SCIENCE & ENGINEERING & TECHNOLOGY CAREERS

GET INSPIRED WITH
ROLE MODELS
STUDY PATHS

EXCITING NEW FEATURES
ROBOTICS & AI
NANOTECHNOLOGY
UNMANNED AERIAL VEHICLES

INFORMATION ON 73 CAREERS
HOW TO GET FINANCIAL AID

2nd Edition

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

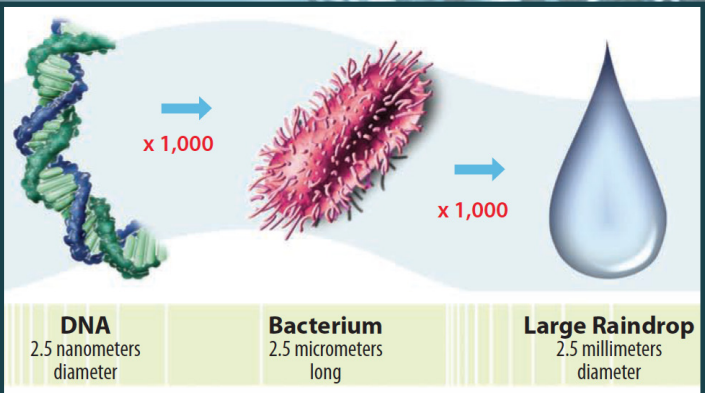
NRF National Research Foundation | SAASTA South African Agency for Science and Technology Advancement

2030 NDP

NANOSCIENCE

THE SCIENCE OF THE VERY SMALL

What is nanoscience and how are scientists and engineers using it to solve problems in energy, medicine, information storage, computing & more?



National Nanotechnology Initiative NNI: Lawrence Berkeley Lab, US. Department of Energy. (www.nano.gov)

Think small, think smaller than anything you can see under a microscope and start thinking of atoms and molecules. You are now down to nanoscales. A nanometer is a billionth of a meter, or a millionth of a milimetre. Put into perspective, a sheet of paper is 100 000 nanometers thick and a 2.5 milimeter raindrop = 2 500 000 nanometers.

Nanoscience is the study of nano-materials and their properties at an incredibly small scale (between 1-100 nanometers). Nanotechnology is about applying nanoscience to create and improve new products.

Because nanostructures are so small scientists have had to come up with innovative methods to manufacture objects in this size range. Scientists use beams of electrons or ions to cut nanostructures into metal, silicon and carbon-based materials for different purposes. They can form nanostructures by reacting chemicals in liquids and gases to generate nanofibers, nanocrystals and quantum dots, some as small as one nanometer wide.

Scientists are even learning how to build three-dimensional structures at the nanoscale, called nano-electro-mechanical systems, or NEMS. These devices might one day be used like microscopic robots to carry out tasks too small for humans to do themselves. For example, NEMS could carry out surgery on a single cell or act as mechanical actuators to move around individual molecules (http://tremblinguterus.blogspot.co.za).

The discovery of carbon nanotubes in 1991 led scientists to develop hundreds of “functionalisations” for nanotube openings. Most of these can be useful as molecular gates. By creating a series of gateway sheets that perform different functions. Some examples of things that the molecular gateways could be useful for are; the removal of carbon dioxide from the atmosphere; desalination; purification of drinking water; programmable drug delivery, through patches or implantable device; to name just a few. (https://www.mattershift.com/technology/)

Illustration of antibody targeted nanospheres travelling through blood vessels to deliver therapeutic drugs to a cancerous tumor

