# PhD & MEng
# RESEARCH TOPICS
## Department Mechanical & Mechatronic Engineering
## 2020

**PhD**

*(Engineering)*

**MEng Research**

*(Mechanical & Mechatronic Engineering)*

**MEng Structured**

*(Mechanical Engineering)*

***(August 2019)***

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## Design & Mechatronics Division

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<tr><td rowspan="3"><u>Lecturer</u>:<br>Prof Anton Basson<br>Dr Karel Kruger</td><td>Email:</td><td>ahb@sun.ac.za ;<br>kkruger@sun.ac.za</td></tr>
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</table>

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

***Research field:***
Industry 4.0 and Cyber-Physical Systems

**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 is reliant on certain enabling technologies, such as cyber-physical systems (CPSs), the Internet of Things and cloud computing. 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", 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, both as task executors and decision makers, within Industry 4.0 environments. We are interested in the adaptation of control architectures and the use of technology (e.g. collaborative robots and wearable eye-tracking systems) to facilitate the integration of humans in CPSs.

| **List of topics:** | **MEng *(Structured)*** | **MEng *(Research)*** | **PhD** | **Funding** |
|---|---|---|---|---|
| 1. Technologies for implementing a "digital twin" in a CPS, for both automated systems and humans. 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 | At least 1 x MEng or PhD |
| 2. The development of an Erlang-based framework to facilitate implementation architectures for CPS. Erlang is a functional programming language that offers advantages in modularity, concurrency and fault tolerance – all of which are important in various levels of CPS implementations. | | X | X | |

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

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

**Research field**:

The modelling of bulk materials handling in the mining and agricultural sectors.
The improvement of fruit packaging in terms of cooling and structural strength.

**General description of research field**:

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 fruit handling to predict damage and bruising and soil-tool interaction with the aim of improving the implements.
Packaging (plastic bags, carton boxes, etc.) is used to protect fruit 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 such as bruising but might prevent proper cooling of the fruit. On the other hand, a box which will allow the fruit to cool properly might not be able to prevent mechanical damage. The optimum design should be found.

| **List of topics:** | **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:<br><br>1 x PhD<br><br>1 x MEng |
| 2. 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:<br><br>1 x PhD<br><br>1 x MEng |

***Specific requirements***:
Finite Element Method where applicable.

| | | | | |
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| **Lecturer**:<br>Dr Danie Els | **Email:** | dnjels@sun.ac.za | | |
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**Division:**
**Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy**

**Research field:**

a. Large Industrial Gearbox Performance and Analysis
b. Agricultural Engineering

**General description of research field:**

a. *Gearboxes:* The main purpose of this research is the investigation of the effect of fan vibrations, start-up loads and the gearbox-motor dynamic motion on the gearbox loads and gear and bearing fatigue life.
b. *Agriculture*: The optimal management of water resources in viticulture and agricultural in general is a topic of particular relevance in the Western Cape. The focus is on the detection of waters stress in plants. These project is a collaboration between the Departments of Mechanical and Mechatronic Engineering and of Viticulture at Stellenbosch University.

| **List of topics:** | **MEng *(Structured)*** | **MEng *(Research)*** | **PhD** | **Funding** |
|---|---|---|---|---|
| 1. Investigation of Air-Cooled Condenser Gearbox Dynamics. | | X | | 1 x MEng |
| 2. Develop a low-cost infrared system to detect water stress in vineyards. | | X | | 1 x MEng |
| 3. Develop an automated Leaf Stem Water Potential Measurement system | | X | | |

***Specific requirements***:

| | | | | |
|---|---|---|---|---|
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**Division:**
**Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy**

**Research field:**
Biomedical Engineering

**General description of research field:**
Research and Development of applications from the engineering field (specifically mechatronics) in the area of medicine and health related problems.

| **List of topics:** | **MEng** ***(Structured)*** | **MEng** ***(Research)*** | **PhD** | **Funding** |
|---|---|---|---|---|
| 1. Neuro-feedback Applied to Improve Concentration Using a Single Intra-Ear EEG | | X | | |
| 2. Identifying the Impedance of the Epidural Epidural Space for Application in Epidural Anaesthesia | | X | | |
| 3. Development of a Fundus Camera Applying a Unique Focus Methodology | | X | | |
| 4. Effect of Music on Speech Development in Children with an Autistic Spectrum Disorder | | X | | |
| 5. Brain Cooling Applying an Acoustic Cooling Technique | | X | | |

***Specific requirements*:**

| | | |
|---|---|---|
| **Lecturer:**<br>Mrs Liora Ginsberg | **Email:** | ginsberg@sun.ac.za |
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**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.

| List of topics: | 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

| | | |
|---|---|---|
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**Division:**
**Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy**
**IBE**

**Research field:**
Biomedical Engineering

**General description of research field:**

The following Research Topics are applications at the intersection of molecular biology, robotics, fluidics and machine learning engineering.

