Project(E) 448 --- List of topics for second semester Skripsie assignment --- March 2020

Mr A Barnard (BarnardA1)	Electronics; Computer systems; Engineering and applied mathematics	Sensors/analogue electronics; Digital/integrated circuits; Space systems	Circuit design and layout; Measurements; System design/simulation	**Ionizing Radiation Monitor for High Altitude Balloon**	A device to monitor ionizing radiation must be developed. The device must be small enough to fly as a payload on a high altitude balloon. Dose measurements must be collected and stored on board and/or transmitted to ground.
Mr A Barnard (BarnardA2)	Computer systems; Electronics; Telecommunication	Sensors/analogue electronics; Wireless networks; Machine learning and pattern recognition	System design/simulation; Algorithm design; Software development	**Passive home air temperature management using smart sensors and controllers**	A system and strategy must be developed to optimize air temperature in a residential home setting using a passive approach (i.e. no powered air cooling/heating). The system must use wireless connected smart sensors and actuators to apply the temperature management strategies.
Mr A Barnard (BarnardA3)	Electronics; Computer systems; Control systems	Digital/integrated circuits; Sensors/analogue electronics; Industrial/feedback control systems	Circuit design and layout; Circuit/electromagnetic/multi-physics simulation; Measurements	**New generation LabAda tutor for Control Systems practicals**	The current LabAda tutors are ageing and becoming difficult to maintain. A new generation device is required to replace the current tutors while adding functionality to broaden the application scope of the device as a Control System tutor for practicals.
Mr A Barnard (BarnardA4)	Computer science; Computer systems; Electronics	Digital/integrated circuits; Numerical and computational methods; Machine learning and pattern recognition	Software development; System design/simulation; Algorithm design	**Automated ARM code evaluation using ARM emulator for Computer Systems practical assessments**	An automated system must be developed using an ARM emulator to evaluate and assess code submissions from Computer System and EDesign practical assessments. The system must evaluate, compile and execute code in an emulated embedded hardware environment on a PC.
Mr JC Bekker (BekkerJC1)	Energy systems; Electronics; Engineering and applied mathematics	High power systems/electronics; Sensors/analogue electronics	Circuit design and layout; System design/simulation; Physical design (materials, dimensions, etc.)	**Design and build a trigger circuit for triggering the High Voltage Lab's impulse generator**	Impulse generators are used in industry to test electrical equipment, i.e. transformers, surge protective devices, etc. The impulse generator in our High Voltage lab cannot be manually trigger, it only relies on break through of the airgaps. For this project you are tasked with designing, simulating, building and testing an electronic circuit with the ability to trigger the impulse generator. Part of the design will have to be installed onto the impulse generator which will result in physical space limitations and exposure to high voltages.
Mr JC Bekker (BekkerJC2)	Energy systems; Electronics; Electromagnetics	High power systems/electronics; Sensors/analogue electronics	Physical design (materials, dimensions, etc.); System design/simulation; Measurements	**High voltage divider**	To measure High Voltage AC, DC and Impulse signals the voltage level need to be reduced to a level that is measurable using standard measurement equipment. For this project you are tasked with researching, designing, simulating, building and testing a voltage divider to be used for measuring High Voltage (up to 1 MV) AC, DC and Impulse signals.
Mr JC Bekker (BekkerJC3)	Energy systems; Electronics; Electromagnetics	High power systems/electronics; Sensors/analogue electronics	Physical design (materials, dimensions, etc.); System design/simulation; Measurements	**High current transducer**	To measure AC. DC and impulse currents with high current levels, in a high voltage environment, the signal's level need to be reduced to a level that is measurable using standard measurement equipment. For this project you are tasked with researching, designing, simulating, building and testing a transducer to be used for measuring currents (>1 kA to 1 MV) for AC, DC and Impulse signals.

Mr JC Bekker (BekkerJC4)	Energy systems; Control systems; Electronics	High power systems/electronics; Digital/integrated circuits; Renewable energy	Circuit design and layout; Physical design (materials, dimensions, etc.); System design/simulation	**Early warning tampering system for overhead rail lines**	Railway overhead wires (catenary and contact wires) are prone for vandalism and theft. Not only is it a financial burden but also disruptive to service delivery. If the vandalism/theft is not detected early enough, it can cause consequential damage as a result of pantograph hook-ups. This project aims to develop a system to monitor the cable and to signal any deviances. As an example, the attached document describes a mechanical system to monitor mechanical tension in the cable, but it could be extended to include more sophisticated systems to monitor cables.
Dr HJ Beukes (BeukesHJ1)	Electronics; Control systems; Energy systems	High power systems/electronics; Industrial/feedback control systems; Sensors/analogue electronics	Circuit design and layout; Software development; Experimental and empirical evaluation	**Development of a back-to-back inverter for voltage regulation**	Poor voltage regulation on ac networks is often limiting the length of feeders, especially in rural areas. This prevents cost effective electrification in sparsely populated areas. In the past electronic voltage regulators were employed in the form of electronic tap changing transformers using thyristor technology. Recent development in silicon carbide MOSFETs allow higher voltage capability, lower losses and higher temperature in inverter technology. These features will benefit the development of an inverter based voltage regulator. A back-to-back inverter needs to be constructed, controlled, tested and evaluated.
Dr HJ Beukes (BeukesHJ2)	Electronics; Control systems; Energy systems	High power systems/electronics; Renewable energy; Sensors/analogue electronics	Circuit design and layout; Software development; Experimental and empirical evaluation	**Space vector control of a single phase PV inverter**	Inverters form the heart of any grid connected renewable power generator. To understand and study the characteristics of these inverters it is required to develop a small demonstration model. This hardware will mainly be used for training purposes. The power electronic circuit with a single-phase space vector current controller circuit will be designed, built and tested. A current measurement circuit needs to be designed that will feed a DSP development board. The current control algorithm will be implemented in C programming language. System performance focussing on output waveform quality and dynamic response will be tested on an existing inverter.
Dr HJ Beukes (BeukesHJ3)	Electronics; Control systems; Energy systems	High power systems/electronics; Renewable energy; Sensors/analogue electronics	Circuit design and layout; Software development; Experimental and empirical evaluation	**Development of a buck converter using silicon carbide MOSFETS**	In the current state of the power system in South Africa, there is a growing need for energy storage systems that can be used with renewable power generation. A dc-dc converter forms the core of such a system and is often not reliable. Development in this area is therefore required to improve on efficiency, reliability and cost. A buck converter needs to be designed built and tested that will convert voltage between 60 and 300 V to a nominal voltage of 48 V to charge lead acid batteries from a PV array. The benefits of using silicon carbide MOSFETs will be explored. The power rating will be 5 kW and the device will be controlled by a DSP.
Prof MM Botha (BothaMM1)	Engineering and applied mathematics; Electromagnetics; High frequency technique	Antennas, guided waves and scattering; Numerical and computational methods	Algorithm design; Software development; Circuit/electromagnetic/multi-physics simulation	**Physical optics code for analysis of reflector antennas applicable to the SKA**	The physical optics (PO) approximation provides for an approximate solution of induced surface currents, when a conducting object is illuminated by an incident electromagnetic field. It works best for structures that are smooth and large in terms of wavelengths. The objective is to firstly design and implement a PO analysis code. Secondly, one or both of two extensions should be considered: support for multi-reflector antennas and edge current corrections. The resultant code will be able to calculate radiation patterns of electrically-large reflector antennas.

Prof MM Botha (BothaMM2)	Engineering and applied mathematics; Electromagnetics; Systems and signals	Numerical and computational methods; Antennas, guided waves and scattering; Signal/image processing	Algorithm design; Software development; Circuit/electromagnetic/multi-physics simulation	**Fast radiated field calculation for known current distributions**	The basis of this work is an electromagnetic integral equation solver library being developed at SU, for applications in antenna and scattering analysis. The library is based on the method of moments, for solving induced currents on conducting objects. Once the surface current density is known, the superposition integral must be evaluated for calculation of the radiated field at specified observation points. The goal of the work is to develop an efficient field evaluation capability, based on low-rank compression methods, such that the observed field points are calculated much faster than with conventional integration in the superposition integral. Far field points will be the first goal, with evaluation of near field points also considered, time permitting.
Prof MM Botha (BothaMM3)	Electromagnetics; Engineering and applied mathematics; Systems and signals	Antennas, guided waves and scattering; Numerical and computational methods; Signal/image processing	Algorithm design; Software development; Circuit/electromagnetic/multi-physics simulation	**Macro basis functions for analysis of antenna arrays with connected elements**	Modelling the radiation properties of large antenna arrays is a challenging task and of particular current interest, in the context of the SKA radio telescope system. This work will connect with ongoing research into more efficient ways of modelling such antennas. The basis of the work is an integral equation solver library. Through solving sub-problems (to obtain macro basis functions (MBFs)), a solution for the whole array must be obtained, with reduced computational cost relative to the conventional approach. The particular focus is on arrays with electrically connected elements. This is a fairly open-ended task requiring creative, novel solutions. A working, efficient solver is the end goal.
Prof JB De Swardt (DeSwardtJB1)	Control systems; Electronics; Energy systems	Sensors/analogue electronics; Industrial/feedback control systems	Circuit design and layout; Measurements; System design/simulation	**Peltier cooling for biosensors**	Biosensors are used to detect and diagnose diseases. These sensors are temperature dependent and are typically calibrated and used at room temperature. Mobile clinics can have high temperature variations and therefore influences the accuracy of the biosensors. In this project a Peltier cooler/heater system must be developed to keep the biosensors at a constant pre-set temperature. A control system must be used to accurately control the Peltier temperature. The complete system must be designed, build and tested.
Prof JB De Swardt (DeSwardtJB2)	Control systems; Electronics; Energy systems	Sensors/analogue electronics; Industrial/feedback control systems	Circuit design and layout; Measurements; System design/simulation	**Laser power control for biosensor measurements**	Biosensors are used to detect and diagnose diseases. Surface plasmon resonance is a technique to detection certain bacteria. This technique uses a laser, but it is important to ensure a constant output power to obtain accurate results. In this project a system must be developed to measure laser output power and then to control it for a pre-set value. The complete system must be designed, build and tested.
Prof JB De Swardt (DeSwardtJB3)	Electronics; High frequency technique; Systems and signals	High frequency components/systems; Sensors/analogue electronics	Circuit design and layout; Measurements; System design/simulation	**Network analyzer for biosensor measurements**	Biosensors are used to detect and diagnose diseases. One of the detection techniques is to use an interdigital electrode and to measure the impedance change at high frequencies when there are antigen-antibody interactions. The frequency is normally below 1 GHz and can typically be measured with a network analyzer. In this project a single frequency network analyzer must be developed to be used at a "point-of-care". The complete system must be designed, build and tested.