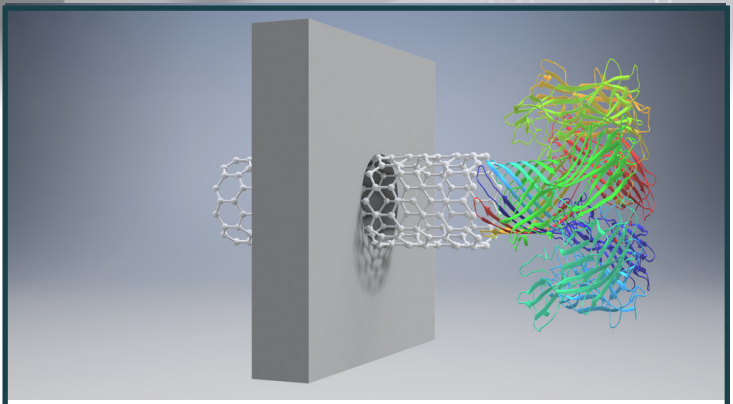
How is Nanoscience Applied

Medicine

One application currently being developed involves the use of nanoparticles to deliver drugs and heat to cancer cells. Nanoparticles are engineered so that they are attracted to cancer cells and this allows direct treatment to the site affected. Because this treatment is non-invasive it reduces the damage to healthy cells in the body and only the required drug dose is used so the side-effects are lowered significantly. This highly selective approach can reduce costs and pain to the patients. Clinical trials are underway to treat cancer patients, and look at vaccines. http://www.understandingnano.com/medicine.html

Electronics

Nano electronics means using nanotechnology in electronic components for electronic and computer applications, providing smaller, faster and more portable systems. These systems can manage and store more and more information. Think of your cell phone today and power and storage it has is ever increasing due to nanotechnology. Todays computer microprocessors have less than 100 nanometers (nm) features. The smaller sizes mean a significant increase in speed and more processing capability. These advances will undoubtedly help achieve better computers increasing the capabilities of electronics devices while reducing their weight and power consumption. (www.brighthubengineering.com)



An example of a catalyst gateway with a Nano Electro Mechanical System (NEMS)

The gateways are called "programmable" because a great variety of gates can be added to their openings, allowing them to manipulate molecules in specific ways, so that complex chemical synthesis can be achieved in compact, inexpensive devices. <https://www.mattershift.com/technology/>

Transportation

Nanomaterials used to build cars and aeroplanes are lighter and stronger, so therefore use less fuel and fewer metals. Nanotechnologies may not only lighten the aircraft to produce fuel savings, but also do so by adding nanoparticles to the fuel of a conventional jet. This significantly increases its efficiency. Graphene, for example, is a carbon sheet the thickness of a single atom, yet it is stronger than traditional products such as steel and alloys used in traditional vehicle production.

In addition graphene possesses a huge range of useful properties, such as electrical conductivity, absorption of white light, and tolerance to temperature and pH change. (http://www.pauley.co.uk/blog/nanotechnology-in-transport).

Renewable Energy

One of the major challenges of our time is replacing fossil fuels such as oil, coal and gas with renewable energy sources such as solar and wind power. Nano structured cells will only use about 1% of the materials used by traditional solar cells suggesting that nano-engineered solar cells could be significantly cheaper to produce and more efficient. They are also a lot more efficient at converting radiation into electrical energy thereby creating a sustainable solution for the use of solar energy and waste heat and lighting, and solve global energy problems. Nanotechnology is being used in a range of energy areas: to improve the efficiency and cost-effectiveness of solar panels; to create new kinds of batteries; to improve the efficiency of fuel production using better catalysis; and to create better lighting systems. Nanotechnology can help in developing new eco-friendly and green technologies that can minimize undesirable pollution.

Every Day Use

Nanoparticles or nanofibers in fabrics can enhance stain resistance, water resistance, and flame resistance of the clothes we wear every day. A tennis racket made with carbon nanotubes bends less during impact, and increases the force and accuracy of the delivery. Nanoparticle-treated tennis balls can keep bouncing twice as long as standard tennis balls. Most sunscreens today are made from nanoparticles that effectively absorb light, including the more dangerous ultraviolet range. Coatings on the surface of vehicles turbine blades and mechanical components stop dirt, scratches, bacteria, rain and mist from settling.

Nanoscience is all about the ultra-small, but it has the potential to have an enormous impact on our lives.

DIAGNOSTIC MEDICAL SONOGRAPHER

Diagnostic medical sonographers are medical assistants trained to operate special imaging equipment which projects ultrasound sound waves into patients' bodies to assess and diagnose various medical conditions. .