The applications all have predefined market needs, i.e. a client from Industry. Successful completion may lead to employment opportunities.

| List of topics: | MEng *(Structured)* | MEng *(Research)* | PhD | Funding |
|---|---|---|---|---|
| 1. Development of a viral load pooling robotic platform | | X | | Yes |
| 2. Development of a nucleic acid collecting electrode | | X | | Yes, possible |
| 3. Development of a microfluidic lymphocyte isolation system | | X | | Yes, possible |
| 4. Development of a bacterial isolation system | | X | | Yes, possible |
| 5. Development of an on-line chemical Reactor to produce a hypochlorous free-radical solution | | X | | Yes |
| 6. Development of a safe, micro-sample extractor for the Gene Expert platform | | X | X | Yes |
| 7. Patient-specific 3D bioprinting of tissue engineered hydrogels | | | X | Yes |
| 8. Machine Learning for Biomarker identification in Diabetes and other diseases | | X | X | Yes, possible |
| 9. Machine Learning for Medical Image Analysis | | X | X | Yes, possible |

***Specific requirements*:**

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

**Research field:**
Robot navigation & metrology.

**General description of research field:**

Motion analysis of athletes with stationary cameras such as the Vicon system does not allow tracking athletes in large scale outdoor environments. Understanding the complex motions involved in disciplines such as mountain biking requires new technologies. With Dr's Smit and Müller, we propose to develop a mobile system relying on UAV-borne camera tracking of a mountain biker on an actual track. This part of the project is about accurately locating the UAV (or robot) so that certain markers on the biker can be tracked at high precision. This project is in collaboration with Dr's Smit and Müller who are respectively looking at the UAV control and body model aspects.

Micro-metrology and optical metrology are exciting new measurement techniques being used more and more by industry. We are busy with various metrology projects, in close collaboration with industry partners. Optical metrology has wide application: manufacturing, quality control, robotics, navigation, medicine, etc. Our focus is on precision. Micro-metrology is an emerging field of high precision measurement with many exciting high technology applications.

| **List of topics:** | **MEng** ***(Structured)*** | **MEng** ***(Research)*** | **PhD** | **Funding** |
|---|---|---|---|---|
| 1. High precision dimensional metrology | | X | X | Apply through CSIR/DST before 28 Sept. |
| 2. Constraining the SLAM feature tracking algorithm with the body model | | X | X | NRF funding |
| 3. Quantifying the impact of the sensor capabilities on the UAV localisation | | X | X | NRF funding |
| 4. Finding an optimal sensor array to achieve the required marker localisation accuracy | | X | X | NRF funding |
| 5. Optical metrology | | X | X | Apply through CSIR/DST before 28 Sept. |

***Specific requirements:***

| | | | | | |
|---|---|---|---|---|---|
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| **Faculty:**<br>Engineering | **Department:**<br>Mechanical and Mechatronic Engineering | | | | |

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

**Research field:**
Robotics, Autonomous heliostat fields.

**General description of research field:**

The Solar Thermal Energy Research Group (STERG) is developing an autonomous heliostat field. This heliostat field will be used to provide process heat for applications like sinter plants and smelters. We think that drones and ground based robots will be able to service an autonomous heliostat field.

| List of topics: | MEng *(Structured)* | MEng *(Research)* | PhD | Funding |
|---|---|---|---|---|
| 1. Design, build and test a quadcopter with a novel configuration for endurance flights. | | X | | |
| 2. Develop a small, low-cost, high quality heliostat facet. | | X | | |
| 3. Improve the state-estimation of a multirotor by using sensor fusion. | | X | X | |

***Specific requirements***:

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

**Research field:**
Biomedical Engineering: Neural Engineering

**General description of research field:**

Unlocking the mysteries of the brain is the next frontier in scientific discovery. The brain is the most complex organ in the human body (arguably in the whole universe) and is responsible for our every thought, action, memory, feeling and subjective experience. Better insights into how this all manifests is necessary for a large number of varied reasons. Neuroscientific discoveries have the potential to pioneer novel ways to treat brain diseases, improve quality of life and even revolutionize current computing technologies. Our understanding of the brain is still riddled with puzzles that cannot be considered in isolation, and therefore our focus is to link the biology of the brain to its applied philosophy.