Prof JB De Swardt (DeSwardtJB4)	Electronics; Systems and signals; Engineering and applied mathematics	Sensors/analogue electronics; Numerical and computational methods	Circuit design and layout; Measurements; System design/simulation	**Noise meter for biosensor applications**	Biosensors are used to detect and diagnose diseases. One of the detection techniques is to use an interdigital electrode and to measure a small current change when there are antigen-antibody interactions. These changes can be very small and currents of pA and voltages of uV are typically measured. Any noise from the voltage regulators, power supply and components can then limit the accuracy of the measurement system. In this project a noise meter must be developed to measure very low noise levels. This will then be used to determine the measurement accuracy of a biosensor. The complete system must be designed, build and tested.
Prof DIL De Villiers (DeVilliersDIL1)	High frequency technique; Electronics; Systems and signals	High frequency components/systems; Sensors/analogue electronics; Signal/image processing	Circuit design and layout; System design/simulation; Measurements	**GPS receiver based radiometer design**	GPS receiver chips are very cheap RF receivers with remarkable capability. This project will re-purpose such a receiver chip to be used as a simple total power radiometer. In the simplest version, the system will just output voltage as a function of input power, but more complex systems can easily be developed here with additional functionality (including calibration which should improve the resolution dramatically). The project will benefit from some knowledge of high frequency systems, and will also involve some microcontroller (and possibly FPGA) programming.
Prof DIL De Villiers (DeVilliersDIL2)	High frequency technique; Systems and signals; Telecommunication	Antennas, guided waves and scattering; Signal/image processing; High frequency components/systems	Circuit/electromagnetic/multi-physics simulation; Experimental and empirical evaluation; System design/simulation	**Interferometry demonstrator**	Many modern radio telescopes, like the SKA, work on the principle of radio interferometry. An interferometer combines the signals from plenty of antennas together to make an image of the radio sources in the sky. This project will explore an interferometric antenna array by designing a simple interferometer system demonstrator. The demonstrator should be used to show the basic working of such a system to someone with no engineering background.
Prof JA Du Preez (DuPreezJA2)	Engineering and applied mathematics; Systems and signals	Probabilistic systems and inference; Machine learning and pattern recognition	Algorithm design; Software development; System design/simulation	**Adding automatic phrase recognition to a toy that bonds with its user.**	The university owns a patent on a toy that automatically “bonds” with a user that regularly interacts with it. We now want to add some speech recognition capabilities layered on top of the signal processing supporting the “bonding” capability. In particular, the user must be enabled to interactively teach the toy a couple of phrases for it to recognise. Coding will be in a Linux c++ environment. The lucky candidate will get exposure to signal processing and machine learning techniques.
Prof JA Du Preez (DuPreezJA3)	Engineering and applied mathematics; Systems and signals	Probabilistic systems and inference; Machine learning and pattern recognition	Algorithm design; Software development; System design/simulation	**Using LDA techniques to match student interests to project descriptions**	Latent Dirichlet Allocation is a powerful technique for analyzing the content of text documents. In this project we will apply it to automatically categorize a number of project descriptions (such as these here), and then match these to the expressed interests of people. You will need a strong mathematical/probabilistic leaning. Coding will be in a Linux c++ environment.
Prof JA Du Preez (DuPreezJA4)	Engineering and applied mathematics; Systems and signals	Probabilistic systems and inference; Machine learning and pattern recognition	Algorithm design; Software development; System design/simulation	**Semi-supervised training using probabilistic graphical models**	Semi-supervised training is concerned with the situation where only a small part of our training database has class labels, but there are plenty other data without labels. In this project the whole training scenario will be presented as a PGM with the class labels as latent variables. These latent variables will then occasionally by known (observed), but mostly remain unknown. Application will be to an image recognition problem. You will need a strong mathematical/probabilistic background as well as strong programming skills in both c++ and python. OS is Linux.

Prof JA Du Preez (DuPreezJA5)	Engineering and applied mathematics; Telecommunication	Wireless networks; Communication systems	System design/simulation; Experimental and empirical evaluation; Circuit design and layout	**Power efficient offline camera surveillance system**	A full hardware and software system design/implementation that can collect (also night-time) images from a number of security cameras and save them on a central repository linked via some wifi-protocol. No mobile phone networks will be available - the system should be designed to function totally standalone with relatively low power consumption. Machine learning code that suppresses uninteresting background movement such as vegetation moving in the wind, will greatly enhance functionality.
Dr JAA Engelbrecht (EngelbrechtJAA1)	Control systems; Engineering and applied mathematics; Computer science	Robotics and autonomous vehicles; Numerical and computational methods; Machine learning and pattern recognition	Algorithm design; System design/simulation; Software development	**Cooperative Collision Avoidance for Autonomous Vehicles using Horizontal Maneuvres**	A cooperative collision prediction and avoidance system for multiple autonomous vehicles must be designed and verified in simulation. The collision avoidance must be performed using horizontal manoeuvres only. The vehicles are assumed to have a minimum forward speed, and a maximum turn rate. It is assumed that all vehicles broadcast their current position, velocity and intent to one another. The vehicles must predict imminent collisions and then cooperatively re-plan their paths to avoid the collisions, while minimising both their control effort and their deviation from their original paths, and while obeying their own vehicle motion constraints.
Dr JAA Engelbrecht (EngelbrechtJAA2)	Control systems; Engineering and applied mathematics; Computer science	Robotics and autonomous vehicles; Numerical and computational methods; Machine learning and pattern recognition	Algorithm design; System design/simulation; Software development	**Guidance and Control for Intercepting a Moving Target using an Autonomous Vehicle**	A guidance and control system must be designed for an autonomous interceptor vehicle to intercept another moving target vehicle. The interceptor vehicle must use proportional navigation (which is a technique used to guide air-to-air missiles to intercept fighter aircraft) to intercept the target vehicle. The project activities include modelling the equations of motion for the interceptor and target vehicles, designing the guidance and control system, implementing and verifying the system in simulation, and if possible, implementing and verifying the system using actual autonomous vehicles.
Dr JAA Engelbrecht (EngelbrechtJAA3)	Control systems; Engineering and applied mathematics; Computer science	Robotics and autonomous vehicles; Numerical and computational methods; Machine learning and pattern recognition	Algorithm design; System design/simulation; Software development	**Feedback Control of a Hexapod Robot**	A motion planning and feedback control system must be designed and implemented for a hexapod robot. The motion planning algorithm must use the leg kinematics to plan the trajectories of the hexapod legs to enable the robot to move at a given forward speed in a given direction. A feedback control system must be implemented to control the hexapod speed and heading while compensating for external disturbances and parameter uncertainty. The motion planning and feedback control system must be implemented and verified in simulation, and if possible using a practical off-the-shelf hexapod robot.
Dr JAA Engelbrecht (EngelbrechtJAA4)	Control systems; Engineering and applied mathematics; Computer science	Robotics and autonomous vehicles; Numerical and computational methods; Machine learning and pattern recognition	Algorithm design; System design/simulation; Software development	**Flight Control and Guidance for a Glider UAV**	A flight control and guidance system for a glider UAV must be designed and verified in simulation. The glider UAV will be released from a high altitude weather balloon and must return to a home location. The project activities include modelling the equations of motion for the glider UAV, designing the control system (airspeed controller, heading controller, climb rate controller), designing the guidance system, and implementing and verifying the system in simulation. Since the air pressure changes significantly from high altitude to sea level, a gain-scheduling strategy must be implemented to adapt the controller gains throughout the flight.