A transducer (skin probe), which is placed directly on the patient's skin, emits pulses of sound that bounce back and are processed and displayed as images. High-frequency sound waves are transmitted from the probe through a gel into the body. The computer then uses those sound waves to create an image. The record of images may be displayed on television monitors or computer which can be used for diagnostic purposes for disease or injury on soft tissue.

The transducer is used to help diagnose the causes of pain, swelling and infection in the body's internal organs and to examine a foetus in pregnant women and the brain and hips in infants. It is also used to help guide biopsies, diagnose heart conditions, and assess damage after a heart attack.

The beauty of ultrasound is that it is safe, non-invasive, and does not use ionizing radiation so there is no radiation exposure to the patient. Because ultrasound images are captured in real-time, they can show the structure and movement of the body's internal organs, as well as blood flowing through blood vessels.

Diagnostic medical sonographers work in comfortable offices or clinics, but they may need to spend long hours on their feet, greeting patients, operating ultrasound machinery and fetching the radiologist or other resident physician to make interpretations and diagnoses.

Some responsibilities of a diagnostic medical sonographer include:

- taking a patient's history; receiving the patient and answering any questions about the procedure
- preparing and maintaining imaging equipment
- operating equipment to get diagnostic images of areas in the patient's body
- recognizing the difference between normal and abnormal images
- analysing results to check for quality and adequate coverage of the area needed for diagnosis
- recording findings and keeping track of patients' records

The sonographic equipment can be used for the diagnosis of various types of soft tissue and internal organs including: liver, gallbladder, spleen, pancreas, kidneys, bladder, uterus, ovaries, and unborn child (foetus) in pregnant patients, eyes, thyroid, scrotum (testicles), brain, hips and spines in infants.

Recent advancements in ultrasound technology include three-dimensional (3-D) ultrasound that interprets the sound wave data as 3-D images.

This technology provides the patient with a three dimensional image of their baby. The best time to perform the scan is between 26 – 32 weeks of pregnancy in the context of a medical ultrasound scan. < http://3d4dstudio.com/the-evolution-of-ultrasounds-2d-3d-4d-5d-compared >

A Doppler ultrasound is a special ultrasound technique that allows the physician to see and evaluate blood flow through arteries and veins in body and organs. An echocardiogram or ultrasound of the heart is also widely used together with this technique to check for valve problems and congestive heart failure, and to assess damage after a heart attack.
The Doppler images can help the physician to see and evaluate blockages to blood flow such as clots and the narrowing of vessels, reduced or absent blood flow to various organs.

Woman undergoing a Doppler ultrasound (angiodynography) scan of the legs to study blood flow and explore potential deep vein issues. < http://www.alamy.com/stock-photo-woman-undergoing-a-doppler-ultrasound-angiodynography-scan-of-the-72433930.html >

How to Enter This Occupation

Level of Schooling & School Subjects

National Senior Certificate meeting the requirements for a degree course.

Each institution has its own entry requirements.

Compulsory Subjects:
Mathematics, Physical Sciences.
Recommended Subjects:
Life Sciences.

Sonographer doing a sonogram on a patient

Further Training

Although sonography is becoming a specialisation and recognised field on its own, in South Africa, sonography is studied under the radiography degree and it caters for the four main disciplines of radiography – Diagnostic (D), Nuclear Medicine (NM), Radiotherapy (T) and Ultrasound (US).

Degree: NDip and BTech Diagnostic Sonography are offered at the Durban University of Technology (DUT).
Bachelor degrees:
A Bachelor of Radiography in Diagnostics: Central University of Technology (CUT) and Cape Peninsula University of Technology (CPUT).
A Bachelor of Diagnostic Radiography: University of Johannesburg.
A Bachelor of Radiography: Nelson Mandela University (NMMU), the University of Limpopo (UL) and the University of Pretoria (UP).

The first year is a general one, and from the second year students may specialise in one of the following fields: Diagnostics, Radiation Therapy or Nuclear Medicine.