Within my research group we aim to answer fundamental questions regarding free will and consciousness; develop low cost brain screening/assessment devices; and look into machine learning and machine consciousness for general AI.

| **List of topics:** | **MEng** ***(Structured)*** | **MEng** ***(Research)*** | **PhD** | **Funding** |
|---|---|---|---|---|
| 1. Decoding Visual Perception and Representation in the Brain | | X | X | 0 |
| 2. The effect of meditation on mind wandering | | X | | 0 |
| 3. Brain mechanisms involved in decision making | | X | | 0 |
| 4. Biologically inspired machine learning algorithms for conscious machines | | X | X | 0 |

***Specific requirements*:**
If you need bursary money to stay alive you will need to find it on your own. Try the postgrad bursary website for info about available bursary opportunities:
http://www.sun.ac.za/english/research-innovation/Research-Development/postgraduate-funding-support

| | | |
|---|---|---|
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**Division:**
**Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy**

**Research field:**
Orthopaedic engineering

**General description of research field:**

Developing solutions for the treatment of musculoskeletal disorders is a challenging yet exciting field of research. It requires the integration of multiple disciplines such as biology, medicine, statistics, computer science and of course, engineering. The Biomedical Engineering Research Group works together with the Advanced Orthopaedic Training Centre to research and improve methods of surgical planning, navigation and reconstruction.

| List of topics: | MEng *(Structured)* | MEng *(Research)* | PhD | Funding |
|---|---|---|---|---|
| 1. Estimation of healthy bone shape and density distribution from partial inputs for implant design | | X | | TBC |
| 2. Reconstruction of 3D models of repeatable pathology from planar x-rays for surgical planning | | X | | NA |
| 3. Automated statistical model construction and analysis tool for CT-based morphometric studies | | X | | NA |
| 4. Semi-automatic segmentation of CT scans for pre-operative printed 3D models | | X | | NA |
| 5. Machine learning methods for implant design and selection: application to the shape and morphology of the knee | | X | | NA |
| 6. Effect of unicompartmental knee replacement design on knee biomechanics | | X | | NA |
| 7. Topology optimisation of patient-specific porous lattice structures based on statistical estimates of healthy bone shape and density | | | X | NA |

***Specific requirements:***

# Mechanics

# Division

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

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

**Research field:**
Digital twin solutions and data analytic for dynamic responses of ice-going ships

**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. Measurements will be combined with engineering models (statistical, physics-based, machine learning, etc.) to explore digital twin solutions for shipping and polar science. Work on this project is highly international and comprises collaborations and possible exchanges with Norwegian, Finnish and German research partners.

| **List of topics:** | **MEng** *(Structured)* | **MEng** *(Research)* | **PhD** | **Funding** |
|---|---|---|---|---|
| 1. Full-scale measurement and analysis of propulsion thrust towards a digital twin for remaining useful life. | | X | X | R70k / R100k |
| 2. The investigation of rigid body motion as a predictor of wave state / motion sickness / task performance towards a digital service for human comfort. | | X | X | R70k |
| 3. "The ship as a sensor" using structural vibration signatures and full-scale instrumentation to infer ship-ice interactions from machine vision and hull strain. | | X | X | R70k / R100k |
| 4. Modal tracking and inverse force estimation of an operational vessel in waves and ice. | | | X | R100k |

***Specific requirements*:**
Students participating in this project must be self-driven, willing to spend time at sea 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.

| | | |
|---|---|---|
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| **Faculty**:<br>Engineering | **Department**:<br>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 the material behaviour with the aim to understand material properties and property degradation mechanisms.

