NELSON MANDELA UNIVERSITY

Graduate Skills and Attributes Framework

What does a Nelson Mandela University physics graduate "look" like?

This document provides an overview of the skills and attributes that you will possess when you graduate from our 4-year physics honours programme. The attributes and skills listed here have been chosen carefully and are in alignment with national requirements developed by the South African Institute of Physics[1]. It is hoped that by reading this document you will become familiar with the personal skills and attributes required to become a successful physicist. Let this framework motivate you by contextualising your studies, and by fostering your sense of identity as a physicist.

DID YOU KNOW?

- The South African Institute of Physics (SAIP) is the voice of Physics in South Africa. Visit their website to find out more: **www.saip.org.za**
- Qualified physicists can register as Professional Physicists (Pr.Phys) with SAIP.

[1] SAIP (2011) Draft Benchmark Statement on BSc Physics and BSc Hons Physics Training in South Africa

How will skills and attributes be developed?

Skills and attributes will continuously be developed throughout your undergraduate and honours years through your theoretical courses, your practical courses, assessments and the general departmental culture. In this document, **the skills and attributes developed during your 1st year practical course will be highlighted.**

Overview of Skills & Attributes

Physics is concerned with the observation, understanding and modelling of natural phenomena and the behaviour of systems. In addition to these core skills, physicists also require a number of other skills to be successful. Figure 1 provides an overview of the skills and attributes described below.

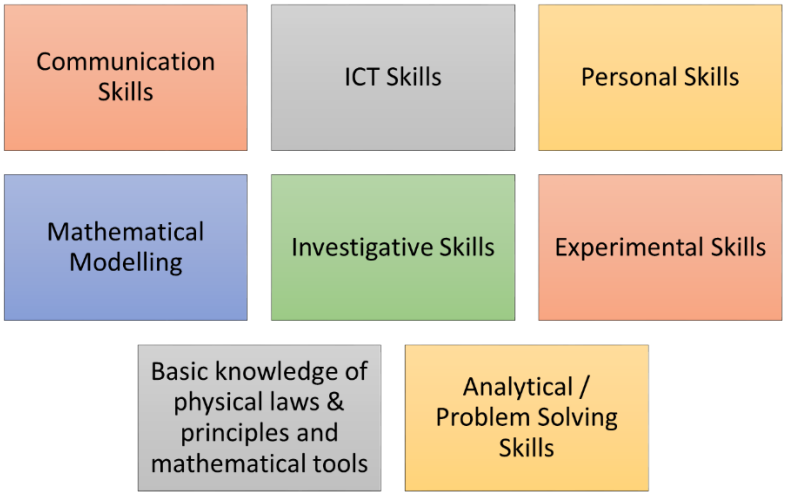

Figure 1: Overview of Skills and Attributes

Basic Knowledge

Physicists require a basic knowledge and understanding of **physical laws and principles** (and applications of these principles) and **fundamental mathematical tools**. Your undergraduate curriculum is made up of a "core physics curriculum"[2] – which is required to be taught at all physics departments across the country – as well as subjects specifically geared towards supporting the department's research focus. Your first year theoretical course covers the fundamentals of a core physics curriculum and is similar to any national or international introductory physics course.

[2] SAIP (2011) Draft Benchmark Statement on BSc Physics and BSc Hons Physics Training in South Africa

1st year practical course:

At the beginning of the year, some time will be dedicated to ensuring that you are well equipped with the basic mathematical tools required to successfully complete the 1st year theoretical course.

Following this, your practical course will afford you the opportunity to experimentally explore the concepts taught in your theoretical course; including topics from mechanics, the physical properties of matter, electricity and magnetism, and optics. Due to time and resource constraints, it is not feasible to experimentally explore all of the concepts covered in your 1st year. The physical concepts covered in your practical course have been prioritised as those which would benefit the most from an experimental component to learning.

Analytical / Problem Solving Skills

Physicists need to know how to formulate and tackle problems in physics – both problems with well-defined solutions as well as open-ended problems. In order to do this, physicists need to be able to:

- Identify the problem in precise terms
- Identify key principles and laws at play, and be able to integrate various elements of Physics
- Identify key parameters
- Identify special and limiting cases and make assumptions and approximations
- Construct logical and reasoned arguments
- Access their problem solving toolbox: e.g. mathematical tools, investigative and experimental skills, etc.