Registration with the Health Professions Council of South Africa (HPCSA) is mandatory for this occupation. Consult the HPCSA website for the most up-to-date information relating to accredited qualifications and registration requirements. This information can be found in the relevant sections under the Professional Board for Radiography & Clinical Technology.

Postgraduate: **An MTech degree is offered at DUT, NMMU and UJ. An honours degree in Radiography is offered at UP. A masters degree is also available at UP.**

Employment

There is a high demand for diagnostic medical sonographers and this demand is set to increase as a large segment of the population ages and the health care industry grows. This is because developments in medical imaging technology will make procedures less expensive and invasive. Work may be sought in provincial and private institutions in South Africa, as well as in most countries abroad. Radiographers may also open their own practices in accordance with the requirements of the Health Professions Council of South Africa (HPCSA).

Diagnostic medical sonographers are medical professionals who can specialize in a variety of different areas of the body. Becoming one requires at least the completion of a degree or certificate programme in the field, clinical experience, and the completion of certification.

- hospitals and clinics (private as well as government controlled)
- Department of Health
- Chamber of Mines
- South African Defence Force
- municipalities
- SANTA
- private radiological practices
- universities and universities of technology
- self-employment, after registration can go into private practice or partnership

Further Information

The Society of Radiographers of South Africa
P O Box 6014
Roggebaai, 8012
Tel: (021) 419-4857 Fax: (021) 421-2566
www.sorsa.org.za

Health Professions Council of South Africa (HPCSA)
P O Box 205, Pretoria, 0001
Tel: (012) 338-9300
Fax: (012) 328-5120
E-mail: hpcsa@hpcsa.co.za
www.hpcsa.co.za

Some Related Careers

Medical Clinical Technologist, Radiation Therapist, Nuclear Medicine Technologist, EEG Technician, MRI, CT or PET Scan Technician.

ENGINEERING SCIENCES

The best way to understand engineering is to imagine a world without it. Engineering plays a role in every part of our daily lives, from riding a mountain bike to checking our Facebook status. From the beginning to the end of each day, engineering technologies improve the ways in which we live, communicate, travel, stay healthy and entertain ourselves.

The field of engineering is as broad as science itself. Whilst science deals with the discovery of knowledge and the understanding of phenomena around us, engineering uses the discoveries of scientists to create useful products and to increase efficiency and reduce expense at every level. At an atomic level, a chemical engineer works on energy storage systems. At a molecular level, a bio-engineer develops new drugs. At an environmental level, an environmental engineer devises suitable methods to rehabilitate polluted seas. At a galactic level, an electronic engineer builds satellites for launching above earth's atmosphere, and on a personal level civil engineers help design and construct our homes, offices and stadiums, to name a few.

Engineering is at the forefront facing the environmental challenges relating to climate change, such as the development of renewable energy sources, as well as finding solutions for environmental disasters. Engineers are primarily concerned with finding solutions to problems and typically work as part of a project team.

Some solutions that would work may be too expensive to implement, other possible solutions might take too long to develop. Typically, a project has very specific time and financial constraints, which means that an engineer must often make difficult decisions.

In the workplace, engineering is an excellent outlet for the imagination: engineers may be involved in design, production, research or running businesses. Engineers are able to work in a variety of fields, such as marketing and sales, research, teaching, administration and supervision. Engineers can work for small or large businesses or even multi-national companies, anywhere in the world. A senior engineer will usually perform less technical work and focus instead on managing a project or a team of engineers.

Engineers typically follow a four-year undergraduate degree in a specific discipline such as chemical, civil, mechanical, electrical or electronic engineering. At undergraduate level students are given basic training in the sciences, including subjects such as mathematics, physics and chemistry. As students advance, they get to work in specialised areas, and many engineers work in multiple disciplines; for example electrical engineers may write software or design an electromechanical motor. Engineering is a financially rewarding field of study and can open up opportunities to enter into many careers.

ENGINEERING SCIENCES STUDY PATHS

National Senior Certificate:
With Mathematics
and Physical Science

Each education institution has its own unique entry requirements for each of its programmes. It is important to check the entry requirements for the programme with the institution of your choice before you apply.