We focus on:

- Develop numerical-experimental techniques.
- Linking manufacturing processes to material performance and structural integrity.
- Develop material models for predictive capabilities.
- Material characterisation and analysis.

www.sun.ac.za/mateng

| List of topics: | MEng *(Structured)* | MEng *(Research)* | PhD | Funding |
|---|---|---|---|---|
| 1. The rising demand for electrical energy in South Africa has forced suppliers to exceed the designed lifetime of existing power plants. Exceeding this design lifetime can have detrimental effects on the plant's reliability. Plant reliability is critically dependent on the integrity of a broad range of materials that make up the structures, machines and systems within the plant. It is necessary to accurately characterise the material condition with regards to the damage level, as well as to understand the damage mechanisms and subsequently to predict the damage that occurs during exposure to operating conditions, and the loss in design properties. | | x | x | 1x PhD |
| 2. One of the concerns when utilising 3D printing technologies are their achievable mechanical properties. To date, various studies have investigated the material performance of 3D printed metals, however, what makes investigations intricate is that the material performance depends on numerous factors. The technological requirements within the context of achievable material performance are often application specific. | | x | x | 1x MEng<br><br>1x PhD |

***Specific requirements***:
Matlab, finite element method, laboratory work at UCT, NMMU and/or aboard.

| **Lecturer:**<br>Prof Deborah Blaine | **Email:** | dcblaine@sun.ac.za |
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**Division:**
**Design & Mechatronics / Mechanics / Thermo fluids / Renewable Energy**

**Research field:**
Mechanical behaviour of materials, powder metallurgy, sintering.

**General description of research field:**

My research projects typically investigate the link between processing, properties and microstructures. I focus specifically on powder metallurgy and sintering, but also explore other manufacturing processes if the opportunity arises through funded projects. The research spans experimental work that uses presses, furnaces, various microscopes, mechanical testing and sometimes computed tomography. There is also scope for finite element modelling and constitutive modelling of mechanical behaviour through co-supervised projects. I collaborate with various national and international universities and research institutions on projects.

| **List of topics:** | **MEng** ***(Structured)*** | **MEng** ***(Research)*** | **PhD** | **Funding** |
|---|---|---|---|---|
| 1. Hybrid machining-powder metallurgy processing of titanium alloys | | X | X | 1 x MEng bursary available.<br><br>Additional MEng/PhD bursaries available - apply to DST Ti-CoC (competitive bursaries) |
| 2. Ultra-strong materials: MAX phase composites, nanomaterials, gel-casting of titanium alloys | | X | X | MEng/PhD bursaries available - apply to WITS CoE in Strong Materials (competitive bursaries) |
| 3. Additive manufacturing: novel powder blends | | X | X | 1 x MEng bursary available<br><br>(in collaboration with Boeing & National Aerospace Centre at WITS) |

***Specific requirements*:**

<table>
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</table>

**<u>Division</u>:**
**Design & Mechatronics / <u>Mechanics</u> / Thermo Fluids / Renewable Energy**

**<u>Research fields</u>:**

Numerical optimization, Artificial Intelligence (AI), Numerical modelling, Computing on the CPU and GPU, topology optimization.

**<u>General description of research field</u>:**

We are interested in the development and application of algorithms for general problems that are problematic in classical optimization, due to, for example, multimodality, discontinuities, etc. In particular, we are interested in very large scale (VLS) optimal design. Typically, hundreds of thousands design variables and constraints may be present. In addition, we are interested in artificial intelligence (AI), using for example particle swarm optimization (PSO) algorithms, differential evolution (DE) and genetic algorithms (GAs), etc.

Typical areas of interest (applications) include structural and multidisciplinary optimization, aspects of renewable or sustainable energy, composite materials, optimal heliostat and wind farm lay-out, and many more. However, we are not only interested in applying the algorithms we use, but also in the fundamental math that is used to formulate these algorithms, with the aim of improving performance.

An overview of my research is available here.

| List of topics: | MEng *(Structured)* | MEng *(Research)* | PhD | Funding |
|---|---|---|---|---|
| 1. Mathematical modelling and optimization – various topics, ranging from mathematical algorithmic intricacies to practical, real-world applications. | | x | x | TBC |
| 2. Artificial Intelligence - again, various topics, ranging from mathematical algorithmic intricacies to practical, real-world applications. | | x | x | TBC |

***Specific requirements***: Knowledge of some computing language, and a sound mathematical background. However, not all topics require mathematicians, nor fear!

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| **Faculty:**<br>Engineering | **Department:**<br>Mechanical and Mechatronic Engineering |
|---|---|

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

**Research field:**
Computational Mechanics – Wide range of structural (finite element) analysis and optimization problems

**General description of research field:**

My research typically deals with complex finite element analysis combined with structural and multi-disciplinary optimization. These techniques are applied to a wide range of interesting problems, 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, inflatable structures and design of real world truck chassis.