Mr C Fisher (FisherC1)	Control systems; Engineering and applied mathematics	Robotics and autonomous vehicles; Numerical and computational methods	Circuit/electromagnetic/multi-physics simulation; Algorithm design	**Simulation of a monopod robot hopping up stairs.**	Using the available mathematical model of a monopod robot, use trajectory optimization methods to generate trajectories of the robot hopping up stairs. Analyse these trajectory and design simple high gain feedback controllers for a physics engine simulation of the robot and see if it can track the desired trajectory.
Mr C Fisher (FisherC2)	Control systems; Engineering and applied mathematics	Robotics and autonomous vehicles; Numerical and computational methods	Circuit/electromagnetic/multi-physics simulation; Algorithm design	**Using trajectory optimization to study disturbance rejection in legged robots**	Mathematically model a standing bipedal robot. Using trajectory optimization methods, analyse the different motions used to reject disturbances. Multiple types of disturbances can be applied (force or torque disturbances). Determine when the robot needs to step backwards/forwards to reject the applied disturbance.
Mr C Fisher (FisherC3)	Control systems; Electronics	Robotics and autonomous vehicles; Industrial/feedback control systems	Experimental and empirical evaluation; Physical design (materials, dimensions, etc.)	**Develop a constant high hopping controller for a monopod robot**	Using the available pneumatic hopping robot and vertical rig, design a constant hopping height controller. What happens when the ground type changes? (hop on sand or gravel etc). This will require using the simplified pneumatics model and developing a simulation of the system to design and test the controller before validating it on the physical system.
Mr C Fisher (FisherC4)	Electronics; Computer systems	Machine learning and pattern recognition; Sensors/analogue electronics	Algorithm design; Circuit design and layout; Measurements	**Development of a 2 axis force sensor for a robot foot**	Using strain gauges in a set configuration, a sensor must be developed that can estimate the ground reaction force (GRF) in the horizontal and vertical plane. This will involve developing the sensor software (reading the ADC values from the strain gauges, logging the data etc) and developing the hardware. Using simple neural networks, can the GRF be estimated. Additional features such as an interrupt pin must be driven high when the force sensor hits the ground.
Prof CJ Fourie (FourieCJ1)	Computer systems; Computer science; Electronics	Digital/integrated circuits; Sensors/analogue electronics; Machine learning and pattern recognition	Circuit design and layout; System design/simulation; Circuit/electromagnetic/multi-physics simulation	**Artificial Neural Network with superconductor circuits.**	Artificial neural networks are computing systems that mimic biological neural networks in a simplistic manner. Develop a way to use superconducting pulse-based RSFQ or current-based AQFP logic to create neurons and weighted interconnects (axon-synapse-dendrite) for a superconductor ANN, and provide a method to adjust weights for supervised learning.
Prof CJ Fourie (FourieCJ2)	Computer science; Computer systems; Systems and signals	Digital/integrated circuits; Numerical and computational methods; Machine learning and pattern recognition	Software development; Circuit/electromagnetic/multi-physics simulation; Algorithm design	**Automated digital test pattern generator**	Design an automated test pattern generator for quantum electronic digital circuits. The pattern generator must assemble simulation test benches when new RSFQ or AQFP superconducting logic gates or larger, synthesized and clocked circuits are specified as "device under test". Given a behavioural description of the circuit functionality, the generator should select input data patterns and infer correct output patterns, simulate the circuits with a superconductor circuit-capable SPICE (JoSIM) and test the simulated outputs against expected results.
Prof CJ Fourie (FourieCJ3)	Electronics; Electromagnetics; High frequency technique	Electromagnetic compatibility/interference; High frequency components/systems; Digital/integrated circuits	Circuit design and layout; Circuit/electromagnetic/multi-physics simulation; Experimental and empirical evaluation	**Adiabatic Quantum Flux Parametron logic circuits**	Adiabatic Quantum Flux Parametron (AQFP) superconducting logic circuits are extremely energy efficient, requiring 100000 less energy per bit switch than conventional semiconductor logic. However, such logic circuits suffer from degraded performance when magnetic flux quanta are frozen into a superconducting chip during cooldown below the superconducting transition temperature. Design AQFP integrated circuit layouts and use the InductEx software package to analyse the effects of trapped flux on the circuits. Develop compact simulation models with which to optimize layouts to minimize the coupling of trapped flux to circuit elements.

Prof CJ Fourie (FourieCJ4)	Computer science; Engineering and applied mathematics; Electromagnetics	Numerical and computational methods; Electromagnetic compatibility/interference; High frequency components/systems	Software development; Algorithm design; Experimental and empirical evaluation	**Parameterized 3D model of cryocooled quantum electronic circuit and environment for EM analysis**	Develop a parameterized 3D model for the cryogenic stage of a cryocooler that contains the thermal and magnetic shields, wires, vacuum sleeve chip carrier and wirebonds to a quantum electronic integrated circuit, and integrate this model with the electromagnetic solvers of InductEx. Use the model to determine the magnetic field at the surface of a cryogenic quantum electronic circuit, and develop optimum shielding strategies to minimize both the magnetic field and the field gradient over the chip surface.
Dr J Gilmore (GilmoreJ1)	High frequency technique; Electromagnetics; Engineering and applied mathematics	Antennas, guided waves and scattering; High frequency components/systems; Numerical and computational methods	Circuit/electromagnetic/multi-physics simulation; Experimental and empirical evaluation; System design/simulation	**Design of an optimally sized Dense Dipole Array prototype for Mid-Frequency Aperture Arrays (SKA Project)**	The international radio-astronomy community is currently designing the next generation of radio telescopes, which are generally being referred to as aperture arrays. These arrays consist of thousands of phase-steered elements used to directly sample the incoming wave front. A number of broadband designs are being evaluated for their use as aperture arrays for phase 2 of the SKA, including the Dense Dipole Array (DDA), which is being developed at the department. Due to the size of the final product, it is not possible to build a full-size prototype during the development phase. This project will focus on determining the minimum size of a Dense Dipole Array that can be built in order to still obtain representative measurement results. (EM344 Required)
Dr J Gilmore (GilmoreJ2)	Electronics; Computer systems; Systems and signals	Sensors/analogue electronics; Signal/image processing; Digital/integrated circuits	System design/simulation; Circuit design and layout; Experimental and empirical evaluation	**Portable Spirometer**	Spirometry is a set of tests used to determine certain aspects of lung functionality that can be used to diagnose and monitor lung conditions such as asthma, COPD, etc. Currently spirometry requires the use of expensive and cumbersome equipment that make it difficult for patients in rural areas to receive the necessary care. This project aims to develop a cost-effective hand-held spirometer that can used along with a laptop in order to make the equipment highly portable. The scope of the project includes designing and building a flow meter as well as the physical interface with the computer and developing the software required in order to do some basic measurements.
Mr LL Grootboom (GrootboomLL1)	Electromagnetics; High frequency technique; Systems and signals	Electromagnetic compatibility/interference; Antennas, guided waves and scattering; Signal/image processing	Circuit/electromagnetic/multi-physics simulation; System design/simulation; Software development	**Suppression of grating lobes**	Grating lobes are an effect of system parameters when electronic beamsteering is implemented using an antenna array. This project will look at the system parameters which cause/affect grating lobes, and what design techniques can be used to reduce these grating lobes. The manipulation of the beamwidth and sidelobe levels of the main lobe will also be investigated.
Mr LL Grootboom (GrootboomLL2)	Electromagnetics; Systems and signals; High frequency technique	Electromagnetic compatibility/interference; Signal/image processing; Antennas, guided waves and scattering	Experimental and empirical evaluation; Measurements; Algorithm design	**Target range measurement system using a Vector Network Analyzer**	This project will make use of a Vector Network Analyser - an instrument used to measure the network parameters (both magnitude and phase) of electrical networks in the frequency domain - to measure a scene containing targets, and plot the downrange location of these targets within the scene.
Dr N Gule (GuleN1)	Control systems; Computer science; Computer systems	Sensors/analogue electronics; Signal/image processing; Digital/integrated circuits	Circuit design and layout; System design/simulation; Software development	**Development of a Pool Monitoring System**	In this project, a pool water quality monitoring system will be developed. The system is supposed to record measurements of the following pool water parameters; temperature, pH, level of disinfectant (ORP), level of salts in the water (conductivity) and water level. In addition, the system should record the pressure of the water pump.