University
Bachelor of Science Degree or
Bachelor of Engineering Degree

Majors in:
Aeronautics
Chemical
Computer
Civil
Electrical
Geodetic
Industrial
Mechanical
Metallurgy
Mining
or any other related subject.

University of Technology
National Diploma

Diploma in:
Chemical
Civil
Electrical
Industrial
Mechanical
Mechatronics
Metallurgy
Refractories
or any other related qualification offered by the institution.

Internship / Workplace Experience

In order to register as a Professional Engineer at the Engineering Council of South Africa (ECSA), you first have to register as a Candidate Engineer and gain three years of work experience.

Professional Review
(Engineer)

After completion of the candidate phase ECSA conducts a professional review of the work experience. You can apply for registration as a Professional Engineer after the review has been completed.

Designation:
Professional Engineer

Only engineers registered with the ECSA may use the designation Professional Engineer. A designation is a title that a professional person may use (write behind her/his name) to indicate that she/he is fully qualified in a certain professional field and is a member of a professional body.

UNMANNED AERIAL VEHICLES

What started out as a platform for hobbyists is now poised to become a multimillion dollar industry. Aerial rebotics, hyperspectral remote sensing and artificial intelligence are now used for environmental protection, storm prediction, food production and can even be used as delivery vehicle.

An Unmanned Aerial Vehicle (UAV), or drone is basically any aircraft flying in the sky without a pilot ranging in size from an airoplane to a bumblebee. Most drones are made of carbon fibre making them light and easy to land without disturbing the environment. Drones have a human controller on the ground.

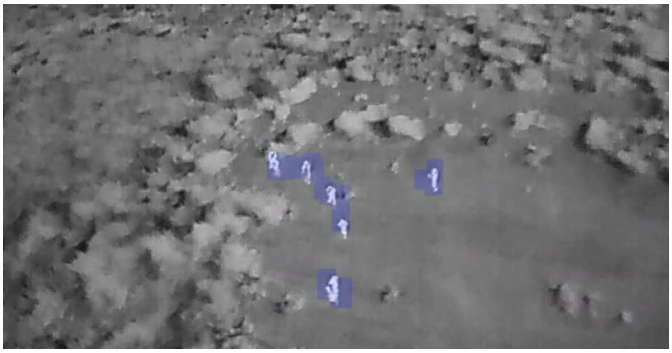
Drones make use of digital cameras to scan and help create 3-D maps. Hyperspectral imaging identifies features of plants and water by measuring reflected light; LiDAR measures how long it takes for an emitted pulse of light to reach a target and return to the sensor, can be used to calculate the distance to an object and its height, which is used for 3-D maps.

Although UAVs have been around for many years they have only recently become widely used for scientific research, conservation and for medical support.

UAV APPLICATIONS

Combat Poaching & Track Wildlife

One of the most innovative use of drones is in the fight against poaching in the Kruger National Park. They use BatHawk fixed-wing drones, fitted with cameras, video transmitters and telemetry, and with battery changes they can fly for more than eight hours over areas difficult to patrol there especially at night. The aim of the project is to up surveillance and help spot suspects quickly using thermal cameras to detect heat from living creatures including humans operating under the cover of darkness. See image below. (https://oxpeckers.org)



Drones are tracking wildlife, counting animal populations, and helping move animals as well as monitoring enforcement in conservation areas. (https://wildtech.mongabay.com/2016/05)

A small but noisy drone being used to guide elephants away from human areas.

Monitor and Track Coral Bleaching

The Great Barrier Reef is roughly the size of Japan and home to around 3,000 reefs stretching 2,300 kilometres. This makes it slow and costly to survey using traditional methods. For this reason drones are being used to monitor and track bleaching level changes for individual corals over time. Low-altitude drones can cover far more area in a day and are not hampered by cloud cover as manned aircraft and satellites are.

