KNOW THE CAREER WORLD

SCIENCE TECHNOLOGY ENGINEERING AND MATHEMATICS

By Dr Charles Mugaviri

ISBN: 978-0-7974-7092-7

A LASOF Careers Institute Publication

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Science Technology Engineering and Mathematics Careers

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Printed in Zimbabwe

A product of

LASOF Careers Institute Publications

Agriculture House

1 Adylin Road, Marlborough

Harare, Zimbabwe

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Purposeful Career Planning

www.lasofcareersinstitute.com

ISBN: 978-0-7974-7092-7

DEDICATION

I dedicate this book to the millions of teenagers in and from the African continent. May your lives be consumed by a deep desire to build leadership legacies that will unlock Africa's potential and greatness. Africa is too rich to be poor. You were born for a purpose. You were born to leave Africa a better continent than you found it. Don't disappoint and don't settle for less.

Acknowledgements

No task of this magnitude can ever be achieved without divine wisdom and knowledge. I would like to first and foremost acknowledge the LORD Almighty for granting me the love to inspire and empower my generation.

Writing is time consuming and requires a lot of support from the family. My life has been blessed with a loving wife and supportive purpose partner Shingie. For close to the three decades that I have known her, she has supported me through thick and thin, highs and lows and has been the most loving and inspirational person I have known in my life time. I would like to also acknowledge the unflinching encouragement I have received from my loving and dear children Tinashe Charles Jr, Tendaishe and Takundanashe. My wider family and friends have been great and deserve special mention.

I would like to also acknowledge the inspiration and motivation that I have received over the years from the legacy building individuals that I have worked with in the Church community, at the University of Zimbabwe and at LASOF Leadership Institute. Our journey together of inspiring and empowering thousands of learners to make purposeful career choices and become character based leaders ignited the desire and vision for this career guidance series.

Each learner, parent, school, company, government department, Church or NGO who came through our career and leadership programs in Zimbabwe and the wider African region has inspired us to continue the journey and they deserve special acknowledgement. You each made me believe this was a worthwhile cause.

Special acknowledgement goes to the Joshua Nkomo Scholarship Fund. The opportunity you granted us to develop the career and leadership capacity of your scholarship beneficiaries (the Joshualites) over the last ten years has been truly a mutually enriching experience which went a long way in inspiring me to write these books.

Introduction

The career world is diverse and dynamic. Before you make a career choice, it is important that you have an appreciation of the width and depth of the career world in terms of options that are available.

A career is a chosen pursuit, a profession or occupation requiring special training, followed as one's lifework. It is a path or course one chooses to follow to earn a living. It is the progression of one's working life or one's professional achievements, for instance a soldier or a teacher. A career is a course of successive situations that make up a person's occupation. A career is therefore doing what one does as a permanent occupation.

The term career is derived from the Latin word *carrera,* which means race. The verb was first attested in 1594 from the notion of a horse "passing a career" on the jousting field. A career is usually considered to pertain to remunerative work and formal education. One can have a sporting career or a musical career without being a professional athlete or musician, but most frequently "career" in the 20th century referenced the series of jobs or positions by which one earned one's money.

Career Cluster is a broad group of related career majors within an occupational interest area. They represent groupings of occupations and industries based on shared traits. There are sixteen (16) career clusters that cover all occupations.

This book focuses on the Agriculture, Food and Natural Resources career cluster.

Perspectives on career planning

One of the most important choices you have to make in your life time is selecting a career. This choice has far reaching implications and it has to be an informed choice. The quality of information you have determines the quality of decisions you make. This book is a tool designed to empower you to make an informed career choice that you won't regret in the future. In this introduction, we are going to share some perspectives that you need to take into account as you make use of this book.

Purpose perspective to career planning

Take a moment and think of the best footballer in your nation. Think also about your favourite local musician. Can you imagine the two of them switching places? How do you think the footballer would perform on the music stage and the musician in the football field?

We were all created and designed to fulfil a specific purpose in life. None of us was created to do everything. You have a life purpose that will bring out your best. That purpose is your life assignment. You need to choose a career that is aligned to that assignment. In fact your career should be an expression of that assignment. The platforms for expressing your purpose may vary from one season to another but the assignment itself does not change. Its expressions may also change but your purpose will remain a constant factor in life.

Many professionals today are not fulfilled and satisfied with their careers mainly because of a lack of purpose perspective in the manner they selected their careers. Your career should be an expression of who you are and it must be an opportunity for you to utilize your gifts, talents, passions and other latent abilities. This is why you must first know yourself well before you make your career choice. This question of self-knowledge is fully addressed in the book "Know Yourself: A Foundation for Career and Character Development" which is the first book in the Career Education series.

Dynamic perspective to career planning

You also need to appreciate the career world is so dynamic and ever changing. Did you know for example, that the top ten jobs in the world in 2010 did not exist in 2004? You need to be aware that some of the jobs that are on demand today may not be relevant in the future. Can you imagine what is happening to someone who invested all their time in developing a career that has to do with manufacturing or repairing manual type writers?

The dynamism of the career world means you need to be prepared to continuously develop new knowledge and skills that are relevant to the ever changing career world. Multi skilling is also important as you will have to adapt to the changing socio economic and political environment.

Please note the career listing in this book is not exhaustive. There are other careers that are not mentioned in this book under this career cluster. The ones listed here are only samples.

Local perspective to career planning

When making a career choice, invest effort in developing an understanding of the economic environment in your country as it has a direct bearing on the labour markets. You don't want to spend years developing knowledge and skills in an area where there are limited or no employment prospects. You need to have some insights in terms of employment trends in your local job market.

For example, a country like Zimbabwe did not have diamond mining until a few years ago. Today, however, diamond mining is redefining the economic terrain in ways that have far reaching implications in terms of new career opportunities. Diamond cutting, for example, is a new career pathway that had never been explored before but that is becoming a major area of employment opportunity as Zimbabwe has the fourth largest diamond deposits in the world. We have other examples of countries in countries that have discovered oil deposits like Ghana. Such developments have far reaching economic implications that are reflected in new career opportunities.

Global perspective to career planning

We encourage all learning to also develop knowledge and an appreciation of regional and global economic and employment trends. There is a lot of migration of skills across nations and continents. Developments in other parts of the world will have some bearing on developments in your nation as well. It is wise to have a global perspective even when you are deciding to pursue your career locally.

In this book, we have looked at the Career world from both an African and global perspective. There will be many careers you may see that you have not heard about before. Some of them may be in your country but you have not been aware of it. Other listed careers may not be found in your country. This broad view should help you to appreciate local, regional and global trends in terms of the career world.

Entrepreneurial perspective to career planning

The rate of unemployment has been growing across the nations of Africa and the world. There is need to rethink the traditional approach to career planning and employment. It is important to observe that in most African nations the informal or Small to Medium Enterprises (SMEs) sector is growing rapidly. Many people are creating jobs for themselves and others instead of seeking and waiting for non-existent employment opportunities.

As you plan your career, you need an entrepreneurial perspective where you see yourself as a prospective employer not just an employee.

Contents

Science, Technology, Engineering and Mathematics Career Pathways and Sample Careers

Focus: Planning, managing, and providing scientific research and professional and technical services (e.g., physical science, social science, engineering) including laboratory and testing services, and research and development services.

Cluster Summary: Careers in the Science, Technology, Engineering and Mathematics cluster are usually very technical and employ people who are good at problem solving and measuring things. People in these occupations may do lots of research. They may work in laboratories or in offices. You can be an engineer, archaeologist, astronomer or meteorologist and be in this career cluster.

Career Pathways	Sample Careers
Engineering and Technology	•Aerospace Engineer •Aeronautical Engineer •Agricultural Engineer •Agricultural Technician •Application Engineer •Architectural Engineer •Automotive Engineer •Biomedical Engineer •Biotechnology Engineer •Chemical Engineer •Civil Engineer •Communications Engineer •Computer Engineer •Computer Hardware Engineer •Computer Programmer •Computer Science Technician •Computer Software Engineer •Construction Engineer •Consultant •Development Engineer •Drafter •Electrical Engineer •Electrician •Electronics Technician •Energy Transmission Engineer •Environmental Engineer •Facilities Technician •Fire Protection Engineer •Geothermal Engineer •Hazardous Waste Engineer •Hazardous Waste Technician •Human Factors Engineer •Industrial Engineer •Industrial Engineering Technician •Licensing Engineer •Manufacturing Engineer •Manufacturing Technician •Manufacturing Processes Engineer •Marine Engineer •Materials Engineer •Materials Lab & Supply Technician Mechanical Engineer •Metallurgic Engineer •Mining Engineer •Naval Engineer •Network Technician •Nuclear Engineer •Ocean Engineer •Operations Research Engineer •Packaging Engineer •Packaging Technician •Petroleum Engineer •Pharmaceutical Engineer •Plastics Engineer •Power Systems Engineer •Product Design Engineer •Project Engineer •Project

	manager •Prototype Engineer •Quality Engineer •Quality Technician •Radio/TV Broadcast Technician •Radiology Engineer •Researcher •Safety Engineer •Software Engineer •Sound Technician •Structural Engineer •Survey Technician •Systems Design Engineer •Technical Sales Manager •Technical Writer •Telecommunications Engineer •Textile Engineer •Transportation Engineer •Nuclear Engineer and •Procurement Engineer
Science and Mathematics	•Analytical Chemist •Anthropologist •Applied mathematician •Archaeologist •Astronomer •Astrophysicist •Atmospheric scientist •Biologist •Botanist •CAD operator •Cartographer •Chemist •Communications technologist •Conservation scientist •Cosmologist •Cryptographer •Crystallographer •Demographer •Dye chemist •Ecologist •Economist •Electronmicroscopist •Environmental scientist •Expert systems scientist •Geneticist •Geologist •Geophysicist •Geoscientist •Herpetologist •Hydrologist •Ichthyologist •Inorganic chemist •Laboratory Technician •Mammalogist •Marine scientist •Materials analyst •Materials scientist •Mathematician •Metallurgist •Meteorologist •Microbial Physiologist •Mycologist •Nanobiologist •Nuclear chemists •Nuclear technician •Numerical analyst •Nutritionist •Oceanographer •Organic chemist •Ornithologist •Paleontologist •Physicist •Polymer scientist •Programmer Protein scientist •Protozoologist •Quality-control scientist •Radio chemist •Research chemist •Research Technician •Science Teacher •Lab Technician •Scientific visualization or graphics expert •Spectroscopist •Statistician •Technical writer •Technologist •Toxicologist •Zoologist.

Career 1: Assayer and Sampler

In the mining industry it is very important that information be obtained on the ore that is mined. It is the responsibility of assayers and samplers to take samples for analysis on a regular basis.

Assaying and sampling are the processes through which small samples of ore are taken systematically from the rock face and used to determine the nature, quality and quantity of the ore.

The work of samplers is aimed at taking onsite samples, either in open-cast or underground workings of the mine. They visit different sections of the mine on a daily basis to take ore samples. This is a specialized task, since the information obtained from the ore is vital for planning.

Assayers mainly work in laboratories and determine, by means of chemical processes or other analytical methods, the quantity and quality of elements, both organic and inorganic compounds, and intermediate products in ores. They also process materials and analyze base metals, non-metallic materials, concentrates, effluents and air samples.

They use chemical processes such as fire or dry assay procedures and wet chemical methods. The determination of trace elements requires an exceptional degree of accuracy. Analyses are conducted for metallurgical accounting, process control, effluent control, environmental health and quality control.

The results obtained from the work of the assayer and sampler helps organizations or clients to plan current and future operations more efficiently.

Working conditions vary from pleasant air-conditioned laboratories to hot, dusty and physically demanding conditions. Assayers normally work in laboratories, where a clean environment usually prevails. Non-functional gas and dust extraction systems may render the environment dusty and dangerous. For samplers, working in open-cast mine or underground environment, conditions range from wet, noisy and hot rock face surfaces underground to dry, clean air, rock face surfaces of open-cast mines.

Some fulfilling and satisfying aspects of this career

- liaising between skilled workers and engineers, management
- in the laboratory, working with state of the art equipment
- playing a vital role in the future planning of a mine and its environmental health

Some demanding and challenging aspects of this career
- some working activities may be routine and monotonous
- exceptional degree of concentration and accuracy required
- responsibility attached to job
- having to keep up with advances in this field
- may have to work overtime to complete tests and analysis

Purpose Orientation
An assayer and sampler should:
- have an analytical mind;
- have an aptitude for scientific inquiry;
- be responsible, systematic and neat;
- be interested in the environment and especially geology;
- maintain good interpersonal relations
- have a medical certificate of fitness.

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Geography

Training
Degree: A BSc with Physics, Chemistry and Mathematics, along with practical training.

Diploma in Analytical Chemistry

Employer
- Analytical, chemical and commercial laboratories of companies involved in prospecting, mining, metallurgical, refining, reduction and research operations

Career 2: Astronomer

Astronomy involves far more than just looking at stars. Comets, planets and stars, as well as collections of stars such as globular clusters (up to 1 million stars) and galaxies (up to 100 million stars) are studied. Astronomy is also concerned with how and when the universe began (the Big Bang theory being one explanation) and what will happen to it in the future.

Astronomers research the nature, origin and evolution of astronomical objects to obtain a deeper understanding of the laws of physics. They are essentially physicists who use the universe as a laboratory.

Because one cannot travel to the stars in order to retrieve pieces of them for analysis in one's laboratory, one must use all other available information, such as radiation across the entire electromagnetic spectrum - from radio waves to gamma rays and cosmic rays - tiny particles that interact with the earth's atmosphere or magnetic field.

Astronomers use their knowledge of mathematics and physics to study the nature, origin and evolution of astronomical objects to obtain a deeper understanding of the universe. This knowledge can be applied to developing navigational systems that will enable us to find our way through space.

Information on astronomical objects is collected by detecting their signals through space-based, ground-based, optical, gamma ray, X-ray and radio telescopes in conjunction with sensitive detecting devices. This data is analysed, often with the aid of computers, and interpreted in the framework of mathematical models incorporating the ideas of modern physics.

Astronomers do not usually work at night and sleep during the day. Many theoretical astronomers work normal hours and do not have to make any observations. Radio observations can be made during the day as well as at night, but much of the telescope's functions are pre-programmed and do not require the constant presence of an astronomer.

Optical and infrared astronomers do the observational part of their work at night. For every week-long "observing run" at night, an astronomer will spend six to ten weeks on a normal daytime schedule, analysing data and doing other work.

Observational astronomy occupies much less of the astronomer's time than analysing data. Observational astronomers plan research which involves the measurement of electromagnetic radiation (such as light waves). They analyse the results obtained and publish the findings so that others in the field will have access to the information.

Theoretical astronomers concentrate on developing theories concerning various aspects of the universe. It is possible to work in both theoretical and observational astronomy, although most astronomers tend to be more active in one or the other.

Some astronomers also teach Mathematics or Physics at a university.

Some fulfilling and satisfying aspects of this career
- the challenge of solving problems which can help gain an understanding of the universe
- knowing either in person or by reputation, many other active astronomers due to the relatively small size of the community of astronomers
- the satisfaction of introducing students to astronomy

Some demanding and challenging aspects of this career
- night, weekend and holiday work
- the frustration and disappointment involved if one's research does not work out as expected
- the large amount of time required to keep up with current work in the field

Purpose Orientation
An astronomer should:
- have serious interest in Physics and Mathematics
- have above-average mathematical ability
- be able to work well independently, as well as in a team
- have good interpersonal skills and adaptability
- have a good imagination and an inquisitive mind
- be persistent and able to concentrate on details
- be able to take criticism and co-operate with others
- have good verbal and literal ability

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Information Technology

Training
Degree: BSc degree with Physics, Mathematics, Engineering or Chemistry as major subjects, Arts majors are also acceptable.

Employer

Job opportunities are limited, but astronomers can usually obtain research grants anywhere in the world. Although they are not always employed in astronomy itself, astronomers are seldom unemployed, because of their high level of training in Physics.

Although astronomers cannot earn their own money directly as an astronomer, there are some who become free-lance astronomy or general science writers, or even science-fiction writers.

Career 3: Automotive Body Repairers or Panel Beaters

Automotive body repairers, or panel beaters as they are commonly known, are responsible for the repair and realignment of damaged and dented panels of the bodywork of motor vehicles.

Panel beaters straighten bent frames, remove dents and replace damaged body parts. They use special machines to align damaged frames, body sections, and unit bodies.

The bent framework or bodywork of a damaged vehicle must firstly, with the help of special equipment, be bent back to its original position so that the doors and bonnet fit properly. To even out the dents and bumps, panel beaters use various hammers to beat the metal from outside or inside until it is even.

In some cases badly damaged sections of body panels are removed and new ones welded in their place. Small dents are repaired by smoothing them out or by filling them with plastic or solder. Dents are then filled, sanded, and painted.

Panel beaters are also responsible for the final assembly and inspection for true fit, as well as for the testing for proper connection and working components in electrical fittings and lights. The work is becoming more and more specialized, for example, in frame straightening, door and fender repairing or the installation of glass.

Panel-beating is hard work. It is not expected that the repair worker handle heavy objects, but the work can be physically tiring and the continuous pounding and grinding can be very wearying. The noise may be unpleasant and the work environment dirty.