Dr N Gule (GuleN2)	Energy systems; Engineering and applied mathematics; Electromagnetics	Electrical machines; Numerical and computational methods; Renewable energy	System design/simulation; Circuit/electromagnetic/multi-physics simulation; Algorithm design	**Estimation of Circuit-model Parameters for Induction Motors**	Generally, induction motor parameters vary because of winding temperature rise, skin effect, and flux saturation. These induction motor parameters are essential for high-performance control. Inaccurate motor parameters lead to motor reduced performance of the induction motor. In this project, the estimation of electrical parameters of a cage rotor induction machine is studied. The steady-state parameters can be estimated using finite element analysis (FEA). A small-signal model is for will also be developed.
Dr N Gule (GuleN3)	Control systems; Electronics; Engineering and applied mathematics	High power systems/electronics; Industrial/feedback control systems; Electrical machines	Circuit design and layout; System design/simulation; Algorithm design	**Development of a Single Phase Induction Motor Controller for PV Powered Pumping Systems**	In this project, a converter and a controller for a PV powered single phase induction motor will be developed. The motor will be matched with the PV array size such that it can operate under varying irradiation and temperature conditions. The entire system will be evaluated through simulations.
Dr N Gule (GuleN4)	Energy systems; Engineering and applied mathematics; Electromagnetics	Electrical machines; Numerical and computational methods; Renewable energy	Circuit/electromagnetic/multi-physics simulation; System design/simulation; Software development	**Thermal Modelling of a Rotor-Tied Doubly Fed Induction Generator**	In the rotor-tied configuration of the doubly fed induction generator, the high power 50Hz winding is located in the rotor whilst the low frequency winding is located on the stator. The advantages of this configuration include higher efficiency and the possibility of developing reasonably sized rotational transformers that can be utilised in place of slip rings. Having the power winding on the rotor introduces cooling challenges. In this project, a thermal model that can be used to estimate the temperature distribution in the machine will be developed and verified.
Dr HW Jordaan (JordaanHW3)	Control systems; Engineering and applied mathematics; Systems and signals	Robotics and autonomous vehicles; Signal/image processing; Industrial/feedback control systems	Algorithm design; System design/simulation; Experimental and empirical evaluation	**Vision-based control for drone racing**	Drone racing entails the a number of waypoints which need to covered in order and in the shortest amount of time. This project will make use of a small multirotor vehicle with a forward-facing camera which identifies these waypoints and autonomously move through them. After a circuit can be completed successfully the autonomous system must be optimised to obtain the shortest time given the hardware constraints.
Dr HW Jordaan (JordaanHW4)	Systems and signals; Control systems; Engineering and applied mathematics	Robotics and autonomous vehicles; Sensors/analogue electronics; Space systems	Algorithm design; Circuit design and layout; Experimental and empirical evaluation	**Kinematic estimator for a nanosatellite based on coarse sun sensors**	Coarse sun sensors are very basic sensors used within satellite to obtain knowledge of its attitude relative to the sun. This project aims to develop an advanced coarse sensor system which can generate robust sun sensor vector which can be used to obtain knowledge of the spacecraft's angular rates. The sensor must be developed along with the necessary algorithm to fuse all the required measurements to obtain the required angular rate information. This system has the possibility to be demonstrated on a high-altitude balloon.
Dr H Kamper (KamperH1)	Computer science; Engineering and applied mathematics	Machine learning and pattern recognition; Numerical and computational methods; Probabilistic systems and inference	Algorithm design; Software development; Experimental and empirical evaluation	**Machine learning for improving reading literacy**	In this project, an automatic reading tutor will be developed. The goal is to use machine learning in order to identify the types of sentences that a first-time reader consistently struggles with. As a first prototype, a reader will read a set of sentences which a human tutor will then mark as correct/incorrect. From this set, an algorithm needs to identify the properties of the sentences with which the user struggles most. This feedback can then be given to the human tutor. If time permits, the application could then be tailored to help the user with their specific issues.

Dr H Kamper (KamperH2)	Computer science; Systems and signals; Engineering and applied mathematics	Machine learning and pattern recognition; Signal/image processing; Numerical and computational methods	Algorithm design; Software development; System design/simulation	**Teaching a robot about new concepts visually and with speech**	Consider a robot that is deployed in a new house where it does not know about the types of objects it will be asked to interact with, or what these objects are called in the language of its owners. This project will involve setting up an environment where a user can show an agent a new object and then speak the object's name in their language. The task of the agent is then to learn how to later pick out this object when asked to. The project will involve collecting a small dataset for testing and implementing the matching algorithm.
Dr H Kamper (KamperH3)	Computer science; Systems and signals; Engineering and applied mathematics	Machine learning and pattern recognition; Signal/image processing; Probabilistic systems and inference	Algorithm design; Software development; System design/simulation	**Tell me which bin to put this into: Visual classification of recycling items**	At the university we currently use three types of garbage bins to dispose waste of different types: recyclables, non-recyclables, and food/compost. Often, however, it is difficult to know which bin to use for a particular item. This project will develop a system which will take a picture of a waste item and then classify it according to its recycling category, indicating to the user which bin to use. A small dataset will be collected on which to test the computer vision algorithm. Depending on the student, the focus can be more on the machine learning algorithm or on the system implementation.
Prof MJ Kamper (KamperMJ1)	Control systems; Electronics; Energy systems	Electrical machines; High power systems/electronics; Industrial/feedback control systems	Circuit design and layout; Measurements; System design/simulation	**Duty cycle control of PM wind generator system for MPPT**	In this project the duty cycle control of a battery connected permanent magnet (PM) wind generator system for maximum power point tracking (MPPT) is further investigated. The existing system consists of a generator, rectifier and dc-dc converter. The system must be simulated in Matlab simulink to investigate the optimum duty cycle. Hardware development consists of micro-controller measuring the dc-link voltage to control in a feed forward way the duty cycle. The system must then be experimentally tested.
Prof MJ Kamper (KamperMJ2)	Electromagnetics; Energy systems; Engineering and applied mathematics	Electrical machines; Numerical and computational methods; Renewable energy	Experimental and empirical evaluation; Physical design (materials, dimensions, etc.); Measurements	**Permanent magnet brushless exciter with variable flux control**	In this project a small permanent magnet (PM) brushless exciter for the field supply of a 15 kW grid-connected wound-rotor wind generator must be developed on a 500 W level. The PMs are used to generate rated voltage. A technique will be used whereby a flux control winding is integrated with the PMs to obtain flux and rotor field control to some extent. It is thus a hybrid brushless exciter. The design will be done with Ansys Maxwell software, and then the exciter must be build and tested
Prof MJ Kamper (KamperMJ3)	Electromagnetics; Energy systems; Engineering and applied mathematics	Electrical machines; Numerical and computational methods; Renewable energy	Experimental and empirical evaluation; Physical design (materials, dimensions, etc.); Measurements	**Synchronous condensor with DC-VRM technology**	Synchronous condensors (SCs) are used to stabilize power systems. In this project the DC-Variable-Reluctance-Machine (DC-VRM) technology is investigated as SC. There is already an existing machine in the laboratory that must be tested and characterised. The SC must then be analysed by Ansys Maxwell software, so to compare measured with calculated results. From this the DC-VRM technology for SC-application must be evaluated for industry.
Prof MJ Kamper (KamperMJ4)	Control systems; Electronics; Energy systems	Electrical machines; High power systems/electronics; Renewable energy	Circuit design and layout; Measurements; System design/simulation	**Rotor field control for MPPT of dc-grid connected wound rotor wind generator**	In this project the rotor field control for maximum power point tracking (MPPT) of fixed voltage dc-grid connected wound rotor wind generators is investigated. The system consist of a geared high speed generator on a 3 kW power level. Detail theoretical analysis must be done. The latter must then be confirmed by laboratory measurements and a designed controller.

Dr DJ Ludick (LudickD1)	Electromagnetics; Computer science; Electronics	Numerical and computational methods; Antennas, guided waves and scattering; Sensors/analogue electronics	Algorithm design; Circuit/electromagnetic/multi-physics simulation; Software development	**Integrating a SPICE engine with a Computational Electromagnetic solver**	The goal of this project is to integrate a SPICE engine (such as NG or LT Spice) with a Method-of-Moments (MoM) computational electromagnetic solver. This integration will allow for the inclusion of non-radiating networks consisting of lumped, linear circuit elements in the MoM simulation.
Dr DJ Ludick (LudickD2)	Electromagnetics; Computer science; Engineering and applied mathematics	Machine learning and pattern recognition; Antennas, guided waves and scattering; Numerical and computational methods	Algorithm design; Circuit/electromagnetic/multi-physics simulation; Software development	**Machine Learning-based Method of Moments (ML-MoM) implementation**	The Method-of-Moments (MoM) is a computational electromagnetic technique widely used in the simulation of radiating and scattering problems. The purpose of this project is to obtain whether Machine Learning algorithms, such as neural networks can be used to accelerate computationally expensive aspects of the MoM.
Dr DJ Ludick (LudickD3)	Electromagnetics; Computer science; Engineering and applied mathematics	Machine learning and pattern recognition; Antennas, guided waves and scattering; Numerical and computational methods	Algorithm design; Circuit/electromagnetic/multi-physics simulation; Software development	**Machine Learning-based Automatic Computational Electromagnetic solver selection**	The memory and runtime efficiency of complex computational electromagnetic simulations can be improved by applying suitable solution methods to various parts of the problem. The goal of this project is to develop a machine learning-based algorithm that can suggest solver settings for different domains in a CEM simulation, based on parameters such as frequency and the geometrical properties of the structures involved.
Dr DJ Ludick (LudickD4)	High frequency technique; Electromagnetics; Systems and signals	Signal/image processing; Machine learning and pattern recognition; Antennas, guided waves and scattering	Circuit/electromagnetic/multi-physics simulation; System design/simulation; Software development	**Real-time failure detection for the Transient Array Radio Telescope (TART)**	The transient array radio telescope (TART) is a 24-element open-source radio interferometer (https://tart.elec.ac.nz/) that looks at GPS L1 satellites. Real-time data streams are available for each antenna channel via an API. The goal of this project is to continually monitor the power-spectra associated with these data-streams and identify failure-scenarios that may occur (e.g. a damaged antenna).
Prof HdT Mouton (MoutonHdT1)	Electronics; Control systems; Energy systems	High power systems/electronics; Digital/integrated circuits; Sensors/analogue electronics	System design/simulation; Software development; Experimental and empirical evaluation	**Digital control of a switch-mode power supply**	The aim of this project is to implement and evaluate a state-of-the-art digital control algorithm to control the output voltage of a dc-to-dc converter. An existing platform, with Silicon-Carbide switches and a digital signal processor, will be provided. The student would have to study the latest control algorithms, design a controller, simulate the controller and implement it on the digital signal processor. A number of experimental tests must be performed, these include the measurement of the closed-loop transfer function and stability margins.
Prof HdT Mouton (MoutonHdT2)	Electronics; Control systems; Electromagnetics	High power systems/electronics; Sensors/analogue electronics; Industrial/feedback control systems	Circuit design and layout; System design/simulation; Experimental and empirical evaluation	**Half-bridge power supply**	The aim of this project is a full redesign of the half-bridge power supply that is currently being used in the Electronics 414 practical. The result will be a detailed design procedure and a printed circuit board that can be used by future generations of students. Special attention must be given to the design of the inductor and the transformer as well as that of the controller. Several experimental tests must be performed. These include the measurement of the closed-loop transfer function and the stability margins of the control loop.