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

| **List of topics:** | **MEng** ***(Structured)*** | **MEng** ***(Research)*** | **PhD** | **Funding** |
|---|---|---|---|---|
| 1. Developing an open source digital image correlation software system in Python. | | X | | Partial |
| 2. Inverse modelling, from experimental digital image correlation data, applied to material characterization of metal components produced with additive manufacturing processes (3D Printing). | | X | | Partial |
| 3. Various topics related to finite element analysis and design of a truck chassis. These projects are done in collaboration with an industry partner and is typically fully funded with a job opportunity after completion of the studies. | | X | | Full |

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

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

**Research fields**:
Generative Design, Machine Learning, Material Modeling, Soft Robots and Inflatables.

**General description of research field**:

Essentially 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 complient 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 disciplinnary field taking elements from a number of computational fields. Researchers in this area will develop skills in non-linear finite element methods, numerrical 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 valumes of data. This is a new field and is open to exploration which can be both challenging and rewarding.

| List of topics: | 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. Selectively reinforced silicon textile composites. | | 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.

# Thermo Fluids

# Division

<table>
<tr><td rowspan="3"><u>Lecturer</u>:<br>Dr Jaap Hoffmann</td><td>Email:</td><td colspan="3">hoffmaj@sun.ac.za</td></tr>
<tr><td>Tel:</td><td colspan="3">+27 21 808 3554</td></tr>
<tr><td>Office:</td><td colspan="3">M3030</td></tr>
<tr><td><u>Faculty</u>:<br>Engineering</td><td colspan="4"><u>Department</u>:<br>Mechanical and Mechatronic Engineering</td></tr>
<tr><td colspan="5"><u>Division</u>:<br>Design & Mechatronics / Mechanics / <u>Thermo Fluids</u> / Renewable Energy</td></tr>
<tr><td colspan="5"><u>Research field</u>:<br>Thermal Engineering (Fluid Mechanics, Heat Transfer and Thermodynamics)</td></tr>
<tr><td colspan="5"><u>General description of research field</u>:<br><br>Research is geared towards using solar energy and/or waste heat for power generation, building comfort and process heat applications. Storing energy in a packed heat for later use is prominent in quite a few projects.</td></tr>
<tr><td>List of topics:</td><td>MEng<br>(Structured)</td><td>MEng<br>(Research)</td><td>PhD</td><td>Funding</td></tr>
<tr><td>1. Flow and heat transfer in packed beds of rock.<br>The objective of this project is to express pressure drop and heat transfer in a packed bed as functions of (amongst others) particle Reynolds number, an equivalent particle diameter, a particle shape factor, particle/flow alignment, and packing structure.</td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td>2. Thermal-non equilibrium models for porous media.<br>The objective of this study is to develop a general (boundary or internal cell), robust, 3D, portable thermal non-equilibrium model for conduction, convection and radiation in a packed bed.</td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td>3. Heat transfer enhancement for receiver tubes.<br>The objective of this project is to identify heat transfer enhancement technologies for tubular receivers that yield a higher percentage increase in heat transfer than the percentage increase in pressure drop, and that are relatively insensitive to thermal stress or deformation. The design selection has to be supported by a practical and inexpensive manufacturing technique.</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td>4. Multi-objective optimization of concentrating solar power plant.<br>The goal of the project is to find a compromise between competing objectives of plant/components to the benefit of all. Suggested activities include, but are not limited to consolidation of all input data, determining the uncertainty and expected future trends in input data, developing high level thermodynamic and financial models of the plant, and selecting/developing a suitable optimization routine.</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td>5. Crushed rock particle shape characterization for pressure drop and heat transfer prediction.<br>Compare various shape descriptors (e.g. equivalent volume, sphericity, aspect ratio, angularity, roundness, etc.) for crushed rock particles, derived from tri-axial</td><td>X</td><td>X</td><td>X</td><td></td></tr>
</table>