Some fulfilling and satisfying aspects of this career
- working with your hands
- rendering a service to others
- seeing the results of your labour

Some demanding and challenging aspects of this career
- becoming soiled and greasy
- keeping up with the physical demands of the work
- having to work overtime on occasion

Purpose Orientation
An automotive body repairer should:
- have a good sense of judgement;

- be able to work accurately;
- have physical strength and stamina;
- have eye-hand coordination;
- have good spatial and form perception;
- be able to work with mechanical tools;
- have manual dexterity;
- possess mechanical insight and knowledge.

School Subjects
Ordinary Level Certificate.
Some employers demand higher qualifications.

Compulsory Subjects: None
Recommended Subjects: Mathematics

Training
Candidates may register as learners with any employer in the motor trade, provided that the employer is able to provide the required training.

Employer
- Auto body repair and paint shops
- Automobile and truck dealers
- Trucking companies
- Bus and transport companies
- Motor vehicle manufacturers
- Other companies that maintain their own motor vehicles
- Government departments such as the Department of Transport
- self-employment, with sufficient capital to start own business

Career 4: Automotive Electricians

Automotive electricians manufacture, install, repair and maintain electrical systems and equipment in motor vehicles.

Motor vehicles have two electrical systems, namely an ignition system and an accessory system. The ignition system consists mainly of the battery, distributor, induction coil, high-tension wires and spark plugs. The starter motor, alternator or generator, voltage regulators, lights, windscreen-wipers, hooters, indicators, electrically operated windows, aerials, radios, tape players, revolution counters and fuel gauges are part of the second system.

Automotive electricians are mainly concerned with accessory systems which comprise the starter motor, generator, lights, windscreen wipers, indicators, hooters, as well as electrically operated windows, aerials, and radios.

They also have a thorough knowledge of ignition systems since defects in accessory systems may have a detrimental effect upon vehicles' electrical systems as a whole. Automotive electricians do a fair amount of routine work such as replacing bulbs and setting regulators. Specialized work includes tracing faults with special equipment.

Some fulfilling and satisfying aspects of this career
- good salaries and benefits
- the satisfaction of solving difficult problems
- working with your hands

Some demanding and challenging aspects of this career
- working in a standing or stooped position
- the possibility of injury whilst on the job

Purpose Orientation
An automotive electrician should be/have:
- mechanically and practically minded
- able to think logically and clearly
- able to work accurately and have self-discipline
- good health and manual dexterity
- good vision and colour discrimination
- reliable and punctual
- safety conscious, to avoid unnecessary accidents like electrical shocks
- business sense and good judgement

- care about the quality of work and customer satisfaction

School Subjects
Ordinary Level Certificate.
Some employers demand higher qualifications.

Compulsory Subjects: None
Recommended Subjects: Mathematics

Training
Automotive electricians receive their training by entering into a learnership with any approved employer in the automotive industry.

Employer
- motor car manufacturers
- garages
- electrical equipment repair shops
- shops specialising in fitting car radios and tape recorders and speed control systems
- self-employment, with enough capital to start own business

Career 5: Automotive Machinists

Automotive machinists are skilled metalworkers who build, assemble, and renew internal combustion engines and engine components according to manufacturer specifications. They perform a variety of machining operations on engines and engine components of used vehicles.

When vehicle engines are worn out, they burn too much oil and fuel and have to be rebuilt. This process includes the dismantling and cleaning of the engine, grinding various parts and manufacturing and fitting others. Automotive machinists inspect all the components thoroughly for cracks and other faults, then clean and rebuild parts where necessary. When turning and fitting the different parts, the re-assembling of the engine's substructure has to be carefully done, before the engine parts can be balanced. The engine is then 'mounted' and a dynamometer used to test if the engine functions correctly.

The work is very precise and is usually carried out indoors, in well-equipped workshops. Working conditions can be somewhat dirty and noisy, as lathes, grinders, drilling and milling machines are used.

Some fulfilling and satisfying aspects of this career
- working with your hands
- steady employment
- being able to see the results of your work
- opportunities to perform a variety of tasks

Some demanding and challenging aspects of this career
- noisy environment
- possible injury on the job
- being on your feet most of the day
- sometimes having to work overtime

Purpose Orientation
An automotive machinist should:
- be able to work independently;
- be able to concentrate on details;
- perform work very accurately, with an eye for detail;
- enjoy working with his hands;
- have mathematical aptitude;
- be able to work with mechanical tools;
- have finger and hand dexterity;

- have good eye-hand coordination;
- possess good physical health and stamina;
- have good eyesight and hearing.

School Subjects
Ordinary Level Certificate.
Some employers demand higher qualifications.

Compulsory Subjects: Mathematics
Recommended Subjects: None

Training
Trained tradesmen train the automotive machinists in different workshops.

Employer
- Motor car assembly factories
- Motor engineering industry
- Garages
- Independent workshops
- Motor manufacturing industry
- Organisations that maintain their own vehicles
- Government departments

Career 6: Automotive Sheet Metal Workers

Automotive sheet metal workers cut and shape sheet metal components into the correct forms and sizes for the bodywork of vehicles.

Automotive sheet metal workers cut and rivet sheet metal, applying heat treatment. They finish off the sheet metal by joining, filing, sanding and smoothing it down. They use electrical and gas welding techniques to join soft steel of different thickness.

Automotive sheet metal workers often have to draw plans, according to which the parts are cut and put together. It is important that the components fit together exactly. They need to know about the qualities of different metals, since decisions must be made as to the correct type of metal to be used.

They usually work indoors in a workshop and mostly at a bench. Neon or indirect lighting is often used to soften the glare reflecting from the bright surface of the sheet metal. The work is of a relatively clean nature. The hammering of the metal sheets causes some noise.

Some fulfilling and satisfying aspects of this career
- working with your hands
- being able to see the results of your work

Some demanding and challenging aspects of this career
- the possibility of injury while on the job
- working in a noisy environment
- sometimes limited job opportunities

Purpose Orientation
An automotive sheet metal worker should:
- like to work with his hands;
- have mathematical aptitude, since geometrical principles are constantly applied;
- have knowledge of and be interested in metals, since decisions must be made as to the correct type and quality of metal to be used;
- be able to work accurately and neatly;
- possess good hand and finger dexterity;
- have good eye-hand coordination;
- have good health and physical fitness;
- have good vision and colour discrimination;
- have manual dexterity.

School Subjects
Ordinary Level Certificate.
Some employers prefer higher qualifications.

Compulsory Subjects: None
Recommended Subjects: Mathematics

Training
Apprenticeship training

Employer
- Motor vehicle manufacturers
- Bus body building companies
- Automotive body repair shops

Career 7: Automotive Trimmers

Automotive trimmers upholster motor vehicle seats, line their roofs, floors and door panels and also install windows, windscreens, backrest boosters, trimmings and leather coverings in the interiors of motor vehicles.

Automotive trimmers use tools and equipment such as scissors, needles, tongs, hammers, screwdrivers, and sewing machines. They first remove the door handles and then detach the upholstery and trimmings from the door panels, floor, roof and seats. Thereafter, they match, measure and cut new material to the required shape, size, and pattern and then upholster the parts concerned. Finally, they replace all hinges, handles, and other trimmings and perform any finishing touches that may be necessary to the interior of the vehicle. Automotive trimmers also check that the seats of the vehicle are fitted in the correct position. They may also work on the interior of vintage cars.

Because trimmers work mostly with new materials, the workshop is usually relatively clean and pleasant. Various machines and tools, such as various types of cringes (leather, synthetic leather and vinyl) and special sewing machines, are available and workshops are well lit and ventilated.

Some fulfilling and satisfying aspects of this career
- being creative with one's hands
- working at a quick pace

Some demanding and challenging aspects of this career
- working under time constraints
- having to work under close supervision

Purpose Orientation
An automotive trimmer should:
- have a good colour sense;
- enjoy working creatively with their hands;
- be able to work quickly and accurately;
- work neatly and carefully;
- be able to work in a team;
- be reasonably strong to be able to pull material tightly over the frames;
- be dexterous;
- have steady hands and deft movements;
- have good eyesight and eye-hand coordination.

School Subjects
Ordinary Level Certificate.

Compulsory Subjects: None
Recommended Subjects: None

Training
After the training period working for an employer in the motor industry, prospective automotive trimmers may qualify and register as tradesmen.

Employer
- Large vehicle manufacturers
- Automotive body repairers
- Larger private garages and workshops
- Upholstery factories

Career 8: Biodiversity Information Management Technician or Specialist

Biodiversity Informatics in Africa, as in other parts of the world, is a young and dynamic field of science, requiring new techniques and innovations to analyse biodiversity data.

A range of professionals and technicians provide essential ICT services to biodiversity organisations. These people combine the necessary knowledge of Information and Computer Technology with their knowledge of biodiversity and ecosystems. Tasks include researching, analysing, organising and presenting biodiversity information and related scientific data and studying the literature related to conservation blueprints, priority landscapes and properties.

They may collect information in digital format, for example, GIS (Geographical Information System) technicians and specialists map information about plants, animals and their distribution patterns, or changes in soil, weather etc. in the form of digital maps.

They may design databases, enter information into databases, and take responsibility for keeping them updated. They may use information contained in existing mathematical models or which they may have to develop themselves.

GIS specialists produce digital maps that can be enlarged to show the various features of an area, e.g. its soil types, micro-climates, vegetation types, distribution of animal populations, human populations and their activities. A variety of other scientists and managers then use this information to develop policies, predict changes, and, where necessary, change the way in which the environment is managed. Very important in the context of climate change and ecosystem degradation, this work can be used to warn people about possible disasters such as storms, floods and droughts that could occur.

GIS specialists usually work in clean, well-lit and well-ventilated offices. They generally work in a shared environment, but can also work in their own cubicle equipped with computers and automated mapping equipment. The work often involves long hours working in front of a computer: some GIS professionals also go into the field to collect data.

Purpose Orientation

- have very good mathematical and general analytic skills
- good computer skills
- spatial reasoning
- visual aesthetes for map-making
- good attention to detail
- in some cases, modelling skills

- be meticulous and handle a lot of data with great care and accuracy
- have social skills
- be able to listen well and interpret the exact nature of the needs of other researchers and managers in order to come up with the correct products, software, models, etc. for them.

School Subjects
- Advanced Level Certificate meeting degree requirements for a degree course
- Ordinary Level Certificate meeting diploma requirements for a diploma course
Each University or College has its own entry requirements.

Compulsory Subjects: Mathematics (to do modelling and programming)
Recommended Subjects: Geography, Information Technology, Computer Applications

Training
Degree: BSc, BA or BSocSc with subjects such as Environmental Management, Geography, Mathematics and Computer Science, all universities.

Postgraduate: Remote Sensing and GIS should be taken at this level.

It is essential to continuously improve one's knowledge because systems are constantly changing.

Possible Career Paths

Entry level in this career is an information officer who can become a GIS specialist.

Employer
• research institutions
• large conservation agencies
• museums
• other government departments.

Career 9: Biodiversity or Conservation Planners

Biodiversity or conservation planners are primarily scientists, whose main tasks are to lead the identification of biodiversity priority areas in the landscape, and the development of strategies and tools that support the conservation of such priority biodiversity areas. This latter process often involves engagement with scientists and other professionals outside of the conservation sector, e.g. policy-makers, land-use planners, environmental managers and landowners.

In order to identify biodiversity priority areas, biodiversity or conservation planners firstly need to have a well-developed sense of the landscape. For this reason, they typically come from an ecology or geography background, and have spent extensive time in the field. They need to have a good understanding of the different elements of biodiversity – species, ecosystems, ecological processes – and how these interrelate. Biodiversity planners need to understand natural systems, and also how these interact with man-made systems.

Biodiversity planning is a scientific rigorous exercise that draws very heavily on data – biodiversity planners therefore work together with biological researchers and institutions – to gather, analyse and interpret biodiversity information.

Due to the complexity of the science and amount of data that inform the process, modern biodiversity planning relies heavily on computers – to perform analyses and also to convey results. Biodiversity planners are therefore good at organising and working with large amounts of data, using database and statistical tools and software.

The primary output of biodiversity planning is always spatial – meaning they are best illustrated with maps. Biodiversity planners, therefore, are skilled operators of spatial analysis software packages (e.g. to analyse satellite remote sensing images), and specifically GIS – Geographical Information Systems.

Biodiversity planners need to be able to convey this complex science, and therefore they need good report-writing skills to capture the scientific assumptions and methodology of each biodiversity planning process (i.e. in a technical report), but also for writing more accessible documents to guide the implementation of the biodiversity plan. For this reason, biodiversity planners need to work closely with the implementers of the plan, in order to understand how best to present the information.

Biodiversity plans are used by conservation agencies to inform their own conservation actions – protected area expansion; reserve management; rehabilitation or restoration, and biodiversity planning can be involved in various levels of those activities, down to developing costing models

for different options, etc.

Biodiversity plans are also used to inform land-use planning and environment management. They often work with authorities such as local or provincial government, to incorporate their conservation or biodiversity plans into the broader planning of the municipality or the province, to ensure that the environment is given attention along with the development needs such as roads, housing and industry.

Biodiversity or conservation planners are likely to travel to destinations all over the country, depending on their assignment. They work in all kinds of weather conditions, depending on the location. Their work involves an interesting combination of being outside surveying the landscape and collecting or verifying data, working indoors with computers, maps and legal and policy documents, and working both on their own and in teams of other scientists, as well as with authorities.

Purpose Orientation
- pay attention to detail
- have good observation skills
- have the ability to integrate data from many sources and test hypotheses rigorously
- have an open and inquiring mind
- have good oral and written communication skills
- be able to work well with people from other organisations and disciplines
- enjoy synthesizing information, analysing data, developing models and finding innovative solutions to problems

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College has its own entry requirements.

Compulsory Subjects: Mathematics (some institutions require Physical Sciences and / or Life Sciences)
Recommended Subjects: Physical Sciences, Life Sciences, Geography

Training
Degree: BA with Geography or Town and Regional Planning or BSc degree in Conservation Ecology, Environmental Science, Natural Resource Management, or other related field, including subjects such as Zoology, Botany, Ecology, Geographic Information Systems, Environmental Management. Another option is BSc Urban and Regional Planning.

Postgraduate: This degree can be followed by a postgraduate qualification or short courses on biodiversity or conservation planning.

Possible Career Paths:

Most people do a basic life science or environmental science degree, often with a GIS component, then start working and develop biodiversity or conservation planning skills through short courses, post-grad studies and ‘learning on the job’.

Employer

• provincial authorities
• municipal and government environmental planning
• research institutes
• wildlife conservation organisations
• environmental conservation companies
• conservation planning agencies
• self-employed – can set up smaller or larger consulting companies providing services to a range of government and industry clients

Career 10: Chemical Engineer

Chemical engineers design, plan and manage plants where chemical products are processed into final or intermediate products of enhanced value. Their work entails the application of techniques that are based on the principles of heat, mass and momentum transfer. They ensure the profitable employment of scientific findings in industrial processes.

Chemical engineers are involved in all phases of chemical products and chemical production. Some work in research, designing and performing experiments and then analysing the results. Others help to design and construct manufacturing facilities, occasionally having to design a pilot plant (or miniature version) as a first step which they follow through to the final step of supervising the workers constructing the actual plant.

Some engineers help to solve the problems involved in producing high quality products at lowest cost. Safety and protection of the environment are key areas.

Chemical engineers design and operate processes for the production of chemicals, plastics, minerals and other raw materials. They may work in crude oil refineries, coal and gas industries and metallurgical industries, as well as in industries involved in the production of food, textiles, plastics, explosives, cement, etc.

Chemical engineers' work can include:

Research And Development: the chemical manufacturing industry is based on processes discovered and developed in the research laboratory.

Economic Evaluation: the economic viability of a production process must be determined by chemical engineers in cooperation with financial and marketing specialists.

Plant And Equipment Design: the manufacturing process entails: selecting the process and type of equipment; compiling mass and energy balances; calculating the capacity and dimensions of the equipment required for the operation of units such as reactors, heating and cooling systems, filters and pipelines; selecting the control system of the plant to control rate of flow, temperature, pressure and concentration; determining flow rate and energy usage; analysing potential hazards to ensure a safe working environment.

Equipment Manufacture And Plant Construction: chemical engineers are involved in the manufacture of the necessary equipment, as well as in the factory layout.

Plant Operation: chemical engineers are responsible for: the testing and commissioning of plant units; the training of operating staff; the start-up of the plant; the efficient and cost-effective running of the factory and solving problems.

Management: as managers, chemical engineers are responsible for ensuring that the chemical plant operates at a profit.

Textile Engineers design and develop processes, equipment and procedures for the production of fibres, yarns and textiles.

Engineering graduates usually begin work under the supervision of experienced engineers and are gradually given more responsibilities as they gain experience. Some engineers with experience and additional education, move into administration or management. Many high-level executives in industry began their careers as engineers.

The chemical engineering industry includes: refineries; industries involved in the extraction of metallurgic materials from ores (for example gold, steel, uranium); industries involved in the manufacture of fertilizer, explosives, paper, chemicals and plastics; industries involved in the processing of coal, and also the management of waste and effluent which may pollute the air and water.

Chemical engineers may be found in a wide variety of work settings ranging from classrooms, as teachers and lecturers, to research laboratories or construction sites. The actual work setting depends on the type of work and on the size, location and financial resources of the employer.

Chemical Engineering Technician
Chemical engineering technicians use their knowledge of engineering and chemistry to operate and improve chemical processes in an efficient, and a safe and profitable way.