Prof HdT Mouton (MoutonHdT3)	Computer systems; Computer science; Electronics	Digital/integrated circuits; Communication systems; Sensors/analogue electronics	Software development; Algorithm design; Circuit design and layout	**Portable card reader**	The aim of this project is to develop a small portable card reader that can be used to monitor student attendance. The system must be small and equipped with a rechargeable battery and battery management system. The lecturer must be able to download attendance logs through his computer's USB port. The student must develop software to organize these logs according to module and timetable. The software must also be capable of performing analytic functions, for instance the correlation between attendance and performance. An additional feature would be the ability to upload attendance logs to a central server form where the head of the department can access it.
Prof HdT Mouton (MoutonHdT4)	Electronics; Energy systems; Computer systems	High power systems/electronics; Sensors/analogue electronics; Industrial/feedback control systems	Circuit design and layout; Physical design (materials, dimensions, etc.); Measurements	**Thyristor rectifier**	The aim of this project is to develop a three-phase thyristor controlled rectifier that can be used to illustrate the operation of thyristors rectifiers in an Electronics 414 practical. The project includes the design of the thyristor bridge, the snubber circuits, the gate drivers and a digital controller. The result must be a well-rounded product that can be manufactured by the E&E workshop. A set of experiments must be designed and tested to illustrate the basic operation of thyristor rectifiers.
Prof HdT Mouton (MoutonHdT5)	Electronics; Energy systems; Electromagnetics	High power systems/electronics; Sensors/analogue electronics; Industrial/feedback control systems	Circuit design and layout; Physical design (materials, dimensions, etc.); Measurements	**Multilevel power electronic converter**	The aim of this project is to develop a three-level converter that can be used for research projects by M.Eng. and Ph.D. students. Multilevel converters are advanced power electronic converters. The first step is to gain an understanding of the operation of multilevel converters. A detailed design must then be carried out. This includes component selection, calculation of the losses, design of snubber circuits and gate drivers. A simple controller must be constructed to test the converter. A full set of experimental measurements must be taken and compared with the design parameters. The end results must be a well-rounded product.
Dr FM Mwaniki (MwanikiFM2)	Computer systems; Electronics; Systems and signals	Digital/integrated circuits; Electromagnetic compatibility/interference; High power systems/electronics	Algorithm design; Software development; System design/simulation	**Design and implementation of a Pseudo-Random Binary Sequence (PRBS) using a Field Programmable Gate Array.**	A PRBS signal for use in system identification purposes is to be generated using an FPGA. The clock frequency and the length of the PRBS should be easily controllable by the user.
Dr FM Mwaniki (MwanikiFM3)	Energy systems; Systems and signals; Electronics	Electrical machines; High power systems/electronics; Signal/image processing	Circuit design and layout; Measurements; Experimental and empirical evaluation	**In Situ Parameter Estimation of a three-phase Low- Voltage network using a Pseudo-Random Impulse Sequence (PRIS).**	A good understanding of the grid impedance characteristics and its variations throughout the day is of importance in power system studies. This project aims at developing an in situ, wide-band grid impedance measurement arrangement for estimating the impedance parameters in a three-phase low-voltage distribution network.
Dr FM Mwaniki (MwanikiFM4)	Computer systems; Electronics; Systems and signals	Digital/integrated circuits; Sensors/analogue electronics; Wireless networks	Circuit design and layout; Experimental and empirical evaluation; Measurements	**Use of wireless devices and Internet of Things (IoT) in monitoring and management of patients with Diabetes and Hypertension.**	Self management is an important part of Diabetes and blood pressure management. The objective of this project is to develop a system that monitors, non-intrusively, body quantities such as blood glucose levels, temperature, blood pressure, pulse rate, etc and avail the data remotely for decision making.

Mr CB Nicholls (NichollsC1)	Energy systems; Computer science; Computer systems	Machine learning and pattern recognition; Wireless networks; High power systems/electronics	Algorithm design; Experimental and empirical evaluation; Software development	**IoT- and Machine Learning-based, Residential Consumer, Energy Consumption and Cost Optimization Solution**	The purpose of the project is to design an IoT- and Machine Learning-based, Residential Consumer, Energy Consumption and Cost Optimization Solution. Meaning, a solution that: a. Quantify the total COST of a Consumer by utilising an Iot Solution, consisting of a LPWAN wire-less (LoRA, NBIoT, RPMA, etc.) IoT-Energy (kWh) Sensor, and an associated back-office Knowledge Application System which can convert the measured kWh's into a fiscal value, utilising the applicable regional Nersa Tariffs. b. Identify the Proportioned allocation of all applicable electricity distribution-board-level circuits, which contributed towards the total energy (kWh) measured within the applicable time period. c. Create a machine learning algorithm, which will provide the consumer with options on how to optimise the measured consumption costs.
Prof TR Niesler (TRN1)	Systems and signals; Computer science; Engineering and applied mathematics	Machine learning and pattern recognition; Signal/image processing; Probabilistic systems and inference	Algorithm design; Experimental and empirical evaluation; Software development	**Detection of coughing in live concert recordings**	At the Stellenbosch University Conservatorium, live concerts are often recorded. These recordings must be post-processed in order to remove unwanted sounds, such as coughing. In this project, the student will be provided with a dataset containing a number of such live recordings, and associated metadata indicating the locations of coughing sounds. The objective is to design an algorithm that can automatically detect the locations of coughing in a new recording. This will require the application of machine learning techniques, specifically the training of statistical classification systems. The candidate should develop and test at least two such classifiers (these can be variants of each other). The project requires excellent programming skills, the ability to function in a Linux-only environment, and strong computational skills (mathematics & statistics).

Prof TR Niesler (TRN2)	Systems and signals; Computer science; Engineering and applied mathematics	Machine learning and pattern recognition; Signal/image processing; Probabilistic systems and inference	Algorithm design; Experimental and empirical evaluation; Software development	**Optimisation of the dynamic time warping (DTW) algorithm**	Dynamic time warping (DTW) was used in the 1980's to achieve automatic speech recognition, before the widespread adoption of hidden Markov models (HMMs) and more recently deep neural networks (DNNs). DTW has the characteristic that requires only a single template to compute a matching score with new audio. For this reason it has recently seen a resurgence in use in situations where extremely little training data is available. This is specifically true for wordspottig applications, where the goal is to determine whether a keyword or key-phrase occurs in an audio signal, and where only a single or very few exemplar keywords are available for the search. However, DTW is also computationally expensive, limiting its use in real-time situations or on low-power devices. for this reason, optimisations to the DTW algorithm have been proposed over the years. The objective of this project is to evaluate these optimisations with a view to informing the DTW implementation used in a current research project, in which keyword spotters are developed for severely under-resourced African languages for the purpose of humanitarian monitoring by the United Nations (UN). This will include the implementation, in software, of competing options, and their evaluation in terms of accuracy and computational complexity. The project requires excellent programming skills, the ability to function in a Linux-only environment, and strong computational skills (mathematics & statistics).
Prof TR Niesler (TRN3)	Systems and signals; Computer science; Engineering and applied mathematics	Signal/image processing; Machine learning and pattern recognition; Probabilistic systems and inference	Algorithm design; Experimental and empirical evaluation; Software development	**Time synchronisation of physically separate audio recorders**	An existing research project in the DSP lab is investigating the location of elephants by detecting their rumble vocalisations. One way of achieving this by triangulation based on audio signals captured by different microphones. To achieve good accuracy, these microphones should be separated by distances that make it impractical to run cables. In addition, it is attractive to use commercially available audio recorders for the capture. However, in order to implement triangulation based on signals recorded by separate recorders, they must be time-synchronised. The purpose of this project is to design, construct and test a time stamping device that can be interfaced with each audio recorder. This device would obtain highly accurate time information from the Global Navigation Satellite System (GNSS) and then add or superimpose regular and precise timestamps into the audio stream. These timestamps can be used later to align the recordings of separate audio recorders. This project requires an aptitude for embedded hardware and especially embedded programming. The project also requires good computational skills (for example using octave/matlab or python) and the ability to do independent reading and research.