1st year practical course:

At a first year level, approximately 80 % of your practical work will be instruction-led, meaning you will be told what to do. However, in order to exercise your analytical skill, the remaining 20 % will be student-led. In these sessions, you will be required to solve a problem without being specifically directed on what to do. At first year level, these problems will be relatively easily defined and based on a single physical concept.

Mathematical Modelling

In order to make quantitative predictions, physicists make use of mathematical models. Typically, an idealised model of some phenomenon is established, the equations for the model are solved (often with further approximations) and the results related back to what is observed experimentally. Physicists need:

- An understanding of how to use mathematics to approximate the physical world.
- Knowledge of common mathematical approximations e.g. linear, exponential etc.
- Curve fitting skills – parameter extraction and numerical analysis
- The ability to compare critically the results of model calculations with those from experiment and observation
- The ability to present and interpret information graphically

1st year practical course:

In your first year you will be introduced to:

- common mathematical approximations e.g. linear, exponential etc.;
- curve fitting concepts, namely linear regression and the calculation of uncertainty in derived parameters; and
- you will be taught how to present and interpret information graphically.

Investigative Skills

Physicists need to be well skilled in independent investigation, and it is essential that students be given the opportunity to develop their ability to manage their own learning. Students will generally have experience in using textbooks, and other available literature, in searching databases and the internet, and in interacting with colleagues to derive important information.

1st year practical course:

Investigative skills will be developed through the completion of literature reviews and pre-practical preparations.

Experimental Skills

Physicists should be familiar with the following experimental skills and concepts:

- Experimental design:
    - Understanding of the scientific method – the ability to plan, execute and analyse critically the results of an experiment or investigation and draw valid conclusions
    - Design of an experimental matrix – for multivariable systems
- Measurement and uncertainty:
    - Significant figures
    - Sources of uncertainty in measurement
    - Quantification of uncertainty, including the propagation of uncertainty
    - Statistical significance of results
- Familiarity with laboratory apparatus
- Lab etiquette

1st year practical course:

In your first year you will be:

- Introduced to the scientific method
- Taught about sources of uncertainty in measurement, how to quantify and propagate uncertainty in calculations, and how to determine the statistical significance of results
- Exposed to various laboratory apparatus e.g. micrometre, thermometer etc.
- Briefed on lab etiquette

Communication Skills

In order to effectively communicate, you need to be able to understand what is being said as well as be understood.

In order to **understand**, physicists need to be able to:

- listen carefully
- read demanding texts
- grasp scientific/technical language

In order to be **understood**, physicists need to be able to communicate scientific information in a clear and concise manner in various settings and in various modes such as oral presentations (scientific talk

and public lecture), poster presentations, scientific reports, journal articles and even newspaper articles.

1st year practical course:

In your first year, you will be required to write 1 scientific report (which includes a literature survey) per semester. You will also be required to give a short oral presentation.

ICT Skills

Physicists need to be experienced in the use of computers for:

- The control of experiments and data acquisition
- Mathematical modelling and simulation
- Data processing, visualization and analysis

1st year practical course:

At the first year level, students make extensive use of Excel for data processing, visualization and analysis, as well as mathematical modelling and simulation. PASCO systems are used for the control of experiments and data acquisition. **https://www.pasco.com/**

Personal Skills

The following personal skills are required:

- **Proactivity:** Students need to develop their ability to work independently, to use their initiative and to organise themselves to meet deadlines.
- **Experience in group work:** Students need experience in group work and need to be able to interact constructively in a group setting.
- **Ethical behaviour:** Students should appreciate that to fabricate, falsify or misrepresent data or to commit plagiarism constitutes unethical scientific behaviour. They should be objective, unbiased and truthful in all aspects of their work and recognise the limits of their knowledge.
- **Industry experience:** Some industry experience is desirable.

1st year practical course:

Group work will be required.

LW Jan 2018