They work in close liaison with chemical engineers to design and develop and operate processes for the large-scale production of chemicals, plastics, synthetic fibres, minerals and other useful commodities. They act as a link between plant operators and chemical engineers and spend a good deal of their time in factory production areas.

Chemical engineering technicians collect information related to a chemical process by taking measurements and consulting the operators. They analyse samples in chemical laboratories. They also make calculations and prepare reports required by factory managers.

They may be involved in the building of experimental plants, testing the processes concerned, solving technical problems and could also be involved in determining the economic viability of projects.

Chemical Engineering Technologist

Chemical engineering technologists work with chemical engineers and chemical engineering technicians, using chemicals and related equipment and products for research and development and also for the manufacture of medical and pharmaceutical preparations.

Chemical engineering technologists test products for strength, durability and purity and also produce compounds through complex organic synthesis. Using sophisticated laboratory equipment, they assist chemical engineers in the design, manufacture and operation of chemical plants for the production of plastics, synthetic fibres, minerals and other useful commodities.

They also perform tests for industry, agriculture and medicine. As laboratory instrumentation and procedures become more complex, the roles of chemical engineering technologists in research and development are expanding. They also develop and adapt laboratory procedures to achieve the best results, and they interpret data and devise solutions to problems under the direction of scientists.

Some fulfilling and satisfying aspects of this career
- solving problems
- working as part of a team
- variety in the work and the many specialities available
- good job opportunities

Some demanding and challenging aspects of this career
- frustration in solving difficult problems
- the location of places / towns where there is employment
- the long period of preparation and study required to register as a professional chemical engineer.
- having to continue your education throughout your career to keep up with the latest technological advances in your field

Purpose Orientation
A chemical engineer should:
- be curious, alert and open-minded
- have an aptitude for Chemistry, Physics and Mathematics
- be able to communicate ideas clearly in speech and in writing
- enjoy working as part of a team
- get along well with others
- be responsible
- have managerial and organizational skills

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Information Technology, Engineering and Technology

Training
Degree: The B. degree in Chemical Engineering

Employer
- chemical manufacturers and other industries, such as: petroleum refining, synthetic fuel manufacture, food processing, brewing, minerals processing, paper and pulp, pollution control, manufacture of synthetic fibres, fertilizers and explosives
- government departments
- universities

Career 11: Chemical Laboratory Technician

Chemical laboratory technicians work with chemists and chemical engineers to develop, produce, sell and utilize chemical and related products and equipment.

They set up and conduct tests on products or processes being developed or improved. They measure reactions, analyze results and carefully record data from these tests and experiments.

Some technicians assist with design, equipment installation, and training or supervision of operators on the production line. Others test materials, production processes and final products to make sure they meet specifications and quality standards. A few technicians work as sales personnel.

Areas of specialization include:

- Analytical chemistry
- Polymer technology
- Food processing
- Medicines
- Research
- Production control
- Quality control.

Some fulfilling and satisfying aspects of this career
- working as part of the scientific team
- a wide variety of specialities available
- working in the field of chemistry, without having to obtain an advanced degree
- good job opportunities

Some demanding and challenging aspects of this career
- having to work long hours, weekends or evenings when a test or experiment has to be completed
- having limited advancement opportunities without additional education
- the possibility of injury on the job if safety precautions are not strictly followed

Purpose Orientation
A chemical laboratory technician should:
- enjoy detailed work
- be accurate and careful

- think creatively
- work well without supervision
- be able to communicate clearly both in speech and in writing
- be safety conscious

School Subjects
Advanced Level Certificate for a diploma course

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

Training
Degree: BTech

Employer
- chemical manufacturers and other industries, such as: petroleum refining, synthetic fuel manufacture, food processing, brewing, minerals processing, paper and pulp, pollution control, manufacture of synthetic fibres, fertilizers and explosives
- Atomic Energy Board
- Uranium Enrichment Corporation
- government departments and non-profit organizations
- educational institutions

Career 12: Chemist

Chemists examine the composition, structure and properties of different materials, as well as the processes and changes they undergo. They work in research and development, as well as production and inspection.

In the research and development field, the properties, the composition of matter and the laws that govern the combination of elements are investigated. Chemists use research findings to help create or improve products.

They are instrumental in the development of new products, for instance, paint or drug products. In the fields of production and inspection, instructions are prepared for plant workers, specifying the kind and quantity of ingredients to use and the mixing time for each stage in the process. In the inspection area, chemists test samples to make certain that industry and government standards are met.

Chemists may specialize in one or more of the following disciplines: organic, inorganic, physical, analytical and theoretical chemistry, as well as biochemistry and industrial chemistry. Some chemists work as teachers and lecturers while others are consultants or technical journalists.

Some fulfilling and satisfying aspects of this career
- working as a member of a scientific team
- creating or improving products which benefit others
- variety of work
- the large number of specialities available

Some demanding and challenging aspects of this career
- working long hours to solve problems
- frustrations at unsuccessful resolution of problems or research
- having to continue upgrading knowledge throughout career to keep up with developments

Purpose Orientation
A chemist should:
- be curious and imaginative;
- be able to accept responsibility;
- be thorough, patient and persistent;
- work well with others;
- be able to communicate well in speech and in writing;

- enjoy learning and studying;
- enjoy working with his hands;
- have above-average scientific and mathematical aptitude;
- have good eyesight and eye-hand coordination.

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

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

Training
Degree: A 3-year BSc degree in Chemistry

Diploma: Various universities offer diplomas for technicians and technologists in Analytical Chemistry

Post-graduate study: A Masters degree or doctorate is needed for higher positions in lecturing, research, and administration.

Employer
- Chemical or other manufacturing industries
- Educational institutions
- Research institutes
- Government departments
- self-employment, as a consultant

Career 13: Climate Change Analyst

Climate change analysts evaluate scientific data and carry out research on the climate. The climate data often includes, but is not limited to, information about atmospheric temperature, ocean conditions, ice masses and greenhouse gases. They use this data to create models and to predict probable changes in the earth's climate in the future, as well as what impacts, if any, these changes will have on natural ecosystems and civilisations. They evaluate both the economic and physical impacts of such changes.

Climate change analysts have to be well-versed in both science and policy, typically focusing mainly on either one aspect or the other. Climate change analysts who focus on science are more heavily involved in detailed mathematical modelling of the scientific data. They collaborate closely with the scientists who gather the climate data and work with them to analyse the information and put it in the context of current environmental practices. They might also model how changes to existing government policies could alter the effects of climate change.

Climate change analysts who focus on policy deal less with primary data; and instead, concentrate more on evaluating the published body of climate data in order to draw conclusions and make predictions from multiple studies. These predictions are used to lobby for or against proposed policy changes. They spend a lot of time communicating their findings to non-scientific audiences such as lawmakers and corporations, as well as the general public.

Climate change analysts mainly work indoors. A substantial amount of their time is spent working on a computer, analysing data and writing research papers and speeches.

Some fulfilling and satisfying aspects of this career
- performing a vital service
- being able to follow one's passion

Some demanding and challenging aspects of this career
- working mainly indoors
- often having to spend evenings or weekends working on their data and findings

Purpose Orientation
- have good computer skills
- be able to communicate well
- be organized and meticulous
- be able to use deductive reasoning

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Life Sciences, Economics, Geography

Training
A bachelor's degree in Environmental Science or a related field with an emphasis on studying weather data or the environment and resource conservation, is necessary. Their courses should include Public Policy and Economics.

Students who would like to concentrate more on the science and mathematical modelling aspects of climate change analysis, would need a graduate degree (masters or PhD) with courses including Mathematics, Statistics, Computer Science and Physics.

Employer
- research organisations and institutions
- government departments
- meteorological departments

Career `14: Coal Technologist

Coal technologists are concerned with the recovery and utilisation of all forms of coal and its by-products. They may work in one of the following major areas:

Geology: Coal technologists specializing in geology conduct geological surveys to determine the location, extent and quality of coal deposits. They are closely involved in drilling programmes to determine whether a coalfield can be mined economically. They also decide what the coal can be used for, e.g. electricity generation or gasification for making petroleum products.

Mining: Technologists regularly analyze samples from the coalface and report results to the mine engineer and manager. They determine the presence of methane gas as well as other explosive coal derivatives. They assist in the washing plant and in grading, and provide management with valuable information which can be used to run the mine at a profit.

Coal Preparation and Processing: This field entails product evaluation, quality control and aspects related to the use of coal in power stations. Technologists are employed by Sasol, the petrochemical and metallurgical industry, as well as in the fields of domestic heating and pollution control.

Coal Analysis: Coal technologists evaluate the product in terms of specialized variables and properties. Chemical, analytical and physical tests are performed depending on the nature and application of the product.

Research: This is conducted to determine how the natural resource can best be utilized for the benefit of mankind. These coal technologists continually strive to improve existing techniques and methods in the coal industry.

Some fulfilling satisfying aspects of this career
- challenging and interesting work
- being able to apply modern technology
- contributing towards the country's economy

Some demanding and challenging aspects of this career
- requires lots of concentration
- the environment can be dangerous
- working in cramped and noisy mine conditions

Purpose Orientation

A coal technologist should:
- have scientific aptitude;
- have analytical reasoning ability;
- be practical:
- approach to his work systematically;
- be responsible; physically fit;
- good concentration

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

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

Training
Degree: A BSc degree with Chemistry and/or Geology, Chemical Engineering

Diploma in Chemical Engineering, BTech to qualify as a technologist. This course includes training in coal processing.

Both the degree and diploma takes three years to complete full-time. Some courses may be completed on a part-time basis.

Employer
- Coal mining companies
- Brick manufacturers
- Cement manufacturers
- Coal marketing companies
- Gas plants
- Power stations

Career 15: Concrete Technologists

Concrete technologists apply their knowledge of the properties of concrete to ensure that concrete is produced to a high standard. They are involved in the practical and technical aspects of concrete construction.

The concrete technologist spends time in the laboratory conducting tests to determine the properties and performance of building materials such as cement, stone, sand, extenders and chemical mixtures. Information obtained is used for mix design purposes and compiling of specifications. They also spend time on the construction site ensuring that concrete is being produced to the correct specifications.

Concrete technologists are involved in research projects and special investigations relating to building and construction material techniques. This is a responsible position since poor quality concrete can negatively affect the strength of a building.

Some fulfilling and satisfying aspects of this career
- working with one's hands
- working on different projects
- usually good employment opportunities

Some demanding and challenging aspects of this career
- doing strenuous work
- lay-offs during cold or rainy periods
- the possibility of injury or accidents on the job
- working in noisy and dirty environments
- sometimes having to travel to find work

Purpose Orientation
A concrete technologist should:
- have an aptitude for mathematics and science;
- have a methodical, but practical approach to problem solving;
- be responsible;
- keep up with the latest developments in technology.

School Subjects
Advanced Level Certificate for diploma courses.

Compulsory Subjects: Mathematics

Recommended Subjects: Physical Sciences

Training
Technologist in Training.

After gaining between 2 to 4 years of appropriate practical experience a civil engineering technician or technologist may register under the auspices of the Engineering Council in their country as:

- Registered Certificated Engineer or
- Registered Engineering Technician or
- Professional Technologist (Engineering).

Employer
- Concrete suppliers
- The ready-mixed concrete industries
- Pre-cast works
- Laboratories
- Cement and Concrete Institute

Career 16: Design Engineer

Design engineers produce designs for new or improved engineering products. They work on a very wide range of highly sophisticated products and structures, including aircraft, bridges, medical equipment and agricultural machinery, computers and telecommunications systems.

Design engineers begin each project by looking at a 'brief', (a set of instructions) which explains what the aim of the project is. A car manufacturer, for example, may want to increase sales of one of their cars by reducing fuel consumption or improving the look of a new model. Design engineers are responsible for making sure that the product meets the manufacturer's needs and is safe, efficient, reliable, and is economical to produce. Before they prepare a design, engineers gather information by talking to other experts, reading engineering literature and looking at the results of test data on materials and processes.

Engineers use computer-aided design (CAD) techniques to produce a design on a visual display screen. The computer performs all the necessary calculations relating to the weight of parts and the loads they must bear. The engineer can compare possible solutions by using drawings, calculations, and physical and computer models. Engineers work on models to check and measure the way a product works, which may result in them having to modify their design.

Design engineers work in teams alongside other engineers, technicians and production staff. They may supervise and lead teams of design draughts people. They are also responsible for preparing regular progress reports for project managers and clients.

Aspects of their work include:
- understanding and using physics
- using mathematics to solve technical and scientific problems
- learning how different machines work
- problem-solving by seeking new ideas
- understanding technical drawings and diagrams
- understanding the scientific uses and properties of materials
- planning howa project is to be carried out
- being interested in 3-dimensional design
- working with electricity and electronics
- being responsible for controlling and adjusting equipment
- keeping accurate records or reports.

Communication skills are an important part of being a design engineer because they have to communicate with the client, especially during product development. A product needs to be

continually improved, so the design engineer will already be working on this, receiving specification information from the clients, dealing with various product issues, writing software, debugging the software, testing the software and resolving problems.

Some fulfilling and satisfying aspects of this career
- working and interacting with people
- seeing your product eventually work and be in demand
- being creative

Some demanding and challenging aspects of this career
- things going wrong during a demonstration of a prototype to the client
- having to work under pressure to meet tight deadlines

Purpose Orientation
- have an understanding of scientific principles and mathematical concepts
- be patient and willing to modify designs several times until you achieve exactly the right result
- have good communication skills and be able to work as part of a team
- have a creative approach to problem solving
- have a good understanding of manufacturing processes and construction skills

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College has its own entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Information Technology, Engineering and Technology

Training
Design engineers normally complete an appropriate engineering degree, such as in electronics. Most engineering courses involve some element of design work. Most practical experience is obtained from training-on-the-job.

Degree: The 4-year BEng degree in Electronic Engineering

Diploma: A 3-year Diploma in Electronic Engineering

Employer
- business and industry
- financial institutions

- companies that do product development

Career 17: Diesel Fitter

Diesel fitters are responsible for the repair and maintenance of diesel engines. These include engines on trucks, tractors, earth-moving machinery, pumps, oil rigs and marine engines.

Diesel fitters detect faults and damage in diesel engines and fuel injection systems. They measure the parts to ascertain the extent of the damage and wear and tear and then repair or replace the parts. Much of the work requires meticulous adherence to standards and specifications and all vehicles are thoroughly tested before being returned to the owner.

Diesel fitters are required to use complex measuring equipment such as micrometers, tachometers, and dynamometers. They use hand tools such as spanners, torque wrenches and specialized testing equipment, and fuel injection equipment that has to be kept in a sealed, dust free room.

Diesel fitters work mostly in workshops and sometimes outdoors. The work can be rather dirty and noisy at times.

Some fulfilling and satisfying aspects of this career
- variety of work tasks
- working with your hands
- the challenge of diagnosing and solving problems
- the opportunity to specialize

Some demanding and challenging aspects of this career
- the possibility of injury or accidents on the job
- working in awkward or cramped positions
- having to work in dirty, noisy workshops
- dealing with impatient, critical or rude customers

Purpose Orientation
A diesel fitter should:
- have mechanical aptitude;
- be able to work independently;
- have problem-solving ability;
- be meticulously accurate and careful;
- have manual dexterity;
- have good hearing and vision;
- have physical strength and stamina to be able to work with heavy machinery and components.

School Subjects
Ordinary Level Certificate.
Some employers prefer higher qualifications.

Compulsory Subjects: None
Recommended Subjects: Mathematics, Physical Sciences, Mechanical Technology

Employer
- Municipalities
- Tractor and agricultural apparatus manufacturers
- Service stations of new and used vehicles and tractor dealers
- Independent repair shops
- Vehicle service stations
- Vehicle parts wholesalers and distributors
- Bus and transport companies
- Organisations that maintain their own vehicles
- Government departments
- Self-employment, with enough experience and capital, can start own business

Career 18: Diesel Mechanic

Diesel mechanics diagnose and repair the mechanical and electrical faults of diesel vehicles and machinery.

Diesel mechanics diagnose engine trouble, dismantle the engine when necessary, and replace or repair defective parts. They reassemble the engine and repair mechanical and electrical faults in construction machinery.

In most cases electrical diagnostic equipment is used to locate problems - experienced diesel mechanics are able to locate a problem by listening to the noise in the engine. Mechanical parts are replaced or minor adjustments made.

Diesel mechanics also complete job cards, furnish information on the parts that should be ordered and assist in training learners. They often perform administrative and managerial tasks. Working conditions of the diesel mechanic vary according to the place of employment - for instance, a well-equipped workshop or farm, ship or construction site.

Some fulfilling and satisfying aspects of this career
- variety of work tasks
- working with your hands
- the challenge of diagnosing and solving problems
- the opportunity to specialize

Some demanding and challenging aspects of this career
- the possibility of injury or accidents on the job
- working in awkward or cramped positions
- having to work in dirty, noisy workshops
- dealing with impatient, critical or rude customers

Purpose Orientation
Diesel mechanics should:
- enjoy working with their hands;
- have mechanical aptitude and ability;
- be able to communicate with people;
- be practical and responsible;
- have good eyesight and hearing;
- have good eye-hand coordination;
- have manual dexterity;

- possess physical strength and good health and stamina.

School Subjects
Ordinary Level Certificate.
Some employers demand higher qualifications.