Prof TR Niesler (TRN4)	Computer systems; Electronics; Energy systems	Digital/integrated circuits; Sensors/analogue electronics; Communication systems	System design/simulation; Experimental and empirical evaluation; Software development	**Intelligent battery tester**	The state of health of a battery has become an important thing to know with the current prevalence of load shedding. The DSP lab, for example, has many computer workstations each with a UPS powered by two 7AH lead-acid batteries. When a UPS begins to fail, it is often difficult to decide which batteries need replacing. Most battery testers base their assessment on the terminal voltage. However, this may be an insufficient indicator of whether a battery is in good health. In particular, the behaviour of the battery under load should be considered. This project involved the design, construction and testing of an intelligent battery tester that measures the voltage-current characteristics of a battery by automatically subjecting it to a varying load, and then assesses this IV characteristic in terms of what it should and should not be. The final device should be microcontroller-controlled, and include a clear display indicating test results, if possible graphically. This project requires an aptitude for embedded hardware and especially embedded programming. The project also requires good computational skills (for example using octave/matlab or python) and the ability to do independent reading and research. (Co-supervised with Dr Riaan Wolhuter).
Dr AJ Rix (RixAJ2)	Energy systems; Electronics; Control systems	Renewable energy; High power systems/electronics; Digital/integrated circuits	Circuit design and layout; Experimental and empirical evaluation; Physical design (materials, dimensions, etc.)	**PV module IV curve tracer**	Design and test a handheld IV curve tracer (and software) for a single PV module that reports the measured results to an Android phone. Fast simultaneous sampling of voltage and current is required to accurately measure the IV curve.
Dr AJ Rix (RixAJ3)	Telecommunication; Electronics; Computer systems	Wireless networks; High power systems/electronics; Digital/integrated circuits	Circuit design and layout; Experimental and empirical evaluation; Software development	**LORA wireless measurement array**	Design and test LORA measurement hardware nodes (and gateway) with a customizable web based software platform that can accomodate as many LORA nodes as possible to record and display measured data. As an extension of the project, possible forecasting algorithms can be implemented to help identify anomalous behaviour of the measured signal.
Dr AJ Rix (RixAJ4)	Energy systems; Electronics; Control systems	Renewable energy; High power systems/electronics; Digital/integrated circuits	Circuit design and layout; Experimental and empirical evaluation; Physical design (materials, dimensions, etc.)	**Solar powered 12 - 48 Vdc MPPT charge controller**	Design and test a 12 - 48 Vdc battery charger for deep cycle lead acid batteries that can be used in a residential solar PV system. Intelligent desicion making by the controller should suggest input voltage ranges (from the PV) dependent on the required output voltage of the charger. The charger should make use of maximum power point tracking to optimally utilise the power available from the PV modules.
Dr AJ Rix (RixAJ5)	Telecommunication; Electronics; Computer systems	Wireless networks; Digital/integrated circuits; Communication systems	Circuit design and layout; Experimental and empirical evaluation; Software development	**Electronic scoring system for Xtreme Steel shooting events**	Design and test an electronic scoring system for www.xsssa.co.za events that incorporates hit sensors on the targets as well as an easy to use user interface for individual scoring. The system should update a local server so that the competition scoring results are automatically generated after the competition. (no internet or cell phone connections are available)

Mr JC Schoeman (SchoemanJC1)	Computer science; Systems and signals; Engineering and applied mathematics	Machine learning and pattern recognition; Signal/image processing; Robotics and autonomous vehicles	Algorithm design; Software development; System design/simulation	**Classification of Environments for Autonomous Robots using Supervised Learning**	An autonomous robot refers to a mobile, computer-controlled system capable of performing tasks with little human intervention. For this to be possible, the robot requires the ability to plan what to do ahead of time. Very often, this plan could vary significantly depending on the robot's surrounding environment. For example, it might behave quite differently in an office building compared to outer space. An important capability of an autonomous system is therefore to automatically (and correctly) identify its surroundings. The aim of this project is to develop a supervised learning solution for automatically classifying previously-unseen environments based on labelled examples.
Mr JC Schoeman (SchoemanJC2)	Computer science; Systems and signals; Engineering and applied mathematics	Machine learning and pattern recognition; Robotics and autonomous vehicles; Probabilistic systems and inference	Algorithm design; Software development; System design/simulation	**Learning to solve Sliding Puzzles using Reinforcement Learning**	In robotics, a manipulator (i.e. robotic arm) is a device used to manipulate objects in its environment. When the manipulation task is relatively complex, it is often difficult for a human to prescribe exactly how the robot should proceed. One possible solution is that the robot figures this out on its own through reinforcement learning (RL). A popular approach for developing RL algorithms for robotic applications is to first test their performance on similar, easy-to-simulate problems. The aim of this project is therefore to develop an RL agent for solving sliding puzzles as a step towards addressing complex manipulation problems.
Mnr WA Smit (SmitWA2)	Computer systems; Electronics; Energy systems	Digital/integrated circuits; Numerical and computational methods; Signal/image processing	Algorithm design; Circuit design and layout; Software development	**Running form measurement device**	The purpose of the project is to build an low-power device based around an accelerometer to determine stride length and cadence of an athlete. This project will extend work done previously.
Mnr WA Smit (SmitWA3)	Computer systems; Telecommunication	Digital/integrated circuits; Communication systems; Wireless networks	System design/simulation; Software development; Experimental and empirical evaluation	**Remote instrumentation monitor system**	Design and build a remote instrumentation monitor system using the Actel Fusion development board. Create a Web interface which can be accessed over radio a radio link.
Mnr WA Smit (SmitWA4)	Computer systems; Electronics	Digital/integrated circuits; Numerical and computational methods; Sensors/analogue electronics	Algorithm design; Circuit design and layout; Software development	**Automotive Head-up Display**	An LCD display that is reflected on the inside of the windshield of a car and that displays pertinent information to the driver. This includes position, speed and the possible integration of an infrared camera and illuminator to assist night time driving.
Prof WH Steyn (SteynWH1)	Electronics; Systems and signals; Engineering and applied mathematics	Sensors/analogue electronics; Signal/image processing; Wireless networks	Experimental and empirical evaluation; Physical design (materials, dimensions, etc.); Measurements	**Directional Hearing Aid Assistant**	The main problem of many hard of hearing persons wearing a hearing aid devices, is to discriminate the voice from a specific person in a room where many are speaking simultaneously. Develop a low cost small parabolic reflector type pickup microphone for connection via Bluetooth to a modern hearing aid device. This will enable people with hearing loss to direct the microphone's signal discrimination in a room with several people. Ensure an optimal frequency response for best results. This topic requires some research into current hearing aid devices and Bluetooth connections.

Prof WH Steyn (SteynWH2)	Control systems; Computer systems; Electronics	Digital/integrated circuits; Industrial/feedback control systems; Sensors/analogue electronics	Circuit design and layout; Measurements; System design/simulation	**Low cost USB port continuous plant for Continuous and Discrete Control Systems Practicals**	A microcontroller based continuous SISO plant needs to be developed with 12-bit A/D sampled output and 12-bit D/A control input for a lightly damped second order open loop response. A programmable delay period to the plant response must also be specified. The Matlab/Simulink interface must be via USB serial communications with a minimum sample period of 1 millisecond. This project will require both microcontroller hardware interfaces and embedded software development. A simple OpAmp second order plant with suitable response can be used. Visual feedback of the output response can be obtained through a low cost analogue volt meter needle.
Prof WH Steyn (SteynWH3)	Control systems; Systems and signals; Computer systems	Machine learning and pattern recognition; Industrial/feedback control systems; Signal/image processing	Algorithm design; Experimental and empirical evaluation; Software development	**Non-lethal self defense remote gun for home security**	A non-lethal paint ball gun on a azimuth/elevation platform will be supplied for this project. The aim will be to use a feedback IR camera to track a moving target and to fire the gun at the target. Initially a laser pointer can be used to determine the tracking accuracy, and finally the performance accuracy of the paintball gun must be determined. The system must track the target autonomously without human intervention and must be able to hit the target at a maximum distance of 25 meters. This project will require discrete servo feedback control in a microcontroller to ensure accurate tracking and real time signal processing on the camera images.
Prof WH Steyn (SteynWH4)	Control systems; Computer systems; Electronics	Industrial/feedback control systems; Sensors/analogue electronics; Space systems	Circuit design and layout; System design/simulation; Measurements	**3-axis Spherical Actuator for satellite attitude control**	A novel spherical ball actuator must be developed to do 3-axis control of an air bearing platform. This actuator has the potential to be more compact with less power than existing 3-axis reaction wheels on small satellites. The idea is to use a metal sphere that can freely rotate in any direction inside a housing with roller ball bearings. A 3-axis configuration of small DC motors with non-slip wheels will press against the sphere to enable rotations in 3 orthogonal directions. This project will be used to determine the practical feasibility and performance limitations of this type of actuator. A microcontroller interface to do speed control of the DC motors and sphere with a X-Bee RF connection to a PC with Matlab/Simulink must be implemented to remotely control the actuator on the air bearing platform.
Dr JM Strauss (StraussJM1)	Electronics; Systems and signals; Energy systems	High power systems/electronics; Sensors/analogue electronics; Industrial/feedback control systems	Circuit design and layout; Software development; Experimental and empirical evaluation	**A 2.5 kW, 230 Vac to 400 Vdc rectifier for LFP battery charger**	This project entails the design of a 2.5 kW PFC (power factor correction) rectifier to serve as the input stage for a LiFePO4 battery charger. The rectifier should be able to completely integrate with the rest of the charger. The charger is intended for use in an ultralight electric vehicle. It should therefore be designed to integrate fully with the rest of the vehicle.
Dr JM Strauss (StraussJM2)	Electronics; Systems and signals; Energy systems	High power systems/electronics; Sensors/analogue electronics; Industrial/feedback control systems	Circuit design and layout; Software development; Experimental and empirical evaluation	**A 2.5 kW, 400 Vdc to 48 Vdc dc-dc converter for LFP battery charger**	This project entails the design of a 2.5 kW charger (with a 400 V input) for 48 V LiFePO4 batteries based on the UCC28951 phase-shifted full-bridge controller. This charger is intended for an ultralight electric vehicle and should therefore be able to communicate with both the BMS of the battery as well as the rest of the vehicles management systems in order to provide current operating conditions and to receive control instructions.

