasibility of tensile membrane structures is of interest.		X		Possibility of funding
***Specific requirements*:** Finite element analysis				

Lecturer: Dr Melody Neaves	***Email*:**	melzvanrooyen@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

Research field:
Materials Engineering

General description of research field:
The Materials Engineering group focuses on investigating material behaviour with the aim to understand material properties and property degradation mechanisms. We focus on:

- Developing numerical-experimental techniques for material characterisation and property analysis.
- Linking manufacturing processes to material performance and structural integrity.
- Developing life prediction capabilities of materials and components.

www.sun.ac.za/mateng

Topics:	*Mark applicable degree with an X*			*Number of bursaries*
	MEng *(Structured)*	**MEng *(Research)***	**PhD**	**Funding**
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 is aimed at the development of an experimental-numerical technique for the material property extraction from small scale samples of power plant-extracted 12 % Cr steel using small punch testing together with finite element simulations, digital image correlation and microstructural characterisation. The project is in collaboration with the University of Cape Town.		X	X	1 x MEng or 1 x PhD
2. Additive manufacturing is a disruptive technology revolutionising the manner in which industries are approaching complex designs. South Africa has gained tremendous traction on the research front of additively manufactured titanium alloys. Research is still required for printing with more specialised nickel superalloys for the aerospace industry. This topic focuses on identifying the optimal parameters for printing high density nickel superalloy parts using laser powder bed fusion. Post-processing methods and property measurements are also necessary for full qualification of these printed materials.		X		Funding anticipated for 1 x MEng

***Specific requirements*:**

Lecturer: Prof G Venter	***Email*:**	gventer@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

Research field:
Computational (structural) mechanics – structural analysis and numerical design optimization and related technologies.

General description of research field:
My research typically deals with complex finite element analyses combined with structural and/or multi-disciplinary optimization. These techniques are applied to a wide range of interesting topics, typically driven by and in collaboration with industry. Currently my group does some work in load recovery of real world forces on complex structures, material characterization using inverse modelling, optimum design and investigation into the fatigue life of welded and bolted connections in high strength steels.

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

Topics:	*Mark applicable degree with an X*			*Number of bursaries*
	MEng *(Structured)*	**MEng *(Research)***	**PhD**	**Funding**
1. Material characterization and validation of rubber isolators for use in vibrating screen applications.		X		Possible
2. Developing a test setup that can accurately measure friction losses in bicycle drive-trains and related components with inputs from industry.		X		Partial
3. Developing an open source digital image correlation software system in Python.		X		Partial
4. Developing a concept for a small shunting truck, used in a yard to move trailers around. The key aspect to be designed is a system to autonomously drive the shunting truck to the point where it hooks the trailer, after the driver parked it close to the trailer. This is a little similar to self-parking cars.		X		Full
5. Applying machine learning to improve the process where a customer selects customized/specialized options and combinations when ordering a new truck.		X		Full

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

Lecturer: Dr MP Venter	***Email:***	mpventer@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

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

General description of research field:
I am interested in computational methods as part of the design process. This allows us to share the burden of making design decisions that can become complex, like biologically inspired artificial creatures and inflatable structures. Over the past few years, I have been exploring the potential applications of compliant and selectively reinforced materials to the fields of pressure rigidised structures and soft robotics. In addition, 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 multidisciplinary field taking elements from several computational fields. Researchers in this area will develop non-linear finite element methods, numerical design optimisation, programming and machine learning skills. Much of what we do requires insightful experiment planning in tandem with advanced tools to deal with large volumes of data. This is a new field and is open to exploration, which can be both challenging and rewarding.

Topics:	*Mark applicable degree with an X*			*Amount of bursaries*
	MEng *(Structured)*	**MEng *(Research)***	**PhD**	**Funding**
1. Silicone elastomer in its various forms is the material of choice for the construction of soft robots. This material is easy to cast into complex shapes and is exceptionally compliant. However, previous research shows that simulated soft robots' stress and deformation results are susceptible to minor changes in the material model parameters. In most applications, soft robots undergo large deformations with large strains. It is therefore critical to ensure that the material model chosen performs well over the entire strain range. *Research Questions*: 1. Which material models can capture the mechanical behaviour of silicone elastomer subjected to high strains? 2. What test methods are suitable for are compatible with these material models, and how sensitive is the fitting process to small perturbations in the test data? 3. How should a researcher account for the uncertainty resulting from the geometric and model fitting sensitivity?		1		Operational funding secured.
2. At present, the rate at which researchers can evaluate new designs restricts much of the development of soft robots. To assess a design, a full prototype must be fabricated and tested. Although several research groups use numerical simulations of soft robots, the simulations are typically used for		1		Operational funding secured.