| | | | | |
|---|---|---|---|---|
| (bounding box) measurements, 2D silhouette projections and 3D scanning. 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. It is possible that particles will fall in distinct classes: small particles that have approximately equal short, intermediate and long axes, comparable with sieve size, and large particles that will have approximately equal short and intermediate axes comparable with sieve size, but a significantly larger long axis. | | | | |
| 6. **Develop a permeable membrane for interfacial heating in a solar still.** Conventional solar stills require that the bulk water is heated to saturation temperature. This requires a significant amount of energy, and high loss to the environment. Using a permeable membrane coated with a selective absorber restricts heating to the interface only. Develop a model to simulate the heat and mass transfer processes through the membrane, and validate it experimentally. | | X | X | |
| **7. Evaluation of atmospheric vortex engine concept.** Investigation (Scale adaptive CFD modelling and experimental validation) of atmospheric vortex engine concept to convert waste heat (typically, from a cooling tower at thermal power station) to work. Suggest and refine modifications to cooling tower configuration. Cross-winds and temperature inversions are expected to impact negatively on system performance. | | X | | |
| **8. Hydrogen as potential energy storage.** Assess the viability of reversible electrolysers/hydrogen fuel cells as alternative storage of renewable energy for power generation. Rudimentary performance modelling of the electrolyser, its interaction with a renewable energy dominant electricity distribution grid, and an economic evaluation is envisaged. | 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. | | | | |

<table>
<tr><td rowspan="3"><u>Lecturer</u>:<br>Dr Mike Owen</td><td>Email:</td><td>mikeowen@sun.ac.za</td></tr>
<tr><td>Tel:</td><td>+27 21 808 4266</td></tr>
<tr><td>Office:</td><td>A609</td></tr>
<tr><td><u>Faculty</u>:<br>Engineering</td><td colspan="2"><u>Department</u>:<br>Mechanical and Mechatronic Engineering</td></tr>
</table>

**<u>Division</u>:**
**Design & Mechatronics / Mechanics / <u>Thermo Fluids</u> / Renewable Energy**

**<u>Research field</u>:**

Industrial heat exchangers, air-cooled condensers, cooling towers, renewable energy systems, sustainable energy use.

**<u>General description of research field</u>:**

Industrial cooling systems are an important component in thermal energy cycles. These systems influence the cycle efficiency and contribute significantly to the water consumption related to thermal energy production. Research aimed at developing and improving dry and/or hybrid cooling systems therefore contributes significantly to the drive towards greater sustainability in the energy sector in general and in the Solar Thermal Energy sector in particular.

Research on dry and hybrid cooling systems typically involves a combination of experimental investigation and numerical analysis.

| **List of topics:** | **MEng** ***(Structured)*** | **MEng** ***(Research)*** | **PhD** | **Funding** |
|---|---|---|---|---|
| 1. Investigation of dry-out phenomena in a delugeable bare tube hybrid (dry/wet) heat exchanger bundle | | x | | 1 x MEng (unconfirmed) |
| 2. Numerical analysis of perimeter windscreen effects for a small air-cooled steam condenser | | x | | |

***Specific requirements***:

| **Lecturer**:<br>Prof Johan van der Spuy | **Email:** | sjvdspuy@sun.ac.za |
|---|---|---|
| | **Tel:** | +27 21 808 4127 |
| | **Office:** | Somewhere |
| **Faculty*:***<br>Engineering | **Department*:***<br>Mechanical and Mechatronic Engineering | |

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

**Research field*:***

1) Axial flow fans for cooling systems
2) Micro gas turbines
3) 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 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 and 2) 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. Incorporate a heat source into the existing micro gas turbine compressor test facility. Upgrade the test facility to run the large compressor test bench.
   b. Incorporate an additional electrical heat source into the existing solar/hybrid gas turbine loop. The gas turbine loop is existing and the heat source, along with the combustor (existing) has to be built into the loop.
3) The use of supercritical $CO_2$ as working fluid for power generation cycles. Current investigations seems to indicate very specific compressor pressure ratio requirements for recuperated $sCO_2$ loops. This thesis will specifically investigate this requirement further.

| **List of topics:** | **MEng *(Structured)*** | **MEng *(Research)*** | **PhD** | **Funding** |
|---|---|---|---|---|
| 1. Design of an axial flow fan for a unique cooling application. | | X | X | project funding available |
| 2. The performance of the 24 ft. installed MinwaterCSP axial flow fan. | | X | X | Project funding available |
| 3. The development of a test facility for a micro gas turbine compressor stage – incorporating a heat source and large compressor test spec. | | X | | limited funding available |
| 4. The development of a micro gas turbine for solar-hybrid application – incorporating a "solar" heat source. | | X | | Limited funding available |
| 5. The specification of a compressor for a recuperated supercritical CO2 loop. | | X | X | Limited funding available |