Drones fitted with hyperspectral cameras can identify reefs threatened by coral bleaching so that this can be more proactively studied and managed. See coral being photogrphed on opposite page. (https://www.uasvision.com/2017/09/04)

Monitor Volcanoes

There are few things more dangerous and difficult to monitor than an unstable volcano. This is why Einat Lev, seen below, a research professor and volcanologist, is using drones to study and improve eruption hazard assessments and predictions. She used drones equipped with a camera to take thousands of photos of the 2014-2015 lava flow of the Holuhraun volcano in Iceland, one of the largest lava flows in recorded history. The photos are being used to create a 3-D digital topographic map of the flow. LiDAR scanned the topography of the main vent and a thermal camera recorded temperatures at cracks and hot springs. (http://blogs.ei.columbia.edu/2015/09/09/from-the-field-mapping-lava-flows-in-iceland/)

Delivery of Medicine

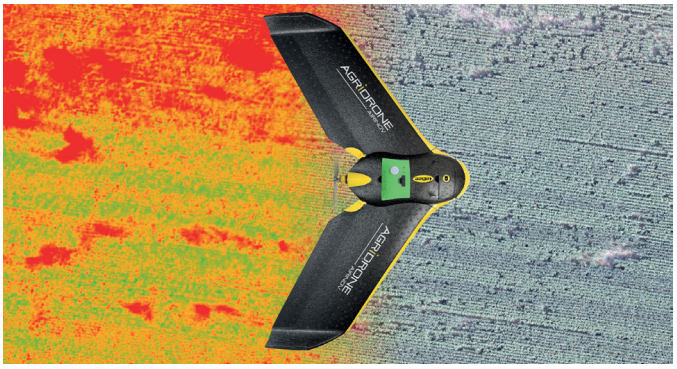
Due to lack of adequate transportation, drones are being used to deliver medicine from cities to rural or remote locations in countries in West Africa. Using this zipline drone service, health professionals at clinics or hospitals call, text, or Whatsapp orders to their nearest distribution centre for the medical products they need. In as little as 15 minutes, the package containing the order is delivered by drone, landing by parachute in a designated area, the size of a few parking spaces. Hospitals are then notified via text message and the drone returns to the centre for its next delivery. The process is faster than any other mode of transport available.

Predict Storms

Drones are used in storm prediction, particularly useful for advanced warning of hurricanes and violent storms. Below, the swirling circulation pattern of Tropical Storm Frank off the southwestern coast of Baja California was captured by Ames Research Center's HDVis camera mounted on the aft fuselage of NASA's Global Hawk unmanned research aircraft Aug. 28 during a hurricane monitoring flight. (http://research.noaa.gov)

Food Production

Drones are being used to measure the height of crops, study crop health and reaction to environmental factors. Flying close to crops, the drone uses a 2-D laser scanner to estimate crop height. Scientists here are also developing a drone that can pick leaves off crops so that they can be analyzed for crop health or to determine the identity of a weed. Natural damages on crops represent tens of million euros of expense every year. AIRINOV UAV can picture the entire crop with 30 cm precision in order to spot impacted zones and assess their size, see below. (https://www.airinov.fr/en/services/crop-damages/)



Conclusion

Drones are constantly being improved, being made smaller, cheaper and more capable. But while they have tremendous potential for scientific research, they have some drawbacks. Smaller ones cannot fly out of the controller's line of sight, and larger ones need a lot of people and technical expertise to fly them. There is also the risk of losing a drone through accidents. And because drone use in science is still in its infancy, scientists are building the guidelines as they go, finding their way programmatically, with funding agencies and working within the restrictions each country has for flying them.

NEED FINANCIAL AID?

One of the biggest factors affecting the career choice of young people today is funding for study.

The good news is that the gates of learning are not closed to financially needy students! This is especially true if you have achieved good marks in maths and science at school. Financial aid is provided in different forms by way of bursaries, scholarships or incentive schemes. Read through the options below and check whether you may be eligible for financial aid.

Bursaries:
A bursary is an amount of money granted to a student for the purposes of study. Bursaries are granted on the basis of academic performance, financial need and other requirements. They are usually not paid directly to the student but are administered by a trust or body set up for this purpose. The terms of the bursary will vary from bursary to bursary. Contract bursaries require that the student "pay" for the bursary by working for the bursary provider on completion of studies.