Dr JM Strauss (StraussJM3)	Electronics; Telecommunication; Computer systems	Digital/integrated circuits; Wireless networks; Communication systems	Circuit design and layout; Software development; Experimental and empirical evaluation	**A cm accurate GPS system for land surveying**	This system will be based on the NEO-M8P high precision GPS modules. These modules rely on a rover/base station pair to obtain centimeter accuracy. You will have to do the hardware (e.g. suitable power supplies and microcontroller control) and firmware/software design of the rover and base station. Communication between the rover and base station should be able to reach several kilometers. Both the rover and base station settings and operation should be controllable via an Android app with Bluetooth communication (a basic app is however optional, however, the ability to be controlled in this way should be demonstrated).
Dr JM Strauss (StraussJM4)	Electronics; Telecommunication; Computer systems	Digital/integrated circuits; Communication systems; Sensors/analogue electronics	Circuit design and layout; Software development; Experimental and empirical evaluation	**An intelligent home energy control system**	Many households are considering battery backed up alternative energy systems (i.e. grid-tie, hybrid or UPS configurations with or without solar photovoltaics) amidst the occurence of frequent load shedding. Unfortunately, very few houses are wired to easily convert to such a new configuration. It is also quite expensive to convert to an inverter/battery system with sufficient capacity to supply the entire house. This project entails the design of an intelligent system to monitor and control household loads depending on supply availability. The system should also collect, store and display all available information for proper management and troubleshooting.
Dr RP Theart (TheartRP1)	Computer science; Engineering and applied mathematics; Systems and signals	Machine learning and pattern recognition; Signal/image processing; Numerical and computational methods	Algorithm design; Software development; System design/simulation	**Extract tree heights from digital elevation model (DEM) images**	Within an orchard the automatic detection of the location and height of trees are important, as this helps tracking the health of the orchard over time. You are given several layers of drone images including multispectral and digital elevation model (DEM) layers. By using the DEM, extract the height of the trees relative to the ground plane. This will require a smart automatic removal of the ground plane. This can be achieved by using image analysis and basic machine learning techniques. You may also consider calculating other parameters, such as an estimation of the volume of the tree.
Dr RP Theart (TheartRP2)	Computer science; Engineering and applied mathematics; Systems and signals	Machine learning and pattern recognition; Signal/image processing; Numerical and computational methods	Algorithm design; Software development; System design/simulation	**Ensembling image layers for automatic tree detection**	Within an orchard it is important to be able to automatically detect the location of the trees in order to analyse the health of the orchard and track growth over time. You are given several layers of drone images including multispectral and digital elevation model (DEM) layers. By using image analysis and basic machine learning, the location of trees must be determined automatically, and either an ellipse must be drawn around the tree or each pixel in the image must be assigned a label of tree/not tree. The student must compare his results to what is produced with existing solutions.
Dr RP Theart (TheartRP3)	Computer science; Engineering and applied mathematics; Systems and signals	Machine learning and pattern recognition; Signal/image processing; Numerical and computational methods	Algorithm design; Software development; System design/simulation	**Image registration of orchard images over time**	In this project you will have access to several layers of drone images for an orchard (including DEM, visual and multispectral images). By using image registration techniques, the student should align images of orchards captured on different dates. One of the major challenges the students must solve is compensating for season changes in the images, which include landscape changes and trees growing. Due to the drone not being at the same elevation when images are taken also often leads to the image being warped between different dates.

Dr RP Theart (TheartRP4)	Computer systems; Computer science; Systems and signals	Digital/integrated circuits; Sensors/analogue electronics; Communication systems	Circuit design and layout; Software development; Measurements	**Cloud Based Weather Station using IoT Devices**	Design and build an inexpensive digital weather station that can be used to measure weather data both indoors and outdoors. At least the following measurements need to be made Temperature, Humidity, Air pressure, UV. Other weather-related parameter such as wind speed and direction as well as rainfall can also be considered. This weather station should be able to connect via Wi-Fi to a server to store the live data. Also develop a cloud-based backend to which the weather data can be sent every minute. Develop a website frontend that reports the current measurements as well as graphing the historical data.
Dr CE van Daalen (vanDaalenCE1)	Computer science; Systems and signals; Engineering and applied mathematics	Probabilistic systems and inference; Signal/image processing; Machine learning and pattern recognition	Algorithm design; Software development; Experimental and empirical evaluation	**Fast and reliable ball tracking using a moving camera**	Ball tracking is very useful for referee aids, improved viewer experience and game analysis in sports such as cricket, soccer and tennis. However, it is very challenging to do reliably with a moving camera due to a changing background, background that have a similar appearance to the ball, and occlusions. Probabilistic techniques could provide tracking reliability, but are often slow if applied naively. The idea of this project is to intelligently combine image processing and probabilistic reasoning techniques to do real-time and reliable ball tracking for a sequence of images taken by a single camera. This project has several interesting avenues, combinations and extensions to explore.
Dr CE van Daalen (vanDaalenCE2)	Computer science; Systems and signals; Engineering and applied mathematics	Probabilistic systems and inference; Machine learning and pattern recognition; Robotics and autonomous vehicles	Algorithm design; ; Software development	**Motion segmentation in stereo image sequences by unsupervised learning**	To operate autonomously in general environments, a robot must be able to detect and track moving objects in its vicinity (e.g. pedestrians, cars). To this end, this project aims to detect moving objects in a sequence of stereo images where the number and type of objects are unknown. The idea is to use an image-feature-based approach to measure 3D points in the environment and then group them according to their relative motion. This is essentially a clustering problem -- a form of unsupervised learning -- which can be solved using probabilistic graphical models. This challenging project is suitable for someone interested in applying probabilistic reasoning to computer vision.
Dr CE van Daalen (vanDaalenCE3)	Computer science; Systems and signals; Engineering and applied mathematics	Probabilistic systems and inference; Robotics and autonomous vehicles; Machine learning and pattern recognition	Algorithm design; Software development; System design/simulation	**Landmark-based localisation of a robot with unknown correspondence**	Any robot has to localise itself (i.e. know its pose -- or position and orientation) to operate effectively. One approach uses measurements of landmarks (recognisable points) in the environment for localisation; however, landmarks often have similar appearances and the correspondence (or association) between the measurements and landmarks are therefore uncertain. The idea of this project is to use probabilistic graphical models to reliably localise a simulated robot by modelling and reasoning about the sources of uncertainty (measurement noise, correspondence uncertainty) in a principled manner. This challenging project is suitable for someone interested in applying probabilistic reasoning to robotics.

Dr CE van Daalen (vanDaalenCE4)	Computer science; Systems and signals; Engineering and applied mathematics	Machine learning and pattern recognition; Probabilistic systems and inference; Robotics and autonomous vehicles	Algorithm design; Software development; System design/simulation	**Learning the structure of an agent's environment from experience**	Young children discover how the world works mostly through experience, despite not initially knowing the meaning of what they see, hear, feel, etc. The goal of this project is to do this, but for a simulated agent in a simple block-world environment. The agent observes the blocks surrounding it as it moves through the environment, but it does not know anything about the world, where the observations come from, or what they mean. The agent should discover the structure of the environment (i.e. learn a map of the environment) from these observations using only general operations such as comparisons and logical operations. This very challenging topic is suitable for someone interested in logic and the foundations of learning.
Prof HJ Vermeulen (VermeulenHJ1)	Electronics; Computer systems; Computer science	Digital/integrated circuits; Sensors/analogue electronics; Wireless networks	Circuit design and layout; System design/simulation; Software development	**LORA Wireless Buoy Tracking System**	Design a LORA wireless system for GPS tracking of a floating buoy. The system topology consists of a battery-operated remote unit and a Raspberry PI base station that communicates using LORA wireless technology. The remote unit is comprised of an efficient power supply, low-power microcontroller, real-time clock, LORA transceiver and GPS receiver. The remote unit performs scheduled updates of the GPS coordinates of the buoy. The Raspberry PI base station receives and logs telemetry data from the remote unit and communicates with a software application program on a PC. The application program should provide high-level functions, such as mapping support.
Prof HJ Vermeulen (VermeulenHJ2)	Computer science; Energy systems; Engineering and applied mathematics	Machine learning and pattern recognition; Numerical and computational methods; Probabilistic systems and inference	Algorithm design; Software development; System design/simulation	**ANN and ANFIS Electrical Load Classification System**	Investigate the use of Artificial Neural Networks (ANNs) and Adaptive Fuzzy Inference Systems (ANFIS) for feature-based classification of residential electrical consumption profiles and load categories. The training dataset consists of temporal residential load profiles, from which Time-of-Use statistical features is extracted to construct feature vectors for the classification models. The study requires performance evaluation of the implemented ANN and ANFIS models using appropriate metrics, cross-validation approaches, etc. The use of data partitioning and clustering methodologies for improving forecasting using ANFIS models must be investigated. A second objective is to evaluate the impacts of embedded solar PV generation on the load categories.
Prof HJ Vermeulen (VermeulenHJ3)	Energy systems; Electronics; Electromagnetics	High power systems/electronics; Numerical and computational methods; Electrical machines	Circuit/electromagnetic/multi-physics simulation; Circuit design and layout; Measurements	**Tesla Coil High Voltage Generator**	A Tesla coil is essentially a resonant high voltage generator consisting of coupled Low Voltage (LV) and High Voltage (HV) coils and a capacitor. This projects involves the design, construction and testing of a small tesla coil HV generator for demonstration purposes. The LV coil, HV coil and capacitor must be designed and analysed using finite element electromagnetic field software such as ANSYS, and the dynamic behaviour of the circuit must be analysed using appropriate models and circuit simulations in Matlab. A suitable controllable primary excitation circuit, including the power supply, must be designed, constructed and tested.
Prof DJJ Versfeld (VersfeldDJJ3)	Systems and signals; Computer systems; Engineering and applied mathematics	Machine learning and pattern recognition; Signal/image processing; Probabilistic systems and inference	Algorithm design; Software development; System design/simulation	**Hidden Markov Models to detect Bryde's whale calls**	The main aim of this project is to develop and investigate Hidden Markov Models and the appropriate feature extraction techniques to detect inshore Bryde's whales calls. We have a couple of recordings of our own data that we collected in False Bay.