**Spesifieke voorvereistes / *Specific requirements*:**
Thermofluids 344, Computational Fluid Dynamics.

| | | | | | |
|---|---|---|---|---|---|
| **Lecturer:**<br>Prof Theo von Backström | **Email:** | twvb@sun.ac.za | | | |
| | **Tel:** | +27 21 808 4267 | | | |
| | **Office:** | M3040 | | | |
| **Faculty:**<br>Engineering | **Department:**<br>Mechanical and Mechatronic Engineering | | | | |
| **Division:**<br>**Design & Mechatronics / Mechanics / Thermos Fluids / Renewable Energy** | | | | | |
| **Research field:**<br>Turbomachinery | | | | | |
| **General description of research field:**<br>Aerodynamics of industrial compressors, fans and diffusers. | | | | | |
| **List of topics:** | **MEng *(Structured)*** | **MEng *(Research)*** | **PhD** | **Funding** | |
| 1. Upgrade Rover gas turbine compressor; install new compressor rotor | | X | | NRF? | |
| 2. Develop slip factor correlation for centrifugal fans | | X | | NRF? | |
| 3. Use of twisted round to square transition sections as inlets and diffusers | | X | | NRF? | |
| 4. Effect of blade trimming on axial flow fan performance and noise | | X | | NRF? | |
| ***Specific requirements*:** | | | | | |

# Renewable Energy

| | | | | |
|---|---|---|---|---|
| **Lecturer:**<br>Dr Jaap Hoffmann | **Email:** | hoffmaj@sun.ac.za | | |
| | **Tel:** | +27 21 808 3554 | | |
| | **Office:** | M3030 | | |
| **Faculty:**<br>Engineering | **Department:**<br>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:**

Research is geared towards using solar energy and/or waste heat for power generation, building comfort and process heat applications. Storing energy in a packed heat for later use is prominent in quite a few projects.

| List of topics: | MEng *(Structured)* | MEng *(Research)* | PhD | Funding |
|---|---|---|---|---|
| 1. **Flow and heat transfer in packed beds of rock.**<br>The objective of this project is to express pressure drop and heat transfer in a packed bed as functions of (amongst others) particle Reynolds number, an equivalent particle diameter, a particle shape factor, particle/flow alignment, and packing structure. | | X | X | |
| 2. **Thermal-non equilibrium models for porous media.**<br>The objective of this study is to develop a general (boundary or internal cell), robust, 3D, portable thermal non-equilibrium model for conduction, convection and radiation in a packed bed. | | X | X | |
| 3. **Heat transfer enhancement for receiver tubes.**<br>The objective of this project is to identify heat transfer enhancement technologies for tubular receivers that yield a higher percentage increase in heat transfer than the percentage increase in pressure drop, and that are relatively insensitive to thermal stress or deformation. The design selection has to be supported by a practical and inexpensive manufacturing technique. | X | X | | |
| 4. **Multi-objective optimization of concentrating solar power plant.**<br>The goal of the project is to find a compromise between competing objectives of plant/components to the benefit of all. Suggested activities include, but are not limited to consolidation of all input data, determining the uncertainty and expected future trends in input data, developing high level thermodynamic and financial models of the plant, and selecting/developing a suitable optimization routine. | X | X | | |
| 5. **Crushed rock particle shape characterization for pressure drop and heat transfer prediction.**<br>Compare various shape descriptors (e.g. equivalent volume, sphericity, aspect ratio, angularity, roundness, etc.) for crushed rock particles, derived from tri-axial | X | X | X | |

| | | | | |
|---|---|---|---|---|
| (bounding box) measurements, 2D silhouette projections and 3D scanning. 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. It is possible that particles will fall in distinct classes: small particles that have approximately equal short, intermediate and long axes, comparable with sieve size, and large particles that will have approximately equal short and intermediate axes comparable with sieve size, but a significantly larger long axis. | | | | |
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| **7. Evaluation of atmospheric vortex engine concept.** Investigation (Scale adaptive CFD modelling and experimental validation) of atmospheric vortex engine concept to convert waste heat (typically, from a cooling tower at thermal power station) to work. Suggest and refine modifications to cooling tower configuration. Cross-winds and temperature inversions are expected to impact negatively on system performance. | | X | | |
| **8. Hydrogen as potential energy storage.** Assess the viability of reversible electrolysers/hydrogen fuel cells as alternative storage of renewable energy for power generation. Rudimentary performance modelling of the electrolyser, its interaction with a renewable energy dominant electricity distribution grid, and an economic evaluation is envisaged. | 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:**<br>Prof Craig McGregor | **Email:** | craigm@sun.ac.za |
|---|---|---|
| | **Tel:** | +27 21 808 4074 |
| | **Office:** | M3034 |
| **Faculty:**<br>Engineering | **Department:**<br>Mechanical and Mechatronic Engineering | |

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

**Research field:**

Concentrating solar power; system modelling and optimisation; thermal energy storage; high temperature process heat.