Scholarships:
A scholarship is an amount of money granted to a learner on the basis of outstanding academic or other achievement in a defined field of study. A scholarship is therefore a type of bursary. The word scholarship is often used when referring to international study.

University Discounts & Incentives:
Many institutions offer incentive schemes in order to attract learners with high academic, sporting and leadership potential. Academic incentives are provided on the basis of school marks. To find out more about incentives contact the financial aid bureau of the institution to which you are applying.

Student Loans:
Most young people do not qualify for a bursary and need funding by way of a loan to pay for their studies. Student loans are offered by banking or other institutions for the purpose of paying for studies. Student loans must be repaid once you have graduated. Most banks require you to pay back your student loan over the same number of years that it took to complete your studies and loans must be paid back with interest. Most banks will require some form of surety or security before they grant a student loan. This means that a relative, friend or sponsor must guarantee to repay the loan if you do not. Some banks will also require the person who signs surety for your loan to pay the interest on your loan while you are studying.

The National Student Financial Aid Scheme (NSFAS)

There is a perception that people from poor homes will never be able to study after school. This is not true! The National Student Financial Aid Scheme of South Africa (NSFAS) is financial aid system that enables academically deserving and financially needy students to study.

The student receiving a loan from NSFAS must pay back the capital and interest on the loan. However, interest charged is less than that charged by the commercial banks. To find out more about incentives contact the financial aid bureau of the institution to which you are applying.

The first step in the process is for the student to apply to and be accepted by a university, university of technology or TVET college. Applications must be made via the institution's Financial Aid Office or Student Support Centre. Visit, www.nsfas.org.za for more information.

Funding for post-graduate studies

"My family are not wealthy, so growing up there were financial challenges. Particularly when I got to University and wanted to do my post-graduate degree in Demography and my parents could not afford it. To overcome this, I studied really hard to secure a scholarship and worked on weekends at a furniture store to be able to study my Honours and Masters degrees. Thankfully the funding I received from the Consortium for Advanced Research and Training in Africa (CARTA) in my PhD was sufficient and I did not need the weekend job anymore. My advice to young people is: be prepared to make short-term sacrifices in order to achieve your long-term goals. The process of learning is challenging and time-consuming, but in order for you to be successful and achieve your goals, make the sacrifices now and later on these will pay off. ***Nicole de Wet***

SO, HOW DID THEY FINANCE IT?

Big dreams, hard work and lots of family support

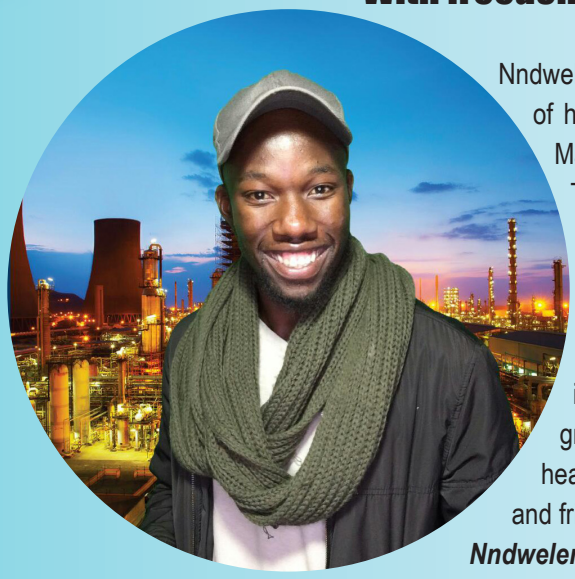
Thakane experienced many financial challenges while studying: "I got financially excluded after my first year and was home for the first month of second year. Towards the end of that month, my mother took my results to the Department of Environmental affairs in Free State and asked them to assist with my fees. I will forever be grateful to her and to the MEC. I did not have additional resources such as laptop and smartphone so I spent more time on campus doing more work than my peers with such resources. Throughout my postgraduate degree, I was a recipient of a bursary from Inkaba ye Afrika. The Inkaba ye Afrika bursary was co-funded by NRF, SA and BMBF Germany. During the last few years of my research, the same Inkaba ye Afrika bursary was funded solely by NRF". ***Thakane Ntholi***

Get a part-time Job!