Prof DJJ Versfeld (VersfeldDJJ4)	Systems and signals; Computer systems; Electronics	Signal/image processing; Digital/integrated circuits; Communication systems	Algorithm design; Software development; Experimental and empirical evaluation	**Low-cost, portable and boat deployable Direction-of-Arrival system for detecting whale and dolphin sounds**	There is currently a need to determine the direction-of-arrival of various whale and dolphin sounds in real-time or near real-time. Using a single array of connected hydrophones, a low-cost system is to be developed to estimate the DoA. The system should be portable, and be able to be deployed from our research sailboat. Correlation-based methods should be used to perform the DoA.
Prof DJJ Versfeld (VersfeldDJJ5)	Systems and signals; Computer systems; Electronics	Signal/image processing; Digital/integrated circuits; Communication systems	Algorithm design; System design/simulation; Measurements	**Localisation and Virtual synchronisation for underwater passive acoustic monitoring.**	Localisation of whale and dolphin vocalisations remain a challenge. By developing a network of sensors, implement an underwater system that can localise vocalisations (using post-processing techniques, i.e., after sensors are retrieved). Due to the fact that communication is extremely difficult for these underwater systems, Real-time clocks must be used for synchronisation, and processing. Various time-keeping strategies must be evaluated to compensate for clock drift.
Prof DJJ Versfeld (VersfeldDJJ6)	Systems and signals; Computer systems; Electronics	Signal/image processing; Digital/integrated circuits; Robotics and autonomous vehicles	Algorithm design; Circuit design and layout; Physical design (materials, dimensions, etc.)	**Acoustic release operating up to 40m depth.**	There is currently a need to deploy and retrieve sensors on the sea bed. An acoustic release is a positively buoyant device, which, once activated, surfaces, allowing equipment to be retrieved. The aim of this project is to develop a low-cost release system, which uses acoustic communication to interrogate the system, as well as sending commands to the system.
Prof DJJ Versfeld (VersfeldDJJ7)	Systems and signals; Computer systems; Electronics	Signal/image processing; Machine learning and pattern recognition; Digital/integrated circuits	Algorithm design; Circuit design and layout; Physical design (materials, dimensions, etc.)	**Low-cost, Long-term acoustic recorder.**	Long-term recorders are used in various passive acoustic monitoring applications (especially for whale and dolphin research). There is a need for a system similar Audiomoth (openacousticdevices.info), but for underwater passive acoustic monitoring.
Prof DJJ Versfeld (VersfeldDJJ8)	Systems and signals; Telecommunication; Electronics	Signal/image processing; Communication systems; Digital/integrated circuits	Algorithm design; Software development; System design/simulation	**Underwater RF for communications.**	RF communications do not propagate well through water, let alone sea water. However, recent research has shown that short-distance RF communications can be achieved. The aim of this project is to investigate, research and demonstrate underwater RF communications over short ranges, making use of Software defined radios.
Dr L Visagie (VisagieL1)	Computer systems; Engineering and applied mathematics; Systems and signals	Digital/integrated circuits; Signal/image processing; Numerical and computational methods	Software development; Circuit design and layout; Algorithm design	**360 degree camera for Tiny Planet videos**	Development of a camera, and associated processing, to produce "Tiny Planet" videos, similar to https://www.youtube.com/watch?v=J4QbQooHKmg. Possibly launch the camera on a high-altitude balloon
Dr L Visagie (VisagieL2)	Computer systems; Telecommunication; Computer science	Digital/integrated circuits; Wireless networks; Communication systems	Circuit design and layout; Software development; System design/simulation	**Wifi (or other) interface for classroom attendance logging card readers**	The 'stokkiesdraai' card readers make use of a cellphone data connection to log data to the server. The mobile data link is unreliable and causes maintenance problems. A more efficient way is needed to log data to the server
Dr L Visagie (VisagieL3)	Engineering and applied mathematics; Control systems	Space systems; Numerical and computational methods; Robotics and autonomous vehicles	Circuit/electromagnetic/multi-physics simulation; Software development; System design/simulation	**CubeSat rendezvous orbital manoeuvres**	Find possible undocking, manoeuvring and docking strategies that can be achieved with a CubeSat with minimal propulsive capabilities. This will require a simulation model with accurate orbital dynamics
Dr L Visagie (VisagieL4)	Engineering and applied mathematics; Computer science; Control systems	Space systems; Numerical and computational methods; Robotics and autonomous vehicles	Software development; Circuit/electromagnetic/multi-physics simulation; Algorithm design	**Remote sensing satellite constellation coverage simulation**	Find the area of the Earth surface (and number of revisits) that a constellation of remote sensing satellites covers. Inputs to the simulation include number of satellites, orbits, and target region(s) of interest

Prof R Wang (WangR1)	Electromagnetics; Energy systems; Computer science	Electrical machines; Numerical and computational methods	Software development; System design/simulation; Measurements	**Development of a more accurate core loss model for electric traction motor design**	Electric vehicles (EV) are increasingly used in both urban and industrial environments. Electrical motors are the essential part of the EV drivetrain systems. Many innovative electric motor technologies have been proposed for EV applications. One of the key design requirements is the high efficiency over a wide operation speed range. To accurately determine the motor losses (especially core losses) is a challenging task in the electrical motor industry. The aim of this project is to develop an alternative core loss model that can predict the core losses in a motor over a wide speed range with reasonable an accuracy.
Prof R Wang (WangR2)	Energy systems; Electromagnetics; Engineering and applied mathematics	Electrical machines; Numerical and computational methods; Renewable energy	Physical design (materials, dimensions, etc.); Measurements; System design/simulation	**Design and analysis of a novel Vernier PM machine**	This project is focused on the development of a new-type of Vernier permanent magnet (PM) machine for applications such as wind power and electric transportation systems. Previous development of Vernier PM machines has showed distinct advantages such as high efficiency and high torque density over conventional PM machines. However, these Vernier machines are known for poor power factor, which is a disadvantage in terms of the size of the power converters. The aim of this project is to evaluate an alternative design concept of Vernier machine, which can realise high power factor and uses less permanent magnet material.
Prof R Wang (WangR3)	Energy systems; Electromagnetics; Engineering and applied mathematics	Electrical machines; Numerical and computational methods; High power systems/electronics	Physical design (materials, dimensions, etc.); Measurements; Circuit/electromagnetic/multi-physics simulation	**Design and analysis of a novel PM motor for a light electric vehicle**	The integrated motor-drive technology promises several user benefits such as single enclosure and reduced EMC and voltage spikes. With the currently rapid development in electrically powered vehicles, there has been an increasing interest from industry on integrated wheel motor drives. The aim of this project is to design and evaluate a fractional-slot permanent magnet motor that can be incorporated into such an integrated design.
Prof R Wang (WangR4)	Electromagnetics; Energy systems; Engineering and applied mathematics	Electrical machines; Numerical and computational methods; High power systems/electronics	Circuit/electromagnetic/multi-physics simulation; Experimental and empirical evaluation; Measurements	**Design improvements and performance evaluation of a traction induction motor**	Induction motors are widely used in traction applications because of their high efficiency, good overload capability, and wide constant power speed range. This project aims at the design improvements and performance evaluation of a recently developed traction induction motor and also the validation of the theoretical design results with the experimental tests.
Prof R Wang (WangR5)	Electromagnetics; Energy systems; Engineering and applied mathematics	Electrical machines; Numerical and computational methods; Renewable energy	Measurements; Circuit/electromagnetic/multi-physics simulation; Experimental and empirical evaluation	**Performance evaluation of a Vernier PM wind generator**	This project is focused on the performance measurements of a recently developed Vernier permanent magnet (PM) machine for direct-drive wind generator applications. The aim of this project is to evaluate the performance characteristics of Vernier PM machine and its potential for wind generator applications.
Dr R Wolhuter (Wol1)	Electromagnetics; Engineering and applied mathematics; Telecommunication	Antennas, guided waves and scattering; Communication systems; Numerical and computational methods	Circuit/electromagnetic/multi-physics simulation; Experimental and empirical evaluation; Measurements	**Design of a 5.8 GHz horn antenna for data links in the SKA area**	An extended rural data communications network is planned for the extended SKA area. RFI from the different point to point link transmitters could be a serious problem for the telescopes and any sidelobe transmissions from the transmitter antennas must be minimised. The plan is to use 5.8 GHz links for cost reasons. A horn antenna could offer a solution and the project entails the design, prototyping and testing of the antenna. The design should be optimised towards min. diffraction in both E- and H planes. Typical 3dB angles would be 30 to 3 deg and gains 15 to 24 dBi.