Compulsory Subjects: None
Recommended Subjects: Mathematics, Mechanical Technology

Training
Apprenticeship training

Employer
- Service stations of new and used vehicle and tractor dealers
- Independent repair shops
- Vehicle service stations
- Vehicle parts wholesalers and distributors
- Bus and transport companies
- Organisations that maintain their own vehicles
- Government departments
- Carbonated soft-drink Industry
- Self-employment, with enough experience and capital, can start own business

Career 19: Domestic Appliance Mechanician

Domestic appliance mechanicians test appliances and locate faults with the aid of various diagnostic techniques, testing equipment and specialized tools. Readings from these instruments are interpreted and evaluated to diagnose the problem. Appliances can vary from kettles to microwave ovens and can include toasters, vacuum cleaners, freezers and stoves.

After repairing appliances, mechanicians test them to see if they are in proper working order. They listen for excessive vibrations and make sure that appliances do not overheat, for example. In the case of automatic machines with programmes, they let the machine run through a programme to make sure it is in good working order.

They must adhere to basic safety measures in order to ensure that it works safely and that a high standard of service is obtained from the appliance. Domestic appliance mechanicians sometimes manufacture their own components or attachments, using sketches and diagrams of electrical circuits and mechanical components.

Some fulfilling and satisfying aspects of this career
- working with your hands
- variety of work tasks and locations
- working with people
- the opportunity to specialize

Some demanding and challenging aspects of this career
- working long hours or overtime
- trying to satisfy difficult customers
- the possibility of accidents or injuries on the job

Purpose Orientation
A domestic appliance mechanician should:
- enjoy working with his hands and handling tools;
- be patient and courteous;
- be responsible and careful;
- be a neat and conscientious worker;
- have mechanical aptitude;
- have manual dexterity and good eye-hand coordination;
- have mechanical and technical skill;
- enjoy working with the public.

School Subjects
Ordinary Level Certificate.
Some employers prefer higher qualifications.

Compulsory Subjects: None
Recommended Subjects: Mathematics, Physical Sciences, Mechanical Technology

Training
Apprenticeship training

Employer
- Engineering factories
- Repairing companies
- Large manufacturing concerns
- Self-employment, with enough experience and capital, can start own business

Career 20: Electrical Engineer

An electrical engineer researches, designs, installs, and tests electrical and electronic equipment and supervises its manufacture. Their work involves the generation, distribution and management of all appliances and installations that generate or use electrical energy.

Electrical engineering is often associated with power generation and distribution of power. Power generation involves the generation of electrical power from a variety of sources: hydro-electrical, thermal coal power, nuclear, as well as renewable sources of power such as solar and wind power. Distribution involves transmission lines and sub-stations that are used to distribute electrical energy for power, heating, lighting and other uses.

The fact that there are so many varieties and sources of electrical power means that there are also numerous areas of specialization in the field of electrical engineering. Specialization may also include the design of electrical transmission systems, electric motors and generators, high voltage engineering and power electronics, to name but a few.

The nature of the work may include research and design of new products, the writing of performance requirements and the development of maintenance schedules. Electrical engineers test equipment, solve operating problems and estimate the time and cost of engineering projects. Many electrical and electronics engineers also work in areas closely related to computers (see Computer Software Engineer and Computer Hardware Engineer).

There are various similarities, although also differences, between electrical and electronics engineering. Electronics engineering is often referred to as "light current" engineering and electrical engineering as "heavy current" engineering. The difference lies in terms of the storage, retrieval, transfer and processing of information associated with electronics engineering, versus the application of electrical energy associated with electrical engineering, which is now split into heavy and light current engineering. See Electronics Engineer for more details. However, there is some blurring between the two areas in today's world and career handbooks today prefer to describe electronics engineering as a sub-division of electrical engineering.

Electrical engineers work in a variety of work environments depending on the nature of the work. These environments include offices, design centres or laboratories, as well as outdoors in the project management of large constructions and installations, for instance power stations.

Engineering graduates usually begin work under the supervision of experienced engineers and are gradually given more responsibilities as they gain experience. Some engineers with experience and additional education, move into administration or management. Many high-level

executives in industry began their careers in engineering.

Electrical Engineering Technician

Electrical engineering technicians are involved in the design, installation and testing of electrical motors, generators, alternators, transformers, cables and switchgears. They often act as a link between the electrical engineer or technologist and the artisan.

Electrical engineering technicians create and assist in the processes which generate electrical energy and with the task of distributing electrical energy to the consumer. They test and maintain equipment linked to these processes. They identify and diagnose the possible causes of electrical problems and then rectify these.

They install new equipment at power plants and test to determine whether it functions effectively. Electrical engineering technicians can be involved in the design of anything from household appliances to power stations. They also supervise their aides, who might prepare drawings of layouts and diagrams showing the required wiring.

Studying to become an electrical engineering technician requires motivation and self-discipline. Electrical engineering technicians should be able to apply their theoretical knowledge practically, once they are in the working environment. They also need to keep abreast of the latest technology in their field.

Electrical Engineering Technologist

Electrical engineering technologists specialize in the heavy and light current fields of electrical systems and are concerned with the maintenance of advanced equipment or control systems.

Electrical engineering technologists can be involved in research projects, complicated designs in the manufacturing field and the testing of equipment and of installed machines.

Electrical engineering technologists design, develop, install and test electrical motors, generators, alternators, transformers, transmission lines, cables and switchgear. Their work entails the generation and distribution of electricity for power, heat and light by means of conventional and alternative energy sources, using the electrical machines and power transformers, electrical protection and power electronics, illumination networks and systems.

Electrical engineering technologists usually work in an office, design centre, or in a laboratory. They also work on the sites of large construction and installation projects such as power stations.

Some fulfilling and satisfying aspects of this career

- many areas to choose from, thus working in your field of interest
- solving problems
- opportunity to be creative
- variety and challenge of the work
- good salaries

Some demanding and challenging aspects of this career
- working long hours to finish a project
- the long period of preparation and study required to register as a professional electrical engineer
- having to continue your education throughout your career to keep up with the latest technological advances in your field

Purpose Orientation
An electrical engineer should:
- be an independent thinker and able to visualize abstract concepts
- have above average mathematical and scientific aptitude
- show originality and initiative
- be able to make fast and correct decisions during times of crisis
- function well with other people
- be able to manage projects
- have an inquiring, analytical mind
- have good health and physical stamina
- keenness to learn, combined with logical reasoning
- have good problem-solving skills

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Information Technology, Electrical Technology

Training
Degree: The 4-year BEng degree in Electrical Engineering

Diploma: The 3-year Diploma in Electrical Engineering

Employer
- Government departments

- Mining industry
- Municipalities
- Universities and universities of technology
- Manufacturers of electrical equipment
- Private engineering consultants
- Self-employment, with enough experience and initiative, can work as a consultant or start own manufacturing or engineering company

Career 21: Electrician / Construction Electrician

Electricians are involved in the generation, transmission, distribution and usage of electricity.

They install, repair and maintain electrically operated equipment such as generators, geysers, refrigerators and stoves. They detect electrical faults and repair them. Repairs may involve replacing fuses, switches, or wires. Once the repair is complete the electrician tests the equipment to ensure that it is working properly.

By law, only qualified electricians are allowed to connect cables to electric motors and switchgear and to handle the electrical wiring of all electrically equipped buildings. During the building, for example, of a new factory, an electrician must ensure that the electrical cables are installed.

A construction electrician is involved in:
- pre-planning of installations in domestic, industrial and commercial premises;
- installation of wire ways and switchboards according to specifications and regulations;
- installation of wiring and metering equipment without clashing with other services;
- calculation of electrical load requirements;
- selection of cables and conductors;
- determination of protective devices.

In the distribution of electricity, electricians supervise the erection of pylons, the connection of high-tension cabling on pylons and ensure the thorough insulation of the pylons. Suitable transformers and switchboards, which reduce the current, must be installed at sub-stations.

Electricians working at power stations install and maintain power generators, including the servicing of electrical meters and transformers. Some perform regular inspections on motors, switchgear and transformers to ensure safe functioning.

Some fulfilling and satisfying aspects of this career
- variety of work tasks and locations
- solving problems
- working with your hands

Some demanding and challenging aspects of this career
- working in awkward or cramped positions
- working in noisy and dirty environments
- the possibility of injury or accidents on the job

- working overtime or at night

Purpose Orientation
Electricians should:
- be responsible, alert and cautious;
- enjoy working with their hands;
- be inventive, self-reliant and accurate;
- be able to work under pressure;
- communicate effectively with fellow workers;
- have good health and stamina;
- have good eyesight and colour vision;
- have manual dexterity and mechanical aptitude.

School Subjects
Ordinary Level certificate
Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Electrical Technology

Training
Apprenticeship training

Employer
- Government departments
- Transportation services
- Municipalities
- Factories
- Mines
- Industries
- Private electrical businesses
- Private companies employing electricians
- self-employment, with enough experience, initiative and capital, can start own business

Career 22: Electronics Engineer

Electronics engineering is concerned with the generation, transmission and processing of information and includes computers, software, transmission networks, telephones, radio, television, signal processing and optics.

They design, develop, test and maintain electronic parts and systems for application in the fields of automation, communication, navigation, military arms, data processing and entertainment. Some manage manufacturing processes, while others may be responsible for the marketing of products.

Some examples of applications of electronics engineering are as follows:

- infrared cameras to "see" in the dark, an example of obtaining information. Phenomena that cannot be observed by human beings are transformed by electronics technology to observable phenomena

- computers to solve complicated problems and to assimilate signals, an example of the assimilation of information

- electronic systems involving the control of mechanical and chemical processes, an example of the control of information

- communications, such as international telephone conversations and videophones, an example of the transference of information

- mass media, such as radio and television, an example of the distribution of information

- power electronics for the control of power generation equipment

- control of processes and production lines using remote control and data acquisition systems (SCADA, etc.)

Some areas of specialization include:

Biomedical Engineers apply engineering methods to solve medical and other life science problems

Computer Engineers design computers and associated equipment, including microelectronics,

which involves the design, testing and manufacture of microchips

Mechatronic Engineers design and maintain machinery with electronic and computer control systems

Telecommunication Engineers design and maintain telecommunications equipment such as optic cables, microwave techniques, cellular radio, satellite communications, etc.

Computer Systems Engineers design and manufacture circuit boards used for interfacing computers to other equipment and sometimes write software for controlling computer operations, etc.

Electronics engineers may design, prepare and supervise designs, prepare specifications, estimates, tenders and contracts. Some are involved in establishing and monitoring performance, setting safety standards and specifying methods for modification, maintenance and repair of equipment and systems. Others may examine installations to ensure that they meet contract conditions.

They are likely to liaise with clients, other engineers, technical officers, technicians, trades people and other workers. Modern management abilities are important. Electronics engineers need to be able to participate in planning, organization and the control of proceedings.

Some fulfilling and satisfying aspects of this career
- many areas to choose from, thus working in your field of interest
- variety and challenge of the work
- solving problems
- good salaries
- opportunity to be creative

Some demanding and challenging aspects of this career
- having to keep up with the latest developments
- working long hours to complete a project
- the long period of preparation and study required to register as a professional electronics engineer

Purpose Orientation
An electronics engineer should be/have:
- independent thinker, able to visualize abstract concepts
- strong creative ability, with imagination and vision
- innovation, inventiveness and ingenuity

- above-average intelligence
- keenness to learn, combined with logical reasoning
- good problem-solving skills
- aptitude for and enjoyment of Mathematics and Science
- capable of working independently and as part of a team
- inquiring and analytical mind
- able to manage and organize projects
- able to work under pressure
- perseverance and motivated to achieve

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Information Technology, Engineering and Technology

Training
Degree: The 4-year BEng degree in Electronic Engineering

Diploma: The 3-year N.Dip. Electronic Engineering

Employer
- manufacturers
- government departments
- electronics companies
- universities
- private electronic engineering consultation firms and development laboratories
- large and small private companies involved with the design, development, production and marketing of electronic systems, sub-systems and components of products
- self-employment, with enough experience and initiative, can work as a consultant or start own manufacturing or engineering company

Career 23: Engineering Patternmaker

The work of patternmakers in the metal and engineering industry involves the manufacture of durable patterns from materials such as wood, plastics, fibreglass or metal. These patterns are the starting point for a chain of activities leading to the manufacture of castings for products such as pumps and bearings.

Patternmakers work from drawings; they select and mark material to the shape and size and cut and saw it. After the material has been finished off, it is assembled into the pattern or model, which is used by moulders to form moulds for castings.

Patternmakers work mostly indoors and use equipment such as woodworking, sawing and sanding machines, so that working conditions can be somewhat noisy. Patternmakers are on their feet most of the day.

Some fulfilling and satisfying aspects of this career
- detailed work
- working with your hands
- relatively good remuneration and benefits
- seeing the results of your work

Some demanding and challenging aspects of this career
- tired feet
- irritation caused by dust
- noisy work environment

Purpose Orientation
A pattern-maker should:
- be able to pay attention to detail;
- be able to work carefully and accurately;
- work well under supervision;
- enjoy working with his hands;
- able to concentrate under noisy working conditions;
- be practical;
- have mathematical aptitude.

School Subjects
Ordinary Level Certificate.
Some employers prefer higher qualifications.

Compulsory Subjects: None
Recommended Subjects: Mathematics, Physical Sciences, Engineering and Graphic Design

Training
Apprenticeship training.

Employer
- Foundries or pattern shops in the metal industry
- Boat, motorcar, aircraft and various other industries

Career 24: Engineering Technologists and Technicians

The engineering team plays a vital and creative role in providing society with the services and products that they need, such as water, housing, transport, electricity, communication, manufacturing, entertainment, medical equipment etc. There are many different branches of engineering, with sub-branches under each.

At as professional level, there are three different categories of engineers: professional engineers, professional engineering technologists and engineering technicians and artisans. Graduate engineers are educated at universities while technicians and technologists study at universities of technology and FET colleges. For further information on professional engineer careers, refer to the detailed sections for each specific field of engineering given elsewhere.

Engineering Technologists

Engineering technologists are educated and trained to solve complex engineering problems. They are required to investigate and analyse these problems carefully, and, if they have the necessary experience, plan their solutions accordingly. The work may be of such a nature that standard engineering methods may easily be applied to solve them. On the other hand, new approaches may be necessary if specific problems are encountered. This may involve designing new processes, equipment, structures and anything else that may be necessary. They will be required to supervise the execution of the work. Each member of their staff must have specific tasks allocated to them to see that the work progresses satisfactorily. It is important that regular meetings be held with the staff on site and elsewhere to ensure this. On top of all this, they must take full responsibility for all the work done under their control.

Engineering Technicians

An engineering technician is the most practical of the professional engineering qualifications. Technicians possess a high degree of skills required for manual work; however the application of these skills requires a fairly high degree of scientific and engineering knowledge and a considerable amount of experience.

Apart from the theory dealt with in the classroom, the syllabi include instruction in laboratory / measurement techniques, drawing office work and workshop practice, where applicable.

Examples of the work done by technologists and technicians in the main engineering sectors are described below:

Aeronautical Engineering: they design, plan, develop, manufacture and test aircraft, missiles,

satellites etc. Technologists are involved with the testing and safety of the aircraft while the technicians gather information, make calculations and perform tests

Agricultural Engineering: they are responsible for designing structures and machinery for farming purposes, such as dairies and wine cellars, irrigation, water storage and drainage, soil conservation and processing, and the transport, storage and processing of agricultural products. They are also involved in the research and development of agricultural production systems.

Chemical Engineering: they are concerned with the manufacturing of chemicals on an industrial scale, as well as with the industrial processes that convert raw material into products with a higher economic value through physical, thermal or chemical changes.

Chemical engineering technologists and technicians are qualified to undertake a wide variety of activities. They research, develop, design, construct and operate the plants required to make a variety of processed products from bricks, metals and plastics to chocolate, soap and cheese.

Civil Engineering: civil engineering projects involve the control and adaptation of the physical environment to mankind's advantage. This includes the design and construction of bridges, roads, docks, airport runways, railways, tunnels, reservoirs, canals, sewerage and drainage systems, gas and water supplies and other large structures.

Electrical Engineering: they are involved in the design and testing of equipment before it leaves the factory, or in the installation and testing of power plants.

The technologists are concerned with the maintenance of advanced equipment or control systems, with research and testing. The technicians assist the engineers with the monitoring of the generation of power and the distribution of electrical energy to the end consumer. There are numerous areas of specialization in the field of electrical engineering.

Electronic Engineering: micro-electronics has caused a revolution in the field of electronics and makes it possible to produce more sophisticated, smaller, cheaper electronic products such as computers, microwave and satellite communication systems, electronic medical equipment, as well as control systems for aeroplanes and missiles.

Electronic equipment is designed and developed by a team consisting of the electronics engineer, technologist and technician. Engineering technicians implement, install and carry out the maintenance of the engineering teams' designs. Technicians usually work in fields such as telecommunications and computers.

Industrial Engineering: they design and develop facilities for the economical manufacture of

products. There are many fields of specialization, such as household equipment and furniture, equipment for cars, the interiors of aircraft and medical equipment. Emphasis is placed on the application of industrial processes and staff utilization. The functions are a combination of engineering and business administration.