design validation or insight. They play no active role in the design process. This research will attempt to create a robust generic workflow for generating and verifying new numerical models to make meaningful progress towards a digital twin for soft robots. *Research Questions*: 1. What tools are suitable for generating arbitrary soft robot geometries? 2. What processes result in the successful simulation of a soft robot? 3. How can the performance of a generalised simulation of a soft robot be verified?				
3. A Digital Twin is the coupling of a digital replica and physical soft robot that allows us to gain insight into the physical system remotely. Using this insight, a user can better control the physical system or propose modifications based on real-world use cases. This tool will make it feasible to incorporate more soft robots into a range of new technology. With greater predictability and responsiveness, innovators will be able to predict more accurately the behaviour of a soft robot in a new environment. *Research Questions*: 1. How can model complexity be reduced to reduce the computational burden of simulating soft robots? 2. How should the digital and physical soft robots be connected to form a Digital Twin? 3. How can the exploration of the design space be automated?			1	Operational funding secured.
***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 have a will to learn more.				

Thermo Fluids Division

Lecturer: Prof JE Hoffmann	***Email*:**	hoffmaj@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / 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.

Topics:	*Mark applicable degree with an X*			*Amount of bursaries*
	MEng *(Structured)*	**MEng *(Research)***	**PhD**	**Funding**
1. Low cost passive condenser for a solar still		**X**		possible
2. Heat transfer in packed beds of crushed rock		**X**	**X**	
3. Modelling thermal performance of packed beds		**X**		
4. Design of rock bed thermal energy storage facility	**X**	**X**	**X**	
5. Reversible solar hydrogen fuel cells		**X**	**X**	
6. High temperature solar receiver for a solarized gas turbine cycle		**X**	**X**	
7. Development of multi-effect distillation plant	**X**	**X**		

***Specific requirements*:**
Topic 2, 3 & 4 require CFD

Lecturer: Prof R Laubscher	***Email*:**	rlaubscher@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

Research field:

a. Numerical modelling of energy systems
b. Scientific machine learning applied to thermo fluids

General description of research field:

a) The application of 1D process- and CFD-modelling to investigate energy transfer phenomena in conventional (Rankine power cycles) and state-of-the-art energy systems (sCO2 power cycles) with a specific focus on heat transfer and combustion.

b) Scientific machine learning pertains to the application of data-driven techniques such as neural networks and ensemble learning to traditional engineering fields. The present research focusses on applying deep neural networks in modelling of thermo fluid processes either using experimental data, physics equations or a combination thereof.

Topics:	*Mark applicable degree with an X*			*Number of bursaries*
	MEng *(Structured)*	**MEng *(Research)***	**PhD**	**Funding**
1. Numerical investigation of the thermal performance of a conceptual biomass-fired sCO2 heater for power generation.		X		Possible funding available
2. CFD modelling of a suspension-fired industrial biomass boiler using open-source software (OpenFOAM).		X		Possible funding available
3. Evaluation of physics-informed neural networks as universal function approximators to solve forward- and reverse-mode incompressible Navier-Stokes equations.		X		

***Specific requirements*:**
Thermofluids 344, Computational fluids dynamics 414

Lecturer: Prof Craig McGregor	***Email*:**	craigm@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

Research field:
Renewable and sustainable energy.

General description of research field:
Concentrating solar power; green hydrogen; thermodynamic cycle analysis; energy storage; high temperature process heat; system modelling, design and optimisation.

Topics:	*Mark applicable degree with an X*			*Number of bursaries*
	MEng *(Structured)*	**MEng *(Research)***	**PhD**	**Funding**
1. System design and optimisation of a modular central receiver Concentrating Solar Power (CSP) plant		x		
2. System design of a rheology-based high density pumped hydro storage system for grid storage of renewable electricity		x	x	
3. System design and modelling of a hybrid gas-turbine / solarised steam Rankine hybrid power plant		x	x	
4. Design and testing of a concentrator optics system with a novel photochemical reactor for green hydrogen production		x	x	
5. Financial analysis of the historic bid-prices of the REIPPP Program to develop projections of future RE costs in South Africa	x			
6. Design and testing of a winch actuated heliostat using digital camera-based feedback control (mechatronics)		x	x	
7. Experimental performance of a particle-air heat exchanger for particle-based receivers in a CST plant.		x		

***Specific requirements*:**

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

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / 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		Project funding available, no bursary.
2. Air-cooled condenser axial flow fan inlet uniformity: measurement, simulation and correlation with fan performance and dynamic blade loading.		X		
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 JP Pretorius	**Email:**	jpp@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

Research field:
Axial flow fans for cooling system applications.