In order to pay for her studies, Vhonani managed to get a student loan and she had 3 part-time jobs to make ends meet.

"There are many challenges which face students today. Students have to learn to do things for themselves and not rely on entitlement". Apply for funding, look out for opportunities, ask questions … show up and just be where things are happening instead of sitting and complaining about that which is not working all the time. Its all about having the right attitude and taking the opportunities that come up". ***Vhonani Netshendama***

With freedom comes responsibility



Nndwelenil matriculated at Ithuteng Secondary school in 2012, top of his class. He received a bursary from GCRA to study BSc Mathematical Sciences at UJ.

The bursary was worth R50 000 at the time, it covered tuition fees, books, food and accommodation.

"I chose BSc Mathematical Sciences because of the love for mathematics and science. I started my first year away from home, the new environment came with the luxury of independence. I had to adapt and learn to be a responsible grown man. In 2015, I had my first fail academically, it was heart breaking. I lost my bursary and through support of family and friends I managed to complete my studies."

Nndweleni Wayne Sithagu

Self-Help Guide
to my future career in
Science, Engineering & Technology

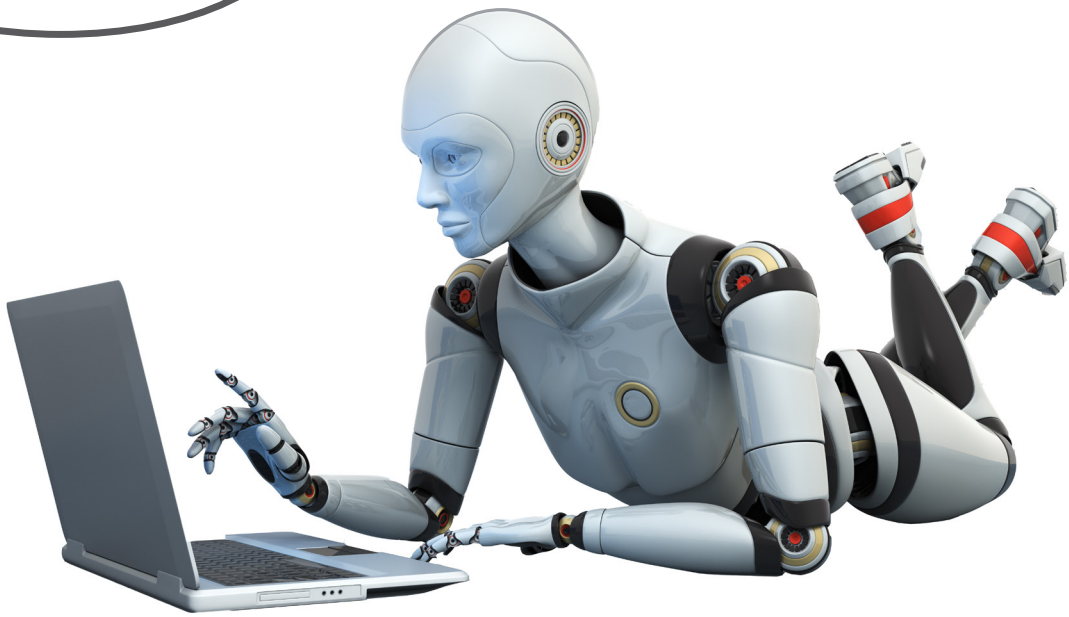
AM I SUITED TO A CAREER IN SCIENCE ?

WHICH FIELD OF SCIENCE AM I BEST SUITED TO ?

WHAT LEVEL OF STUDY SHOULD I COMPLETE ?

HOW DO I FINANCE MY STUDIES ?

WHAT ARE PROFESSIONAL BODIES ?



science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation | SAASTA South African Agency for Science and Technology Advancement

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