Mechanical Engineering: they deal with all kinds of machines and are involved in the manufacture, construction, layout, operation, maintenance and supervision of moving machinery and mechanical appliances. Activities include transport, power generation, air-conditioning and other services such as water supply to mines, factories and large buildings.

Metallurgical Engineering: they are involved in extraction of various kinds of metal from ore. The ore is crushed, concentrated and then processed to metal, either through a melting or chemical process. They are also required to determine the cause of defects in metals and propose possible solutions.

Mining Engineering: they ensure effective and safe production. They often work with other engineers and technical management. They are engaged in ore extraction activities from both underground and from the surface workings. Technicians fine the most economical and practical ways of extracting metals from ores.

The engineering technician's work consists of both intellectual and hands-on work. In large companies they may be employed in a highly specialized capacity, using sophisticated techniques and equipment. The work environment varies including laboratories, offices, factories and production sites.

Some fulfilling and satisfying aspects of this career
- generally financially rewarding
- many areas to choose from, thus working in your particular field of interest
- often challenging work, having to solve engineering problems

Some demanding and challenging aspects of this career
- having to work long hours
- frustrations when difficulties are faced in solving problems or repairing items

Purpose Orientation
- accurate and careful worker
- enjoy detailed work and solving problems
- scientific and mathematical aptitude
- sense of responsibility
- perseverance and resourcefulness

- good interpersonal and communication skills
- work well without supervision, and as part of a team
- good health and stamina

School Subjects
For entry into University engineering studies, a minimum of an Advanced Level Certificate is required.

Compulsory Subjects: Mathematics and Physical Sciences
Recommended Subjects: Information Technology, Engineering and Technology, Geography (in certain fields).

Training

Engineering Technologist
BTech degree in Engineering. First of all, a National Diploma in Engineering must be completed at a university. It is a three-year course of which two years are spent on full-time studies and the remainder with an employer in industry where experiential training is acquired. One of the advantages of the technologist course is that this "experiential training" component is an extension to the formal component of the tuition provided, and gives the student first-hand experience of the demands of the working environment.

It also provides the student with valuable contacts in industry for future job prospects. A student who has successfully completed both the theoretical and practical components of their study is eligible for registration as a Candidate Engineering Technologist. This is followed by a further year of full-time or two years part-time studies at a university to obtain the BTech degree in Engineering.

After the completion of a further two years of practical experience, a successful candidate may apply to their country's Engineering Council for registration as a Professional Technologist (Engineering). They will then be in a position to practise as engineering technologists either in private practice or employed as such by a company of their choice.

There are other opportunities for engineering technologists to advance their studies by obtaining the related Masters (MTech) and Doctorate (DTech) degrees.

Engineering Technician
A National Diploma in Engineering. It is a three-year course of which two are spent in full-time study at the university and one with an employer in industry.

After the completion of a further two years of acceptable practical experience, a successful

candidate may apply to their Engineering Council for registration as Registered Engineering Technicians under the auspices of the Engineering Council. There are other opportunities for engineering technicians to advance their studies, by obtaining a Bachelors Degree in Technology (BTech) and the related Masters (MTech) and Doctorate (DTech) degrees.

Employer

- manufacturers
- mining industry
- research laboratories
- universities and universities of technology
- government departments
- universities

Career 25: Extraction Metallurgist

Extraction metallurgists are involved in the recovery of useful metals or minerals such as gold, coal, diamonds, copper and iron, from the ore bodies in which they occur.

After a foundation in physical science has been followed, this field of study branches into the following areas of specialization:

- Ore preparation: extraction processes used are based on the chemical and physical properties of the material
- Pyro metallurgy: processes are based on the heating and smelting of materials in order to extract the valuable metals
- Hydrometallurgy: processes are developed to work with and recover metals in solution.

Some ore bodies contain as little as 5 grams per tonne (5 parts per million) of a precious metal. Extraction metallurgists are required not only to recover these small amounts of material, but also to do so in the most economical way. The skill of a metallurgist to extract as much of the mineral as possible from these ores at the lowest possible cost, will thus become even more important in the future.

They need a detailed understanding of the physical and chemical characteristics of metals and minerals and how these vary under different conditions. They use this knowledge to design, test, operate and maintain processes and plants to extract the metals and minerals, efficiently and economically.

Because of the need to recover as much of the mineral as possible, modern plants use the latest instruments and computers to help monitor the processes and pinpoint problems on the plant as soon as they occur. Hence the metallurgist also needs to be familiar with these systems, amongst others.

The first stage of ore extraction involves the concentration of the minerals in the ore. Through the use of various beneficiation methods the valuable material is separated from the waste material to form an ore concentrate. The initial process of concentration is known as beneficiation, ore preparation or mineral preparation.

The type of material and the grade of the product required determine the exact process used. Thereafter various hydro-metallurgical and pyrometallurgical technicians are available to obtain a product of the correct quality.

Some fulfilling and satisfying aspects of this career
- contributing to a strong economy
- working with valuable materials and minerals

Some demanding and challenging aspects of this career
- economic slumps
- losing your job when the mine is no longer economically viable

Purpose Orientation
An extraction metallurgist should:
- have mathematical and scientific aptitude;
- have insight and logical thinking
- have well-developed problem-solving skills
- have self-discipline and concentration
- have ability to work with and to lead people
- have good communication skills

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Engineering and Technology

Training
Degree: Chemical Engineering or Metallurgical Engineering degrees

Diploma: Chemical Engineering, Metallurgical Engineering (Extraction Metallurgy)

Employer
- mining companies
- metallurgical extraction plants
- metallurgical research laboratories
- educational institutions
- government departments
- self-employment - suitably qualified and experienced extraction metallurgists can establish themselves as independent consultants offering specialist advice and service to metallurgical plants and companies throughout their country

Career 26: Food Consultant

Food consultants are specialists in food and its preparation and have a good knowledge of nutrition, food science, food marketing and promotion. They are food experts orientated towards the consumer.

Their duties may include: answering consumer queries about food; developing products and recipes for the food production industry; food styling and photography; television productions and demonstrations; and writing about the products for the media, such as articles for magazines and newspapers.

Some fulfilling and satisfying aspects of this career
- working with food
- variety of the work
- working with people

Some demanding and challenging aspects of this career
- frustration when new recipes do not work
- not being able to help consumers with their queries

Purpose Orientation
A food consultant should:
- enjoy working with food;
- be creative and innovative;
- have an outgoing personality;
- be eloquent;
- be able to communicate and liaise with the public tactfully.

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics
Recommended Subjects: Life Sciences, Physical Sciences, Consumer Studies

Training
Degree: BSc Food Science

Diploma in Food Technology, Hospitality Management

Employer

Employment opportunities exist in

- large food and appliance companies
- manufacturing industries
- food retailers and distributors
- the food media.

Career 27: Food Scientist and Technologist

Food scientists and food technologists are responsible for applying the findings of research in food processing to the development and improvement of products.

Food science is the scientific study of food substances and components and the changes they undergo during various processes. It concerns research on preservation techniques, the development of new products, troubleshooting and problem-solving.

Food scientists and technologists are involved in the following areas:

- Product research and development: Research is mainly undertaken to evaluate existing problems in the food industry, as well as to initiate and keep pace with developments in food science and technology.

- Food scientists and technologists conduct research to solve problems in the food industry and keeps pace with new developments. They analyse samples to determine their physical, microbiological, chemical or spectrographical nature.

- Decay is still the main cause of food loss in many countries, as people do not know how to prevent food from being spoiled. Food scientists are able to overcome many of these problems by generating new knowledge on the chemical, biochemical, physical and microbiological attributes of food and food components.

- Processes such as freezing, canning or drying can preserve food products so that they are available throughout the year. Food scientists must however, be able to apply these processes while trying to reduce to the minimum, negative effects such as loss of nutrients or texture changes.

- Research on product development leads to the improvement of existing products by either changing the substances or the manufacturing techniques to make them more profitable or to improve the quality of the product. Food scientists and technologists work closely with the marketing section, which keeps them informed of consumer needs and preferences.

- *Quality Control*: Food scientists and technologists in food factories have to ensure that products satisfy prescribed quality requirements and to report any deviations from the standard. They might undertake inspection at manufacturers to ensure that grading regulations and hygiene specifications are met. They analyse samples at various stages of processing to check quality. They also determine whether raw foodstuffs are suitable for processing and seek methods to

make products more usable

- *Production*: Food scientists and technologists at food producers specialize in the following areas: the structural requirements that a food factory must satisfy; hygiene requirements in the factory and for the equipment, as well as the workers; quality requirements of raw material, the manufacturing process and general processing; the quality of the end product; the handling of the product after manufacture of the product, packaging material, labelling and product composition.

- *Administration*: Food scientists and technologists are also responsible for administrative work, reporting and supervising. This forms part of the work for which all technologists are responsible in a laboratory of a research institution or a factory, where supervision of food manufacturing processes is done. They also supervise laboratory assistants and food plant workers.

Some fulfilling and satisfying aspects of this career
- applying research results and technological advances in food processing
- helping to produce processed foods that satisfy customer preferences
- the challenge and variety in the work

Some demanding and challenging aspects of this career
- having to travel to various factories for quality control and inspection purposes
- frustration when a promising technique fails to materialize

Purpose Orientation
A food scientist and technologist should:
- like to work with biological material, especially food products;
- be accurate and methodical;
- be responsible;
- make independent decisions;
- work well with others;
- establish good relationships with people (due to essential teamwork).

School Subjects
Advanced School Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Life Sciences, Consumer Studies

Training
Degree: BSc Food Science

Diploma: Food Technology, Hospitality Management

Employer

- Research Institute for Fruit and Fruit Technology
- food processing factories for fruit and vegetables, cereals, meats, dairy products, vegetable oils
- government departments, as inspectors of food processing
- marketing boards
- universities and universities of technology
- self-employment - can work as a consultant for businesses and supply them with professional advice; can also start own food processing business with enough experience and capital

Career 28: Forensic Analyst/Scientist

Forensic scientists apply scientific knowledge and skills to investigate crimes. The information they provide may help the police to find or eliminate a suspect in a crime. Forensic scientists usually specialize in one area of forensics, such as DNA analysis, firearms examination, or toxicology, which is the analysis of body samples for traces of drugs and poisons.

The service that forensic analysts provide is invaluable in police and legal work, and their expertise is called upon to detect traces or confirm the presence of substances such as poison, drugs and alcohol, in the human body at post-mortems. This information is then used by the police to assist in solving crimes and by the legal profession to secure convictions or to prove innocence.

Another branch of forensic analysis is in the field of preventive medicine where foods, beverages and habit-forming drugs are tested to determine their safety for human consumption.

Forensic scientists may visit crime scenes to find evidence. They analyse physical evidence such as fibres, glass, debris, firearms, bullets and marks made by tools or weapons. They also analyse biological evidence such as hair, blood and body fluids. They write reports on the results and findings.

They may be required to give evidence in court. They are sometimes called to investigate civil court cases, such as fire or insurance claims. They may travel locally and around the country to attend crime scenes and court cases.

Forensic scientists need to know about using science to investigate crime. They need to understand the chemical make-up of everyday things, such as paint or textiles, as well as that of blood, body tissues and DNA. They also need to know about poisons and drugs, firearms and explosives. The knowledge required will vary, depending on their areas of specialization, which include:

Fingerprinting: There are three main types of fingerprints: arches, whorls, and loops. Each of these has several subcategories. Most fingerprints have a delta (triangular formation) near their core. A visible print is patent while an invisible print is latent. Fingerprints are usually latent and can be found at just about any type of crime scene.

Document Analysis: The vast majority of the crimes that take place involve paper or are committed on paper. Everything about the paper concerned is a potential clue. Document analysis includes handwriting analysis, fraud and forgery.

Firearms and Ballistics: The science of ballistics allows matches to be made between firearms and their ammunition.

Explosives: This involves analysis of bomb components, that is, its power source, its initiator, and its explosive substance. If a bomb explodes, analysts examine the bomb's residue by scanning the debris for fragments of the bomb in order to piece together its composition.

Forensic Anthropology: To a forensic anthropologist, truth lies embalmed in the marrow of the dead. By examining the various characteristics of a person's bones, certain deductions may be made about their age from the fusion of bones; diseases suffered, from bone erosions and anomalies; gender, from the size, characteristics and shape of bones; and race, from bone characteristics and shape

Chemistry and Toxicology: To analyse substances for chemicals, including poisons and drugs, forensic scientists use such instruments as mass spectrometers, which provide molecular "fingerprints" of unknown substances; X-rays, to detect potassium cyanide and other chemical; dielectrometers, which send out electric impulses and record energy absorption, marking differences such as wall imperfections or different densities.

Behaviour Profiling: Forensic analysts attempt to solve crimes by understanding a criminal's MO or "Modus operandi", which is the method by which a particular criminal commits a crime, including the time and place, type of crime, property involved, victim type, tools or implements used, disguises, props, or associates. Of significance are "signatures" or the psychological "calling cards" or imprints, some criminals are motivated to leave.

Blood: When a sample of blood is sent to a lab, as in any other science of identification, there are things that can be read from it, and others which remain elusive. Certain things about the donor can be determined from blood (excluding the process of DNA testing) such as whether it is animal or human and the blood grouping (A, B, AB & O), besides types of genetic markers, which are specific enzymes and proteins.

Entomology: A dead body attracts flies. Forensic entomologists use the clues provided by flies to find out exactly how long the body has been dead.

DNA (Deoxyribonucleic Acid): DNA has been called the biological equivalent of fingerprints. As with every person, each DNA arrangement is unique, the only exception being in the case of identical twins.

Hair and Fibres: Based on the theory of transfer, which states that when a person comes into

contact with another person or place, there is a transference of evidence to that person and to that environment, and vice versa.

Photography: Photography when it was first developed, quickly replaced branding as the preferred means of identifying criminals. Now standardized criminal photographs, known as the "mug shots", are essential forensic tools.

Photo-Identification: One of the first crime scene activities is the taking of photographs. Their value as evidence is obvious: they are visual testaments to an inaccessible point of the past; permanent records that allow other evidence to be preserved.

Surveillance: Film is an important part of surveillance, which is the secret monitoring of suspected criminals in the hopes of gaining vital information and which might lead to arrests, etc. Specialized equipment is necessary for long-range photography and for hidden cameras that must operate for long periods without maintenance.

Some fulfilling and satisfying aspects of this career
- solving problems and puzzles
- helping to solve crimes

Some demanding and challenging aspects of this career
- the possibility of coming into contact with human body fluids
- firearms, explosives and chemical hazards
- visiting unpleasant and distressing crime scenes

Purpose Orientation
A forensic analyst should:
- have a scientific aptitude and skill in interpreting scientific results
- be thorough, methodical, accurate and careful
- be honest, responsible and able to keep information private
- have well-developed problem-solving skills
- have excellent written and oral communication skills
- have good eyesight, very observant and an eye for detail
- have analytical and organizational ability
- have maturity and self-confidence to cope with rigorous cross-examinations
- have strong stomach to deal with some very unpleasant crime scenes

School Subjects
Advanced Level Certificate meeting diploma degree requirements

Each University or College will have its own minimum entry requirements.

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

Training
Degree: BSc majoring in Chemistry, Analytical Chemistry or Pharmacology

Diploma: Forensic Investigations or Chemistry / Analytical Chemistry.

Many practical forensic science skills are also gained on the job. Once employed, training is given in the specific scientific techniques required in the job.

Employer
- Department of National Health
- Police Force
- Government laboratories and offices
- Private laboratories

Career 29: Geohydrologist

Geohydrologists scientifically investigate and evaluate underground water resources, their quality and characteristics. They are involved in the exploration of groundwater by means of geophysical techniques.

Geohydrology is a relatively new science and is an important field for various reasons. Many reservoirs cannot hold as much ground water as before, due to sedimentation. In recent years, there is also a much higher degree of public awareness regarding healthy or contaminated water. Geohydrology helps improve quality of life and environmental safety.

Groundwater is a natural resource of on-going importance. As surface water resources become fully utilized, the importance of groundwater will increase. Groundwater is important for the mining industry, while irrigation from boreholes is also increasing rapidly.

Geohydrologists investigate the occurrence and exploitation possibilities of groundwater in different geological formations. They investigate the quality of groundwater and study groundwater systems by means of mathematical models and statistical analyses. They render expert advice to institutions and users of groundwater. The work of geohydrologists varies from office work to fieldwork.

Geohydrological technicians: assist geohydrologists by working with computers or files to store information; using geohydrological measuring, testing and collecting equipment and other technical equipment.

Some fulfilling and satisfying aspects of this career
- discovering new methods of improving the quality of water
- contributing to public health and a hygienic environment
- working both outdoors and indoors

Some demanding and challenging aspects of this career
- working in adverse working conditions
- being away from home often
- the inconvenience of site camps
- frustrating when groundwater cannot be found

Purpose Orientation
A geohydrologist should:
- enjoy outdoor living, travelling and camping
- have aptitude for the physical / natural sciences and mathematics
- be observant, accurate and objective
- have problem-solving skills
- be interested in the physical and mathematical sciences

- able to communicate clearly in writing and in speech
- responsible and dedicated
- prepared to work out in the field
- enjoy nature and travelling
- computer literate
- flexible and adapt easily to new situations
- good health and stamina

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

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

Training
Degree: BSc degree or Hydrology and Groundwater Studies.