General description of research field:
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. During operation, the fan blades deflect due to the pressure on the blades, which may cause changes in the operating point compared to the design. This study will quantify this effect and use inverse design methods to numerically design a fan blade that will run in the same position as intended during the design phase.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
Design of ACC fan using inverse design method		**X**		Project funding available

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

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

Division:
Design & Mechatronics / Mechanics / Thermo fluids / Renewable Energy

Research field:
Turbomachinery:
a. Axial flow fans for cooling systems
b. Micro gas turbines

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

List of topics:	***MEng (Structured)***	***MEng (Research)***	***PhD***	**Funding**
1. Design of an axial flow fan for a unique cooling application.			**X**	Project funding available
2. Measuring the performance of the 24 ft. installed MinwaterCSP axial flow fan.		**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 micro gas turbine for solar-hybrid application.		**X**	**X**	Project funding available

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

Renewable Energy

Lecturer: Dr G Erfort	***Email*:**	erfort@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	
Division: **Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy**		
Research field: Wind energy and CFD		
General description of research field:		

Topics:	*Mark applicable degree with an X*			*Number of bursaries*
	MEng *(Structured)*	**MEng *(Research)***	**PhD**	**Funding**
1. Development of a horizontally stable platform for offshore weather monitoring		X		
2. Air pollution modelling around a coal fired power station using CFD			X	
3. ABL modelling of pollutants in CFD		X		

***Specific requirements*:**

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Lecturer: Prof JE Hoffmann	***Email*:**	hoffmaj@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / 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.

Topics:	*Mark applicable degree with an X*			*Number of bursaries*
	MEng *(Structured)*	**MEng *(Research)***	**PhD**	**Funding**
1. Solar co-generation of electricity and potable water		**X**		possible
2. Reversible solar hydrogen fuel cells		**X**	**X**	
3. Feasibility of coupling an organic Rankine cycle to a solar still	**X**	**X**		
4. High temperature solar receiver for a solarized gas turbine cycle		**X**		
5. Techno-economic evaluation of solarized gas turbine power plant	**X**	**X**		

***Specific requirements*:**

Lecturer: Prof Craig McGregor	***Email*:**	craigm@sun.ac.za
Faculty: Engineering	***Department:*** Mechanical and Mechatronic Engineering	

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

Research field:
Renewable and sustainable energy

General description of research field:
Concentrating solar power; green hydrogen; thermodynamic cycle analysis; energy storage; high temperature process heat; system modelling, design and optimisation.

Topics:	*Mark applicable degree with an X*			*Number of bursaries*
	MEng *(Structured)*	**MEng *(Research)***	**PhD**	**Funding**
1. System design and optimisation of a modular central receiver Concentrating Solar Power (CSP) plant		x		
2. System design of a rheology-based high density pumped hydro storage system for grid storage of renewable electricity		x	x	
3. System design and modelling of a hybrid gas-turbine / solarised steam Rankine hybrid power plant		x	x	
4. Design and testing of a concentrator optics system with a novel photochemical reactor for green hydrogen production		x	x	
5. Financial analysis of the historic bid-prices of the REIPPP Program to develop projections of future RE costs in South Africa	x			
6. Design and testing of a winch actuated heliostat using digital camera-based feedback control (mechatronics)		x	x	
7. Experimental performance of a particle-air heat exchanger for particle-based receivers in a CST plant.		x		

***Specific requirements*:**

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

Division:
Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy

Research field:
1) Dry cooling systems for power generation applications
2) Utility-scale PV power plant performance enhancement

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. Natural draft direct dry cooled (NDACC) systems 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 study (topic 1) will conduct numerical simulation (1D and CFD models) to investigate the annual performance characteristics of an ACC vs a NDACC for a typical Concentrated Solar Power (CSP) plant configuration to determine which system performs best.
2) Solar power generation using Photovoltaic (PV) power plants have seen a dramatic rise in popularity in recent years. Large PV plants continue to be constructed all around the world, including South Africa. Due to the continually decreasing price of PV panels and the relative construction simplicity of such power plants, it is expected that they will remain competitive in the medium to long term. One drawback of such power plants is that overheating dramatically reduces the efficiency of the PV panels. This study (topic 2) will conduct numerical simulation (using CFD) to investigate the effect of wind on a utility-scale PV power plant, while also evaluating measures to enhance the performance of the PV panels under wind conditions.

Individual topics listed:	**MEng** ***(Structured)***	**MEng** ***(Research)***	**PhD**	**Funding**
1. Numerical modelling of ACC vs NDACC performance for a CSP application		**X**	**X**	Limited funding available
2. Numerical modelling of wind effects on PV power plants and investigation into performance enhancement		**X**		Project funding available

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

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

Division:
Design & Mechatronics / Mechanics / Thermo fluids / Renewable Energy

Research field:
Turbomachinery:

a. Axial flow fans for cooling systems
b. Micro gas turbines

General description of research field:

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

List of topics:	***MEng (Structured)***	***MEng (Research)***	***PhD***	**Funding**
1. Design of an axial flow fan for a unique cooling application.			**X**	Project funding available
2. Measuring the performance of the 24 ft. installed MinwaterCSP axial flow fan.		**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 micro gas turbine for solar-hybrid application.		**X**	**X**	Project funding available

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