**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. Design and experimental performance of an enclosed heliostat concentrator to enable wind-free and dust-free operation | | X | X | |
| 2. Assessment of hybrid air/water cooling for the s-$CO_2$ cycle in concentrating solar applications | | X | X | |
| 3. Modelling of CSP plants for peaking power application on the South African grid | | X | | |
| 4. Design and performance of an engineered material for thermal energy storage (TES) in hot oil or molten salt CSP plants | | X | X | |
| 5. Design of the thermal transport and heat transfer equipment for particle-based receivers in a CST plant. | | X | | |
| 6. Design and manufacture of an automated flux map sensor for the Helio100 receiver. | | X | X | |
| 7. Techno-economic assessment and optimisation of a hybrid CSP/PV power plant | | X | | |
| 8. Techno-economic assessment and optimisation of a Carnot battery (thermal energy storage) in both a CSP plant and as a retrofit to existing coal-fired power station | | X | X | |

***Specific requirements*:**

| | | |
|---|---|---|
| **Lecturer:**<br>Dr Mike Owen | **Email:** | mikeowen@sun.ac.za |
| | **Tel:** | +27 21 808 4266 |
| | **Office:** | A609 |
| **Faculty:**<br>Engineering | **Department:**<br>Mechanical and Mechatronic Engineering | |

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

**Research field:**

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| 2. Numerical analysis of perimeter windscreen effects for a small air-cooled steam condenser | | x | | |

***Specific requirements***:

| **Lecturer**:<br>Prof Johan van der Spuy | **Email:** | sjvdspuy@sun.ac.za |
|---|---|---|
| | **Tel:** | +27 21 808 4127 |
| | **Office:** | Somewhere |
| **Faculty***:*<br>Engineering | **Department***:*<br>Mechanical and Mechatronic Engineering | |



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

**Research field***:*

1) Axial flow fans for cooling systems
2) Micro gas turbines
3) 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 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 and 2) focus on the design, testing and analysis of axial flow fans for these systems.
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| 2. The performance of the 24 ft. installed MinwaterCSP axial flow fan. | | X | X | Project funding available |
| 3. The development of a test facility for a micro gas turbine compressor stage – incorporating a heat source and large compressor test spec. | | X | | limited funding available |
| 4. The development of a micro gas turbine for solar-hybrid application – incorporating a “solar” heat source. | | X | | Limited funding available |
| 5. The specification of a compressor for a recuperated supercritical CO2 loop. | | X | X | Limited funding available |

**Spesifieke voorvereistes / *Specific requirements*:**
Thermofluids 344, Computational Fluid Dynamics.

<table>
<tr><td rowspan="3"><u>Lecturer</u>:<br>Prof Theo von Backström</td><td>Email:</td><td>twvb@sun.ac.za</td></tr>
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</table>

| | | | | |
|---|---|---|---|---|
| **Division:**<br>**Design & Mechatronics / Mechanics / Thermo Fluids / Renewable Energy** | | | | |
| **Research field:**<br>Rock bed thermal energy storage. | | | | |
| **General description of research field:**<br>Modelling and experimental investigation of rock bed thermal energy storage systems, solar receivers and concentrating solar energy (CSP) power plant performance. | | | | |
| **List of topics:** | **MEng** ***(Structured)*** | **MEng** ***(Research)*** | **PhD** | **Funding** |
| 1. Further development of SCRAP receiver, either internal or external | | X | X | NRF? |
| 2. Further development of Tadpole solar receiver | | X | X | NRF? |
| 3. Investigation of the effects of ratcheting on rock bed container design | | X | X | NRF? |
| 4. Further development of existing experimental rock bed at Mariendahl farm | | X | X | NRF? |
| ***Specific requirements*:** | | | | |