Employer
- Departments of Water and Forestry
- Municipalities
- Universities
- Self-employment, with enough experience and capital, can open own business, for example in collaboration with an engineering firm

Career 30: Geological Engineer

Geologists study the structure, composition and history of the earth's crust. Geological engineers apply their knowledge of geological principles to the planning, designing, construction, operation and safety of civil and structural engineering projects.

Geological engineers examine the types and geological structures of soils at construction sites and ensure that large structures such as high buildings, dams, roads, or new townships are designed to suit the soil conditions or strength of the rock. They ensure the firm and safe construction of the foundations in the most cost-effective way. They also examine the materials used in the construction of roads. Geological engineers work most closely with civil engineers.

Geological engineers conduct studies to analyse geological and geotechnical conditions, and they plan, develop and coordinate programmes of geotechnical, geological, geophysical or geohydrological data acquisition, analysis and mapping to assist in the development of civil engineering, mining, petroleum and waste management projects, or for regional development.

They analyse and prepare recommendations and reports for the construction of, or improvements to, the foundations of civil engineering projects, such as rock excavation, pressure grouting, rock slope stabilization and hydraulic channel erosion control. They conduct theoretical and applied studies of groundwater flow and contamination, and they develop specifications for site selection, treatment and construction.

They also plan, develop, coordinate and conduct theoretical and experimental studies in mining exploration, evaluation and feasibility studies with regard to the mining industry. They conduct surveys and studies of ore deposits, ore reserve calculations and mine design. They design, develop and implement computer applications for geophysics, geochemistry, geology, mapping and related fields, and they supervise technologists, technicians and other engineers and scientists.

Some fulfilling and satisfying aspects of this career
- working outdoors part of the time
- solving problems and ensuring that structures are safe
- the variety of work
- working with others

Some demanding and challenging aspects of this career
- sometimes having to be away from home and family for long periods
- primitive living conditions in the field

- the pressure of ensuring accurate work, as mistakes could cost lives

Purpose Orientation
A geological engineer should:
- have scientific and mathematical aptitude;
- have above-average intelligence;
- be dedicated to their work;
- have good observation skills;
- work independently or as part of a team;
- be adaptable;
- be willing to work outdoors under all weather conditions.

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Geography

Training
BSc (Honours) degree, or a 3-year diploma in Geology

Employer
- Civil engineering companies
- Government departments
- Municipalities
- Large institutions concerned with civil engineering projects
- Consulting geological companies
- Quantity surveyors
- Self-employment, with enough experience and capital, can start own business as a consultant

Career 31: Geologist

Geologists, geochemists and geophysicists conduct theoretical and applied research to extend knowledge of surface and subsurface features of the earth, its history and the operation of physical, chemical and biological systems that control its evolution.

Geologists, geochemists and geophysicists conduct programmes of exploration and research to extend knowledge of the structure, composition and processes of the earth and to locate and identify hydrocarbon, mineral and groundwater resources. They also plan and implement programmes of hydrocarbon and mineral extraction, and they assess and mitigate the effects of development and waste disposal projects on the environment.

These scientists plan, direct and participate in geological, geochemical and geophysical field studies, drilling and geological testing programs, and seismic, electromagnetic, magnetic, gravimetric, radiometric, radar and other remote sensing programmes. They also plan, direct and participate in the analysis of geological, geochemical and geophysical survey data, the analysis of core samples, drill cuttings and rock samples in order to identify chemical, mineral, hydrocarbon and biological composition, and also the analysis of well logs, other test results, maps, notes and cross-sections.

They develop applied software for the analysis and interpretation of data. They assess depositional environments and geological age, and they assess the size, orientation and composition of mineral ore bodies and hydrocarbon deposits. They also identify deposits of construction materials and determine their characteristics and suitability for use as concrete aggregates, road fill or other applications. They assess the movement of ground and surface waters, and they advise in areas such as waste management, route and site selection, and the restoration of contaminated sites.

They recommend the acquisition of land, exploration and mapping programmes, and mine development, and they conduct geological and geophysical studies for regional development, site selection and the development of public works projects.

They identify and anticipate natural risks, such as slope erosion, landslides, soil instability, subsidence, earthquakes and volcanic eruptions, and they may supervise and coordinate well drilling, completion and work-over, as well as mining activities.

Geological research helps in locating mineral deposits, predicting earthquakes, and advising on the suitability of sites for buildings, dams and highways. The knowledge obtained is also used in a wide variety of ways, from determining the components of plaster on walls of buildings where

lime and other mixtures are used, to the discovery and refinement of oil and other energy sources.

Geology is a very broad-based science, which draws from virtually every other science including the natural, engineering and economic sciences. There are various careers within the field of geology, for example: cartography, economic geology, environmental geology, engineering geology, geochemistry, geotechnology, geohydrology, geophysics, mineralogy, mining geology, palaeontology, petroleum geology.

The broad areas of specialization within this field include: earth material; earth processes and earth history. The sub-specialities include: economic geology, mineralogy, geochemistry, geophysics, palaeontology, marine geology, mineral economics, engineering geology and environmental planning.

General geologists can specialize in various fields of application, of which only a few are discussed here:

Basic mapping is the drawing of a map on which geological information such as the distribution of different rocks is shown. This is one of the most important tasks of geologists.

Economic geology studies the deposit of economic minerals and the processes leading to their formation.

Environmental geology studies recent sediments deposited in river valleys, on beaches and in the oceans, in order to acquire information on aspects such as climatic changes, erosion of coastlines and the influence of human activities on the environment.

Engineering geologists study the physical and chemical properties of rocks and soil in order to ensure that dams, road, tunnels and buildings are built at the most suitable sites and in the most cost-effective manner. They also study materials used in road construction.

Geohydrologists study the water-storing capacity of various geological formations and the flow of groundwater in these formations. The development of cavities in rocks through cracks and faults as well as the chemical solution of rocks are also studied by geohydrologists. Post-graduate study and specialization at an honours degree level is essential for a career as geohydrologist.

Palaeontologists study fossils to make deductions concerning the climate that prevailed during deposition and the environment where the organisms occurred. This information is used amongst other things, to understand the origin and formation of certain minerals in sedimentary rocks and

to find further resources. The study of fossils also contributes to our knowledge of factors that led to the extinction of species and the origin of new species.

Geophysicists make geophysical measurements to determine the distribution of rocks underneath the soil. They also try to determine the deep-seated structure of the earth's crust as well as its physical qualities.

Geologists work in a variety of settings. They may work outdoors at a site under investigation, with conditions varying from sub-zero temperatures to the scorching heat in a desert. In addition, they may work indoors in laboratories, offices and classrooms.

Some fulfilling and satisfying aspects of this career
- the outdoor life
- solving problems
- variety of work and choice of specialisations
- travelling
- working with others

Some demanding and challenging aspects of this career
- being away from home and family for long periods;
- the physically demanding nature of the work while at a remote site under investigation
- the primitive living conditions in the field

Purpose Orientation
A geologist should be/have:
- curious and imaginative
- observant, responsible and objective
- able to visualize things three-dimensionally
- problem-solving skills
- enjoy working with others
- flexible and adapt easily to new situations
- able to communicate clearly in writing and in speech
- enjoy travelling and nature
- prepared to work out in the field
- good health and stamina

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Life Sciences, Geography, Economics, Information Technology

Training
Degree: BSc with Geology as a major, Geological Science

Diploma in Economic Geology or Geo-Technology

Postgraduate study (for masters and doctors degrees)

Employer
- petroleum and mining companies
- consulting geology, geophysics and engineering firms
- government departments
- Chamber of Mines
- civil engineering firms
- universities of technology and universities
- self-employed, as a consultant

Career 32: Geophysicist

Geophysicists study the earth's physical features, including its atmosphere and hydrosphere. They examine and measure seismic, gravitational, electrical, thermal and magnetic forces, using the principles of physics, mathematics and chemistry.

They analyse data to compute the earth's shape, estimate composition and structure of the earth's interior, determine flow patterns of ocean tides and currents and help locate petroleum and mineral deposits. They investigate the origin and activity of volcanoes, glaciers and earthquakes.

They compile data to prepare navigational charts and maps, predict atmospheric conditions, prepare environmental reports and establish water supply and flood control programmes. Some may also study other planets. Solid earth, fluid earth and upper atmosphere, are three general fields of geophysicists.

Geophysics involves the use of a number of techniques used to solve specific problems. The most important of these are: the gravity technique, the magnetic method, seismic techniques, electric and electromagnetic methods and radio magnetic methods.

Geophysicists generally spend a certain percentage of their time in the field carrying out geographical measurements, while the rest of the time is spent in the laboratory or office, processing, interpreting, modelling, evaluating and reporting the results.

Some fulfilling and satisfying aspects of this career
- the variety and challenges of the work;
- working with scientists from other fields
- increasing scientific knowledge about the universe

Some demanding and challenging aspects of this career
- frustration involved in doing research
- working in remote areas

Purpose Orientation
A geophysicist should:
- be curious;
- think analytically;
- have mathematical ability;
- be able to communicate well both in speech and in writing;
- be able to work as part of a team;

- have good health;
- enjoy working outside and away from home.

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Science
Recommended Subjects: Geography

Training
Degree: BSc majoring in Geography

Employer
- mining groups
- government departments (Geological Survey, Water Affairs)
- industry
- Chamber of Mines
- research institutes
- universities
- consulting companies
- self-employment, as a consultant

Career 33: Geotechnicians and Geotechnologists

Geotechnicians and geotechnologists do scientific research on and in the crust of the earth with the objective of locating and extracting natural resources, or of determining subsurface conditions and locating building materials prior to building large civil constructions.

They are initially given a broad and generalized training, but will usually specialize in one of four directions, namely, mining and exploration, geophysics, geohydraulics or engineering geology, and will be involved in the following types of activities:

Mining and exploration geology, where they are usually employed by one of the large mining companies and will either work at a mine or in the field. In the course of mining activities, they will work underground three or four times per week for three-hour shifts, gathering information on newly exposed rock surfaces with the objective of locating ores or predicting hazardous mining conditions.

Exploration geology involves the search for new natural resources such as gemstones, precious minerals, basic metals, fossil fuels (coal and petroleum), ceramic minerals, building material or ground water. These are sophisticated and expensive research projects, where teams of scientists are involved in fieldwork using satellite and aerial photographs, geophysical observations, sampling and analysis of soil, rocks and plants and deep-drilling methods. The end results of these projects are the establishment of new mines, quarries and water resources.

Geophysics is the process where sophisticated instruments are used to evaluate conditions in the earth's subsurface. Geophysics is also used in many other types of geological research such as the location of ores, of groundwater and in the evaluation of bedrock conditions for the design of foundations for large civil constructions. Geophysics involves fieldwork and computer analysis and requires an advanced understanding of Mathematics, Physics and Geology.

Geohydrology involves the analysis of ground-water conditions with the objective of finding new water resources, locating waste-disposal dumps or evaluating groundwater-pollution situations. Geohydrology involves fieldwork, usually incorporating aerial photographs and geophysics, together with computer analysis.

Engineering geology, where two distinct applications are involved. On the one hand,engineering geotechnicians are involved in the establishment of large civil constructions, which includes dams, bridges, tunnels, roads, large buildings and new townships. They must gather information on geological conditions in the subsurface in order to make recommendations for the design of foundations.

On the other hand geotechnicians locate building materials that will be used in large construction projects. They usually work on construction sites where they are involved with surface mapping, drilling projects or geophysical observations. They are also involved with computer analysis.

Some fulfilling and satisfying aspects of this career
- uncovering usable and viable sites
- working both indoors and outdoors
- variety of work
- travelling

Some demanding and challenging aspects of this career
- dangers of working underground
- sometimes having to travel to very isolated sites

Purpose Orientation
- enquiring and analytical mind
- interested in geography
- fond of travelling, camping and outdoor life
- observant and practical
- capable of working independently and in isolation
- also able to work in a team
- capable of conceptual, differential and divergent thinking
- good three-dimensional perception

School Subjects
Advanced Certificate meeting diploma requirements for a diploma course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics and Physical Sciences
Recommended Subjects: Geography

Training
Diploma: 5 semesters at the university of technology and one semester at an employer, where they undergo in-service training in order to gain practical experience.

Employer
- large mining companies

- construction companies
- research institutes
- engineering companies
- government departments
- universities
- laboratories
- educational institutions
- self-employment, with enough experience, can work as a private consultant for mining companies or research institutes

Career 34: Hydroelectric Power Plant Production Manager

Hydroelectric power is generated by harnessing the energy of the water in dams or waterfalls, using hydraulic turbines to create electricity. Hydroelectric power is considered to be a clean, renewable source of energy, releasing a very low level of greenhouse gases when compared to fossil fuels. Costing far less to produce and operate than fossil fuel, it is a growing sector of the renewable energy industry.

Careers in the Hydroelectric Industry:
As with many of the other renewable energy technologies, the design, construction and maintenance of hydropower plants require electrical and mechanical engineers, technicians and skilled workers. If the hydropower project involves managing the reservoir and the surrounding land, the developer will also hire recreation planners and resource managers. In addition, laws now require current or prospective hydropower plant developers to assess the environmental effects of their operation. Thus, the hydropower industry will also employ environmental scientists (biologists, hydrologists, ecologists and wildlife habitat specialists, for example) to assess the environmental impact and to take into account and to address these issues.

The production of hydroelectric power involves a team of plant operators under the hydroelectric production manager who is responsible for managing the resources dedicated to the operation of power generating facilities. The objective of the team is to produce the maximum amount of electricity in the least possible time with minimum of breakdowns and other problems whilst also complying with all relevant safety procedures.

Some of the tasks of the production manager are to:
supervise and manage the operations and maintenance of the hydroelectric power facilities
supervise the people in charge of handling the various sections of the plant monitor operations to ensure that generation conforms to applicable operational and safety regulations and standards develop, review and implement operating budgets, annual plans, power contracts, power rates, standing operating procedures or engineering studies
communicate power system emergencies in accordance with approved procedures maintain records of hydroelectric facility operations, maintenance and repairs inspect hydroelectric equipment such as generators, hydro-turbines and control systems to ensure their optimum condition.

Since electricity is a diminishing resource, there is an urgency to produce it using renewable sources of energy. Therefore electricity generated by means of wind, water, sun, etc are fields of technology where a lot of innovation is expected to emerge in the future.

Some fulfilling and satisfying aspects of this career
- interesting and challenging
- satisfaction that natural energy is being produced and the environment protected

Some demanding and challenging aspects of this career
- frustration when breakdowns occur

- can be challenging to maintain control at all times

Purpose Orientation

Professionals in this area should:
- have good communication skills
- have highly developed observational skills
- able to work well with other people who are experts in their own field
- have strong interpersonal skills

School Subjects
- Advanced Level Certificate meeting degree requirements for a degree course

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Engineering and Technology, Geography

Training
Degree: BEng Electrical / Mechanical Engineering

Employer
- hydroelectric power stations

Career 35: Hydrologist

Hydrology is a field of study that focuses on the management of water. A hydrologist makes an accurate assessment of the available water and future needs and makes recommendations on long-term management practices.

Hydrologists study and do research on the waters of the earth, its distribution on and below the surface of the earth and in the atmosphere. They try to secure the optimal utilisation of the country's water resources by advising civil engineers on the flow of rivers and where to build the most economical water schemes, to ensure that sufficient water of acceptable quality can be supplied in the most cost-effective manner.

They also advise design engineers on the frequency and magnitude of floods in order to minimize flood risks and to ensure the best operation procedures for flood control and drought periods. They identify underground water as sources of water supply, evaluate the effect of man's activities on the quantity and quality of water, and study the interaction between components within the hydrological cycle.

Water is a scarce commodity and part of the job of a hydrologist is to identify problem areas and make recommendations as to how these problems should be solved. A hydrologist should understand the needs of water users, including agricultural, domestic and industrial users, as well as the possible options available for water resource development.

Work is not confined to an office, but includes short periods of fieldwork. For geohydrologists, fieldwork is particularly important. A great deal of work is done outdoors when visits are made to catchment areas, rivers, dams and consumer areas for observation. Work indoors is carried out in offices and laboratories where field information is received, analyzed and interpreted, and where water is tested for its chemical, physical and biological quality. Office work also includes administrative duties such as the compilation and editing of reports, the processing of data, liaison with clients and planning of new projects.

Some fulfilling and satisfying aspects of this career
- doing a great deal of the work in the open
- camping and caravanning, which form part of the field work
- knowing that the work is essentially contributing to the optimal utilization of our water resources, which is rapidly becoming the most valuable resource in any country

Some demanding and challenging aspects of this career
- the amount of training before one is qualified
- having to do overtime work occasionally
- being away from home for long periods

Purpose Orientation
A hydrologist should:
- be fond of travelling and outdoor life;

- like to do research and analyse data;
- have initiative;
- be able to work independently;
- work accurately;
- be physically healthy and have stamina
- have computer skills.

School Subjects
An Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Geography

Training
Degree: BSc majoring in one of the following: Hydrology, Geology, Geography, Biochemistry, Microbiology, Chemistry, Engineering, Statistics, Computer Science, Applied Mathematics, Mathematics, Physics, Hydrology and Groundwater Studies

Post-graduate studies: for appointment as a hydrologist, the minimum requirement is an honours degree, with one or more of the following as the principal field of study:

- Applied Hydrology: Computer Science, Operations Research, Statistics, Civil Engineering
- Geohydrology: Geology, Geohydrology, Geophysics, Geochemistry, Applied Geophysics and Mathematics
- Hydrological Research: Chemistry, Soil Physics, Botany, Zoology, Geography
- Basic fields of study: Hydrology, Mathematics, Applied Mathematics, Physics, Geography, Chemistry
- Water Quality: Botany, Zoology, Microbiology, Chemistry and Limnology

Employer
- Government departments
- Water Boards
- Municipalities
- Universities and universities of technology
- Engineering firms
- Self-employment, a skilled and entrepreneurial hydrologist can open a private practice and act as a consultant.

Career 36: Materials Scientist/Engineer

Materials scientists or engineers study the structures and properties of various materials such as metals, alloys, ceramics, semiconductors and polymers. The purpose of these studies is to understand and characterize materials and to develop new materials for commercial and scientific benefit.

The financial yield of selling finished products is generally much higher than that of selling natural resources that are still in ore form. Materials scientists find and develop creative and economical ways of converting natural resources into final products. This covers a very broad spectrum and they perform a range of different functions in various industries.

Materials scientists can specialize in areas such as the following:

- guiding technical staff in developing materials for a specific use of a projected product
- mining and processing materials
- extracting certain elements from minerals
- processing minerals into materials such as metals, ceramics and plastics
- using materials in engineering structures
- disposing of waste materials
- managing a furnace or rolling mill
- conducting laboratory experiments in the production of materials, to confirm the feasibility of processes and techniques for potential users

Some fulfilling and satisfying aspects of this career
- challenge of applying research to finding ways of improving a process or product
- variety of work
- choice of specializations

Some demanding and challenging aspects of this career
- long working hours
- the hard work and dedication required

Purpose Orientation
A materials scientist should:
- have scientific and mathematical aptitude;
- have above-average intelligence;
- have an analytical and practical inclination;
- be able to conceptualize abstract ideas;

- be highly motivated and dedicated.

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: None

Training
Degree: BSc: Metallurgical Engineering / Extraction Metallurgy

Diploma in Metallurgical Engineering

Employer
Employers include the manufacturers of microprocessors and computers, electronic equipment, plastics, ceramic, steel, glass and other products.

Self-employment is also an option, with enough experience, a materials scientist or engineer can start their own business and work as consultants, particularly in the fields of welding, casting, corrosion and failure analysis.

Career 37: Mechanical Engineer

Mechanical engineers research, develop, design, manufacture and maintain machines, machine components and systems in various fields of application.

They work on power-producing machines such as generators, engines, and steam and gas turbines. They also work on power-using machines such as refrigeration and air-conditioners, robots used in manufacturing, elevators and escalators, and industrial production equipment. Mechanical engineering can be considered to be the cornerstone of modern technology because it applies the principles of natural science in a way that leads to the greater convenience, progress and safety of mankind.

Mechanical engineers usually specialize in one of the fields set out below:

Transportation: these engineers, together with other engineering specialists, design and develop equipment such as aircraft, helicopters, missiles, ships, motorcars, trains, as well as the steam and gas turbines and petrol and diesel engines needed for propulsion.

Power Generation: engineers in this field attempt to provide the energy required by consumers. The demand on existing natural resources provides a challenge for engineers to provide energy and power without harming the environment or depleting resources.

Agriculture: by providing modern equipment such as threshing machines, tractors, harvesters and milking machines for food producers, engineers in this field assist in the economic production of food.

Mining: the wealth-producing minerals and mining industry is one of the sectors where great demands are made on the initiative of the mechanical engineer. Pumping plants, hauling machines, winding equipment, ventilation fans, conveyor belts, drilling-machines and underground railways are a few of the devices which require the input of a mechanical engineer.

Environmental Engineering: specialist mechanical engineers create the controlled indoor environment that people need in order to work in comfort. Factors such as humidity, temperature and cleanliness of the air in the workplace are monitored, adjusted and controlled by these engineers. In this field of study the mechanical engineer works particularly closely with engineers from other disciplines.

Biomedical Engineering: heart-lung machines, artificial kidney machines, heart valves, pacemakers and operation monitors are all examples of the work of a biomedical engineer.

Without this equipment the medical profession could not progress (see the article on the biomedical engineer).

Industrial Engineering: mechanical engineers also play a major role in industrial and manufacturing processes such as production technology and quality control (see the article on the industrial engineer).

Other areas of specialization include:

- transportation equipment
- fluid mechanics
- heating, ventilation and air-conditioning
- instrumentation
- machines for specialized industries such as rubber, petroleum and plastics
- construction

Mechanical engineers usually work in offices where the computer plays a major role. It is also necessary that the premises, for which the engineer designs equipment or coordinates maintenance, be inspected beforehand.

Engineering graduates usually begin work under the supervision of experienced engineers and are gradually given more responsibilities as they gain experience. Some engineers with experience and additional education move into administration or management. Many high-level executives in industry began their careers in engineering.

Mechanical Engineering Technician

Mechanical engineering technicians carry out technical support functions in mechanical engineering research, design, manufacture, operations and maintenance. Mechanical engineering technicians may work under the direction of mechanical engineers in all stages of planning, design, maintenance and production.

They develop and design machinery and equipment, often with the aid of computer-aided design or drafting (CAD), and implement mechanical engineering technology. Some design precision equipment, machine tools and production machinery. Technicians fill the gap between the tasks performed by engineers, technologists and scientists and those performed by artisans.

Mechanical engineering technicians develop many different machines and are involved in the manufacture, construction, layout, operation, maintenance and supervision of moving machinery and mechanical appliances. This includes transport (ships, railways, aircraft, automobiles),

power generation (steam, oil, gas, nuclear), air-conditioning, as well as other services such as water supply to mines, factories, buildings and so forth.

Mechanical engineering technicians study the project instructions of engineers to ensure that the test specifications and proposed procedures are suitable for the artisan to construct. They determine the nature of technical problems and put forward possible solutions, such as modifications to existing designs, techniques and procedures. The work also often requires the design and evaluation of materials and components by means of information collected from experiments.

They may also perform workshop and field tests using standard instruments and methods, and assist in developing quality control tests for products and parts. Mechanical engineering technicians can specialize in such areas as: boiler testing, hydraulic controls, mechanical detail drafting, mechanical engineering drafting, pipe testing or tool design detail drafting.

Mechanical Engineering Technologist

Mechanical engineering technologists fill the gap between the tasks performed by engineers and those performed by technicians.

Mechanical engineering technologists are involved with the design, development, production, marketing, installation, maintenance and general research of machinery and mechanical equipment, in almost every type of industry and technology.

The work of mechanical engineering technologists is mainly practical and involves planning, designing, modelling and testing of systems. They assist engineers in design and development by making sketches and rough layouts of proposed machinery and other equipment. The cost and practical value of designs is also analysed.

They usually specialize in one of the different fields described in detail under Mechanical Engineer in this book.

Some fulfilling and satisfying aspects of this career

- solving problems
- the challenge and variety of the work
- many areas of specialization available in this field
- good salaries
- advancement opportunities

Some demanding and challenging aspects of this career

- having to work long hours to finish a project

- the long period of preparation and study required to register as a professional engineer
- having to continue your education throughout your career to keep up with the latest technological advances in your field

Purpose Orientation
A mechanical engineer should:
- have an aptitude and preference for experimenting, planning and research;
- enjoy detailed work;
- enjoy solving problems
- have above average intelligence and an analytical mind;
- be meticulously accurate in calculations and drawings;
- have mathematical and mechanical aptitude;
- ability to visualize objects three-dimensionally and interpret 3D drawings;
- be a good decision-maker;
- prepared to accept responsibility - defects in designs can affect lives
- be creative;
- work well with others;
- have managerial qualities.

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Information Technology, Technical Drawing, Mechanical Technology

Training
Degree: BSc in Mechanical Engineering

Diploma: Mechanical Engineering

Employer
- Manufacturing industries
- Government departments
- Mining companies
- Consulting engineering firms
- Universities and universities of technology

- Self-employment, a registered mechanical engineer with the necessary experience and initiative can work as a consultant in any of the above-mentioned organizations or can also start own manufacturing engineering company

Career 38: Mechatronic Engineer

Mechatronic engineers design and maintain machinery with electronic and computer control systems, such as aircraft, robots, motor vehicles, cameras, power generators and mining and chemical plant machinery.

Mechatronic engineering is a new focus area in engineering that promises to become even more important in the future, in Africa as well as internationally. With automation currently regarded as the key to improved productivity, the need for mechatronics (which makes it possible to generate simpler, more economical, reliable and versatile systems) increases by the day.

Mechatronic engineering is a combination of precision mechanical engineering, electronics and computer systems.

Mechatronic engineers may perform the following tasks:
- design, develop, maintain and manage high-technology engineering systems for the automation of industrial tasks
- apply mechatronic or automated solutions to the transfer of material, components or finished goods
- apply advanced electronic control systems, which are usually computer-driven
- design and assist in the manufacture of consumer products, such as cameras and video recorders
- apply electronic and mechanical processes and computers to tasks where the use of human labour may be dangerous (eg underwater exploration, mining or forestry)
- carry out studies into the feasibility, cost implications and performance benefits of new mechatronic equipment

Workplaces range from laboratories and processing plants to engineering design offices.

Some fulfilling and satisfying aspects of this career
- many areas to choose from, thus working in your field of interest
- solving problems
- opportunity to be creative
- variety and challenge of work
- good salary

Some demanding and challenging aspects of this career

- working long hours to finish a project
- many years of study required
- having to keep up with the latest technological advances in your field

Purpose Orientation
- enjoy technical and engineering activities
- have good communication skills
- able to work as part of a team
- able to think creatively and solve problems
- interested in mechanical equipment, such as robotic and production equipment, and good at Physics and Mathematics

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Information Technology, Electrical Technology

Training
Degree: BEng (Mechatronic)

Mechatronic engineers need to have a degree in mechanical engineering, electrical engineering, computer science, control systems engineering or in a similar field in order to be eligible for employment as a mechatronics engineer.

Postgrad: For research posts, a Masters or PhD is required with courses taken in the field of mechatronics

Employer
Companies and organisations involved in the following:
- aerospace industry
- automotive industry
- chemical processing
- computers
- communications
- education
- electronics
- healthcare
- manufacturing and process

- marine engineering
- mining
- research and development

Career 39: Metallurgical Engineer

Metallurgy is the art of extracting metals from ore and forms an essential part of the mining effort. Metallurgical engineers play an important role in the development of metalliferous minerals used daily in many products such as alarms, kettles, cars, etc.

The metallurgical engineer is trained in the processes and methods for the reclamation and processing of ore and mineral resources. After the process of purification, the metallurgical engineer combines science, mathematical and engineering principles to extract various kinds of metal from the ore. The optimally correct metal for each application must be created.

Apart from producing metal products the metallurgical engineer must also be able to determine the cause of defects in metals and prescribe possible solutions.

Metallurgical engineering can be divided into two complementary fields:

Extraction Metallurgy or Minerals Processing: This is the science and technology of refining and processing minerals to useful metals by way of production and manufacturing processes. First, the preparation of reclaimed ore for the extraction process is handled and secondly the reclamation of metal from the prepared ore is taken care of. After the ore has been prepared, it undergoes a further extraction process through which metal is obtained from the concentrate - see Extraction Metallurgist for further details.

Material Engineering or Physical Metallurgy: This field is concerned with original raw materials that are alloyed, formed into useful components and treated with heat to achieve the required characteristics. This includes combining different metals to form alloys which give products with specific qualities, such as sheets, wire and bars. The metallurgical engineer must also determine the cause of defects in metals and suggest repair measures - see Materials Scientist / Engineer for further details.

Metallurgical Engineering Technician
Metallurgical engineering technicians bridge the gap between metallurgical engineers and artisans. The technicians' main function is to assist in the search for metals and alloys with improved, desirable properties.

Metallurgy is a multidisciplinary field that combines engineering principles and the basic sciences to concentrate, extract and refine metals from ores, and to manufacture them into a wide

variety of finished products, from everyday household utensils to sophisticated engineering components.

Metallurgical technicians find the most economical and practical ways of extracting metals from ores. This is done by studying and testing the structure and properties of metals to determine such things as grain structure, soundness, consistency and the physical properties and chemical content of various metal objects. The work entails testing the accuracy of instruments, calculating the necessary changes and ensuring that the finished work meets the specified quality standards.

The work of the metallurgical engineering technician is visible in a wide range of products. Metals are used in the construction of aeroplanes, chemical plants, cars, etc.

Some fulfilling and satisfying aspects of this career
- opportunity to specialize in an interesting and varied field
- playing a key role in the development of metalliferous metals

Some demanding and challenging aspects of this career
- fault analysis can be frustrating
- determining the cause of defects in metals can sometimes take a long time

Purpose Orientation
A metallurgist should:
- have mathematical and scientific ability;
- have a thorough knowledge of scientific methods;
- able to think logically and analytically;
- have good judgement and common sense
- be creative, innovative and have a receptive attitude towards change
- have good interpersonal relations and leadership ability
- be computer literate
- be self-driven, motivated and some interest in finance

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Life Sciences, Engineering and Technology

Training
Degree: BTech in Metallurgical Engineering, Chemical and Metallurgical Engineering

Postgraduate: MTech and DTech qualifications in Metallurgical Engineering,

Employer
- individual mining groups
- metal manufacturing industries
- iron and steel industry
- universities
- self-employment, with the necessary experience, can be an independent consultant

Career 40: Mathematician

Mathematicians create, investigate and analyse mathematical structures in order to solve and understand mathematical problems. Mathematical structures are also found in related fields such as physics, computer science or economics.

Mathematicians work either as theoretical (pure) or as applied mathematicians. Both types of mathematicians develop new mathematical theories, techniques and approaches to solve problems.

Pure Mathematics demands abstract thinking for the development of mathematical theories and methods. These mathematical theories and methods are essential in the qualitative and quantitative description of our world and are practically applied in most sciences. It will, for example, be used to determine, all factors considered, how an industry must be managed in order to show maximum profit.

Applied Mathematics involves mathematical modelling, numerical analyses and operational research. It forms a bridge between Mathematics theory and practice and concentrates on solving problems in Engineering, Physics and Computer Science, as well as practical problems such as industrial research, research on population growth, the development of ecological systems and predictions on the performance of, for example, artificial limbs. Statistics and computer science are related fields of study.

Problems for which mathematical analyses are used to find solutions or to solve problems are in such areas as: medical research, agricultural research, psychological research, genetic research, engineering and ecological research. Mathematical models are also used in trade and industry, for example, in marketing management, quality control and auditing.

Most mathematicians work indoors in classrooms, offices and laboratories. The type, size, location and financial resources of the employer and the experience, education and ability of the mathematician determine the actual work setting.

Some fulfilling and satisfying aspects of this career
- solving problems
- having variety and challenge in one's work
- knowing that one's work may benefit others

Some demanding and challenging aspects of this career
- having to concentrate on one's work for long periods of time

- continually studying to keep up with the latest advancements in their field
- having to obtain post-graduate degrees to obtain a responsible position

Purpose Orientation
A mathematician should:
- have mathematical aptitude;
- enjoy solving problems and have good reasoning ability;
- be imaginative;
- be intellectually curious;
- enjoy working with abstract ideas;
- be thorough and accurate;
- be able to use calculating machines and computers.

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics
Recommended Subjects: Physical Sciences

Training
Degree: Most universities offer BSc, BCom or BA with Mathematics as major subject. The second major depends on the field of specialisation e.g. humanities, statistics, actuarial or Information Technology.

Post-graduate study: An Honours degree in Mathematics is the minimum qualification for a career as a mathematician. High level teaching and research require a masters or doctors degree in Mathematics.

Employer
- Schools, colleges and universities
- Government departments
- Mining companies
- Insurance and investment companies- Self-employment, a mathematician can act as consultant and also give private classes in mathematics

Career 41: Mine Surveyor

Mine surveyors undertake both underground and surface surveys designed to produce information for the construction of mine plants. Mine Surveyors are responsible for maintaining accurate plans of mines as a whole and will update maps of the surface layout to account for new buildings and other structures, as well as surveying the underground mine workings in order to keep a record of the mining operation.

They plan the direction and extent of all underground workings, and use advanced surveying techniques and instruments to give these directions underground. All underground workings are plotted and kept regularly updated, so that surface officials and management can pinpoint any spot underground at any given time.

Mine surveyors are responsible for measuring the areas and volumes blasted by underground crews. Each month they measure the quantity of work done by mining contractors underground, and calculate their contractual earnings. More importantly, surveyors are involved in the measuring process to calculate ore production, in volume or mass units, from the mining operation.

In addition to this, the volume of the dumps of waste accumulating on the surface of the mining property will also be surveyed. This aspect of the work has turned mine surveyors into managers of mines' resources.

Mine surveyors are responsible for taking regular samples of reefs exposed in underground excavations, to determine which areas are profitable to mine. Thus, their work has to be very accurate at all times. Senior survey personnel also perform management functions, as well as managing the underground "ore" reserve.

Mine surveyors will usually perform the practical underground work in the mornings and spend the afternoons on the surface, assimilating findings and doing the necessary calculations.

Some fulfilling and satisfying aspects of this career
- working both outdoors and indoors
- challenge and variety of work
- relatively stable employment
- working with others

Some demanding and challenging aspects of this career
- working underground
- the risk of injury on the job
- being stuck on one mine in an isolated region

Purpose Orientation
A mine surveyor should:

- work accurately;
- have an aptitude for figure work;
- be honest;
- have integrity;
- be physically fit;
- able to trust own judgement and make own decisions;
- able to work independently and as part of a team.

School Subjects
Advanced Level Certificate meeting diploma requirements for a diploma course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Geography, Information Technology

Training
Diploma in Mine Surveying, Mineral Surveying, Land Surveying or Surveying and Mapping.

Employer
- local and international mining groups
- self-employment, with enough experience, can start own business and work on a contractual basis for mining groups

Career 42: Miner

Miners work underground and are involved in the supervision of the processes of drilling, blasting and rock clearing in order to extract minerals. The ore is moved to the surface by means of rails and hoisting apparatus. Large earth-moving machines and ore carriers are used to remove minerals on the surface at opencast mines.

Each miner is usually in charge of about 40 mineworkers. They have to plan and organize their work and are also responsible for their safety. The mineworkers load the materials onto mine cars or conveyors, and install timber, roof bolts or cribs to support the walls and roofs of mines. Some miners open up passageways, air vents, auxiliary tunnels, rooms and shafts.

Miners are sometimes exposed to demanding working conditions. In deep level underground mining, certain areas of the mine could be humid, cold or hot. The breaking of rock and moving of ore is a noisy operation. Underground workers may be required to work in excavations in which working and environmental conditions range from one extreme to the other.

Miners may specialize according to the type of mine they work in, such as a gold mine, iron mine, platinum mine, asbestos mine, diamond mine or coal mine.

Some fulfilling and satisfying aspects of this career
- working with one's hands
- the opportunity to obtain work without a lot of education
- higher than average salaries

Some demanding and challenging aspects of this career
- the dangerous nature of this work
- the possibility of obtaining phthisis and silicosis
- working in a cramped, dark and damp environment underground

Purpose Orientation
Miners should:
- enjoy working with their hands;
- be safety conscious;
- have leadership qualities;
- have good health and physical stamina;
- have dexterity and coordination;
- have good vision;
- not be afraid of dark or enclosed areas.

School Subjects
Ordinary Level Certificate.
For advancement to managerial positions, an Advanced Level Certificate is necessary.

Compulsory Subjects: None

Recommended Subjects: Mathematics, Physical Sciences, African Languages

Training
In-service training to obtain a Permanent Blasting Certificate:

Duration of course: 12 months. Content of course: Rock-Breaking; People Management; Safety and Health Education; Productivity and Cost Effectiveness; Communication Skills

Employer
- Mining companies
- Mining contractors
- Self-employment, with enough experience and capital, can open own mine

Career 43: Mineralogist

Mineralogists study minerals in terms of their form, crystalline structure, physical and chemical properties.

Areas of specialization in which they can apply their knowledge include:

- Geological Exploration
- Metallurgical Extraction
- Civil Engineering
- Fire-Resisting Materials Industry
- Ceramic Manufacture
- Cement Production
- Building Research

Petrographic microscopes are used in the research for and analysis of minerals or finely ground mineral powders. If microscopic analysis does not give exhaustive results, X-ray apparatus and electron micro-analysis are used.

Some fulfilling and satisfying aspects of this career
- opportunity to specialize in an interesting and varied field
- playing a key role in the development of metalliferous metals

Some demanding and challenging aspects of this career
- microscopic analysis can be frustrating
- possible eyestrain

Purpose Orientation
A mineralogist should:
- have patience and perseverance;
- be attentive;
- be systematic;
- be inquisitive and curious;
- have an open mind and be intuitive;
- have good vision;
- be observant;
- be able to communicate clearly in speech and in writing.

School Subjects
Advanced Level Certificate meeting diploma and degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Geography, Economics

Training
Degree: BSc with Chemistry and Geology

Post-graduate training: for researchers, at least an honours degree in Geology (with specialization in Mineralogy) is required. A master's degree in Mineralogy is recommended.

Employer
- Department of Minerals and Energy
- National Institute of Metallurgy (extraction process mineralogy)
- private companies in mining, ceramics and fire-resisting materials production.
- self-employment, with the necessary experience, can be an independent consultant

Career 44: Mining Assistant

Mining assistants perform a variety of duties underground in mines as well as on the surface.

Mining assistants may erect and dismantle scaffolding at a construction site on the mine; collect waste material; help with the laying of pipes and cables; do bricklaying; transport materials and equipment to and from the workplace; load and unload crates; install, maintain and dispatch mechanical and electrical machinery under the supervision of trained operators; or maintain the premises and gardens of the mine.

Some fulfilling and satisfying aspects of this career
- steady employment
- good benefits, such as housing provided

Some demanding and challenging aspects of this career
- working underground
- the possibility of injury on the job

Purpose Orientation
A mining assistant should:
- enjoy working with their hands;
- be safety conscious;
- have good health and physical stamina;
- be trustworthy;
- be responsible;
- not be afraid of enclosed areas;
- maintain good interpersonal relations.

School Subjects
No specific requirements.

Compulsory Subjects: None
Recommended Subjects: None

Training
The mining assistant receives training on the job. Work experience is gained over a period of time.

Employer
- Mining companies
- Mining contractors

Career 45: Mining Engineer

Mining engineers are responsible for the effective, safe and profitable operation of mining undertakings. They are mining experts and engineers and have a background in geology as well as civil, mechanical and electrical engineering.

Mining engineers must be prepared to supervise any phase of mining and are responsible for the effective managing of the mine. They plan, design, construct and operate the facilities that are used to get solid materials out of the earth. They are responsible for the economical and efficient operation of mines. They have to take mining safety and the safety of the workers seriously.

Mining engineers work with geological and metallurgical engineers to locate and appraise new ore deposits. They may develop new equipment or processes for mining and try to improve working conditions. Some conduct research on mining issues or work on problems related to the protection of the environment.

It is important to note that, although most of the mining engineers' time is spent in the office, they also work on site to check that instructions are being followed as planned.

Engineering graduates usually begin work under the supervision of experienced mine engineers and are gradually given more responsibilities as they gain experience. Some engineers with experience and additional education move into administration or management. Many high-level executives in industry began their careers in engineering.

Some fulfilling and satisfying aspects of this career
- variety of tasks and areas to choose from
- good benefits, such as housing provided
- higher than average salaries
- solving problems

Some demanding and challenging aspects of this career
- dealing with labour issues
- trying to ensure the safety of workers, especially underground
- working long hours to complete a project
- the long period of preparation and study required to register as a professional mining engineer
- having to continue your education throughout your career to keep up with the latest technological advances in your field

Purpose Orientation

A mining engineer should:
- be able to visualize objects three-dimensionally;
- have good health and stamina;
- have mathematical and scientific ability;
- be curious;
- have creativity and initiative;
- be responsible;
- have self-confidence;
- have organisational skills;
- able to command respect;
- maintain a cool head and take charge of a situation;
- have speech and writing skills.

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Information Technology, Engineering and Technology, Geography, Languages

Training
Degree: A B.degree in Mining Engineering

Diploma in Mining Engineering

Employer
- Mining companies
- Mining equipment manufacturers and suppliers
- Universities of technology and universities
- Private consultants
- Government mining departments as inspectors
- Self-employment, can work as an independent consultant for mines

Career 46: Nanoscientist/Nanosystems Engineer

Nanoscientists design, develop and supervise the production of materials, devices and systems of unique molecular or macromolecular composition, applying principles of nanoscale physics and electrical, chemical and biological engineering.

Nanoscientists study structures of 100 nanometres (nm) or less. Since a nanometre only measures one billionth of a metre, it's difficult to imagine anything smaller. Nanotechnology is expected to become one of the most strategic and dominant technologies in the next 10 to 20 years. Nanotechnology will have an almost endless string of applications in biotechnology, biology and biomedicine.

Nanotechnology has had several commercial applications in advanced laser technology, hard coatings, photography, pharmaceuticals, printing, chemical-mechanical polishing and cosmetics. Soon there will be lighter cars using nanoparticle-reinforced polymers, insulin that can be taken orally, artificial joints made from nanoparticulate materials and low-kilojoule foods with nanoparticulate taste enhancers.

Nanoscientists create designs or prototypes for nanosystem applications, such as biomedical delivery systems and atomic force microscopes.

They design or engineer nanodevices etc. using three-dimensional computer-aided design (CAD) software. They coordinate or supervise the work of suppliers or vendors in the designing, building or testing of nanosystem devices, such as lenses or probes.

They design or conduct tests on new nanotechnology products, processes, or systems and engineer production processes for specific nanotechnology applications, such as electroplating, nanofabrication, or epoxy. They conduct research related to a range of nanotechnology topics, such as packaging, heat-transfer, fluorescence detection, nanoparticle dispersion, hybrid systems, liquid systems, nanocomposites, nanofabrication, optoelectronics and nanolithography.

Daily tasks include lab work and analysis, meetings with students and internal meetings, computer work, articles to write, numerous discussions about research findings and much reading to keep up with current information.

In areas as diverse as designing medical diagnostic devices to building better batteries, from creating cosmetics to enhancing energy efficient windows, from auto and plane manufacturing to researching the nature of matter itself, knowledge of nanoscale science and technology will be increasingly important during upcoming years and decades.

As nanoscale science and technology come to have increasing impacts on many aspects of our daily lives, the opportunities for careers in these fields are expanding rapidly. A major challenge for the field is the education and training of a new generation of skilled workers.

Some fulfilling and satisfying aspects of this career
- able to improve people's quality of life
- excitement of new discoveries

Some demanding and challenging aspects of this career
- the need to keep up with current research
- work is very demanding

Purpose Orientation
- have good communication skills
- able to work as part of a team
- have a very enquiring mind
- be extremely dedicated
- have strong analytical skills
- have determination and patience

School Subjects
Advanced Level Certificate meeting requirements for the relevant degree or diploma.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: Computer Science

Training
Because nanoscience is such a wide field, there is not one defined path to follow. One could start with BSc Honours in Physics, Chemistry, Biochemistry or Engineering, and then specialise at Master's and Doctorate level.

Potential fields of study include:
Biology, Chemistry, Physics, Environmental Science,
Agricultural Science, Engineering, Medicine, Materials Science, Forensic Science, Law and Business Ethics.

Not everyone working in the field will require a doctorate degree in one of these fields. A skilled workforce trained at a variety of levels is needed.

Employer

Career opportunities, exist in areas such as:
electronics / semiconductor industry
materials science including textiles, polymers, packaging, amongst others
car and aerospace industries
sports equipment
pharmaceuticals including drug delivery and cosmetics
biotechnology and medical fields
optoelectronics
environmental monitoring and control
food science including quality control and packaging
forensics
university research
national security and the military

Nanoscale science and technology are fuelling a revolution in manufacturing and production, creating new materials and novel processes. Not only will the areas listed above continue to grow and benefit from nanotechnology, but the following fields are expected to undergo developments on a massive scale:

medicine: diagnostics and therapeutics (eg drug delivery)
energy: capture, storage and use, fuel cells, batteries
environmental remediation: in conjunction with genetically modified microbes
robotics: many uses
manufacturing: self-assembly; “bottom-up” fabrication of novel and innovative materials
commerce: radio frequency identification (RFID) “smart” tags

Career 47: Roll Turner

The trade name of a 'roll turner' is descriptive of the work. A metal blank is formed (turned) to a specific shape required for the rolling of steel in a rolling mill. Railway rails are one of the products made by roll turners.

At rolling mills metals are shaped by passing heated metal blocks back and forth between the specially formed rolls of a mill stand, until the desired shape and length have been obtained. Roll turners form and shape these sets of rolls by means of lathes and specially prepared tools such as templates (patterns) until they conform to the specified shape.

Working from blueprints, roll turners clamp steel blocks in giant lathes and cut the desired grooves into the steel blocks, using cutting tools. Roll turners constantly check the shape and size of the grooves on the roll against a template (pattern). In this way the rolls, to be used in rolling mills to shape other steel blocks, are manufactured.

Some fulfilling and satisfying aspects of this career
- working with your hands
- reasonably clean work and the noise is bearable
- little risk in the work
- usually normal working hours

Some demanding and challenging aspects of this career
- occasional monotony of the work
- being on your feet for long periods
- bending over lathes can be tiring

Purpose Orientation
A roll turner should:
- be meticulously accurate;
- concentrate for long periods;
- be a very careful worker;
- be responsible;
- like to work with his hands.

School Subjects
Ordinary Level Certificate.
Some employers prefer higher qualifications.

Compulsory Subjects: None
Recommended Subjects: Mechanical Technology, Mathematics, Engineering and Graphic Design

Training
Apprenticeship training.

Employer
- Large engineering enterprises

Career 48: Physicist

Physicists are scientists who study the fundamental properties of matter. This ranges from the microscopic world of subatomic and molecular particles, to the macroscopic world of cosmology and astrophysics. Systematic observation and experimentation provide the data from which theories describing the fundamental forces and laws of nature can be developed.

Physics is the science that deals with the structure of matter and the interactions between the fundamental constituents of the observable universe. Its object of study, therefore, ranges from quarks (tiny particles making up the nuclei of atoms) to quasars (apparently star-like objects, but brighter than billions of stars put together), found at the edge of the universe. Nothing is too small or too big for the physicist to investigate - the entire universe is their field of study.

Physicists usually specialize in theoretical or experimental physics:

Experimental physicists: supply the fundamental data on which physics is founded. They spend a lot of time in the laboratory where new phenomena are examined through systematic and exact measurements, and experiments are performed to test existing theories.

Theoretical physicists: formulate the laws of nature that determine the properties and transformation of matter and energy. This is done in mathematical terms and electronic computers are often used for the calculations.

Areas of specialization include:

- Solid-state physics and material science
- Nuclear, particle and radiation physics
- Optics and spectroscopy
- Environmental physics
- Medical physics and biophysics
- Solar-terrestrial physics, astronomy and astrophysics
- Plasma physics
- Engineering physics

With some employers, physicists can do original research while with others they apply their knowledge to the solution of specific problems.

Physicists usually work regular hours in offices and/or laboratories, but they may be required to work longer hours if they are intensely involved in their research. In general, the work is not

hazardous. Some physicists may spend time working away from home to use national or international facilities that have unique equipment.

Some fulfilling and satisfying aspects of this career
- making new discoveries or coming up with new laws of nature is exciting
- working with other scientists
- challenge and variety of work
- knowing you are increasing the knowledge and understanding of the physical universe

Some demanding and challenging aspects of this career
- keeping abreast of developments in the field
- research can sometimes be frustrating
- sometimes having to work long, irregular hours

Purpose Orientation
A physicist should:
- have a strong aptitude for mathematics and physical science;
- have above average intelligence;
- have an aptitude for abstract reasoning;
- be curious and imaginative;
- be able to work independently;
- be a keen observer;
- be practical;
- have good observation skills;
- adaptability to learn new skills;
- ability to cope with advances in science and technology

School Subjects
Advanced Level Certificate meeting degree requirements for a degree course

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences
Recommended Subjects: None

Training
Degree: BSc Physics and Mathematics or Chemistry, Geology, Astronomy, Applied Mathematics or Statistics

Post-graduate study: BSc Honours is the minimum requirement to become a physicist. Many employers prefer physicists to be qualified to a doctorate level.

Employer

- Manufacturers of materials
- Manufacturers of equipment
- Hospitals
- Mining companies
- Research organisations
- Universities and universities of technology
- Government departments
- Self-employment, with appropriate experience may act as a private consultant

Career 49: Topographical and Engineering Surveyor

Surveying is the science of representing the layout of the land accurately on maps or plans, and indicating the exact position of any structure or other man-made or natural object, above or below ground. Surveying plays a vital role in the planning, provision and maintenance of all forms of construction and development.

Surveying comprises mainly two fields:

Topographical surveying entails the gathering of information to map the forms of the earth. This is done by means of: triangulation (measuring of angles); traversing; levelling (determining of heights); aerial photographs; calculating positions and heights; establishing place names; annotating aerial photographs by indicating the topographical features.

Back in the office, the surveyor applies this information to the task of preparing a detailed land map. A photogrammetric machine is used to assist in the process.

Engineering surveying entails the collection of all relevant information on the site of a proposed construction project and mapping out the area. Once the design of the project is complete, the surveyor pegs it out on the actual site and also monitors construction in progress to ensure that it does not exceed the layout.

Some fulfilling satisfying aspects of this career
- developing roads, bridges and other structures for the benefit of society and the general economy
- a good balance of field and office work
- meeting new people

Some demanding and challenging aspects of this career
- being away from home often
- working out of doors in adverse weather conditions work

Purpose Orientation
A topographical and engineering surveyor should:
- have mathematical ability - especially in trigonometry;
- have intellectual ability;
- have good observation skills;
- be responsible;
- work accurately;
- have drawing ability;
- be willing to work in the field;
- be able to work independently or with people.

School Subjects
Advanced Level Certificate meeting diploma and degree requirements

Each University or College will have its own minimum entry requirements.

Compulsory Subjects: Mathematics
Recommended Subjects: Physical Sciences, Geography, Mechanical Technology

Training
Degree: Land Surveying

Diploma in Surveying takes 3 years, and consists of theoretical instruction and practical experience with an employer.

Employer
- Government departments
- Municipalities
- Universities
-Civil engineering firms
- Building contractors
- Private land surveying companies
- Self-employment, with enough experience, initiative and capital, can start own practice and / or work as a consultant